ARC Centre of Excellence
Coral Reef Studies

2008 ANNUAL REPORT

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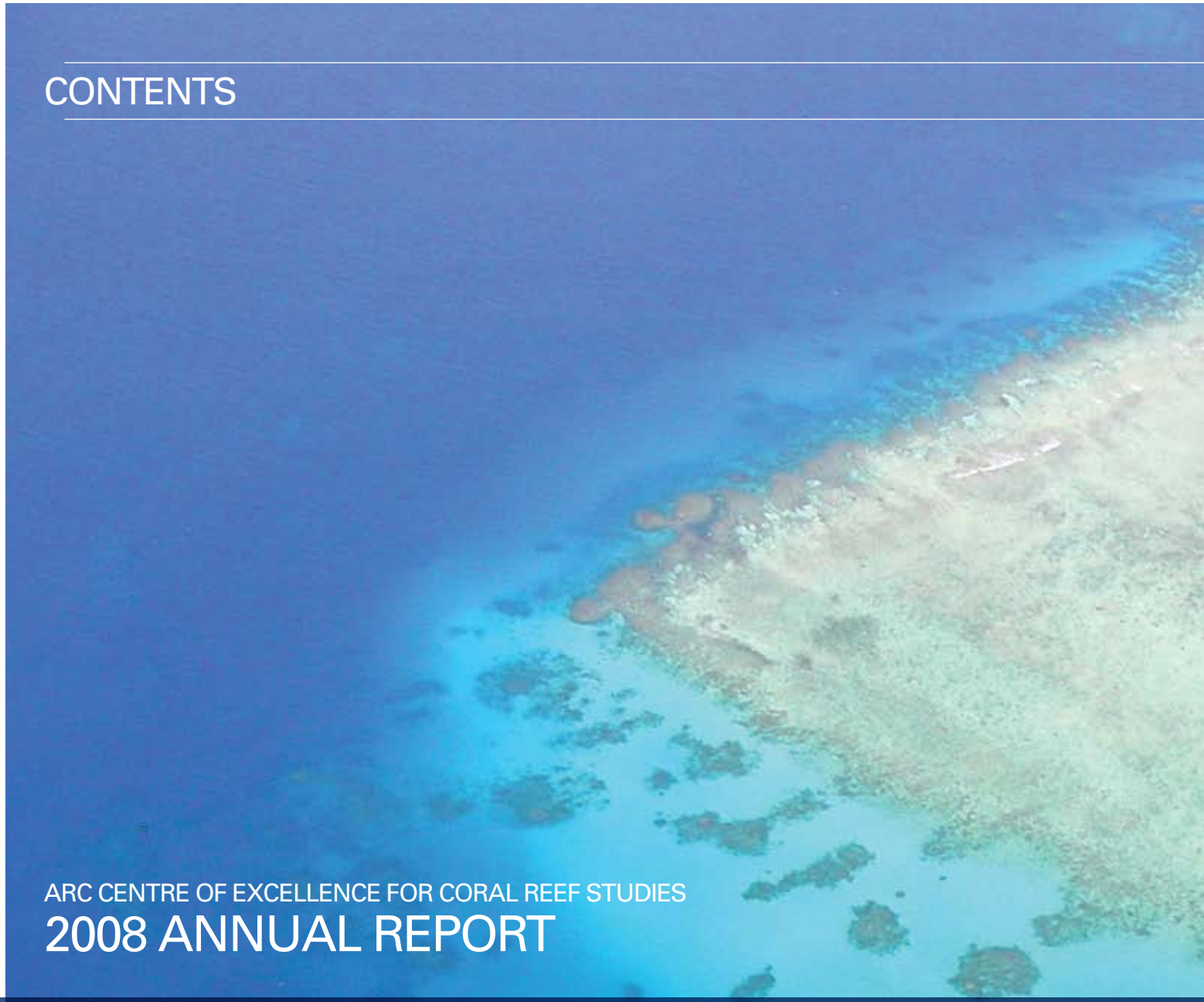
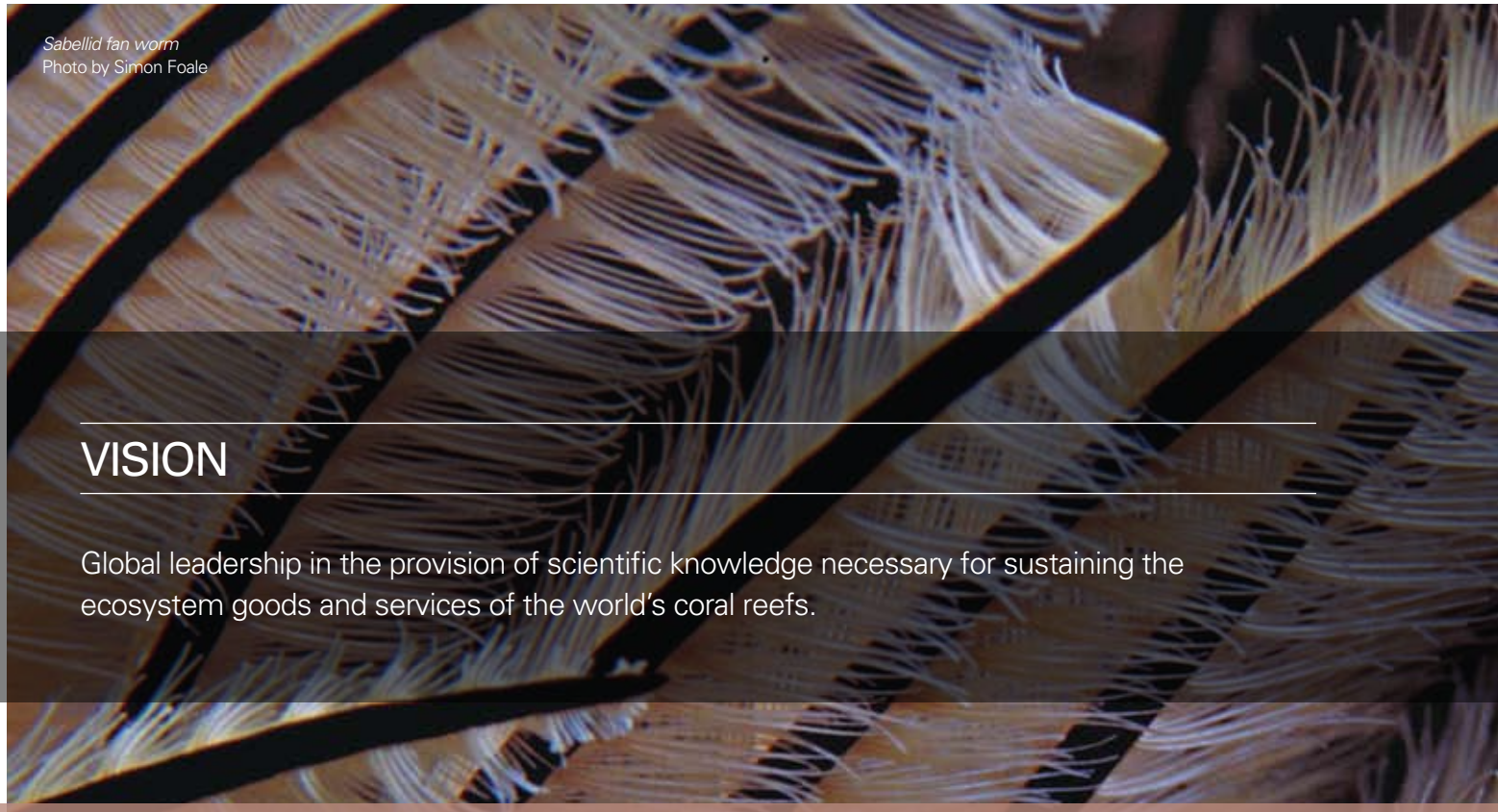


ARC CENTRE OF EXCELLENCE FOR CORAL REEF STUDIES

2008 ANNUAL REPORT

Cover Photo – Squid sp.
Photo by Simon Foale

Aerial shot- Great Barrier Reef near Lizard Island
Photo by Mary-Jo Boyle



Sabellid fan worm
Photo by Simon Foale

VISION

Global leadership in the provision of scientific knowledge necessary for sustaining 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:

Research

The Centre's research is world-best, innovative, and highly relevant to coral reef science and management.

Research Training and Professional Education

The Centre attracts and trains 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 knowledge, technologies and research outcomes by the Centre 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 undertaken by the Centre extend knowledge transfer, nationally and globally.

OVERVIEW

The ARC Centre of Excellence for Coral Reef Studies was established in July 2005 under the ARC Centres of Excellence Program. 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) as well as collaborative links to 263 institutions in 45 countries.

Major research themes include adaptation to climate change, managing biodiversity, emergent coral diseases, fisheries biology, design of marine parks, conservation planning, social studies and governance and policy – in short, the applied and basic science that underpins the sustainable delivery of goods and services from the world's coral reefs.

DIRECTOR'S REPORT

Welcome to our 2008 annual report. The Centre's performance over the past 3 years was formally reviewed by ARC in September 2008, and I'm very pleased to confirm that our core funding has been extended to the end of 2013. James Cook University has responded by generously increasing their financial support, and by providing us with more space to cater for further growth. The Centre's research capacity has continued to expand rapidly during 2008, as our membership in Australia nudges past 200 people. By the end of 2008, we have recruited 37 Research Fellows and 151 graduate students (from 37 countries), making the Centre the largest provider of graduate and early career training in coral reef science in the world. In the past year, the Centre produced 186 publications, representing a 2-fold increase in output over the past 3 years.

