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14

ARC Centre of Excellence
Coral Reef Studies

ARC CENTRE OF EXCELLENCE FOR CORAL REEF STUDIES

ANNUAL REPORT 2014

Contents

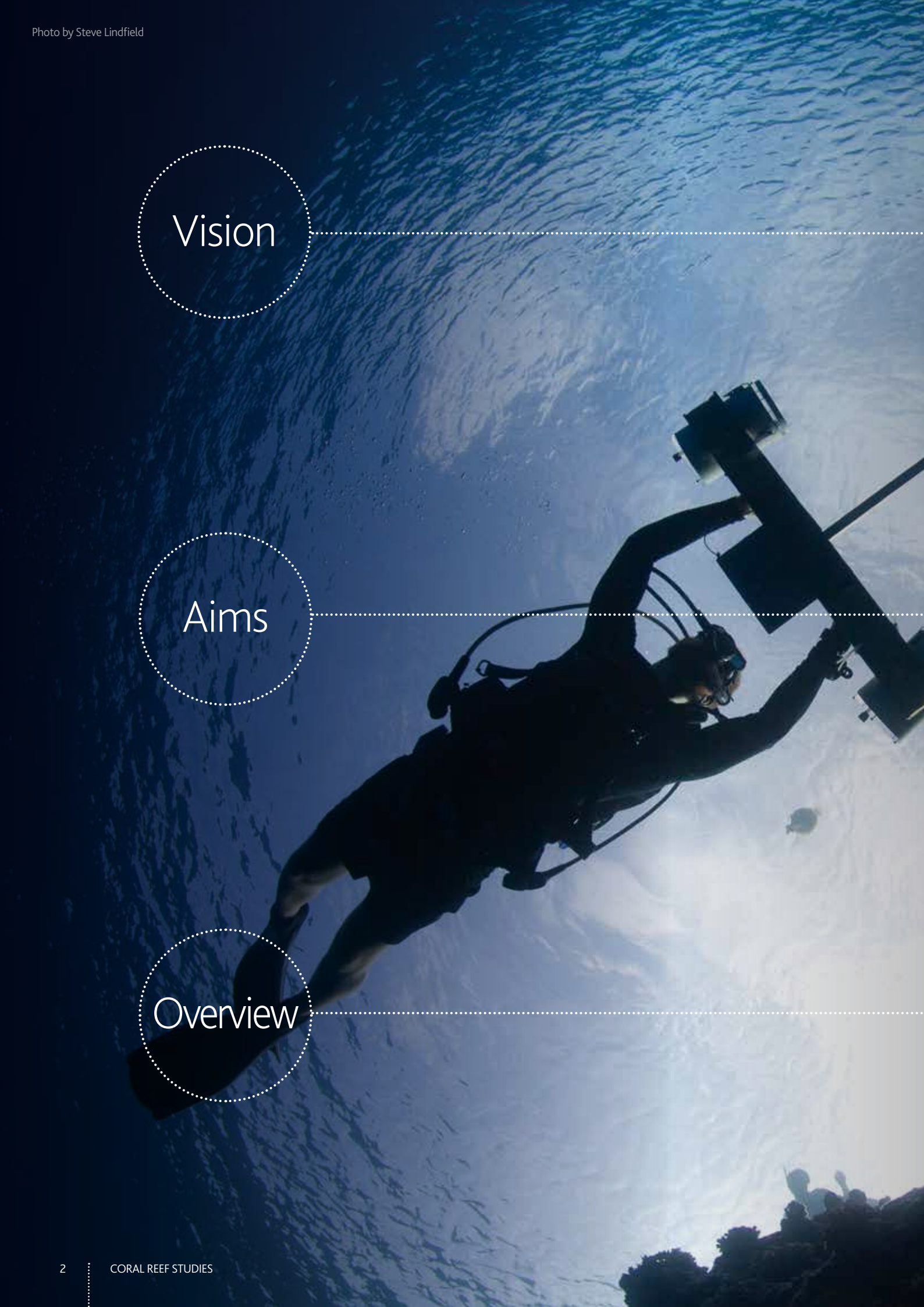
At the ARC Centre of Excellence for Coral Reef Studies we acknowledge the Australian Aboriginal and Torres Strait Islander peoples of this nation. We acknowledge the Traditional Owners of the lands where we conduct our business. We pay our respects to ancestors and Elders, past, present and future.

Cover photo by Raphael Williams
Photo by Stefano Montanari

AR 14

ARC Centre of Excellence
Coral Reef Studies

Photo by Steve Lindfield



Vision

Aims

Overview

Leading 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.

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, 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.

The ARC Centre of Excellence for Coral Reef Studies commenced operations in 2014 following the award of $28 million from the Australian Research Council to fund the Centre for seven years. Headquartered at James Cook University, the ARC Centre partnership includes the Australian Institute of Marine Science (AIMS), the Australian National University (ANU), 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, Stanford University (COS, USA), WorldFish (Malaysia), the University of Queensland (UQ), and the University of Western Australia (UWA).

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 reefs worldwide. This research is both multifaceted and transdisciplinary. It focuses not only on the responses of coral reef organisms to the rapidly changing local and global environments but also examines the dynamics of reefs through the integration of ecology, evolution, genetics, oceanography and palaeontology. 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.

Director's Report

Photo by Ed Roberts

Welcome to the 2014 annual report of the *Australian Research Council (ARC) Centre of Excellence for Coral Reef Studies*, the first in our new funding cycle. Our Centre was launched at the Australian Academy of Science in Canberra in July 2014, by the Chief Executive Officer of the ARC, Professor Aidan Byrne. Immediately following the opening, we presented two days of seminars, which were widely reported on TV and in other forms of media, and are also available on YouTube (**www.youtube.com/user/CoralCoE**).

An early task for the new Centre has been recruiting new researchers to bolster three areas: social science, mathematical modelling, and marine ecology. James Cook University provided a big boost to the development of the Centre, by funding six new tenured research positions. As well, we have hired six new Research Fellows since October, two each in the three current research programs. Some of this new blood will arrive from distant places – like Hawai'i, Norway and South Africa – in the first half of 2015.

During the year the Centre has undertaken fieldwork in 21 tropical countries, particularly in Australia, the Coral Triangle (Philippines, Indonesia, Malaysia, Papua New Guinea, Timor Leste, Solomon Islands), Fiji, French Polynesia, Saudi Arabia, Kenya, the Maldives, the Seychelles, Mexico, and parts of the Caribbean.

The Centre's researchers produced more than 300 publications in 2014, one for every working day of the year! Our co-authors this year come from 277 institutions in 53 countries, reflecting our expanding collaborative network around the world. The Centre's three research Program summaries on pp11–28 provide an overview of our activities throughout 2014.

The Centre's membership consists of 23 Chief Investigators (including 12 Research Fellows), 30 Partner and Adjunct Researchers, 51 full-time Research Fellows and Asscoiates, 156 PhD students (from 41 countries). Membership of the Centre in 2014 has been further enhanced by the recruitment of 63 new PhD, Masters and Honours students. In addition, in 2014, we hosted 67 international visitors to the Centre's nodes in Townsville, Brisbane, Perth and Canberra.

The uncertainty over the World Heritage status of the Great Barrier Reef, the port dredging controversy in Australia, and concerns over coral bleaching in the Pacific, have placed coral reefs in the spotlight in 2014. We provided many briefings, workshops and consultancies to governments, management agencies, non-government organisations (NGOs) and businesses. Examples include Australian government departments, Deutsche Forschungsmeinschaft, Fisheries Research and Development Corporation, the Great Barrier Reef Marine Park Authority, IUCN, National Oceanic and Atmospheric Administration (NOAA), Solomon Island Ministries, The Nature Conservancy, and USAID. During the year, I was appointed by Australia's Environment Minister, the Hon Greg Hunt, as one of the reviewers of the 2014 *Great Barrier Reef Outlook Report*. Our Centre also played a lead role in crafting the submission to the Commonwealth from the *Australian Academy of Science,* on the draft *2050 Great Barrier Reef Sustainability Plan*.

Looking forward to 2015, we plan to take our Centre's annual symposium to Hobart, on 6th-7th October. Yes, it is cold in Tasmania and there are very few corals! However, we look forward to engaging more with our "cold-water" colleagues, many of whom are examining issues such as marine parks, ocean acidification, and regime-shifts – research topics that resonate with many of our own projects.

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, and to our partners from many institutions in Australia and overseas. I am especially grateful to the Centre's Assistant Director, David Yellowlees, and to our fantastic administrative team, led by Chief Operations Officer, Jenny Lappin, for the key roles they play in keeping our researchers so productive.

Terry Hughes
Director

Photo by Giles Winstanely

2014 Highlights

The new Australian Research Council Centre of Excellence for Coral Reef Studies commenced operation.

Dr Brian Walker *FAA* was appointed Chair of the Centre's Advisory Board. Brian works in the field of resilience and sustainability in social-ecological systems and was previously the Chief of what is now the CSIRO Division of Ecosystem Sciences.

Professor Katrina Brown accepted our invitation to Chair the Centre's Scientific Management Committee (p66).

Three research Programs were established:

- Program 1: *People and Ecosystems*. Leaders: Terry Hughes and Bob Pressey (p11)
- Program 2: *Ecosystem Dynamics: Past, Present and Future*. Leaders: Sean Connolly and John Pandolfi (p17)
- Program 3: *Responding to a Changing World*. Leaders: Malcolm McCulloch and Bette Willis (p23).

A fulltime Communications Manager, Eleanor Gregory, was appointed.

Awards (p62) for long term contributions to coral reef science:

- Ove Hoegh-Guldberg received an award from Prince Albert II of Monaco for his contributions to climate change
- Terry Hughes was awarded an Einstein Professorship by the Chinese Academy of Sciences, and an honorary doctorate from the Universiti Malaysia Terengganu
- Geoff Jones was awarded the Australian Marine Sciences Association's 2014 Jubilee Award for excellence in marine research.

Centre members published more than 310 research articles (p52).

Researchers in the Centre received significant new funding from agencies including:

- ARC ($525k) (DECRA and LIEF)
- Queensland Government Accelerate Fellowships ($1m)
- Fisheries Research and Development Corporation ($400k)
- The Great Barrier Reef Foundation ($365k).

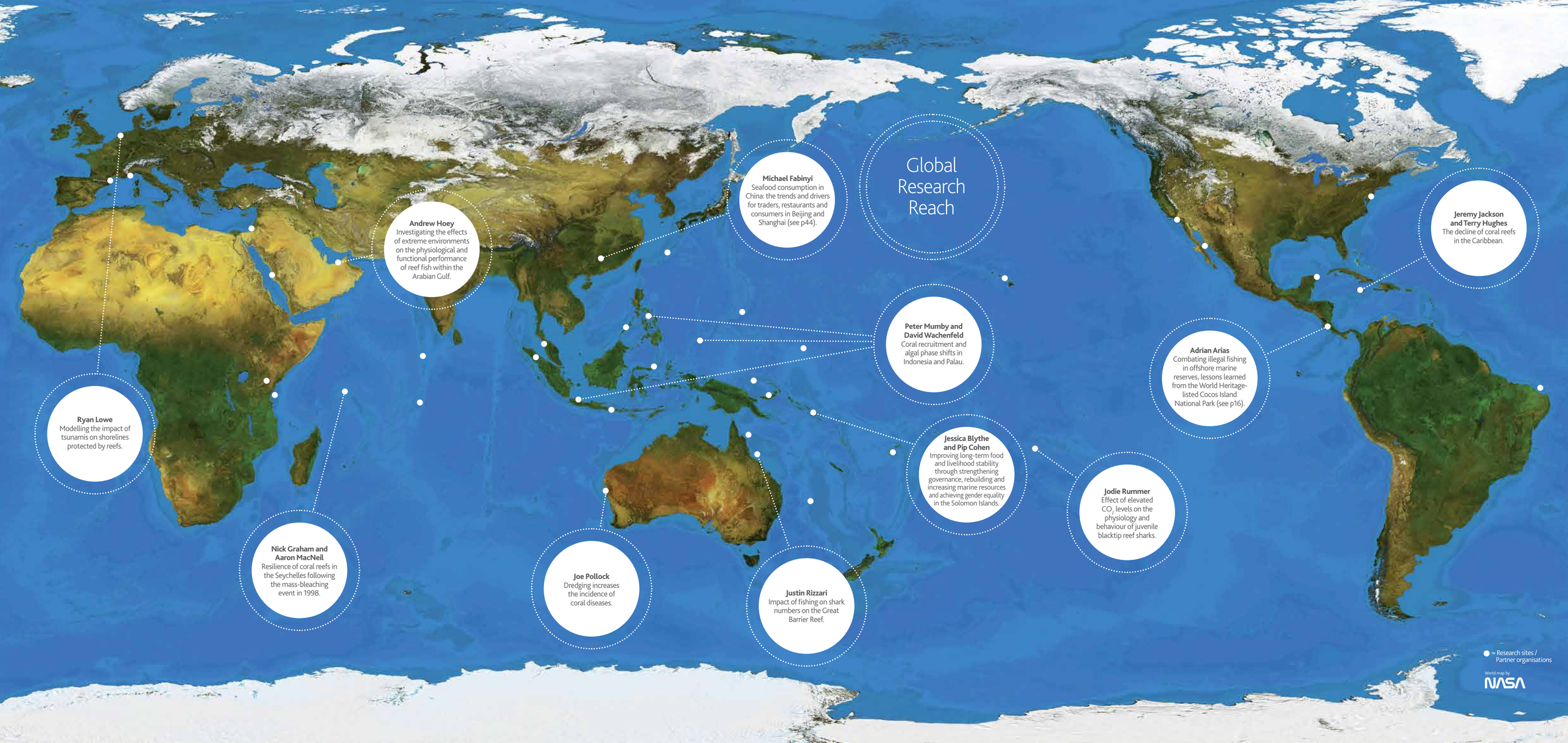
54 research students successfully completed their studies, including 28 PhD students.

63 research students including 26 PhD students commenced.

70% of our postgraduate student population come from overseas.

155 delegates attended the Centre's Symposium *The Future of Coral Reefs* at the Australian Academy of Science's Shine Dome in Canberra in early July.

Centre members provided 100 briefings to industry, business and government


Global Research Reach
Michael Fabinyi
Seafood consumption in China: the trends and drivers for traders, restaurants and consumers in Beijing and Shanghai (see p44).
Andrew Hoey
Investigating the effects of extreme environments on the physiological and functional performance of reef fish within the Arabian Gulf.
Jeremy Jackson and Terry Hughes
The decline of coral reefs in the Caribbean.
Peter Mumby and David Wachenfeld
Coral recruitment and algal phase shifts in Indonesia and Palau.
Adrian Arias
Combating illegal fishing in offshore marine reserves, lessons learned from the World Heritage-listed Cocos Island National Park (see p16).
Jessica Blythe and Pip Cohen
Improving long-term food and livelihood stability through strengthening governance, rebuilding and increasing marine resources and achieving gender equality in the Solomon Islands.
Jodie Rummer
Effect of elevated CO_2 levels on the physiology and behaviour of juvenile blacktip reef sharks.
Ryan Lowe
Modelling the impact of tsunamis on shorelines protected by reefs.
Nick Graham and Aaron MacNeil
Resilience of coral reefs in the Seychelles following the mass-bleaching event in 1998.
Joe Pollock
Dredging increases the incidence of coral diseases.
Justin Rizzari
Impact of fishing on shark numbers on the Great Barrier Reef.
= Research sites / Partner organisations
World map by NASA

Associate Professor Sophie Dove is a Chief Investigator in the ARC Centre. She began her tertiary education in Edinburgh, Scotland, where she studied Mathematics and Philosophy. Her introduction to marine science occurred in California where she began working on the light organs of fish. Before she knew it, she was at the University of Sydney, Australia, working towards a PhD in Marine Biology and Biochemistry. Here, a side project led her to the discovery that the pink, purple and blue colouration of corals belonged to the newly discovered family of Green Fluorescent Proteins (GFPs) which have revolutionised cell biology. Sophie and colleagues subsequently patented the non-fluorescent varieties of these proteins that they identified in reef-building corals.

Sophie's passion for the past 20 years has been coral reef science, and she addresses fundamental questions associated with the response of reef organisms to environmental change. In particular, her recent research has focused on the effect of projected future increases in ocean temperature and acidification on processes, such as calcification, that underpin the existence of reefs over the long-term and provide essential services to coastal communities through the absorption of wave energy.

Sophie is a co-director of the Coral Reef Ecosystems laboratory at the University of Queensland. Here, she has had the good fortune to work with many talented individuals who have allowed her to investigate many aspects of coral reef biology, from the responses of different algae to elevated nutrients, to the construction of energy budgets for bio-eroding sponges.

Sophie has sought to understand why corals of the same species have different colouration. She has sought to gain a better understanding of the respective roles of photosynthesis and heterotrophy in zooxanthellate corals and zooxanthellate sponges. She is now beginning to focus on questions such as: are there environmental conditions under which algal endosymbionts switch from an autotrophic mode of living to a heterotrophic one? That is, are the symbionts more mixotrophic than we have given them credit for? Sophie's prior life as a philosopher is integral to her approach to science. She says, "Core assumptions should always be identified and should always be open to challenge. If orchids, from the same genus, can be autotrophs, mixotrophs and heterotrophs, then why not *Symbiodinium* sp, the zooxanthellae found in corals?"

One of her key achievements to date is the development of a facility on Heron Island, on the southern GBR, that allows for the experimental testing of the responses of both reef organisms and mesocosms ("patch-reefs", representative of key reef locations) to future, but naturally variable, levels of temperature and acidification. The system allows for experiments to be run over a number of years to provide physiological and molecular responses of organisms under controlled conditions. Most importantly, however, the "photographic" results obtained are easily interpretable by the general public giving a clear insight into the potential fate of reefs should we continue along our present pathway of CO_2 release into the atmosphere. Sophie has had the opportunity to share these experiments with US and Australian politicians, school students, holidaymakers, and corporate leaders. Sophie comments, "In today's world, it is fundamentally important to find ways to effectively communicate the results of one's research as expediently as possible. Having come to this realisation, I find the research I conduct today far more satisfying than even the discovery of a patentable molecule!"

Chief Investigator Profile

Associate Professor Sophie Dove

"Congratulations for creating a great wave of awareness about threats and opportunities for coral reefs!"

Silvia Earle

Former Chief Scientist of NOAA congratulating the authors (including Terry Hughes and Jeremy Jackson) on the IUCN publication, Status and Trends of Caribbean Coral Reefs: 1970-2012

Photo by Krisanadej Jaroensutasinee

Graduate Profile

Georgina Gurney

Georgina discussing her research with a field assistant in Indonesia.

Why do people initiate and participate in the management of natural resources? How are people affected by and respond to such initiatives? How do we promote and design natural resource management to build natural and human capital?

"Answering these questions is critical to improving the management of ecosystems, such as coral reefs, because ultimately we manage people and their behaviour towards natural resources rather than the resource itself," says Centre of Excellence student Georgina Gurney.

It's these important questions that form the basis of Georgina's PhD research, supervised by Professors Bob Pressey and Josh Cinner, at the ARC Centre in Townsville.

Georgina's first foray into coral reef research was during the Honours year of her undergraduate degree in marine science at the University of Tasmania, Australia. Preferring warmer waters for diving, she headed north to the Philippines to undertake research on modelling futures of coral reef ecosystems under alternative climatic and management scenarios. A key focus of her work was developing ecological simulation models as decision-support tools for guiding local management of reef systems.

"My experience in the Philippines reinforced my understanding of the importance of a coupled social-ecological systems approach to resource management and policy," says Georgina. "I decided I needed to build my understanding of the human dimensions of marine resource management, and headed to Townsville to do so through a PhD at the Centre".

Poor understanding and limited incorporation of socio-economic considerations in natural resource management has been widely cited as an important factor contributing to the limited success of conservation initiatives. The aim of Georgina's PhD research is to contribute to addressing this gap, using marine protected areas (MPAs), a key tool employed in marine management globally, as a case study.

"The success of MPA management hinges on the support of local stakeholders" says Georgina. " I'm particularly interested in understanding why people initiate and participate in management, and how to promote and develop management strategies to meet local stakeholders' needs and aspirations".

Her thesis aims to investigate the impacts of MPAs on associated human communities, identify the relative role of multiple-scale social and institutional factors influencing stakeholders' involvement in MPA management, and explore alternatives for integrating socio-economic factors into MPA spatial planning. To do this, Georgina takes an interdisciplinary approach, drawing on theory and methods from a range of disciplines, including social psychology, ecology, behavioural economics and human geography.

Georgina is pursuing her research in the context of coral reef management in Indonesia and Fiji. "The importance of understanding the socio-economic dimensions of MPA management is particularly acute in developing countries because coastal people's livelihoods and identity are often intimately related to marine ecosystems" she says.

As part of her PhD research, Georgina works closely with non-government organisations and resource managers, and spent several months living in coastal villages in Indonesia. During her time in villages in north Sulawesi and Bali, Georgina and colleagues conducted surveys, and undertook experimental economic games designed to understand people's cooperative behavioural disposition.

