

2006 Annual Report





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Vision

Global leadership in the provision of scientific knowledge necessary for coral reef managers to preserve the world's coral reefs.

Mission

To create a world-best integrated research framework that addresses regional and global issues and knowledge gaps in coral reef science and management.

Aims

1. Research

Research is world-best, innovative, and highly relevant to coral reef science and management.

2. Research Training & Professional Education

The Centre attracts and trains outstanding coral reef scientists at all stages of career, emphasizing practical outcomes and problem solving.

3. End-user linkages

Transfer of knowledge, technologies and research outcomes to end-users, industry and the wider community promotes co-operation and improves the management of coral reefs.

4. National and International linkages

The Centre's networks and activities nationally and internationally represent a global hub for coral reef science collaborations.

5. Management and Governance

Centre management is collaborative, co-operative, multi-institutional, communicative and continuously improving.

6. Commercialisation

Commercialisation activities extend knowledge transfer, nationally and globally.

Overview

The ARC Centre of Excellence for Coral Reef Studies was established in July 2005 under the ARC Centres of Excellence program. Led by James Cook University (JCU), 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) and The University of Queensland (UQ) with formal collaborative links to twenty-four additional institutions in nine countries.

Sustainability of coral reef resources is vital for economies and societies in tropical maritime countries worldwide and Australia plays a leading role in the science that underpins coral reef management. The ARC Centre of Excellence creates multidisciplinary teams of leading scientists with a balance of University-based researchers, collaborating organisations and distinguished overseas partners, in addition to strong linkages with industry partners and end-users. The multi-institutional research teams have unprecedented access to the major tropical marine research infrastructure in Australia.





Director's Report



Welcome to the 2006 annual report for the ARC Centre of Excellence for Coral Reef Studies, our first full year

of operation. What a year it has been! We produced 132 peer-reviewed publications in 2006, a 29% increase on 2005. Major research themes include adaptation to climate change, managing biodiversity, emergent diseases, fisheries biology, design of marine parks, and coastal management – in short, the science that underpins the sustainable delivery of goods and services from the world's coral reefs. Our publications this year include co-authorships from 93 institutions in 29 countries.

The added visibility and scope of the ARC Centre has led to a substantial increase in our level of engagement with governments, industry, NGOs, and the general public (see report on p.32). We have also reached a financial milestone in 2006, securing over \$12 million in additional cash income beyond the award from ARC, bringing our budget for 2005-2010 to more than \$35 million. The Centre's Administering Institution, James Cook University, has generously increased its cash support for 2006 and beyond by 50%.

Graduate training continues to be a major focus of the Centre (see a summary of research student activities on page p.25). The number of postgraduates supervised by Centre personnel has increased to 110, up sharply from 74 in 2005. Our students now come from 29 countries, making us a global leader in

the provision of graduate training in coral reef studies. Thirteen students completed higher degrees in 2006, a number that is on course to double by 2009. We have established a student committee, which is resourced to help enhance the graduate experience of research students through mentoring activities, including several multi-nodal seminar series, student travel awards and prizes, and an annual retreat. Thirty-five graduate students now have multi-institutional supervisory arrangements, taking advantage of expertise and resources at all of the Centre's main nodes.

The Centre has invested heavily in recruiting 15 postdoctoral fellows in 2006, including 6 from overseas. Three of these appointments arise from new co-investment in collaborative projects with the Australian Institute of Marine Science and CSIRO. Three of the Centre's researchers were also awarded new prestigious ARC Fellowships in 2006 (for a 2007 start) – an Australian Postdoctoral Fellowship (APD), Australian Research Fellowship (ARF) and a Federation Fellowship. Following a series of workshops on grant-writing, conducted in late 2006 at the JCU and UQ-nodes, the Centre has sponsored the research costs associated with 10 applications for ARC Fellowships in the pending round of the ARC Discovery Program. Many of the newly-arrived postdoctoral researchers have initiated additional commercial consultancies in 2006.

Our new Centre of Excellence website has been highly successful, growing from zero to >600,000 hits in its first year, with 84% being from outside Australia. The website caters for multiple audiences, including a diverse suite of end-users,

other researchers and students, school children, and the general public. It will continue to develop, and is an important tool in presenting our outputs and research services to the world. Our media up-take in 2006 has grown by 5-fold, with more than 700 stories featuring the 2006 activities of the ARC Centre, for national and international audiences. By the end of 2006, a Google search for "ARC Centre of Excellence" places us first among 1.1 million websites.

The Centre's 2006 performance has exceeded all of its Key Performance Indicators and the Centre has approached the Australian Research Council to review targets for 2007.

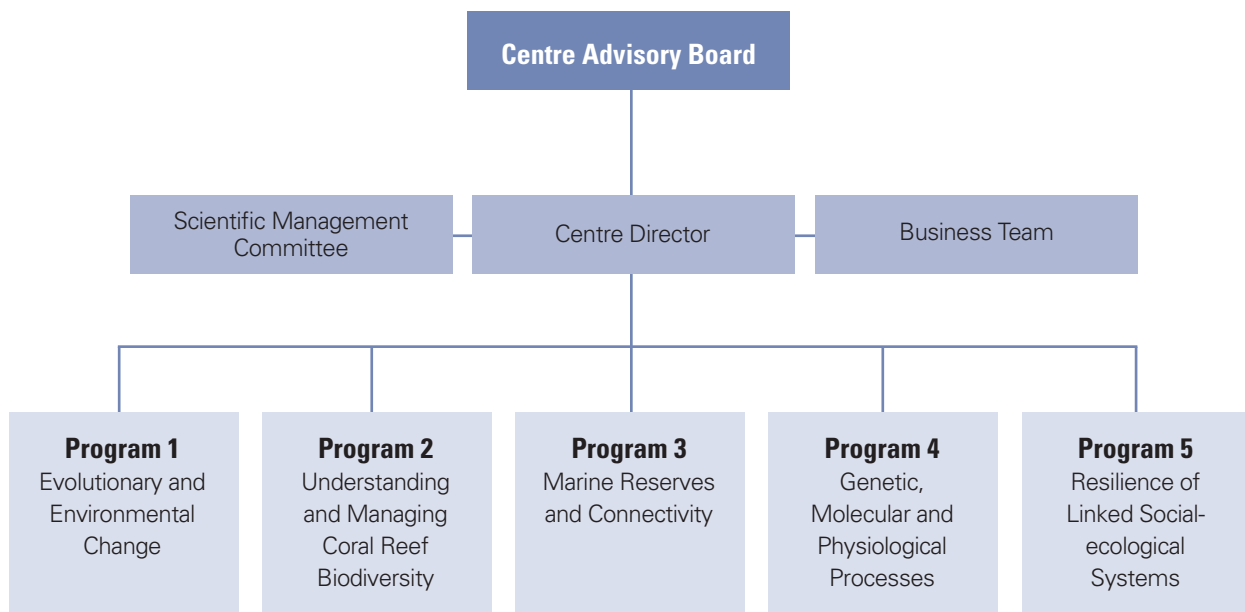
This coming year, 2007, will be even busier than the last! Highlights will include additional recruitment of research fellows, further website development to improve delivery of our research products and services, developing a major new research program (Program 6) in Conservation Planning, leading a National Forum on Coral Reef Futures (in collaboration with the Australian Academy of Science), and undertaking a full-blown external review of the Centre.

Finally, I offer my congratulations and sincere thanks to all of the Centre's personnel for an outstanding year. I thank our new and existing collaborators around the world for their friendship and intellectual input into our joint endeavors. I am especially grateful to the Centre's Chief Operations Officer, Jenny Lappin, and our KPI Officer, Louise Taylor, for their hard work, patience and enthusiasm. Well done, everybody!

Terry Hughes
Director



Management Structure



Governance

A key goal of the Centre is to establish governance structures that engage stakeholders in planning and management processes and that provide easy access to emerging technologies, knowledge and information. The Centre is governed by a Centre Advisory Board and a Scientific Management Committee. We are privileged to have access to the expertise and experience of university, industry and scientific leaders and we extend our thanks to them for their advice and contribution in establishing the Centre.

Major research and operational decisions are made by the Centre Director in consultation with the Chief Operations Officer and the Program Leaders. The operational framework for the Centre is provided by the ARC Funding Agreement, collaborators' Centre Agreement, ARC funding Rules and Centre Application.

Centre Advisory Board

The Centre Advisory Board contributes to the development of strategies and vision of the Centre and facilitates improved linkages between the Centre, industry, government and the wider community to facilitate uptake of research outcomes. The Board provides advice on research directions, centre structure, membership and commercialisation.

The Centre Advisory Board held its inaugural meeting in May 2006. Key on the list of its discussion points was its role and the recruitment of a Chair for the Board. Board members agreed that their focus would be strategic and long term, to develop end-user engagements, to assist in encouraging cross-nodal team research and in leveraging ARC funding to secure long term funding for the Centre. International research was identified as a strength of the Centre and pursuing end-user linkages and developments in this area was considered a priority. An eminent business leader has been recruited as the Chair from 2007. The composition of the Board in 2006 was:

Professor Norman Palmer

Pro-Vice-Chancellor (Research and Innovation)
James Cook University

Dr Ian Poiner

Chief Executive Officer
Australian Institute of Marine Science

Professor David Siddle

Deputy Vice Chancellor (Research)
University of Queensland

Honorable Virginia Chadwick

Chair
Great Barrier Reef Marine Park Authority

Professor Lawrence Cram

Deputy Vice-Chancellor (Research)
Australian National University

Professor Terry Hughes

Centre Director

Scientific Management Committee

The Scientific Management Committee is responsible for the high-level operational management of the Centre and for its scientific research program objectives. During 2006 the Committee met formally four times in February, May, August and October. Priorities for 2006 included establishing the objectives and operations for the Centre's research programs, recruiting high-quality postdoctoral fellows, developing an effective communications strategy and implementing new processes for engaging effectively with the Centre's graduate students. Committee Members are:

Professor Yossi Loya (Chair)

Professor of Marine Biology
The Raynor Chair for Environmental Conservation
Research
Department of Zoology
Tel Aviv University
Israel

Professor Garry Russ

School of Marine Biology and Aquaculture
James Cook University

Professor David Bellwood

School of Marine Biology and Aquaculture
James Cook University

Dr. David Wachenfeld

Director, Science Technology and Information Group
Great Barrier Reef Marine Park Authority

Professor Ove Hoegh-Guldberg

Centre for Marine Science
University of Queensland

Professor Malcolm McCulloch

Environmental Geochemistry and Geochronology
Research School of Earth Sciences
Australian National University

Professor Terry Hughes

Centre Director





Membership

Research staff

Chief Investigators

Professor Terry Hughes

James Cook University

Dr Kenneth Anthony

University of Queensland

Dr Andrew Baird

James Cook University

Professor David Bellwood

James Cook University

Dr Roger Bradbury

Australian National University

Dr Sean Connolly

James Cook University

Dr Sophie Dove

University of Queensland

Professor Ove Hoegh-Guldberg

University of Queensland

Professor Geoffrey Jones

James Cook University

Professor Michael Kingsford

James Cook University

Dr Mark McCormick

James Cook University

Professor Malcolm McCulloch

Australian National University

Professor David Miller

James Cook University

Dr Philip Munday

James Cook University

A/Professor John Pandolfi

University of Queensland

Dr Morgan Pratchett

James Cook University

Professor Garry Russ

James Cook University

Professor Bette Willis

James Cook University

Professor David Yellowlees

James Cook University

Partner Investigators

Professor Carl Folke

Stockholm University

Professor Ronald Karlson

University of Delaware

Dr Janice Lough

Australian Institute of Marine Science

Dr Laurence McCook

Great Barrier Reef Marine Park Authority

Dr Mark Meekan

Australian Institute of Marine Science

Dr Serge Planes

University of Perpignan

Professor Robert Steneck

University of Maine

Dr Madeleine Van Oppen

Australian Institute of Marine Science

Research Fellows

Dr Glenn Almany

James Cook University

Dr Andrew Baird

James Cook University

Dr Line Bay

James Cook University / AIMS

Dr Kathleen Broderick

James Cook University / CSIRO

Dr Joshua Cinner

James Cook University

Dr Kathryn Ferguson

James Cook University

Dr Simon Foale

James Cook University

Dr Terry Hughes

James Cook University

Dr Stacey Jupiter

Australian National University / AIMS

Dr Bill Leggatt

University of Queensland

Dr Susan McIntyre-Tamwoy

James Cook University

Dr Pippa Moore

University of Queensland

Dr Philip Munday

James Cook University

Dr Morgan Pratchett

James Cook University

Dr Mauricio Rodriguez-Lanetty

University of Queensland

Technical Staff

Lewis Anderson

James Cook University

Mary Boyle

James Cook University

Andrew Christian

Australian National University

Vivian Cumbo

James Cook University

Claire Farnsworth

James Cook University

Chris Fulton

James Cook University

Mizue Hisano

James Cook University

Andrew Hoey

James Cook University

Emily Howells

James Cook University

Les Kinsley

Australian National University

Selma Klanten

James Cook University

Jessica Maddams

James Cook University

Kat Markey

James Cook University

Graham Mortimer

Australian National University

Nela Rosic

University of Queensland

Maya Srinivasan

James Cook University

Lubna Ukani

James Cook University

Administrative Staff

Jennifer Lappin

Chief Operations Officer

Roslyn Burgess

Finance Manager and Graduate Coordinator

Lisa Pope

Australian National University

Louise Taylor

Office Manager and KPI Officer

Veronica Westacott

University of Queensland

Graduate Students

(see page p.25)



Research Program Leaders



Professor Malcolm McCulloch

Professor Malcolm McCulloch is one of the Centre's two Deputy Directors and Program Leader of Program 1: Evolutionary and Environmental Change. He is the Professor and head of Earth Environment, Research School of Earth Sciences, at The Australian National University, Canberra, and has held this position since 1996. His research interests focus on the modern part of the geologic record using isotopic and trace element geochemical methods to determine how climate and anthropogenic processes have influenced both past and present environments with particular emphasis on coral reefs. Malcolm has received a number of awards, including Fellowships of the Australian Academy of Science (2004) and the American Geophysical Union (2002) and in 2007 was awarded an Honorary Doctorate from Curtin University of Technology. His 208 scientific papers have been published in leading international journals including 22 in *Science* or *Nature*.



Professor David Bellwood

Professor David Bellwood is Program Leader of Program 2, *Understanding and Managing Coral Reef Biodiversity*. His research encompasses biogeography, paleoecology, biomechanics and behavioural ecology. His primary interests focus on the role of fishes on coral reefs and the relationship between species diversity and ecosystem function at global scales. He is particularly interested in the role of history in shaping the structure and functional characteristics of reef fish communities. After holding positions in the Ministry of Agriculture, Fisheries and Food (UK) and the Natural History Museum (London), he received his doctorate from James Cook University in 1985. Subsequently, he held postdoctoral positions at Silliman University, Philippines (1986) and at JCU (1987-1990). David joined the staff at JCU in 1991, where he now holds a Personal Chair in Marine Biology. He has published over 110 articles in leading international journals, including 10 in *Science* or *Nature*. He currently supervises an active research group of six graduate students and conducts collaborative projects with researchers in five countries.