Our fieldwork in 2008 was undertaken in 21 countries. During the year, we signed an MOU with *The Nature Conservancy* (the world's largest conservation NGO), which focuses mainly on the Centre's ongoing research in the Philippines, Indonesia, Papua New Guinea and the Solomon Islands. Our 186 publications in 2008 were co-authored by colleagues from 263 institutions in 45 countries, reflecting our worldwide activities. The number of short- and long-term international visitors to the Centre's nodes in Townsville, Brisbane and Canberra has tripled since 2005, to 75 in 2008.

The Centre is working more closely than before with dozens of government agencies and international NGOs. Activities in 2008 included 22 consultancies, policy briefings, reports for World Heritage sites, legislative reports, the Australian National Climate Change Adaptation Research Plans, the ARC Advisory Council, the Graeme Clark Research Outcomes Forum, and much more. In November, the Centre provided expertise and logistical support to an international workshop of over 100 participants in Townsville, part of the Australian Government's contribution to the international Coral Triangle Initiative (see article on p.48.). A further highlight of 2008 has been the launch and rapid growth of the Centre's Program 6, entitled

Conservation Planning for a Sustainable Future (p.24) led by Professorial Fellow Bob Pressey. Next year, 2009, we will be establishing two new Programs, bringing the total to eight.

The Centre's two Deputy Directors, Ove Hoegh-Guldberg and Malcolm McCulloch were each awarded prestigious 5-year Premier's Fellowships in 2008, from the States of Queensland and Western Australia, respectively. Only one or two Premier's Fellowships are awarded annually by each State, so having two such awards in the same year is a great outcome for Ove, Malcolm, and the Centre.

This year the Centre has continued to expand its outreach activities. Our website (*www.coralcoe.org.au*) received 4.1 million hits in 2008, up from 1.9 million in 2007 and 680,000 in 2006. Our media coverage has also grown rapidly, with well over 1000 stories published or broadcast in 2008 (p.42). As a contribution to the *2008 International Year of the Reef*, the ARC Centre posted twenty-one 15-minute seminars on our website. These were video-recorded in front of a large audience at the Australian Academy of Science headquarters in Canberra. The "webinars" focus on important and topical issues including climate change, fisheries management, conservation planning, capacity building, ecosystem-based management and adaptive governance. Since May 2008, these presentations have been downloaded more than 20,000 times, a testament to the huge demand for information on sustaining coral reefs. The ARC Centre also made a major contribution to the 11th International Coral Reef Symposium, held in Florida in July. The Centre's membership, including 66 students, presented 124 talks and posters during the 5-day event, including the symposium's opening and closing plenary talks.

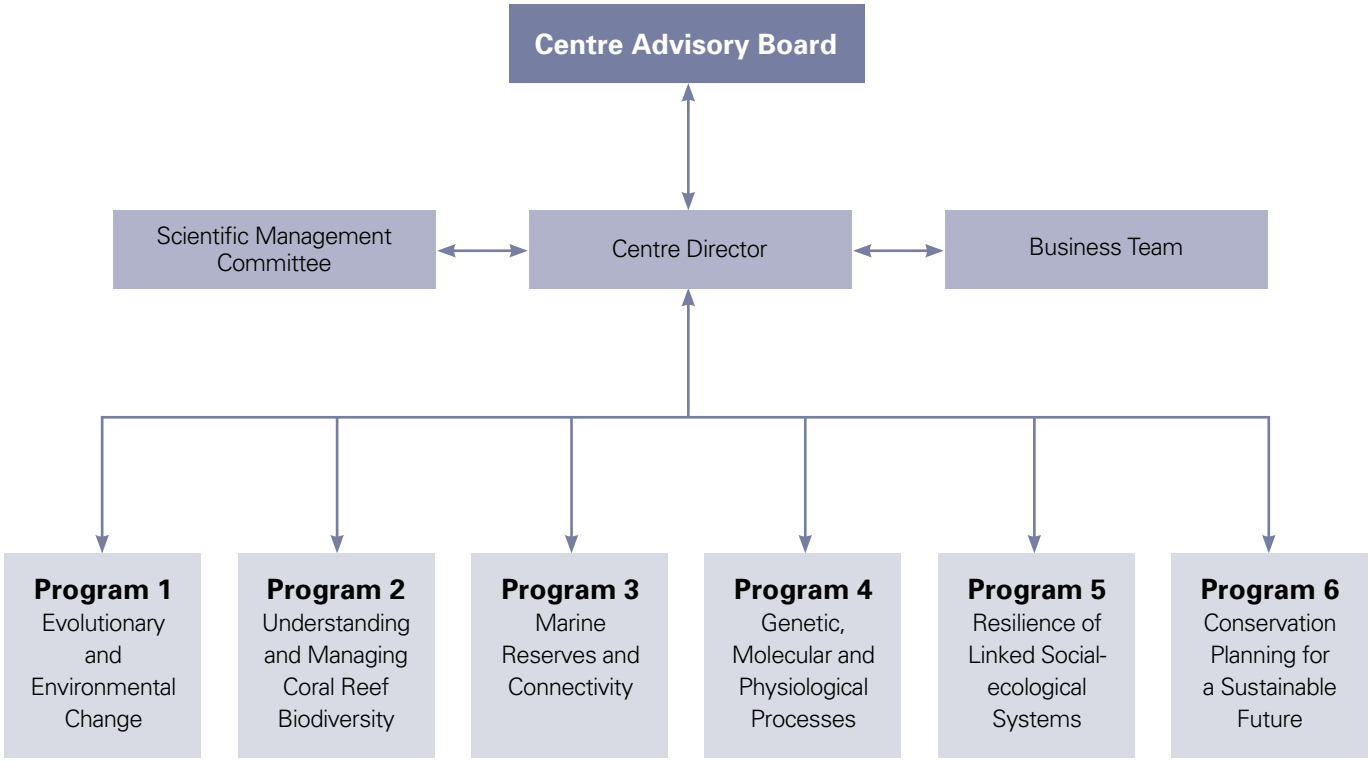
I'd like to finish by thanking my University colleagues, our partners in the *Australian Institute for Marine Science* and the *Great Barrier Reef Marine Park Authority*, and our many overseas friends, for their contributions to a third outstanding year. I am especially grateful to the Centre's Advisory Board and our administrative team – Jenny Lappin, David Yellowlees, Louise Taylor, Olga Bazaka, and Janet Swanson – for their dedication and enthusiasm.

As always, we welcome your feedback and comments on the Centre and our report.

Terry Hughes
Director

Big Eye trevally Caranx sexfasciatus
Photo by Simon Foale

MANAGEMENT STRUCTURE



GOVERNANCE

The Centre has established flexible governance structures that engage stakeholders in planning and management processes. The diagram opposite illustrates the current corporate structure and relationship between the members in the Centre. Program 6 was initiated in January 2008. The governance structures of the Centre will be revised during 2009, to better reflect the Centre's extensive international research profile and to incorporate two new research programs.

The Centre is administered from JCU reporting through the Centre Director, Terry Hughes to Professor Chris Cocklin, the Deputy Vice-Chancellor (Research and Innovation). The Centre's Chief Investigators are located in three faculties at JCU, and at the Australian National University and the University of Queensland. Partner Investigators are based at the Australian Institute of Marine Science, the Great Barrier Reef Marine Park Authority, and in overseas institutions. Day-to-day operations are managed by the Chief Operations Officer, Jenny Lappin, in consultation with the Centre Director and Assistant Director, David Yellowlees. The Centre Director oversees the Centre's research programs together with the two deputy directors, Ove Hoegh-Guldberg (UQ) and Malcolm McCulloch (ANU).

CENTRE ADVISORY BOARD

The ARC Centre's Advisory Board provides vision and strategic advice and facilitates improved linkages between the Centre and the private sector, State/Territory, Commonwealth Government, research institutions and the wider community. The Director and Chief Operations Officer of the Centre provide the link between the Advisory Board, Centre operations and the Scientific Management Committee. The Board met formally in Townsville in April 2008. A key focus for the Advisory Board during 2008 was preparing the Centre for its formal review by the ARC. A trial review of the Centre was undertaken during February by Board member Professor Mandy Thomas (ANU) and Professor Rob Whelan (University of Wollongong), and facilitated by the Chair Dennis Trewin. The Centre is very grateful for the trial review panel's expertise and advice which provided invaluable assistance in preparing for the Centre's formal review later in 2008. The outcome of the review was a full extension of ARC funding over the next 5 years.

In 2008, the Advisory Board's membership was:

- **Dennis Trewin** (Chair)
  Former Australian Statistician
- **Professor Norman Palmer** (until June 2008)
  Pro-Vice-Chancellor (Research and Innovation)
  James Cook University
- **Professor Chris Cocklin** (from June 2008)
  Deputy Vice-Chancellor (Research and Innovation)
  James Cook University
- **Professor David Siddle**
  Deputy-Vice-Chancellor (Research)
  University of Queensland
- **Professor Mandy Thomas**
  Pro-Vice-Chancellor
  Australian National University
- **Dr Ian Poiner**
  Chief Executive Officer
  Australian Institute of Marine Science
- **Dr Russell Reichelt**
  Chair, Great Barrier Reef Marine Park Authority
- **Honourable Virginia Chadwick**
  Former Chair, Great Barrier Reef Marine Park Authority
- **Professor Terry Hughes**
  Centre Director

SCIENTIFIC MANAGEMENT COMMITTEE

Ongoing 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 six Centre's Research Programs and the Director of Science, Technology and Information Group from GBRMPA (the major federal agency responsible for reef management in Australia), the Centre's principal end-user in Australia. Priorities for each meeting include reviewing and expanding the objectives and operations for the Centre's research programs, recruiting high-quality postdoctoral fellows and students, undertaking an effective communications strategy and reviewing processes for engaging effectively with the Centre's many end-users around the world. The Committee met 4 times in 2008, in February (videoconference), May (Townsville), July (Miami) and September (Townsville).

