Annual Report 2007

ARC Centre of Excellence
Coral Reef Studies

Annual Report 2007

Contents

Vision

Global leadership in the provision of scientific knowledge necessary for coral reef managers to sustain the ecosystem goods and services of the world's coral reefs.

Aims

The aims of the ARC Centre of Excellence for Coral Reef Studies are that:

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

Research Training & Professional Education
We attract and train outstanding coral reef scientists at all stages of career, to build human capacity and expertise in coral reef science world-wide.

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

National and International linkages
Our networks and activities nationally and internationally represent a global hub for coral reef science collaborations.

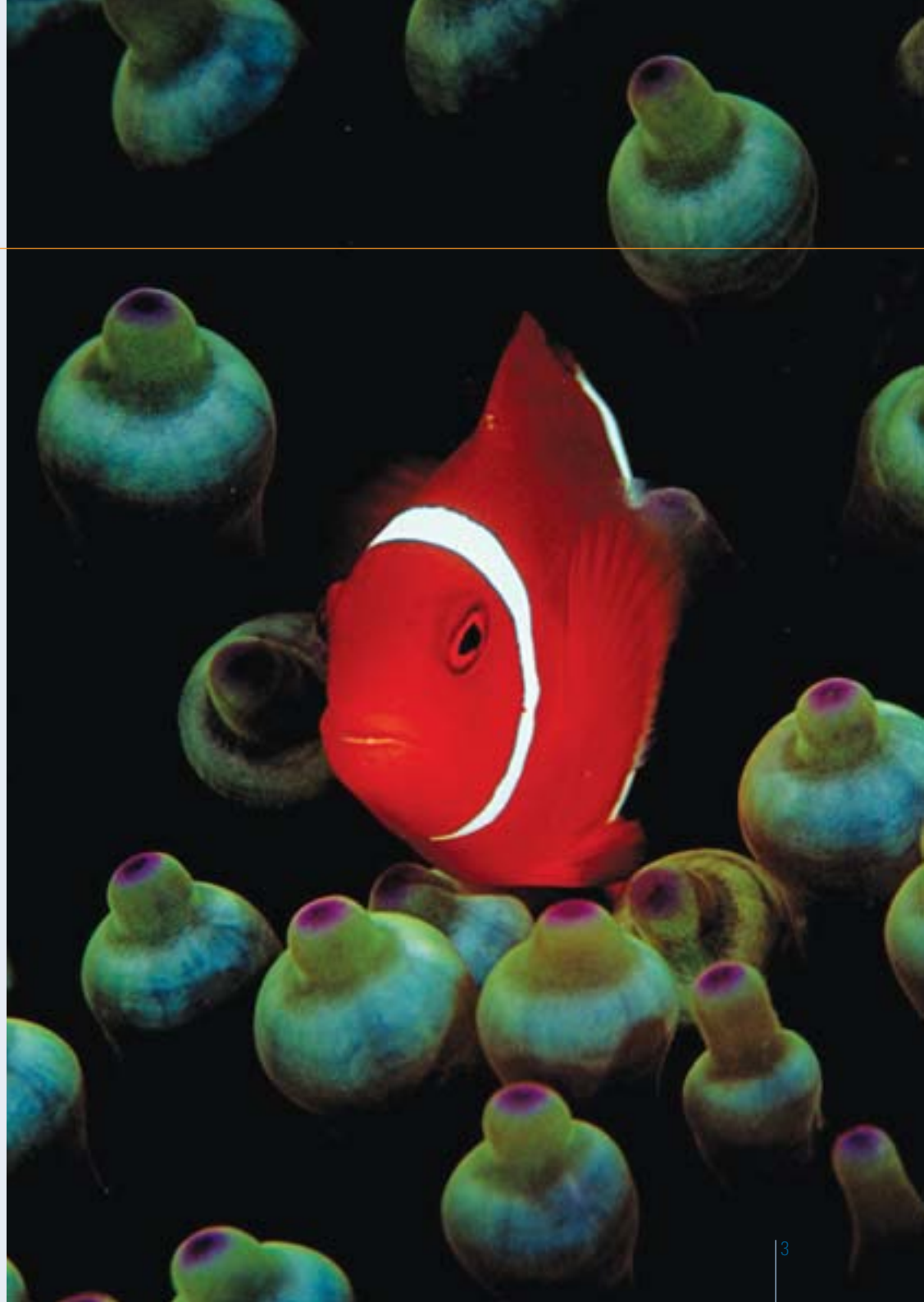
Management and Governance
Centre management is collaborative, co-operative, multi-institutional, communicative and continuously improving.

Commercial Activities
Commercial activities and research contracts extend knowledge transfer, nationally and globally.

Overview

The ARC Centre of Excellence for Coral Reef Studies was established in July 2005 under the Australian Research Council Centres of Excellence program. Headquartered at 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 collaborative links to 162 institutions in 36 countries.

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.



Director's Report

Welcome to the 2007 annual report, for our second full year of operation. This year the Centre has continued to expand its research and training programs, and to develop a growing array of outreach and entrepreneurial activities. The ARC approved our request to substantially raise our Key Performance Indicators for 2007 and beyond. Our applied and basic research focuses on the science that underpins the sustainability and management of the world's coral reefs, not just Australia's. Consequently, the Centre's 2007 publications involved co-authors from 162 institutions in 36 countries, and our 60 or so end-users (see also last year's report) are well and truly global. The publication output of the Centre for this past year includes 127 articles in 67 journals (see p.42), reflecting the multi-disciplinary nature of our research. New research contracts, fellowship awards and consultancies have added to our 2005-2010 cash income, which will exceed $50 million in the coming year (p.55).

The Centre's engagement with governments, industry, NGOs, and the general public continues to grow rapidly. For example, in October, the Centre's membership and distinguished guest speakers gathered in Canberra to hold a 2-day Coral Reef Futures Forum, which was co-sponsored by the Australian Academy of Science. Over 130 delegates from the private sector, state and commonwealth government departments and agencies and universities registered to hear the latest science on issues such as climate change, fisheries management, conservation planning, capacity building, ecosystem-based management and adaptive governance. We continue to add new material to our website (p36) which received almost 2 million hits in 2007, triple that of last year, with greater than 90% from outside Australia. Our media up-take from 26 press releases this year has also grown rapidly, with over 850 stories featuring the 2007 activities of the ARC Centre, for national and international audiences.

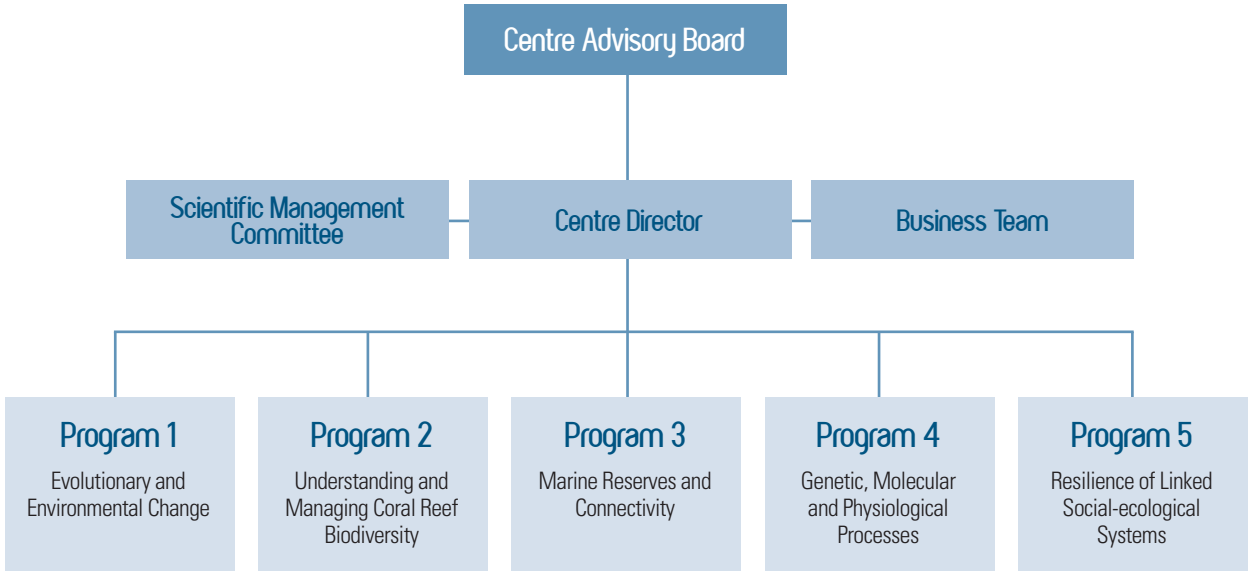
The number of postgraduates supervised by Centre personnel grew to 129 students in 2007, double the number of just two years ago (p.22). Our research students now come from 33 countries, creating a vibrant multi-cultural Centre that extends globally Australia's expertise in coral reefs, to the next generation of researchers and reef managers. The number of research fellows in the Centre also continues to grow very rapidly, from 4 in 2005 to 19 by the end of 2007, and a further 7 will be recruited by mid-2008. Many of our Fellows, Chief Investigators and students received awards and prizes in 2007 (p.48).

A highlight in the coming year will be the launch of Program 6, entitled Conservation Planning for a Sustainable Future (p. 40), which will augment our other applied research activities (p. 30). It will be led by Professor Bob Pressey, who has been recruited to the Centre's headquarters in Townsville (with the support of James Cook University's Strategic Research Leader Program). Program 6 is already attracting students, research fellows and significant consultancies from environmental management agencies, governments and non-government organizations, both nationally and internationally. Other upcoming activities include a trial review of the Centre to be undertaken by Professors Mandy Thomas and Rob Whelan, scheduled for mid-February, followed by a formal review by ARC in the second half of 2008. In mid-year, the Centre will play a major role in the 11th International Coral Reef Symposium in Florida, where members will be co-chairing 8 sessions.

Finally, I'd like to sincerely thank all of the Centre's personnel and our partners around the world (especially in the Australian Institute for Marine Science and the Great Barrier Reef Marine Park Authority), for another outstanding year. I am especially grateful to the Centre's Chief Operations Officer, Jenny Lappin, our Assistant Director, David Yellowlees, and to Louise Taylor and Olga Bazaka, for their hard work, patience and enthusiasm, and to the guidance we receive from our Advisory Board. This coming year, 2008, will be even busier and more productive!

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 to the Centre.

Major research and operational decisions are made by the Centre Director in consultation with the Chief Operations Officer and 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

Vision and strategic advice for the Centre is provided by the Centre Advisory Board. The Board facilitates and advises on improved linkages between the Centre and the private sector, government and the wider community. In 2007, Dennis Trewin was appointed as Chair of the Board. Dennis brings enormous experience and knowledge of government to the role, as the former Australian Statistician. The Board met formally twice in 2007, in March and September.

- **Dennis Trewin (Chair)**
  Former Australian Statistician
- **Professor Norman Palmer**
  Pro-Vice-Chancellor (Research and Innovation)
  James Cook University
- **Professor David Siddle**
  Deputy Vice Chancellor (Research)
  University of Queensland
- **Professor Mandy Thomas /Professor Will Steffan**
  Pro Vice-Chancellor
  Australian National University
- **Dr Ian Poiner**
  Chief Executive Officer
  Australian Institute of Marine Science
- **Honorable Virginia Chadwick**
  Chair
  Great Barrier Reef Marine Park Authority
- **Professor Terry Hughes**
  Centre Director

Scientific Management Committee

High-level operational management of the Centre and planning for its scientific research program is the responsibility of the Scientific Management Committee (SMC). The SMC is chaired by an eminent Israeli researcher, Professor Yossi Loya. Other members are the leaders of each of the Centre's research programs and Director of Science, Technology and Information Group from Great Barrier Reef Marine Park Authority, the Centre's principal industry partner. During 2007 the Committee met formally four times in February, May, August and October. Priorities for 2007 included progressing the targets for the Centre's research programs, continuing to recruit high-quality research fellows, building on our communications strategy and reviewing processes for engaging effectively with the Centre's graduate students. In 2007, the SMC realigned resources to expand the research programs of the Centre by adding a new Program on Conservation Planning (see pxx) which will become operational from 2008.

Committee Members are:

- **Professor Yossi Loya (Chair)**
  Professor of Marine Biology
  The Raynor Chair for Environmental Conservation Research
  Tel Aviv University
  Israel
- **Dr David Wachenfeld**
  Director, Science Technology and Information Group
  Great Barrier Reef Marine Park Authority
- **Professor Malcolm McCulloch**
  Leader, Research Program 1
  Australian National University
- **Professor Sean Connolly**
  Leader, Research Program 2
  James Cook University
- **Professor Garry Russ**
  Leader, Research Program 3
  James Cook University
- **Professor Ove Hoegh-Guldberg**
  Leader, Research Program 4
  University of Queensland
- **Professor Terry Hughes**
  Leader, Research Program 5
  Centre Director
  James Cook University

Membership

Research

- **Professor Terry Hughes**
  Centre Director and Federation Fellow (2002-2007, 2007-2012)
  James Cook University
- **Dr Glenn Almany**
  Research Fellow
  James Cook University
- **Dr Kenneth Anthony**
  Chief Investigator
  University of Queensland
- **Dr Andrew Baird**
  Research Fellow
  James Cook University
- **Dr Line Bay**
  Smart State Fellow (2008-2010)
  James Cook University / AIMS
- **Professor David Bellwood**
  Chief Investigator
  James Cook University
- **Dr Kathleen Broderick**
  Research Fellow
  James Cook University / CSIRO
- **Dr Joshua Cinner**
  Australian Postdoctoral Fellow (2008-2010)
  James Cook University
- **Assoc Professor Sean Connolly**
  Program 2 Leader and Australian Professorial Fellow (2008-2012)
  James Cook University
- **Dr Sophie Dove**
  Chief Investigator
  University of Queensland
- **Dr Simon Dunn**
  Research Fellow
  University of Queensland
- **Dr Toby Elmhirst**
  Research Fellow
  James Cook University
- **Dr Kathryn Ferguson**
  Australian Postdoctoral Fellow (2007-2009)
  James Cook University
- **Dr Simon Foale**
  Research Fellow
  James Cook University
- **Professor Carl Folke**
  Partner Investigator
  Stockholm University
- **Professor Ove Hoegh-Guldberg**
  Deputy Director and Program 4 Leader
  University of Queensland
- **Professor Geoffrey Jones**
  Chief Investigator
  James Cook University
- **Dr Stacy Jupiter**
  Research Fellow
  Australian National University / AIMS
- **Professor Ronald Karlson**
  Partner Investigator
  University of Delaware
- **Professor Michael Kingsford**
  Chief Investigator
  James Cook University
- **Dr Bill Leggat**
  Chief Investigator
  James Cook University
- **Dr Janice Lough**
  Partner Investigator
  Australian Institute of Marine Science
- **Dr Laurence McCook**
  Partner Investigator
  Great Barrier Reef Marine Park Authority
- **Dr Mark McCormick**
  Chief Investigator
  James Cook University
- **Professor Malcolm McCulloch**
  Deputy Director and Program 1 Leader
  Australian National University
- **Dr Susan McIntyre-Tamwoy**
  Research Fellow
  James Cook University
- **Dr Mark Meekan**
  Partner Investigator
  Australian Institute of Marine Science
- **Dr Pippa Moore**
  Research Fellow
  University of Queensland
- **Professor David Miller**
  Chief Investigator
  James Cook University
- **Dr Philip Munday**
  Australian Research Fellow (2003-2007)
  Queen Elizabeth II Fellow (2008-2012)
  James Cook University
- **Professor John Pandolfi**
  Chief Investigator
  University of Queensland
- **Dr Serge Planes**
  Partner Investigator
  University of Perpignan
- **Dr Morgan Pratchett**
  Australian Research Fellow (2007-2011)
  James Cook University
- **Professor Bob Pressey**
  Research Fellow
  James Cook University
- **Dr Guillermo Diaz-Pulido**
  Research Fellow
  University of Queensland
- **Dr Mauricio Rodriguez-Lanetty**
  Research Fellow
  University of Queensland
- **Professor Garry Russ**
  Program 3 Leader
  James Cook University
- **Professor Robert Steneck**
  Partner Investigator
  University of Maine
- **Dr Madeleine Van Oppen**
  Partner Investigator
  Australian Institute of Marine Science
- **Professor Bette Willis**
  Chief Investigator
  James Cook University

- **Dr Shaun Wilson**
  Research Fellow
  James Cook University
- **Professor David Yellowlees**
  Chief Investigator
  James Cook University

Visiting Scholars

- **Dr Stefan Gelcich**
  Universidad Catolica de Chile
- **Dr Akira Nishikawa,**
  Japan Society for Promotion of Science
- **Dr Jon Norberg**
  Stockholm University
- **Dr Per Olsen**
  Stockholm University
- **Dr Lucie Penin**
  Université de Perpignan
- **Dr Willem Renema**
  Natinaal Natuurhistorisch Museum
  Naturalis

Technical Staff

- **Lewis Anderson**
  James Cook University
- **Mary Boyle**
  James Cook University
- **Andrew Christian**
  Australian National University
- **Jennifer Donelson**
  James Cook University
- **Claire Farnsworth**
  James Cook University
- **Andrew Hoey**
  James Cook University
- **Emily Howells**
  James Cook University
- **Mizue Hisano**
  James Cook University
- **Les Kinsley**
  Australian National University
- **Selma Klanten**
  James Cook University
- **Kathryn Markey**
  James Cook University
- **James Moore**
  James Cook University
- **Graham Mortimer**
  Australian National University
- **Cathie Page**
  James Cook University
- **Nela Rosic**
  University of Queensland
- **Maya Srinivasan**
  James Cook University
- **Lubna Ukani**
  James Cook University
- **Sharon Wismer**
  James Cook University

Business Team

- **Jennifer Lappin**
  Chief Operations Officer
- **David Yellowlees**
  Assistant Director
- **Olga Bazaka**
  Finance Manager and Graduate Coordinator
- **Lianne de Gunzbourg**
  Project Officer
- **Louise Taylor**
  Office Manager and KPI Officer

Graduate Students

(see page 24)

Research Program Leaders

Professor Malcolm McCulloch

Professor Malcolm McCulloch is one of the Centre's two Deputy Directors and 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), Fellowship of the Geological Society of Australia (2007) and the American Geophysical Union (2002) and in 2007 was awarded an Honorary Doctorate from Curtin University. His 208 scientific papers have been published in leading international journals including 22 in Science or Nature.