Professor Garry Russ

Professor Garry Russ is Program Leader of Program 3: *Marine Reserves and Reef Connectivity*. Garry studies the biology of reef fish of commercial and recreational fishing significance (mostly serranids, lutjanids and lethrinids). A major area of research involves population and community dynamics of reef fish of commercial/recreational significance on coral reefs opened and closed to fishing. In Southeast Asia and Australia, he is undertaking long-term (23 year) monitoring of reef fish populations inside and outside marine reserves. Russ received his PhD from the University of Melbourne in 1981. He was a Queens Fellow at the Australian Institute of Marine Science from 1982-1986. He subsequently held a lectureship at the University of Sydney (1986-87). Garry moved to JCU 1988 where he is currently a Professor in Marine Biology. Garry has published over 55 papers international journals. In 1999, he received a prestigious PEW Fellowship in Marine Conservation jointly with his long-time colleague Dr. Angel Alcalá.



Professor Ove Hoegh-Guldberg

Professor Ove Hoegh-Guldberg is the other Deputy Director and Program Leader of Program 4: *Genetic, molecular and physiological processes*. He is the Director of the Centre for Marine Studies at University of Queensland, and Director of the Stanford-Australia Program at UQ. His research interests span a broad range of topics including marine biology, evolution, physiology, biochemistry and molecular biology of plant-animal symbioses, co-evolution, coral bleaching and climate change. Ove is Chair of the GEF/World Bank Working Group on Coral Bleaching and Related Ecological disturbances, one of six expert groups within the IOC and World Bank Coastal Program's Global Coral Reef Targeted Research and Capacity Building Project. In the area of marine symbioses, he leads a large research group including 9 post doctoral fellows, 13 postgraduate and 3 Honours students as Senior Investigator with the Marine Animal and Plant Symbioses Laboratory at UQ. Ove has published over 90 papers, including 6 in *Science* or *Nature*.



Professor Terry Hughes

Professor Terry Hughes is the Director of the ARC Centre of Excellence, the Centre's Federation Fellow (2002-2007) and Program Leader of Program 5: Resilience of linked social-ecological systems. Terry has broad research interests in ecology, marine biology and the dynamics of coral reefs. He received his doctorate in 1984 from Johns Hopkins University in Baltimore, Maryland, USA. From 1984-1990, he was a Postdoctoral and Research Fellow at the University of California, Santa Barbara. In 1990, Terry was recruited by JCU to develop and lead a program in coral reef ecology. He was awarded a Personal Chair in 2000, and was elected a Fellow of the Australian Academy of Sciences in 2001 in recognition of "a career which has significantly advanced the world's store of scientific knowledge". He has been awarded two Federation Fellowships by the Australian Research Council, from 2002-2012. As Centre Director, Terry provides academic leadership and oversees the strategic development of the Centre. He currently supervises 6 graduate students and directs a very active field program of biogeographic-scale research in eight countries. He has published over 80 influential scientific papers on the biology and management of coral reefs, including 18 in *Science* or *Nature*.





Research



Program 1

Evolutionary and environmental change

Researchers

Malcolm McCulloch (Program Leader)

Roger Bradbury

Sean Connolly

Ove Hoegh-Guldberg

Terry Hughes (Research Fellow)

Stacey Jupiter (Research Fellow)

Michael Kingsford

Janice Lough

Pippa Moore (Research Fellow)

John Pandolfi

Robert Steneck

Knowledge of the past improves our ability to predict future influences of natural environmental variability, human impacts, and climate change on coral reefs. Centre researchers use fossil and historical records to develop novel methods to identify potential causes of global change in biodiversity and ecosystem function. Together with ecological studies, this broad array of work provides a unique perspective on community change that ranges from centuries to millennia. Two new Postdoctoral Fellows were recruited to Program 1 in 2006 - Stacy Jupiter from the USA, and Pippa Moore from the UK.

Program 1 is documenting the ecological effects of climate change during the Quaternary interval, in order to understand how regional diversity patterns respond to climate change. Researchers from the UQ and ANU nodes, led by John Pandolfi and Malcolm McCulloch have focussed on the uplifted Holocene reefs of the Huon Peninsula, Papua New Guinea. Similar studies are also underway along a latitudinal gradient on Western Australian coral reefs. In WA, Malcolm McCulloch is utilizing the 5-6m higher sea-levels

associated with warmer conditions of the Last Interglacial period to provide a benchmark for understanding future rises in sea level. In another project, Pandolfi and colleagues have found persistence in coral community structure from raised reef terraces of Barbados through a 115 ka interval. These studies show how analysis of ecological patterns in fossil coral reefs can provide estimates of the natural variability of coral reef communities in the absence of human interactions.

In February, the ARC Centre held a workshop in Townsville to plan a research strand on the issue of shifting baselines, focusing in particular on the social, economic and environmental history of the Great Barrier Reef and its catchment. This is a joint Program 1 and 5 set of projects, involving all nodes of the ARC Centre.

This year, Program 1 and 2 launched a new multi-disciplinary, multi-national collaboration to study the origins and evolutionary development of the shallow marine biota of the Indo-Pacific region over the last fifty million years. Led by John Pandolfi and David Bellwood, the project currently comprises top researchers from Australia, Europe and Southeast Asia, involving universities, museums, oil companies and private consultants. These specialists are tackling a range of geological and ecological issues around a central theme of the plate tectonic development of S.E Asia, the stratigraphic response, and the affect this has on coral reef, sea-grass, and mangrove biota. The initial focus of the group is to compile and interpret faunal turnover data to investigate the Indo-Pacific longitudinal diversity gradient. The Centre sponsored an initial

meeting of the group in Leiden, the Netherlands, in December.

Research on water quality commenced in 2006 in Princess Charlotte Bay, in the northern GBR, a new collaboration between the ARC Centre and the Australian Institute of Marine Science. The principal researchers involved are Malcolm McCulloch, Stacy Jupiter, Janice Lough and Katarina Fabricius. A series of coral cores have been collected from reefs offshore from the mouths of the Normanby and Kennedy Rivers which drain into the bay. These cores will provide a continuous 100-200 year geochemical record of changes in water quality along an inshore to outer reef gradient. Preliminary observations already suggest that previous perceptions regarding the relatively pristine nature of the region may have been ill-founded.

Community participation in Program 1 and 4 in 2006 is exemplified by ongoing research addressing long-term changes in water quality in the Mackay-Whitsunday region of the central Great Barrier Reef. This project, involving Professors Hoegh-Guldberg (UQ) and McCulloch (ANU), PhD student Guy Marion, and research fellow Stacy Jupiter, has demonstrated the strong connectivity between coral reefs and the adjacent Pioneer River catchment and estuaries bordering the reef. The project is receiving considerable support by the Mackay Council, the Mackay-Whitsunday Natural Resource Management Group and GBRMPA, but also notably the wider Mackay community. The ARC Centre continues to provide advice to the Mackay City Council, which has a very active program in improving water quality via improvements in storm-water outlets and flood mitigation.

Ocean breakthrough on global warming

A major discovery in Program 1 has opened the way for researchers to measure the ability of the world's oceans to absorb man-made CO₂ - a key factor in global warming. The discovery by Professor Malcolm McCulloch, deputy director of the Australian Research Council Centre of Excellence for Coral Reef Studies (CoECRS) and colleagues from Italian research institutions led by Dr Paolo Montagna, will allow researchers to see far into the past to understand the biological and chemical makeup of the oceans. This may solve one of the biggest questions facing global warming: whether or not the oceans can keep pace with human CO₂ output.

Professor McCulloch's findings are published in 2006 in the international journal *Science*. They reveal a way to calculate the amount of phosphorus, a nutrient of vital importance to all life.

"Now that we have this tool we can look more closely at the role of nutrients in the ocean and try and understand, in a lot more detail, how they operated in the past," says Prof. McCulloch. "We can now find out how the oceans responded to previous increases in carbon dioxide (CO₂) and how quickly they can absorb it," he says.

The tool could help answer one of the biggest questions in the global warming debate: whether the 'biologic pump', through which the oceans naturally absorb CO₂ from the atmosphere, can keep pace with the vast amounts now being produced by humans.

Plants and animals in the oceans' surface waters drive the 'biologic pump' by taking up much of the CO₂ from the air and storing it inside their bodies. Eventually the CO₂ stored in their bodies descends to the deep ocean and becomes part of the sea floor. The turbulent mixing of the oceans also helps to absorb CO₂. Scientists fear that if the 'biologic pump' cannot keep up with human CO₂ emissions, the waters of the oceans will become more acid. This could hinder the growth of coral reefs, and may also be detrimental to other plants and animals that are critical to the operation of biological pump, which could ultimately lead to the collapse of one of the main systems that helps to remove greenhouse gases from the atmosphere.

The more plants and animals in the ocean the more productive it becomes and the more the 'biologic pump' can absorb greenhouse gases. The productivity of an area of ocean is indicated by the amount of phosphorus in it. "Phosphorus is a key nutrient in the ocean that limits or controls biological productivity. Organisms use it up and because there is only so much available, there is a limit to how many organisms there can be," explains Prof. McCulloch.

"We can go back in time and look at the past history of the earth and look at how it reacted," says McCulloch, "This complements ongoing studies of our oceans, because the dilemma is that you often don't know whether we are in an irreversible situation till after it has happened, so we try to better understand these processes by looking at how the planet has responded in the past."

This view into the past is made possible because of Prof. McCulloch's discovery that the preserved skeletons of ancient deep sea corals store phosphorous in exactly the same amounts as the surrounding oceans. By using sophisticated and accurate dating methods on the corals he can piece together information on the oceans as far back as the last glacial period, nearly 20 000 years ago.

Prof. McCulloch plans to use the newly discovered tool in future studies to provide a 'health check-up' of the biologic pump in order to see whether it will be able to keep up with the rate of greenhouse gas emissions from humans.

5 July 2006



Program 2:

Understanding and Managing Coral Reef Biodiversity

Researchers

David Bellwood (Program Leader)

Andrew Baird (Research Fellow)

Sean Connolly

Terry Hughes (Research Fellow)

Geoffrey Jones

Ronald Karlson

Pippa Moore (Research Fellow)

Philip Munday (Research Fellow)

John Pandolfi

Morgan Pratchett (Research Fellow)

Robert Steneck

Though widely recognized as a critical factor for the maintenance of robust ecosystems, biodiversity at local and global scales is poorly understood. Program 2 aims to understand the mechanisms and processes that maintain coral reef biodiversity, using a combination of mathematical modeling and field studies. This multi-disciplinary approach informs knowledge-based management of biodiversity resulting in environmental, social and economic benefit to tropical maritime nations.

Australian Research Fellow, Philip Munday, in collaboration with colleagues at the University of California Santa Barbara, has identified the mechanisms underlying the diverse sexual strategies in sex-changing fishes. Munday's 2006 research, published in *Proceedings of the Royal Society*, showed that the interplay between genes and the environment early in life plays a key role in which individuals become primary males or females. This research contributes to the increasing appreciation of the diversity and flexibility of sexual strategies in fishes.

In a related study, Mark McCormick found that stressed fish have smaller offspring, with lower chances of survival. The

ability to cope with stress – and produce large, healthy fry – determines which females contribute to future generations and influences the resilience of fish populations. Mark and Geoff Jones have secured a 3-year contract with the Nature Conservancy to monitor coral reef health, biodiversity and fisheries resources in 4 local marine reserves in Kimbe Bay, Papua New Guinea. The project will analyze the efficiency of current marine conservation efforts and use this data to implement future marine conservation strategies in the Bay.

The increasing violence of storms under global climate change will have major effects on coral reefs – and has important implications for their future management. In a paper in *Nature*, JCU graduate Joshua Madin and Sean Connolly use mathematical models to calculate the forces that coral is subjected to by wave, storm surge or tsunami, and the probability of the colonies being dislodged from the sea-bed. These new models provide an essential tool to predict how coral reefs will look under different future scenarios, and to plan accordingly.

Understanding, predicting and managing the potential impacts of climate change on coral reef ecosystems is a major focus of many of the Centre's projects. In 2006, Program 2 researchers examined the effects of climate-induced coral depletion on coral reef fishes, in collaboration with colleagues from the University of Newcastle-upon-Tyne and UC Santa Barbara. Work was conducted in Australia, Fiji, French Polynesia, PNG, and at several locations in the Indian Ocean, highlighting a new area of expertise within the ARC Centre. For example, a team led by Australian Research Fellow Morgan Pratchett documented significant population declines and localized

extinctions of coral-feeding butterflyfishes on the Great Barrier Reef, following coral bleaching. Morgan and Andrew Baird also gave a series of briefings in 2006 to the Western Australia oil and gas industry, on a range of issues, including the use of coral spawning predictions for management, the scale of spatial stock-recruitment relationships, and the consequences of recruitment failure of coral reef organisms.

A series of high-profile publications in 2006 and 2007 demonstrate that fish will play a vital role in the response of Australia's Great Barrier Reef to climate change. A team of 8 researchers from Program 2 and 5, led by Centre Director Terry Hughes, undertook a large-scale fish-exclusion experiment to explore the role of herbivorous fishes in bolstering the resilience of corals to global warming. The experiment tracked the recovery of corals following severe bleaching, in areas of reef where fish were experimentally excluded, and on adjacent areas within a no-fishing zone. In the absence of fish, the corals failed to recover, and instead a phase-shift occurred from dominance by corals to a reef covered by dense stands of seaweed. Where fish were abundant, coral cover more than doubled, and no algal bloom occurred. The team concluded that maintaining intact fish populations will be vital to successfully managing the resilience of tropical coral reefs from the impacts of climate change and human activity. These results strongly support management strategies of the Great Barrier Reef Marine Park Authority and other coral reef agencies worldwide. The importance of this project is accentuated by the findings of the April 6th 2007 report of the IPCC, which the ARC Centre of Excellence contributed to.

Scientists torpedo reef theory

Three James Cook University researchers at the new ARC Centre of Excellence for Coral Reef Studies (CoECRS) have called for the worldwide networking of tropical marine parks and protected areas to limit the risk of large-scale extinctions under global change, in the light of new scientific findings. Their research, published in March 2006 in the international science journal *Nature*, finds evidence from sites across the Pacific Ocean to refute the "neutral theory of biodiversity", which had been proposed as a framework for conservation.

"Worldwide, coral reefs are in decline – and it's clear that current management approaches are not working," says the study's lead author, Dr Maria Dornelas. "We wanted to find out whether this new theory provided a way forward. So we decided to ask the corals."

Dr Dornelas and Centre researcher Dr Sean Connolly, both of James Cook University, tested the theory's predictions by teaming up with Centre Director Professor Terry Hughes, who had recently completed a huge survey of coral diversity at 180 sites spread over 10,000 kms from Sulawesi to French Polynesia.

"Not only did we find that the theory didn't work," says Dr Connolly, "it failed in a completely unexpected way, totally different from what critics of the neutral theory had been expecting. By looking closely at how and why the theory failed, we gained some new insights into how coral reefs sustain so many species."