GOVERNANCE

Priorities for the SMC in 2008 included preparing the Centre for its ARC review and expanding and initiating a large number of projects, especially in the Coral Triangle region. The Committee realigned resources to launch a new Program on Conservation Planning (see p.24) which commenced operations on 1 January 2008. Significant planning effort has also been invested in the creation of two new research programs which will commence operations in 2009.

Committee Members

- **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
  James Cook University
- **Professor Bob Pressey**
  Leader, Research Program 6
  James Cook University

MEMBERSHIP

Researchers

- **Professor Terry Hughes**
  Centre Director and Federation Fellow (2002-2007, 2007-2012), Program 5 leader
  James Cook University
- **Dr Tracy Ainsworth**
  Australian Postdoctoral Fellow (2008–2010)
  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 Natalie Ban**
  Research Fellow
  James Cook University
- **Dr Line Bay**
  Smart State Fellow (2008–2010)
  James Cook University
- **Professor David Bellwood**
  Chief Investigator
  James Cook University
- **Dr Joshua Cinner**
  Australian Postdoctoral Fellow (2008–2010)
  James Cook University
- **Professor Sean Connolly**
  Australian Professorial Fellow (2008–2012) and Program 2 Leader
  James Cook University
- **Dr Maria Dornelas**
  Research Fellow
  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
- **Debora de Freitas**
  Research Associate
  James Cook University
- **Dr Pedro Fidelman**
  Research Fellow
  James Cook University
- **Dr Simon Foale**
  Research Fellow
  James Cook University
- **Professor Carl Folke**
  Partner Investigator
  Stockholm University
- **Dr Nick Graham**
  Research Fellow
  James Cook University
- **Lauretta Grasso**
  Research Associate
  James Cook University
- **Professor Ove Hoegh-Guldberg**
  Deputy Director Queensland Smart State Premier's Fellow 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 Johnathan Kool**
  Research Fellow
  James Cook University / AIMS
- **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 Philip Munday**
  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 and Program 6 Leader
  James Cook University

MEMBERSHIP

- **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
- **Dr Benjamin Walther**
  Research Fellow
  Australian National University
- **Professor Bette Willis**
  Chief Investigator
  James Cook University
- **Dr Shaun Wilson**
  Research Fellow
  James Cook University
- **Professor David Yellowlees**
  Chief Investigator
  James Cook University

Resident International Scholars

- **Dr Tatjana Good**
  Swiss National Foundation
- **Dr Jon Norberg**
  Stockholm University
- **Dr Esben Olsen**
  University of Oslo
- **Dr Lucie Penin**
  Université de Perpignan
- **Dr Willem Renema**
  Natinaal Natuurhistorisch Museum Naturalis

Adjunct Researchers

- **Dr Alison Green**
  The Nature Conservancy
- **Dr Alexander Kerr**
  University of Guam
- **Professor Yossi Loya**
  Tel Aviv University
- **Dr Tim Lynam**
  CSIRO
- **Dr Laurence McCook**
  Great Barrier Reef Marine Park Authority
- **Dr Madeleine van Oppen**
  Australian Institute of Marine Science
- **Dr David Wachenfeld**
  Great Barrier Reef Marine Park Authority

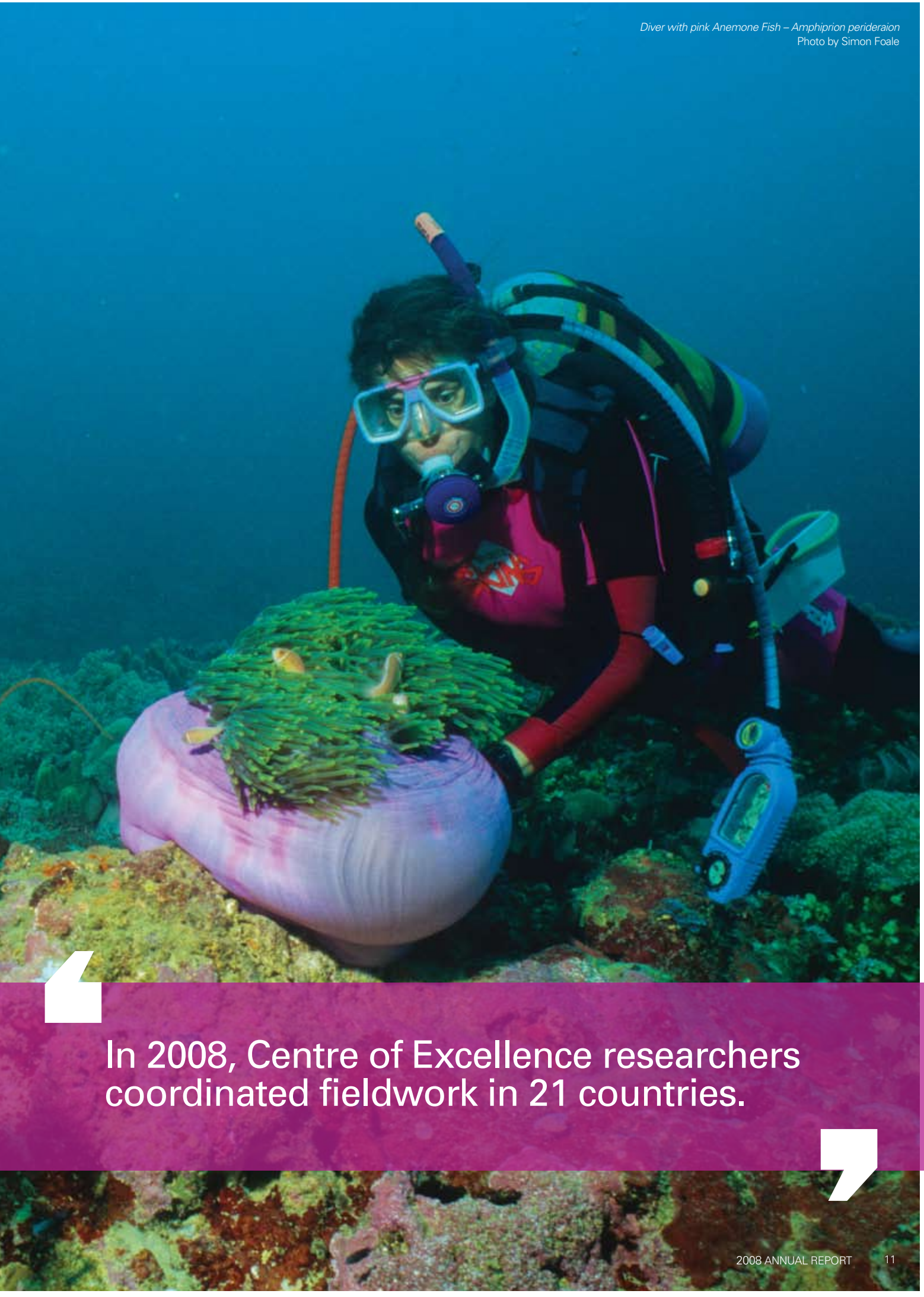
Graduate Students
(see page 29)

Technical Staff

- **Lewis Anderson**
  James Cook University
- **Mary Boyle**
  James Cook University
- **Mizue Hisano**
  James Cook University
- **Les Kinsley**
  Australian National University
- **Richard Krege**
  Australian National University
- **James Moore**
  James Cook University
- **Graham Mortimer**
  Australian National University
- **Tyrone Ridgway**
  University of Queensland
- **Nela Rosic**
  University of Queensland
- **Maya Srinivasan**
  James Cook University
- **Lucija Tomljenovic**
  James Cook University
- **Sharon Wismer**
  James Cook University

Business Team

- **Jennifer Lappin**
  Chief Operations Officer
  James Cook University
- **Professor David Yellowlees**
  Assistant Director
  James Cook University
- **Olga Bazaka**
  Finance Manager and Graduate Coordinator
  James Cook University
- **Lianne Cook**
  Project Officer
  University of Queensland
- **Dr Leanne Fernandes**
  Marine Resource Management Coordinator
  James Cook University
- **Janet Swanson**
  Administrative Assistant
  James Cook University
- **Louise Taylor**
  Office Manager and KPI Officer
  James Cook University



Diver with pink Anemone Fish – Amphiprion perideraion
Photo by Simon Foale

> In 2008, Centre of Excellence researchers coordinated fieldwork in 21 countries.

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 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 prestigious awards, including Fellowships of the Australian Academy of Science (2004), the Geological Society of Australia (2007), the Geochemical Society (2008) and the American Geophysical Union (2002). In 2007 he was awarded an Honorary Doctorate from Curtin University and in 2008 he received the Western Australian Premier's Fellowship for 2009 to 2013. Malcolm is an *ISI Highly Cited Researcher*. His 228 scientific papers have been published in leading international journals including 23 in *Science* or *Nature*.

Professor Sean Connolly

Professor Sean Connolly, from the School of Marine and Tropical Biology at JCU, 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 32 publications in leading international journals, including 5 in *Science* or *Nature*, and he has supervised 22 Postgraduate and Honours students since 2001. He currently holds an Australian Professorial Fellowship from the Australian Research Council, and was most recently honoured by the award of the 2009 Fenner Medal of the Australian Academy of Science, for pioneering new approaches to understanding biodiversity.