Associate Professor Sean Connolly

Associate Professor Sean Connolly is Leader of *Program 2: Understanding and Managing Coral Reef Biodiversity*. Sean combines mathematical and statistical modelling with fieldwork and laboratory experiments to study the dynamics of biological turnover at all scales, including population dynamics, species interactions and biodiversity, and macroevolution. He received his doctorate in 1999 from Stanford University in California, USA for research on the ecology of rocky shores. In 1999-2000, he was a postdoctoral research fellow at the University of Arizona, USA, where he examined global dynamics of marine biodiversity in the fossil record. In 2000, he was recruited to JCU to develop and lead a research program in ecological modelling applied to coral reefs. Sean has 28 publications in leading international journals, including 5 in *Science* or *Nature*, and he has supervised 8 PhD, 4 Masters, and 7 Honours students since 2001. He has recently been awarded an Australian Professorial Fellowship by the Australian Research Council, taking on this new leadership role within the ARC Centre.

Professor Garry Russ

Professor Garry Russ is Leader of P*rogram 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 applied 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 in 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 Alcala.

Professor Ove Hoegh-Guldberg

Professor Ove Hoegh-Guldberg is the other Deputy Director and 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 9 in *Science* or *Nature*.

Professor Terry Hughes

Professor Terry Hughes is the Director of the ARC Centre of Excellence and Leader of *Program 5: Resilience of linked social-ecological systems*. He is a member of the newly established ARC Advisory Council and is on the Advisory Panel for the Australia-India Strategic Research Fund. 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 moved to 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 Science in 2001 in recognition of "a career which has significantly advanced the world's store of scientific knowledge". As Centre Director, Terry provides academic leadership and is responsible for the strategic development of the Centre. He has published over 80 influential scientific papers on the biology and management of coral reefs, including 21 in *Science* or *Nature*.

Research

Program 1 – Evolutionary and environmental change

Researchers

- Malcolm McCulloch (Program Leader)
- Sean Connolly
- Ove Hoegh-Guldberg
- Terry Hughes (Research Fellow)
- Stacy Jupiter (Research Fellow)
- Michael Kingsford
- Janice Lough
- Pippa Moore (Research Fellow)
- John Pandolfi
- Willem Renema (Visiting Research Fellow)
- Robert Steneck

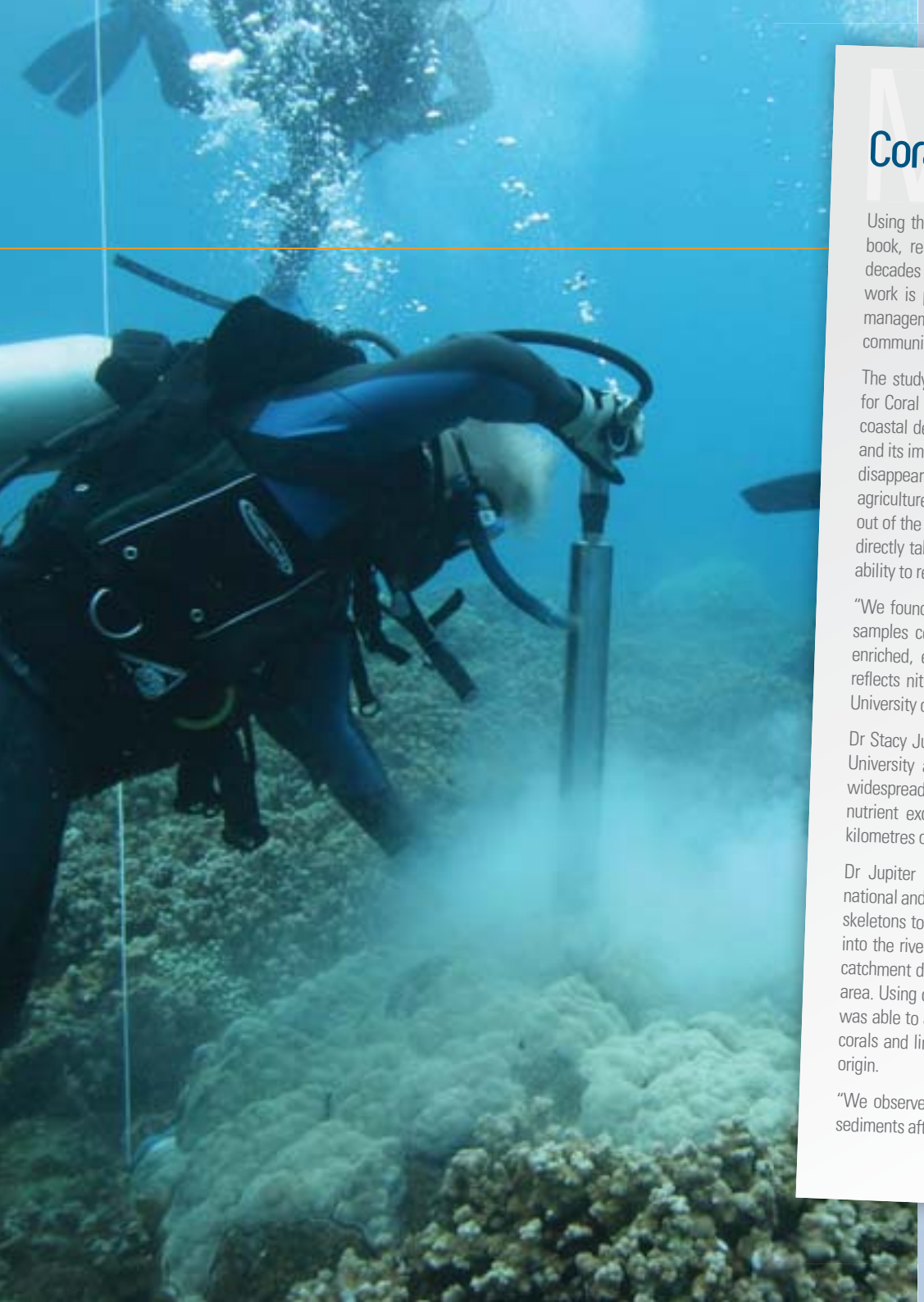
Knowledge of the past improves our ability to predict future influences of natural environmental variability, human impacts, and climate change on coral reefs. Centre researchers use fossil and historical records to develop novel methods to identify potential causes of global change in biodiversity and ecosystem function. Together with ecological studies, this broad array of work provides a unique perspective on community change that ranges from centuries to millennia.

Researchers from the UQ and ANU nodes, led by Professor John Pandolfi and Professor Malcolm McCulloch utilize regional patterns of biodiversity in coral reefs to explore the influence of past and future climate change. In the Last Interglacial period, coral reefs grew along the Western Australian coastline, ~125,000 years ago. During this period, global temperatures were several degrees warmer and sea levels were up to 4 to 5 metres higher due to more extensive melting of land-based icesheets. This occurred as a result of increased solar radiation being received in the northern hemisphere, an outcome of relatively subtle changes in the Earth's orbital parameters. Warmer temperatures also resulted in prolific growth and expansion of coral reefs to higher latitudes, especially along the relatively arid margins of the Western Australian coastline. Results from our studies show that, in the absence of mankind's footprint, and given sufficient time, coral reefs can adapt to the effects of global warming. Furthermore, the higher sea-levels associated with warmer conditions of the Last Interglacial period provide a benchmark for understanding future rises in sea level. The response of corals on the Great Barrier Reef to climate change is being evaluated using the novel geochemical method of boron isotopic variations which directly reflects changes in seawater chemistry. Using cores from long-lived corals, research being undertaken by Malcolm McCulloch, Janice Lough and colleagues is showing substantial environmental shifts from pre-industrial times to today. These shifts generally correlate with the steady increase in the levels of greenhouse CO2, but they also show unexpectedly large fluctuations, indicating the dynamic nature of seawater chemistry. These changes point to a more complex trajectory of future climate change.

Program 1 and 2 researchers, John Pandolfi and Sean Connolly, have focussed this year on the application of neutral theory to coral reef communities, using fossil data from Pleistocene coral communities in Barbados. Program 1 and 5 reseachers are also examining long-term changes in the paleoecology and ecology of the Great Barrier Reef and Moreton Bay, to establish base-line conditions, for comparison with modern communities. Fieldwork in 2007 by John Pandolfi and his students has included coring fieldtrips to the Palm Island Group (near Townsville) and Moreton Bay (close to Brisbane) to obtain major data set on past community structure change in nearshore GBR coral reefs and sub-tropical marginal habitats of SE Queensland. Pandolfi and colleagues have also established a group, Network for Ecological Baselines into Environmental Law, interested in using the history of ecosystem health to set enforceable benchmarks for ecosystem rehabilitation. Partners include the National Environmental Law Association, the Environmental Defenders Office, and the Australian Conservation Foundation.

Program 1 and 4 researchers are also examining long-term changes in water quality in the Mackay-Whitsunday region of the central Great Barrier Reef. The project is supported by the Mackay City Council, the Mackay-Whitsunday Natural Resource Management Group and Great Barrier Reef Marine Park Authority.

In October 2007, Program 1 extended its network overseas by convening a workshop on "Coral Reef Indicators of Land-Based Pollution" in Mombasa, Kenya. Twenty-two scientists and reef managers from eight countries (Australia, Comoros, Italy, Kenya, Netherlands, Tanzania, UK, and the USA) presented talks. Given the setting in East Africa, special attention was focused on the challenges that developing nations have in protecting reef resources.



Media Release

Corals reveal impact of land usage

31 May 2007

Using the corals on the Great Barrier Reef (GBR) as a history book, researchers have linked land use along the coast to decades of declining water quality and poor coral health. Their work is pioneering the development of new tools for better management of the quality of Australia's coastal waters by the communities that depend on them.

The study by researchers from the ARC Centre of Excellence for Coral Reef Studies focuses on the hundred-year history of coastal development around the Queensland town of Mackay and its impact on nearby coral reefs which have been gradually disappearing. According to the study a history of land clearing, agriculture and flooding is linked to nutrient rich waters flowing out of the Pioneer River catchment. These excess nutrients are directly taken up by coastal corals, affecting their survival and ability to recover from adverse conditions.

"We found that the nitrogen isotopes from particles in water samples collected all along the catchment area were highly enriched, especially in the lower reaches of the river. This reflects nitrogen from fertilisers," said Dr Guy Marion of The University of Queensland and CoECRS.

Dr Stacy Jupiter, a research fellow at the Australian National University and CoECRS said inshore reefs were covered in widespread stands of algae, a condition that may reflect chronic nutrient excess. "The reef condition didn't improve until 50 kilometres offshore," Dr Jupiter said.

Dr Jupiter said while the study is local, its findings have national and even global significance. The study also uses coral skeletons to reveal the history of nutrient and sediment runoff into the river and coastal waters from human activities in the catchment dating back to European settlement of the Mackay area. Using coral skeletons more than a century old, the team was able to analyse chemicals and sediments taken up by the corals and link them geochemically to their place and time of origin.

"We observed a large increase in the delivery of land-based sediments after the surrounding areas were cleared for farming in the late 19th century," said Dr Marion. "After World War II, when fertilisers were used to increase sugar cane production, the coral records reveal substantial accumulations of fertiliser-derived nutrients in near-shore GBR waters. This is a global issue because development is taking place in coastal areas all over Australia and around the world. This is the first time corals have been used to trace the history and origin of nutrients in the marine environment and link changes in water quality back to changes taking place on the land."

The study's findings will be presented at a public workshop meeting at the Mackay Botanical Gardens on Friday, June 1. The meeting will feature leading researchers from CoECRS as well as representatives from local, regional and federal management agencies.

"We hope we have increased the available information for assisting in better management of coastal land as well as identifying significant environmental risks for the Great Barrier Reef," said UQ's Professor Ove Hoegh-Guldberg, a project leader. "The changes indicate that this is something that we should all be paying serious attention to. We hope to create discussion between the stakeholders, the scientists and the public so these results can be used to better manage the area."

The meeting will highlight the "four-pronged" approach taken in the investigation into the history of changes in the land and the decline in water quality. These comprise the history of development and clearing since pioneer settlement in the area; the chemical composition of water from points along the river and out to sea; the chemical composition of coral skeletons dating back before European settlement; and the varying health of coral communities extending from the mouth of the river to far out to sea.

"There is potential to use these tools to manage our coastal environments and water quality right round Australia and even worldwide," said Dr Jupiter. "The impact on our long-term understanding of change in Australia's coastal areas is highly significant."

Research

Program 2 – Understanding and Managing Coral Reef Biodiversity

Researchers

- Sean Connolly (Program Leader)
- Andrew Baird (Research Fellow)
- David Bellwood
- Guillermo Diaz-Pulido (Research Fellow)
- Terry Hughes (Research Fellow)
- Geoffrey Jones
- Ronald Karlson
- Pippa Moore (Research Fellow)
- Philip Munday (Research Fellow)
- John Pandolfi
- Lucie Penin (Visiting Research Fellow)
- Morgan Pratchett (Research Fellow)
- Robert Steneck
- Shaun Wilson (Research Fellow)

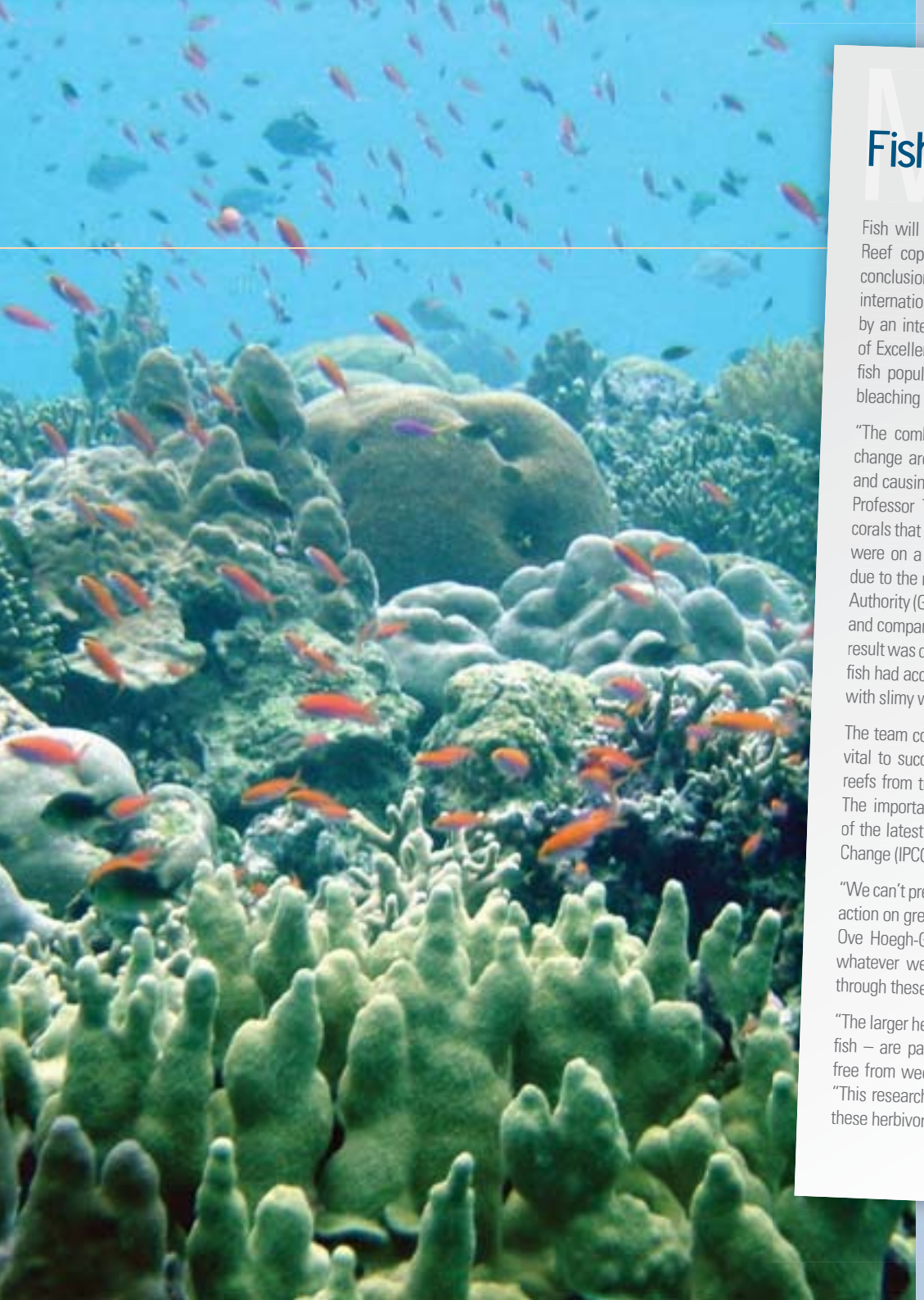
Program 2 aims to understand the mechanisms and processes that maintain coral reef biodiversity, using a combination of mathematical modelling and field studies. This multi-disciplinary approach informs knowledge-based management of biodiversity resulting in environmental, social and economic benefit to tropical maritime nations.

The effects of climate change on coral reef biodiversity has emerged as a major new research thrust within Program 2. Activities in this area included the establishment of new research collaborations, recruitment of new staff, new research findings and syntheses of existing knowledge, as well as direct communication of research findings to end-users: Program 2 hosted a workshop on the effects of global warming on coral reef fishes in February 2007, which culminated in a major review paper for *Oceanography and Marine Biology*: an Annual Review (Pratchett et al. in press). Philip Munday also wrote the first comprehensive assessment of the impacts of climate change on fishes of the Great Barrier Reef in a book (*Climate Change and the Great Barrier Reef: A Vulnerability Assessment*) published by the Great Barrier Reef Marine Park Authority. New collaborative links with one of the world's leading overseas research teams on global climate change and coral reef fishes (based at the University of Newcastle, UK) were strengthened with the appointment of a co-funded research fellow, Shaun Wilson. In addition, Australian Research Fellow, Morgan Pratchett, will use a prestigious Churchill Fellowship to spend two months at the University of Newcastle in 2008.

A joint initiative involving both Program 1 and 2 on 'Indo-Pacific biodiversity through time,' led by John Pandolfi and David Bellwood, is continuing. The project involves leading researchers from Australia, Europe and Southeast Asia, who are assessing a range of geological and ecological information around the central theme of the plate tectonic development of SE Asia and the effect of this changing geological and oceanographic framework on the development of coral reefs, sea-grass and mangrove biota. The prime focus of the work is to assemble and interpret faunal turnover and to investigate how the Indo-Pacific longitudinal diversity gradient has responded to these changes. This working group is the basis of a session on 'Biotic response to ancient environmental change in Indo-Pacific coral reefs' for the 11th International Coral Reef Symposium (Florida, 2008)

A team of eight researchers from Program 2 and 5, led by 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 a paper published in February 2007 (see opposite), 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. The study is already being widely used by reef managers to justify the establishment of no-take areas as tools for managing biodiversity and ecological resilience.