Their research has been hailed by *Nature* as "a paper that will turn our attention in a completely new direction", in a commentary by Dr John Pandolfi of the University of Queensland. It "has clearly invigorated the debate over the importance of biological details in determining the co-existence of species within communities," he says

Neutral theory argues that coral species colonise reefs in a random way, much like a lottery. However the team's studies of living reefs revealed that location and environmental change play a critical role in determining what sorts of corals settle and flourish – and which ones fail to establish.

This has major implications for the long-term survival of corals – and for how marine conservation areas are managed, Dr Connolly says. "Just because a particular location's environment suits some corals' specific strengths now, doesn't mean that it will always be so. Corals need to disperse their offspring widely, so that when conditions change, some of their offspring are in places where the environment has become more suitable for them."

The team likens this approach to biodiversity management to maintaining a balanced portfolio of investments on the stock market. Leaving all your money in one stock increases the risk of a mishap – a broad spread cushions the impact. "Most marine protected areas (MPAs) around the world are too small and too isolated to preserve the links between populations on different reefs. This increases the risk that a rare group of animals could go extinct unless they can colonise a more favourable reef," says Professor Hughes. "The recent re-zoning of the Great Barrier Reef is a step in the right direction, but we need to see MPAs networked worldwide across national borders to help reefs cope with the large-scale environmental changes expected with global warming."

2 March 2006



Program 3:

Marine Reserves and Reef Connectivity

Researchers

Garry Russ (Program Leader)

Glenn Almany (Research Fellow)

Andrew Baird (Research Fellow)

David Bellwood

Sean Connolly

Terry Hughes (Research Fellow)

Geoffrey Jones

Michael Kingsford

Laurence McCook

Mark McCormick

Mark Meekan

Philip Munday (Research Fellow)

Serge Planes

John Pandolfi

Morgan Pratchett (Research Fellow)

Garry Russ

Bette Willis

Networks of marine reserves (no-take zones) are used to manage biodiversity and fisheries. Consequently, zoning for multiple levels of usage and protection is fast becoming the principal mode of management of maritime resources.

An improved understanding of marine connectivity and barriers to dispersal is central to this endeavor.

Centre research fellow Glenn Almany and colleagues have continued to develop novel methods for direct marking of larval fishes, and have conducted a number of trials in Australia, Indonesia and PNG, using a range of reef fish, including several of major commercial and recreational importance (e.g. large groupers, including coral trout). These

experiments employ enriched isotope larval markers to quantify exchange among adjacent subpopulations and examine export of larvae from their natal reef. A key paper, based on these new technologies, is in press in *Science*.

In 2006, Program Leader Garry Russ and colleagues completed the first field assessments of the new re-zoning on nearshore reefs the Great Barrier Reef Marine Park. Initial data from the Whitsunday Islands indicated a relatively fast and positive response of targeted reef fish populations to the new zoning. Geoff Jones, Glen Almany and Garry also began pilot experiments to test if no-take zones in the Keppel Islands of Great Barrier Reef (GBR) export larvae of commercially and recreationally important reef fish to adjacent fished areas. Clearly, this work is highly relevant for numerous management agencies responsible for the sustainability of the GBR Marine Park.

Garry continues to work in the Philippines with colleague Angel Alcala, with the implementation of a major new research program in 2006. It will produce an oceanographic and larval dispersal model of the region (the Bohol Sea) and a rigorous biogeographic description of the coral reef fauna. This new information will be used as inputs into a major site-selection process to assist in designing and expanding the marine reserve network in the Philippines.

Geoff Jones and Partner Investigator Serge Planes from the University of Perpignan have been awarded additional funding from the Coral Reef Initiative of the South Pacific (CRISP) program. Their project will provide critical information on the size and spacing of marine protected areas, and develop an understanding of how reef fish populations are likely to respond to increasing scales of coral reef degradation. Geoff and Canadian colleague Peter Sale will lead a joint ARC Centre of Excellence-World Bank Global Environment Fund (GEF) workshop in Townsville next year on "New insights into connectivity and implications for coral reef management".

Program 3 has clearly defined and direct links to Program 1 (contemporary and historical fishing levels on the Great Barrier Reef), Program 2 (management of biodiversity within and outside marine reserves), Program 4 (prevalence of coral diseases inside and outside marine reserves) and Program 5 (community-based management of marine reserves and its relationship to social and governance systems).

Media Release

No-fish zones boost coastal communities

Evidence is emerging from around the world that 'no fishing' zones can lead to better catches and more income for coastal communities. A triumphant 30-year experiment in no-fishing zones in the Philippines has led to recovery in depleted fish stocks, improved fish catches outside the zone and higher tourist income for coastal communities. The findings of the research, published in a major review paper in *Ambio* during 2006, have major implications for Australia's coastal towns and cities, says Professor Garry Russ, Program 3 Leader at the Australian Research Council Centre of Excellence for Coral Reef Studies.

In the 1970s and 1980s Philippines coral reefs and fisheries were devastated by reef bombing and by 'muro ami' harvesters. "These are the marine equivalent of forestry clear-felling, in which industrial-scale vessels plunder all of the living resources off reefs using armies of fishers and gleaners," Prof. Russ explains.

The southern Philippines has now become the cradle of an international revolution in the way marine resources are managed. This began in the early to mid 1970's when areas were closed to fishing at two small islands in the southern Philippines, Sumilon and Apo.

"These were the sites of the first, and still the best known, no-take marine reserves in the country, established by my colleague Dr. Angel Alcala," Prof. Russ says. "These islands have produced some of the best evidence available that no-take marine reserves, protected and managed by local communities, can play a key role in biodiversity conservation and fisheries management.

"The success of these two small no-take reserves and their associated marine resource management has helped establish a network of no-take reserves across the entire Philippines. There are 64 no-take reserves in the southern Philippines, with 600 now established across the whole island chain, as communities fight to bring back their threatened way of life."

Prof. Russ says the expansion of no-take reserves has contributed substantially to a major shift in national policy of management of marine resources. Management responsibility has been partly devolved to local governments and communities which now co-manage, with the national government, marine resources out to 15 km from the coast.

"I think it is the thing I am most proud of in my scientific career," Prof. Russ reflects. "The no-take zones have returned power over their resources to local communities. These coastal communities have largely excluded the plunderers, and now have the legal right to do so."

Importantly too, the work of Prof. Russ and his colleagues has demonstrated that no-take zones can, in the long-term, improve the socio-economic conditions of coastal communities, especially in developing nations. Professor Russ says there are important take-home lessons for the management of Australia's coral reefs from this story. The recent rezoning of the Great Barrier Reef, which established a network of no-fishing zones covering 33 per cent of the Marine Park, had as its objective protection of biodiversity and bioregions.

"This will likely help sustain substantial national income from tourism. What is less appreciated is that the rezoning may also help to sustain coral reef fisheries in the long-term.

"The Philippine experience also suggests that when implementing major change in marine resource management, coastal communities should be involved in the decision-making process from the outset."

20 June 2006



Program 4:

Genetic, molecular and physiological processes

Researchers

Ove Hoegh-Guldberg (Program Leader)

Ken Anthony

Line Bay (Research Fellow)

Sophie Dove

Bill Leggatt (Research Fellow)

David Miller

Madeleine van Oppen

Mauricio Rodriguez-Lanetty (Research Fellow)

Bette Willis

David Yellowlees

This diverse program seeks to understand coral reef processes at a molecular and physiological level to examine potential mechanisms for adaptation and acclimatization to environmental change. Specific areas of study include biochemical analysis of coral-zooxanthellae interactions, coral bleaching, physiology, sub-lethal stress indicators, energetic modeling, coral diseases and genomics.

Centre fellow Bill Leggatt moved from the UQ node of the Centre to take up a permanent lectureship position at JCU, while Chief Investigator Ken Anthony moved from JCU to UQ. Two new fellows were also appointed, Line Bay in Townsville, and Mauricio Rodriguez-Lanetty in Brisbane. Program Leader, Ove Hoegh-Guldberg, chairs the World Bank Global Environmental Fund (GEF) Working Group on Coral Bleaching. In 2006, the ARC Centre initiated joint workshops, co-funded postdoctoral positions, and developed several new research projects involving GEF researchers.

Bette Willis led a major expansion in 2006 of the Centre's research focus on coral disease. Bette is Co-Chair (with her colleague, Drew Harvell from Cornell University) of the World Bank Global Environmental Fund (GEF) Working Group on Coral Disease. In January, she and Program 4 Leader Ove Hoegh-Guldberg organized a joint ARC Centre of Excellence-GEF international workshop on "Integrating the GBR into a Global Research Plan for the Study of Coral Disease". In April, Bette led a capacity-building workshop for East African coral reef managers sponsored by the World Bank GEF Program, the ARC Centre, and a consortium of government agencies and NGOs. In June, she presented an overview of coral disease on the GBR and Indo-Pacific to NOAA's (National Oceanic and Atmospheric Administration) Coral Disease and Health Consortium Workshop, in Honolulu. Willis is also coordinating an international committee to develop standard nomenclature and survey methods for Indo-Pacific corals diseases, for publication as a NOAA Technical Report. In July, she provided a background briefing paper on coral disease on the Great Barrier Reef at the request of the Environmental Protection Agency Brisbane for the Queensland State Minister for the Environment. Fieldwork this year focussed on identifying links between thermal anomalies and coral disease, to predict the impact of global warming on emergent disease dynamics.

Centre fellow Line Bay, Partner Investigator Madeleine Van Oppen

and Bette Willis launched a new set of collaborative projects that will investigate the potential for adaptation by corals and their symbionts. Initial work is focussing on estimating the level of genetic connectivity among GBR populations of corals and their algal endosymbionts, and on identifying mechanisms of adaptation by coral populations to climate change. This work includes a common-garden experiment, designed to determine whether gene expression differences are maintained between populations from different thermal environments.

A series of papers by Ken Anthony, Ove Hoegh-Guldberg and others, on physiological responses to environmental stressors were completed this year. They all address key environmental issues on coral reefs (thermal and light stress, water quality and sedimentation). Sophie Dove demonstrated the role of coral pigments in facilitating photosynthesis. A series of experiments were undertaken to successfully infect juvenile corals with specific strains of symbionts under a range of temperature and light regimes. A large team of researchers in Program 4, led by Bill Leggatt and Dave Miller, have also developed expanded microarrays for *Acropora* and *Symbiodinium* in 2006, setting the scene for activities next year that will contribute significantly to understand the molecular and genetic response of the coral-dinoflagellate holobiont to thermal stress.



Scientists check the health of the reef

In a major checkup of the health of the central Great Barrier Reef, scientists report that while corals on the outer reef are in excellent condition, coral health is in sharp decline close to the Queensland coast. Inshore corals have been seriously affected by losing the competition for space with seaweed. The increased competitiveness of seaweeds has been triggered by increased nutrients and sediment moving off the land (over many years) and now coral bleaching caused by the hot summer, reports Professor Ove Hoegh-Guldberg, Program 4 Leader of the ARC Centre of Excellence for Coral Reef Studies.

A 9-day underwater survey by 14 researchers covering a 150-kilometre transect of reef running due east from Mackay found that the effects of poor water quality and coral bleaching were plainly evident on inshore reefs.

"Our results indicate that stresses to reef health occur along a gradient," says Guy Marion, a PhD researcher working on the project. "[Inshore] we observed low coral and fish abundance, and consistent bleaching across all reefs, however further offshore we observed intact, healthy reef structure and virtually no bleaching from the stress we saw earlier this year," he says.

Guy Marion is also working on a novel method for assessing the condition of the reef over the past 200 years. His research involves drilling cores from long-lived corals using underwater air tools, which are then analysed for trace metal elements and nitrogen isotopic "signatures" within the skeleton. The cores, which can be up to 2.5m long, can take over an hour of patient drilling underwater to collect. They are then transported to the lab and sliced into thin sections where analysis of the organic matter – just 0.01% of the skeleton – begins.

Sections of the core showing an abnormal jump in the nitrogen "signature" can pinpoint past flood events and changes in nutrient sources in the water – a possible sign of man-made pollution. Each section of the core can be dated, giving a timeline of water quality for the region, in some cases extending back to the 1880s – prior to European settlement. These changes in the GBR lagoon health can then be matched to records on coastal development, temperature, rainfall and floods, in order to identify the sources of pollution.

"The project is trying to put numbers on the steady, long-term change in GBR water quality, in order to gauge current conditions relative to baseline, pre-European water quality. We want to know how inshore reef health has changed in response to coastal land clearing for city building and farming," says Marion.

Marion's work will be combined with the work of his supervisors and colleagues, Postdoctoral Fellow Stacy Jupiter and Professor Malcolm McCulloch, who are each using new techniques to provide fresh insights into the historical relationship between water quality and reef health in the GBR. "We hope that this approach of integrating multiple land, satellite, and coral based techniques can become a blueprint study for reef studies worldwide," says Marion.

The survey is part of a three year project which, on completion, will provide a detailed diagnosis of aspects of the health of the central Great Barrier Reef, both past and present, so that policies and practices can be further developed to ensure that coastal development and reef use is sustainable in the future.

The survey is part of a collaborative research project between leading members in Programs 1 and 4 of the ARC Centre of Excellence and Stanford University in California.

7 August 2006

Program 5:

Resilience of linked social-ecological systems

Researchers

Terry Hughes (Program Leader)

Andrew Baird (Research Fellow)

David Bellwood

Kathleen Broderick (Research Fellow)

Joshua Cinner (Research Fellow)

Kathryn Ferguson (Research Fellow)

Simon Foale (Research Fellow)

Carl Folke

Laurence McCook

Susan McIntyre-Tamwoy (Research Fellow)

John Pandolfi

Garry Russ

Robert Steneck

This new program seeks to provide new solutions to managing resilience and coping with change, uncertainty, risk and surprise in complex social-ecological systems. The objective is to improve the governance and management of natural systems and enhance their capacity to sustain human and natural capital. Innovative multi-disciplinary research combines expertise on coral reef biology, management, governance, economics and social sciences.

Program 5 was initiated in 2006, rapidly building up steam through the recruitment this year of five new postdoctoral fellows, and via a series of international working groups. In March, the Centre hosted a week-long meeting with the Resilience Alliance, which included the development of new tools for managing social-ecological resilience, in collaboration with Partner Investigator Laurence McCook and end-users from the Great Barrier Reef Marine Park Authority.