A key aim of her research in north Sulawesi was to understand how people were affected by and responded to an MPA project that was designed to achieve the dual goals of conservation and poverty alleviation. The project was implemented by USAID over a five-year period during the late 1990s. Using 15-years' worth of social data from villages with and without MPAs, the research showed that the MPAs appeared to contribute to poverty alleviation during the implementation period, after which reductions in poverty did not continue to accrue.

"This finding questions the efficiency of the short-term approach taken in many international donor-assisted protected area projects, which are often designed with the expectation that project activities will be sustained and related benefits will continue to accumulate after external support is terminated," she says.

Georgina is continuing her work on the socio-economic impacts of resource management initiatives, and is working with the Wildlife Conservation Society to develop the socio-economic component of their global marine monitoring program.

Photo by Pip Cohen

Research Program 1

People and Ecosystems

RP1

RP1 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 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*. In 2008, he was awarded the prestigious quadrennial Darwin Medal by the International Society for Reef Studies. From 2008-2010, he was a member of the ARC Advisory Council. 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. He is an *ISI Highly Cited Researcher* with 24 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, in Stockholm.

Professor Bob Pressey *FAA*

Professor Bob Pressey is co-leader of 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 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 is an *ISI Highly Cited Researcher* and 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, Amélie Augé, David Bellwood, Jessica Blythe, Jana Brotankova, Joshua Cinner, Pip Cohen, Ian Craigie, Michael Fabinyi, Nick Graham, Christina Hicks, Geoff Jones, Laurence McCook, David Mills, John Pandolfi, Garry Russ, Ruth Thurstan, Rebecca Weeks, Amelia Wenger.

Program 1 is designed to expand the Centre's scope from a predominantly biological focus, to encompass a broader understanding of the linkages between coral reef ecosystems, the goods and services they provide to people, and the wellbeing of human societies. The key objective is to improve the governance and management of natural systems and to enhance our capacity to sustain both human and natural capital. The scale of this Program is global, and includes a focus on issues such as climate change, poverty and development, institutions and multi-scale governance.

Program 1 began the year with a working group in Monterey, California in January, in collaboration with the *Center for Ocean Solutions* at Stanford University. The focus of this working group, which includes Christina Hicks and Nick Graham, Josh Cinner, and Terry Hughes, is to examine how the value of ecosystem services (e.g. fisheries, aquaculture and coastal protection by coral reefs) changes in response to social and economic drivers (e.g. human population growth, globalisation and greenhouse gas emissions), and how economic valuations can be incorporated as a tool to improve reef management and bolster social and ecological resilience.

Josh Cinner published a ground-breaking analysis in *Current Opinion in Environmental Sustainability* on two emerging threads of social science research that are helping to better shape our understanding of coral reef livelihoods. One is a growing appreciation of the non-material benefits that coral reef fisheries provide, such as people's identity, lifestyle, and social norms. The second is the role of livelihood diversity in addressing overfishing, complying with fisheries and protected area management, and in influencing willingness to exit coral reef fisheries. Importantly, Josh's evaluation shows that current theory and empirical research does not always support the notion that diversification of livelihoods will lead to reduced fishing effort, or lower environmental impacts on coral reefs.

Christina Hicks led a study on the responses of coral reef artisanal fishers in the Seychelles to different management approaches. She and her colleagues show that fishers identified a diversity of benefits associated with the fishery but overall fishery, option, bequest, and existence benefits were assigned the highest priorities. Fishers with high earnings tended to prioritise option, whereas fishers with lower earnings tended to prioritise fishery benefits. These findings have implications for fisheries management decision-making. For example, decentralised approaches, such as fisheries co-management, are only likely to succeed for the group of fishers who demonstrated a high likelihood of cooperation. In a second paper in *Proceedings of the National Academy of Sciences*, Christina and Josh Cinner examined how people perceive ecosystem service benefits, based on their studies of 28 coral reef fishing communities in four countries. They show that bundles of benefits are mediated by key mechanisms that influence access to fisheries. Interestingly, social, institutional, and knowledge mechanisms were associated with the greatest number and diversity of benefits. The study concluded that resource managers can focus on these access mechanisms to maximise ecosystem service benefits while minimising human-environment impacts.

Mike Fabinyi published a series of papers in 2014, broadly based on his anthropological approach to governance of fisheries and coral reefs in China and south east Asia. These included papers on social development near the Philippines/Malaysia maritime border *(Development Policy Review)*, social trust and luxury seafood banquets (p44) in contemporary Beijing *(Asian Anthropology)*, and China's policy for global fisheries *(Ocean and Coastal Development)*.

Photo by Simon Foale

In a policy article published in *Nature Climate Change*, Terry Hughes joined a distinguished group of economists, social scientists and ecologists to analyse the likely effectiveness and social-ecological risks of geoengineering the earth's climate, especially for vulnerable social-ecological systems such as coral reefs. The study's main conclusion is that when the use of geoengineering is politically feasible, the intervention may not be effective; and that, when its use might be effective, its deployment may not be politically feasible. The many problems with geoengineering and the geopolitical challenges that would be triggered by its use suggest that contemplation of geoengineering does little to diminish the need to address the root causes of climate change. The study concludes that the prospect of geoengineering should strengthen the resolve to tackle climate change directly, by limiting atmospheric concentrations of greenhouse gases.

The conservation planning group within Program 1 led by Bob Pressey focuses on the research that underpins spatial solutions to diverse resource-management problems, involving the design of conservation areas and application of management actions. Research on systematic conservation planning provides a rigorous approach to decision-making that synthesises advances in biology, geography, economics, the social sciences, and spatial modelling. In 2014, newly developed research topics are grouped under nine broad themes: Planning for connectivity, Planning for a changing climate, Prioritising management actions, Integrated cross-realm planning, People and protected areas, Conservation economics, Data and tools for conservation planning, Conservation impact evaluation, and Protected-area implementation and management.

The conservation planning group published 20 journal papers in 2014, based on fieldwork conducted across and around Australia, through the Coral Triangle and Oceania, in Mexico, the USA, Brazil, Costa Rica and East Africa. Rebecca Weeks led a study of governance and capacity building in the Coral Triangle, centered on the effective design of marine protected areas, published in *F1000Research*. Part of Rafael Magris' PhD research was published in *Biological Conservation* in a comprehensive review of approaches to considering connectivity and climate change in designing systems of marine protected areas. Other papers developed models of pollutant loads entering marine ecosystems from catchments (*Journal of Environmental Management*, led by Jorge Álvarez-Romero), an analysis of policy for environmental offsets in the Great Barrier Reef (*Environmental Science and Policy*, led by PhD student Melissa Bos), and the social impacts of marine protected areas in Sulawesi (*Global Environmental Change*, led by PhD student Georgina Gurney). Bob Pressey was invited to contribute a commentary to *Nature* in the lead-up to the high-profile international World Parks Congress, convened in Sydney in November.

Program 1 was the Centre's main target for expansion in 2014 - we recruited two new tenured researchers and three additional Research Fellows with expertise in social-ecological systems, who will join us in 2015.

Photo by Simon Foale

MEDIA RELEASE

18 NOVEMBER, 2014

History's lesson reveals depth of fish catch decline

Scientists in Australia have used historic media to measure the decline in Queensland's pink snapper fishery, highlighting a drop of almost 90 per cent in catch rates since the 19th Century.

Researchers from the ARC Centre of Excellence for Coral Reef Studies (Coral CoE) at the University of Queensland and the Department of Agriculture Fisheries and Forestry examined thousands of newspaper articles dating back to 1870 to reveal the historic catch rates for the iconic Queensland fishery.

"We found that 19th century recreational fishers regularly caught hundreds of fish off the coast of Queensland, often in just a few hours of fishing," says Dr Ruth Thurstan, a Research Fellow from the Coral CoE.

Combining historical data with statistical analyses allowed the researchers to calculate catch rates, which are the number of fish caught per hour fishing per day, for nearly 300 fishing trips between 1871 and 1939.

When the researchers compared the findings to contemporary fishing trips, they found that recent catch rates averaged just one-ninth of historical levels.

The old news articles have given researchers unparalleled insights into the history of the Queensland snapper fishery.

"When we searched through these old newspapers we were amazed by the level of detail they provided," Dr Thurstan says.

"They give us a much better understanding of just how rich and productive this fishery used to be, as well as providing us with some fascinating insights into the development of offshore recreational fishing in Queensland."

"Crucially, these newspaper articles place the modern day fishery into a longer-term perspective that isn't available using only official records. This helps us understand the changes that have occurred in the fishery over time, and provides an additional piece of the puzzle for those managing this fishery today," Dr Thurstan says.

Study co-author, Professor John Pandolfi, also from the Centre of Excellence for Coral Reef Studies agrees.

"This is one of the most comprehensive perspectives on historical trends in catch rates for Australian fisheries ever compiled," Professor Pandolfi says.

"We expect similar trends to be uncovered for other Australian fisheries."

Paper

Thurstan, RH, Campbell, AB and Pandolfi, JM. Nineteenth century narratives reveal historic catch rates for Australian snapper *(Pagrus auratus)*. *Fish and Fisheries*. doi: 10.1111/faf.12103.

MEDIA RELEASE

13 NOVEMBER, 2014

Combatting illegal fishing in offshore marine reserves

Researchers from the ARC Centre of Excellence for Coral Reef Studies (Coral CoE) at James Cook University have found a way to predict illegal fishing activities to help authorities better protect offshore marine reserves.

Marine reserves are the most common strategy used to protect and maintain marine ecosystems around the world.

The International Convention of Biological Diversity aims to have 10 per cent of the world's marine areas protected by 2020.

But scientists are concerned that while a great deal of effort is being made to create reserves, many countries are simply not able to enforce the laws that are supposed to protect them.

The majority of fishers obey the law, but some don't.

"Enforcement and compliance issues for large off-shore marine parks are fundamentally different to near-shore protected areas," says Professor Josh Cinner from the Coral CoE.

"The biggest problems facing countries trying to enforce offshore marine reserves are their distance from land and the difficulty and cost of patrolling large tracts of ocean," he says.

In a bid to combat the problem, researchers at the Coral CoE examined five years' worth of data collected from the World Heritage-listed Cocos Island National Park, a unique marine protected area in the Pacific Ocean about 500 kilometres off the west coast of Costa Rica.

From the records they were able to identify illegal fishing patterns and predict both when and where illegal fishing was likely to happen.

They found that illegal fishing was concentrated in a few 'hotspots' and really ramped up during specific lunar phases of some months.

Professor Bob Pressey, also from the Coral CoE, says authorities could use this knowledge to match patrols to the time and place when illegal fishers are most likely to be in action.

"Using a targeted approach helps authorities catch and deter illegal fishers, while saving money on patrols," Professor Pressey says.

Study lead author, Coral CoE PhD candidate, Adrian Arias says the model of predicting illegal patterns from old records can be used elsewhere.

"Our research in Costa Rica showed how a systematic and periodic analysis of patrol records could help to increase the probability of catching illegal fishers. This could be done pretty much anywhere that patrol data are available," he says.

He adds that by better targeting limited resources, authorities have a greater chance of successfully protecting marine parks.

Paper

Arias, A, Pressey, RL, Jones, RE, Álvarez-Romero, JG and Cinner, J. Optimizing enforcement and compliance in offshore marine protected areas: a case study from Cocos Island, Costa Rica. *Oryx,* doi:10.1017/S0030605314000337.

Research Program 2

Ecosystem Dynamics: Past Present and Future

RP2

Photo by Tom Bridge

RP2 Research Program Leaders

Professor Sean Connolly

Professor Sean Connolly, from James Cook University, is co-leader of 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 70 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 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 (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 was recipient of 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, Nick Graham, Alastair Harborne, Hugo Harrison, Andrew Hoey, Jeremy Jackson, Geoff Jones, Michael Kingsford, 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, Ruth Thurstan, Sue-Ann Watson, David Williamson.

Photo by James Tan

Program 2 aims to understand the multi-scale dynamics of coral reefs, through the innovative integration of ecology, evolution, genetics, oceanography and paleontology. Researchers focus particularly in four key areas. We examine the historical transitions of ecosystems, improving knowledge of how the resilience of coral reefs evolves and responds to human impacts. 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 examine how populations of organisms living on different reefs are connected to each other through the dispersal of their offspring, diseases, and new species introductions. Finally, we study the level of functional diversity and redundancy in coral reef assemblages, modelling and assessing the effects of changes in biodiversity on ecosystem function at regional to global scales, as well as investigating the effects of management on the dynamics of reef ecosystems.

In 2014, the impacts of climate change on biodiversity were a major focus of research. In a paper in the journal *Nature,* John Pandolfi, working with a large team of international researchers, used information about species' climate requirements to predict regions of potential loss of biodiversity. Similarly, Morgan Pratchett found that reef fishes with high levels of ecological specialisation also had more limited capacity to shift their geographical ranges in response to climate change. In the journal *Nature Climate Change*, Joana Figueiredo and Andrew Baird, working with Sean Connolly, used an innovative combination of mathematical models and laboratory experiments to show that warmer temperatures would increase the proportion of offspring of corals that return to the reefs where they were produced. This has the potential to reduce the rate of spread of warm-adapted coral genotypes, while increasing the rate at which isolated reef systems are likely to recover from disturbances.

Centre researchers also continued to make breakthroughs in our understanding of how ocean acidification will affect the behaviour of fishes. In a series of papers in *Global Change Biology, Proceedings of the Royal Society,* and *Nature Climate Change*, Philip Munday, Jodie Rummer, Sue-Ann Watson, and Mark McCormick, identified several important impairments in fish learning that increase their predation risk, and discovered that similar behaviourally-mediated effects of acidification increase predation risk in invertebrates. Moreover, the team's work at natural CO_2 seeps in Papua New Guinea revealed that these effects remained present even after long-term exposure to acidified water.

Centre researchers continued to lead the world in advancing understanding of the effects of fishing on coral reefs, and the capacity to utilise networks of protected areas to make fishing a more sustainable source of livelihoods. Ruth Thurstan, working with John Pandolfi, used historical sources from the 19th century to document a long-term decline in the catch rates of Queensland snapper (p15), and PhD student Justin Rizzari, working with Ashley Frisch and Sean Connolly, assessed the abundance of reef sharks to demonstrate precipitous fishing-induced declines of these animals on the Great Barrier Reef. Because establishing networks of no-take protected areas is a major way to protect such species from overfishing, Peter Mumby and colleagues modelled how such networks could be established in a way that would minimise the short-term reduction in fishers' yield and revenue, and predicted that a gradual increase in the size of protected areas over time would be most effective.

Centre members also continued to advance fundamental understanding of the origins, maintenance, and consequences of biodiversity, discoveries with important implications for the conservation and sustainable use of coral reefs' rich biological

resources. In a paper in the journal *Proceedings of the National Academy of Sciences*, a large international team of researchers, led by Sean Connolly, undertook an unprecedented global analysis of marine ecosystems ranging from tropical reefs to the Antarctic deep sea, to conduct the most comprehensive and robust test to date of a controversial theory of biodiversity, termed neutral theory. They found that the structure of marine ecosystems includes too much variation in abundances among species to be explained by the processes included in neutral theory. This highlights the importance of considering how species traits shape their abundance patterns and role in the functioning of ecosystems. Similarly, a paper in the journal *Ecology*, led by Centre PhD student Brigitte Sommer, working with John Pandolfi, found that species traits were also key determinants of species' capacity to tolerate marginal reef habitats, and thus of their potential geographical distributions. However, the relationship between the traits that determine abundances, and those that determine geographic ranges, appear to be quite different: Terry Hughes, working with Sean Connolly and David Bellwood, found no relationship between the abundance and geographic extent of species in a paper in *Current Biology*, debunking the widely-held view that species with small geographic ranges tend to be numerically rare and therefore suffer from substantially elevated extinction risk. Their findings have substantial implications for reef management, and challenge the recent push to list one-third of the Indo-Pacific's coral species as threatened with extinction.

In other work, an international team of researchers including David Bellwood found, in papers published in the *Proceedings of the National Academy of Sciences* and *Ecology Letters*, that biodiversity provides a limited degree of redundancy of ecological function in reef fishes: most biodiversity is packed into a relatively few functional groups, leaving the others vulnerable to depletion, (p29).

Program 2 researchers also made important contributions to policy and management, both within Australia and overseas. Philip Munday was a lead author for the United Nations Environment Program's *Convention on Biological Diversity* report on the effects of Ocean Acidification, and also participated in a *State-of-the-Science Considerations for Small Island Developing States Forum* on the same topic, which developed recommendations for heads of government and governmental institutions at the UN Small Islands Developing States meeting. Nick Graham is advising the Seychelles Fishing Authority on fishery management targets for its inshore reef fishery. Morgan Pratchett and Andrew Hoey undertook reef assessments at Elizabeth and Middleton reefs on behalf of the Australian Department of the Environment.

Photo by Tau Morove

MEDIA RELEASE

29 APRIL, 2014

More coral babies staying home on future reefs

Increasing ocean temperatures due to climate change will soon see reefs retaining and nurturing more of their own coral larvae, leaving large reef systems less interconnected and potentially more vulnerable.

"We found that at higher temperatures more coral larvae will tend to stay on their birth reef," says the lead author, Dr Joana Figueiredo from the ARC Centre of Excellence for Coral Reef Studies (Coral CoE) at James Cook University.

"This is good news in an otherwise cloudy picture for isolated reefs, because in the future they will be able to retain more of their own larvae and recover faster from severe storms or bleaching events," she adds.

Professor Sean Connolly, also from the Coral CoE, explains that while more coral larvae will stay close to their parents, fewer will disperse longer distances, leaving reefs less connected.

"The loss of connectivity can make reef systems such as the Great Barrier Reef more vulnerable," he said.

"So, interconnected reef systems that depend on the recruitment of coral larvae may take more time to recover after a disturbance, such as a cyclone, because fewer larvae will disperse from other reefs to the disturbed reef."

Professor Connolly adds that weaker connections between reefs means warm-adapted corals, such as those in the northern Great Barrier Reef, may take longer to expand their ranges to the south.

Similarly for isolated reefs, Dr Saki Harii from the University of the Ryukyus says, "While isolated reefs can retain more of their own larvae, this also leaves them with fewer possibilities to change their species composition to adjust to climate change."

Professor Andrew Baird from the Coral CoE says the implications of the research present management with both challenges and opportunities.

"Our results demonstrate that global warming will change patterns of larval connectivity among reefs. On a positive note, the stronger link between adults and recruits means an even greater benefit if we reduce local threats such as dredging and fishing methods that can damage corals," Professor Baird says.

Nevertheless, he explains, "This does not reduce the need for global action on climate change."

Paper

Figueiredo, J, Baird, AH, Harii, S and Connolly, SR (2014). Increased local retention of reef coral larvae as a result of ocean warming. *Nature Climate Change* 4(6): 498-502.

MEDIA RELEASE

10 DECEMBER, 2014

You are what you eat if you are a coral reef fish

Photo by Tane Sinclair-Taylor

In a world first study, researchers have found a coral-eating fish that disguises its smell to hide from predators.

"For many animals, vision is less important than their sense of smell," says study lead author Dr Rohan Brooker from the ARC Centre of Excellence for Coral Reef Studies (Coral CoE) at James Cook University.

"Because predators often rely on odours to find their prey, even visually camouflaged animals may stick out like a sore thumb if they smell strongly of 'food'," Dr Brooker says.

The research, published in the journal *Proceedings of the Royal Society B*, found that the harlequin filefish changed its smell to match the coral it ate.

"By feeding on corals, the harlequin filefish ends up smelling enough like its food that predators have a hard time distinguishing it from the surrounding coral habitat," Dr Brooker says.

Study co-author, Professor Philip Munday from the Coral CoE says the ability to chemically camouflage itself is a great advantage for the fish.

"The harlequin filefish shelters among the branches of coral colonies at night, where not only does it look like a coral branch, it also smells like one, enabling it to remain undetected by nocturnal predators."

Professor Doug Chivers from the University of Saskatchewan, who is also a co-author, agrees.

"A finely-tuned combination of visual and chemical camouflage may be an effective anti-predator strategy that helps the fish to avoid being eaten," Professor Chivers says.

Not only does the filefish confuse its predators, it matches the odour of the coral so closely that small crabs, which live on coral branches, couldn't distinguish it from coral.

Professor Munday says it's a remarkable example of how closely animals can adapt to their habitats.

"However, the filefish's cover is blown if it shelters in a different species of coral to the one it has been eating. Then the predators can distinguish its presence and track it down," Professor Munday says.

The ability to chemically 'blend in' occurs in some plant-eating invertebrates, but this is the first time this type of camouflage has been found in higher order animals, such as fish.

"This is very exciting because it opens the possibility of a wide range of different animals also using similar mechanisms, right under our noses," Dr Brooker says.

Paper

Brooker, R, Munday, P, Chivers, D and Jones, G. You are what you eat: diet-induced chemical crypsis in a coral-feeding fish. *Proceedings of the Royal Society* B, doi: 10.1098/rspb.2014.1887.

Photo by Anna Froik

Research Program 3

Responding to a Changing World

RP3

RP3 Research Program Leaders

Professor Malcolm McCulloch *FRS, FAA*

Winthrop Professor Malcolm McCulloch is one of the Centre's two Deputy Directors and co-leader of Program 3: *Responding to a Changing World*. Malcolm is an ARC Australian Laureate Fellow in the School of Earth & 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 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 Program 3: *Responding to a Changing World* 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, factors driving 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 Facility/World Bank Working Group on Coral Disease and participates in a range of national and international working groups to further understanding of the ecology of infectious coral diseases and raise awareness of this issue throughout the Indo-Pacific.