Professor Garry Russ

Professor Garry Russ is Leader of Program 3: *Marine Reserves and Reef Connectivity*. Garry studies the biology of reef fish of commercial and recreational fishing significance (mostly serranids, lutjanids and lethrinids). A major area of applied research involves population and community dynamics of reef fish of commercial/recreational significance on coral reefs opened and closed to fishing. In the Coral Triangle region and Australia, he is undertaking long-term (25 year) monitoring of reef fish populations inside and outside marine reserves. Russ received his PhD from the University of Melbourne in 1981. Subsequently he was awarded an ARC Queens Fellowship at the Australian Institute of Marine Science. Garry moved to JCU from the University of Sydney in 1988 where he is currently a Professor in Marine Biology. Garry has published over 65 papers in international journals. In 1999, he received a prestigious Pew Fellowship in Marine Conservation jointly with his long-time colleague Dr. Angel Alcala. In 2007, he was awarded recognition for his contributions to management of the Great Barrier Reef, by the Great Barrier Reef Marine Park Authority.

Professor Ove Hoegh-Guldberg

Professor Ove Hoegh-Guldberg is one of two Deputy Directors of the ARC Centre and Leader of Program 4: *Genetic, molecular and physiological processes*. He is also the Director of the Centre for Marine Studies at The University of Queensland. His research interests span a broad range of topics including marine biology, physiology, biochemistry and molecular biology of plant-animal symbioses, co-evolution, coral bleaching, ocean acidification and climate change. In 1999, he was awarded the *University of NSW Eureka Prize for Scientific Research*, for "research by an Australian scientist under 40". Ove is Co-Chair of the GEF/World Bank Working Group on *Coral Bleaching and Related Ecological Disturbances*, one of three expert groups within the IOC and World Bank Coastal Program's Global Coral Reef Targeted Research and Capacity Building Project that includes members from the ARC Centre. He has published over 120 papers, including 15 in *Science* or *Nature*. He is well known as an advocate for coral reefs and their future fate in the face of rapid climate change, and maintains an active blog, which regularly features the ARC Centre's research. In 2008 Ove was awarded the prestigious Queensland Premier's Smart State Fellowship (2008-2013).

Professor Terry Hughes

Professor Terry Hughes is the Director of the ARC Centre of Excellence and Program Leader of Program 5: *Resilience of linked social-ecological systems*. He received his PhD in 1984 from Johns Hopkins University in Baltimore, USA and was an NSF Postdoctoral Fellow at the University of California, Santa Barbara before moving to Australia and JCU in 1990. Terry was elected a Fellow of the Australian Academy of Science in 2001 in recognition of "a career which has significantly advanced the world's store of scientific knowledge". He has been awarded two Federation Fellowships by the Australian Research Council, from 2002-2012, and is a Fellow of the *Beijer Institute for Ecological Economics*, in Stockholm. In 2007 he was awarded the *Sherman Eureka prize for Environmental Research*. He is a member of the ARC Advisory Council and Board Member of the *Resilience Alliance* and the *Beijer Institute*. Terry has broad research interests in ecology, marine biology and the social-ecological dynamics of coral reefs. As Centre Director, he provides academic leadership and is responsible for the strategic development of the Centre. He is an *ISI Highly Cited Researcher*, ranked #1 in Australia for citations in Ecology & Evolution. In 2008, he was awarded the prestigious quadrennial *Darwin Medal* by the International Society for Reef Studies.

Professor Bob Pressey

Professor Bob Pressey was recruited by JCU in late 2007 to establish and lead the ARC Centre's new Program 6: *Conservation planning for a sustainable future*. Bob's research includes aspects of spatial data sets on biodiversity, geographic information systems, spatial modeling of species and human activities, software development, explicit frameworks for deciding on the location and timing of conservation investments, and the socio-economic issues involved in implementing conservation action. Prior to moving to JCU he was a professorial research fellow at the University of Queensland. Before that, he worked as a research scientist for the New South Wales National Parks and Wildlife Service for almost 20 years. During that time, he developed and applied leading-edge techniques in conservation planning, influenced policy and conservation practice, and began a long series of international collaborations. Along with Malcolm McCulloch and Terry Hughes he is one of three *ISI Highly Cited Researchers* in the ARC Centre and serves on the editorial boards of the three leading journals. Bob was awarded *The Royal Botanic Gardens*' Eureka Prize for Biodiversity Research, in 2002. His most recent recognition is the inaugural (2008) *Australian Ecology Research Award* from the Ecological Society of Australia.

PROGRAM 1
EVOLUTIONARY AND ENVIRONMENTAL CHANGE

Researchers

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

One of the main objectives of Program 1 is to determine how coral reefs respond to climate change to better understand and provide new insights into the key processes that determine their longer-term sustainability. This research is of growing importance because it is now becoming increasingly clear that contemporary changes are occurring at a faster pace than anticipated due to the combination of local environmental impacts and changes in climate and ocean chemistry from rapidly rising levels of atmospheric CO_2.

Researchers from the ANU, AIMS, UQ and JCU have combined resources to develop and apply novel geochemical methods, historical records and ecological studies to identify and understand changes in biodiversity and ecosystem function, over a range of timeframes. This multi-disciplinary approach using modern as well as fossil coral reef systems is critically important for improving the management of reefs. In 2008, Research Fellow Stacy Jupiter and colleagues published their findings of a three year study of the effects of runoff from the Pioneer River catchment onto the nearby coral reefs offshore from Mackay on the central coast of Queensland. The project addressed land use changes in the catchment since European settlement, in particular the impact of highly intensive sugarcane plantations on water quality in the catchment and the ongoing decline of the mangrove and nearby coral reef environments as a result of extensive land clearing and urbanisation. This study has strong stake-holder support, and has led to improved land-use practices in the catchment of the Great Barrier Reef.

In a novel approach, Research Fellow Benjamin Walther is utilising the chemical signatures of fish ear bones (otoliths) together with those from coral skeletons to assess the impact of water quality and temperature on the wider marine biota. Coupled with estimates of growth rate responses at different life history stages, otolith and coral chemical proxies have the potential to reveal how a variety of reef habitats and biota have responded to changes in environmental parameters occurring over a range of timeframes. This is critically important for assessing ongoing changes in near-shore reefs and the efficacy of management interventions.

On longer timescales John Pandolfi and Malcolm McCulloch are undertaking paleontological and geochemical studies of the regional dynamics of biodiversity in coral reefs under differing past climates (see media release opposite). Studies are continuing of Last Interglacial coral reefs that grew along the Western Australian coastline ~125,000 years ago when global temperatures were several degrees warmer and sea levels were up to 4 to 5 metres higher. These studies suggest that coral reefs can adapt to the effects of global warming (in the absence of humankind's footprint, and given sufficient time). An international working group, involving both Program 1 and 2 on 'Indo-Pacific biodiversity through time' led by John Pandolfi and David Bellwood, published interim results in *Science* in August 2008.

New multidisciplinary research in 2008 focuses on the effects of the declining concentration of carbonate ion in surface waters of the world's oceans, a direct consequence of increased uptake of CO_2 by seawater from greenhouse gas emissions. In Program 1, this process, known as ocean acidity, is being evaluated on the Great Barrier Reef using novel geochemical tools based on boron isotopic variations, which directly reflects changes in seawater acidity (pH). Using long-lived coral cores, this research is showing substantial shifts in seawater pH from pre-industrial times to today, of up to several tenths of pH units. Overall these changes on reefs are substantially greater than those predicted for open ocean waters, and point to a more complex interaction and sensitivity of coral reefs to increasing acidity. Thus, while global warming may increase the potential for coral reefs to expand away from tropical equatorial regions, this migration is likely to be more than offset by reduced calcification at higher latitudes due to the effects of reduced concentrations of carbonate ion. Further field studies are planned to better understand these processes at the individual reef scale in controlled sites at Heron Island.

One additional activity in 2008, led by John Pandolfi, is addressing the relationships between ecosystem dynamics and human health among 21 Pacific Island nations. This group met in September 2008, at the East-West Centre in Hawaii under the forum title of *Marine Conservation and Health: Science, Policy and Coral Reef Ecosystems in the Asia-Pacific*. The group is composed of scientists and students from the NSF IGERT project on 'Ecology, Conservation and Pathogen Biology' centered at the University of Hawaii, with international collaboration from SUNY-Stonybrook, University of Queensland and James Cook University.

Chaetodon trifasciatus and coral Acropora muricata
Photo by Terry Hughes

MEDIA RELEASE

Corals may head south to beat the heat

The tropical corals of Western Australia may be heading south due to climate change.

The seaboard between Perth and Geraldton could end up with coral reefs as rich and varied as the celebrated reefs of Ningaloo, two marine scientists say in new research published in the international journal *Global Change Biology*. Greenstein, BJ and Pandolfi, JM (2008). Escaping the heat: range shifts of reef coral taxa in coastal Western Australia. *Global Change Biology* 14(3): 513-528.

Working from fossil evidence of what happened in WA under an earlier warm phase in the global climate 125,000 years ago, Professor John Pandolfi of the ARC Centre of Excellence for Coral Reef Studies and Professor Benjamin Greenstein of Cornell College, Iowa, USA, conclude tropical corals could soon be headed south once more to escape warming oceans.

"Back then there used to be rich coral reefs dotted all along the WA coastline, from south of Perth to north of Dampier," Prof. Pandolfi says. "When the seas cooled with the onset of the most recent ice age, many of the corals contracted north. "The result is that today there are two distinct coral communities – the rich and beautiful one capable of reef growth we know from places like Ningaloo, and a far simpler community with fewer species scattered on rocky outcrops in the cooler waters of the south."