In August, the ARC Centre convened a second working group meeting on fisheries management at the University of Maine, in collaboration with Partner Investigator Bob Steneck. In September, Director Terry Hughes travelled to Stockholm to liaise with Partner Investigator Carl Folke on developing projects and further links with the Beijer Institute and the new Stockholm Resilience Centre. In October, he also met with the steering committee for the World Bank Coral Reef Targeted Research program in Mexico, to build on our existing research and training activities. The publication outputs from Program 5 in 2006 included two policy articles in *Science*, on the resilience of coastal communities to environmental disasters, and on the economics and governance of fisheries. Andrew Baird and colleagues also published a series of influential papers on the aftermath of the Asian tsunami and management of coastal resources in Indonesia. Other highlights include:

Research Fellow Susan McIntyre-Tamwoy was invited in 2006 by the Department of Environment and Heritage to take on the role of Secretariat to the National Culture Heritage Forum (NCHF). The NCHF is comprised of the heads of the peak cultural heritage NGOs in Australia. It meets with the Commonwealth Minister responsible for heritage twice a year and more frequently with senior officials of the Department to discuss matter relating to National heritage interests. Research Fellow Josh Cinner led a new team that conducted extensive field work in Tanzania this year on socioeconomic

aspects of coral reef management. Part of his field work involved training of four NGO and government employees in socioeconomic data collection and analysis (personnel from The Kenya Sea Turtle Conservation Committee (KESCOM), the Tanzanian Institute for Marine Science, and the Tanga Coastal Zone Conservation and Development Project). This project included a series of presentations of results to both communities and government agencies across Northern Tanzania and Zanzibar. Outcomes of these presentations include uptake of the results by government policy-makers in the Tanga area of Tanzania. In particular, the Tanzanian Fisheries Department has modified the use of beach seine nets and is amending legislation to regulate their use in open waters.

Senior Fellow Simon Foale and his colleagues Mouli MacKenzie and Martha Macintyre undertook research with the PNG Education Department, and teachers and students of New Ireland Province, PNG. The work is about designing and delivering scientific education materials on the environmental impacts of mining in PNG, funded by the mining industry. The outputs will be published in booklet and DVD formats for all schools in New Ireland Province. Simon also undertook consultancy work in 2006 for the Ausaid Community Sector Program (CSP), training Solomon Islanders in systems and approaches for minimizing environmental impacts associated with the delivery of infrastructure (hospitals, clinics, schools), water supplies, and with new sustainable fisheries and mariculture initiatives.



Of urchins and roving bandits

In an article in the leading journal *Science* an international team of researchers say that highly mobile fishing enterprises – which they describe as ‘roving bandits’ – are plundering marine resources at an unsustainable rate, threatening the collapse of ecosystems and eroding the ability to sea-life to withstand climate change. The raiders clean out entire fisheries and then move on to the next resource beyond the reach of local authorities, in a worldwide marine version of the “tragedy of the commons”, warn 15 leading ecologists, social scientists and resource economists.

“What makes roving banditry different from most commons dilemmas is that a new dynamic has arisen in the globalized world: new markets can develop so rapidly that the speed of resource exploitation often overwhelms the ability of local institutions to respond,” says Professor Fikret Berkes of the University of Manitoba, Canada.

“Today, the intense targeting of key species by these mobile roving bandits can seriously destabilize marine systems, causing unpredictable collapses,” warns Professor Terry Hughes, Director of the Australian Research Council’s Centre of Excellence for Coral Reef Studies

The study cites the case of a sea urchin fishery in Maine, USA. “The urchins underwent a boom following the collapse of the cod fishery, then were targeted for the *sushi* market and collapsed in turn within six years. The sea urchin fishery in Maine resulted in one of the largest ecosystem-scale changes in a coastal zone attributable to a single fishery. The ripple effects are seen throughout Maine’s 3000 mile coastline,” adds Prof. Bob Steneck of Maine University, who is also a Partner Investigator in the ARC Centre.

“Ecologically, the consequences of roving banditry are clear: the simplification of food webs and loss of biodiversity are eroding the resilience of marine ecosystems and increasing their vulnerability to environmental change,” says Professor David Bellwood, a senior researcher at the ARC Centre of Excellence for Coral Reef Studies.

“Depletion of herbivorous fishes has contributed to algal blooms on reefs because algae released from their consumers out-compete corals for space. Consequently, overfished reefs are less resilient to recurrent disturbances such as hurricanes, and more vulnerable to coral bleaching and mortality caused by global warming,” says Prof. Bellwood.

“Even the Great Barrier Reef Marine Park, the largest in the world, is too small to fully maintain all the turtles, fish and sharks that swim in and out of its boundaries,” adds Australia’s Prof. Hughes.

The 15 researchers are calling for urgent action at global, regional, national and local scales to bring overfishing under control and prevent fresh disasters. This includes enforcing local property rights and licensing, closing areas to fishing, reforming markets and using flexible management approaches that can adapt quickly to changing circumstances.

“It will also require extensive education and behavioural change in the consumers whose demands drive the industry economically”, Professor Bellwood adds.

17 March 2006



Students

The ARC Centre of Excellence is the world's largest provider of graduate training in coral reef science. The Centre's goal is to build human capacity and expertise in coral reef science, by supporting and training outstanding students. Approximately \$3.5 million of our ARC award for 2005-2010 is earmarked in support of the research costs of student projects. In addition, the Centre's Student Committee has been provided with \$40,000 for student mentoring activities each year.

In 2006, 22 Honours, 20 Masters and 90 PhD students were supported and supervised by Centre personnel. Graduate students are heavily involved in new multi-nodal (video-conferenced) research seminars and quarterly review/planning meetings for each of the Centre's Programs. In addition, 35 student members of the ARC Centre currently have multi-institutional supervisory

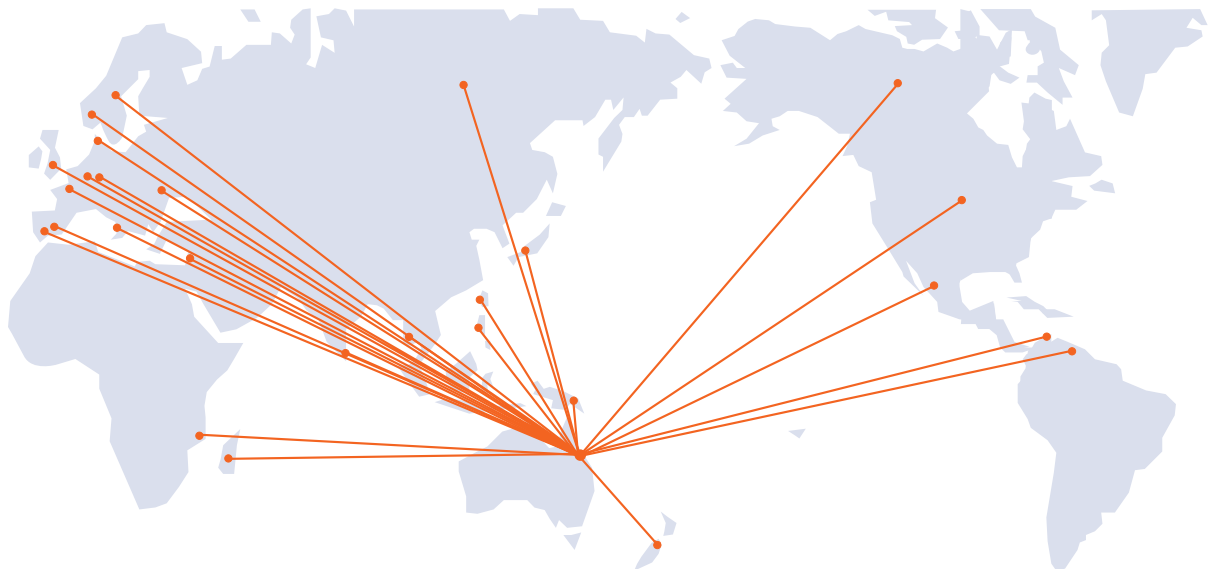
arrangements. At JCU, 8 of the Centre's students are also members of AIMS@JCU. Students and their projects are highlighted on the ARC Centre's website at www.coralcoe.org.au/people-students.html

The Centre convened a National Mentoring Day in August 2006 following the Australian Coral Reef Society symposium in Mission Beach, Queensland. The event was attended by 54 PhD and Masters students from seven universities, and focused on enhancing students' research and publication skills. Discussions were led by Terry Hughes (JCU), Ove Hoegh-Guldberg (UQ), Laurie McCook (GBRMPA) and Morgan Pratchett (JCU). The Centre also provided two workshops in 2006 to assist students at JCU, UQ and ANU in preparing postdoctoral fellowship applications. As a result, ten fellowship proposals were submitted in the current

ARC round. Five \$1000 prizes for the ARC Centre's Best Student Papers for 2006 were awarded to *Tracy Ainsworth* (UQ), *Bridget Ayling* (ANU), *Maria Dornelas* (JCU), *Mia Hoogenboom* (JCU), and *Ailsa Kerswell* (JCU). Maria also received a University Medal from JCU for an outstanding PhD thesis.

At the end of 2006, the Centre recruited a new student administrator, Olga Bazaka, who will liaise closely with the Centre's students and the Student Committee. In 2007, student mentoring workshops will be held in Fremantle, WA, in October. Student members will also be actively participating in the ARC Centre's *National Forum of Coral Reef Futures*, which will be held at the Australian Academy of Science, in Canberra on October 17-19th, 2007.

The ARC Centre's international network of students. In 2006, 64 of the ARC Centre's graduate students came to Australia from 29 countries.



2006 Student members of the ARC Centre of Excellence

STUDENT	COUNTRY OF ORIGIN	THESIS TITLE	CoE SUPERVISORS
David Abrego (JCU, AIMS)	Mexico	Flexibility in coral-dinoflagellate symbiosis: implications for adaptation to climate change. (PhD)	A.Prof B Willis, Dr M van Oppen
Tracy Ainsworth (UQ)	Australia	Microbial and histopathological changes associated with coral disease and stress on the Great Barrier Reef. (PhD)	Prof O Hoegh-Guldberg
Shelley Anthony (JCU)	USA	Tissue sloughing and coral disease in a large-scale reef mesocosm. (PhD)	A.Prof B Willis
Bridget Ayling (ANU)	New Zealand	Reconstruction of past interglacial climates using geochemical proxies in fossil Porites corals and giant Tridacna clams. (PhD)	Prof M McCulloch
Ray Bannister (JCU, UQ)	Australia	Sponge energetics: implications for aquaculture practices. (PhD)	Dr K Anthony
Brian Beck (UQ, JCU)	USA	Palaeoecological dynamics of coral communities along a disturbance gradient, Solomon Islands. (PhD)	A.Prof J Pandolfi, Dr S Connolly
Maria Beger (UQ, JCU)	Germany	Biodiversity, complementarity and rules for the selection of sites for marine reserves. (PhD)	Dr G Jones
Victor Beltran Ramirez (JCU, AIMS)	Mexico	Molecular aspects of the coral-algal symbiosis. (PhD)	Prof D Miller, Prof D Yellowlees, Dr M van Oppen
Rose Berdin (ANU)	Philippines	Holocene palaeoclimate history of the Northern Indo-Pacific warm pool from raised coral reefs in the Philippines. (PhD)	Prof M McCulloch
Michael Berumen (JCU)	USA	Influence of resource availability on life-history traits of coral feeding butterfly fishes. (Pisces: Chaetodontidae). (PhD)	Dr M Pratchett, Dr G Jones
Maria Berzunza-Sanchez (UQ)	Mexico	Historical ecology of Papua New Guinea. (Hons)	A.Prof J Pandolfi, Dr P Moore
Bernardo Blanco-Martin (JCU)	Spain	Dispersal of coral larvae: a modelling perspective on its determinants and implications. (PhD)	Prof T Hughes
Teresa Bobesko (UQ, JCU)	Australia	The effects of different Ci concentrations on the photosynthesis of endosymbionts in scleractinian corals. (Hons)	Dr S Dove, Dr W Leggat
Lynda Boldt (UQ)	Australia	Symbiodinium photosynthetic genes and the effect of varying environmental conditions on photosynthetic processes. (PhD)	Dr S Dove, Dr W Leggat
Roberta Bonaldo (JCU)	Brazil	The role of parrot fishes grazing in the benthic community structure of the Great Barrier Reef. (PhD)	Prof D Bellwood, Dr S Connolly
Mary Bonin (JCU)	USA	Investigating the mechanisms of predation: functional response, selectivity, and the effects of habitat complexity on a coral reef piscivore. (MSc)	Dr G Jones
Holly Boyett (JCU, AIMS)	USA	The ecology and microbiology of black band disease and brown band syndrome on the Great Barrier Reef. (MSc)	A.Prof B Willis
Dan Breen (JCU, UTAS)	Australia	Field and simulation studies in the design of programs monitoring tourist impacts on coral reefs. (PhD)	Dr G Jones
Kate Bromfield (UQ, CSIRO)	Australia	Adaptation and Evolution of Coral Species during the Miocene-Pliocene faunal turnover, across the Indo-Pacific region. (PhD)	A.Prof J Pandolfi
Samantha Burgess (ANU)	Australia	Geochemical Ecology of a Temperate Coral. (PhD)	Prof M McCulloch
Neal Cantin (JCU, AIMS)	Canada	Effects of the herbicide diuron on coral reproduction and larval competency. (PhD)	A.Prof B Willis



STUDENT	COUNTRY OF ORIGIN	THESIS TITLE	CoE SUPERVISORS
Mike Cappo (JCU)	Australia	Influences of habitat and ontogeny on composition and size structures of demersal fish communities on tropical shelves. (PhD)	Prof M Kingsford
Andrew Cole (JCU)	Australia	Prevalence and importance of corallivory in labrid fishes. (Hons)	Dr G Jones, Dr M Pratchett
Timothy Cooper (JCU, AIMS, UQ)	Australia	Physiological and ecological health/stress indicators of the effects of water quality on nearshore coral reefs of the Great Barrier Reef. (MSc)	Dr K Anthony, Prof M Kingsford
Melissa Cowlishaw (JCU)	Australia	Determinants of home range and territorial behaviour in coral reef fishes: roles of body size, habitat structure and population density. (PhD)	Dr G Jones, Dr M McCormick
Vivian Cumbo (JCU)	Australia	Thermal tolerance in corals: the role of the symbiont. (PhD)	Prof T Hughes, Dr A Baird
Kathy Danaher (JCU)	Australia	Natural diets and aquaculture of ornate rock lobster larvae, <i>Panulirus ornatus</i> . (PhD)	Prof M Kingsford
Joanne Davy (UQ)	NZ	Characterisation of white patch syndrome, a putative disease affecting corals in the Genus <i>Porites</i> at Heron Island, Australia. (PhD)	Prof O Hoegh-Guldberg, Dr W Leggat
Jeffry Deckenback (UQ, Monash)	USA	Maturation, turn-over, oligomerization, and transport of Pocilloporins. (PhD)	Dr S Dove, Dr W Leggat
Martial Depczynski (JCU)	Australia	Small cryptic fishes on coral reefs: a new perspective on reef fish ecology and life histories. (PhD)	Prof D Bellwood
Ayax Diaz-Ruiz (UQ)	Mexico	The use of coral associated fauna as indicators of coral health. (PhD)	Prof O Hoegh-Guldberg, A.Prof J Pandolfi
Jennifer Donelson (JCU)	Australia	Interactions between parental and environmental effects in a coral reef fish. (Hons)	Dr P Munday, Dr M McCormick
Maria Dornelas (JCU)	Portugal	Neutral coral community dynamics. (PhD)	Dr S Connolly, Prof T Hughes
Andrea Downing (JCU, UQ)	Switzerland	Factors that mediate mass bleaching and their relevance to coral bleaching. (MAppSc)	Dr K Anthony, Dr S Connolly
Janelle Eagle (JCU)	Australia	Local scale hydrodynamics influence spatial patterns of coral and fish recruitment and the diversity of coral reef assemblages. (PhD)	Prof M Kingsford, Dr G Jones
Maxi Jennifer Eckes (UQ)	Germany	Ultraviolet sunscreens in reef fish mucus. (PhD)	Dr S Dove
Udo Engelhardt (UQ)	Australia	Community-level ecological responses of coral reef biota to mass coral bleaching events. (PhD)	Prof O Hoegh-Guldberg
Richard Evans (UQ)	Australia	Effects of marine reserves on fisheries management. (PhD)	Prof G Russ, Dr G Jones
Michael Fabinyi (ANU, JCU)	Australia	Complexities of illegal fishing in the Calamianes (Philippines). (PhD)	Dr S Foale
David Feary (JCU)	New Zealand	The influence of coral degradation on tropical fish community structure. (PhD)	Dr G Jones, Dr M McCormick, Dr G Almany
Ida Fellegara (UQ)	Italy	Ecology and physiology of corals living in an extreme environment. (PhD)	Prof O Hoegh-Guldberg
Paul Fisher (UQ)	UK	Investigating the photophysiology of Symbiodinium and its relationship to coral bleaching. (PhD)	Dr S Dove, Prof O Hoegh-Guldberg