Researchers

Tracy Ainsworth, Andrew Baird, Anthony Bertucci, Pim Bongaerts, Sean Connolly, Juan Pablo D'Olivo Cordero, Sophie Dove, Jim Falter, Sylvain Forêt, Migual Gongalez-Rivero, Hugo Harrison, Ove Hoegh-Guldberg, Michael Holcomb, Mia Hoogenboom, Geoff Jones, Michael Kingsford, Bill Leggat, Janice Lough, Ryan Lowe, Vimoksalehi Lukoschek, Ben Mason, Mark McCormick, David Miller, Aurélie Moya, Philip Munday, Stephen Palumbi, Morgan Pratchett, Jodie Rummer, Eugenia Sampayo, Verena Schoepf, Madeleine van Oppen, Sue-Ann Watson, Zhenlin Zhang.

Understanding the responses of coral reef organisms and biological processes to rapidly changing local and global environments is key to understanding the sustainability of coral reefs and the ecosystem services they provide to societies and economies. Research in Program 3 focuses on understanding processes underpinning reef resilience in three vital areas, the dynamics of coral associations in changing environments, the integrity of carbonate reef frameworks, and mechanisms for adapting to a challenging future.

In 2014, new insights into the critical role of microbial symbionts in coral health and their capacity to respond to changing environments were revealed by Program 3 members working on several fronts. PhD student Kim Lema, working with Bette Willis, showed that the symbiotic association between corals and nitrogen fixing bacteria is established in coral larvae and is stable in adults. This confirms the importance of this symbiosis for corals living in N-limited environments (*Environmental Microbiology, Molecular Ecology*). Tracy Ainsworth continues to explore the niche specificity of the core coral microbiome, further highlighting the tight associations that exist between the coral host and its microbial partners. Exploring a new frontier within the coral holobiont, Madeleine van Oppen and colleagues published the first viral metagenome of a coral in *Frontiers in Microbiology*, laying the foundation for understanding the roles of this critical but hitherto unexplored group.

The first major outcomes of an extensive research program led by Malcolm McCulloch, along with Ryan Lowe and Jim Falter, to compare coral calcification rates along the Western Australian coastline from the Kimberley in the north to temperate reefs off Rottnest Island in the south, were published in 2014. Significantly, differences in calcification rates for similar species were generally minimal, suggesting that corals have a narrow range of optimal growth rates despite the large gradient in temperatures surveyed (*JEMBE*). Using coral cores as proxy climate indicators, Malcolm McCulloch, Janice Lough and colleagues revealed Niño/Niña signatures associated with long-term Leeuwin Current variability since 1795 (*Nature Communications),* and Janice Lough and colleagues found evidence for reduced northeastern Australian summer monsoon activity ~6,000 years ago, important for testing global climate models (*Paleoceanography).* Ryan Lowe and Jim Falter published an invited review in *Annual Review of Marine Science* on how ocean processes shape coral reef systems.

Two significant pieces of research in Program 3 have highlighted the negative impacts of sediments and dredging on corals and support the need for improved catchment management. On the Great Barrier Reef, geochemical analyses of coral cores to reconstruct long-term records of seawater temperature, seawater pH and terrestrial runoff, led by Juan Pablo D'Olivo Cordero, showed that coral growth is reduced in years with decreased water quality associated with high runoff (*Biogeosciences Discussions*). Complementing this, PhD student Joe Pollock, working with Bette Willis and colleagues at the Western Australian Department of Parks and Wildlife (*PloS One*), have demonstrated that the prevalence of coral disease doubles with increasing exposure to sediment and turbidity associated with offshore dredging.

Photo by Adrian Arias

New research on the capacity of reef organisms to acclimatise to future ocean warming was undertaken in both corals and fishes in 2014. By quantifying thermal performance curves of four coral populations along a 3°C temperature gradient, Mia Hoogenboom and colleagues concluded that thermally tolerant corals have limited capacity to acclimatise to future warming (*Global Change Biology)*. In research, also published in *Global Change Biology,* Jodie Rummer found that thermal optima for aerobic scope of equatorial reef fishes are close to current day temperatures, thus they have limited scope for acclimatisation to warming sea temperatures.

Centre researchers also explored the mechanisms used by coral reef organisms to adapt to acidifying oceans. Using whole transcriptome analyses to compare the effects of acute and prolonged exposure to high levels of pCO_2, Aurélie Moya, Sylvain Forêt, David Miller and colleagues found that coral juveniles have the capacity to rapidly acclimate to elevated pCO_2. This involved both up-regulation of a set of Heat Shock Proteins and suppression of apoptosis (programmed cell death) in coral cells.

Probing the underlying physiological basis of calcification, Michael Holcomb, working with Malcolm McCulloch and collaborators at the Centre Scientifique de Monaco, found that a coral's ability to control its internal pH is tightly linked to external pH changes. Published in *Scientific Reports,* their work shows that, while corals up-regulate pH during calcification, it will be more difficult for new coral larvae to establish themselves, for fragmented corals to bond to new substrates, and for damaged corals to regrow as oceans become more acidic.

Research into the effects of high CO_2 on marine fish, led by Philip Munday, Mark McCormick and colleagues, showed that the effects of projected future CO_2 levels on fish learning occur because high CO_2 interferes with one of the primary neurotransmitters in the brain (*Global Change Biology)*. This has consequences for larval homing, habitat selection and predator avoidance. Similar effects of high CO_2 on the behaviour of an invertebrate were reported for the first time by Sue-Ann Watson, indicating that the behaviour of a broad spectrum of marine species could be adversely affected by rising CO_2 levels (*Proceedings of the Royal Society B)*.

In a novel study using natural CO_2 seeps in Papua New Guinea, Philip Munday and Jodie Rummer, working with colleagues from the Australian Institute of Marine Science, documented the same behavioural effects in fish populations naturally exposed to CO_2 levels projected for the end of this century. Importantly, the study demonstrates that reef fish living in these higher CO_2 levels do not adjust to these conditions (*Nature Climate Change)*. In companion laboratory studies, Philip Munday and PhD student Megan Welch showed that behavioural impacts of high CO_2 are undiminished by parental exposure to a high CO_2 environment (*Nature Climate Change)*. However, Philip Munday, Mark McCormick and PhD student Bridie Allan have found that there is potential for acclimation of behavioural impairment across generations for some traits (*Proceedings of the Royal Society B)*. Together, these studies show that reef fishes are highly sensitive to rising CO_2 levels in the ocean and have limited potential to acclimate through phenotypic plasticity.

Photo by Adrian Arias

MEDIA RELEASE

8 JULY, 2014

Lessons from the West: Great Barrier Reef in danger

Scientists are examining degraded reefs off the northwest Australian coast in an effort to determine what lies ahead for the Great Barrier Reef.

"Reefs north of Exmouth have experienced large-scale bleaching in the past five years," says Professor Malcolm McCulloch from the ARC Centre of Excellence for Coral Reef Studies at the University of Western Australia.

Professor McCulloch is in the midst of an autopsy of this Pilbara bleaching event, collecting and analysing living and dead stony coral. He says the bleaching happened both inshore and offshore. Interestingly, this was across the dredging grounds of Barrow and Onslow as well as the now near-pristine Montebellos – an area pretty much abandoned by humans since atomic bomb testing took place at the site mid-last century.

"The Pilbara reefs experienced bleaching due to higher temperatures that extended way beyond the dredging areas," he says, pointing to the La Niña of the past five years as one of the main contributors to an intense and prolonged warming along the west coast.

McCulloch warns that while the upcoming El Niño will relieve conditions in the west, intense warming will swoop down the east coast of Australia, including the Great Barrier Reef.

McCulloch expresses worry for the Great Barrier Reef as it faces the combined effects of the natural El Niño phase, anthropogenic climate change and a possible increase in coastal development.

"Climate change pays no attention to whether an area is pristine or polluted," he explains.

"And when dredging and climate change interact, there are quite serious effects that don't happen separately, they happen together."

McCulloch says the dredging undertaken at Barrow, part of the massive $54 billion Gorgon project, was one of the biggest dredging projects of its kind in the world.

"With the scale of project similar to what's proposed for the Great Barrier Reef and Abbot Point, what we can take away from this experience in Western Australia is a likely indication of the effects that lie ahead for the Great Barrier Reef."

"The El Niño years of 1998 and 2002 were the warmest and most devastating years on record for the Great Barrier Reef," continues McCulloch.

"The chances of bleaching are already much greater during these natural warming phases, but when superimposed with anthropogenic warming and other coastal effects, the results can be devastating."

"With the Great Barrier Reef now about to get warmer, what we do hope is that at the very least, dredging in this area be delayed until the cooler phase of La Niña returns to the east coast."

"Coral resilience – their ability to bounce back – will be affected by degraded conditions from factors such as dredging activity and river runoff," concludes McCulloch.

MEDIA RELEASE

3 DECEMBER, 2014

A glimmer of hope for corals as baby reef builders cope with acidifying oceans

Photo by Aurelie Moya

While the threat of coral bleaching as a result of climate change poses a serious risk to the future of coral reefs worldwide, new research has found that some baby corals may be able to cope with the negative effects of ocean acidification.

Ocean acidification, which is a direct consequence of increased atmospheric carbon dioxide levels, is expected to have a deleterious effect on many marine species over the next century.

An international team examining the impact of ocean acidification on coral has found that a key reef building coral can, over a relatively short period of time, acclimate to a doubling of atmospheric carbon dioxide levels.

"Our aim was to explore the effect of a more acidic ocean on every gene in the coral genome," says study lead author, Dr Aurélie Moya from the ARC Centre of Excellence for Coral Reef Studies.

The researchers exposed baby corals from the Great Barrier Reef to acidified seawater for varying lengths of time and investigated how they responded at a molecular level.

"We found that, whereas three days of exposure to high CO_2 disrupts formation of the coral skeleton, within nine days the baby corals had re-adjusted their gene expression to pre-exposure levels. Longer exposure seems to be less detrimental to corals than we had assumed based on shorter-term studies," Dr Aurélie Moya says.

"These findings suggest that baby corals have the capacity to acclimate to elevated carbon dioxide."

"We saw that within a few days, juvenile coral adapted to CO_2 levels double those experienced today, with no obvious disruption to its life processes," says study co-author, Professor David Miller also from the Coral CoE.

Professor Miller says the findings are particularly significant as they centred on staghorn coral.

"Staghorn corals are the key reef building corals throughout the Pacific and Indian Oceans. These are traditionally considered to have poor stress tolerance. So this work provides a glimmer of hope that coral reefs can attenuate the effects of ocean acidification."

The research team examined tens of thousands of coral genes and was able to identify those that were responsible for enabling acclimation to high carbon dioxide.

Dr Moya says the study is an essential first step to better understand how reef building corals adapt to environmental stress.

However, both Dr Moya and Professor Miller remain cautious about the ability of corals to tolerate the combination of increased carbon dioxide and climate change.

"The next step is to investigate the effect of combined stressors on corals' gene expression."

Paper

Moya, A, Huisman, L, Forêt, S, Gattuso, JP, Hayward, DC, Ball, EE and Miller, DJ (2014). Rapid acclimation of juvenile corals to CO_2-mediated acidification by upregulation of heat shock protein and Bcl-2 genes. *Molecular Ecology* 24(2): 438-452.

ARTICLE
26 SEP 2014

Photo by Serge Andréfouët

Photo by S. Andrefouët

Single species may be key to reef health

By Karl Gruber

Just a few important species doing important jobs could make or break an ecosystem

Coral Reefs may depend on just a few key players, rather than a bouquet of species, according to a new Australian study.

Previously scientists have found that fish are important for maintaining a reef's health, but this new research identifies keystone species that are irreplaceable.

"There is a general assumption that high diversity systems are more secure, or better insured, because if one species is lost others can take its place," says lead researcher Professor David Bellwood a marine ecologist at James Cook University. Yet, hosting a wealthy number of species may not be enough, he says.

Keystone species prop up reef ecosystems

In the study, David and colleagues examined 169 tropical coral reefs from around the world, along with thousands of associated fish species. They found that different jobs performed by these fish are not evenly distributed, meaning that some key jobs are only done by a few or even a single species.

The parrotfish on the Great Barrier Reef, for example, is the only one of thousands of reef fish species that regularly performs the task of scraping and cleaning inshore coral reefs. "This parrotfish is a particularly valuable species," David says.

This theory of many species covering important roles is much like the way humans operate in densely populated areas, says Dr Lucie Penin, from the Marine Ecology Laboratory (ECOMAR) at the University of Reunion Island, who was not involved in the research.

"If one person leaves there would still be someone else to fulfil their job", she says. But this new study shows this assumption to be wrong, at least for coral reefs. "Reef fish communities all display a wide range of functional entities, but also many of these jobs are taken on by only one species. As a consequence, losing such irreplaceable species could be catastrophic for the whole ecosystem, like a local community losing their only doctor or garbage man."

Australian coral reefs have experienced major setbacks in recent years, and this study may help develop new approaches to aid with their conservation, says David.

"This work highlights the need to move beyond the conservation of biodiversity," he says. "When developing conservation approaches we need to consider not just the number of species but what they do and how vulnerable they may be".

The take-home message is that even species-rich systems can be vulnerable. "In essence, it is the quality of biodiversity that is important not just the quantity," David says.

Reproduced with thanks to Australian Geographic, ***Single Species may be key to reef health***, by Karl Gruber, 26 September, 2014, www.australiangeographic.com.au/news/2014/09/single-keystone-species-may-be-key-to-reef-health

Knowledge Transfer

Australia

Centre members' research findings have been incorporated into the latest 5-year Commonwealth report card for the Great Barrier Reef, the GBR Outlook Report 2014 which guides future management for the Reef. (Centre contribution to the national research priority of an environmentally sustainable Australia p49).

Joe Pollock, Joleah Lamb, Bette Willis and others have shown that sediment and turbidity associated with off-shore dredging increase coral disease. These research findings have been used by a number of government and non-government agencies to curtail the dumping of dredge spoil within the GBR Marine Park.

Jairo Rivera's research on how to control crown of thorns starfish has contributed to the development of a single injection that causes the starfish to rapidly break up, replacing the previous method requiring up to 20 injections. Environment Minister Greg Hunt reported that this has resulted in a four-fold increase in the eradication rate on Australia's Great Barrier Reef. The technique is being adopted in other Indo-Pacific countries such as Samoa, Vanuatu and Fiji. Project leader, Morgan Pratchett, is a member of the advisory panel guiding GBRMPA COTS control efforts.

Morgan Pratchett is the principal scientist providing advice to the Australian Department of Environment on the sustainability of coral harvesting throughout Australian tropical waters. Morgan was instrumental in showing that this process is currently undermined by a lack of good empirical data on distribution, abundance and demographics of key harvest species, leading to the formulation of a research partnership between industry, managers and researchers, which will enable science-based management of the national coral fishery.

Ryan Lowe is collaborating with researchers and managers at the Western Australian Department of Parks and Wildlife on several coral reef research projects in the Ningaloo and Pilbara region of northwestern Australia. This is providing new baseline data on environmental variability in the Pilbara region to assist with their marine monitoring, as well as improved understanding of fine-scale patterns of reef connectivity for northwest coral reefs.

Indonesia

Peter Mumby, Nils Krück and colleagues have developed larval dispersal connectivity matrices that include various fisheries target species in the Indonesian Sunda-Banda seascape. Maps generated from these matrices are informing strategic marine spatial planning by WWF and Wildlife Conservation Society in Indonesia, with a view to improving livelihoods in the region.

Micronesia

Rebecca Weeks is providing technical support and advice to the Conservation Society of Pohnpei and The Nature Conservancy Micronesia to support their efforts to design an ecologically effective protected area network for Pohnpei, Federated States of Micronesia.

United Nations

Philip Munday provided expert advice on the impacts of ocean acidification on fishes and other reef organisms to the *Ocean Acidification: State-of-the-Science Considerations for Small Island Developing States* meeting. Recommendations about ocean acidification monitoring and adaptation for small island states from the meeting were referred to the main United Nations SIDS meeting attended by heads of government and governmental institutions.

Mexico

Jorge Álvarez-Romero is collaborating with partners in Mexico to design a network of marine reserves in the Midriff Islands, Gulf of California, where globally significant species and ecosystems, and the livelihoods of coastal communities, are threatened by overfishing, pollution, and climate change. The project was recently featured as a case study in Mexico's *5th National Report to the Convention on Biological Diversity*, demonstrating some of the ongoing activities contributing to the Aichi Targets.

USA

Christina Hicks has been collaborating with lawyers and policy analysts at Stanford University in assessing the application of current fisheries policy (California's Marine Life Management Act). This work is being conducted in conjunction with State fisheries agencies and is tailored towards the development of a ten-year strategy for state managed fisheries in California.

EAST AFRICA

Josh Cinner, Nick Graham and Christina Hicks' research on evaluating social and ecological vulnerability of coral reef fisheries to climate change has formed the basis of social and ecological monitoring for the international conservation organisation, Wildlife Conservation Society. Christina is also acting as social advisor to the Kenya Wildlife Service in the development of, and training for, region wide (western Indian Ocean) adaptive management.

Graduate and Early Career Training

Photo by Ed Roberts

The ARC Centre is the world's largest provider of graduate training for coral reef research. Our postgraduate students are trained in a broad spectrum of the natural and social science disciplines that contribute to knowledge of coral reefs worldwide.

During our first year of operation 220 research students were enrolled, supervised by Centre researchers at the four collaborating universities of the Centre and at the Australian Institute of Marine Science. Of these, 63 are new students in 2014 and 156 are studying for a PhD, with the remaining being enrolled in either Honours or Masters degrees. Our financial investment in these students and their research activities constitutes more than 25% of our annual budget.

Our postgraduate students are recruited from around the world, with 73% being from 40 overseas countries, most of whom have a language other than English as their native tongue. Students and their projects are highlighted individually on the ARC Centre's website at **www.coralcoe.org.au/people/students**. This emphasises not only the critical role played by our students in the research and training conducted by the ARC Centre but also the internationalisation that our student body brings to our Centre.

We provide a strong mentoring environment for our students and early career researchers over and above that provided through any of the four collaborating universities. Other than research project mentoring provided by each student's supervising team and performance management processes for staff, the Centre provides more generalised mentoring in both generic and more specific topics. For instance, in 2014, we contracted Highland Statistics to provide two one-week workshops on *The use of R for statistical analysis of research data*. The Centre also provides mentoring workshops, conducted by our established as well as early career researchers (ECR), designed to enhance our student and ECR research and publication skills and to provide training in grant writing so as to support future research and fellowship applications. Where appropriate, we also send researchers to external workshops and courses to enhance their development and leadership skills. For example, Jodie Rummer attended the UQ Business School Executive Education's *Women in Research Leadership* course. Students and ECRs engage through our weekly seminar programs which are video-conferenced across the Centre's nodes, and to which they regularly contribute. In addition, they compete each year in an elimination round to determine the Centre's nomination for the *My Research in 3 Minutes* competition. Georgina Gurney (PhD student), Hugo Harrison (ECR) and Mary Bonin (ECR) represented the Centre in the James Cook University competition. Experienced journalist, Dr Liz Tynan from the Graduate Research School at JCU, provided expert training sessions for the Centre's participants focusing on how to communicate their research to a lay audience.

The Centre's Student and Postdoctoral Committees manage annual funding allocations of $50k for training, mentoring activities and prizes. The ARC Centre of Excellence for Coral Reef Studies Student Committee had a very successful 2014. The highlight was the student workshop held on the day prior to the Centre's Annual Symposium in Canberra. We thank the nine invited speakers who took part in a mixed-format workshop focussed on career choices for PhD graduates; Alison Green (The Nature Conservancy), Hedley Grantham (Conservation International), Janice Lough and Jamie Oliver (Australian Institute of Marine Science), Julian Pepperell (Pepperell Research & Consulting), Will Steffen (ANU, Climate Change Institute), Inger Mewburn (ANU, "The Thesis Whisperer"), Ian Cresswell (CSIRO), and Andrew Leigh (Member of Parliament). The day kicked off with some short presentations - "A day in the life of..." – and concluded with some fun and light-hearted 'career speed-dating', where students and speakers talked in smaller, more personal groups. Feedback on the event was overwhelmingly positive; the speakers were truly inspirational, having all been PhD students before pursuing diverse career pathways.

The Centre's Student Committee also instigated a student-to-student mentor program in 2014, with extra perks like 2-4-1 coffee and UPF long-sleeved sun-shirts designed for fieldwork.