Maria Dornelas was recruited at the end of 2007 as a Research Fellow for Program 2. She joins the Centre from the Gatty Marine Laboratory, at the University of St Andrews, UK. Sean Connolly, Program 2 Leader, was awarded an ARC Australian Professorial Fellowship for 2008-2012, and Philip Munday received an ARC Queen Elizabeth II Fellowship for the same period. Both of the new ARC Fellowships are co-funded by the School of Marine and Tropical Biology at JCU.



Media Release

Fish: Healthcare Workers of the Reef

9 February 2007

Fish will play a vital role in helping Australia's Great Barrier Reef cope with the ravages of climate change. That's the conclusion of a major scientific paper published today in the international journal *Current Biology*. A dramatic experiment run by an international team of researchers from the ARC Centre of Excellence for Coral Reef Studies has shown that a healthy fish population is essential for coral recovery after a severe bleaching event, storm or disease outbreak.

"The combined effects of overfishing, pollution and climate change are seriously damaging coral reefs around the world and causing their replacement by weedy growth," team leader Professor Terry Hughes said. "We followed the recovery of corals that had been severely damaged by bleaching. The corals were on a reef where fish populations were unusually intact due to the no-take policy of the Great Barrier Reef Marine Park Authority (GBRMPA). We also 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 slimy weed and the corals failed to recover."

The 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. The importance of this result is accentuated by the findings of the latest report of the Intergovernmental Panel on Climate Change (IPCC).

"We can't prevent future bleaching except through international action on greenhouse gas emissions," said co-author Professor Ove Hoegh-Guldberg. "In the meantime, it's important to do whatever we can to minimize the damage and assist reefs through these difficult times."

"The larger herbivorous fishes – such as parrot fish and surgeon fish – are particularly important in keeping recovering corals free from weedy overgrowth," Professor Dave Bellwood said. "This research indicates it is important to avoid overfishing of these herbivores at all costs."

"For reefs to withstand the rigours of climate change, they need to be resilient – able to bounce back after a severe shock such as a bleaching episode, an outbreak of disease or a hurricane," Australian Research Fellow Morgan Pratchett said. "That means maintaining the richness and diversity of their assemblages of coral, fish and other animals."

A sixth of all the world's coral reefs were hit during a recent major heating event (1998-99), pointing to the potential scale of climate impacts. In many areas already affected by human activity such as pollution and overfishing, they have not yet recovered.

"As the world continues to warm, it's only a matter of time before the next major bleaching event occurs. Once corals are replaced by weed – known as a phase shift – it is extraordinarily difficult, if not impossible, to bring them back again," Prof Hughes said.

"This experiment shows that one way to prevent a phase shift from taking place is to have an intact population of herbivores ready to pounce on any weeds that may sprout before the corals can regenerate," Prof Bellwood said. "Herbivorous fish are rarely caught by professional fishermen in Australia – though they are still hunted by spear fishers - but around the world they are under remorseless pressure. Over time this could lead to the permanent loss of huge swathes of coral reef with serious consequences for communities which depend on them."

Fellow author and Research and Monitoring Manager with GBRMPA, Dr Laurence McCook, said the research provided valuable information for the protection of the Great Barrier Reef. "This study shows that no-take areas such as those applied on the Great Barrier Reef in the Green Zones made important contributions to the Reef's resilience. Maintaining resilience is a vital aspect of reef management." A priority for GBRMPA is to build the Reef's resilience through initiatives such as no take zoning and reducing water pollution."

Research

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)
- John Pandolfi
- Serge Planes
- Morgan Pratchett (Research Fellow)
- 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 endeavour. Program 3 has made remarkable breakthroughs, published in *Science* and *Nature*, in developing new technologies that can tag and track the movement of larvae. In 2007, the David and Lucille Packard Foundation awarded a substantial 3-year grant, entitled "Evaluating the effectiveness of Marine Protected Areas: Quantifying larval export from coral reef sanctuaries in Papua New Guinea and the Great Barrier Reef", to Simon Thorrold (Woods Hole Oceanographic Institute), Glenn Almany, Geoff Jones, Garry Russ and Rick Hamilton (The Nature Conservancy). This grant is specifically to support field trials of novel larval tagging techniques. Additional co-funding for work on the Great Barrier Reef has also been received from the Reef and Rainforest Research Centre (supported by the Commonwealth Environmental Research Fund).

In Australia, extensive larval marking experiments (using Barium isotopes) and DNA sampling were carried out in late 2007 on commercially and recreationally important species of reef fishes in the Keppel Islands. These experiments employed enriched isotope larval markers to quantify self-recruitment and dispersal among adjacent subpopulations. The research was specifically designed to assess the magnitude of larval export from green zones on the Great Barrier Reef. Over 6000 fishes (of various species) from three different green zones in the Keppel islands were caught, tagged (tags courtesy of Suntag) and released. Recreational fishers from the Keppel Bay and Gladstone Sportfishing Clubs worked alongside researchers from the ARC Centre and James Cook University to capture, tag and release reef fish within Marine National Park (green) zones of the Keppel Island group. The total fishing effort contributed to the project was 196 vessel-days or 503 fisher-days. All captured coral trout (*Plectropomus spp.*), stripey snapper (*Lutjanus carponotatus*) and long-finned rockcod (*Epinephelus quoyanus*) were injected with a small dose of enriched stable isotope barium chloride (BaCl2) solution and fin-clipped for a DNA sample. The barium injection provides a unique trans-generational marker which is passed from female fish to their offspring. Recruit (juvenile) fish will be collected from reefs in the Keppel Island group between March and June 2008 and screened to determine larval dispersal patterns. This ambitious field experiment has major significance to a key stakeholder, the Great Barrier Reef Marine Park Authority. Similar larval tagging experiments associated with marine reserve connectivity are underway or planned for PNG, Belize and the Philippines.

In October 2007, Program 3 and 2 launched a new working group entitled "Connectivity and population resilience – sustaining coral reefs during the coming century", in Townsville. The working group is a partnership between the ARC Centre of Excellence and the connectivity projects of the World Bank GEF Coral Reef Targetted Research and Capacity Building for Management Project, led by Peter Sale. Twenty-eight of the world's leaders in the field of coral reef connectivity, from 7 different countries, participated. A major focus was the impact that rapid climate change will have on connectivity in coral reef ecosystems. These changes have important implications for the management of coral reef ecosystems, especially for the design and placement of marine protected areas. The major outputs of this working group are being prepared as an invited set of 6 papers for a "Theme Section" in *Coral Reefs*.

Research Fellow Glenn Almany spent 2007 on secondment with the Brisbane headquarters of The Nature Conservancy, collaborating on numerous projects now underway in PNG, Indonesia and the Solomon Islands.

Media Release

Baby fish "smell their way home"

22 January 2007

Marine scientists working on Australia's Great Barrier Reef have uncovered evidence that baby fish, only millimetres long, manage to find their way to their home coral reef across miles of open sea by using their sense of smell. Remarkable in itself, the discovery by a team including Professor Mike Kingsford of the ARC Centre of Excellence for Coral Reef Studies and James Cook University and colleagues from Woods Hole, USA, also shines a new light on how the breathtaking diversity of fish on coral reefs has arisen. This has major implications for how reefs are managed.

"The babies of many coral fish species are swept off their home reef by ocean currents within days of hatching. Ordinarily you'd expect them to be thoroughly mixed up and this would mean the population of one reef would be pretty much the same, genetically, as another," he says. "But that is not the case. There are major genetic differences between fish of the same species on reefs only a few kilometres or even hundreds of metres apart."

This diversity between populations of the same fish species is what drives evolution on the Reef and underpins the spectacular richness of its sea life, Prof. Kingsford says. "This genetic separation between reefs may be what gives rise to so many different species in coral reef systems."

The researchers were intrigued how tiny damsel and cardinal fish, born on one reef, managed to find their way back home to preserve such remarkable population differences, braving strong currents and ferocious predators in their 20 days at sea – all when only a centimetre or so in size.

"We tested several ideas, but the most attractive seemed to be that they could smell the unique trace of their home reef – rather like salmon can smell the home river. We know these late stage fish larvae, generally between about 9 and 14mm long, already have developed noses – but the question was whether they could use them to recognise what the home reef smelt like, when they left it only a day or so after hatching."

The team exposed tiny fish larvae in a tank to pure streams of water from four different reefs. To their amazement, within minutes a surprisingly high percentage of baby fish had congregated in the water flow from their home reef.

"It was a lot more than you'd expect to happen by pure chance – and it applied, in differing degrees, across several species of fish," Mike says.

The fish could also be responding to other stimuli, including distant noise off a reef and the behaviour of other fish, but the team concluded that smell was probably the dominant factor leading the babies home. "Every reef gives off its own unique chemical signature, a rich mixture of the proteins and amino acids emitted by corals, all the plankton and mucus from its life. We think baby fish can pick this up and distinguish it from other reefs. We think some fishes then choose currents that smell like 'home' and swim up them. The ones that cannot do this perish. The ones that get home preserve the unique 'ethnic' make-up of their tribe – and so continue the process of evolving into separate new species."

How the fish learn the unique smell of home is a mystery still. The researchers theorise that it is imprinted on them either when they are an egg inside their mothers, a fertilised egg swept around on the bottom, or new-hatched fry loose in the stream or brooded in their parents' mouths.

"An egg, even a fry, hasn't a fully developed sense of smell, but it may have a way of absorbing the local molecules and then recognizing their signature as "home" when it grows up a bit and is ready to settle," Mike says. "This evidence that individual coral reefs play such a key role in the emergence of new species is a fresh reason to take even greater care in how we look after them."

The research has been published in the Proceedings of the US National Academy of Sciences on January 16, 2007.

Research

Program 4 – Genetic, molecular and physiological processes

Researchers

- Ove Hoegh-Guldberg (Program Leader)
- Ken Anthony
- Line Bay (Research Fellow)
- Guillermo Diaz-Pulido (Research Fellow)
- Sophie Dove
- Simon Dunn (Research Fellow)
- Bill Leggat
- David Miller
- Madeleine van Oppen
- Mauricio Rodriguez-Lanetty (Research Fellow)
- Bette Willis
- David Yellowlees

Program 4 draws on researchers across multiple nodes to understand coral reef organisms at a molecular and physiological level, and to examine potential mechanisms of coral reefs 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. The Centre's standing in this area of research was recognized by the Intergovernmental Panel on Climate Change (IPCC), with two Centre members (Hoegh-Guldberg, Hughes) contributing to the influential 2007 IPCC assessment report.

The Centre is building new strengths in genomics and microarray technologies, and in 2007 Centre researchers continued to develop novel EST libraries for both the coral host and their algal symbionts. These sequences constitute the gene complement used to construct microarrays which have the potential to revolutionise our understanding of the molecular and physiological processes in corals. David Miller and his colleagues in the ARC Special Research Centre for the Molecular Genetics of Development have established a number of EST libraries for the coral *Acropora millepora*. These libraries are currently being used to examine the impact of thermal stress on corals using experimental temperature manipulations that are consistent with a range of climate change projections. Ove Hoegh-Guldberg, Bill Leggat, Sophie Dove and David Yellowlees have also established an EST library for *Symbiodinium* clade C3, which they are using to investigate a range of previously unknown physiological processes in corals and other invertebrate-dinoflagellate associations.

Numerous projects in Program 4 are investigating symbiont acquisition, and the potential for corals to select among potentially competing strains of zooxanthellae (Madeleine van Oppen, Line Bay, Gomez-Cabrerra, Guillermo Diaz-Pulido, Mauricio Rodriguez-Lanetty and others). The role of temperature as a driver in coral disease dynamics is also a major focus. (This work, by Bette Willis and colleagues, was cited in Federal Parliament in a debate on renewal of the Great Barrier Reef Marine Park Act). Progress has also been made with major technological advances in the development of RNAi in corals (Simon Dunn).

Collaborators in Programs 2 and 4 (Andrew Baird, Madeleine van Oppen, Sean Connolly, Bill Leggat) have completed a global map of the biodiversity of zooxanthellae, the one-celled algae that inhabit corals and provide them with most of their energy needs. Because different types of zooxanthellae differ in their tolerance for high temperatures and other environmental stresses, knowing their global distributions is critical to assessing corals' capacity to adapt to global warming.

In January 2007, Program 4 and the National Science Foundation (NSF) co-sponsored a joint workshop. This collaborative undertaking brought together over 60 researchers on Heron Island Research Station to improve understanding of the cellular and molecular biology of symbiosis, and how this new knowledge could potentially provide tools for reducing the impacts of rapid climate change on coral reefs. A CD of the presentations was produced. In April 2007, Bette Willis led a capacity-building workshop for East African coral reef managers, sponsored by the World Bank GEF Program, with further support from the ARC Centre, and a consortium of government agencies and NGOs.

Media Release

Key found to moonlight romance

19 October 2007

An international team of Australian and Israeli researchers has discovered what could be the aphrodisiac for the biggest moonlight sex event on Earth. An ancient light-sensitive gene has been isolated by researchers from the ARC Centre of Excellence for Coral Reef Studies that appears to act as a trigger for the annual mass spawning of corals across a third of a million square kilometres of Australia's Great Barrier Reef, shortly after a full moon. The genes, known as a cryptochromes, occur in corals, insects, fish and mammals - including humans - and are primitive light-sensing pigment mechanisms which predate the evolution of eyes.

In a new paper published in the international journal *Science* today, the team, headed by Marie Curie Scholar Dr Oren Levy, of the University of Queensland reports its discovery that the Cry2 gene, stimulated by the faint blue light of the full moon, appears to play a central role in triggering the mass coral spawning event, one of nature's wonders.

Professor Ove Hoegh-Guldberg, who leads the laboratory in which the genes were discovered, said "This is the key to one of the central mysteries of coral reefs. We have always wondered how corals without eyes can detect moonlight and get the precise hour of the right couple of days each year to spawn."

What allows corals to spawn simultaneously along the immense length of the Great Barrier Reef - and also in other parts of the world - has been a scientific mystery till now, though researchers knew that tide, water temperature and weather conditions played a part, says Dr Levy. However the remarkable synchronisation of spawning occurring all along the Reef immediately following a full moon suggested that moonlight was a key factor.

Exposing corals to different colours and intensities of light and sampling live corals on reefs around the time of the full moon, Dr Levy found the Cry2 gene at its most active in Acropora corals during full moon nights. "We think these genes developed in primitive life forms in the Precambrian, more than 500 million years ago, as a way of sensing light," he explains. "The fact they are linked with the system that repairs damage from ultraviolet (UV) radiation suggests they may evolved in eyeless creatures which needed to avoid high daytime UV by living deep in the water, but still needed to sense the blue light shed by the moon to synchronise their body clocks and breeding cycles."

"They are, in a sense, the functional forerunners of eyes," Professor Hoegh-Guldberg said. In humans, cryptochromes still operate as part of the circadian system that tunes us to the rhythms of our planet, though their light-sensing function appears lost to us, he went on to explain.

"They play important roles in regulating the body-clocks of many species, from corals to fruit flies, to zebra fish and mice. The proteins they produce are similar to those in humans and other mammals, though they appear to function more like those in the fruit fly," says Professor David Miller of JCU.

The coral cryptochrome genes were initially identified by Dr Levy and Dr Bill Leggat working with Professor Hoegh-Guldberg (UQ) on Heron Island. Prof. Miller and Dr David Hayward, of the Australian National University, were able to add information on the coral cryptochromes from a large library of coral genes that they have been compiling (so far they have catalogued about 10,000 out of an estimated 20-25,000 genes in coral), and leading circadian clock biologists from Bar-Ilan and Tel-Aviv Universities in Israel played important roles in interpreting the data.

"Many of these genes developed in deep time, in the earliest phases of organised life on the planet," Dr Leggat says. "They were preserved for hundreds of millions of years before being inherited by corals when they developed about 240 million years ago, and are still found today in modern animals and humans. They are an indicator that corals and humans are in fact distant relatives, sharing a common ancestor way back."

Research

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)
- Toby Elmhirst (Research Fellow)
- Kathryn Ferguson (Research Fellow)
- Simon Foale (Research Fellow)
- Carl Folke
- Laurence McCook
- Susan McIntyre-Tamwoy (Research Fellow)
- Jon Norberg (Visiting Research Fellow)
- Per Olsen (Visiting Research Fellow)
- John Pandolfi
- Bob Pressey (Research Fellow)
- 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.

Simon Foale has been engaged since 2007 in ongoing consultancy work 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. He has also been engaged, since 2006, in an ongoing large-scale social and economic survey project in the Solomon Islands, again with Ausaid, the outputs of which are pivotal to the formulation of Australia's aid policies on governance and capacity building in a politically volatile region.

In 2007 the Centre signed a Memorandum of Understanding with the Stockholm Resilience Centre to cooperate and collaborate in areas of mutual interest in research. As part of this initiative, two Visiting Fellows, Jon Norberg and Per Olsen, have undertaken new research projects at JCU, while Terry Hughes and Joshua Cinner visited Stockholm in 2007. A range of other joint activities have been established, including working groups jointly funded by both organizations.

A novel study by Per Olson, Carl Folke and Terry Hughes has analysed the strategies and actions that enable transitions towards ecosystem-based management, using the recent governance changes of the Great Barrier Reef Marine Park as a case study. The study focuses on interplay between individual actors, organizations, and institutions, particularly the Great Barrier Reef Marine Park Authority. This agency was instrumental in the transformation of the Reef's governance regime and provided leadership throughout the recent re-zoning process. The strategies identified in this study involved internal reorganisation and management innovation, leading to an ability to coordinate the scientific community, to increase public awareness of environmental issues and problems, to involve a broader set of stakeholders, and to manoeuvre the political system for support at critical times. The transformation process was triggered by increased pressure on the Great Barrier Reef (from terrestrial run-off, over-harvesting, and global warming) that triggered a new sense of urgency to address these challenges. It shifted the focus of governance from protection of selected individual reefs to stewardship of the larger-scale seascape. The study emphasizes the significance of stewardship that can change patterns of interactions among key actor and allow for new forms of management and governance to emerge in response to environmental change.