STUDENT	COUNTRY OF ORIGIN	THESIS TITLE	CoE SUPERVISORS
Rebecca Fox (JCU)	UK	Quantifying the impact of roving herbivorous fishes across a reef gradient. (Hons)	Prof D Bellwood
Matthew Fraser (JCU)	Australia	Egg predation at reef fish spawning aggregations: consequences for fitness. (PhD)	Dr M McCormick, Dr G Jones
Ashley Frisch (JCU, Griffith)	Australia	An investigation of the relationship between social interaction, reproductive conditions and sex hormones in coral trout (<i>Plectropomus leopardus</i>) with an emphasis on the dynamics of sex change. (PhD)	Dr M McCormick
Chris Fulton (JCU)	Australia	Wave energy and the role of swimming in reef fish ecology. (PhD)	Prof D Bellwood
Monica Gagliano (JCU)	Italy	The role of selective mortality in the early life history of coral reef fishes. (PhD)	Prof M Kingsford
Naomi Gardiner (JCU)	Australia	Habitat specialisation, co-occurrence and resting site fidelity in cardinalfish on coral reefs. (PhD)	Dr G Jones
Alonso Gonzalez-Cabello (JCU)	Mexico	Aspects of cryptobenthic reef fish ecology in the Great Barrier Reef. (PhD)	Prof D Bellwood, Prof G Russ
Luis Gonzalez-Reynoso (JCU, Griffith)	Mexico	Mechanisms of stress inhibition of reproduction in <i>Acanthochromis</i> . (PhD)	Dr M McCormick
Erin Graham (JCU)	USA	The development and calibration of a general model of coral dispersal. (Hons)	Dr S Connolly, Dr A Baird
Marcus Gregson (UTS, JCU)	Australia	Latitudinal variation in diets of butterfly fishes. (PhD)	Dr M Pratchett
Andrew Halford (JCU, AIMS)	Australia	The roles of recruitment and disturbance in assemblages of reef fishes in NW Australia. (PhD)	Dr G Jones
David Harris (UQ)	Australia	Ecology of high latitude populations of <i>Pomacentrus coelestis</i> . (PhD)	Prof O Hoegh-Guldberg
Meegan Henderson (UQ)	Australia	Microbial ecology of coral disease: The use of molecular techniques in understanding bacterial community shifts. (PhD)	Prof O Hoegh-Guldberg
Gretta Hillersoy (JCU)	Norway	Gene under selection in coral trout. (Hons)	Prof G Russ
Jean-Paul Hobbs (JCU)	Australia	Geographic clines in species abundances. (PhD)	Dr P Munday, Dr G Jones
Andrew Hoey (JCU)	Australia	Algal-herbivore interactions: the role of herbivory in structuring benthic algal communities across an exposure gradient. (PhD)	Prof D Bellwood, Prof G Russ
Tom Holmes (JCU)	Australia	Selectivity of predation at settlement. (PhD)	Dr M McCormick
Mia Hoogenboom (JCU, UQ)	Australia	Demographic and energetic correlates of coral life history strategies. (PhD)	Dr S Connolly, Dr K Anthony
Emily Howells (JCU, AIMS)	Australia	Fine-scale genetic diversity of zooxanthella populations in soft corals through space, time and early host development. (Hons)	A.Prof B Willis, Dr M van Oppen
Akira Iguchi (JCU)	Japan	Molecular genetics of gamete interactions in corals. (PhD)	Prof D Miller
Jessica Jarret (UQ)	USA	Distribution, function and regulation of pocilloporins (GFP-like proteins) in <i>Montipora digitata</i> on Heron Island reef flat, on the southern GBR. (Hons)	Prof O Hoegh-Guldberg, Dr S Dove
Jacob Johansen (JCU)	Denmark	Swimming ability, refuging behaviour and habitat use of labriform fishes on the Great Barrier Reef. (MSc)	Prof D Bellwood, Dr S Connolly



STUDENT	COUNTRY OF ORIGIN	THESIS TITLE	CoE SUPERVISORS
Kerryn Johns (JCU)	Australia	Causes and correlates of female reproductive success in a coral reef fish. (Hons)	Dr G Jones
Paulina Kaniewska (UQ)	Sweden	The effect of bleaching on coral community structure and composition. (PhD)	Prof O Hoegh-Guldberg, Dr K Anthony
Ailsa Kerswell (JCU)	Australia	Biogeography of seaweeds. (PhD)	Prof T Hughes, Dr A Baird
Brent Knack (JCU)	Australia	Intregins in the coral Acropora. (Hons)	Prof D Miller
Valeriya Komyakova (JCU)	Russia	Habitat specialization in coral reef fishes and its influence on patch composition and local species diversity. (MSc)	Dr G Jones, Dr P Munday
Narinatana Kongjandtre (UQ)	Thailand	Taxonomy of favid corals in Thailand. (PhD)	Prof O Hoegh-Guldberg
Charlotte Kvennefors (UQ)	Sweden	Immune molecules in corals. (PhD)	Dr W Leggat, Prof O Hoegh-Guldberg
Rachael Lahari (UPNG/WCS)	PNG	Coral harvesting for lime production at Andra Island, Manus Province, Papua New Guinea: Strategies to sustain future harvesting. (Hons)	Dr M Pratchett
Nicholas Larsen (JCU/AIMS)	USA	Comparative growth and survival for corals infected with clade C1, C2 and D Symbiodinium. (MAppSc)	A.Prof B Willis, Dr M van Oppen
Angela Lawton (UQ)	USA	The effects of micro-scale variation on the photosynthetic productivity of the symbiotic algae of reef building corals. (PhD)	Prof O Hoegh-Guldberg
Anne Leitch (JCU/CSIRO)	Australia	Community perceptions and environmental management of the GBR catchment. (PhD)	Prof T Hughes
Tove Lemberget (JCU)	Australia	Growth and body condition in a tropical larval fish and its importance to replenishment. (PhD)	Dr M McCormick
Raechel Littman (JCU/AIMS)	USA	Investigation of wild sources of zooxanthellae for infection of corals. (MAppSc)	A.Prof B Willis, Dr M van Oppen
Carole Lonergan, (JCU)	Australia	The effect of temperature on Vibrio coralliilyticus disease in Montipora corals at Magnetic Island. (Hons)	A.Prof Willis
Jessica Maddams (JCU)	Australia	Factors influencing female reproductive output and larval quality of a protogynous reef fish. (Hons)	Dr M McCormick
Rachel Manassa (JCU)	Australia	The use of chemical alarm cues for predation risk assessment in coral reef fishes. (Hons)	Dr M McCormick
Thomas Mannering (JCU)	USA	Does recruitment differ between marine reserves and fished areas? (MSc)	Dr G Jones
Chrystal Mantyka (JCU)	Canada	A direct evaluation of macroalgal removal and selectivity by herbivorous reef fishes. (Hons)	Prof D Bellwood
Guy Marion (UQ/ANU)	USA	Nitrogen isotopic composition of coral skeletal organic matter: a tool for provenance analysis. (PhD)	Prof O Hoegh-Guldberg, Prof M McCulloch, A.Prof J Pandolfi
Abbi McDonald (JCU)	Australia	The recovery fast or slow lane: reliance on sexual reproduction, asexual reproduction, and growth on the Great Barrier Reef. (PhD)	Prof T Hughes, Dr A Baird, Dr M Pratchett
Luiz Mendes-de Gusmao (JCU)	Brazil	The use of biochemical methods for the evaluation of zooplankton secondary production. (PhD)	Prof M Kingsford
Vanessa Messmer (JCU)	France	Ecological and evolutionary factors influencing the genetic structure of coral reef fishes. (PhD)	Dr G Jones, Dr P Munday

STUDENT	COUNTRY OF ORIGIN	THESIS TITLE	CoE SUPERVISORS
Rachel Middlebrook (UQ)	Australia	Acclimation of <i>Acropora aspera</i> to thermal stress and the role of <i>Symbiodinium</i> sp. in thermal tolerance. (Hons)	Prof O Hoegh-Guldberg, Dr W Leggat
Anne Mooney (UQ)	USA	Historical ecology of Indo-Pacific dugongs. (MSc)	A.Prof J Pandolfi
James Moore (JCU)	Australia	The impacts of coral bleaching on the early life-history of coral reef damselfish (Pisces: Pomacentridae). (Hons)	Dr M McCormick, Dr P Munday
Bryan Murphy (JCU)	USA	Conditionality of mutualistic coral reef symbioses. (MSc)	Dr G Jones
Nong Narinrantana (UQ)	Australia	Systematic and phylogeography of <i>Favia</i> corals in the Western Pacific. (PhD)	Prof O Hoegh-Guldberg, Dr M Rodriguez-Lanetty
Juan Carlos Ortiz (UQ)	Venezuela	Eco-physical dynamics of the Heron Island Coral Reef. (PhD)	Prof O Hoegh-Guldberg
Cathie Page (JCU)	Australia	Prevalence and impact of coral disease on the Great Barrier Reef. (PhD)	A.Prof B Willis
Allison Paley (UQ/JCU)	USA	The relationship between bleaching tolerance and genotype in <i>Acropora millepora</i> . (MSc)	A.Prof B Willis, Dr K Anthony
Pepito (Sonny) Fernandez (ANU/JCU)	Australia	Inter-Municipal Alliance for Livelihood and Resource Conservation in Marine Protected Areas in Northeastern Panay, Philippines. (PhD)	Dr S Foale
Srisakul Pimvaragorn (JCU)	Thailand	Spatial patterns in coral communities and recruitment in the Gulf of Thailand. (PhD)	Prof T Hughes, Dr A Baird
Eneour Puill-Stephan (JCU/AIMS)	France	Self-nonsel self recognition and chimerism in <i>Acropora millepora</i> and the acquisition of immunity. (PhD)	A.Prof B Willis, Dr M van Oppen
Dingchuang Qu (ANU)	China	Late Quaternary climate in the Indo-Pacific Warm Pool reconstructed from the raised coral reefs of Sumba, Indonesia. (PhD)	Prof M McCulloch
Jill Quaintance (UQ)	USA	Changes in coral diversity, growth form and bleaching frequency in Great Barrier Reef corals: evidence from death assemblages. (Hons)	A.Prof J Pandolfi
Kamal Ranatunga (JCU)	Sri Lanka	Demographic plasticity of the exploited reef fishes: a multi-scale perspective. (MSc)	Prof G Russ
Charmaine Read (JCU)	Australia	Molecular phylogeny of fishes. (PhD)	Prof D Bellwood
Ruth Reef (UQ)	Israel	The effect of temperature on the accumulation and repair of UV damage in zooxanthellae and corals. (PhD)	Prof O Hoegh-Guldberg, Dr S Dove, Dr W Leggat.
Alejandro Reyes (JCU)	Columbia	Cellular mechanisms of coral calcification. (PhD)	Prof D Miller, Prof D Yellowlees
Claire Reymond (UQ)	Australia	Community variation through the early to mid Holocene period: temporal and ecological dynamics of Foraminifera from a fossilised reef system - Huon Peninsula, PNG. (Hons)	A.Prof J Pandolfi
Zoe Richards (JCU/MTQ/AIMS)	Australia	Rarity in the genus <i>Acropora</i> : genetic consequences and conservation. (PhD)	Prof D Miller, Dr M van Oppen, A.Prof B Willis
Maria Rodrigues (JCU)		Effects of herbivory on coexistence of coral and algae. (PhD)	Prof T Hughes, Dr A Baird
George Roff (UQ)	UK	Coral disease on the Great Barrier Reef. (PhD)	A.Prof J Pandolfi, Prof O Hoegh-Guldberg
Alexandra-Sophie Roy (JCU)	Canada	Trans-generational marking of fish larvae via maternal transmission of stable isotopes in clown fishes. (MSc)	Dr G Jones
Christopher Ryen (JCU)	USA	Growth related sex change in coral reef fishes. (MSc)	Dr M McCormick, Dr P Munday