Awards to ARC Centre students in 2014 included:

- Three students graduated *cum laude* on completion of their PhDs; Hugo Harrison, Kirsty Nash and Jean-Baptiste Raina.
- Amelia Wenger was awarded the Dean's Award for Excellence by the Graduate Research School at JCU.
- Six Centre students received *GBRMPA Science for Management Awards:* Kristen Anderson, Brock Bergseth, Melissa Bos, Ciemon Caballes, Tessa Hempson, Chiara Pisapia and Tiffany Sih.
- Joe Pollock was awarded $30,000 from the *Higher Education Partnership or Participation Program* to support the very successful Aboriginals and Torres Strait Islanders in Marine Science (ATSIMS) program (see photo below).
- Competitive travel grants were awarded to Blanche D'Anastasi, Kristen Anderson, Lisa Boström-Einarsson, Susannah Leahy and Chiara Pisapia (*Australian Coral Reef Society*), Jeroen van de Water (*Association for the Sciences of Limnology and Oceanography*), Adrian Arias (*AusAID*), Davina Poulos (*International Society for Behavioural Ecology*) and Chaoyang Kuo (*3rd Asia-Pacific Coral Reef Symposium*).
- Several students were awarded external grants to support their PhD research; Blanche D'Anastasi (*Australian Museum* and the *Australian Wildlife Society*), Adrian Arias and Tiffany Sih (*PADI Foundation Grant*), Adrian Arias (*AusAID*), Davina Poulos (*Ian Potter Foundation*) and Tiffany Sih (*Holsworth Wildlife Research Fund*).
- Blanche D'Anastasi received a *Young Science Ambassador Award* from the *Australian Academy of Technological Sciences and Engineering*.
- Erin Graham received the Best Paper Award for the journal *Coral Reefs*, for her work uncovering the mechanisms that underpin the extraordinary dispersal capacity of coral larvae.

The Virginia Chadwick Awards are awarded by the Centre each year to the authors of the five most outstanding publications by postgraduate students in peer-reviewed international journals. The student must be the lead author on a paper published in a high-ranking journal. Each attracts a prize of $1,000. Congratulations to the 2014 winners, Bridie Allan, Simon Brandl, Georgina Gurney, Justin Rizzari and Brett Taylor.

The Student Committee make a valuable and critical contribution to the culture and success of the Centre and we are extremely grateful for their input and the activities they organise to promote student development. The Committee in 2014 consisted of Tiffany Sih, April Boaden, Kristen Anderson, Simon Brandl, Sarah Buckley, Ashton Gainsford, Lucy Georgio, Georgina Gurney, Tessa Hempson, Jess Hopf, Hannah Markham, Katia Nicolet, Chiara Pisapia, Justin Rizzari and Jessie Short. A special thanks to Tiffany Sih who has been a great contributor with a bundle of energy and ideas, and to our Graduate Co-ordinator, Olga Bazaka.

2014 Student Members

Student	University	Country of Origin	Thesis Title	ARC Centre Supervisors
Michele Achlatis	UQ	Netherlands	Investigating future changes to bioerosion on reefs and potential downstream consequences for carbonate chemistry and calcification rates. (PhD)	O Hoegh-Guldberg, S Dove, P Mumby
Novi Susetyo Adi	UQ	Indonesia	Assessment of coral reef productivity using remote sensing data. (PhD)	S Dove, O Hoegh-Guldberg
Catalina Aguilar Hurtado	JCU, ANU	Colombia	The immune response of the coral *Acropora millepora* under CO_2 stress. (PhD)	D Miller
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
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 Aurellado	UQ	Philippines	Effect of predation risk on behaviour and microhabitat use of parrotfish. (PhD)	P Mumby, A Harborne
Caroline Baille	UQ, Agrocampus Ouest	France	A dynamic model of parrotfish (family: Scaridae) populations for the management of herbivory on Caribbean coral reefs. (MSc)	P Mumby
Stephen Ban	JCU	Canada	Multiple stressor effects on coral reefs. (PhD awarded)	R Pressey, N Graham, S Connolly
Giulio Barone	JCU	Italy	Habitat isolation effects on recruitment and predation on coral reefs. (MSc awarded)	G Jones, M Bonin
Anne Bauer	JCU	USA	Effects of coral species and morphology on habitat use by coral reef fishes. (MSc awarded)	G Jones
Roger Beeden	JCU	New Zealand	A dynamic understanding of coral reef health informs resilience-based management of the Great Barrier Reef. (PhD awarded)	B Willis
Brock Bergseth	JCU	USA	Drivers of recreational fisher compliance on the Great Barrier Reef: implications for policy and practice. (PhD)	J Cinner, D Williamson, G Russ
Kathryn Berry	JCU, AIMS	Canada	Effects of bioeroding sponges on reef accretion in a changing climate. (PhD)	M Hoogenboom
Sandra Binning	ANU	Canada	Phenotypic plasticity in coral reef fish ecomorphology. (PhD awarded)	D Yellowlees
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)	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 GBR. (PhD)	M Kingsford, D Williamson
Teressa Bobeszko	JCU	Australia	The role of carbonic anhydrase in the coral-dinoflagellate symbiosis. (PhD)	W Leggat, D Yellowlees
Lynda Boldt	JCU	Australia	*Symbiodinium* photosynthetic genes and the effect of varying environmental conditions on photosynthetic processes. (PhD)	W 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
Dominique Bradbury	JCU	USA	Inter- and intra-specific variation in bleaching susceptibility among scleractinian corals. (PhD awarded)	M Pratchett, A Baird, T Hughes
Simon Brandl	JCU	Germany	Pair formation in herbivorous reef fishes: environmental and ecological implications. (PhD)	D Bellwood
Hayley Brien	JCU	Australia	Effects of ocean acidification on competition between corals and algae. (MSc awarded)	M Hoogenboom, S-A Watson
Rohan Brooker	JCU	New Zealand	Habitat specialisation and its consequences for a corallivorous filefish. (PhD awarded)	G Jones, P Munday
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)	R Lowe

Student	University	Country of Origin	Thesis Title	ARC Centre Supervisors
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)	J Pandolfi
Ciemon Caballes	JCU	Philippines	Environmental constraints on reproduction and development of crown-of-thorns starfish. (PhD)	M Pratchett, J Rivera
Alexandra Carter	JCU	Australia	The effects of no-take zoning, region and year on reproductive output of the common coral trout, *Plectropomus leopardus*. (PhD)	M McCormick, G Russ
Jordan Casey	JCU	USA	The role of territorial grazer behaviour and community structure in coral reef trophic dynamics. (PhD)	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
Napo Cayabyab	UWA	Philippines	Tropical seagrasses in extreme macrotidal environments: understanding the ecological processes of intertidal seagrasses in the Kimberley region of northwestern Australia. (PhD awarded)	R Lowe, J Falter
Adriana Chacón	JCU	Costa Rica	The contribution of the environment to wellbeing. (MSc)	R Pressey
Neil Chan	JCU, UQ	Malaysia	Modelling the effects of pH, temperature and flow on calcification of reef corals. (PhD)	S Connolly
Jessica Cheok	JCU	Singapore	Developing a theoretical matrix framework to evaluate current status and progress of co-management in Australia's marine protected areas. (MSc)	R Pressey, R Weeks
Lawrence Chlebeck	JCU	USA	Role of croppers on offshore and inshore Philippine reefs. (MSc)	G Russ
Karen Chong-Seng	JCU	Seychelles	The mechanistics of regeneration in coral reef ecosystems. (PhD awarded)	N Graham, D Bellwood, M Pratchett
Michael Civiello	JCU, AIMS	USA	Stable isotope probing of black band disease in corals: towards a mechanistic understanding of black band disease. (MSc)	B Willis
Geoffrey Collins	JCU	Australia	Hypoxia tolerance in barramundi fish. (PhD)	J Rummer
Nicola Conci	JCU	Italy	Tissue-specific expression of biomineralisation-related genes in the mushroom coral *Heliofungia actiniformis*. (MSc awarded)	A Bertucci, A Moya, B Willis
Amanda Cooper	JCU	Canada	Variability in reef fish functional groups along depth gradients. (MPhil)	G Jones, T Bridge
Amy Coppock	JCU	United Kingdom	Making sense of scents: olfactory discrimination in juvenile coral reef fishes. (MPhil awarded)	G Jones
Andrew Corley	JCU	USA	The effects of long term exposure to elevated CO_2 on metabolic enzyme activity in coral reef fishes. (MPhil)	J Rummer
Zara-Louise Cowan	JCU	UK	The role of predation in population regulation of crown-of-thorns starfish (Acanthaster spp.)	M Pratchett, V Messmer
Melissa Cowlishaw	JCU	Australia	Determinants of home range and territorial behaviour in coral fishes: roles of body size, habitat structure and population density. (PhD awarded)	G Jones, M McCormick
Alicia Crawley	UTS, UQ	Australia	The synergistic effect of rising ocean temperature and acidification on coral reef ecosystems. (PhD Awarded)	S Dove
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
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
Anderson de Sevilha	JCU	Brazil	Systematic conservation planning for the Parana River Basin, Brazil. (PhD)	R Pressey
Amy Douglas	JCU	Australia	Seasnake and tiger shark interactions. (MSc)	M McCormick
Edwin Drost	UWA	The Netherlands	The impact of tropical cyclone forcing on Australia's northwestern coastal system	R Lowe
Britt Edelman	JCU	USA	Trophodynamics of garfish (Hemiramphidae) in the tropics. (MPhil)	G Russ
Norbert Englebert	UQ	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
Jacob Eurich	JCU	USA	Processes underlying ecological versatility in an equatorial guild of fishes. (PhD)	M McCormick, G Jones

Student	University	Country of Origin	Thesis Title	ARC Centre Supervisors
Franz Martin Fingerlos	JCU	Austria	Interannual variations in species composition in Cleveland Bay. (MPhil awarded)	G Russ
Eric Fisher	JCU, AIMS	Australia	Spawning aggregation sites on tropical reefs. (MPhil)	M McCormick
Taryn Foster	UWA	Australia	Potential impacts of higher ocean acidity and warmer water temperatures on Abrolhos Island coral reefs. (PhD)	M McCulloch, J Falter
Grace Frank	JCU	Australia	Patterns of spatial abundances of reef corals. (MSc awarded)	M Hoogenboom, S Connolly
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
Connor Gervais	JCU	USA	The effects of ocean acidification on growth, activity, and temperature mediated movements in newly hatched epaulette sharks. (MPhil)	J Rummer
Sarah Gierz	JCU	Australia	Acclimation of *Symbiodinium* to thermal stress. (PhD)	W Leggat, D Yellowlees
Alyssa Giffin	JCU	Australia	Habitat associations in juvenile reef fishes. (MSc awarded)	G Jones
Christopher Goatley	JCU	United Kingdom	The ecological role of sediments on coral reefs. (PhD awarded)	D Bellwood
Ollin Gonzalez-Cuellar	JCU	Mexico	Mapping and characterising rocky-reef fish communities using species distribution modelling: the influence of spatial scale and implications for conservation planning. (MPhil)	J Álvarez-Romero
Benjamin Gordon	JCU, AIMS	Australia	The metabolome of *Symbiodinium* phylotypes and their coral hosts. (PhD)	W Leggat
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)	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)	R Pressey, S Andréfouët
Margaux Hein	JCU	Monaco	The potential of marine protected areas to ameliorate coral health in one of the world's diving hotspots: Koh Tao, Thailand. (MSc awarded)	B Willis
Tessa Hempson	JCU, AIMS	South Africa	Coral reef mesopredator trophodynamics in response to reef condition. (PhD)	N Graham, G Jones
Alejandra Hernandez-Agreda	JCU, UQ	Venezuela	Coral core micorbiome: composition, microhabitat distribution, host influence and response to environmental change. (PhD)	W Leggat, T Ainsworth
Sybille Hess	JCU	Switzerland	Do suspended sediments damage the gills of clownfish larvae? (MPhil awarded)	J Rummer, A Wenger
Jessica Hopf	JCU	Australia	Metapopulation analysis of the role of connectivity in marine protected areas design. (PhD)	S Connolly, G Jones, D Williamson
Vera Horigue	JCU, University of Philippines	Philippines	Scaling-up to form marine protected area networks: the role of institutional collaborations and coordination of initiatives in the Philippines. (PhD awarded)	R Pressey
Christina Horstmann	JCU	USA	Thermal tolerance of free-living *Symbiodinium*. (MPhil)	V Cumbo
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
Andres Jacome Rodriguez	JCU	Colombia	Macroalgae as a reservoir of pathogens on coral reefs. (MSc awarded)	M Hoogenboom, A Hoey
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
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
Charlotte Johansson	JCU, AIMS	Sweden	A functional analysis of herbivory on Ningaloo Reef, Australia. (PhD awarded)	D Bellwood
Martijn Johnson	JCU, Griffith University	Australia	The effects of ocean acidification on growth, development, and predator sensing in shark embryos. (MPhil)	J Rummer
Saskia Jurriaans	JCU, Centre Scientifique de Monaco	Netherlands	Thermal acclimation and the geographic range limits of reef-building corals. (PhD)	M Hoogenboom, S Connolly
Jung Ok Kang	ANU	Korea	Anthropogenic increase of atmospheric carbon dioxide and ocean acidifying and global warming: implications for long-term changes in the classification rate of coral reefs. (PhD awarded)	M McCulloch

Student	University	Country of Origin	Thesis Title	ARC Centre Supervisors
James Kerry	JCU, AIMS	United Kingdom	Structural complexity and the ecology of large reef fish. (PhD)	D Bellwood
Catherine Kim	UQ	USA	Combining high resolution imagery of benthic reef habitats with physical data to improve predictions regarding bleaching and disease. (PhD)	S Dove, O Hoegh-Guldberg
Kimberly Kiskas	JCU	USA	Assessing marine turtle bycatch risk in Australian commercial fisheries: patterns, gaps and solutions. (MPhil)	M Fuentes
Judith Kok	JCU	Netherlands	Coral-reorganisation driven by climate change influences competition and aggression in juvenile coral-reef fishes. (MSc awarded)	M Hoogenboom, N Graham
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
Daniel Kraver	JCU, Griiffith University	USA	The effects of ocean acidification on development of shark embryos. (MPhil)	J Rummer
Virginia Krone	JCU	USA	Can feeding scars from crown-of-thorns starfish help explain the prevalence of coral disease? (MSc)	B Willis
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
Joleah Lamb	JCU, AIMS	USA	Influence of reef-based industries on coral health and disease. (PhD awarded)	B Willis, G Russ
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
Anais Kimberley Lema	JCU, AIMS	Mexico	Diversity, stability and uptake of diazotrophic bacterial communities associated with corals of the Great Barrier Reef. (PhD awarded)	B Willis
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)	J Pandolfi
Govinda Liénart	JCU, University of Saskatchewan	Austria	Temperature effects of chemically mediated predator-prey interactions. (PhD)	M McCormick
Mei-Fang Lin	JCU, ANU	Taiwan	Transcriptiomics of Corallimorpharian *Rhodactis indosinensis* (Cnidaria: Anthozoa) and its usefulness to understanding coral bleaching. (PhD)	D Miller
Oona Lönnstedt	JCU	Sweden	Omnious odour – the role of olfactory cues in predator-prey interactions. (PhD awarded)	M Kingsford, M McCormick, P Munday
Judi Lowe	JCU, CDU	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, University of 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	Optimising 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
Alyssa Marshell	UQ	Australia	The ecological role of herbivorous surgeonfish (Acanthuridae) on coral reefs. (PhD awarded)	P Mumby, A Harborne
Robert Mason	UQ	Australia	Linking coral physiology to remote sensing of reefs. (PhD)	S Dove, O Hoegh-Guldberg
Ian McLeod	JCU	New Zealand	Influence of temperature on the early life history of coral reef fishes. (PhD awarded)	G Jones, M McCormick, P Munday
Mattheus Mello Althayde	UQ	Brazil	Metabolism and calcification rates of corals across distinct reef zones and in response to climate change. (PhD)	S Dove
Morana Mihaljević	UQ	Croatia	Indo-Pacific coral evolution: neogene reefs from the South China Sea. (PhD awarded)	J Pandolfi
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
Jose Montalvo Proana	JCU, AIMS	Ecuador	Hunting for viruses in corals: the development of a molecular assay for targeting and RNA virus possibly infecting *Symbiodinium*. (MSc)	B Willis, M van Oppen
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

Student	University	Country of Origin	Thesis Title	ARC Centre Supervisors
Katie Motson	JCU	United Kingdom	Developmental thermal acclimation in reef fishes. (MSc awarded)	P Munday
Lauren Nadler	JCU	USA	Influence on climate change on shoaling behaviour in coral reef fish. (PhD)	M McCormick, P Munday
Kirsty Nash	JCU	United Kingdom	Assessment of scale dependent function in reef fish, and its application to the evaluation of coral reef resilience. (PhD awarded)	N Graham, D Bellwood
Tiffany Nay	JCU	USA	The physiology of microhabitat utilisation in coral reef fishes. (MPhil)	J Rummer
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
Paul O'Brien	JCU, AIMS	Australia	CO_2 seeps predict that ocean acidification will cause shifts in coral-associated bacterial communities. (MSc)	B Willis
Rebecca O'Donnell	UWA	New Zealand	Last interglacial sea level and Leeuwin Current events: a dual stratigraphic and geochemical approach. (PhD)	M McCulloch
Jue-Sheng Ong	ANU	Malaysia	Psytrans: parasite and symbiont transcriptome separation. (MAppSc awarded)	S Forêt
Maria Palacios Otero	JCU	Colombia	Ecological selection in a complex marketplace. (PhD)	M McCormick, G Jones
Allison Paley	JCU, AIMS	USA	Colour polymorphism and its role in stress tolerance in the coral *Acropora millepora* on the Great Barrier Reef. (PhD awarded)	B Willis, M van Oppen, L Bay
Pedro Pereira	JCU	Brazil	Competition, habitat selection and imprinting of coral dwelling gobies. (PhD)	P Munday, G Jones
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)	M Pratchett
F. Joseph Pollock	JCU, AIMS	USA	Understanding the drivers of white syndrome coral diseases on the Great Barrier Reef. (PhD awarded)	B Willis
Andrew Pomeroy	UWA	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 De Freitas 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	United Kingdom	A multi-disciplinary approach to predictive management of coral reef fisheries. (PhD)	P Mumby
Sarah Questel	JCU	Saint Kitts and Nevis	Relative effects of no-take marine reserves and benthic structure on parrotfish in the Philippines. (MSc awarded)	G Russ
Kate Quigley	JCU, AIMS	Spain	Genetic and environmental basis for *Symbiodinium* specificity in the coral-dinoflagellate association. (PhD)	B Willis, W Leggat, L Bay
Paola G. Rachello-Dolmen	UQ, Australian Museum	Colombia	Historical changes in marine molluscan assemblages from subtropical Moreton Bay Marine Park, Queensland (Australia). (PhD awarded)	J Pandolfi
Veronica Radice	UQ	USA	Assessing echinoderm abundance, diversity and function across distinct coral reefs. (PhD)	O Hoegh-Guldberg, S Dove
Ryan Ramasamy	JCU	Australia	The plasticity of escape responses: does prior predator experience alter escape performance in a juvenile coral reef fish? (MPhil)	M McCormick
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)	N Graham, M Pratchett, A Hoey
Justin Rizzari	JCU	USA	Reef sharks on the Great Barrier Reef: putting the bite on underwater visual census methods. (PhD)	M McCormick, G Jones, A Frisch, A Hoey
Thomas Roberts	JCU, AIMS	Australia	Depth distribution patterns in reef-building corals. (PhD)	G Jones, A Baird, T Bridge
Jan Robinson	JCU	United Kingdom	Disentangling the causes of vulnerability to fishing in aggregating reef fishes. (PhD)	N Graham, J Cinner, G Almany
Dominique Roche	ANU, JCU	Canada	Bio-physical interactions and predator-prey relationships in coral reef fishes. (PhD awarded)	D Yellowlees
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

Student	University	Country of Origin	Thesis Title	ARC Centre Supervisors
David Rowen	JCU	Australia	Jellyfish as biomonitors of insecticides. (MPhil)	M Kingsford
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
Laura Elena Segura Mena	UWA	Costa Rica	A quantitative assessment of the morphological behaviour of reef-fronted beaches in Western Australia	R Lowe
Jessie Short	UWA	Canada	The effects of ocean acidification on calcification rates of reef-building corals and crustose coralline algae. (PhD awarded)	M McCulloch, J Falter
Tiffany Sih	JCU, AIMS	USA	Fisheries for deep sea snappers. (PhD)	M Kingsford
Justin Smith	JCU	Australia	Movement and habitat assessment of *Natator depressus* and *Lepidochelys olivacea* in the Gulf of Carpentaria, Australia. (PhD)	M Fuentes
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)	J Pandolfi
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
Richard Stevens	UQ, York University	United Kingdom	Sharks: friend or foe? (MSc)	R Thurstan
Robert Streit	JCU	Germany	Body-size drives functional distinction within browsing herbivorous fishes on coral reefs. (MPhil Awarded)	A Hoey, D Bellwood
Chun Hong Tan	JCU, AIMS	Malaysia	Environmental controls and evolutionary constraints on growth and reproduction in corals. (PhD)	A Baird, M Pratchett
Brett Taylor	JCU	USA	Parrotfish demography throughout Micronesia: effects of life histories on environmental and fishery-induced variability. (PhD)	G Russ
Loic Thibaut	JCU, U. Pierre et Marie Curie	France	Resilience in coral reef and model ecosystems. (PhD)	S Connolly, T Hughes
Georgina Torres-Jorda	JCU	Spain	Does physical damage from fishing gear influence the susceptibility of corals to ciliate infections? (MSc)	D Williamson, G Russ, B Willis
Cheng-Han Tsai	JCU, AIMS	Taiwan	The structure and dynamics of reef fish communities. (PhD)	S Connolly, D Bellwood
Jeroen van de Water	JCU, AIMS	Netherlands	Corals under stress: a study of the coral innate immune system. (PhD awarded)	B Willis, W Leggat, M van Oppen
Rene van der Zande	UQ	Netherlands	Monitoring metabolic changes to reef sediment and framework in response to present day and future diurnal and seasonal dynamics. (PhD)	S Dove, O Hoegh-Guldberg
Heather Veilleux	JCU	Canada	Olfactory mechanisms at the genomic level by which dispersing coral reef fish larvae orient towards settlement sites. (PhD)	P Munday, W 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,UQ	Australia	Toward the ecosystem-based co-management of exploited brown-marbled grouper spawning aggregations. (PhD)	J Cinner, G Almany, R Hamilton
Donald Warren	JCU	USA	The impacts of CO_2 on competitive interactions and the potential for acclimation. (MPhil)	M McCormick, P Munday
Megan Welch	JCU	USA	Transgeneration effects of CO_2 on fish behaviour. (PhD)	P Munday, M McCormick
Heather Welch	JCU	USA	Implications for spatial management of dynamics of chlorophyll a in the Coral Sea. (MAppSci awarded)	R Pressey
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	Germany	An investigation of the nearshore hydrodynamics on contrasting open-coast and reef-protected beaches in Western Australia. (PhD)	R Lowe
Erika Woolsey	JCU, U. Sydney	USA	Reefs on the edge: coral biogeography and larval ecology in a warming ocean. (PhD awarded)	A Baird
Jiangtao Xu	UWA	China	Ocean dynamics and connectivity on the Ningaloo shelf. (PhD awarded)	R Lowe
Matthew Young	JCU	Australia	Reef fishing: a social ecological perspective. (PhD)	D Bellwood

National and International Linkages

The ARC Centre of Excellence is a global hub for coral reef science collaboration, increasingly transdisciplinary in its engagement. The Centre's linkages are illustrated by multi-institutional publications, international working groups we convene, visits to overseas institutions, and by the number of international scholars we host at all four nodes of the ARC Centre. The Centre's research profile and reputation have attracted many overseas postgraduate students (p32), including 47 new postgraduate enrolments in 2014. Centre personnel also play leadership roles in many international research consortia and in activities such as field work and end-user engagement in many countries.