Joshua Cinner leads a new team that is conducting extensive field work in Kenya, Tanzania, Madagascar, Mauritius and the Seychelles on social and economic aspects of coral reef management. In 2007, this work included the training of eight scientists and four NGO and government employees in socio-economic data collection and analysis, in Mombasa. Outcomes from the research included the adoption of policies to regulate the use of destructive fishing gear by the Tanzania Fisheries Department.

Toby Elmhirst, a mathematician, was recruited from Canada in 2007 as a Centre Research Fellow in Program 5. His research focuses on chaos theory, thresholds, and how networks of protected areas influence the resilience of coupled social-ecological systems. The work bridges Programs 2, 3, and 5, and is co-funded with the Resilience Alliance, and the Applied Environmental Decision Analysis Centre at the University of Queensland.

Media Release

Investigating the trochus "El Dorado"

12 February 2007

Scientific and indigenous knowledge must join together to better manage disappearing marine resources in developing countries, such as shark, trochus, and sea cucumber stocks on the islands to Australia's north. That's the view of Dr Simon Foale, a research fellow with the ARC Centre of Excellence for Coral Reef Studies, who studies coral reef fisheries in the Solomon Islands as they undergo rapid and dramatic change.

"Cultures change as the societies become more modern… the people become more detached from old beliefs and traditions erode," says Foale. "Once large amounts of money enter a region, it undergoes an abrupt power shift and the traditions are marginalised," he says.

"Traditionally, Melanesian cultures believe in nature spirits… it is seamlessly part of nature and part of their culture…They would manage their reefs by prohibiting fishing for periods of time. Anyone who broke these rules would come under a curse.

"But traditional management tends to fall apart when the external pressure increases. When global markets expand, demand rises and marine products command high prices, the traditional rules are no longer sufficient to prevent overfishing," says Foale.

In studies of the Solomon Islands Trochus fisheries (a mollusc whose pearly shell has been a valuable source of cash for almost two centuries for Pacific Islanders) Foale found that gaps in the locals' knowledge of the species were making their harvesting practices unsustainable.

"The Nggela people have a tradition of harvesting trochus during a certain time in the lunar cycle when they are easier to find. However, while they identified these times as good for harvesting, they seemed oblivious to the fact that the trochus are breeding at that time too. "They assumed the trochus they harvested were replaced by individuals from an "El Dorado" of trochus living in deeper water that wandered up to shallower parts of the reef.

"A large part of this problem is that fishers are unaware of the connection between the adult fish populations and the rate of supply of larvae that replenish those populations. When people are unaware of the reproductive cycle of fish, where spawned eggs and sperm combine in the sea to produce microscopic larvae that disperse and later settle to become juveniles, they tend to attribute the control of fish populations to other factors, including supernatural forces," he says.

While these beliefs remain and the pressure to harvest continues, Foale argues that these gaps in knowledge influence the Nggela people to believe they are not responsible for declines in the numbers of trochus.

"Fishers in many parts of the Pacific commonly fail to make the connection between their fishing activity and the decline or collapse of fish and marine stocks," he says.

Foale argues that sharing cultural and scientific knowledge is essential to improving coral reef and fish stock management in developing countries, which usually have little or no access to information through libraries, scientists and the internet.

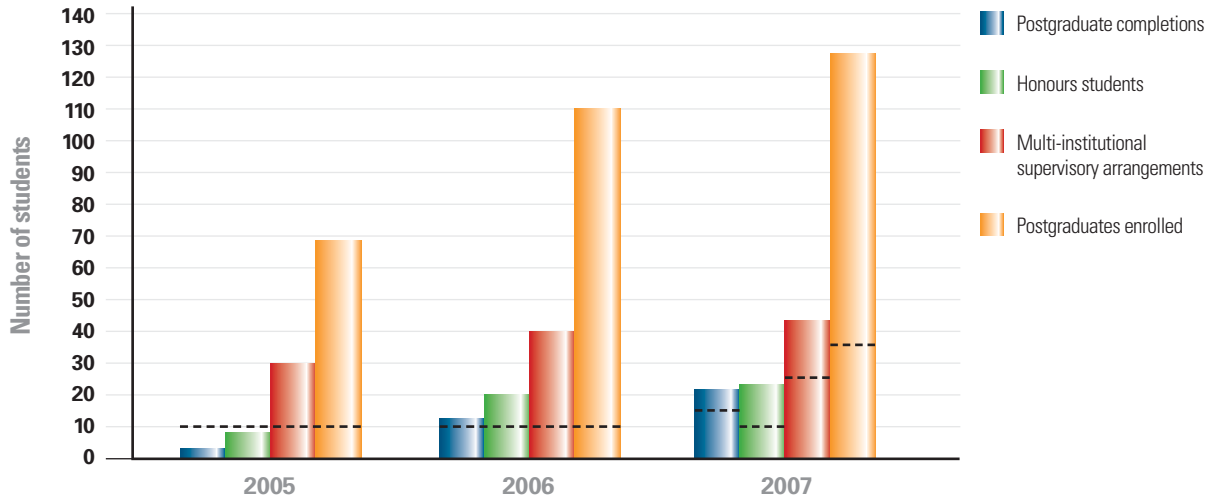
"The scientific community can contribute much to sustainable marine management in developing countries, but it is critical that when they deliver it they understand the cultural, economic and political context, and the beliefs of the local people," says Foale "Sharing knowledge is a two way process. There is a huge amount of knowledge in the heads of a both fisherpeople and scientists. Combining the two sets of knowledge, wherever possible, will make for better management of marine resources."

Graduate Training

The Centre's goal is to build human capacity and expertise in coral reef science, by supporting and training outstanding students. The Centre provides a unique opportunity for Australian and non-Australian graduate students to receive research training (at the Honours, Masters and PhD level) in coral reef science, with opportunities for multi-disciplinary and multi-institutional supervision. Over a quarter of our ARC Centre budget is earmarked to support the research costs of these student projects. The Centre actively involves students through a Student Committee which manages an annual allocation of $40,000 for student mentoring activities, student awards and internodal visits. Five $1000 prizes for the ARC Centre's Best Student Papers for 2007 were awarded to **George Roff** (UQ), **David Feary** (JCU), **Jacob Johansen** (JCU), **Cathie Page** (JCU) and **Marian Wong** (JCU).

The ARC Centre of Excellence is the world's largest provider of graduate training in coral reef science. In 2007, 108 PhD, 21 Masters, and 23 Honours students were supported and supervised by Centre personnel. Forty-six of our graduate students have multi-institutional supervisory arrangements, a 60% increase since the Centre's establishment in 2005 (see graph, right). At JCU, 18 of the Centre's students are also members of AIMS@JCU, with supervisory arrangements involving both institutions.

Multi-nodal (video-conferenced) research seminars and discussion groups were introduced in 2006 with 31 being held this year. Graduate students are heavily involved in seminars as well as the quarterly review/planning meetings for each of the Centre's Programs. Students and their projects are highlighted individually on the ARC Centre's website at **www.coralcoe.org.au/people-students.html**.



Centre training trends in the ARC centre of Excellence 2005 to 2007

Plans for 2008 include the expansion of the Centre's website to develop a "student highlights section" to further promote their research projects and outputs. Student research is also promoted through the Centre's quarterly newsletters published on our website at **www.coralcoe.org.au/pub-newsletters.html**.

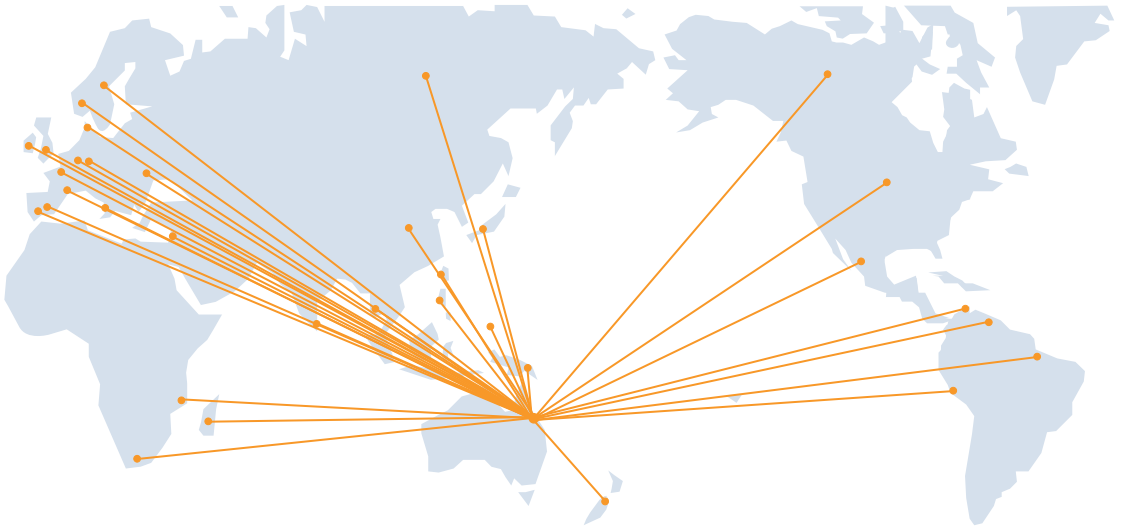
The Centre's 2007 annual National Student Mentoring Day was held in October, following the Australian Coral Reef Society symposium in Fremantle, Western Australia. The event was attended by 49 postgraduate students from ten universities, providing access to the ARC Centre of Excellence for all Australian students. The program's focus was on developing the students' research and publication skills as well as preparing them for careers in either research or management agencies. Students were also offered opportunities to discuss and learn from each other as well as from experts in coral reef research and management. Discussions were led by Malcolm McCulloch (ANU), John Pandolfi (UQ), David Wachenfeld (GBRMPA), Andrew Baird and Morgan Pratchett (JCU). At the end of the year, grant development assistance was provided by Terry Hughes to assist early career researchers at JCU, UQ and ANU in preparing postdoctoral fellowship applications. As a result, six fellowship proposals have been submitted in the 2009 ARC round. Media exposure is also provided to our students. Following training

by Julian Cribb, students were actively involved in many of the Centre's 26 media releases in 2007.

In March 2007, the Centre appointed a new student co-ordinator, Olga Bazaka, who liaises closely with the Centre's students and the Student Committee. Sixteen students were funded and actively participated in the ARC Centre's *National Forum of Coral Reef Futures*, convened at the Australian Academy of Science, in Canberra on October 17-19th, 2007.

In 2008, the Centre is investing over $60,000 in student participation in the International Coral Reef Society symposium in Florida, where over 20 Centre of Excellence students will be presenting their research next July.

We thank our 2007 student committee: Rose Berdin (ANU), Paulina Cetina-Heredia (JCU/AIMS), Rachael Middlebrook (UQ), Ruth Reef (UQ) and Marcelo Visentini Kitahara (JCU) for their important contribution to the Centre.



The ARC Centre's international network of students. In 2007, 82 of the ARC Centre's graduate students came to Australia from 33 countries.

Graduate Training

2007 Student members of the ARC Centre of Excellence

Student	University	Country of Origin	Thesis Title	CoE Supervisor/s
Rene Abesamis	JCU	Philippines	Demographic connectivity of reef fish populations in the Philippines. (PhD)	Prof G Russ, Prof G Jones
David Abrego	JCU, AIMS	Mexico	Flexibility in coral-dinoflagellate symbiosis: implications for adaptation to climate change. (PhD)	Prof B Willis, Dr M van Oppen, A.Prof S Connolly
Tracy Ainsworth	UQ	Australia	Disease and stress in reef building corals. (PhD)	Prof O Hoegh-Guldberg
Shelley Anthony	JCU, Reef HQ	USA	Tissue sloughing and coral disease in a large-scale reef mesocosm. (PhD)	Prof B Willis
Ray Bannister	JCU	Australia	Sponge energetics: implications for aquaculture practices. (PhD awarded)	Dr K Anthony
Christopher Bartlett	JCU	USA	Marine conservation in Vanuatu. (PhD)	Dr J Cinner
Brian Beck	UQ	USA	Palaeoecological dynamics of coral communities along a disturbance gradient, Solomon Islands. (PhD)	Prof J Pandolfi, A.Prof S Connolly
Roger Beeden	JCU, UQ	New Zealand	How healthy is the Great Barrier Reef in a warming world? (PhD)	Prof J Pandolfi, Prof B Willis
Maria Beger	UQ, JCU	Germany	Models and framework that enhance systematic planning for coral reefs. (PhD)	Prof J Pandolfi, Prof G Jones
Victor Beltran Ramirez	JCU	Mexico	Molecular aspects of the GFP-like proteins in the scleractinean coral Acropora millepora(PhD awarded)	Prof D Miller, Dr W Leggat
Dorothea Bender	UQ	Germany	Effects of macroalgae on the regeneration of coral tissue. (MSc)	Prof J Pandolfi, Dr S Dove, Prof O Hoegh-Guldberg
Rose Berdin	ANU	Phillipines	Late quaternary palaeoclimate history of the Northern Indo-Pacific warm pool from raised coral reefs in the Philippines. (PhD)	Prof M McCulloch
Duan Biggs	JCU	South Africa	Climate change, disturbance and the resilience of tourism-driven systems. (PhD)	Prof T Hughes, Dr J Cinner
Bernardo Blanco-Martin	JCU	Spain	Dispersal of coral larvae: a modelling perspective on its determinants and implications. (PhD awarded)	Prof T Hughes
Teressa Bobeszko	JCU	Australia	The Role of Carbonic Anhydrase in the Coral-Dinoflagellate symbiosis (PhD)	Dr W Leggat, Prof D Yellowlees
Lynda Boldt	JCU	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 ecosystem role of parrot fishes. (PhD)	Prof D Bellwood, A/Prof S Connolly
Pim Bongaerts	UQ, ANU	Netherlands	Ecological significance of deep, light-dependent coral communities. (PhD)	Prof O Hoegh-Guldberg, Dr M Rodrigues-Lanetty

Student	University	Country of Origin	Thesis Title	CoE Supervisor/s
Mary Bonin	JCU	USA	Causes and consequences of habitat specialization in coral reef fish communities. (PhD)	Prof G Jones, Dr G Almany
Emmanuelle (Manue) Botte	JCU	France	Molecular response of fish to stress. (PhD)	Dr M McCormick
Daniel Breen	JCU, Fisheries NSW	Australia	Systematic conservation assessments for marine protected areas in New South Wales, Australia. (PhD)	Prof G Jones
Sophie Bretherton	ANU	Australia	Monsoon extremes, environmental shifts and catastrophic volcanic eruptions: quantifying impacts on the early human history of southern Australasia. (PhD)	Prof M McCulloch
Samantha Burgess	ANU	Australia	Geochemistry of high latitude environments using coral climate proxy. (PhD awarded)	Prof M McCulloch
Neal Cantin	JCU, AIMS	Canada	Effects of the herbicide diuron on coral reproduction and larval competency. (PhD)	Prof B Willis
Mike Cappo	JCU, AIMS	Australia	Spatial patterns of demersal vertebrate assemblages in inter-reef waters. (PhD)	Prof M Kingsford
Paulina Cetina-Heredia	JCU, AIMS	Mexico	Modelling physical and biological processes driving larval transport and supply in reef systems. (PhD)	A.Prof S Connolly
Rowan Chick	JCU	Australia	Reseeding for the enhancement of abalone stocks in NSW. (PhD)	Prof M Kingsford
Tara Clark	UQ, AIMS	Australia	Dating and mapping historical changes in Great Barrier Reef coral communities. (PhD)	Prof J Pandolfi
Tim Cooper	JCU, UQ, AIMS	Australia	Coral bioindicators of environmental conditions on coastal coral reefs. (PhD)	Prof M Kingsford, Dr K Anthony
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)	Prof G Jones, Dr M McCormick
Peter Cowman	JCU	Ireland	Evolutionary History of the Labridae. (GDRM)	Prof D Bellwood
Alicia Crawley	UQ	Australia	The synergistic effect of rising ocean temperature and acidification on coral reef ecosystems. (PhD)	Dr S Dove
Natalie Crawley	JCU	England	Influence of sedimentation and turbidity on the pelagic and benthic ecology of coral reef fishes. (PhD)	Prof G Jones, Dr P Munday
Vivian Cumbo	JCU, AIMS	Australia	Thermal tolerance in corals: the role of the symbiont. (PhD)	Prof T Hughes, Dr A Baird, Dr M van Oppen
Belinda Curley	JCU	Australia	The ecology of temperate and subtropical reef fishes. (PhD)	Prof M Kingsford
Kathy Danaher	JCU	Australia	Oceanography and the condition of plankton. (PhD)	Prof M Kingsford
Joanne Davy	UQ	UK	Characterisation of White Patch Syndrome, a putative disease affecting corals in the genus Porites on the Great Barrier Reef. (PhD awarded)	Prof O Hoegh-Guldberg
Andrea de Leon	ANU	Australia	Palaeo-pH records of the Southern Ocean: insights from the boron isotope composition of biogenic silica. (PhD)	Prof M McCulloch
Jeffry Deckenback	UQ, Monash, JCU	USA	Maturation, turn-over, oligomerization, and transport of pocilloporins. (PhD)	Dr S Dove, Dr W Leggat
Ayax Diaz-Ruiz	UQ	Mexico	The use of coral associated fauna as indicators of coral health. (PhD)	Prof O Hoegh-Guldberg, Prof J Pandolfi
Danielle Dixson	JCU	USA	Settlement cues in coral reef fishes and response to habitat change. (MSc)	Prof G Jones, Dr M Pratchett