STUDENT	COUNTRY OF ORIGIN	THESIS TITLE	CoE SUPERVISORS
Armagan Sabetian (JCU)	NZ	Parrotfish fisheries in tropical oceans; an ethnographic and demographic approach. (PhD)	Prof G Jones
Yacov Salomon (JCU)	Australia	Competition, connectivity, and coexistence in lottery competition systems. (Hons)	Dr S Connolly
Eugenia Nijgh de Sampayo (UQ)	Netherlands	Symbiodinium diversity and the ecology of Pocilloporid corals. (PhD)	Dr S Dove, Prof O Hoegh-Guldberg
Alison Sampey (JCU/ AIMS)	Australia	Influence of environmental conditions on the growth and survival of tropical fish larvae from the North West Shelf of Australia. (MSc)	Dr M McCormick, Dr M Meekan
You Sato (JCU/AIMS)	Japan	Dynamics of a black band disease outbreak. (MAppSc)	A.Prof B Willis
Francois Seneca (JCU/ AIMS)	Monaco	Molecular genetics of stress in corals. (PhD)	Prof D Miller, Dr M van Oppen
Chuya Shinzato (JCU)	Japan	Evolution of sex determination mechanisms. (PhD)	Prof D Miller, Dr D Yellowlees
Segu Shio (ANU/JCU)	Australia	Choice of fishing strategies in southeast Cebu, the Philippines. (PhD)	Dr S Foale
Michael Short (JCU)	Australia	The recovery of coral reefs following ship grounding disturbances. (MSc)	A.Prof B Willis
Luke Smith (JCU/AIMS)	Australia	Coral bleaching in Western Australia. (PhD)	Prof T Hughes
Jeremy Sofonia (JCU/ UQ)	USA	Sediment responses of corals on inshore reefs, Great Barrier Reef. (MSc)	Dr K Anthony, A.Prof B Willis
Maya Srinivasan (JCU/ AIMS)	Australia	Recruitment in time and space: the dynamics and distribution of reef fish populations on a low latitude coral reef. (PhD)	Dr M McCormick
Meir Sussman (JCU)	Israel	Pathogens, reservoirs and vectors for coral disease on the GBR and in the Indo-Pacific. (PhD)	A.Prof B Willis
Grant Taylor (JCU)	Australia	Influence of sedimentation on coral reef fish communities. (MSc)	Dr G Jones, Dr P Munday
Loc Thibaut (JCU/ University Pierre et Marie Curie)	France	Modelling approaches to reef ecosystem resilience. (PhD)	Prof T Hughes, Dr S Connolly
Lucia Tomljenovic (JCU)	Croatia	Examination of the cellular role of mouse MYO44 fly DPIT47 and coral AMTPR1 genes homologs of a putative human tumour suppressor TTC4 gene. (PhD)	Prof D Miller
Annamieke van den Heuvel (UQ)	Australia	Characterization of genes, proteins and the regulatory pathways involved in nitrogen uptake and assimilation in Acropora sp and its symbiont Symbiodinium sp. (PhD)	Dr W Leggat, Dr S Dove
Ida Vincent (UQ)	Sweden	Historical ecology of Fiji's coral reefs, and the recent road to recovery. (Hons)	A.Prof J Pandolfi
Stefan Walker (JCU)	Australia	The sociobiology of life history transitions and lifetime fecundity in a tropical harem reef fish. (PhD)	Dr M McCormick, Dr P Munday
Rebecca Weeks (JCU)	UK	Using site selection algorithms to design Marine reserve networks. (PhD)	Prof G Russ, Dr G Jones
David Williamson (JCU)	Australia	Fishery effects and benefits of marine protected areas within the Great Barrier Reef Marine Park. (PhD)	Prof G Russ, Dr G Jones
Marion Wong (JCU)	UK	The evolution of monogamy in coral reef fish. (PhD)	Dr P Munday, Dr G Jones

End-User Engagement and Co-investment

In 2006, the ARC Centre of Excellence engaged with over 60 industry, government and NGO organizations, in many cases for the first time. The Centre has become a major research provider to local, national, and global organisations, informing policy, and providing knowledge and training to diverse industry partners. Centre of Excellence researchers were major contributors in 2006 to intergovernmental organisations such as the International Union for the Conservation of Nature (IUCN), the World Bank, UNESCO, and the Intergovernmental Panel on Climate Change, that are involved in key global declarations, World Heritage designations, and endangered or threatened species status decisions.

Knowledge transfer from the ARC Centre of Excellence to industry and governments included new technologies that can better predict coral bleaching, enhanced understandings of reef responses to climate change, and improvement in the efficiency of conservation planning. The Centre also provided training to conservation and resource management projects, and to governments and NGOs around the world. The table below provides an overview of the year's activities:



2006 Summary of End-User Engagement Activities

TASKS	MAJOR END-USERS	KEY RESEARCHERS
Centre of Excellence researchers design and implement research with industry partners to directly inform resource-management decision-making. In particular, we provide research on climate change, fishing and protected areas, resilience, shifting-baselines, and coral disease.	<ul style="list-style-type: none"> ▶ AusAid ▶ Burdekin Dry Tropics NRM ▶ GBR Marine Park Authority ▶ Philippine Bureau of Fisheries and Aquatic Resources ▶ Regional Assistance Mission to Solomon Islands (RAMSI) ▶ Tanzania Fisheries Department ▶ The Nature Conservancy ▶ US Geological Survey (USGS) ▶ US National Oceanic & Atmosphere Administration (NOAA) ▶ Wildlife Conservation Society (PNG/Indonesia) 	Almany, Anthony, Baird, Bellwood, Broderick, Cinner, Dove, Foale, Hughes, Jones, Jupiter, McCormick, McCulloch, Munday, Pandolfi, Pratchett, Russ, Willis
Providing strategic research planning by serving on boards, councils, review committees.	<ul style="list-style-type: none"> ▶ Australian Climate Group ▶ Great Barrier Reef Research Foundation ▶ International Coral Reef Society ▶ The Beijer International Institute of Ecological Economics ▶ The Census of Marine Life ▶ The Museum of Tropical Queensland ▶ The Resilience Alliance ▶ World Bank GEF Program 	Hoegh-Guldberg, Hughes, Jones, Kingsford, McCormick, Munday, Pandolfi, Planes, Steneck, Willis
Establishing research consortiums and international steering groups – for research on coral genomics, resilience-based reef management, integrating human and coral health.	<ul style="list-style-type: none"> ▶ IUCN ▶ NOAA - National Ocean Service ▶ USA National Science Foundation ▶ Western Pacific Fishery Management Council 	Cinner, Dove, Hughes, Leggat, Miller, Pandolfi, Willis
Advising major donors on funding priorities for coral reef research.	<ul style="list-style-type: none"> ▶ Packard Foundation ▶ The Nature Conservancy ▶ World Bank 	Hoegh-Guldberg, Hughes, Jones
Providing information and advice to industry on subjects ranging from the impacts of dredging and oil exploration to environmentally sustainable seafood.	<ul style="list-style-type: none"> ▶ Axfood and ICA (two large Swedish food importers/Supermarkets) ▶ Pilbara Iron ▶ Pro-Dive, Cairns ▶ Southeast Asian Petroleum Exploration Society ▶ Under-Sea Explorer, Port Douglas ▶ Woodside Petroleum 	Baird, Bellwood, Hoegh-Guldberg, Hughes, Pandolfi, Pratchett, Willis
Initiating conservation projects, including a network of 69 marine protected areas (MPAs) in the Philippines and PNG, and a sustainable harvesting project in PNG.	<ul style="list-style-type: none"> ▶ Andra village (PNG) ▶ Mahonia Na Dari, PNG ▶ Philippine Bureau of Fisheries & Aquatic Resources ▶ Philippine Department of Environment and Natural Resources ▶ Wildlife Conservation Society, PNG 	Almany, Cinner, Jones, Pratchett, Russ
Providing advice to management agencies on governance structure and management of new marine parks, heritage conservation and environmental assessment matters.	<ul style="list-style-type: none"> ▶ Connell Wagner PPI ▶ NT Government (Dept. of Natural Resources, Environment & the Arts), ▶ Parks Victoria ▶ Stockland Residential Developments ▶ Sydney Ports Corporation ▶ TransGrid 	Hughes, McIntyre-Tamwoy

TASKS	MAJOR END-USERS	KEY RESEARCHERS
Advising Australian government agencies, officials and ministers, providing briefing papers and information on heritage policy matters, climate change, and other issues of strategic importance.	<ul style="list-style-type: none"> ▶ Australian Local Government Association ▶ Carpentaria Land Council ▶ Department of Environment and Heritage ▶ Federation of Australian Historical Societies ▶ GBRMPA ▶ Government of WA ▶ Injinoo Apudhama Lands Trust ▶ Mackay City Council ▶ Mackay-Whitsunday Natural Resource Management Group ▶ QLD Environmental Protection Agency Australian Climate Group ▶ Queensland Department of Natural Resources and Water 	Bellwood, Hoegh-Guldberg, Hughes, Jupiter, McIntyre-Tamwoy, Willis
Providing international governments with advice on World Heritage Areas, climate change, endangered species.	<ul style="list-style-type: none"> ▶ Governor of Sebang, Aceh, Indonesia, ▶ International Council on Monuments and Sites ▶ International Panel on Climate Change (IPCC) ▶ UNESCO 	Bellwood, Hoegh-Guldberg, Hughes, McIntyre-Tamwoy, Munday, Richards
Training in monitoring methods for socioeconomic and ecological research. Trainees include park rangers, government and NGO staff, and government researchers.	<ul style="list-style-type: none"> ▶ AusAid, Queensland Park & Wildlife Service ▶ AusAid-funded Regional Assistance Mission to Solomon Islands (RAMSI) ▶ Kenya Sea Turtle Conservation Committee ▶ Motupore Island Research Station, PNG ▶ NOAA ▶ Reef Check (Japan) ▶ Tanga Coastal Zone Development & Conservation Project (Tanzania) ▶ Tanzanian Institute for Marine Science (University of Dar Es Salaam) ▶ University of Guam ▶ University of the Philippines ▶ Wildlife Conservation Society PNG 	Almany, Baird, Cinner, Foale, Hughes, Jones, Munday, Pratchett, Russ, Willis
Providing training and information to industry partners.	<ul style="list-style-type: none"> ▶ Davos Leadership convention ▶ Great Barrier Reef Foundation ▶ Rio Tinto 	Anthony, Dove, Hoegh-Guldberg, Kingsford
Improving environmental education in primary and secondary schools by developing teaching resources and conducting workshops.	<ul style="list-style-type: none"> ▶ Mahonia Na Dari (PNG) ▶ Mundingburra State School ▶ PNG Education Department ▶ Teachers and students of New Ireland Province, PNG 	Bay, Foale, Munday





National and International Linkages

In 2006, the ARC Centre produced 88 publications with cross-institutional co-authorship (28 more than 2005), involving researchers from 93 institutions in 29 countries. The ARC Centre hosted 51 international visitors from 17 countries, and Centre personnel traveled to 20 countries. The ARC Centre participated in or hosted 7 national and 17 international working groups during 2006. Centre personnel are actively involved in many international activities (including consultancies and end-user engagement, see p.32), including membership of editorial boards for nine international journals.

Nationally, the Centre Chief Investigators contribute to five ARC Networks, reflecting their broad range of expertise. The Centre is represented at the *Australian Academy of Sciences* by two Fellows, Terry Hughes (JCU) and Malcolm McCulloch (ANU). The three main University nodes are linked to research and industry partners throughout Australia. In 2006, co-funding agreements were established for 4 shared postdoctoral fellows, with AIMS, CSIRO and *The Resilience Alliance*. Two more will follow in 2007. Internationally, major linkages were developed and strengthened during the past year, including collaborations with *The Resilience Alliance*, *The Beijer International Institute for Ecological Economics*, and *The World Bank Coral Reef Targeted Research Program*, which are described briefly below.

The Resilience Alliance

www.resalliance.org

The ARC Centre of Excellence for Coral Reef Studies is a Member Organization of the Resilience Alliance (RA). The RA is a multi-disciplinary research group that explores the dynamics of linked social and ecological systems in order to discover foundations for sustainability. It is an extensively networked organization, with 17 member organizations in Australia, Canada, France, the Netherlands, Sweden,

Thailand, the USA and Zimbabwe. RA members are world-leaders in the ecological, mathematical, and social sciences, covering a broad range of disciplinary expertise. The ARC Centre is represented by Hughes on the RA's Board of Directors, and on the editorial board of their journal, *Ecology & Society*. In March 2006, the ARC Centre hosted a working group meeting of the RA in Townsville, funded by the Packard Foundation. The Centre also funded a working group in August, held at the University of Maine, in collaboration with Professor Bob Steneck, a Centre Partner Investigator. The RA will host its next meeting in Corsica in September 2007. *The Resilience Alliance* has also agreed to co-fund a postdoctoral position based at the Centre's Townsville node in 2006-2007. A series of joint research funding initiatives are also planned for next year.

The Beijer International Institute for Ecological Economics

www.beijer.kva.se

The Beijer Institute operates under the auspices of the *Royal Swedish Academy*, working at the interface of ecology and economics, co-directed by Professor Carl Folke, who is a Partner Investigator in the ARC Centre. It conducts research and training internationally, funded by Swedish and international research councils. The ARC Centre Director, Terry Hughes, was appointed to the Board of Directors of the Beijer Institute in 2006, for a period of 3 years. The Beijer Institute and two additional Swedish partners received 22 million Euros in funding in 2006 from the Swedish *Foundation for Strategic Environmental Research (MISTRA)* to establish a major new Centre of Excellence, to be called the *Stockholm Resilience Centre*. With pending support from the State of Queensland, we plan to establish a framework within which collaboration between the new Australian and Swedish

Centres can develop further in 2007.

A major outcome will be the development and application of policy guidelines and processes that further the global development of adaptive governance systems. *The Australian Academy of Science* has formally endorsed the ARC Centre's growing engagement with *Royal Swedish Academy*.

Global Coral Reef Targeted Research (CRTR) Program www.gefcoral.org

The ARC Centre of Excellence is the single largest contributor of expertise to this global research partnership, which includes the World Bank, The Intergovernmental Oceanographic Commission, US National Oceanic and Atmospheric Administration (NOAA), the University of Queensland, and 60 other research groups. The consortium of researchers aims to conduct specific, targeted research to fill critically important information gaps in the fundamental understanding of coral reef ecosystems so that management and policy interventions can be strengthened globally. Five International Working Groups, each with approximately a dozen leading researchers, form the scientific basis for the program. In 2005, the Centre is represented on four groups which dovetail well with Programs 3 and 4 of this proposal: (a) *Diseases Working Group*: Willis (Co-chair), (b) *Connectivity Working Group*: Jones, Planes and Steneck, (c) *Bleaching Working Group*: Hoegh-Guldberg, (Chair), (d) *Modelling Working Group*: Bradbury (Chair). In 2006, the ARC Centre contributed to working group meetings on Heron and Orpheus Islands, and in Brisbane, Miami, Paris and Townsville. The Centre Director, Terry Hughes, met with the CRTR Steering Committee in Mexico in October 2006, to develop additional collaborative activities, which will include a major workshop in Townsville during 2007.