The ARC Centre established formal Partner Organisation agreements in 2014 with the Australian Institute for Marine Science, the Center for Ocean Solutions at Stanford University (USA), the Centre National de la Recherche Scientifique (CNRS, France), the Great Barrier Reef Marine Park Authority, the International Union for the Conservation of Nature (IUCN, Switzerland) and WorldFish (Malaysia). We welcome our new partners. Initial collaborations with these organisations in 2014 are already resulting in dozens of co-authored publications and research projects, exchange of researchers and recruitment of co-funded postdoctoral fellows.

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 elected Fellows of the *Australian Academy of Science*. Malcolm McCulloch is also a Fellow of *The Royal Society* (London).

In 2014, ARC Centre researchers produced 206 publications with cross-institutional co-authorship, involving researchers from 277 institutions in 53 countries. The ARC Centre convened 20 international working groups during 2014. During the year, we hosted 67 international visitors from 27 countries, and ARC Centre personnel visited 91 international collaborators at laboratories and research facilities in 34 countries.

The ARC Centre's major international collaborations in 2014 include:

Centre National de la Recherche Scientifique (CNRS)

CNRS lead the *Groupement de Recherche International, Biodiversity of Coral Reefs* (GDRI), 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 Partner Investigator in the new ARC Centre. The large research group he leads will contribute to research Program *2: Ecosystem Dynamics: Past, Present and Future*, building new collaborations with Geoff Jones, Peter Mumby, Morgan Pratchett, Garry Russ, and others. One activity which contributed to this collaboration in 2014 was the award of an *Institut des Récifs Coralliens du Pacifique* (IRCP) early career award to Super Science Fellow, Dr Jodie Rummer, to conduct research at *Centre de Recherche Insulaire et Observatoire de l'Environnement* (CRIOBE) in Moorea, French Polynesia. In addition, Dr Glenn Almany, a CNRS Research Fellow was appointed in 2014 as an Adjunct Researcher in our Centre, which has contributed to new collaborations on fish ecology and larval dispersal.

Center for Ocean Solutions, Stanford University

The Center for Ocean Solutions (COS) is a consortium of three leading marine science and policy institutions in California – Stanford University, the Monterey Bay Aquarium and the Monterey Bay Aquarium Research Institute (MBARI). COS combines Stanford's expertise in marine biology, oceanography, engineering, economics, law and policy with the Aquarium's exceptional capacity for public education and outreach, and MBARI's leadership in deep-sea technology, exploration and monitoring, as well as marine and coastal economics. In addition to undertaking research, COS engages with decision-makers from government, business and the non-profit sectors to translate the results of marine science and policy research into action. Professor Stephen Palumbi, Director of the Hopkins Marine Laboratory, joined the ARC as a Partner Investigator in 2014. Christina Hicks is a jointly funded COS-ARC Centre research fellow in Program 1: *People and Ecosystems*. In 2014, COS and the ARC Centre co-hosted two working group meetings, one in January in Monterey that focused on developing a major project on valuation of coral reefs, and the second, in Townsville in June on ecosystem services in practice.

International Union for Conservation of Nature (IUCN) – Global Coral Reef Monitoring Network

The IUCN is the world's largest global environmental organisation, whose mission is to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that the use of natural resources is equitable and sustainable. The ARC Centre is collaborating with IUCN on many fronts, particularly in their Global Marine and Polar Program, which supports the rapidly-

evolving Global Coral Reef Monitoring Network (GCRMN). In 2014, Professor Jeremy Jackson, the Director and Project Leader of the GCRMN joined the new Centre as a Partner Investigator, and contributes to research Programs 1 and 2. In July, the Centre and IUCN co-funded a working group in Townsville on Caribbean coral reefs, designed to establish better assessment and monitoring approaches and technologies that will be used to develop novel systems for improving reef management in the face of rapid environmental change.

WorldFish

WorldFish is an international non-profit scientific agency working 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 researcher David Mills and research fellow Pip Cohen are hosted in the ARC Centre. Jessica Blythe has been recruited as a joint WorldFish/ Centre of Excellence postdoctoral fellow to pursue research on governance and sustainability of Pacific Island coastal fisheries. In addition, WorldFish Regional Director (Pacific), Neil Andrew, is a new Partner Investigator and member of the Centre's Advisory Board, building novel and substantial collaborative projects in the Solomon Islands, elsewhere in the Coral Triangle region, and in east Africa. These collaborations align closely with the objectives of the Centre's research Program 1: *People and Ecosystems* and link the Centre to a global network of WorldFish research partners, NGOs, national resource agencies, and the private sector. Planning is underway to hold a joint working group meeting in 2015 to bring together a small, interdisciplinary group of ecologists, economists, and social scientists with expertise in the governance of small-scale fisheries.

Overseas visiting researchers

In 2014, 67 international visitors were hosted by one or more nodes of the ARC Centre, or participated in working group meetings convened by the Centre.

Photo by Jordan Casey

International visitors to the ARC Centre of Excellence for Coral Reef Studies in 2014

Visitor	Organisation	Country
Dr Amir Abdulla	International Union for Conservation of Nature	Spain
Dr Rene Abesamis	Silliman University	Philippines
Dr Serge Andréfouët	Institut de Recherche pour le Développement	New Caledonia
Dr William Arnold	National Oceanic and Atmospheric Administration	USA
Dr Ivonne Bejarano	National Oceanic and Atmospheric Administration	USA
Dr Michael Berumen	King Abdullah University of Science and Technology	Saudi Arabia
Dr Jorge Cortés Núñez	University of Costa Rica	Costa Rica
Dr Katie Cramer	Smithsonian Institute	USA
Prof Graeme Cumming	University of Capetown	South Africa
Prof Wang Daoru	Hainan Academy of Ocean and Fisheries Sciences	China
Dr Emily Darling	University of North Carolina	USA
Dr Danielle Dixson	Georgia Institute of Technology	USA
Dr Camila Domit	Federal University of Paraná	Brazil
Dr Mary Donovan	University of Hawaii	USA
Dr Maria Dornelas	St Andrews University	United Kingdom
Dr Carlos Duarte	Mediterranean Institute for Advanced Studies	Spain
Prof Karl Flessa	University of Arizona	USA
Dr Alan Friedlander	University of Hawaii	USA
Prof Ed Gomez	University of the Philippines	Philippines
Prof Detlef Günther	ETH Zurich	Switzerland
Adam Habary	University of Copenhagen	Denmark
Prof Sam Ham	University of Idaho	USA
Dr Fanny Houlbreque	Institut de Recherche pour le Développement	New Caledonia
Prof Jeremy Jackson	Smithsonian Institute	USA
Noel Janetski	PT Koko Smart	Indonesia
Dr Fredrik Jutfelt	University of Gothenburg	Sweden
Dr Jack Kittinger	Conservation International	USA
Dr Halvor Knutsen	Institute of Marine Research	Norway
Elizabeth Kolbert	The New Yorker	USA
Prof Ibrahim Komoo	University of Malaysia Terengganu	Malaysia
Prof Anton Le Roex	University of Cape Town	South Africa
Dr Yi Jin Liew	King Abdullah University of Science and Technology	Saudi Arabia
Prof Han Lindeboom	Wageningen University	Netherlands
Prof Wang Lisheng	Department of Science and Technology	China

Visitor	Organisation	Country
Dr Carl Gustaf Lundin	International Union for Conservation of Nature	Switzerland
Dr Paulina Martinetto	Instituto de Investigaciones Marinas y Costeras	Argentina
Prof Pere Masque	Autonomous University of Barcelona	Spain
Dr Tim McClanahan	Wildlife Conservation Society	Kenya
Dr Loren McClenachan	Colby College	USA
Dr Anna Metaxis	Dalhousie University	USA
Prof David Mouillot	University of Montpellier	France
Prof Chris Perry	University of Exeter	United Kingdom
Graham Raby	Carleton University	Canada
Prof Tim Ravasi	King Abdullah University of Science and Technology	Saudi Arabia
Dr Chris Raymond	University of Copenhagen	Denmark
Dr John Reece-Hoyes	Novartis Institutes for Biomedical Research	USA
Dr Claire Reymond	Leibniz Centre for Tropical Marine Ecology, ZMT Bremen	Germany
Dr Riccardo Rodolfo-Metalpa	Institut de Recherche pour le Développement	New Caledonia
Dr Murray Rudd	University of York	UK
Dr Ben Ruttenberg	California Polytechnic State University	USA
Dr Taewoo Ryu	King Abdullah University of Science and Technology	Saudi Arabia
Dr Pablo Saenz-Agudelo	King Abdullah University of Science and Technology	Saudi Arabia
Dr Jim Sanchirico	University of California	USA
Chen Shaohua	Department of Science and Technology	China
Dr Bob Sheibling	Dalhousie University	Canada
Dr Mark Spalding	University of Cambridge	United Kingdom
Prof Dale Squires	National Oceanic and Atmospheric Administration	USA
Dr Josefin Sundin	University of Gothenburg	Sweden
Prof Claudiu Supuran	University of Florence	Italy
Dr Kentaro Tanaka	Hokkaido University	Japan
Dr Richard Taylor	University of Auckland	New Zealand
Dr Mark Vermeij	Carmabi Research Institute	USA
Prof Robert Warner	University of California	USA
Prof Zulfigar Yasin	Universiti Sains Malaysia	Malaysia
Prof Zhang Yucang	Hainan University	China
Prof Chen Zhibin	Hainan Medical University	China

ARTICLE
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Photo by Michael Fabinyi

Effects of Changing Tastes in China Extend Abroad

By Mike Fussell

The traditional Chinese dinner plate is getting a makeover as tastes in the country begin to change. Exotic seafood and different meats are now being purchased at increasing rates.

In fact, China is the largest overall consumer of seafood in the world - with an increase of more than ten percent in fish consumption over the past decade according to the World Bank. During that same time, the USDA reports, the amount of pork people eat in China rose nearly 40 percent.

Michael Fabinyi, a Research Fellow at the ARC Centre of Excellence for Coral Reef Studies, notes substantial socioeconomic trends are influencing what people eat in the Middle Kingdom.

"This is part of a broader change in food consumption patterns in China that include a shift to a greater consumption of meat," said Fabinyi. "Some of the broader, larger factors contributing to this shift are urbanisation and increased incomes."

Pork has always been a staple in China, but as the middle class in the country grows and has more money to spend, its consumption of this traditional meat - as well as others - is increasing rapidly.

In addition to the evolving Chinese economy, social factors are driving people to buy more of these products than ever before. Fabinyi claims the luxurious banquet culture among the country's elite is a large reason why the high-end market for seafood like live reef fish, sea cucumbers and shark fins is thriving.

"It's a way of cementing social ties with important business and government partners," said Fabinyi. "Often, people who are in high level positions in government or the private sector attend several banquets a week as part of their work obligations. During these banquets, hosts are expected to impress their guests by serving very high status foods like these types of seafood."

Analysts note Chinese regulations, recently put in place to eradicate government corruption, are diminishing the effects of banquet culture but high-end seafood and pork consumption are continuing to grow overall.

In spite of this, some government policies are actually encouraging Chinese people to eat meat and seafood – and have done so throughout history.

USDA agricultural economist Fred Gale said Deng Xiaoping - one of China's first post-Mao leaders who focused on directing the country toward a market economy - made it a point to support the changing diet to keep the Chinese people competitive in the global marketplace.

"[Deng Xiaoping] stated, we must fundamentally change the racist food structure - increasing the meat and dairy intake in our diet to improve the physique of the Chinese people," said Gale. "So, they will rank among the excellent members of humanity. At this point, meat and dairy became a nationalistic thing and promoting production became a major national policy goal."

Regardless of the Chinese Communist Party's intentions, negative effects associated with the increase of pork and seafood consumption are leaving a bad taste in some peoples' mouths. Environmentalists argue there are ecological problems occurring on land and at sea within these animal populations.

Fabinyi explained the environmental problem of overfishing spans beyond China affecting countries such as the Philippines, Indonesia and Malaysia which are seafood suppliers - especially when ultra-effective methods are used to catch fish.

"A tablet of cyanide is dissolved in a water bottle which is then squirted by a diver into the coral that stuns the fish," said Fabinyi.

"Then, the fish are scooped up and revived when taken back up to the surface. Because this is a much more efficient method than hook and line, it obviously is a large contributor to fishing pressure, apart from the effects that the cyanide has on the coral reefs."

But not every aspect of getting these increasingly popular foods to the dinner table is unpalatable. Fabinyi argues fishing opportunities for people living on islands with poor agricultural potential provide a livelihood for a population that has few other natural resources to draw from.

"The trade in live-fish has been a massively important economic stimulus to local communities," said Fabinyi. "Relative to where they were previously, many households have been able to improve their standards of living from assistance-level only to being able to invest in basic-level education for their children, some level of healthcare and material goods that have resulted in the improved standard of living."

Chinese eaters are becoming more adventurous than ever before. In turn, as the flavors they seek grow in complexity, so do the effects of the country's massive consumption. Food experts claim both the positive and negative consequences of China's changing diet are already beginning to cross borders, become international issues and will continue to do so as consumption grows.

Reproduced with thanks to Voice of America, Effects of changing tastes in China extend abroad, by Mike Fussell, 1 May, 2014
http://www.voanews.com/content/effects-of-changing-tastes-in-china-extend-abroad/1905858.html

Photo by Michael Fabinyi

Media and Public Outreach

The ARC Centre of Excellence engages with the wider community through the media and a diverse range of outreach activities aimed at increasing public awareness of coral reef science and management. As part of its communications strategy the Centre has developed an active media presence and in 2014 we employed Eleanor Gregory as a full time Communications Manager to oversee and develop the Centre's media program.

The Centre's communications strategy is multi-stranded and targets local, national and international news and current affairs organisations. We promote the Centre of Excellence research outcomes through media releases, an engaging and regularly updated website, social media, webinars, public lectures, community workshops, annual conferences and by participating in international symposia as well as providing government and industry briefings and generating reports and brochures on our activities.

The ARC Centre website is the first point of contact for the public, with 10 million hits in 2014. It caters for multiple audiences, providing information about the Centre of Excellence, access to resources, research services and downloads of research, teaching and educational tools. The website also provides links to the Centre's Twitter, YouTube and Flickr accounts, and enables direct sharing from the site across social media.

Public Outreach

In 2014, researchers from the Centre participated in more than 55 public outreach events and programs locally, nationally and internationally, some examples are listed below:

- The ARC Centre's role as an international leader in coral reef research is increasingly being recognised. In 2014, Centre members were invited to present at a broad range of forums around the world, from research institutes, to schools, to local fishing communities. For example, Terry Hughes addressed researchers and students at the Chinese Academy of Sciences in Guangzhou and the Institute of Oceanology in Qingdao, China, on managing and sustaining coral reefs as part of the Academy's Einstein Professorship Program. Ove Hoegh-Guldberg presented at the John Kerry Summit in Washington D.C. on the *State of Science, Ocean Acidification*. Philip Munday gave a Smithsonian Public Lecture in Bocas, Panama. Peter Mumby was invited by NOAA to give a public lecture in Russia on Caribbean reef fisheries. Nick Graham presented a public lecture on *Seychelles reef trajectories 1994 – 2014* at the Seychelles Fishing Authority in the Seychelles. Michael Fabinyi presented a public lecture and led a discussion panel on the implications of Chinese seafood consumption for the Asia-Pacific region at the Woodrow Wilson Centre for International Scholars in Washington D.C.
- ARC Centre researchers also delivered a number of public talks across a diverse range of forums in Australia in 2014. For example, Malcolm McCulloch presented at the Curtin University John de Laeter Open Day in Perth. Jorge Álvarez Romero presented on the topic *Social network analysis to untangle connections in NRM governance* at the Biodiversity Research Seminar in Broome, and Jodie Rummer was an invited speaker in the TEDx JCUCAIRNS symposium *Torrid talks – why Aristotle was wrong*. Verena Schoepf gave a public lecture in the Kimberly on the *Resistance of Kimberly corals to ocean warming*. David Williamson gave a presentation to the Rotary Club of Townsville, Ove Hoegh-Guldberg gave a public talk on *Australia and the future of fossil fuel* in Brisbane and Morgan Pratchett recorded an online video discussing his research on the Great Barrier Reef, which has been posted across a number of websites.
- In 2014, the Centre of Excellence continued building links between scientists, resource managers and policy makers, providing briefings and workshops to government agencies, non-government organisations and business. For example, Ove Hoegh-Guldberg addressed the Ocean Conservation Community in Washington D.C. on the *Implications for Ocean Management*. David Williamson gave presentations at The Great Barrier Reef Marine Park Authority's Reef Guardian School's Teacher Training Workshops. Ryan Lowe briefed marine rangers and the general public on macrotidal reefs in the Kimberly as part of a community awareness program in Western Australia. Jorge Álvarez Romero gave two seminars in Western Australia to government agencies and environment groups, on *Social network analysis to untangle connections in natural resource management governance*.
- Activities aimed at school children continue as a focus of the Centre's outreach program. For example, PhD student, Joe Pollock took 40 high school students on a five-day field excursion to Orpheus Island as part of the *Aboriginals and Torres Strait Islanders in Marine Science* (ATSIMS) initiative. Alistair Harborne gave two presentations on coral reef ecology to primary school students in the UK city of Birmingham and Peter Mumby spoke to high school students and parents at the Tertiary Studies Expo in Brisbane. Morgan Pratchett talked to Year 10 students at the Annandale Christian College in Townsville about the Great Barrier Reef and climate change and how his research contributes to successful management.

Social media

In 2014, the Centre diversified its media focus to include an increased emphasis on social media, and the Centre developed its new Twitter and YouTube accounts. As part of the communications strategy, Centre research publications, news, events and seminars are cross-promoted between the website and social media channels. This has proved a highly successful strategy. Twitter followers have increased significantly throughout 2014, up from 36 at the start of the year to about 840 by the end of December. Twitter 'impacts' average about 30,000 per month.

The Centre utilised social media to great effect to promote the recruitment of PhD students and Research Fellows.

The Centre's YouTube account is a popular platform for our seminars, talks and symposia videos and is accessed regularly by the public. In 2014, 58 new videos, including seminars, symposia talks and Three Minute Thesis presentations were added to the site.

Media releases

The ARC Centre issued 26 media releases in 2014. They generated more than 3,776 commentaries across a wide range of online and traditional media outlets around the world, with an average of 464 social media mentions per month, mostly on Twitter.

Coverage of the Centre's research ranged across print, online, television and radio news and current affairs at local, national and international levels. The Centre's research is in constant demand, with many news organisations approaching the ARC Centre for expert commentary on coral reef science.