Graduate

Student	University	Country of Origin	Thesis Title	CoE Supervisor/s
Maxi J Eckes	UQ	Germany	How do coral reef fish protect themselves from solar ultraviolet radiation? (PhD)	Dr S Dove
Martin Elin	JCU	Sweden	Effects of exploiting a nonlinear dynamic food web model. (MAppSc awarded)	A.Prof S Connolly
Udo Engelhardt	UQ	Australia	Community-level ecological responses of coral reef biota to mass coral bleaching events. (PhD)	Prof O Hoegh-Guldberg
Richard Evans	JCU	Australia	Effects of marine reserves: ecology and reproductive connectivity. (PhD)	Prof G Russ, Prof 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 awarded)	Prof G Jones, Dr McCormick, Dr Almany
Ida Fellegara	UQ	Italy	Ecophysiology of the marginal, high latitude corals (Coelenterata: Scleractinia) of Moreton Bay, Queensland. (PhD awarded)	Prof O Hoegh-Guldberg
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
Matthew Fraser	JCU	Australia	Dynamics of egg predation at tropical fish spawning sites. (PhD)	Dr M McCormick
Ashley Frisch	JCU	Australia	Population biology of painted crayfish on the Great Barrier Reef. (PhD)	Dr M McCormick
Monica Gagliano	JCU	Italy	The role of selective mortality in the early life history of coral reef fishes. (PhD awarded)	Prof M Kingsford
Naomi Gardiner	JCU	Australia	Habitat specialisation, co-occurrence and resting site fidelity in cardinal fish on coral reefs. (PhD)	Prof G Jones
Chris Goatley	JCU	UK	Ecomorphology of reef fish assemblages. (MAppSc)	Prof D Bellwood
Alonso Gonzalez-Cabello	JCU	Mexico	Cryptobenthic reef fish ecology in the Great Barrier Reef, Australia. (PhD)	Prof D Bellwood
Luis Gonzalez-Reynoso	JCU, Griffith	Mexico	Mechanisms of stress inhibition of reproduction in a reef fish. (PhD)	Dr M McCormick
Jessica Haapkyla	JCU, AIMS	Finland	Assessing the impact of disease on coral populations. (PhD)	Prof B Willis
Andrew Halford	JCU, AIMS	Australia	Disturbance, habitat structure and coral reef fish communities. (PhD)	Prof G Jones
David Harris	UQ	Australia	Ecology of high latitude populations of Pomacentrus coelestis. (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
Jean-Paul Hobbs	JCU	Australia	Isolation, endemism and the structure of coral reef fish communities on islands. (PhD)	Prof G Jones, Dr P Munday
Jennifer Hodge	JCU	USA	Larval dispersal in coral reef fishes. (MSc)	Prof G Jones
Andrew Hoey	JCU	Australia	Algal-fish interactions on coral reefs. (PhD)	Prof D Bellwood, Prof G Russ
Tom Holmes	JCU	Australia	Selectivity of predation on newly settled tropical reef fish. (PhD)	Dr M McCormick
Mia Hoogenboom	JCU, UQ	Australia	Physiological models of performance for scleractinian corals. (PhD)	A.Prof S Connolly, Dr K Anthony
Akira Igushi	JCU	Japan	The molecular basis of fertilisation in coral Acropora and its role in speciation. (PhD awarded)	Prof D Miller

Student	University	Country of Origin	Thesis Title	CoE Supervisor/s
Jacob Johansen	JCU	Denmark	Energetics of habitat choice in planktivorous coral reef fishes. (PhD)	Prof G Jones, Prof D Bellwood
Paulina Kaniewska	UQ	Sweden	The role of colony morphology in optimising light climates of corals interactions between scleractinian coral morphology. (PhD awarded)	Prof O Hoegh-Guldberg, Dr K Anthony
Ailsa Kerswell	JCU	Australia	Biogeography of seaweeds. (PhD awarded)	Prof T Hughes, Dr A Baird
Marcelo Visentini Kitahara	JCU, Smithsonian Institute	Brazil	Taxonomic and phylogenetic trends among azooxanthellate corals, using morphological and molecular aspects. (PhD)	Prof D Miller
Brent Knack	JCU	Australia	Cell adhesion factors in Cnidarians. (PhD)	Prof D Miller, Dr W Leggat
Valeriya Komyakova	JCU	Russia	Recruitment-site specialization in coral reef fishes. (MSc)	Prof G Jones, Dr P Munday
Narinratana Kongjandtre	UQ	Thailand	The taxonomy and systematics of the coral genus Favia from Thai waters. (PhD)	Prof O Hoegh-Guldberg, Dr M Rodriguez-Lanetty
Charlotte Kvennefors	UQ, JCU	Sweden	Immune molecules in corals. (PhD)	Dr W Leggat, Prof O Hoegh-Guldberg
Nicholas Larsen	JCU, AIMS	USA	Comparative growth and survival for corals infected with clade C1, C2 and D Symbiodinium. (MAppSc awarded)	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	Local government decision making about climate change in the Great Barrier Reef region. (PhD)	Prof T Hughes
Tove Lemberget	JCU	Norway	Importance of body condition and growth to larval survival of a Caribbean lizardfish. (PhD)	Dr M McCormick
Raechel Littman	JCU, AIMS	USA	The dynamics of bacterial populations associated with corals and the role of bacterial pathogens in coral bleaching. (PhD)	Prof B Willis
Matt Lybolt	UQ	USA	Causes of change in coastal ecosystems: past, present and future. (PhD)	Prof J Pandolfi
Thomas Mannering	JCU	UK	Do marine reserves augment recruitment in nearby fished areas? (MSc)	Prof G Jones
Guy Marion	UQ, ANU	USA	Nitrogen isotopic composition of coral skeletal organic matter: a tool for provenance analysis. (PhD awarded)	Prof O Hoegh-Guldberg, Prof M McCulloch, Prof J Pandolfi
Ewen McPhee	JCU	Australia	Coastal confusion: the maritime cultural heritage of the Great Barrier Reef	Dr S McIntyre-Tamwoy
Luiz-Felipe Mendes-de Gusmao	JCU, AIMS	Brazil	Studies on secondary production of zooplankton in tropical seas and aquaculture. (PhD)	Prof M Kingsford
Vanessa Messmer	JCU, U.Perpignan	France	Ecological and evolutionary factors influencing the genetic structure of coral reef fishes. (PhD)	Prof G Jones, Prof S Planes
Rachael Middlebrook	UQ, JCU	Australia	How do thermal threshold vary between and within coral taxa? (PhD)	Dr S Dove, Prof O Hoegh-Guldberg, Dr K Anthony, Dr W Leggat
Ann Mooney	UQ	USA	Impacts of ocean acidification on scleractinian coral skeletal integrity. (MSc awarded)	Dr K Anthony

Graduate

Student	University	Country of Origin	Thesis Title	CoE Supervisor/s
Bryan Murphy	JCU	USA	Experimental evaluation of mutualistic interactions on coral reefs. (MSc)	Prof G Jones
Roshni Narayan	UQ	Canada	Modern and historical (Holocene) foraminifera assemblages of Moreton Bay, Queensland, Australia: a record of faunal changes, anthropogenic impacts and possible implications for coral communities. (PhD)	Prof J Pandolfi
Stephan Neale	JCU	Australia	Impacts of water quality on recruitment of corals. (GDRM)	Prof B Willis
Juan Carlos Ortiz	UQ	Venezuela	Eco-physical dynamics of the Heron Island coral reef. (PhD)	Prof O Hoegh-Guldberg
Cathie Page	JCU	Australia	Ecology and biology of coral diseases on the Great Barrier Reef. (PhD)	Prof B Willis, Prof T Hughes
Allison Paley	JCU, AIMS	USA	Genetic diversity, bleaching sensitivity and colour polymorphism of a common reef-building coral. (MSc)	Prof B Willis, Dr M van Oppen, Dr L Bay
Caroline Palmer	JCU, U.Newcastle (UK)	England	The basic biological mechanisms of scleractinian immune defences involved in wound healing and disease mitigation. (PhD)	Prof B Willis
Srisikul Primovaragorn	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-nonself recognition and chimerism in Acropora millepora. (PhD)	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
Charmaine Read	JCU	Aus	Origins of Indo-Pacific fish biodiversity. (PhD)	Prof D Bellwood
Ruth Reef	UQ, JCU	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 S, Dr W Leggat
Alejanro Reyes	JCU	Columbia	Cellular mechanisms of coral calcification. (PhD awarded)	Prof D Miller
Claire Reymond	UQ	Australia	Modern evolutionary and palaeoecology of foraminifera from the Great Barrier Reef: establishing a baseline. (PhD)	Prof J Pandolfi
Zoe Richards	JCU, AIMS	Australia	Characteristics of rare and common corals: implications for conservation. (PhD)	Prof D Miller, Dr M van Oppen, Prof B Willis
Alma Ridep-Morris	JCU	Palau	Dynamics of a black band disease outbreak in Palau. (MAppSc)	Prof B Willis
Maria Rodrigues	JCU	Mozambique	Effects of herbivory on coexistence of coral and algae. (PhD)	Prof T Hughes, Dr A Baird
George Roff	UQ	United Kingdom	Historical ecology of coral communities from the inshore Great Barrier Reef. (PhD)	Prof J Pandolfi, Prof O Hoegh-Guldberg
Alexandra-Sophie Roy	JCU	Canada	Trans-generational marking of clownfish larvae via maternal transmission of stable isotopes. (MSc)	Prof G Jones
Christopher Ryen	JCU	USA	Growth related sex change in coral reef fishes. (MSc awarded)	Dr M McCormick, Dr P Munday
Aleksay Sadekov	ANU	Russia	Distribution of trace elements within foraminiferal tests as the proxy for paleoclimatology and foraminiferal biology. (PhD)	Prof M McCulloch
Eugenia Nijgh de Sampayo	UQ	Netherlands	Diversity and ecology of Symbiodinium in pocilloporid corals. (PhD awarded)	Dr S Dove, Prof O Hoegh-Guldberg

Student	University	Country of Origin	Thesis Title	CoE Supervisor/s
Yui Sato	JCU, AIMS	Japan	Dynamics of a black band disease outbreak. (MSc)	Prof B Willis
Jessica Scannell	JCU	USA	Influence of habitat degradation on mortality in fishes. (MSc)	Dr M McCormick
Francois Seneca	JCU, AIMS	Monaco	The molecular stress response in a model scleractinian coral: Acropora millepora.(PhD)	Prof D Miller, Dr M van Oppen
Segi Shio	ANU, JCU	Australia	Choice of fishing strategies in southeast Cebu, the Philippines. (PhD)	Dr S Foale
Chuya Shinzato	JCU	Japan	Cnidarian Sox genes and the evolution of function in the Sox gene family. (PhD awarded)	Prof D Miller
Michael Short	JCU	Australia	The recovery of coral reefs following ship grounding disturbances. (MSc)	Prof B Willis
Luke Smith	JCU	Australia	Coral bleaching in Western Australia. (PhD)	Prof T Hughes
Meir Sussman	JCU, AIMS	Israel	A molecular approach to the study of coral diseases. (PhD)	Prof B Willis
Jill Sutton	ANU	Canada	Sothern Ocean nutrients and climate change: insights from isotopic and elemental signatures of diatoms and sponges. (PhD)	Prof M McCulloch
Loic Thibaut	JCU, U. Pierre et Marie Curie	France	Resilience in coral reef and model ecosystems. (PhD)	A.Prof S Connolly
Lucija Tomljenovic	JCU	Croatia	TTC4-like genes, mediators of development and cell proliferation. (PhD awarded)	Prof D Miller
Lubna Ukani	JCU, AIMS	India	Characterisation of DNA methylation systems in Acropora and other lower animals. (PhD)	Prof D Miller
Annamieke Van Den Heuvel	UQ, JCU	Australia	Characterisation of genes, proteins, and the regulatory pathways involved in nitrogen uptake and the assimilation in Acropera aspera and its symbiont Symbiodinium sp.	Dr S Dove, Dr W Leggat, Prof D Yellowlees
Ana Villacorta-Rath	JCU, AIMS	Peru	Selective mortality and productivity of sprats. (MSc)	Dr M McCormick, Dr M Meekin
Stefan Walker	JCU, AIMS	Australia	The socio-biology of life history transitions and lifetime fecundity in a tropical haremic reef fish. (PhD)	Dr M McCormick, Dr P Munday
Yvonne Weiss	JCU	Germany	The immune system of Acropora millepora: identification and characterisation of candidate genes. (PhD)	Prof D Miller
David Williamson	JCU	Australia	An evaluation of the effects of no-take marine reserves on fish communities of the Great Barrier Reef Marine Park. (PhD)	Prof G Russ, Prof G Jones
Giles Winstanley	JCU	UK	Simulation frameworks for investigating spatially-explicit modelling of competition and coexistence in coral assemblages. (MAppSc)	A.Prof S Connolly
Marian Wong	JCU, Centre for Science, Spain	UK	The evolution of animal societies: monogamy, group-living and conflict in a coral-dwelling fish. (PhD)	Dr P Munday, Prof G Jones
Huibin Zou	JCU	China	Genome-wide screen and analysis of Acropora millepora immune related genes by EST microarrays. (PhD)	Prof D Miller

Applied Science for the management of coral reefs

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, cultural and aesthetic value to this country. Income from tourism and fishing on the Great Barrier Reef alone contributes over $6 billion annually to the nation's economy. Consequently, the applied and basic science which underpins management of coral reefs is a national priority, and the core activity of the ARC Centre. ARC Centre of Excellence researchers are major contributors to intergovernmental organizations such as the IUCN, the World Bank, UNESCO, and the Intergovernmental Panel on Climate Change (IPCC), involved in key global declarations, World Heritage designations, and endangered or threatened species status decisions. In 2007, the ARC Centre of Excellence engaged with over 60 industry, government and NGO organizations worldwide.

Globally, the welfare of greater than 200 million people is closely linked to the goods and services provided by coral reef biodiversity. Uniquely among tropical and sub-tropical nations, Australia has extensive coral reefs, a small population of relatively wealthy and well-educated citizens, and well-developed infrastructure. Coral reef research, research training and management is one area where Australia has the capability, indeed the obligation, to claim world-leadership. How to manage corals reefs proactively, in anticipation of future uncertainty is a key unifying theme in all of the Centre's research programs.

Below are just a few examples of how the Centre's research impacts on reef management and the development of policy for sustainable resources:

- Garry Russ's pioneering work in the Philippines (with his colleague Angel Alcala) has produced some of the best evidence available that no-take reserves, protected and managed by local communities, can play a key role in biodiversity conservation and fisheries management. These studies have led directly to the extraordinary expansion of this approach nationally in the Philippines. Russ's impact on establishing the National Integrated Protected Area System (NIPAS) and the Philippines Fisheries Code has been enormous, and was recognized by the award to him of a prestigious Pew Fellowship. Currently more than 400 no-take areas are being established each year across the world
- In September 2007, the ARC Centre co-hosted the *Townsville Forum on Sustainable Development of Pacific Coastal Resources*. The AusAid-funded forum was a collaboration between the Centre, Pacific Island nations and the French and Australian governments (represented locally by the Reef and Rainforest Research Centre, the administrating body for the Marine and Tropical Science Research Fund). The objectives of the Forum were to improve international networking, scientific co-operation, and capacity-building in Pacific nations.
- In 2007, Centre members contributed to 8 chapters for the first comprehensive assessment of the impacts of climate change on the Great Barrier Reef in a book (*Climate Change and the Great Barrier Reef: A Vulnerability Assessment*) published by two key domestic end-users of coral reef research, the Great Barrier Reef Marine Park Authority and the Australian Greenhouse Office.
- In PNG, work by Joshua Cinner is being used by the Secretariat for the Pacific Community, (an international resource management organization), as the basis for introducing sustainable harvesting practices. The knowledge transfer from this research has led to engagement with conservation groups and communities, a new conservation project, and has resulted in significant economic benefit to the local community.
- 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. For example, in 2007 Terry Hughes, working with Queensland Parks and Wildlife Service (QPWS), has developed a series of workshops on the "Key Principles and Research Findings in Marine Resources Management" which is presented to marine park rangers and managers. Ove Hoegh-Guldberg leads a Rio-Tinto employee program to raise awareness of the importance of the Great Barrier Reef. Research Fellows, Morgan Pratchett and Andrew Baird, recently gave a

series of briefings to the Western Australia oil and gas industry, on a range of issues, including the use of coral spawning predictions for management of port dredging. In July 2007, Bette Willis provided a background briefing paper on coral disease on the Great Barrier Reef at the request of the Environmental Protection Agency in Brisbane, for the Queensland State Minister for the Environment. Research Fellow Simon Foale and his colleagues have developed The Environmental Education Plan for the Lihir (EEPL) Project, which includes a set of four booklets, a Teacher's Guide and a DVD with animations explaining some of the often complex direct and indirect environmental impacts of mining at Lihir, PNG. This work was done in collaboration with the PNG Education Department's Curriculum Development Division, and was co-funded by Lihir Gold Ltd. The Secretary of the PNG Education Department, and heads of the Curriculum Development Division, all expressed strong support for this program. Our 2006 report documents many more such examples.

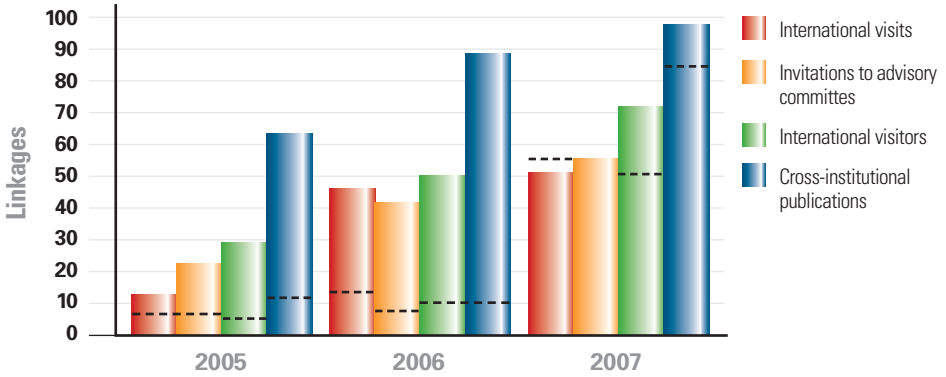
- The ARC Centre's impact is also exemplified by ongoing research addressing long-term changes in water quality on the Great Barrier Reef. One project, involving Ove Hoegh-Guldberg and Malcolm McCulloch, PhD student Guy Marion, and Stacy Jupiter, has demonstrated the strong connectivity between coral reefs and the adjacent Pioneer River catchment and estuaries bordering the Mackay-Whitsunday region of the central Great Barrier Reef. The project is receiving considerable support by the Mackay City 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. In June 2007, a workshop to present the findings was followed by a brief with the Mackay City Council to inform better planning and adoption of management strategies to facilitate improved land care practices and measures to ensure the general health of downstream ecosystems.
- David Bellwood and Morgan Pratchett provide advice to the Great Barrier Reef Marine Park Authority, the Department of Primary Industries and Fisheries (DPI&F) and Aquarium Industries, Australia. In April 2007, they briefed these agencies on the impact and management of Australia's ornamental fish trade. Overseas, the collection of reef fishes for the aquarium trade is largely unregulated, especially in developing countries such as the Philippines and Indonesia, which has led to the overexploitation of many species of reef fishes. The goal of this and subsequent meetings with industry representatives, is to develop a scientific basis for management practices in this unusual multi species fishery.
- Research by Terry Hughes, David Bellwood, John Pandolfi, Bob Steneck and others has provided 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. A key finding is that phase-shifts following coral bleaching (due to global warming) can be prevented by protecting stocks of herbivorous fishes, and by controlling nutrients. These studies have prompted the Great Barrier Reef Marine Park Authority and other management agencies worldwide to build the resilience of reefs through initiatives such as no-take zoning and policies and interventions for reducing water pollution. Terry Hughes was recently asked by US Congressional advisors to provide a definition of "coral reef resilience" that has been incorporated into the Coral Reef Conservation Amendments Act, which was passed by the Congress on October 22nd, 2007.