With oceans warming again due to greenhouse, the researchers say, the rich, diverse northern corals are likely to spread south again, travelling on the Leeuwin current, in search of places to survive global warming and avoid impacts such as bleaching and coral disease which occur when tropical waters warm too much for them to tolerate.

"For example the genus *Acropora* – which forms the classic plate and branching corals – was not known to occur in southern waters until a specimen was found at Rottnest Island, off Perth, in 1993. From the fossil evidence, we feel there is a strong likelihood *Acropora* will continue showing up south of the Houtman-Abrolhos Islands as the climate warms again," Professor Pandolfi says.

The researchers surveyed fossilised Late Pleistocene reefs from around 125,000 years ago – in the warm phase between two ice ages – at five localities along the WA coast and compared the results with coral occurrence data for the modern reefs offshore of each locality.

"We found that modern reef coral communities show a pronounced gradient in coral composition all along the WA coast, while the gradient in community composition is not as strong for Pleistocene communities".

However the researchers are cautious about other impacts of global change which could affect the ability of corals to colonise new areas: "We cannot predict how the interplay of light, carbonate saturation state, pollution, disease, ocean acidification due to rising CO_2 levels, and associated habitat loss or availability will affect the ability of reef corals to expand their latitudinal ranges over the next century or longer," they say.

"So it becomes particularly important to look after and manage these potential new reef habitats, to be sure there are places where our tropical corals can take refuge from climate change," Prof. Pandolfi says.

1 January 2008

PROGRAM 2
UNDERSTANDING AND MANAGING CORAL REEF BIODIVERSITY

Researchers

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

Ultimately, coral reef biodiversity underpins the important functions and services performed by reef ecosystems, such as sustaining the productivity of fish stocks on which many tropical nations depend for their livelihoods. 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 benefits to tropical maritime nations.

ARC Centre research in 2008 involved several key breakthroughs in our understanding of how global climate change will influence the corals that provide the structure of the reef, and the fish communities that depend on this structure. For instance, David Bellwood, working with Chris Fulton of the Australian National University, discovered that levels of sedimentation on reefs play a critical role in the ecological and geological phenomenon of "drowned" reefs, a finding with important implications for understanding how reefs will respond to rising sea levels. Another team of researchers, led by Nick Graham, analyzed the effects of coral bleaching in the Indian Ocean on the integrity of reef structure, and they found that such effects were strongest towards the equator and were not ameliorated within poorly enforced No-Take Areas. This work highlights the importance of managing reefs for climate change at the whole-of-seascape level, rather than relying exclusively on small areas where fishing is banned; it also helps to prioritize international efforts at conservation and management of coral reefs in developing countries. In related work, Shaun Wilson and colleagues examined the effects of climate change on fish assemblages, and discovered that they are most damaged when degradation of reef structure coincides with overfishing: the synergistic impacts of these two stressors are greater than their individual effects.

One of the most enigmatic problems in coral reef biodiversity has been explaining the origins of the global biodiversity "hotspot" for reefs, which lies just north of Australia. In 2008, an international team of researchers, led by John Pandolfi and David Bellwood, used evidence from multiple scientific disciplines to show that this biodiversity hotspot is ancient, and was not caused by sea level fluctuations during the Ice Ages, as was previously proposed (see media release opposite). In related work, Sean Connolly convened an international working group of researchers from several disciplines to develop mathematical models for the origin and maintenance of global patterns in reef biodiversity, taking advantage of the new knowledge emerging from the hotspot research and other studies in the ARC Centre.

Program 2 researchers also made numerous important contributions to coral reef policy issues at State, Commonwealth, and international levels. For example, Sean Connolly led a team of researchers focussing on the management of shark fishing in the Great Barrier Reef World Heritage area, and briefed senior officials in Canberra about a proposed Coral Sea Heritage Park. Philip Munday and Morgan Pratchett briefed the Parliamentary Secretary for the Pacific, Hon Duncan Kerr MP, on the likely consequences of climate change for Pacific fisheries. Pratchett and several colleagues from Program 2 were also commissioned to lead a vulnerability assessment of Pacific fisheries for the Secretariat of the Pacific Community. Andrew Baird contributed to a review of the Economics of Biodiversity Loss for the European Commission.

Nick Graham (PhD, University of Newcastle, UK) was appointed as a Research Fellow in Program 2, and Lucie Penin (PhD, University of Perpignan, France) also joined Program 2, having been awarded a prestigious Marie Curie Fellowship from the European Union. Existing Centre Fellows also received prestigious travel fellowships from the Australian Academy of Science – a North America Travel Scholarship awarded to Morgan Pratchett, and a Short Term Fellowship to Andrew Baird for research in Japan.

Photo by Terry Hughes

MEDIA RELEASE

"Hopping Hotspots" reveal how the planet drives life

An international team of marine scientists has proposed that huge explosions of life may be due in part to continental 'traffic accidents' – the Earth's tectonic plates slamming into one another.

The researchers have tracked the global heartbeat of tropical marine biodiversity halfway round the world, from a focal point over western Europe/Africa around 50 million years ago, to its present-day location around South East Asia and Australia, identifying three major hotspots along the way.

The explanation for these "hopping hotspots" with the greatest array of marine species appears to be plate tectonics as well as climate, says the team led by Willem Renema, John Pandolfi and David Bellwood. Their review paper appears in the latest issue of the journal *Science*.

"By examining fossil and molecular evidence, we could clearly see that the global centre of marine mega-diversity was over western Europe and Africa in the Eocene, around 50 million years ago – a time when there was a shallow ocean called Tethys between the two continents," says Pandolfi.

In more recent times, the global centre of the action hops to the Indo-Asian-Australian region, which is the greatest hotspot of marine biodiversity today, leaving an ageing Arabian fauna to senesce.

"In each of these cases we think that the emergence of many species and their gradual dwindling can be largely explained by plate tectonics, as well as climate change."

Each of the three marine biodiversity hotspots coincides with the site of a major collision between continental tectonic plates.

The gradual approach of the African plate to the European plate created shallow, warm seas with many islands and bays, ideal for new species to evolve in, while the currents of Tethys which was open at both ends, swept through. These conditions would promote the emergence of new species and their spread, Pandolfi says.

As Arabia joined the Asian landmass, conditions became less favourable. However, further east again, the progressive collision of the Australian plate with SE Asia, and the eruption of island chains forming modern Indonesia, the Philippines, and Papua New Guinea created conditions ideal for sea life to flourish in all its diversity, the team says.

"The evidence seems to be saying that when habitats are disrupted, increasing in area, and highly variable, you get more species. When they are reduced in size and number, and become more consistent, the range of species declines," says Bellwood.

"As continents merge tectonically, seas close up, nutrients increase, currents subside – and the range of habitats and species also declines. This period of senescence is of particular interest, as it is important to understand whether species richness in a particular area is declining naturally due to tectonic changes, or due to man-made changes," says Renema.

The team says its work provides a new way to view biological hotpots and the factors that cause them to arise and decline. This will help researchers to better understand the factors propelling species decline in particular regions.

1 August 2008

PROGRAM 3
MARINE RESERVES AND REEF CONNECTIVITY

Researchers

- Garry Russ (Program Leader)
- Glenn Almany (Research Fellow)
- Andrew Baird (Research Fellow)
- David Bellwood
- Sean Connolly (Research Fellow)
- Nick Graham (Research Fellow)
- 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 areas) are used to manage biodiversity and fisheries. Zoning for multiple levels of use and protection, including no-take areas, has become one of the principal mechanisms for management of marine resources in Australia and around the world. Program 3 focuses on how marine reserves enhance biodiversity and fisheries management. A major issue is the level of larval dispersal and connectivity within and between marine reserve networks. Program 3 focuses on the optimal design of reserve networks for coral reef conservation and fisheries management; and on the consequences of shifts in connectivity, due to climate change and other processes that affect stock-recruitment relationships.

Garry Russ and colleagues at JCU and AIMS continued their field assessments of the Representative Areas Program (RAP) on inshore coral reefs of the Great Barrier Reef in 2008. This research indicates that the new no-take zones, established by the Australian government in 2004, are already working, with coral trout abundances increasing in the no-take zones (relative to the fished zones) in the Palm, Whitsunday and Keppel Islands (see media release opposite). This research is being augmented by extensive larval marking experiments (using stable Barium isotopes) and DNA sampling on commercially and recreationally important species of reef fish in the Keppel Islands. The objective is to quantify the magnitude of larval export from green zones on the Great Barrier Reef (GBR). Preliminary results indicate that the larval tagging technologies are highly effective for tracking large reef fish species of fishing significance. This work is co-funded by the ARC Centre and the Australian Government's Marine and Tropical Sciences Research Facility. It will enable, for the first time, measurement of the vitally important connections between no-take green zones and fished areas of the world's largest network of marine no-take areas.

In Papua New Guinea, Geoff Jones and colleagues used larval tagging and genetic studies to demonstrate that larval dispersal connects fish populations, in a network of marine protected areas. This research, in collaboration with *The Nature Conservancy*, has demonstrated high levels of self-recruitment within small reefs, but also demographically significant connectivity over scales of 30 km.