The global standing of the Centre is reflected in the leading advisory role it has played during 2014 in many national and international TV documentaries. Terry Hughes was interviewed for an ABC Four Corners program on the future of the Great Barrier Reef. Ove Hoegh-Guldberg acted as a consultant for the latest Sir David Attenborough documentary on the Great Barrier Reef. Sylvain Forêt was interviewed for a French/German documentary on epigenetics, Michael Kingsford and David Williamson were interviewed for an ABC TV Catalyst program on the Great Barrier Reef and Anthony Bertucci advised a French documentary team on coral spawning for its program on the Great Barrier Reef.

Some highlights of media uptake in 2014 include:

New Scientist, *Pacific coral happy as acidity of the ocean rises,* P Munday, 1 January 2014

The Philippine Star, *Endangered turtles face new threat in Indonesia*, P Mumby, 17 January 2014

BBC News, *Underwater time-lapse shows secret life of a coral reef,* P Bongaerts, 17 January 2014

Science News, *ScienceShot: Acidic oceans could impair fish vision*, P Munday, 7 February 2014

The Guardian, *Coral off WA suffers shocking damage from marine heatwaves, scientists say*, M McCulloch, 13 February 2014

The Australian - Higher Education, *Higher temps put fish at risk*, J Rummer, 13 February 2014

BBC World Service, *Aboriginals and Torres Strait Islanders in Marine Science (ATSIMS) as part of Saving the Ocean series*, FJ Pollock, 22 February 2014

The Huffington Post, *Great Barrier Reef Faces 'Irreversible' Damage: Report*, O Hoegh-Guldberg, 7 March 2014

ABC Radio Australia News, *IPCC Working Group II report: Scientists predict Australia will continue to get hotter*, O Hoegh-Guldberg, 23 March 2014

Australasian Science, *Corals reveal Pacific cycles*, J Pandolfi, 26 March 2014

Sky News Australia, *Great Barrier Reef's 'bleak future'*, O Hoegh-Guldberg, 31 March 2014

French Tribune, *Global warming to impact unique coral reefs of Western Australia: study*, J Lough, 1 April 2014

ABC [PM], *Ocean acidification making fish do strange things*, P Munday, 14 April 2014

The China Post, *Fish lose survival instinct in acidic oceans: study*, P Munday, 15 April 2014

Scientific American, *Designer-made coral reefs could survive climate change's hot seas*, S Palumbi, M van Oppen, D Miller, 26 April 2014

Science 2.0, *Corals adjust quickly to rising ocean temperatures*, S Palumbi, 27 April 2014

The Guardian, *Great Barrier Reef: If the fossil fuel industry made ice cream*, T Hughes, O Hoegh-Guldberg, 29 April 2014

The Australian, *Coral stays home when the heat's on*, S Connolly, A Baird, 29 April 2014

Albuquerque Express, *Effects of changing tastes in China extend abroad*, M Fabinyi, 2 May 2014

The Exeter Daily, *Reef decline food fears*, P Mumby, 3 May 2014

Business Insider Australia, *The Great Barrier Reef may be more resilient to climate change than we thought*, J Pandolfi, 18 June 2014

Science Newsline - Nature and Earth, *From despair to repair: dramatic decline of Caribbean corals can be reversed*, T Hughes, 2 July 2014

Nature World News, *Climate change makes it hard for fish to tell friend from foe*, L Nadler, 2 July 2014

National Nine News, *Reef dredging must stop: expert*, T Hughes, 3 July 2014

Ecos Magazine, *Pilbara lessons indicate Great Barrier Reef in danger from 'perfect storm'*, M McCulloch, 9 July 2014

National Geographic News, *Digging up the seafloor makes coral reefs sick*, J Pollock, 16 July 2014

Telegraph.co.uk, *Coral reefs face increased risk of fatal disease from dredging*, J Pollock, 17 July 2014

The Conversation, *Dredge spoil linked to coral disease, WA study shows*, T Hughes, J Pollock, B Willis, 17 July 2014

The Guardian, *Coral reefs face heightened risk of fatal disease from dredging, says research*, J Pollock, 17 July 2014

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The Australian, *'Ugly' reef unable to regenerate by 2050, Senate inquiry told*, P Mumby, 22 July 2014

Daily News, *Ecosystems can have their fish, and we can eat them too,* P Mumby, 2 August 2014

National Geographic News, *Following Nemo: clownfish make epic ocean journeys*, H Harrison, 18 September 2014

ABC News, Fact File: *How healthy is the Great Barrier Reef*, T Hughes, 3 September 2014

New York Times, *On the cusp of Climate Change*, S-A Watson, 22 September 2014

BBC News, *Will coal exports kill the Great Barrier Reef?* J Pollock, 22 October 2014

The Guardian, *Great Barrier Reef dredging could damage fish populations, says study*, A Wenger, G Jones, 23 October 2014

MSN.com, *Sediment plumes might be killing Nemo,* A Wenger, 23 October 2014

Cairns Post, *James Cook University scientists find small reef shark may cope with effects of climate change,* J Rummer, 24 October 2014

Scientific American, *A to-do list for the world's parks,* B Pressey, November 2014

Nature World News, *Poacher profiling: combatting illegal fishing with science*, J Cinner, A Arias, 14 November 2014

ABC Science, *Extinction risk may be overrated but reefs still vulnerable,* D Bellwood, 14 November 2014

ABC TV Catalyst Program, *Great Barrier Reef Coral Trout*, D Williamson, M Kingsford, 20 November 2014

Bloomberg View, *Victims under the South China Sea*, T Hughes, 27 November 2014

The East African, *Communities conserving the Kenyan coastline*, J Cinner, 28 November 2014

The Guardian, *Baby coral research gives glimmer of hope reefs could adapt to global warming*, A Moya, D Miller, 3 December 2014

Discovery News, *Crafty reef fish disguises smell to fool predators*, R Brooker, P Munday, 9 December 2014

The Age, *Harlequin Filefish adapts to the smell of the coral it consumes*, P Munday, R Brooker, 10 December 2014

Photo by Ed Roberts

National Research Priority Case Study

The Great Barrier Reef

The Great Barrier Reef is a national treasure and international icon. The Reef provides many economic, social, aesthetic and cultural values to Australia and the world – hence the need for science-based management to secure its integrity for future generations. Providing that science, and translating it into practical action and long-term outcomes, is the ARC Centre's core business.

Every five years the Great Barrier Reef Marine Park Authority (GBRMPA), a key end-user of the ARC Centre, publishes the Great Barrier Reef Outlook Report; a forward-looking assessment of the status of the Great Barrier Reef (GBR) that is designed to inform government policy and the ongoing evolution of adaptive governance and management. These reports, a statutory requirement under the amended GBR Act, rely heavily on the scientific knowledge provided by the Centre. The second Outlook Report was released by the Commonwealth government in 2014, and was peer reviewed by the Centre's Director, Terry Hughes and three other Australian scientists.

The 2014 Outlook Report states "*Notwithstanding positive actions since 2009, the greatest risks to the Great Barrier Reef have not changed. Climate change, poor water quality from land-based run-off, impacts from coastal development, and some remaining impacts of fishing remain the major threats to the future vitality of the Great Barrier Reef*". These challenges inform and influence research that is conducted in the ARC Centre of Excellence for Coral Reef Studies. Consequently, the Centre's research provides vital information needed to inform and guide reef management, both in Australia and throughout the tropics, resulting in substantial long-term environmental, economic and social benefits.

Hence, our goal as a research Centre is to provide and communicate the scientific knowledge that underpins sustainable use of the world's coral reefs, in particular the Great Barrier Reef. Increasingly, the Centre's research focus is not limited to the natural bio-physical attributes of the reef and its flora and fauna, but also includes a growing focus on the many interactions between people and reefs. In 2014, the ARC Centre published 313 articles, the majority of which were either specifically or indirectly relevant to the GBR. In addition, we provided informed analysis to the ongoing public discussion about the future of the Reef and the major challenges it faces. One example in 2014 was the leading role the ARC Centre played in preparing the public submission to the Commonwealth from the Australian Academy of Science, to help improve the draft 2050 Great Barrier Reef Sustainability Plan. Throughout 2014, these outreach and knowledge transfer activities encompass policy pieces in peer-reviewed scientific journals, contributions to both the electronic, such as *The Conversation*, and paper media, many briefings and workshops delivered to government and non-government agencies, and presentations to public forums and community groups. Many of these activities are detailed throughout this Annual Report. The Centre's governance structure is also key to maximising the impact of our research on reef policies and management.

One management challenge that urgently needs new research is the potential for a decline in fisheries caused by losses of corals. Ongoing studies by Centre researchers have been instrumental in demonstrating that coral loss and habitat degradation from climate change and other drivers can have serious effects on reef fish populations. However, many questions have remained about the flow-on effects to ecosystem function and fisheries productivity. New data syntheses and modelling approaches reveal that declining coral cover and loss of habitat structural complexity can have far-reaching consequences for reef fishes and their functional role in coral reef ecosystems. By analysing data from over 20 different studies, Morgan Pratchett, Andrew Hoey and Shaun Wilson showed in 2014 that some large-bodied reef fishes, including species important to nearshore fisheries, can be just as vulnerable to habitat degradation as many smaller species of reef fish. Furthermore, ongoing habitat degradation reduces functional redundancy in reef fish communities, which could reduce the resilience of coral reefs, and thus increase their vulnerability to future disturbances. Using an ecosystem model, Alice Rodgers and Peter Mumby have further demonstrated that the loss of physical habitat structure on reefs could have substantial effects on fisheries productivity. While the magnitude of such effects will vary geographically, and depend on the interaction with fishing intensity and other factors, these studies indicate that the ecological function and productivity of reef fish communities will be eroded by climate change and local drivers of reef degradation.

Climate change has been identified by GBRMPA as the most significant risk to the Reef. Research by the ARC Centre into the direct effects of rising temperatures and ocean acidification on reef fishes has surged ahead in 2014. For example, a team of Centre researchers led by Jacob Johansen and Morgan Pratchett found that activity levels of coral trout declined markedly at higher temperatures, with potential implications for foraging, growth and reproduction of this ecologically and commercially important species. In a comparison of reef fish populations for the southern Great Barrier Reef to near the equator in Papua New Guinea, Jodie Rummer and Philip Munday, showed that low-latitude populations are more vulnerable to climate change because they are already living at or above their thermal optimum. In contrast, reef fish populations on southern reefs may be living below their thermal optimum and thus have a greater

Photo by Jordan Casey

safety margin to cope with future warming. Such information can help managers identify regions where the effects of warming on reef fish populations will be most pronounced.

Two new studies published in *Nature Climate Change* also demonstrate the potential effects of ocean acidification on reef fish communities. First, Philip Munday and colleagues used natural carbon dioxide (CO_2) underwater seeps in Papua New Guinea as a novel field-laboratory to study the effects of rising CO_2 levels on reef fishes. They found that CO_2 levels predicted to occur within this century cause dramatic behavioural changes in reef fishes that could affect their survival. Philip Munday and PhD student Megan Welch, then showed that these behavioural problems are not mitigated by transgenerational phenotypic plasticity. Studies are now underway to test the potential for reef fishes to genetically adapt to rapid warming and rising CO_2 levels.

Rivers provide the avenue for export of terrestrial run-off, transporting nutrients, sediments and other land-based pollutants onto the Great Barrier Reef, and present a major management challenge in Queensland and elsewhere. The ARC Centre in collaboration with TropWater at JCU has produced a new framework for understanding the risk of runoff to coral and seagrass ecosystems, based on satellite imagery, which will assist with assessment and management of such events. Studies of the biological impact of sediment on coral reefs are limited. Centre researchers contributed to our knowledge in 2014 by showing that suspended sediment prolongs larval development and could significantly reduce numbers of larvae competent to settle, with a consequent effect on the adult population dynamics. This year also saw Centre researchers provide the first evidence linking dredging-associated sedimentation and turbidity with an increase in coral disease. These results help to explain, in part, the observed increases in global coral disease and suggest that minimising sedimentation and turbidity associated with coastal development will provide an important management tool for its control.

The Centre has also conducted novel research on coping with destructive outbreaks of coral-eating starfish. During 2014, a new crown of thorns starfish (CoTs) outbreak occurred between Lizard Island and Cairns. Research in the Centre focused on the localised control of crown of thorns starfish using a single shot injection and the development of markers to study the genetic heterogeneity of starfish outbreaks on the GBR. Other research has demonstrated that damage to corals by CoTs predation promotes brown band disease in corals.

Contemporary reef management also focusses on sustaining threatened megafauna, such as turtles. Climate change, in particular increased atmospheric temperatures, poses a threat to marine turtles which exhibit temperature dependent sex determination (TSD). Increases in temperature within nesting sites are known to result in extreme sex ratio biases. Research by Mariana Fuentes, in the Centre over the past 12 months has focussed on determining the primary sex ratio of populations with TSD, providing baseline data to inform management strategies and to accurately predict how future climate change may affect turtle populations.

The executive summary of the 2014 GBR Outlook Report concludes that "*Reef-wide, regional and local actions are required to prevent the projected declines in the Great Barrier Reef and to improve its capacity to recover.*" The ARC Centre will continue to contribute to the science needed to make informed decisions on how this sustainability of the Great Barrier Reef can be best achieved. Our new ARC Centre will assist GBRMPA in many ways, by providing advice and briefings, running technical courses and working groups, contributing to and reviewing GBRMPA reports, participating in Strategic Assessments, raising public awareness, and by training current and future GBRMPA employees.

ARTICLE
07 NOV 2014

Though well-managed, Australia's Great Barrier Reef is deteriorating.

Photo by Ed Roberts

Plan to Protect Great Barrier Reef Under Fire

By Dennis Normile and Leigh Dayton

Continuing degradation threatens reefs World Heritage Site status

Australia's Great Barrier Reef is under assault from fishers, agricultural runoff, and coastal development, and now climate change looms as a threat. But it was the prospect of humiliation—a threat by the World Heritage Committee to list the reef as "in danger"—that finally spurred the Australian government to act. It has crafted what it calls a comprehensive strategy to protect the reef 's "values" while allowing "sustainable development and use." Scientists who have reviewed the draft plan are not impressed.

The plan "fails to effectively address" any of the pressures the reef is facing, according to a statement last week from the Australian Academy of Science, which argued that "much bolder action is required" to prevent further degradation. Scientists hope the government will considerably strengthen the Reef 2050 Long-Term Sustainability Plan before submitting it to the World Heritage Committee early next year.

Australia created the 344,400-square kilometer Great Barrier Reef Marine Park off the state of Queensland in 1975, along with a Marine Park Authority to protect it. Conservation efforts were bolstered in 1981, after the reef was designated a World Heritage Site in recognition of its "outstanding universal value."

Yet conditions at the reef have deteriorated. In a 2012 report in the *Proceedings of the National Academy of Sciences*, Glenn De'ath of the Australian Institute of Marine Science in Townsville and colleagues reported that the reef 's coral cover shrunk by half between 1985 and 2012. The culprits, De'ath's group found, were cyclones, predation by crown-of-thorns starfish, and bleaching—loss of the coral's photosynthetic organisms when the water gets too warm. "Without intervention," the team warned, "the GBR may lose the biodiversity and ecological integrity for which it was listed as a World Heritage Area."

The Great Barrier Reef 's decline has alarmed scientists around the world. "The fact that a very well managed reef system is still showing substantial deterioration should be cause for general concern, because it reveals how pervasive our impacts are and how serious the consequences are for coral reefs," says Peter Sale, a reef ecologist and professor emeritus at the University of Windsor in Canada. It has also alarmed the World Heritage Committee, which warned last summer that in the absence of a long-term plan by early next year, it would consider listing the reef as "in danger." That "would be such a public shame for Australia," says Selina Ward, a reef ecologist at the University of Queensland, St. Lucia.

The draft 2050 plan acknowledges that more work is needed to address threats to the reef and calls for targets on water quality, biodiversity, ecosystem health, and economic and community benefits. But the Academy points out that "many important targets are not quantified, nor are they connected to any mechanisms through which they can be achieved." The Australian Coral Reef Society adds that the plan anticipates port expansion and dredging and sets an objective of completing such work with "no detrimental impact on the health and resilience of the Great Barrier Reef." However, states the society, "There is no indication of the method to achieve this ambitious objective." Nor, states the Australian Museum, does the plan address "the long term viability of fisheries and endangered species."

For a long-term conservation strategy, the plan pays little attention to climate change, says Terry Hughes, director of the ARC Centre of Excellence for Coral Reef Studies in Townsville. It notes that climate change will lead to more frequent bleaching and extreme weather events. But it doesn't offer any solutions, Hughes says. Earlier this year, the Australian government repealed the nation's carbon tax and is promoting the development of coal deposits for export from Queensland.

The Australian government says it is listening to critics, but hasn't tipped its hand on how it may revise the plan. "We appreciate community engagement in how we can better manage the reef," wrote an environment ministry representative in an e-mail to *Science*. He did note that the plan acknowledges that climate change is a global problem which requires global action, and is being addressed by the government through other policies."

"We hope that the government will improve the plan, and we'd like to help with that," Hughes says. A final plan must be submitted to the World Heritage Committee by 1 February, after which an advisory panel will review it and present a recommendation at the committee's annual meeting in Bonn in June. At a 2 October press conference, Environment Minister Greg Hunt said he's "optimistic" the committee will maintain the reef 's current status.

From Normile, D and Dayton, L (2014) Plan to protect the Great Barrier Reef under fire. *Science* 346: 683. Reprinted with permission from AAAS.

Publications

The ARC Centre produced 313 publications in 2014, comprising 287 journal articles, 11 books and book chapters, two Symposium papers, and 13 reports.

In 2014, Centre researchers published 93 articles in journals with Impact Factors greater than four, including 18 in prestige publications – *Science*, the *Nature* Journals, *Trends in Ecology or Evolution,* and *Ecology Letters*. The average Impact Factor for all 287 journal articles in 2014 was 4.5. The Centre's research outputs were published in a total of 111 journal titles, spanning many fields of research and reflecting the multidisciplinary breadth of the Centre's publication output.

According to *Scopus*, Centre of Excellence researchers were cited 22,853 times in 2014, 19 researchers were each cited more than 500 times and seven had more than 1,000 citations in the past 12 months.

League table achievements for publications in 2014 include:

- *The Faculty of 1000* recommended seven of the ARC Centre's papers:

  Lamb JB; True JD; Piromvaragorn S and Willis BL (2014). Scuba diving damage and intensity of tourist activities increases coral disease prevalence. *Biological Conservation* 178:88-96.

  Connolly SR, MacNeil MA, Caley J, Knowlton N, Cripps E, Hisano M, Thibaut LM, Bhattacharya BD, Benedetti-Cecchi L, Brainard RE, Brandt A, Bulleri F, Ellingsen KE, Kaiser S, Kroencke I, Linse K, Maggi E, O'Hara TD, Plaisance L, Poore GCB, Sarkar SK, Satpathy KK, Schueckel U, Williams A and Wilson RS (2014). Commonness and rarity in the marine biosphere. *Proceedings of the National Academy of Sciences of the United States of America* 111(23):8524-8529.

  Palumbi SR, Barshis DJ, Traylor-Knowles N, Bay RA (2014). Mechanisms of reef coral resistance to future climate change. *Science* 344(6186):895-898.

  Munday PL, Cheal AJ, Dixson DL, Rummer JL and Fabricius KE (2014). Behavioural impairment in reef fishes caused by ocean acidification at CO_2 seeps. *Nature Climate Change* 4(6): 487-492.

  Young MAL, Foale S and Bellwood DR (2014). Impacts of recreational fishing in Australia: historical declines, self-regulation and evidence of an early warning system. *Environmental Conservation* 41:350-356.

  Mouillot D, Villéger S, Parravicini V, Kulbicki M, Arias-González JE, Bender M, Chabanet P, Floeter SR, Friedlander A, Vigliola L and Bellwood DR (2014). Functional over-redundancy and high functional vulnerability in global fish faunas on tropical reefs. *Proceedings of the National Academy of Sciences of the United States of America* 111:13757-13762.

  Feary D, Pratchett MS, Emslie M, Fowler A, Figueira W, Osmar L. Yohei N, Booth D (2014). Latitudinal shifts in coral reef fishes: why some species do and others don't shift. *Fish and Fisheries* 15: 593-615.

- ISI Essential Science Indicators identified nine Research Fronts during 2014 that highlight the ARC Centre's research. A research front is a group of recent highly cited papers, referred to as Core Papers, in an emerging topic defined by a bibliometrical cluster analysis. The Research Fronts are:
  - Marine protected areas and larval dispersal
  - Coral reef resilience
  - Ocean acidification
  - Thermal tolerance and climate change
  - Coral reef fish and fisheries
  - Metabolic interactions
  - Coral reef conservation
  - Coral reef calcifiers
  - Coral reef ecosystems

Twenty-four Core Papers in these Research Fronts were authored by Centre members Glenn Almany, David Bellwood, Pim Bongaerts, Joshua Cinner, Sean Connolly, Guillermo Diaz-Pulido, Sophie Dove, Nick Graham, Ove Hoegh-Guldberg, Hugo Harrison, Andrew Hoey, Terry Hughes, Jeremy Jackson, Geoff Jones, Bill Leggat, Laurence McCook, Mark McCormick, Peter Mumby, Philip Munday, Kirsty Nash, Morgan Pratchett, Bob Pressey, Garry Russ, Eugenia Sampayo, Madeleine van Oppen, David Williamson, Sue-Ann Watson, Bette Willis and David Yellowlees.