National and International Linkages

In 2007, the ARC Centre produced 101 publications with cross-institutional co-authorship (39 more than 2005), involving researchers from 162 institutions in 36 countries. The ARC Centre hosted 72 international visitors from 22 countries, and Centre personnel traveled to 24 countries. The ARC Centre participated in or hosted 17 international working groups during 2007. Centre personnel are members of editorial boards for nine international journals.

Since its establishment in 2005 there has been a steady growth in the engagement of the Centre's researchers with their international colleagues (see graph). This is exemplified by co-authored publications, visits to overseas institutions and visitors to all three nodes of the Centre. The Centre's profile is increasingly attracting overseas postgraduate students who come from 33 different countries around the world. Centre personnel are also actively involved in many international activities (including consultancies and end-user engagement, see p.30). The Centre's international standing was recognized by the Intergovernmental Panel on Climate Change (IPCC), with two Centre members (Hoegh-Guldberg, Hughes) contributing to the influential 2007 IPCC assessment report.

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 Science by two Fellows, Terry Hughes and Malcolm McCulloch. The three main University nodes are linked to research and industry partners throughout Australia. Co-funding agreements sponsored 7 shared postdoctoral fellows with AIMS, CSIRO, University of Newcastle (UK), the Dutch Government and The Resilience Alliance in 2007.



The Centre's international linkages in 2005 to 2007. All four metrics have shown strong growth. The dotted lines are targets, which were substantially increased for 2007.

Internationally, the Centre has participated in a range of major projects during the past year, including collaborations with newly established Stockholm Resilience Centre, The World Bank Coral Reef Targeted Research Program, and The Townsville Forum on Sustainable Development of Pacific Coastal Resources which are described briefly below. In addition strong linkages and collaboration have been maintained with The Resilience Alliance and The Beijer International Institute for Ecological Economics as detailed in our 2006 report.

The Stockholm Resilience Centre

www.stockholmresilience.org

In 2007 the ARC Centre of Excellence for Coral Reef Studies signed a Memorandum of Understanding with the newly established Stockholm Resilience Centre to cooperate and collaborate in areas of mutual interest in research. This new international centre advances trans-disciplinary research for governance of social-ecological systems with a special emphasis on resilience - the ability to deal with change and continue to develop. The centre is a joint initiative between Stockholm University, the Stockholm Environment Institute and the Beijer International Institute of Ecological Economics at The Royal Swedish Academy of Sciences. As part of the agreement Jon Norberg and Per Olsen have spent sabbaticals at JCU in 2006 and 2007, while Josh Cinner will visit Stockholm on a 6 week exchange (co-funded by the Australian Academy of Science) in early 2008. A range of other joint activities have been established, including working groups jointly funded by both organizations.

Global Coral Reef Targeted Research (CRTR) Program

www.gefcoral.org

The CRTR Program is a partnership between the Global Environment Facility, The World Bank, The University of Queensland (project executing agency), the National Oceanic and Atmospheric Administration (NOAA) and approximately 40 research institutes & other third parties around the world. The ARC Centre of Excellence is a major contributor of research expertise to this global partnership. This program aims to fill critically important information gaps in the fundamental understanding of coral reef ecosystems, and conducts a range of research and extension activities around the world including in Zanzibar, the Philippines and Mexico, and Australia. Five International Working Groups, each with approximately a dozen leading researchers, form the scientific basis for the program. In 2007, the Centre is represented on four groups which dove-tail well with our Programs 3 and 4: (a) Diseases Working Group: Bette Willis (Co-chair), (b) Connectivity Working Group: Geoff Jones, Serge Planes and Bob Steneck, (c) Bleaching Working Group: Ove Hoegh-Guldberg, (Chair), (d) Modelling Working Group: Roger Bradbury (Chair). Contributions from Centre members in 2007 included two major workshops. In April, Bette Willis led a capacity-building workshop for East African coral reef managers. While in October, a workshop entitled "Connectivity and population resilience - sustaining coral reefs during the coming century" was held in Townsville. This was a partnership between the ARC Centre's Program 3 and the Connectivity Working Group of the GEF Project (see Program 3 report) .

Townsville Forum on Sustainable Development of Pacific Coastal Resources

In September 2007 the ARC Centre co-hosted the Townsville Forum on Sustainable Development of Pacific Coastal Resources. The AusAid-funded forum was a collaboration between the Centre, Pacific Island nations and the French and Australian Governments, with the key objective to improve networking, scientific co-operation, and capacity-building in Pacific nations. It was attended by senior government officials and experts from 13 Pacific Island countries: Cook Islands; Federated States of Micronesia; Fiji; Kiribati; Palau; PNG; Samoa; Solomon Islands; Tokelau; Tonga; Tuvalu; Vanuatu; and New Caledonia and French Polynesia. The Forum was a platform to discuss research, management and governance of coral reefs and other coastal ecosystems in the Pacific, to improve networking, enhance scientific co-operation, build capacity and explore solutions to common problems. The Forum examined Pacific capacity and identified both key issues and best practice solutions under the four key themes; Marine Protected Area management; integrated coastal management; economic development options; and governance to develop actions.

Malcolm McCulloch briefing the Prime Minister, Kevin Rudd.

National and International Linkages

Visiting researchers

- Professor C. Menchie Ablan, De La Salle University Manila Philippines
- Dr Kevin Ariggo, Stanford University, USA
- Dr Juan Pablo Bernal Uruchurtu, Unioversidad Nacional Autonoma de Mexico
- Dr Michael Berumen, Woods Hole Oceanographic Institute, USA
- Ms Meredith Blake, Pacific Islands Museum Association & ICOMOS Pasifika, Vanuatu
- Professor Louis Botsford, University of California, Davis, USA
- Professor Mark Butler, Old Dominion University, USA
- Dr John Bythell, University of Newcastle, UK
- Dr Ken Caldeira, Stanford University, USA
- Professor Mary Alice Coffroth, University of Buffalo, USA
- A/ Professor Troy Day, Queens University, Canada
- Professor Aart de Zeuw, Beijer Institute, Sweden
- Professor Robert Dunbar, Stanford University, USA
- Dr. Michael Eitel, University of Hannover, Germany
- Dr Stefan Gelcich, Universidad Catolica de Chile, Chile
- Professor Benjamin J Greenstein, Cornell College USA
- Professor Dan Heath, University of Windsor, Canada
- Dr Fanny Holulbreque, Stanford University, USA
- Dr John Hurd, ICOMOS Scientific Council, U.K
- Professor Ross Hynes, University of PNG, Papua New Guinea
- Dr Tsuyoshi Iizuka, University of Tokyo, Japan
- Dr Hanne Jarmer, Danish Technical University Denmark
- Dr. Jaap Kaandorp, University of Amsterdam, Netherlands
- Professor Yossi Loya, Tel Aviv University, Israel
- Dr. Min Liu, University of Hong Kong, China
- Dr C MacDonald, Stanford University, USA
- Professor Claudio Mazzoli, University di Padova, Italy
- Professor Gifford Miller, University of Colorado, USA
- Dr Paolo Montagna, ICRAM, Italy
- Prof Peter Mumby, University of Exeter, UK
- Dr H Bjorn Nielsen, Danish Technical University Denmark
- Dr Jon Norberg, Stockholm University, Sweden
- Dr Magnus Nystrom, Stockholm University, Sweden
- Dr Beth O'Leary, New Mexico State University, USA
- Professor Heinrich Reichert, University of Basel, Switzerland
- Dr Clair Paris, Rosenstiel School of Marine and Atmospheric Science, USA
- A/ Professor Camille Parmesan, University of Texas, USA
- Dr Adina Payten, Stanford University, USA
- Dr Lucie Penin, University of Perpignan, France
- Dr, Serge Planes, University of Perpignan, USA
- Professor Don Potts, University of California, Santa Cruz, USA
- Ms Faustina Rehuher, ICOMOS Pasifika, Palau
- Dr. Willem Renema, Leiden Museum, The Netherlands
- Dr Brendon Roark, Stanford University, USA
- Professor Peter Sale, United Nations University, Canada
- Dr Christophe Sande, ICOMOS Pasifika, New Caledonia
- Dr Sergio Silenzi, ICRAM, Italy
- Professor Robert Steneck, University of Maine, USA
- Professor Michel Thibiet, French Embassy Canberra France
- Dr Frank Thomalla, Stockholm Resilience Centre, Sweden
- Dr Simon Thorrold, Woods Hole Oceanographic Institute, USA
- Mr Richard Tuheiava, ICOMOS Pasifika French Polynesia
- Dr Gangjian Wei, Guangzhou Institute of Geochemistry PR China
- Professor Oded Yarden Hebrew University, Jerusalem, Israel
- Dr Jens Zinke, UV Amsterdam, The Netherlands

A delegation of Indonesian government officials responsible for the implementation of the national Coral Reef Rehabilitation and Management Program (Coremap) also visited the Centre this year, for discussions on scientific advances in coral reef sciences and their implications for management of coral reefs in Indonesia:

- Mr Abdul Hamid,
- Mr Jamaluddin Jompa
- Mr Yusdi Lamatenggo
- Mr Risnawati Mangidi
- Mr Markus Mansnembra
- Mr Yudha Miasto
- Ms, Afliana Salean
- Mr Natsir Sulaiman
- Mr Dedy Syahputra
- Mr Syahrun
- Mr Syarir Wahab
- Mr, Rudi Wahyudin

Student visitors

- Susanne Arnold, University of Maine, USA
- Jonathan Belmaker, Ben Gurion University, Israel
- Cecile Fauvelot, University of Perpignan, France
- Alex Greer, Stanford University, USA
- Derek Hogan, Student University of Windsor, Canada

How we keep the Reef great

Climate change is affecting the Great Barrier Reef, but researchers, government authorities and tourism operators are cooperating to protect Australia's greatest natural asset.

A trip to the Great Barrier Reef is not undertaken lightly. It is usually a two-hour boat trip each way, the expense in direct proportion to the number of passengers. Weather doesn't always cooperate and viewing quality often depends on the tides. But these hurdles have helped preserve the condition of the reef – by keeping humans at bay. Along with global warming, people pose its greatest threat.

"To kill a coral reef is simple," says Professor Terry Hughes, director of the ARC Centre of Excellence for Coral Reef Studies. "Pollute it and take away fish that eat the seaweed. You're fertilising it and removing the lawnmowers."

Nutrient run-off from nearby catchments and the loss of fish and marine mammals that graze on seagrass are decreasing the ability of coral to withstand threats like global warming. Warmer water causes coral to eject the organisms that give the coral its pigment – coral bleaching. Not every piece of bleached coral will die, but if it's not resilient, it probably will. One third of the world's reefs have degraded in the past 30 years – that means they're of little use for tourism and fisheries.

The Great Barrier Reef is in better shape than any of the world's other reefs, partly because much of it is far from population centres. Neither does Australia systematically harvest its herbivores. But its list of grievances is considerable. Commercial harvest of sharks and rays has increased fourfold since 1993; in 40 years the numbers of nesting turtles have plummeted 50 to 80 per cent; coastal Queensland's dugong population has dwindled to three per cent of the 1960s figure; nutrient and sediment discharge has quadrupled over the last century. In 1998 and 2002, the reef suffered its two worst coral bleaching episodes during record hot summers. The 2002 event triggered declines of 50 to 90 per cent of coral cover on some inshore reefs.

Scientists expect more of the same. "It's too late to stop global warming," Hughes says. "The world is committed to future climate change. It's not a distant thing, it's happening now. Bleaching is definitely happening."

The Australian Research Council (ARC) Centre of Excellence for Coral Reef Studies is based at Townsville's James Cook University (JCU). It encompasses researchers and support from JCU, the University of Queensland, the Australian National University, the Australian Institute of Marine Science and the Great Barrier Reef Marine Park Authority (GBRMPA). Researchers come from more than 120 countries – and they are coming up with some rather interesting discoveries.

One research team set up an experiment and found that uncontrolled fishing of weed-eaters such as parrotfish and surgeonfish hurts the reef, leading to the coral quickly becoming smothered by weed. "Remove them and you as good as remove the reef itself," says Centre of Excellence researcher Professor David Bellwood.

Another team debunked the current neutral theory of reef biodiversity (that coral species randomly colonise reefs). It discovered that location and environment are critical in determining what sorts of corals settle and flourish.

The study's lead author, Dr Maria Dornelas, says protected areas need to be close enough for marine life, including coral spawn, to flow freely between them. This gives the corals the best chance of preserving their biodiversity as the environment changes. The research team has called for worldwide networking of tropical marine parks and protected areas to limit the risk of large-scale extinctions due to global change.

Professor Hughes says, "Most Marine Protected Areas around the world are too small and isolated to preserve the links between populations on different reefs. This increases the risk that a rare group of animals could become extinct unless they colonise a more favourable reef." While Hughes says that trying to change care of our reefs is like "turning around a supertanker", he is ultimately optimistic: "There's a lot of gloom and doom about reefs. They are changing. I don't think they'll be dead in 30 years, but they'll be different. The danger with the message is that people will throw up their hands and do nothing."

One step in the right direction was the rezoning of the reef in 2004 by GBRMPA to make more than 30 per cent a "no-take" area – compared to the 4.6 per cent that was protected previously.

And the tourism industry has been deputised to help preserve its cash cow. Operators monitor their patch and provide information essential to the management of the reef – such as areas of coral bleaching, population and movements of marine fauna, reproductive behaviour and changes in behaviour – to the Marine Park Authority.

People have to see and understand the reef to know what is worth preserving. "We have an obligation to present the reef to visitors and without the industry we could never have taken that on," says Daniel Geschwind, chief executive of the Queensland Tourism Industry Council. "The average person doesn't have their own private yacht to see [the reef] whenever they want."

Hughes agrees. "The tourism industry takes the responsibility very seriously.

Written by Lisa Southgate. Reproduced with thanks: QANTAS The Australian Way January 2007.

Media Coverage

The ARC Centre of Excellence for Coral Reef Studies seeks to communicate its research to diverse audiences. The award of an ARC Centre of Excellence has enabled us to develop a robust media strategy, which has both improved and increased our public outreach enormously. The Centre's media adviser Julian Cribb works closely with Centre researchers to craft fortnightly press releases and promulgate them to a huge audience. These releases, accompanied by images and promoted on the Centre's website, generated 892 media stories in 2007. About a quarter of the Centre's website's hits are generated by the fortnightly press releases that highlight these research findings In 2007, hits on the Centre's website grew to almost 2 million for the year, a 3-fold increase from 2006.

In its second year of operation, the ARC Centre's website was expanded to include an educational resources page designed predominantly for school-age children. One of the Centre's key aims is capacity building, so we have added this year an alumni page to the website to promote the careers of those members of the Centre who have moved on to progress their careers elsewhere. Both pages have proved popular with users of our website. Plans are underway to further upgrade the web site during 2008 to promote our students, to enhance access to the research services we provide, and to improve navigability to over 400 research publications since 2005.

The award of the ARC Centre has provided us with the capacity to harness the media by creating our own news stories, to build public awareness of their investment via the ARC in coral reef science. For example, in 2007 the Centre promoting the research presented at its Canberra Forum, and the Forum's *Consensus declaration on coral reef futures*. The research, and the international call for action to sustain coral reefs, was reported on Australia's television networks and press outlets (ABC, Channel 7, Channel 9, Sky News, Sydney Morning Herald, The Age and The Australian) as well as internationally through UPI. In sum, media from the Forum generated almost 100 media stories.

Internationally, enormous media coverage was generated by an international debate sponsored by the BBVA Foundation in Madrid, in which Terry Hughes reported on addressing the global threats to coral reefs. Hughes joined leading international experts to present their latest research into the scale, causes and consequences of global loss of coastal habitats. Eighty media stories in newspaper, television, radio and on the web were generated, principally across Europe and South America, in response to the event.

The 892 media stories included 420 on the web, 66 television reports, 165 on radio, 186 in newspapers, and 30 magazine articles (see the Qantas article, p.35). Highlights of the Centre's 892 media hits in 2007 include:

2SM, Sydney radio, *Brisbane's marine playground under threat*. 16/3/07 T Hughes.

AAP Newswire, *Global warming could kill off reef fish*. 12/6/07 M McCormick, M Meekin.

ABC 2 (News) Perth, *Climate change taking it's toll on WA coastline*. 8/10/07 M McCulloch, K Anthony.

Australasian Science, *Australia Coral Reefs under Stress*. 02/04/07 ARC Centre of Excellence.

The Australian, *Push to protect reef in the heat*, 9/5/07 B. Willis.

Australian Life Scientist. *Chow down, batfish*. 1/2/07 D Bellwood.

Australian R&D Review, *Reef Motor*. 1/10/07 D Yellowlees.

BBC World Service Radio Science Program, UK, *Coral Fish Larvae*. 1/5/07 G Almany.

Biophotonics International, USA, *Close observation reveals unexpected player in coral reef recovery*. 1/2/07 D.Bellwood.

Canwest News Service, Canada, *Full moon may spark Australia's reef madness*. 20/10/07 O.Hoegh-Guldberg.

China Fisheries newsletter. *How fish punish queue jumpers*. 27/6/07. G Jones, M Wong.

Dailyindia.com. *Greenhouse gas threatens coral reefs*. 17/10/07 M McCulloch.

Discovery Channel, International. *Sharks at Risk as Traditions Decline*. 25/5/07 S Foale.

Divingmalaysia.com, Malaysia. *Fish starve themselves to avoid conflict*. 7/4/07 P Munday, M Wong.

El Mundo, Spain. *Terce debate sobre Biologica de la Consevacion*. 11/10/07 T Hughes.

Fisheries Newsletter, South Pacific. *Baby Fish "Smell Their Way Home*. 25/1/07 M Kingsford.

Dethlev Cordts Germany television, *Climate change and coral reefs*. 4/4/07. G Diaz-Pulido, O Hoegh-Guldberg.

Good Weekend, Sydney Morning Herald, Australia, *The Tropical Time Bomb*. 13/10/07. A Baird, D Bellwood, S Connolly, T Hughes, J Lough, J Pandolfi, M van Oppen.