2006 international visitors:

Dr Kevin Arrigo
Stanford University, USA

Dr Shankar Aswani
University of California Santa Barbara
USA

Professor John Avise
University of California, USA

Mr Jonathon Belmaker
PhD student at Ben Gurion University,
Israel

Dr Michael Berumen
University of Arkansas, USA

Professor Harry Biggs
Resilience Alliance, South Africa

Dr Michael Brooke
New Scientist Magazine, UK

Professor Nancy Budd
University of Iowa, USA

Dr Ken Caldeira
Stanford University, USA

Dr Stuart Campbell
World Wildlife Conservancy, Indonesia

Dr Kenneth Clifton
Lewis and Clark College, Portland, USA

Professor Robert Dunbar
Stanford University, USA

Dr Mark Eakin
NOAA, USA

Dr Michel Etienne
INRA Ecodevelopment Unit, France

Dr Maoz Fine
University of Haifa, Israel

Dr Dominik Fleitmann
University of Massachusetts, USA

Mr Nicholas Graham
University of Newcastle, UK

Dr Rina Grant-Biggs
Sanparks, South Africa

Dr Benjamin Greenstein
Cornell College, USA

Professor Lance Gundersen
Resilience Alliance, USA

Dr Jurgen Herler
University of Vienna, Austria

Professor Sally Holbrook
University of California Santa
Barbara, USA

Professor Jeremy Jackson
Scripps Institute of Oceanography, USA

Dr Alex Kerr
University of Guam Marine Laboratory,
USA

Dr David Kline
Tropical Research Institute / Scripps
Institute of Oceanography, USA

Professor Yossi Loya
University of Tel Aviv, Israel

Dr C MacDonald
Stanford University, USA

Dr Misha Matz
University of Texas, USA

Dr Monica Medina
University of California, USA

Professor Giff Miller
University of Colorado, Boulder, USA

Dr Wolfgang Mueller
University of London, UK

Dr Stuart Murray
University of Toronto, Canada

Mr Vithal Nadkarni
The Economic Times of India, India

Dr Per Olsson
University of Stockholm, Sweden

Dr Adina Payten
Stanford University, USA

Dr Jeanine Pfeiffer
University of California, USA

Ms Basu Radsha
Environment reporter, The Straits Times,
Singapore

Dr Wolfgang Reichardt
University of Philippines, Philippines

Dr Willem Renema
Nationaal Natuurhistorisch Museum,
Netherlands

Professor Eugene Rosenberg
Tel Aviv University, Israel

Professor Russell Schmitt
University of California Santa Barbara,
USA

A/Professor Garriet Smith
A/Prof U South Carolina, USA

Dr Shunichi Takahashi
National Institute for Basic Biology,
Japan

Dr Phil Taylor
Resilience Alliance, Canada

Dr Simon Thorrold
Woods Hole Oceanographic Institution,
USA

Dr James True
University of Hong Kong, Hong Kong SAR

Dr Gangjian Wei
Guangzhou Institute of Geochemistry,
China

Dr Jörg Wiedenmann
Universität Ulm, Germany

Dr Bry Wilson
University College, Dublin, Ireland

Professor Oded Yarden
Hebrew University, Jerusalem and
University of Tel Aviv, Israel

Dr Yusuke Yokoyama
University of Tokyo, Japan

Dr Erika Zavaleta
Christensen Fund, USA

Media Coverage

Communicating research to diverse audiences

Once they leave high-school, most Australians rely heavily on the media and the internet for life-long learning of science and technology. A scary thought, perhaps, but also a challenge and an opportunity for scientists to better communicate their findings.

The ARC Centre of Excellence for Coral Reef Studies was established in 2005 to conduct research on the science that underpins the sustainability of goods and services provided by coral reef ecosystems. "The award of an ARC Centre of Excellence allowed us to develop a robust media strategy, which has increased our outreach enormously," Centre Director Professor Terry Hughes says.

"The smartest thing we did was invest at the outset in the services of a professional media consultant. He works closely with us to craft fortnightly press releases, converting our sometimes nerdy science into everyday language and propagating them to a huge audience. These releases generated 736 media stories – two a day – in 2006."

"Our new website has developed rapidly during our first full year operation, and is running now at well over a million hits per annum, with 85% coming from overseas. About a quarter of the hits are generated by the fortnightly press releases that highlight our research findings."

"Coral reef researchers do have a natural advantage, because our work is topical and often visually stunning. In the past though, we usually only responded more-or-less passively to media enquiries.

Now, we have deliberately set out to harness the media by creating our own news stories, to build public awareness of their investment in coral reef science", says Professor Hughes.

One recent example from February 2007 was a press release entitled "Fish: Healthcare workers of the Reef". It was based on a large-scale field experiment which showed that a healthy fish population is essential for coral recovery after a severe bleaching event, storm or disease outbreak. "We followed the recovery of corals that had been severely damaged by bleaching due to global warming. The corals were on a reef where fish populations were unusually intact due to the Great Barrier Reef Marine Park Authority's no-take policy. We fenced the fish out of some areas, and compared coral recovery with and without lots of fish."

"The result was dramatic. The coral cover virtually doubled where the fish had access, while the fenced-off areas became overgrown with seaweed and the corals failed to recover."

The research team concluded that having intact fish populations will be vital to successfully managing the resilience of tropical coral reefs from the impacts of climate change and human activity. "We can't prevent future bleaching except through international action on greenhouse gas emissions," said co-author Professor Ove Hoegh-Guldberg, and Deputy Director of the ARC Centre. "In the meantime, it's important to do whatever we can to minimize the damage and assist reefs through these difficult times."

This research was reported on ABC, in New Scientist, on the Discovery Channel, Taiwan News, the New York Sun, the San Francisco Chronicle, the Washington Post, and over 40 other outlets.

Fellow author and Research and Monitoring Manager with the Great Barrier Reef Marine Park Authority, Dr Laurence McCook, said the research provided valuable information for the protection of the Great Barrier Reef.

"Publicising research findings like this helps the public to appreciate the measures needed to protect coral reefs, and to understand why it is sometimes necessary to close areas of reef to fishing. This builds public support for best-practice management and for the science that underpins it", says Professor Hughes. Sustainability of coral reef resources is vital for economies and societies in tropical maritime countries worldwide. In Australia alone the Great Barrier Reef is valued at over \$5 billion a year, employs 68,000 people and is a celebrated cultural icon. The ARC Centre currently provides support and supervision to 114 research students from 29 countries, making it a global leader in the provision of graduate training in coral reef studies. Led by James Cook University, the ARC Centre of Excellence for Coral Reef Studies is a partnership with the University of Queensland, The Australian National University, The Australian Institute of Marine Science, CSIRO, and the Great Barrier Reef Marine Park Authority.



Highlights of the Centre's 737 media hits in 2006 include:

- ABC, *Catalyst Climate change documentary*. 1/05/06, Hoegh-Guldberg O
- ABC America News International, *Batfish protect reef in Australia*. 21/12/2006, Bellwood D, Hughes TP
- ABC Radio National 'The National Interest', *Coral stress like never in history*. 12/12/2006, Pandolfi J
- AFP French Multimedia Wire, *Corals facing worst impacts in history*. 19/06/2006, Pandolfi J
- Al Jazeera, *Climate change and marine ecosystems*. 3/05/2006, Hoegh-Guldberg O
- Australasian Science Magazine, *Corals facing worst impacts in history*. 20/06/2006, Pandolfi J
- BBC Radio, *Fish evolution and ecology*. 10/02/2006, Bellwood D
- BBC World Service, *The World Today*. 4/04/2006, Baird A
- Channel TEN, Scope, *Coral spawning*. 8/05/2006, Willis B
- Daily India, *Batfish play important role in aiding coral reef recovery*. 19/12/2006, Hughes TP, Bellwood D, Hoey A
- David Attenborough Television programme "Are we changing the Earth", *Bleaching and climate change*. 24/05/2006, Hoegh-Guldberg O
- Diario de Noticias, *Cientista portuguesa propoe conservacao mais eficaz para corais*. 2/03/2006, Dornelas M
- Earth Observatory – NASA, *Coral reefs are increasingly vulnerable to angry oceans*. 22/11/2006, Connolly S
- FPFA (San Francisco), *Coral Threatened by Global Warming*. 28/12/06, Pratchett M
- Ingo, *"Heiß kommt der tod"*. 1/04/2006, Hoegh-Guldberg O
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National Benefit Case-Study

Case Study 1 Science for Managing Reef Fisheries

The unifying theme of the ARC Centre for Coral Reef Studies is the development of frontier technologies for management and sustainable use of the world's coral reefs. A major approach to management and sustainable use of renewable resources is spatial zoning for multiple levels of use and protection. A key aspect of this zoning approach is the establishment of no-take marine reserves, where all extractive practices by humans are banned permanently.

Our recent studies have highlighted the need for networks of marine reserves for management of biodiversity and fisheries. Such zoning for multiple levels of use and protection is fast becoming a principal mechanism of management of marine resources in Australia and elsewhere. No-take reserves are often established to conserve species, ecological communities, habitats, ecosystems and bioregions. They are increasingly also being advocated as a tool for fisheries management. To date, some of the largest and most successful applications of no-take marine reserves have been on coral reefs. A notable example is Australia's Great Barrier Reef Marine Park (GBRMP), with a no-take area of over 100,000 km².

Program 3 of the ARC Centre has made substantial progress in 2006 in (a) assessing the importance of marine reserves for fisheries management on coral reefs, (b) determining the optimal design of reserve networks for management of ecological resilience, and (c) identifying the levels of larval dispersal and connectivity within and between coral reef systems and marine reserve networks. In 2006, Program

3 Leader, Garry Russ and colleagues (DH Williamson, RD Evans) completed the first field assessments of the new Representative Areas Program (RAP) on inshore coral reefs of the GBR. Initial data from the Whitsunday Islands indicated a relatively fast and positive response of targeted reef fish populations to the new zoning. Sean Connolly and JCU co-authors Will Robbins, Mizue Hisano and Howard Choat combined direct underwater counts of shark abundance with mathematical models to project future population trends based on information about reef sharks' current survival, growth and reproductive rates. These results generated considerable media attention in 2006 regarding the RAP rezoning of the GBR which was initiated by federal legislation enacted in July 2004.

A key development of the ARC Centre over the past 12 months has been the development of new tagging technologies for coral reef fish of major commercial and recreational fishing importance (e.g. large groupers, including coral trout). Larval rearing and marking experiments (Ba isotopes) were completed successfully in 2006 on a large commercially important grouper, by Glenn Almany, Geoff Jones and colleagues. Work by Mike Kingsford and colleagues from Woods Hole Oceanographic Institute demonstrated that larval fishes are behaviourally sophisticated, capable of cuing into environmental signals that allow them to distinguish their natal reef. Field experiments in coming months will employ enriched isotope larval markers to measure dispersal of coral trout larvae (*Plectropomus* spp.) from marine protected areas to adjacent fished populations in the Keppel Islands. These results are of major significance to a key stakeholder, the GBR Marine Park Authority.

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National Benefit Case-Study

Case Study 2 Building Resilience to Climate Change

The coral reefs of Australia, particularly the Great Barrier Reef, Ningaloo Reef, and Lord Howe Island World Heritage Area are Australian national icons, of great economic, social, and aesthetic value. Tourism and fisheries on the Great Barrier Reef alone contribute \$5.9 billion annually to the nation's economy, and provides employment for 63,000 people. Globally, the welfare of 500 million people is intricately linked to the goods and services provided by coral reef biodiversity, such as fisheries and tourism. Uniquely among tropical and sub-tropical nations, Australia has extensive coral reefs, a small population of relatively very wealthy and well-educated citizens, and well-developed infrastructure. Coral reef research is one area where Australia has the capability, indeed the obligation, to achieve world-leadership.

Coral bleaching, over-fishing and declining water-quality can result in destructive algal blooms and a loss of ecological resilience. One of the most visible signs of a decline in the condition of coral reefs is the widely documented "phase-shift" from a healthy coral-dominated state to a weedy macro-algal dominated state. Loss of coral following bleaching can also lead to reductions in fishes and other reef organisms. In 2006, the ARC Centre has undertaken cutting-edge research that provides new insights into the processes involved in undesirable phase-shifts, and how they can be controlled and managed. This information is of critical importance to reef managers and policy makers worldwide.

Programs 2 and 5 have begun this year to quantify successional changes in algal and coral assemblages on reefs that are open and closed to fishing, and to undertake novel experiments that manipulate the density of herbivorous and carnivorous fishes. Response variables include the demographic mechanisms of coral-macroalgal interactions and sub-lethal changes in the physiology of corals following coral bleaching and algal blooms. Mathematical modelling was also undertaken by Sean Connolly and his team in 2006 to understand how changes in run-off of nutrients from coastal agriculture, which promotes algal growth, affects the control of algal blooms by grazing reef fishes.

Phase-shift can be triggered by a loss of herbivores, especially parrotfishes and surgeonfishes. However, the critical question remains: how can this coral-algal phase-shift be reversed? In one of the world's largest herbivore exclusion experiments, a team from the ARC Centre of Excellence simulated overfishing on the Great Barrier Reef, which triggered a phase-shift to macro-algae on a previously healthy reef. They then filmed the recovery of the reef once herbivorous fish were re-introduced, using remote underwater digital videos cameras. Remarkably, only two of the 27 herbivorous fish species present in the region had any significant impact. What was most surprising was that the dominant browser was a rare batfish, *Platax pinnatus*, a species previously thought to be an invertebrate feeder. Parrotfishes and surgeonfishes, which are the routine consumers of seaweed on coral reefs, were unable to reverse run-away algal blooms. The results revealed the unexpected importance of a single

rare species in the recovery of coral reefs. This finding was highlighted in December 2006 in over 50 media stories published worldwide.

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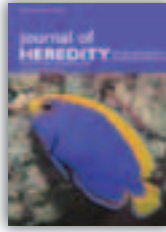