Detailed, ground-breaking research conducted by Phil Munday, Geoff Jones, Morgan Pratchett and colleagues has shown that increasing ocean acidification, a major threat to ocean ecosystems caused by uptake of additional carbon dioxide at the ocean surface, can disrupt the ability of larval fish to "smell their way home". The ability of larval clownfish to detect olfactory cues from adult habitats was disrupted when the fish were reared in conditions simulating ocean acidification. Larvae became strongly attracted to olfactory stimuli they normally avoided when reared at levels of ocean pH that could occur in 2100. The results indicate that if acidification continues unabated, the impairment of sensory ability will reduce population sustainability of many marine fish species, with potentially profound consequences for marine biodiversity and for connectivity patterns of populations and networks of marine reserves.

As with all of the Centre's Programs, Program 3 has established considerable international links, including numerous collaborators at the Woods Hole Oceanographic Institute (USA), Perpignan University (France), Silliman University's Angelo King Center for Research and Environmental Management (Philippines), and the Boston University Marine Program (USA). Apart from ongoing work on the Great Barrier Reef, much of the future research activity of Program 3 will be centered on the Coral Triangle region.

Photo by Terry Hughes

MEDIA RELEASE

Protected fish stage a comeback

Spectacular recovery in coral trout numbers on unfished reefs has been reported by researchers following the imposition of a strict no-fishing policy across 33 per cent of the Great Barrier Reef.

A team led by Garry Russ of the ARC Centre of Excellence for Coral Reef Studies and Hugh Sweatman of the Australian Institute of Marine Science and co-funded by the ARC Centre and the Australian Government's Marine and Tropical Sciences Research Facility (MTSRF), has found coral trout numbers rebounded by 31-75 per cent on a majority of reefs which had been closed to fishing for as little as 1.5 to 2 years.

Their results, which are reported in the latest issue of the journal *Current Biology*, have international significance in a world in which most major fisheries are in decline, according to the United Nations Food & Agriculture Organisation.

Closing reefs to fishing is controversial, both politically and socially, and there has been huge public interest in the outcome, the researchers say. This makes accurate assessment of the effects of closure essential.

Closed inshore reefs in the Palm and Whitsunday islands showed increases in coral trout population densities of 65 and 75 per cent respectively compared with paired reefs left open to fishing. Closed reefs offshore of the cities of Townsville (64%), Cairns (53%) and Mackay (57%) also showed marked improvements.

However densities of coral trout on the reefs left open to fishers showed little or no change in fish density. On only one closed reef was there a decline in the trout population - the Keppel Islands which, in March 2006, were hit by a devastating coral bleaching episode.

The team said that angling effort displaced from the closed reefs onto open reefs probably had little effect, as there was at the same time a decline in commercial fishing on these reefs.

In time, they say, the higher fish populations on closed reefs may lead to improvements in fish numbers on open reefs, as juveniles from closed areas settle on open ones.

"The results are very convincing, because we surveyed such a huge area – 56 reefs spread over more than 1000 kilometres from north of Cairns to the Capricorn-Bunker islands in the south," Dr Peter Doherty, Research Director of AIMS, says.

"The data from these reefs was remarkably consistent – and we were pleasantly surprised to observe such rapid improvements in fish densities. Though it is still early days, it certainly looks as if the no-take marine reserves are working as hoped."

"We now have greater protection for the tourism industry on the GBR, which is worth in excess of $5bn - and the extra protection may also enhance the sustainability of reef fishing in the longer term."

"This means a great deal. A major precedent has been set. Our findings show that large scale reserve networks, set up to protect biodiversity and ecosystems, can produce rapid positive responses for harvested species. It is an important lesson for the entire world."

24 June 2008

PROGRAM 4
GENETIC, MOLECULAR AND PHYSIOLOGICAL PROCESSES

Researchers

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

Program 4 focuses on the genetic, molecular and physiological processes of reef-building corals and their symbionts, in particular how they respond to thermal stress, ocean acidification and diseases. Alongside experimental studies, work is progressing on the development of a modeling framework that links the stress mechanisms at physiological and genomic levels with the responses at population and community levels.

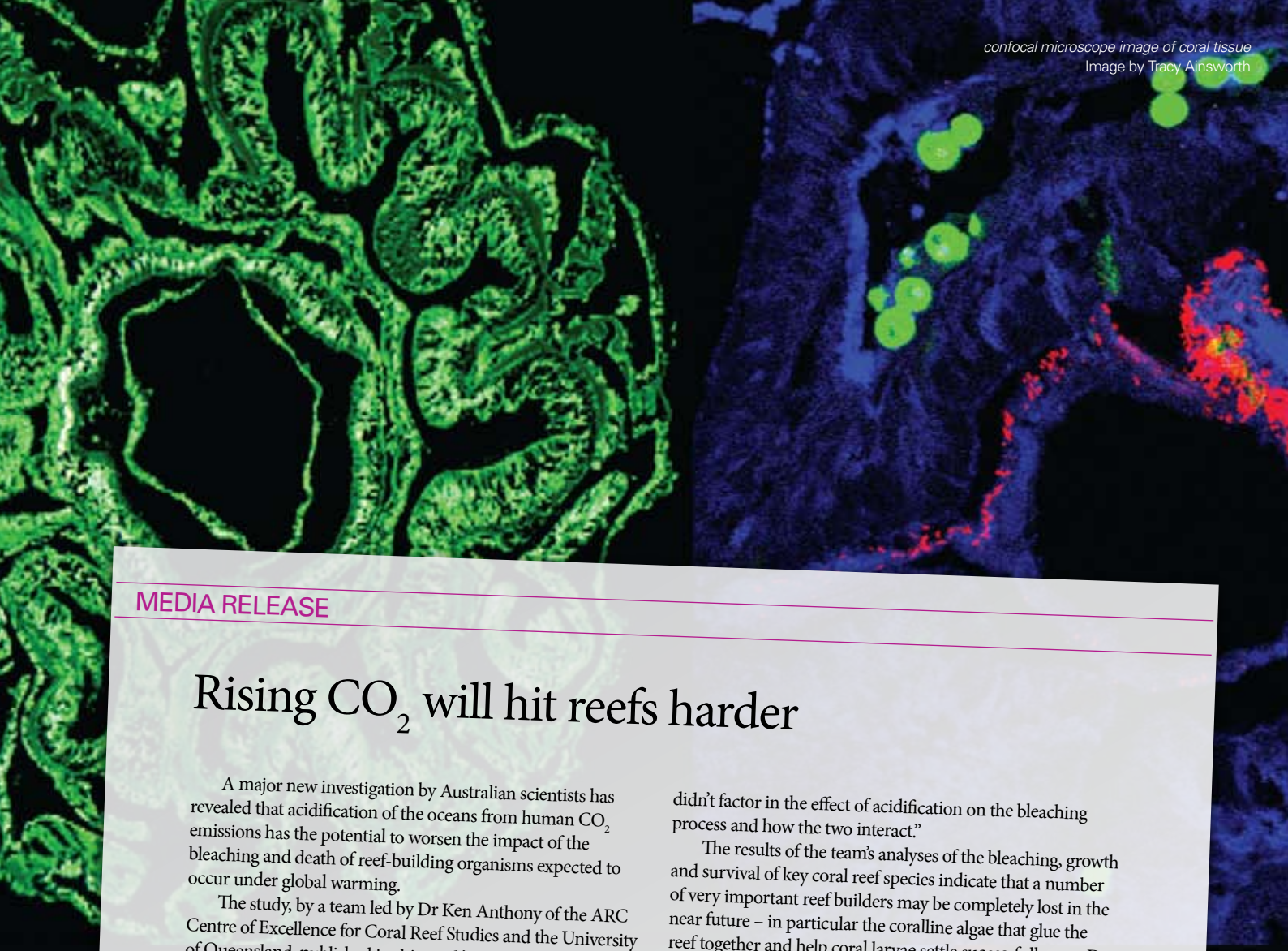
Ken Anthony, Ove Hoegh-Guldberg and co-workers published the first study demonstrating the linkage between ocean acidification and susceptibility to coral bleaching in the *Proceedings of the National Academy of Sciences* (see media release opposite). This publication demonstrates that projections of coral health, that only consider sea surface temperature, drastically underestimate the impact of climate change. The goal of these ongoing studies is to determine why coral physiology and symbiosis are so sensitive to ocean acidification.

Coral disease is clearly on the increase, as demonstrated by quantitative studies along the length of the Great Barrier Reef (Bette Willis). Importantly, the Centre's research supports the thesis that some (although not all) coral diseases are due to secondary consequences of stress and are not caused by infectious diseases affecting healthy corals. Projects have investigated the impact of white syndrome disease on symbiont photosynthesis (Jez Roff) and, contrary to previous reports, Tracy Ainsworth has demonstrated bleaching in the coral *Oculina patagonica* is not bacterially driven, and instead may be a physiological response to increased temperature or environmental impacts.

The genetic divergence of the various *Symbiodinium* clades on coral function and susceptibility to stress has been a growing and important theme to the research in Program 4. This is exemplified by the work of Eugenia Sampayo, a PhD student supervised by Sophie Dove and Ove Hoegh-Guldberg, who discovered that patterns of thermal sensitivity correlated with particular genetic varieties of clade C. Working with Bill Leggat and David Yellowlees, Lynda Boldt (PhD student) has also demonstrated significant differences in the photosynthetic molecular machinery between different clades. The importance of the algal symbiont in the sustainability of the symbiotic association has raised the question of how this partnership is established, how the selection of *Symbiodinium* takes place and how it is maintained. Results indicate that juvenile corals possess a completely different suite of genetically distinct symbionts to those found in the adult (Maria Del Carmen-Gomez, PhD student). This distinction is probably a function of host immune responses impinging on the selection process (Simon Dunn) which is mediated by a C-type lectin identified by Charlotte Kvennefors (PhD student). David Abrego, who is supervised by Bette Willis and Madeleine van Oppen, has also found the specific species interactions between the coral and different algal genotypes leads to significantly different thermal responses, demonstrating the complexity of the coral-algal symbiosis.