Illustrated Science, Denmark. *Coral Suicide*. 2/4/07 T Ainsworth.

Impossible Pictures – Film, UK, *Coral reefs under stress*. 5/3/07 O Hoegh-Guldberg.

National Geographic, *Moonlight Triggers Mass Coral "Romance"*. 22/10/07 W Leggat.

New Scientist, UK, *Indonesian earthquake lifted coral to its death*. 12/4/07 A Baird.

New York Times, USA, *Scientists Discover Details of Coral Reproduction*. 19/10/07 O Hoegh-Guldberg.

Qantas: The Australian Way. *How we keep the reef great*. 1/1/07. D Bellwood, T Hughes.

Quality Marine News, USA, *Corals reveal impact of land use*. 31/5/07 S Jupiter, G Marion, O Hoegh-Guldberg, M McCulloch.

Radio National, Australia, *Growing acid levels in the worlds oceans*. 18/10/07 M McCulloch O Hoegh Guldberg.

Science Magazine, USA. *A World Without Corals?* 4/5/07 O Hoegh-Guldberg, T Hughes, J Pandolfi.

7:30 Report, Australia, *Business leaders launch reef fund*. 22/2/07 O Hoegh Guldberg.

The Age, Australia, *Oh coral, I am but a fool*. 19/10/07 D Miller.

The Canberra Times, Australia, *'Swindle' has experts fired up*. 12/7/07 M McCulloch.

The Coral Reef Alliance, international web, *Climate Change and coral bleaching funded*. 17/7/07 L Bay.

The DNA Files, US Radio Documentary, *Coral and climate change*. 24/3/07 T Hughes.

The Science Show, Radio National, Australia. *Conference of marine scientists*. 27/10/07. Centre of Excellence.

The Weekend Australian, *Tracking Down the Serial Killers on Coral Reef*. 24/3/07 K Anthony.

Western Cape Bulletin, *Sharks threatened by overfishing*. 18/1/07 S Connolly, W Robbins M Hisano.

WIN News, television, *Climate Change threatening survival of young fish*. 12/6/07 M McCormick.

Sciencedaily.com, *Coral reefs on brink of disaster* 22/10/07 Consensus declaration on Coral Reef Futures Forum.

Washingtonpost.com, USA, *Panel: Warming will end some species*. 31/3/07 T Hughes.

National Benefit Case-Study

Case Study 1: The missing link in coral reef management: where do the larvae go?

Increasingly the ARC Centre is being recognized for its world leadership in research necessary for the sustainable management of coral reefs. Program 3 of the Centre focuses on (a) assessing the importance of marine reserves for fisheries management, (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. These research themes are entirely consistent with *National Research Priority #1 – An Environmentally Sustainable Australia*.

Most of the team's field work has been undertaken in Australia, PNG and the Philippines. A key breakthrough by the team, published in *Science* and *Nature*, has been the development of new tagging technologies for tracking the dispersal of larval fishes (Almany et al. 2007) (See opposite). Larval rearing and novel marking experiments (using Barium isotopes) have now been completed successfully on a large commercially important grouper. Jones, Almany and colleagues received a major funding boost in 2007 with the receipt of a US$460K David and Lucille Packard Foundation Grant to support field trials of novel larval tagging techniques. This work is a collaborative undertaking with Principal Investigator, Simon Thorrold of the Woods Hole Oceanographic Institute. Related work by Mike Kingsford, also with colleagues from Woods Hole, demonstrated that larval fishes are behaviourally sophisticated, capable of cuing into environmental signals that allow them to distinguish and return to their natal reef (Gerlach et al. 2007).

In 2007, Geoff Jones and Glenn Almany have been conducting novel fish larval tagging experiments and DNA sampling of reef fishes on the Great Barrier Reef, to measure dispersal of commercially important fish between no-take (Green) zones of the GBR Marine Park and fished areas. This ambitious field program was achieved through the collaboration of 15 researchers from JCU and 20 volunteer recreational fishers. Related work by colleague Jeff Leis at the Australian Museum focuses on larval behaviour and hydrodynamics. Program 3 Leader, Garry Russ and colleagues have undertaken the first field assessments of the new Green Zones (no-take areas, where fishing is prohibited) on inshore coral reefs of the Great Barrier Reef to compare the abundance of targeted species inside and outside of the new zones. Initial data from the Whitsunday Islands indicated a relatively fast and positive response of targeted reef fish populations to the shift in management. These research projects on the Great Barrier Reef are co-funded by the Reef and Rainforest Research Centre.

In related work, Australian Research Professor Connolly and co-authors have combined direct underwater counts of sharks with mathematical models to project their future population trends, based on information about reef sharks' current survival, growth and reproduction (Robbins et al. 2006). Their research show a dramatic fall in shark numbers due to over-harvesting. These new findings have been used by Queensland DPI&F, who released proposed fishing changes in 2007 that list these species as "vulnerable", bans their targeting by fishers, and reduces the incidental by-catch that can be retained.

These results are of major significance to a key stakeholder and collaborator of the ARC Centre, the Great Barrier Reef Marine Park Authority (GBRMPA). For example, Russ's studies of inshore no-take zones on the GBR provided key assistance to GBRMPA to defend its policy of expanding the no-take zones in the GBR Marine Park from 4.5% to 33%. His findings provide the best demonstration that the GBR no-take zones produce "more fish and bigger fish". Larger fishes are disproportionately more fecund, exporting larvae across the boundary of green zones. In a public ceremony in Canberra, GBRMPA awarded Russ a *Certificate of Appreciation* in 2007 for the relevance and impact of his work on the management of the Great Barrier Reef Marine Park.

Selected 2007 publications:

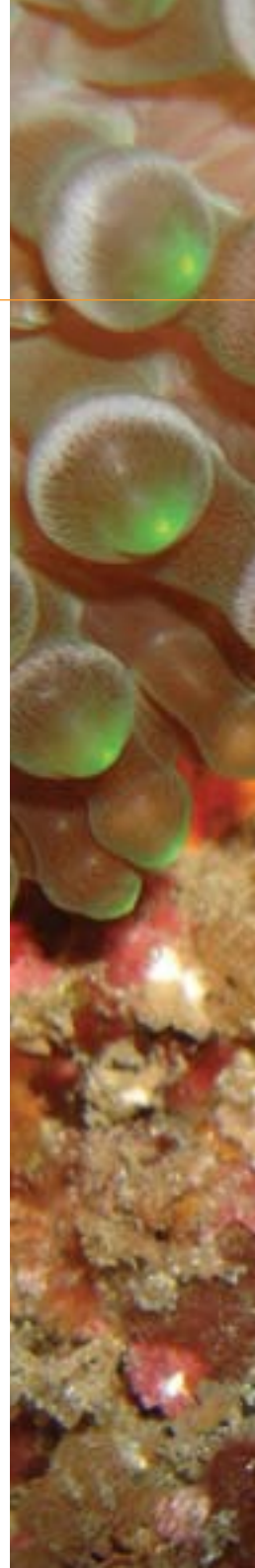
Almany, GR, Berumen, ML, Thorrold, SR, Planes, S and Jones, GP (2007). Local Replenishment of coral reef fish populations in a marine reserve. *Science* 316(5825): 742-744.

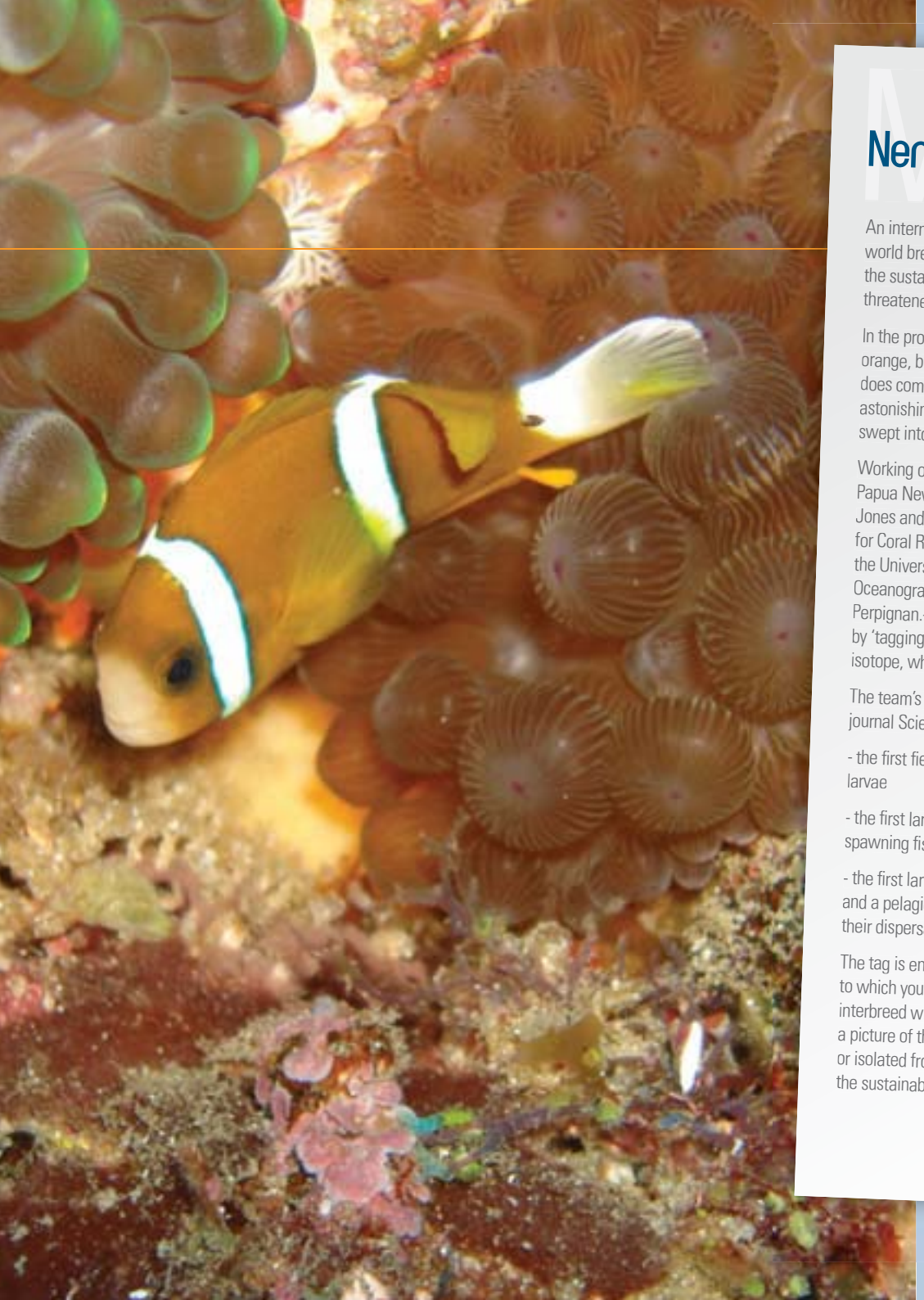
Burgess, SC, Kingsford, MJ and Black, KP (2007). Influence of tidal eddies and wind on the distribution of presettlement fishes around One Tree Island, Great Barrier Reef. *Marine Ecology Progress Series* 341: 233-242.

Fauvelot, C, Lemaire, C, Planes, S and Bonhomme, F (2007). Inferring gene flow in coral reef fishes from different molecular markers: which loci to trust? *Heredity* 99(3): 331-339.

Gerlach, G, Atema, J, Kingsford, MJ, Black, KP and Miller-Sims, V (2007). Smelling home can prevent dispersal of reef fish larvae. *Proc. National Acad. Sci.* 104(3): 858-863.

Jones, GP, Srinivasan, M and Almany, GR (2007). Population Connectivity and Conservation of Marine Biodiversity. *Oceanography* 20(3): 42-53.





Media Release

Nemo comes home with a tag

4 May 2007

An international team of coral reef scientists has achieved a world breakthrough in tracking fish that could revolutionise the sustainable management of coral reefs and help restore threatened fisheries.

In the process, they have established that Nemo – the lovable orange, black and white clownfish of movie fame – really does come home, with around 60 per cent completing the astonishing journey back to their tiny home reef after being swept into the open ocean as babies.

Working on pristine coral reefs in a marine protected area in Papua New Guinea, an international team - led by Dr Geoff Jones and Dr Glenn Almany of the ARC Centre of Excellence for Coral Reef Studies, working with Michael Berumen of the University of Arkansas, Simon Thorrold of Woods Hole Oceanographic Institute and Serge Planes of the University of Perpignan.- has pioneered a new way to study fish populations by 'tagging' adult fish with a minute trace of a harmless isotope, which they then pass on to their offspring.

The team's findings were announced in the international journal Science today, and contain three scientific world-firsts:

- the first field-based use of a new method of tagging fish larvae

- the first larval tagging study of a free-water (pelagic) spawning fish species

- the first larval tagging study of a bottom (benthic) spawner and a pelagic spawner in the same location and comparison of their dispersal patterns.

The tag is enabling the researchers to understand the extent to which young fish return to their 'home' area or go off to interbreed with more distant populations. This helps to build a picture of the extent to which fish populations are connected or isolated from one another – currently a vital missing link in the sustainable management of fish stocks.

"If we can understand how fish larvae disperse, it will enable better design of marine protected areas and this will help in the rebuilding of threatened fish populations," Dr Almany explains.

In trials at Kimbe Bay, PNG, researchers tagged over 300 female clownfish and vagabond butterflyfish with a barium isotope. Females pass the isotope to their offspring and it lodges in their ear-bones (otoliths). "The isotope is stable, non-radioactive and quite harmless to the fish in these minute amounts – or to humans if it were to be used to tag a table fish," Dr Almany explains. "It's simply a way of telling one group of fish of the same species from another."

The team returned to confirm the tags had worked and study how many of the offspring had returned to the home reef or had dispersed to other reefs. They found around 60% of the juvenile fish returned to the home reef – a tiny dot in the ocean only 300m across – after being carried out to sea as babies. "Just as importantly, 40% of the juveniles came from other reefs that are at least 10 kilometres away, which indicates significant exchange between populations separated by open sea," he adds. "This shows how marine protected areas can contribute to maintaining fish populations outside no-fishing zones."

The team will next conduct trials with coral trout off Great Keppel Island on the Great Barrier Reef. Similar studies are planned for coral trout in PNG and in the Caribbean with a threatened species, the Nassau groper. In both cases the team hopes the new insights from larval tagging will improve management and the fish populations' chances of recovery.

"In a situation where you are trying to protect fish caught for the table, tagging would help you to select the right reefs to protect, in order to maintain the overall population – and the fish catch into the future," Dr Almany explains.

National Benefit
Case-Study

Case Study 2: Conservation planning for a sustainable future

Conservation reserves, including many World Heritage Areas, are at the core of strategies to protect biodiversity, ecosystem services, cultural heritage and recreation resources. No-take reserves are often established to conserve species, ecological communities, habitats, ecosystems and bioregions. To date, some of the largest and most successful applications of no-take marine reserves have been on coral reefs, mostly notably is Australia's Great Barrier Reef Marine Park, with a no-take area of over 100,000 km^2. Developing a new program, Program 6, within the Centre that specifically addresses conservation planning is a natural progression for us, which came to fruition at the end of 2007. This timely research focus is led by Bob Pressey, who is recognised internationally as a leading proponent and innovator in the field of systematic conservation planning. He invented and quantitatively defined seminal concepts (e.g. efficiency, irreplaceability, vulnerability, scheduling) that underpin systematic planning methods. Pressey and colleagues have created and continue to advance an influential framework for conservation that has been implemented in many parts of the world, including Australia, Brazil, Mexico and South Africa (see opposite).

Pressey's award-winning C-Plan software recognizes the importance of people as part of the natural landscape and includes stakeholders in the process of balancing resource use and protection. It has been used as a major planning tool by 350 registered users around the world. In 2007, Pressey and his students worked with Federation Fellow Professor Hugh Possingham, Director of The Ecology Centre, University of Queensland, in addressing Australia's environmental planning, decision making and policy approaches. They have developed a range of new tools and techniques to help environment managers overcome management and policy challenges. Upgrades C-Plan are available from the ARC Centre's website, as part of a growing portfolio of research services provided to a wide range of end-users.

Program 6 also integrates the work of many other Centre members who provide the underlying science that is incorporated into conservation planning of reefs. For example:

- Geoff Jones and Partner Investigator Serge Planes from the University of Perpignan have begun a new project to 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. This work is co-funded by the Coral Reef Initiative of the South Pacific (CRISP) program and the ARC Centre.
- In Papua New Guinea, Phil Munday serves on the board of the Mahonia Na Dari Research and Conservation Centre in Kimbe Bay, New Britain Province (**www.mahonia.org**), in recognition of his expertise in marine park planning. The mission of this NGO is to "understand and conserve the natural environment of Kimbe Bay and Papua New Guinea for the benefit of present and future generations".
- Also in PNG, Josh Cinner's social science research is being used by the Wildlife Conservation Society as a basis for the development of a multi-site network of conservation protected areas, based on the customary management practices. New conservation projects undertaken by the WCS in PNG are based around customary management, developing new and improved conservation techniques that more appropriately reflect the local culture.

Program 6 research is consistent with *National Research Priority #1 – An Environmentally Sustainable Australia*. In particular, three Priority Goals all embrace this major research initiative: A2 (*Transforming existing industries*), A5 (*Sustainable use of Australia's biodiversity*), and A7 (*Responding to climate change and variability*).

Selected 2007 publications:

Cinner, J (2007). Designing marine reserves to reflect local socioeconomic conditions: lessons from long-enduring customary management systems. *Coral Reefs* 26(4): 1035-1045.

Cinner, JE and Aswani, S (2007). Integrating customary management into marine conservation. *Biological Conservation* 140(3-4): 201-216.

Hughes, TP, Gunderson, LH, Folke, C, Baird, AH, Bellwood, D, Berkes, F, Crona, B, Helfgott, A, Leslie, H, Norberg, J, Nystrom, M, Olsson, P, Osterblom, H, Scheffer, M, Schuttenberg, H, Steneck, RS, Tengo, M, Troell, M, Walker, B, Wilson, J and Worm, B (2007). Adaptive Management of the Great Barrier Reef and the Grand Canyon World Heritage Areas. *Ambio* 36(7): 586-592.

Pressey, R.L., Cabeza, M., Watts, M.E. Cowling, R.M. and Wilson, K.A. (2007). Conservation planning in a changing world. *Trends in Ecology and Evolution* 22(11): 583-592.