Photo by Thomas Vignaud

Book (3)

1. Hilbert, DW, Hill, R, Moran, C, Turton, SM, Bohnet, I, Marshall, NA, Pert, PL, Stoeckl, N, Murphy, HT, Reside, AE, Laurance, SGW, Alamgir, M, Coles, R, Crowley, G, Curnock, M, Dale, A, Duke, NC, Esparon, M, Farr, M, Gillet, S, Gooch, M, Fuentes, M, Hamman, M, James, CS, Kroon, FJ, Larson, S, Lyons, P, Marsh, H, Meyer, SD, Sheaves, M and Westcott, DA (2014). Climate change issues and impacts in the wet tropics NRM cluster region. James Cook University, Cairns, 176 pp. ISBN: 978-1-4863-0291-8
2. Leadley, PW, Krug, CB, Alkemade, R, Pereira, HM, Sumaila, UR, Walpole, M, Marques, A, Newbold, T, Teh, LSL, van Kolck, J, Bellard, C, Januchowski-Hartley, SR and Mumby, PJ (2014). Progress towards the Aichi biodiversity targets: an assessment of biodiversity trends, policy scenarios and key actions. Secretariat of the Convention on Biological Diversity Montreal, QC, Canada, 502 pp. ISBN: 978-9-2807-3414-0
3. Mumby, PJ, Flower, J, Chollett, I, Box, SJ and Bozec, Y-Mea (2014). Towards reef resilience and sustainable livelihoods: a handbook for Caribbean coral reef managers. University of Exeter, Exeter UK, 172 pp. ISBN: 978-0-902746-31-2

Book Section (9)

1. Ban, N, Kittinger, J, Pandolfi, J, Pressey, R, Thurstan, R and Hart, S (2014). 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. Bonaldo, R, Hoey, AS and Bellwood, DR (2014). The ecosystem roles of parrotfishes on tropical reefs. In: Hughes, R, Hughes, D and Smith, I. (eds). *Oceanography and Marine Biology: An Annual Review*, CRC Press, 81-132 pp.
3. Brandl, SJ and Bellwood, DR (2014). Pair-formation in coral reef fishes: an ecological perspective. In: Hughes, R, Hughes, D and Smith, I. (eds). *Oceanography and Marine Biology: An Annual Review*, CRC Press, 1-80 pp.
4. Caballes, C and Pratchett, M (2014). Reproductive biology and early life history of the crown-of-thorns starfish. In: Witmore, E. (ed). *Echinoderms: Ecology, habitats,and reproductive biology*, Nova Science Publishers, New York, 101-146 pp.
5. Craig, R and Hughes, T (2014). Marine protected areas, marine spatial planning, and the resilience of marine ecosystems. In: Garmestani, AS and Allen, C. (eds). *Social-Ecological Resilience and Law*, Columbia University Press, 416 pp.
6. Hoegh-Guldberg, O, Cai, R, Poloczanska, E, Brewer, P, Sundby, S, Hilmi, K, Fabry, V and Jung, S (2014). The Ocean. In: Barros, VR, Field, C, Dokken, D, Mastrandrea, M, Mach, K, Bilir, T, Chatterjee, M, Ebi, K, Estrada, Y, Genova, R, Girma, B, Kissel, E, Levy, A, MacCracken, S, PR, M and White, L. (eds). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, 1655-1731 pp.
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8. Pratchett, M, Caballes, C, Rivera-Posada, J and Sweatman, H (2014). Limits to understanding and managing outbreaks of crown-of-thorns starfishes (*Acanthaster* Spp). In: Hughes, R, Hughes, D and Smith, I. (eds). *Oceanography and Marine Biology: An Annual Review*, CRC Press, Boca Raton, FL, 133-200 pp.
9. Wilson, SK, Graham, NAJ and Pratchett, MS (2014). Susceptibility of butterflyfish to habitat disturbance: do 'chaets' ever prosper? In: Pratchett, MS, Berumen, ML and Kapoor, BG. (eds). *Biology of Butterflyfishes*, CRC Press, Boca Raton, FL, USA, 226-245 pp.

Conference Paper (2)

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2. Lawes, M, Mohd-Azlan, J, Adams, V, Hilton-Taylor, C, Rondinini, C, Visconti, P and Pressey, R (2014). Evaluating the efficacy of Sarawak's protected areas network for conserving native wildlife. *RIMBA3: Sustaining livelihoods through prudent utilization and management of natural resources*. Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak, Kuching, Sarawak, Malaysia, 134-146 pp.

Journal Article (287)

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5. Albouy, C, Velez, L, Coll, M, Colloca, F, Le Loc'h, F, Mouillot, D and Gravel, D (2014). From projected species distribution to food-web structure under climate change. *Global Change Biology* 20(3): 730-741.
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and management approaches for the interlinked ecology of the open oceans. *Marine Policy* 49: 127-136.

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Recognition of Excellence by Centre Members

2014 has been marked by the recognition of the achievements of several members of our new ARC Centre. These awards recognise the excellence of our research and teaching not only within the four host universities, but more significantly at the national and international level. Examples include:

1. Ove Hoegh-Guldberg was the recipient of the Climate Change award presented annually by the Prince Albert II of Monaco Foundation. Ove was presented with his award by Prince Albert at a Ceremony in Palm Springs, California for his research on coral reef biology with a special focus on the impact of climate change on marine ecosystems. This prize also recognised his contribution as the co-ordinating lead author for the 'Oceans' chapter of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

2. Terry Hughes was awarded an Einstein Professorship through the Einstein Professorship Program, a key initiative of the Chinese Academy of Sciences. Einstein Professorships are awarded to 20 distinguished international scientists each year who are actively working at the frontiers of science and technology. As part of this award Terry undertook a two week lecture-tour to China during November. Terry was also the recipient of an Honorary Doctorate (D.Sc.) from the Universiti Malaysia Terengganu, awarded for his ground-breaking research on coral reefs.

3. Pip Cohen and Sue-Ann Watson were recipients of 2014 Queensland Tall Poppy Science Awards presented by Hon Ian Walker, the Minister for Science, Information Technology, Innovation and the Arts in the Queensland Government. Sue-Ann won the overall award of the Queensland Tall Poppy Scientist of the year. She received $7,500 "for use in support of the awardee's research and/or directly related science promotion activities".

4. Jodie Rummer was awarded the George A. Bartholomew distinguished young investigator in comparative physiology, biochemistry, and functional and integrative biology. She is the 22nd winner of this annual award presented by the Society for Integrative and Comparative Biology. Jodie also received an ARC DECRA Fellowship.

Geoff Jones received the 2014 Jubilee Award of the Australian Marine Sciences Association (AMSA) at their annual conference in July. This award honours excellence in marine research and is presented to a scientist who has made an outstanding contribution to marine research in Australia (see opposite). The national President of AMSA, Sabine Dittmann, said the award recognises Geoff's important and unique contributions in the areas of larval connectivity, ecological interactions, and the dynamics of reef fish populations. His research has had a major impact on the understanding of how marine fish populations function and has also influenced the design and management of marine protected areas in Australia and worldwide.

Ove Hoegh-Guldberg, Terry Hughes and the Chair of the Centre Advisory Board, Brian Walker, were among those listed as being the World's Most Influential Scientific Minds for 2014 by Thomson Reuters. This recognition was based on analysing data using Web of Science and InCites platforms to determine which researchers have produced work that is most frequently acknowledged by peers. These highly cited researchers were determined by analysing citation data over the last 11 years to identify those who published the highest impact work (2002-2012 and 2012-2013). These individuals are deemed to be influencing the future direction of their fields, and of the world.

Sean Connolly received a Citation for Outstanding Contributions to Student Learning awarded by the Commonwealth Government Office for Learning & Teaching.

Other highlights were:

- Mary Bonin was the winner of the Early Career Researcher category at the finals of the JCU *My Research in 3 Minutes*.
- Geoff Jones was the recipient of the JCU 2014 Primary Advisor of the Year, for supervision of postgraduate students.
- Ryan Lowe was the recipient of the UWA 2014 Vice Chancellor's Mid-Career Research Award, which recognises research excellence.
- Philip Munday received the 2014 JCU Award for Excellence in Research from the Vice Chancellor, Sandra Harding
- Bette Willis was the recipient of a James Cook University Special Award for Outstanding Career Achievement in Higher Degree by Research Supervision. This is the first time the award has been presented, and it recognises Professor Willis' sustained, high performance as a supervisor of research students.

Australian
Marine Sciences
Association

Professor Geoff Jones

AMSA
Jubilee
Awardee
2014

Professor Geoff Jones is a world leader in reef fish ecology, who has made important and unique contributions in the areas of larval connectivity, biogeography, and the dynamics of reef fish populations and communities. His research has had a major impact on our understanding of how marine fish populations function and has influenced the design and management of marine protected areas in Australia and worldwide.

Professor Jones has focused his ground-breaking research on two key aspects of the ecology of reef fishes that directly inform conservation strategies. In each of these fields, he has built and led international teams that have developed new technologies (such as parentage analysis for dispersal and connectivity studies) and changed our views on fundamental aspects of reef fish ecology.

The first aspect of his research focuses on quantifying larval fish dispersal and demonstrating the significance of self-recruitment and connectivity for metapopulation dynamics. Geoff was a pioneer in the development of new methods to directly determine where reef fish larvae go and the techniques he has employed have become the gold standard in this field of study. Geoff was the first to show that fish populations on the Great Barrier Reef can have high levels of self-recruitment, which overturned the widely accepted dogma of the time. Through this research, Jones and colleagues have successfully addressed significant gaps in scientific knowledge necessary for the effective design and spacing of no-take reserves for the conservation of marine biodiversity.

Geoff's second major research focus is on population and community responses of reef fishes to changes in habitat structure, with particular reference to coral cover, coral diversity and habitat complexity. His research has been pivotal in demonstrating the close links between coral reef habitat and the structure of reef fish populations, including the risk of population decline in reef fishes caused by the deteriorating state of coral reef habitats.

Geoff is a Professor in the School of Marine and Tropical Biology at James Cook University and a Chief Investigator in the ARC Centre of Excellence for Coral Reef Studies. He has published over 220 peer-reviewed papers, including several highly cited landmark publications in his research field, and 21 major review articles. He provides unparalleled opportunities for early career researchers in his team and has supervised over 100 graduate student projects.

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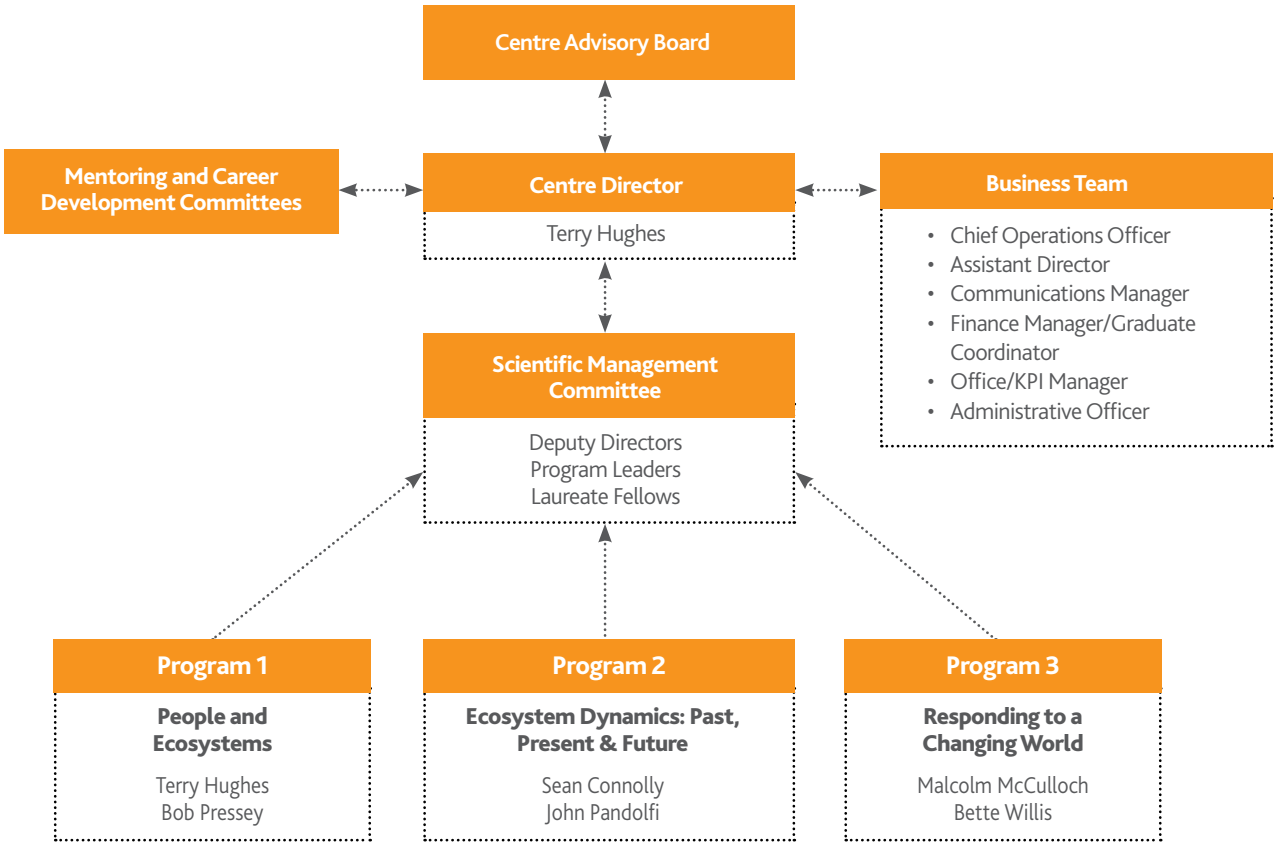
Governance

The governance structures of the Centre of Excellence reflect its research profile and engage stakeholders in planning and management processes. The diagram below illustrates the governance structure and relationships. James Cook University is the administering organisation with the Centre Director, Terry Hughes, reporting directly to the Senior Deputy Vice-Chancellor, Professor Chris Cocklin who leads JCU's Research and Innovation Division. Day-to-day operations are managed by the Chief Operations Officer, Jenny Lappin, in consultation with the Centre Director and Assistant Director, David Yellowlees. Business support is also provided by staff at the Australian National University, the University of Queensland and the University of Western Australia.

The Centre Director oversees the Centre's research programs and liaises regularly with the two Deputy Directors, Ove Hoegh-Guldberg (UQ) and Malcolm McCulloch (UWA). Chief Investigators are located in several academic Colleges 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 overseas institutions. Adjunct researchers make a significant contribution to the Centre's research Programs and are located in both national and international institutions.

The Centre also supports two mentoring and career development committees (Student and Postdoctoral) run by early career postdoctoral Fellows and by research students, tasked with promoting career development of the Centre's personnel, and with the organisation of annual retreats and training workshops.



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 day to day Centre operations.

The Board is chaired by a distinguished international researcher, Professor Brian Walker *FAA* from CSIRO. 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 an international NGO, WorldFish. Our sincere thanks to the members of the Board for their invaluable advice and support. In 2015, membership of the Board will be expanded to include additional international senior representatives from NGOs or research organisations. The Advisory Board met twice in 2014, in July and December. The key focus of the Centre Advisory Board meetings in 2014 was providing advice on the establishment of the Centre of Excellence following its success in attracting a further seven years of funding from 2014 to 2020.

Membership of the Centre Advisory Board:

Dr Brian Walker *FAA* (Chair)
CSIRO Ecosystem Sciences

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

John Gunn
Chief Executive Officer
Australian Institute of Marine Science

Professor Terry Hughes *FAA*
Director
ARC Centre of Excellence

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

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

Scientific Management Committee

Operational management of the Centre, planning and stewardship of its scientific research program is the responsibility of the Centre's Scientific Management Committee (SMC). We are delighted to report that in 2014 eminent international social science researcher Professor Katrina (Kate) Brown from Exeter University accepted the Centre's invitation to chair the Centre's Scientific Management Committee. A profile of Kate Brown is on page 66. Other members are the leaders of each of the Centre's research programs, the Centre's current Laureate Fellows, and the Director – Reef Recovery at GBRMPA (the government agency responsible for the management of the Great Barrier Reef, and the Centre's principal end-user). The Centre's Chief Operations Officer, Jennifer Lappin, is the SMC secretary. The Committee met twice formally in the second half of 2014, with frequent informal communication on establishing the new Centre and its research programs. Priorities in 2014 included establishing the Centre's research Programs, fostering trans-disciplinary research within and across the Centre's nodes, recruiting high-quality Research Fellows and students, developing and implementing an international communications strategy, and reviewing processes for engaging effectively with the Centre's end-users.

Membership of the Scientific Management Committee:

Professor Kate Brown (Chair)
Chair in Social Science
Environment and Sustainability Institute
Exeter University, United Kingdom

Professor Terry Hughes *FAA*
ARC Australian Laureate Fellow
Leader, Research Program 1
James Cook University

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

Professor Sean Connolly
Leader, Research Program 2
James Cook University

Professor John Pandolfi
Leader, Research Program 2
University of Queensland

Professor Malcolm McCulloch *FRS FAA*
ARC Australian Laureate Fellow
Leader, Research Program 3
University of Western Australia

Professor Bette Willis
Leader, Research Program 3
James Cook University

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

Professor Peter Mumby
ARC Australian Laureate Fellow
University of Queensland

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

Leader Profile

Professor Katrina Brown

We are delighted to welcome Professor Katrina (Kate) Brown as the new Chair of the Centre's Scientific Management Committee. Kate holds the Professorial Chair in Social Science in the Environment and Sustainability Institute (ESI) at the University of Exeter, in the United Kingdom.

As a distinguished environmental social scientist with degrees in both natural and social sciences, Kate works on environmental change and how people and communities understand and respond to change. Her research focuses on ideas about resilience and how these are interpreted and applied into policy and by different communities of practice. She also works on ideas around ecosystem services and how these relate to well-being. Her work crosses disciplinary boundaries and involves collaborations with ecologists, engineers, climate scientists, economists, geographers, political scientists and latterly, arts scholars and practitioners, all of which she finds inspiring and intellectually stimulating.

Kate is a pioneer of interdisciplinary research, and her first post-doc position was as an 'interdisciplinary scientist' at the newly created *Centre for Social and Economic Research on the Global Environment* (CSERGE) at the University of East Anglia, which rapidly became internationally renowned for working at the forefront of interdisciplinary research, on a range of environmental issues. She was also the Deputy Director (Social Sciences) and Programme leader of the Tyndall Centre for Climate Change Research. At the ESI, established in 2012, she now leads research on social sciences and environmental change.

Kate's research has taken her all over the planet including sub-Saharan Africa, Latin America, the USA, the Caribbean, and South Asia. She started her research career with a PhD on women's collective action in eastern Kenya. This project examined how participating in women's farming groups might help the poorest households to escape poverty traps and overcome vulnerability to drought and other shocks. This work showed her how issues of poverty and environmental change are inextricably linked, and how social, economic and political factors – including gender, knowledge, property rights and culture – influence and mediate change. This early-career research drew her to focus her work on development studies for nearly 20 years; holding a faculty position in the School of International Development at University of East Anglia.

Environmental change and how individuals and societies respond to change has been Kate's passion for over 20 years. From 2004 to 2014 she co-edited the journal *Global Environmental Change*. With Neil Adger and Declan Conway, she helped develop the journal as the premier outlet for cutting edge and interdisciplinary work in this rapidly moving and expanding research field. In 2014 she won the inaugural 'Outlook' award from AXA Research Fund, which has enabled her to expand transdisciplinary research to work with an NGO, S.A.F.E. Kenya, to develop a participatory drama production with coastal communities in Kenya on resilience to extreme weather and climate change. The award also sent her to New Orleans to make a film with *National Geographic* on the peoples' experiences and recovery after Hurricane Katrina. Her research combines the lived experiences of change with advancing theoretical understandings of resilience, vulnerability and adaptation. Other current work led by Kate explores how adaptation to climate change creates new vulnerabilities in coasts, and the opportunities for poverty alleviation from marine and coastal ecosystem services.

Membership

In 2014, the Centre's membership comprised 55 Chief Investigators and Research Fellows, seven Research Associates, and 30 Partner Investigators, resident international scholars and adjunct researchers. This year, 18 of the Centre's Research Fellows are funded by Australian Research Council (ARC) Fellowships (Laureate, Future, DECRA and Super Science) and one is a Queensland Smart Futures Fellow.