A key tool in much of the research in Program 4 has been the availability of genomic resources for both the coral host and zooxanthellae. These sequences have been incorporated into microarrays by the ARC Centre researchers, with the first coral microarray paper being published in 2008 by David Miller's group. In the coming year, the specificity of these tools will be improved using high-throughput techniques (454 sequencing) and by the establishment of oligo-arrays for the coral, *Acropora millepora*, and its algal symbiont, *Symbiodinium*.

Tracy Ainsworth became a Research Fellow in Program 4 following the award of an Australian Postdoctoral Fellowship. She also played a major role in the organisation of an international workshop at Heron Island Research Station, convened and chaired by David Miller in September 2008 on the *Genomics of Lower Animals*.



confocal microscope image of coral tissue
Image by Tracy Ainsworth

MEDIA RELEASE

Rising CO_2 will hit reefs harder

A major new investigation by Australian scientists has revealed that acidification of the oceans from human CO_2 emissions has the potential to worsen the impact of the bleaching and death of reef-building organisms expected to occur under global warming.

The study, by a team led by Dr Ken Anthony of the ARC Centre of Excellence for Coral Reef Studies and the University of Queensland, published in this week's *Proceedings of the National Academy of Sciences* concludes that earlier research may significantly understate the likely damage to the world's reefs caused by man-made change to the Earth's atmosphere.

In a large experiment on Australia's Heron Island, the team simulated CO_2 and temperature conditions predicted for the middle and end of this century, based on current forecasts of the world's likely emission levels and warming by the Intergovernmental Panel on Climate Change (IPCC).

"We found that coralline algae, which glue the reef together and help coral larvae settle successfully, were highly sensitive to increased CO_2. These may die on reefs such as those in the southern Great Barrier Reef before year 2050," says Dr Anthony.

"Every time you start your car or turn on the lights, half the CO_2 you emit ends up in the oceans, turning them just a tiny bit more acidic, as well as causing the climate to warm. What is new is an understanding of how these two effects interact to affect the corals and reef building algae."

"The results, frankly, are alarming," says Prof Ove Hoegh-Guldberg. "They clearly suggest that previous predictions of coral bleaching have been far too conservative, because they didn't factor in the effect of acidification on the bleaching process and how the two interact."

The results of the team's analyses of the bleaching, growth and survival of key coral reef species indicate that a number of very important reef builders may be completely lost in the near future – in particular the coralline algae that glue the reef together and help coral larvae settle successfully, says Dr Guillermo Diaz-Pulido.

On the positive side, some coral species seem able to cope with the levels of ocean acidification expected by the mid-century by enhancing their rates of photosynthesis, says team member Dr David Kline. "This is an important discovery that can buy the reef time while the nations of the world work together to stabilise CO_2 emissions," he says.

"The implications of this finding are massive because it means that our current bleaching models, which are based on temperature only, severely underestimate the amount of coral bleaching we will see in the future," Dr Anthony says.

"These results highlight the urgency of reducing CO_2 emissions globally. Without political will and commitment to abatement, entire reef systems such as the Great Barrier Reef will be severely threatened in coming decades," the team warns. The results of the research are being offered to reef managers to help them develop strategies to protect the reefs which are most at risk.

28 October 2008

PROGRAM 5
RESILIENCE OF LINKED SOCIAL-ECOLOGICAL SYSTEMS

Researchers

- Terry Hughes (Program Leader)
- Andrew Baird (Research Fellow)
- David Bellwood
- Joshua Cinner (Research Fellow)
- Toby Elmhirst (Research Fellow)
- Kathryn Ferguson (Research Fellow)
- Pedro Fidelman (Research Fellow)
- Simon Foale (Research Fellow)
- Carl Folke
- Nick Graham (Research Fellow)
- Laurence McCook
- Susan McIntyre-Tamwoy (Research Fellow)
- Jon Norberg (Visiting Research Fellow)
- John Pandolfi
- Bob Pressey (Research Fellow)
- Robert Steneck

Program 5 focuses on the interface between people, economies and coral reef ecosystems. Our objective is to undertake research and develop new tools that improve the governance and management of natural systems and enhance their capacity to sustain human and natural capital. Program 5's multi-disciplinary research combines expertise on coral reef biology, management, governance, economics and the social sciences.

Program 5 convened several international working groups in 2008, including one on adaptive management of fisheries, held in Santiago in January, co-chaired by Terry Hughes and Professor Juan-Carlos Castilla, from Universidad Católica de Chile. In Australia, Visiting Fellow Jon Norberg, from the Stockholm Resilience Centre, chaired another working group meeting in Cairns, focussing on the transition of tropical countries to a low carbon world, their vulnerabilities to shocks and their adaptive capacity to change. Participants included three ARC Federation Fellows – Terry Hughes, Hugh Possingham and John Quiggan. The Centre's Memorandum of Understanding with the Stockholm Resilience Centre has encouraged several similar collaborations, including a project by Per Olson, Carl Folke and Terry Hughes, which was published this year in *Proceedings of the National Academy of Sciences* (see media release opposite). The study focuses on shifts in governance of the Great Barrier Reef Marine Park, and how they were achieved. Many agencies world-wide are keen to understand how their management of coral reefs can be improved, and the lessons that the GBR case provides.

Josh Cinner undertook research in Papua New Guinea, Indonesia and East Africa, where customary management by local communities often still applies. His recent work shows that these customary rules break down due to the growth of markets, urbanization, and the erosion of traditional authority. Closed Marine Protected Areas like those adopted in Australia, seldom work in developing countries, because their boundaries can impose difficult burdens on individuals and families. Josh and his colleague Shankar Aswani, from the University of California at Santa Barbara, are investigating the feasibility of new 'hybrid' systems, which combine customary management and modern science. Josh's most recent scientific publications look at the thresholds at which customary management starts to break down – the point where urgent action is needed.

Toby Elmhirst, Sean Connolly and Terry Hughes have developed a series of novel mathematical models that focus on how networks of protected areas influence the resilience of coupled social-ecological systems. Initial findings are in press, which underscore the importance of the interplay between local and seascape-level processes for coral reef management, and demonstrate the enhanced contribution that networks of protected areas make to the sustainable use of coral reefs when those networks constitute a substantial proportion of the reef seascape.

Senior Research Fellow Simon Foale and his collaborators from Japan, Norway and the University of Melbourne began a major new project in Melanesia in 2008, assessing the role of local people's understandings of fish population dynamics by gathering ethnographic data that will describe in detail fishers' knowledge of the species they target, along with their social and economic motives. One outcome will be an improved understanding of the resilience of various fisheries to rising fishing pressure. This project will also develop and trial environmental education materials for upper primary and lower secondary schools in the Solomon Islands and Papua New Guinea that address the knowledge-related drivers of overfishing, and to mainstream these materials. A further goal is to deliver policy recommendations to governments and development agencies on the importance of learning and educational approaches to fishery management.

ARC Centre students Yui Sato and David Abrego undertaking disease surveys
Photo by Lewis Anderson

MEDIA RELEASE

Finding a cure for the coral crisis

The management of Australia's Great Barrier Reef Marine Park has been hailed as a groundbreaking international model for better managing the oceans, in a leading United States scientific publication.

In a study published in the prestigious *Proceedings of the National Academy of Science*, Terry Hughes of the ARC Centre of Excellence for Coral Reef Studies in Australia, and Per Olsson and Carl Folke of the Stockholm Resilience Centre, have identified the keys to successful marine ecosystem-based management. Their findings were revealed today at the 11th International Coral Reef Symposium, in Fort Lauderdale, Florida, where the world's leading coral reef scientists and managers have gathered.

"The core issue is that the global 'coral crisis' is really a crisis of governance," says Prof. Terry Hughes. "Many people have tried to protect marine environments but as soon as some form of governance was put in place and everyone relaxed, it was overtaken by events – either human or natural. The critical realization in the case of the Great Barrier Reef was that its management had to be flexible and adaptive, based on continual scientific monitoring of what is going on."

"This flexibility was important in order to deal with change and to navigate the transition to an improved system of governance" Dr. Olsson says.

The paper highlights the role of leadership and consensus-building, and credits the Great Barrier Reef Marine Park Authority and its Chair, Virginia Chadwick, with having sought and gained the support of the public, industry and governments at all levels for putting the management of the world's largest coral reef system onto an ecological footing. A critical step in the process was to convince local communities that the reef was facing many threats, and to enlist public support for managing it more flexibly.

"Combined with the declines in populations of dugongs, turtles, sharks and other fish, polluted runoff from the land and global warming impacts; it became clear to everyone that the original management system was becoming less and less adequate as the pressures on the reef grew." Prof. Hughes says.

"The Barrier Reef example illustrates a shift in thinking to an integrated view of humans and nature, based on active stewardship of marine ecosystems for human well-being" Dr. Olsson says.

Backing all of this was the necessary legislation and regulatory powers and also having a sufficient flow of good science to inform the management process constantly. The study underscores the particular importance of integrating good science with good policy.

The report concludes that laws alone cannot bring about the changes necessary to protect the world's ocean ecosystems – good science and public understanding and support are also vital.

"In contrast to the GBR case, marine zoning in some countries has been severely constrained because of poverty, inflexible institutions, lack of public support, difficulties developing acceptable legislation, and failures to achieve desired results even after zoning is established. These are the critical barriers that we must urgently address and overcome" Professor Hughes said.