Wilson, KA, Underwood, EC, Morrison, SA, Klausmeyer, KR, Murdoch, WW, Reyers, B, Wardell-Johnson, G, Marquet, PA, Rundel, PW, McBride, MF, Pressey, RL, Bode, M, Hoekstra, JM, Andelman, S, Looker, M, Rondinini, C, Kareiva, P, Shaw, MR and Possingham, HP (2007). Conserving Biodiversity Efficiently: What to Do, Where, and When. PLoS *Biology* 5(9): e223.

Media Release

Keeping on top of wildlife threats

14 August 2007

One of Australia's greatest conservation challenges in protecting the Great Barrier Reef and other natural assets is staying one jump ahead of both the movement of protected species and the emergence of new and unforeseen threats. Working out ways to give local communities as well as conservation managers the power to do this is the work of Professor Bob Pressey of the ARC Centre of Excellence for Coral Reef Studies. Pressey specialises in systematic conservation planning – the development of strategies that keep endangered species and habitats going in the long term. His research has been cited by over 3000 scientific publications worldwide.

"We've long known you can't just put a fence round wildlife and expect it to survive. It moves in response to many factors, especially changing climate. And new threats emerge," he says. "We have to find ways of protecting our native species that allow both for movements by the species and changes in the nature of the pressures and threats they face."

Pressey has summarised current scientific thinking about these challenges in a review paper titled "Conservation planning in a changing world", soon to be published in the prestigious journal Trends in Ecology and Evolution.

The Great Barrier Reef is a case in point. As climate change advances, scientists expect that its corals will become increasingly stressed and start to migrate towards environments that suit them better, meaning that protected areas may have to shift also. While we are gaining a good understanding of the range of threats the Reef faces today – rising water temperature, runoff and sediment from the land, man-made toxins, overfishing and development pressures – new ones, such as the gradual acidifying of the world's oceans due to CO2, are emerging. "It means you can't afford to stand still if you want to hand your children the natural wonders you love and value," Pressey says.

Working in threatened environments worldwide from southern Africa to the Amazon floodplain, Pressey says that local people are enormously important to the successful protection of their environment.

"My job is to give them tools to understand the changes that are taking place, both in the protected species or ecosystems themselves and in the threats and pressures they face – and to look into the future to see where these might lead. "For example, the Green (no-fishing) Zones of the GBR will benefit Fisheries. But what we do on land is also immensely important to their long-term health and survival. You can still harm the Reef in other ways besides overfishing."

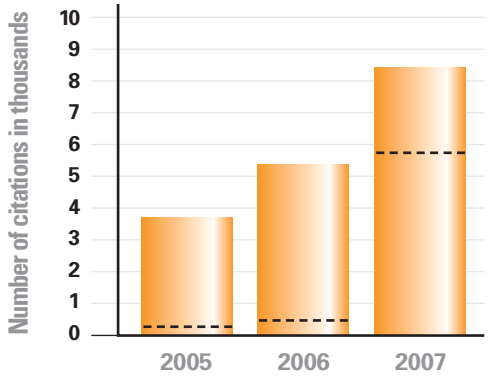
The important thing, he argues, is to give local communities choices about how they plan their future – and ways to visualise the results they might achieve from various courses of action. "If you can see how a certain development or activity might affect native species decades into the future you might decide to explore other options that are just as economically fruitful, but which save more wildlife," he suggests. "Or if you find that one area is absolutely vital to the survival of a particular species, you may ask: where else can we locate our industries or developments?"

Pressey's research aims to build practical planning tools that enable local communities to anticipate both movement in native species and take a precautionary approach to the emergence of new risks. Behind these tools there is the sophisticated and complex science of understanding and modelling changes in natural and human systems, and predicting how they affect one another.

He is presently designing new software that can be used by local communities, agencies, and non-government organisations to guide decisions about conservation investments, on the land and in the sea.

Publications

The ARC Centre of Excellence for Coral Reef Studies produced 149 publications in 2007, almost 50% above the Centre's initial 2005 output. 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 2007 for the number of journal publications and citations in coral reef science. Twenty-nine 2007 articles were published in journals with Impact Factors greater than four, including eight papers in *Science, Nature, PNAS* and *Current Biology.* The average Impact Factor for all 127 journal articles in 2007 was 5.3.



Citations to members of the ARC Centre of Excellence each year for 2005-2007. The Centre personnel received 8313 citations in 2007, a 128% increase from 2005. Twenty-two researchers were cited >100 times each in 2007, and nine of these had >300 citations in the 12-month reporting period. Three Program Leaders in the Centre are recognized in 2007 by ISI as Highly Cited Researchers, in the top half of one percent for citations in their field.

Centre researchers received widespread national and international recognition in 2007 for the quality of their research, including 29 invitations to provide international keynote addresses (in Australia, France, Germany, Ireland, Japan, the Netherlands, the Philippines, Indonesia, South Africa, Spain, Sweden, the UK, and the USA), and 34 invitations to write major reviews.

League table achievements in publications for 2007 include: ISI Essential Science Indicators identified six Research Fronts in 2007 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 Fronts were Adaptive governance of social-ecological systems, Unified neutral theory, Climate change and species distributions, Coral Reef Ecosystems, Coral symbiosis and bleaching, and Coral reef resilience. Sixteen core papers in these Research Fronts were authored by A. Baird, D. Bellwood, S. Connolly, M. Dornelas, O. Hoegh-Guldberg, A. Hoey, T. Hughes, J. Pandolfi, B. Pressey, and by Partner Investigators C. Folke, J. Lough, and R. Steneck.

The Faculty of 1000 Biology highlighted five of our publications for review in 2007:

Berumen, ML and Pratchett, MS (2006). Recovery without resilience: persistent disturbance and long-term shifts in the structure of fish and coral communities at Tiahura Reef, Moorea. *Coral Reefs* 25(4): 647-653. Evaluated 25 May 2007.

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Almany, GR, Berumen, ML, Thorrold, SR, Planes, S and Jones, GP (2007). Local Replenishment of Coral Reef Fish Populations in a Marine Reserve. *Science* 316(5825): 742-744. Evaluated 18 May 2007.

Hughes, TP, Rodrigues, MJ, Bellwood, DR, Ceccarelli, D, Hoegh-Guldberg, O, McCook, L, Moltschaniwskyj, N, Pratchett, MS, Steneck, RS and Willis, B (2007). Phase shifts, herbivory, and the resilience of coral reefs to climate change. *Current Biology* 17(4): 360-365. Evaluated 16 April 2007.

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Recognition of Excellence by Centre Members

Members of the ARC Centre of Excellence for Coral Reef Studies received wide scale recognition of their contributions to coral reef science in 2007. For example:

The Centre's Director, Terry Hughes, received three major honours in 2007. He was awarded his second Federation Fellowship in May (for 2007-2012). Later in the year, his contribution to environmental research was recognised with the award of the Australian Museum Sherman Eureka Prize (**www.amonline.net.au/eureka)**. Finally, in December, he was awarded the prestigious quadrennial Darwin Medal of the International Coral Reef Society, which will be presented at the 2008 ICRS meeting in Fort Lauderdale (US).

Dr Morgan Pratchett was awarded a Churchill Fellowship by the Churchill Trust (**www.churchilltrust.com.au**). This provides financial support to enable him to travel to the University of Newcastle to build his collaboration with the group led by Professor Nick Polunin.

A number of Centre members were successful in the 2007 ARC Fellowship awards: Sean Connolly (APF), Phil Munday (QEII), Tracy Ainsworth and Josh Cinner (APD). In addition Line Bay was awarded a highly competitive Queensland Smart State Fellowship.

The Centre's PhD students have also been very successful in 2007, with a number receiving recognition nationally and internationally for their research. These awards include:

Maria Rodrigues was one of three Australians to win the "L'Oreal-UNESCO Young women in science 2008 fellowship". This provides US$25,000 for 2 years to cover her field expenses for her postdoctoral research in East Africa (Mozambique, Kenya and Tanzania). **www.loreal.com/_en/_ww/index.aspx?direct1=00008&direct2=00008/00001**

Maria Dornelas won the 2007 IMAR-Luiz Saldanha prize for her paper "Coral reef diversity refutes the neutral theory of biodiversity", *Nature* 440, 80-82 (2 March 2006). IMAR, the network of Portuguese research institutes that undertake marine research, awards this prize every year to the most significant publication on marine sciences by a young Portuguese author.

Rene Abesamis won the 2007 Zonal CHED Republica Award for Natural Sciences. The award was presented in Cebu City for her paper with Garry Russ on marine reserves in the Philippines. **www.visayandailystar.com/2007/November/13/negor5.htm**

Andrew Hoey was awarded an Ian Potter Foundation Doctoral Fellowship to conduct fieldwork on Lizard Island
Kate Bromfield was runner up in the prestigious American Paleontology Society award.

Luiz-Felipe Mendes-de Gusmao won a prize to attend the 4th International Zooplankton Production Symposium in Hiroshima, Japan, on May 28 - June 1, 2007.

The two major prizes to postgraduate students by the Australian Coral Reef Society were awarded to Richard Evans (the Terry Walker Prize) and Vivian Cumbo (the Danielle Simmons Prize). Richard Evans also won the GBRMPA Science for Management award.

Garry Russ (right) receiving Certificate of Appreciation for his contribution to management of the Great Barrier Reef Marine Park from John Tanzer, Executive Director, Great Barrier Reef Marine Park Authority

Performance Measures

Research findings

Measure	Outcome 2006	Target 2007	Outcome 2007
Number of publications	132	135	149
Publications in journals with an impact factor > 4	33	34	29
Number of citations	5353	5500	8313
Invitations to provide plenary addresses at international conferences	29	30	29
Invitations to provide review articles	33	35	26
Number and nature of commentaries about the centre's achievements	737	750	892
Awards, Prizes or Recognition	14	15	18

Research training and professional education

Measure	Outcome 2006	Target 2007	Outcome 2007
Number of postgraduates enrolled	110	24	129
Number of postgraduate completions	13	14	22
Number of Honours students	22	12	23
Number of professional workshops	10	10	23
Participation in professional workshops	22	20	24
Number and level of graduate student courses and workshops in the priority area(s)	12	20	12

International, national and regional links and networks

Measure	Outcome 2006	Target 2007	Outcome 2007
Number of international visitors	52	55	72
Number of national and international Working Groups	15 Centre investigators participated in 17 international and 7 national working groups.	12	18 Centre investigators participated in 17 working groups.
Number of visits to overseas laboratories and research facilities	46	50	53
Invitations to membership of national and international boards and advisory committees	41	40	56
Number of cross-institutional publications.	88	85	101
Number of multi-institutional supervisory arrangements of graduate students.	42	40	46
Number & nature of contractual arrangements. increase the level of internationally funded students increase level of consultancies and contract research	 16 12	 20 over 5 yrs 5	 28 16
Number of government, industry and business briefings	30	25	36
Number of Centre trained/ing personnel in knowledge / technology transfer and commercialization	6	5	9
Public Awareness programs Website hits Public awareness presentations	 0.61m 12	 1.00m 12	 1.96m 31

Performance Measures

Organisational support

Measure	Outcome 2006	Target 2007	Outcome 2007
Annual cash contributions from Collaborating Organisations	$1.2m	$1.25m	$1.46m
Annual in-kind contributions from Collaborating Organisations	$2.8m	$2.9m	$3.1m
Number of new Organisations recruited to or involved in the Centre	10	5	25
Level and quality of infrastructure provided to the Centre	$0.93m	$0.97m	$1.02m
Annual cash contributions from other new organisations	$0.17m	$0.18m	$1.1m

National Benefit

Measure	Outcome 2006	Target 2007	Outcome 2007
Measures of expansion of Australia's capability in the priority area(s)	62% increase in Publications 81% increase in Citations	100% increase on benchmark year by year 5.	46% increase in Publications
	30 briefings	30 briefings to government, business and industry groups	36 briefings
	17 Cross-nodal publications	17 cross-institutional co-authored publications	20 Cross-nodal publications
	88 Cross-institutional publications	90 cross-institutional publications	101 Cross-institutional publications
Case studies of economic, social, cultural or environmental benefits	26 Media Releases	2 to be highlighted in the annual report and distributed to media agencies	26 Media Releases See p.36

Governance

Measure	Outcome 2006	Target 2007	Outcome 2007
Breadth and experience of the members of the Advisory Board		Senior representation from all nodes. Representation of eminent international researchers. Members with commercial and business links.	See p.7
Frequency and effectiveness of Advisory Board meetings	4 Scientific Management Committee meetings held. Inaugural Centre Advisory Board meeting held in May 2006.	2 Centre Advisory Board meetings p.a.. 4 Scientific Management Committee meetings pa..	See p.7
Quality of the Centre strategic plan	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.	The Centre's progress against the plan will be formally reported to the Advisory Board and be renewed in light of outcomes.	Strategic Plan reviewed and endorsed by the Centre Advisory Board. Ongoing performance against plan reviewed at Scientific Management Committee meetings.
Effectiveness of arrangements to manage Centre nodes	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	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	All nodes and research programs represented at Scientific Management Committee meetings Monthly nodal and program leader meetings held In 2007 management meetings held at each of the 3 nodes In 2007 research planning meetings held for Centre and each research program Cross-nodal attendance at all research planning meetings
The adequacy of the Centre's Key Performance Measures	Centre outperformed benchmark institutions	International benchmarking to research in top international marine research centres.	The Centre outperformed benchmarked institutions

Financial Statement

ARC Centre of Excellence for Coral Reef Studies

Statement of Operating Income and Expenditure for year ended 31 December 2007

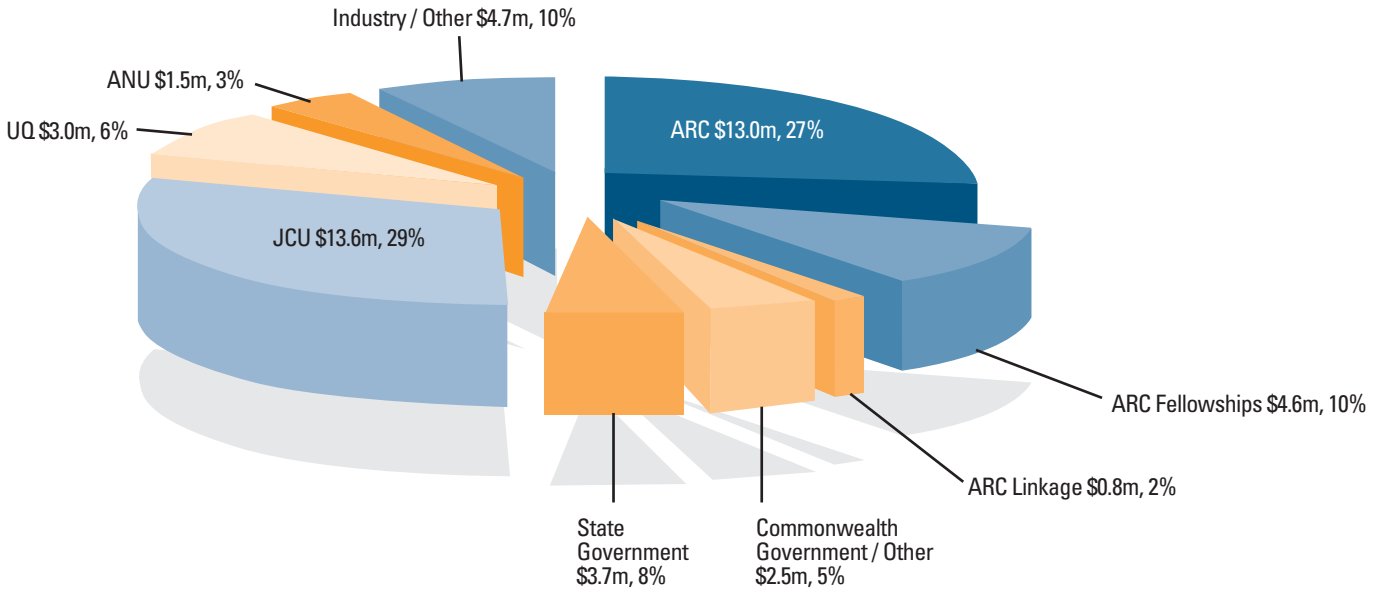
Income	2006 $	2007 $
ARC Centre Grant	3,722,158	**$2,547,520**
ARC Fellowships	420,562	**326,975**
ARC Networks Program	30,000	**30,000**
Host Institutions support	1,205,000	**1,389,642**
Local Government	25,000	
State Government	20,000	**10,000**
Commonwealth Government other grants	193,000	**433,000**
International income & other contracts	59,083	**249,329**
Total Income	$5,674,803	**$4,986,466**

Expenditure	2006 $	2007 $
Salaries	1,893,885	**2,576,541**
Equipment	206,878	**542,122**
Travel	587,903	**925,936**
Research Maintenance & consumables	567,313	**687,958**
Scholarships and prizes	36,642	**39,544**
Public Outreach and Administration	127,444	**127,698**
Total Expenditure	$3,420,065	**$4,899,799**
Surplus (Deficit)	$2,254,738	**$86,667**
Balance brought forward from prior years		**2,508,061**
Total carry forward		**$2,594,728**

Financial Status

The operating cash and in-kind operating budget for the Centre of Excellence for 2005-2010 currently totals $47.2m, a 49% increase from 2005 projections. The chart below indicates the budgeted level of income from the various funding sources.

ARC Centre of Excellence Cash & inkind funding outlook 2005-2012 – Total $47.2m



Acknowledgements

The ARC Centre of Excellence for Coral Reef Studies would like to thank the following groups and people for their ongoing support:

- The Australian Research Council
- James Cook University
- The Australian National University
- The University of Queensland
- School of Marine and Tropical Biology, JCU
- School of Pharmacy and Molecular Sciences, JCU
- School of Arts and Social Sciences JCU
- Centre for Marine Studies, UQ
- The Ecology Centre, UQ
- Research School for Earth Sciences, ANU
- Reef and Rainforest Research Centre- project managers for MTSRF
- Queensland Government- Smart State
- Australian Institute of Marine Science
- Great Barrier Reef Marine Park Authority
- Stockholm Resilience Centre
- Stockholm University
- University of Delaware
- University of Maine
- University of Perpignan
- Douglas Shire Council
- Great Barrier Reef Research Foundation
- Resilience Alliance
- Mackay City Council
- Mackay-Whitsunday NRM Group
- Packard Foundation
- Western Indian Ocean Marine Science Association
- The Nature Conservancy
- United Nations University
- World Bank GEF Coral Reef Targeted Research Program
- ICOMOS

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