Chief Investigators and Research Fellows

Professor Terry Hughes
Centre Director, ARC Australian Laureate Fellow, JCU

Dr Tracy Ainsworth
ARC Super Science Fellow, JCU

Dr Jorge Álvarez-Romero
Research Fellow, JCU

Dr Amélie Augé
Research Fellow, JCU

Professor Andrew Baird
Chief Investigator, JCU

Professor David Bellwood
Chief Investigator, JCU

Dr Anthony Bertucci
ARC Super Science Fellow, JCU

Dr Jessica Blythe
Research Fellow, JCU and WorldFish Center, Malaysia

Dr Pim Bongaerts
Research Fellow, UQ

Dr Mary Bonin
Research Associate, JCU

Dr Yves-Marie Bozec
Research Fellow, UQ

Dr Tom Bridge
Research Fellow, JCU and Australian Institute of Marine Science

Dr Jana Brotankova
Research Associate, JCU

Professor Joshua Cinner
ARC Australian Research Fellow, JCU

Professor Sean Connolly
Chief Investigator, JCU

Dr Ian Craigie
Research Associate, JCU

Dr Vivian Cumbo
Research Associate, JCU

Dr Juan Pablo D'Olivo Cordero
Research Fellow, UWA

Assoc Professor Sophie Dove
Chief Investigator, UQ

Dr Michael Fabinyi
Society in Science Research Fellow, JCU

Dr James Falter
Research Fellow, UWA

Dr Sylvain Forêt
ARC Discovery Early Career Researcher Award, ANU

Dr Mariana Fuentes
Research Fellow, JCU

Dr Manuel Gonzalez-Rivero
Research Fellow, UQ

Dr Nick Graham
ARC Discovery Early Career Researcher Award, JCU

Dr Alistair Harborne
ARC Discovery Early Career Researcher Award, UQ

Dr Hugo Harrison
Research Fellow, JCU

Dr Christina Hicks
Research Fellow, JCU and Stanford University, USA

Professor Ove Hoegh-Guldberg
Deputy Director, ARC Australian Laureate Fellow, UQ

Dr Andrew Hoey
ARC Discovery Early Career Researcher Award, JCU

Dr Michael Holcomb
ARC Super Science Fellow, UWA

Dr Mia Hoogenboom
Chief Investigator, JCU

Professor Geoffrey Jones
Chief Investigator, JCU

Professor Michael Kingsford
Chief Investigator, JCU

Dr Nils Krück
Research Fellow, UQ

Assoc Professor Bill Leggat
Research Fellow, JCU

Professor Ryan Lowe
ARC Future Fellow, UWA

Dr Vimoksalehi Lukoschek
ARC Discovery Early Career Researcher Award, JCU

Professor Mark McCormick
Chief Investigator, JCU

Professor Malcolm McCulloch
Deputy Director, ARC Australian Laureate Fellow, UWA

Dr Vanessa Messmer
Research Fellow, JCU

Professor David Miller
Chief Investigator, JCU

Dr Aurélie Moya
Research Fellow, JCU

Professor Peter Mumby
ARC Australian Laureate Fellow, UQ

Professor Philip Munday
ARC Future Fellow, JCU

Dr Kirsty Nash
Research Associate, JCU

Professor John Pandolfi
Discovery Outstanging Researcher Award, UQ

Professor Morgan Pratchett
Chief Investigator, Smart Futures Fellow, JCU

Professor Bob Pressey
Research Fellow, JCU

Dr Jairo Rivera Posada
Research Fellow, JCU and Australian Institute of Marine Science

Dr Jodie Rummer
ARC Super Science Fellow, JCU

Professor Garry Russ
Chief Investigator, JCU

Dr Eugenia Sampayo
Research Fellow, UQ

Dr Verena Schoepf
Research Fellow, UWA

Dr Ruth Thurstan
Research Fellow, UQ

Dr Sue-Ann Watson
Research Associate, JCU

Dr Rebecca Weeks
Research Fellow, JCU

Dr Amelia Wenger
Research Associate, JCU

Dr David Williamson
Research Fellow, JCU

Professor Bette Willis
Chief Investigator, JCU

Dr Ke Zhang
Research Associate, JCU

Dr Zhenlin Zhang
ARC Super Science Fellow, UWA

Resident International Scholars

Dr Pip Cohen
Research Fellow, WorldFish, Malaysia

Professor Bruno Lapeyre
Professor, Centre National de la Recherche Scientifique, France

Dr David Mills
Research Fellow, WorldFish, Malaysia

Dr Benjamin Mason
National Science Foundation International Research Fellow, USA

Partner Investigators and Adjunct Researchers

Dr Vanessa Adams
Charles Darwin University

Dr Glenn Almany
University of Perpignan, France

Professor Serge Andréfouët
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 Louisa Evans
Exeter University, United Kingdom

Dr Ashley Frisch
James Cook University

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

Maurice Knight
World Wildlife Fund, Indonesia

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

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Université Montpellier 2 Sciences et Techniques, France

Professor Stephen Palumbi
Stanford University, USA

Dr Serge Planes
University of Perpignan, France

Professor John Tanzer
World Wildlife Fund, Switzerland

Professor Madeleine van Oppen
Australian Institute of Marine Science

Dr David Wachenfeld
Great Barrier Reef Marine Park Authority

Graduate Students (see page 32)

Research Support Staff

Giovanni Bernal Carrillo
University of Queensland

Carlin Bowyer
University of Western Australia

Aaron Chai
University of Queensland

Karen Chong-Seng
James Cook University

Christopher Goatley
James Cook University

Maria Gomez-Cabrera
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David Hayward
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Mizue Hisano
James Cook University

Cindy Huchery
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Jue Sheng Ong
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Deborah Pratchett
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Kai Rankenburg
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Annamieke Van Den Heuvel
University of Queensland

Matt Young
James Cook University

Business Team

Jennifer Lappin
Chief Operations Officer, JCU

Professor David Yellowlees
Assistant Director, JCU

Olga Bazaka
Finance Manager and Graduate Coordinator, JCU

Nicola De Silva
Administrative Officer, UQ

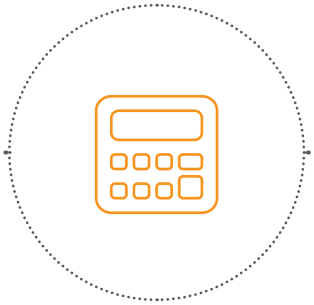
Eleanor Gregory
Communications Manager, JCU

Janet Swanson
Administrative Assistant, JCU

Karen van Staden
Administrative Officer, UWA

Rose-Marie Vasiljuk
Office Manager and KPI Officer, JCU

Hayley Ware
Project Officer, UQ



Financial Statement

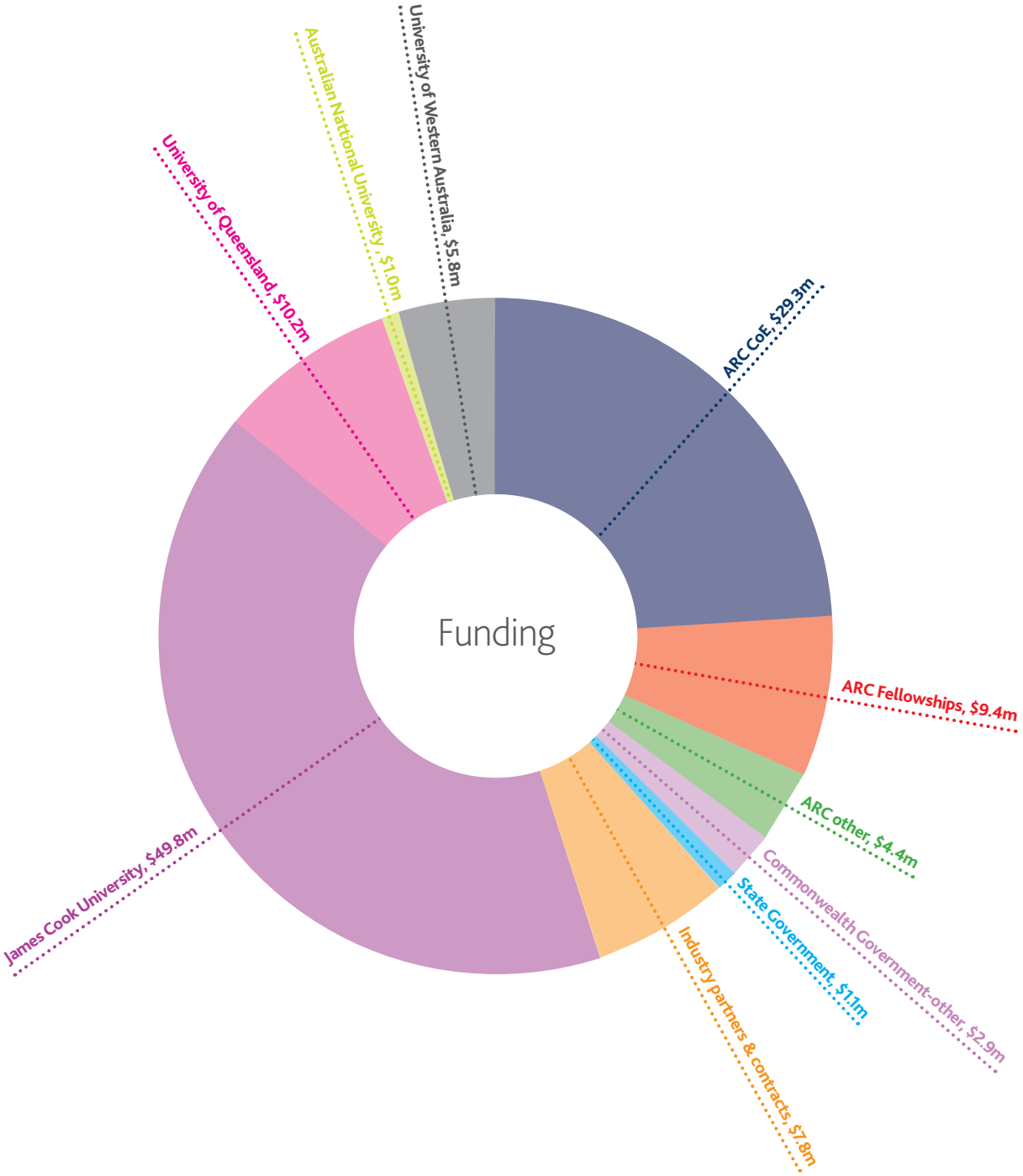
ARC Centre of Excellence for Coral Reef Studies
Statement of Operating Income and Expenditure for year ended 31 December 2014

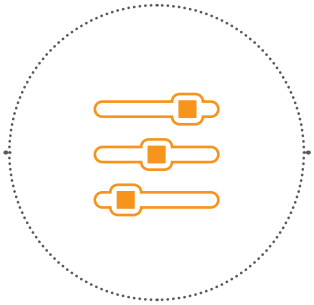
	2014
Income	**$**
ARC Centre Grant	$4,120,882
ARC Fellowships	1,743,575
Host Institutions cash support	3,377,461
QLD State Government	95,000
Commonwealth Government other grants	955,707
International and other contracts	523,347
Total Income	**$10,815,972**

Expenditure	**$**
Salaries	$5,582,715
Equipment	402,277
Travel	1,235,412
Research maintenance and consumables	1,466,972
Scholarships	121,432
Public outreach and administration	77,779
Total Expenditure	**$8,886,588**
Surplus	**$1,929,384**

Financial Outlook

As at December 2014, the total cash and in-kind budget for the ARC Centre of Excellence for Coral Reef Studies for 1 January 2014 to 31 December 2020 totals $121.6m.





Key Performance Indicators

Research findings

Measure	Target 2014	Outcome 2014
Number of research outputs (p52)	250	313
Publications in journals with an Impact Factor > 4	60	93
Mean Impact Factor for journals published	3.5	4.5
Faculty of 1000 commentaries	5	7
Number of citations (p52)	16,000	22,853
No. of Centre researchers with >500 citations	15	19
No. of invited talks/papers/keynotes at international meetings	20	22
Number and nature of commentaries about the Centre's achievements (p46)		
Articles	2,000	3,776
Media releases	26	26
Awards, prizes or recognition (p62)	20	29

Research training and professional education

Measure	Target 2014	Outcome 2014
No. of professional training courses for staff and postgraduate students attended	20	37
No. of Centre attendees at all professional training/development courses offered by the Centre	80	481
No. of students mentored	150	156
No. of student attendances at Centre professional development events	60	268
No. of early career researchers participating in annual performance reviews, attending seminars, visiting other Centre nodes, attending ECR committee events	25	33
Stakeholder participation in Centre Working Group meetings, workshops and planning meetings	10	10
No. of new postgraduates enrolled (p32)	150 over life of Centre	47
No. of postgraduate completions and completions times:		
No. of completions	175 over life of Centre	45
No. submitting within 4 years of commencement	15	19
No. of new honours students	80 over life of Centre	16
No. of new postdoctoral researchers	40 over life of Centre	8
No. of Early Career Researchers	10	33

International, national and regional links and networks

Measure	Target 2014	Outcome 2014
No. of international visitors	50	67
No. of national and international Working Groups held/organised by the Centre	8	20
No. of visits to overseas laboratories and research facilities	75	91
Metrics of interdisciplinary research supported by the Centre:		
• No. of journal titles in which Centre outputs are published	80	111
• No. of four digit Field of Research disciplines in which the Centre research publications are classified	15	22
• No. of students with multidisciplinary supervisory arrangements	30	31

End-User links

Measure	Target 2014	Outcome 2014
No. of government, industry and business briefings	60	100
Public awareness programs	30	57
No. of talks open to the public	40	29
Website hits	5.0m	10.0m

Organisational support

Measure	Target 2014	Outcome 2014
Annual cash contributions from Administering and Collaborating Organisations:		
JCU	$1.0m	$1.0m
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	$6.28m
ANU	$0.06m	$0.09m
UQ	$1.18m	$1.18m
UWA	$0.60m	$0.60m
Annual cash contributions from Partner Organisations:		
AIMS	$114k	$143k
IUCN	$28k	$28k
CNRS	$7k	$3k
GBRMPA	$0k	$61k
Stanford	$54k	$54k
WorldFish	$56k	$38k

Annual in-kind contributions from Partner Organisations:		
AIMS	$312k	$312k
GBRMPA	$25k	$25k
IUCN	$139k	$139k
CNRS	$54k	$54k
Stanford	$189k	$189k
WorldFish	$100k	$100k
Other research income secured by Centre staff:		
ARC Grants	$2.30m	$2.00m
Other Australian competitive	$0.30m	$0.96m
Public sector	$0.30m	$0.10m
Industry and other research income	$0.10m	$0.52m
No. of new organisations collaborating with, or involved in the Centre	100 over life of Centre	18
Level and quality of infrastructure provided to the Centre	$1.4m	$1.47m

Governance

Measure	Target 2014	Outcome 2014
Breadth, balance and experience of the members of the Advisory Board		See page 64
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 64
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	70	93
• No. of multi-institutional supervisory arrangements	40	70
• No. of cross-nodal publications	30	33
Capacity building of the Centre through scale and outcomes:		
No. of countries where the Centre:		
• Undertakes fieldwork	20	20
• Advises governments and NGOs	10	10
• No. of international co-authors	30	560
• Overseas graduate student completions	100 over life of Centre	38

National Benefit

Measure	Target 2014	Outcome 2014
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	41
• Interactions with industry, business and government	60 briefings	100 briefings
• Cross-institutional publications	130	206
Contribution to national research priorities	1 case study highlighted in the annual report	See page 49
Measure of reputation and competitiveness	Benchmarking of publications and citations against other world leading institutions	The Centre is ranked #1 in the world for citations and outputs in coral reef science

Centre specific performance indicators

Measure	Target 2014	Outcome 2014
Prestige publications	100 publications over life of Centre	18
Publications with cross-institutional co-authorships	150	206
New Centre graduate students attracted to Australia from overseas	100 over life of Centre	38
Centre graduate students with cross-nodal supervision	120 over life of Centre	39
Gender equity in research fellow appointments	50:50	6 males: 2 females

Acknowledgements

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

- Australian Academy of Science, Canberra
- Australian Genome Research Facility (AGRF), Brisbane
- Australian Government: Department of the Environment
- Australian Institute of Marine Science (AIMS), Townsville
- Australian Coral Reef Society, Australia
- Australian Museum
- Bioplatforms Australia
- Center for Ocean Solutions, Stanford University, USA
- Centre National de la Recherche Scientifique, France
- Centre Scientifique de Monaco, France
- Conservation International, Philippines
- Coral Reef Initiatives for the Pacific (CRISP), Noumea
- 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, Melbourne
- International Union for the Conservation of Nature
- King Abdullah University of Science and Technology, Saudi Arabia
- Lizard Island Research Station, Queensland
- Lord Howe Island Board
- Marine Parks Authority, Lord Howe Island Marine Park
- National Environment Research Program, Australia
- National Oceanic and Atmospheric Administration, USA
- National Parks Association of Queensland
- National Science Foundation, USA
- Northern Gulf Resource Management Group, Queensland
- Northern Fisheries Centre, Queensland Department of Agriculture, Fisheries and Forestry
- Okinawa Institute of Science and Technology Graduate University, Japan
- Palawan State University, Philippines
- Prince Albert II of Monaco Foundation, Monaco
- Queensland Department of Science, Information Technology, Innovation and the Arts
- RARE Conservation, Philippines
- Reef Rescue
- Resilience Alliance, Sweden
- Royal Swedish Academy of Science, 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
- Universiti Malaysia Terengganu, Malaysia
- Virginia Chadwick Foundation, Australia
- Western Australian Department of Parks and Wildlife
- Western Australian Department of Fisheries
- Western Indian Ocean Marine Science Association (WIOMSA), Zanzibar
- Wildlife Conservation Society, USA
- Wildlife Preservation Society of Queensland
- WorldFish, Malaysia
- World Wildlife Fund (International), USA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14
ARC Centre of Excellence
Coral Reef Studies

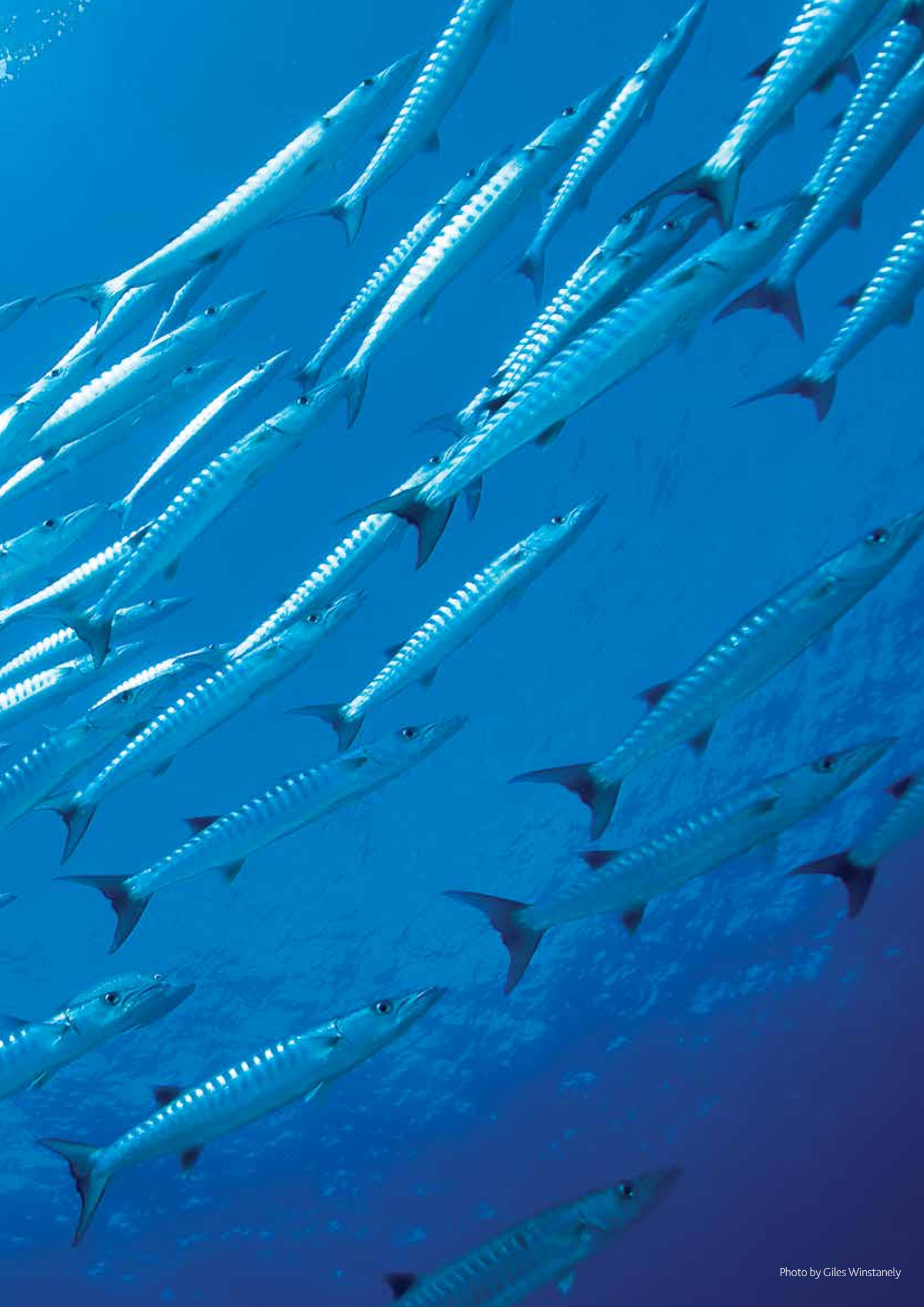

Photo by Giles Winstanely

ARC Centre of Excellence
Coral Reef Studies

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