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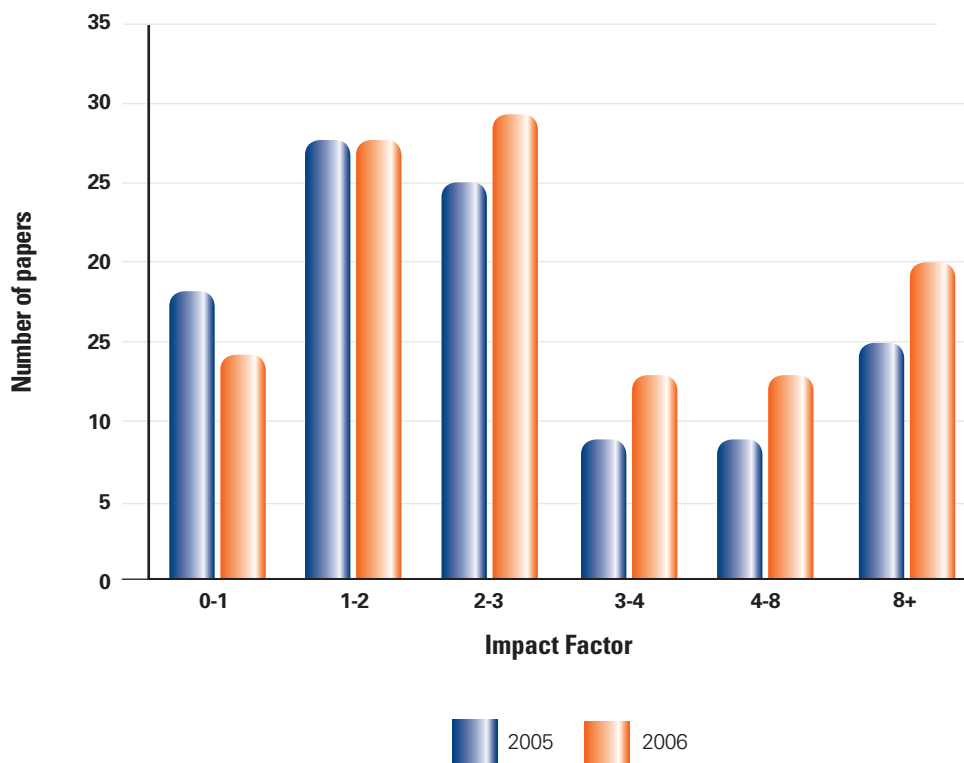
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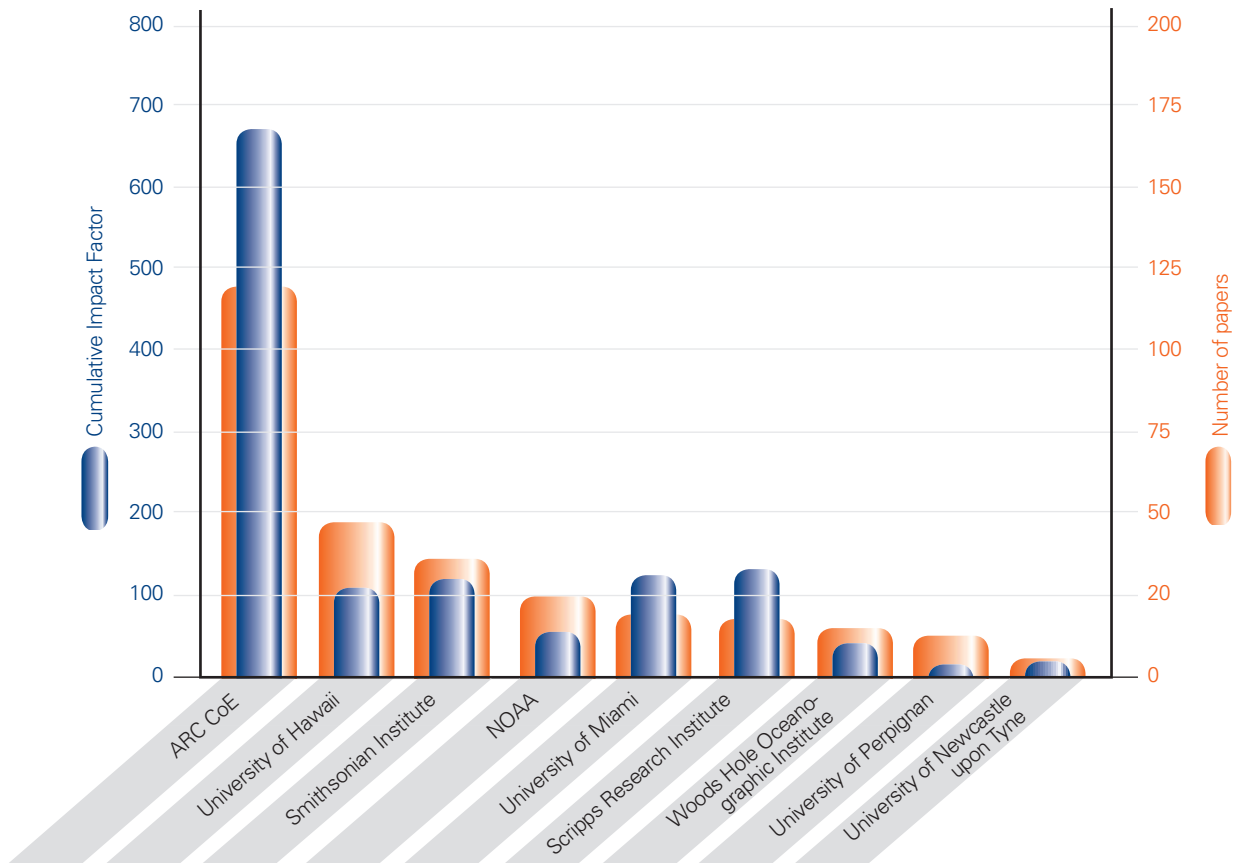
Publication Benchmarking

The ARC Centre of Excellence for Coral Reef Studies is a world leader in coral reef science. In 2006, the Centre produced 132 publications, up by 29% from 102 in 2005. According to *ISI Web of Science*, if the ARC Centre of Excellence for Coral Reef Studies was a country, it would have ranked second in the world behind the USA in 2006 for the number of journal publications and citations in coral reef science.

There was a marked improvement in the quality of journals targeted by the ARC Centre in 2006, from a mean Impact Factor of 5.1 in 2005 to 5.8 in 2006. Thirty-three 2006 articles were published in journals with Impact Factors greater than four, including twelve papers in *Science* and *Nature* (up from 8 in 2005).



The Impact Factor distribution of the ARC Centre's publications in 2005 and 2006.



Comparison of 2006 journal publications in coral reef disciplines with international Benchmark Institutions.

The graph compares the total number of journal articles on coral reef science published in 2006, and the summed Impact Factor of those publications. The data was generated by searching ISI *Web of Science* for "coral*" and the names of leading institutions. Note the high Impact Factor relative to the number of publications for the ARC Centre of Excellence, the University of Miami, and the Scripps Institution of Oceanography.

The Centre researchers received widespread national and international recognition in 2006 for the quality of their research, including 29 invitations to provide international keynote addresses (in Australia, Canada, China, France, Germany, the Netherlands, Indonesia, Malaysia, Spain, the UK, and the USA), and 33 invitations to write major reviews. The Centre personnel received 5353 citations in 2006, a 47% increase compared to 2005. Eighteen Centre of Excellence researchers were cited >100 times each in 2006, and six of these had >300 citations each in the reporting period.

League table achievements in publications for 2006 include:

Connolly, S.R., T.P. Hughes, D.R. Bellwood, R.H. Karlson (2005).

Community structure of corals and reef fishes at multiple scales. *Science* 309: 1365-1365. (Ranked in March and April 2006 by the *Faculty of 1000*, as an *Exceptional Publication*).

(www.f1000biology.com/article/16511493/evaluation).

Dornelas, M., S.R. Connolly, T.P. Hughes (2006) *Nature* 440: 80-82. (Ranked in March, April and September 2006 by the *Faculty of 1000*, as an *Exceptional Publication*).

(www.f1000biology.com/article/16123298/evaluation).

ISI Essential Science Indicators identified three *Research Fronts* in 2006 that highlight the leading research and exceptionally high level of citation by the

Centre's personnel. A research front is a group of *highly cited papers*, referred to as *core papers*, in a specialized topic defined by a cluster analysis. The Research Fronts were "Coral Reef Ecosystems", "Coral bleaching", and "Coral reef resilience". Six core papers in the 2006 Research Fronts were authored by Research Fellow *A. Baird*, by Chief Investigators *D. Bellwood, S. Connolly, O. Hoegh-Guldberg, T. Hughes*, and *J. Pandolfi*, and by Partner Investigators *C. Folke, J. Lough*, and *R. Steneck*.

ISI Essential Science Indicators identified *O. Hoegh-Guldberg* as the #4 ranked scientist in the Global Warming special topic. His most cited paper is ranked at #1 on the 10 year list of papers on this topic.

(<http://esi-topics.com/gwarm2006/interviews/OveHoegh-Guldberg.html>)



Performance Measures

Research findings

MEASURE	OUTCOME 2005 ¹	TARGET 2006	OUTCOME 2006
Number of publications	51	60	132
Publications in journals with an impact factor > 4	14	5	33
Number of citations	1823	300	5353
Invitations to provide plenary addresses at international conferences	6	5	29
Invitations to provide review articles	7	3	33
Number and nature of commentaries about the centre's achievements	109	60	737
Awards, Prizes or Recognition	6	3	14

Research training and professional education

MEASURE	OUTCOME 2005	TARGET 2006	OUTCOME 2006
Number of postgraduates enrolled	66	50 ²	110
Number of postgraduate completions	4	50 ²	13
Number of Honours students	9	50 ²	22
Number of professional workshops	3	2	10
Participation in professional workshops	5	2	22
Number and level of graduate student courses and workshops in the priority area(s)	6	6	12

1. Outcomes for 2005 have been halved to represent the 6 months from 1 July to 31 December
 2. Over 5 years.

International, national and regional links and networks

MEASURE	OUTCOME 2005	TARGET 2006	OUTCOME 2006
Number of international visitors	25	10	51
Number of national and international Working Groups	13 Centre investigators participated in 3 international and 5 national working groups.	3	15 Centre investigators participated in 17 international and 7 national working groups.
Number of visits to overseas laboratories and research facilities	12	12	46
Invitations to membership of national and international boards and advisory committees	21	7	41
Number of cross-institutional publications.	62	10	88
Number of multi-institutional supervisory arrangements of graduate students.	29	6	42
Number & nature of contractual arrangements.			
▶ increase the level of internationally funded students	16	10 over 5 yrs	16
▶ increase level of consultancies and contract research	8 research contracts with industry	2	12
			(5 continue from 2005)
Number of government, industry and business briefings	9 industry and 8 government briefing	6	11 industry and 19 government briefings
Number of Centre trained/ing personnel in knowledge / technology transfer and commercialization	0	1	6
Public Awareness programs			
▶ Website hits	13,305	36,000	608,268
▶ Public awareness presentations	3	2	12



Governance

MEASURE	OUTCOME 2005	TARGET 2006	OUTCOME 2006
Breadth and experience of the members of the Advisory Board	Centre Advisory Board and Scientific Management Committee established	Senior representation from all nodes. Representation of eminent international researchers. Members with commercial and business links.	See page p.7
Frequency and effectiveness of Advisory Board meetings	Inaugural Scientific Management Committee meeting in February 2006. Inaugural Centre Advisory Board meeting scheduled for early 2006.	Annual face-to face meeting attended by entire Centre Advisory Board. Face-to-face meeting of entire Scientific Management Committee twice per year.	See page p.7 4 Scientific Management Committee meetings held. Inaugural Centre Advisory Board meeting held in May 2006.
Quality of the Centre strategic plan	Draft Strategic Plan developed and presented to Scientific Management Committee. To be reviewed by business, science and university.	The Centre's progress against the plan will be formally reported to the Advisory Board and be renewed in light of outcomes.	Strategic Plan endorsed by the Centre Advisory Board and will be reviewed annually. Ongoing performance against plan is reviewed quarterly by the Scientific Management Committee.
Effectiveness of arrangements to manage Centre nodes	<ol style="list-style-type: none"> All nodes and research programs represented at Scientific Management Committee meetings Monthly nodal and program leader meetings held In 2005 management meetings held at each of the 3 nodes In 2005 research planning meetings held for Centre and each research program Cross-nodal attendance at all research planning meetings 	<p>The nodes will communicate through:</p> <ol style="list-style-type: none"> Meetings of the Scientific Management Committee where each node and program is represented monthly nodal leader phone or video conferences Annual rotational visits to the nodes Annual research retreats for all Centre participants Annual research Program planning meetings with cross-nodal attendance 	<ol style="list-style-type: none"> All nodes and research programs represented at Scientific Management Committee meetings. Nodal leader discussions are continuous, occurring at least weekly. Each Node leader visited the other nodes at least once during 2006. In 2006, research planning meetings were held for; the Centre, Programs 1- 5, research fellows, & graduate students Each node was represented at all planning meetings
The adequacy of the Centre's Key Performance Measures	The Centre outperformed benchmarked institutions	International benchmarking to research in top international marine research centres.	Centre outperformed benchmark institutions (see p.49)

Organisational support

MEASURE	OUTCOME 2005	TARGET 2006	OUTCOME 2006
Annual cash contributions from Collaborating Organisations	Nil	\$1,115,000	\$1,205,000
Annual in-kind contributions from Collaborating Organisations	1,116,654 ¹	5% above 2005 level	\$2,799,021 (25% increase)
Number of new Organisations recruited to or involved in the Centre	8	2 New Organisations	10
Level and quality of infrastructure provided to the Centre	\$878,843 of infrastructure provided to the Centre.	5% above 2005 level	\$922,785
Annual cash contributions from other new organisations	Additional funding of \$100,000 from CSIRO	20% above 2005 level	Additional new funding of \$167,083 (67% increase)

National Benefit

MEASURE	OUTCOME 2005	TARGET 2006	OUTCOME 2006
Measures of expansion of Australia's capability in the priority area(s)	16% increase in Publications	1) A growth trajectory of 10% in citations and Publications from 2000-2004 as the benchmark.	62% increase in Publications 81% increase in Citations
	17 briefings	2) 6 briefings to government, business and industry groups	30 briefings
	14 Cross-nodal publications 62 Cross-institutional publications	3) 14 cross-institutional co-authored publications	17 Cross-nodal publications 88 Cross-institutional publications
Case studies of economic, social, cultural or environmental benefits	1 See 2005 annual report	2 to be highlighted in the annual report and distributed to media agencies	26 Media Releases in 2006 See p.43

Financial Statement

ARC Centre of Excellence for Coral Reef Studies Statement of Operating Income and Expenditure for year ended 31 December 2006

Income	\$
ARC Centre Grant	3,722,158
ARC Fellowships	420,562
ARC Networks Program	30,000
Host Institutions support	1,205,000
Local Government	25,000
State Government	20,000
Commonwealth Government other grants	193,000
International income & other contracts	59,083
Total Income	\$5,674,803

Expenditure	\$
Salaries	1,893,885
Equipment	206,878
Travel	587,903
Research Maintenance & consumables	567,313
Scholarships	36,642
Administrative expenses	127,444
Total Expenditure	\$3,420,065

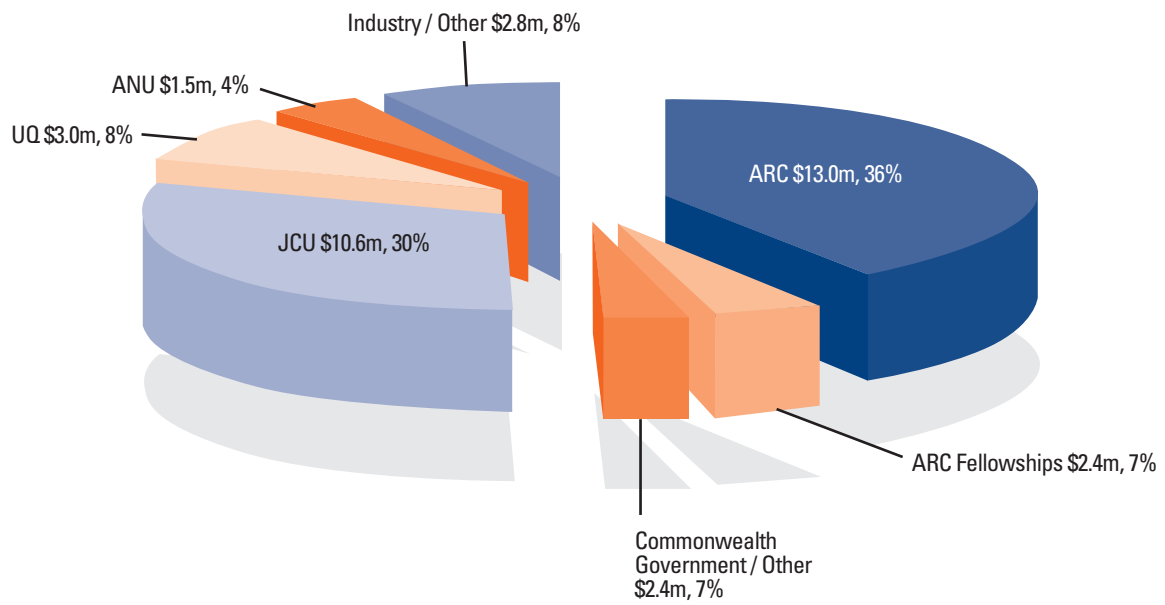
Total carry forward	\$2,254,738
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Financial Status

The operating cash and in-kind operating budget for the Centre of Excellence for 2005-2010 currently totals \$35.7m, a 13% increase from 2005 projections. The chart below indicates the budgeted level of funding from the various funding sources.

ARC Centre of Excellence funding outlook 2005-2010





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