7 July 2008

PROGRAM 6
CONSERVATION PLANNING FOR A SUSTAINABLE FUTURE

Researchers

- Bob Pressey (Program Leader)
- Natalie Ban (Research Fellow)
- Debora de Freitas (Research Associate)
- Tatjana Good (Visiting Research Fellow)
- Johnathan Kool (Research Fellow)

This new program of applied research, established in 2008, focuses on spatial solutions to resource management problems, involving the design of static and dynamic conservation areas that are managed to promote the persistence and sustainable use of natural resources, and implemented with local communities and other stakeholders. The program was established to synthesise the many threads of conservation science with the social, economic and political aspects of planning. The program concentrates on research projects in tropical marine environments in Australia and internationally, although the program also has projects within freshwater and terrestrial environments and the interfaces between them. Four Research Fellows and seven PhD students were recruited in 2008, with further growth planned for 2009.

Five closely connected research themes were developed during 2008. Theme 1 (Conservation planning in a changing world) focuses on methods for planning to promote the persistence of biodiversity processes in the context of expanding anthropogenic pressures on the natural environment. This theme is the major thrust of the Coral Triangle Initiative (see p.48). Theme 2 (Integrated coastal planning) is aimed at developing practical methods for integrated planning of coastal catchments and near-shore marine waters, including the catchments of the Great Barrier Reef. The focus of theme 3 (Reconciling conservation values and economics) is on new approaches to incorporating conservation costs (including acquisition costs, opportunity costs and management costs) into planning decisions. Theme 4 (New decision-support systems for sustainable management) involves research and development to produce new software tools for participatory decision-making to better involve stakeholders in conservation decisions. These themes are all closely related to theme 5 (Implementation of conservation action with stakeholders) that will build close links between the Program's research and the activities of managers and policy-makers.

Research Fellow Natalie Ban leads a project on patch dynamics and conservation planning with a particular focus on the Bismarck Sea (Papua New Guinea), within the Coral Triangle region. Patch dynamics include phenomena such as pelagic productivity, coral bleaching, and storm damage to marine habitats. The focus on the Bismarck Sea has established another strong collaborative link with *The Nature Conservancy* (see opposite).

Research Fellow Tatjana Good joined the Centre in 2008, supported by a Swiss NSF Fellowship grant, to work on issues of scale, including both the extent and resolution of data, in conservation planning. Data on biodiversity such as habitat types and species records vary widely in resolution, tending to be coarser (larger grained) over larger planning regions. This raises important questions about the information content and value for conservation planning of coarser- versus finer-resolution data, as well as the cost and cost-effectiveness of producing data at different resolutions. A related aspect of her postdoctoral work concerns the need to move between scales, from global to local, in setting priorities and implementing conservation action.

Research Fellow Johnathan Kool began work with the Program in late 2008. He is co-funded by the Australian Institute of Marine Science (AIMS). He will be leading research and software development on two lines of work. One will involve modelling of connectivity of coral reef systems, extending his PhD work at the University of Miami. The second line of research will use extensive marine data sets such as the CSIRO-AIMS seabed biodiversity samples for the Great Barrier Reef Marine Park to analyse compositional turnover and species-area curves for different marine habitats as a basis for formulating better conservation objectives. Research Associate Debora de Freitas will focus on the management of coastal catchments, to balance upstream use with downstream effects on tropical seas, specifically the Great Barrier Reef.

Program 6 led an international workshop in May 2008 on patch dynamics and conservation planning, held on Magnetic Island in North Queensland. The Program also hosted an international workshop and training session in August 2008 on software tools for ecosystem based management of coastal zones. Program 6 has already developed strong collaborative links with other research providers and management authorities in Australia and abroad, including AIMS, CSIRO, the Great Barrier Reef Marine Park Authority, Natural Resource Management Boards, TNC, WWF, IUCN, and others.

MEDIA RELEASE

Urgent action on international coral reef crisis

Coral reef scientists and policy makers from the world's most prominent coral reef nations are meeting in Australia this week to develop urgent action plans to rescue the world's richest centre of marine biodiversity from gradual decline.

Human pressures on the Coral Triangle have raised grave concerns about the future of its fish, corals and other sea life, leading to a proposal by Indonesian President Susilo Bambang Yudhoyono for joint action by six governments, scientists, agencies and environmental non-government organisations of the region.

Marine scientists from the Australian Research Council Centre of Excellence for Coral Reef Studies (CoECRS) at James Cook University and the Australian Institute of Marine Science (AIMS) are assisting the largest reef conservation program ever undertaken, known as the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security.

The Coral Triangle (CT) spans Indonesia, Malaysia, the Philippines, Papua New Guinea, Timor Leste and the Solomon Islands, and has over 200 million inhabitants, a third of whom depend on the sea for food security or livelihood.

Spread over 5.7 million square kilometres, the CT has the highest diversity of marine life of any area on Earth. It contains three quarters of the world's known coral species, a third of the world's coral reefs, more than 3,000 species of fish and the world's richest mangrove forests. It generates $2.3 billion in sea products each year and is a major spawning ground for tuna and other valuable species.

"Everyone recognises that coral reefs, and the economic and social benefits they generate, are at risk," CoECRS Director Professor Terry Hughes said. "Fish, corals and climate change don't respect national boundaries – so the need for region-wide action is paramount.

"This is a critical initiative by many countries, acting together for the first time, to sustain the livelihoods of millions of people," he said. "In developing countries, millions of local people suffer real hardship when reefs and ocean habitats are degraded. There is a social and economic imperative to protect them."

According to AIMS Acting Research Director Frank Tirendi, "Better collaboration between Coral Triangle experts and Australian experts may well be a fundamental requirement to ensure the knowledge base is in place to prevent an environmental crisis to our north and ensure longer term regional fisheries and food security".

The CTI is a partnership between the six Coral Triangle countries, other governments, aid agencies, donors, WWF, The Nature Conservancy (TNC) and Conservation International (CI).

The CTI has a current global commitment projected to be at least $US500 million and its plan of action includes:

- Developing an ecosystem based approach to fisheries management across the Coral Triangle
- Building a network of marine protected areas across the region
- Measures to help adaptation to climate change
- Measures to help protect threatened marine species

From 10 to 14 November the ARC Centre of Excellence and AIMS will help present an international forum on Management and Conservation of the Coral Triangle in Townsville, hosted by Australia's Department of the Environment, Water, Heritage and the Arts.

10 November, 2008

GIS image of Fiji
Image by Morena Mills

GRADUATE TRAINING

One of the ARC Centre's core aims is to provide research training and support to high quality postgraduate students in order to build human capacity and expertise in coral reef science. The Centre is the world's leading provider of such training with 124 PhD, 27 Masters and 16 Honours students enrolled and supervised by Centre personnel in 2008. Over a quarter of the ARC Centre's budget is devoted to support the research costs of these students.

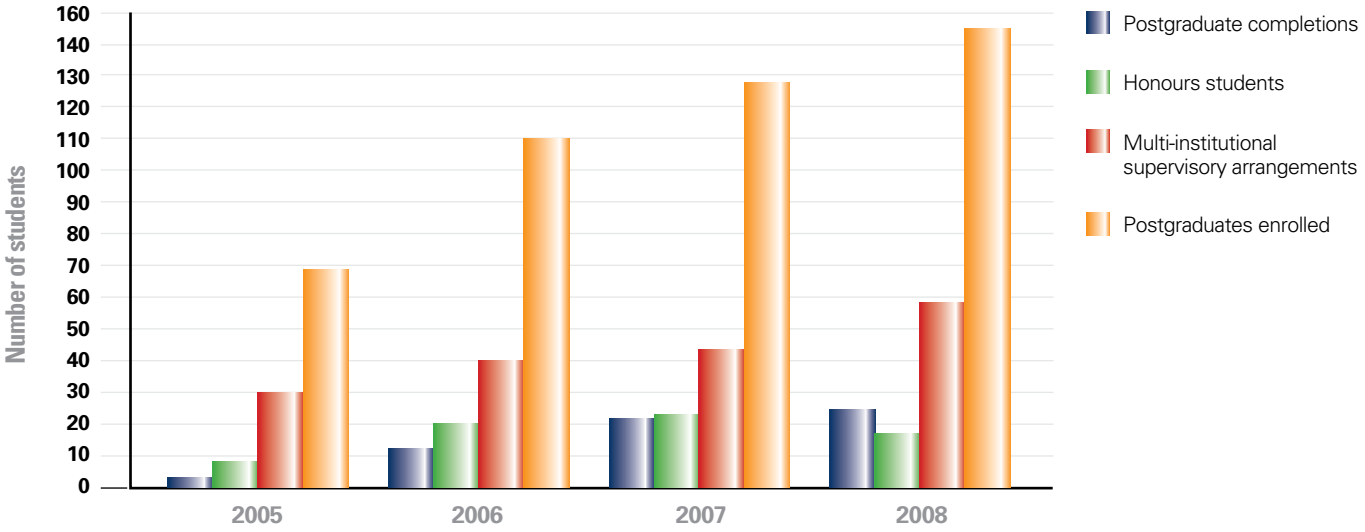
Graduate students are heavily involved in weekly multi-nodal (video-conference) research seminars and quarterly review/ planning meetings for each of the Centre's Programs. In addition, 57 student members of the ARC Centre currently have multi-institutional supervisory arrangements. Students and their projects are highlighted individually on the ARC Centre's website at *www.coralcoe.org.au/people-students.html*. The Centre funds exchanges and travel between the nodes of the Centre and with collaborating partners including the Australian Institute of Marine Science, the Great Barrier Reef Marine Park Authority, and CSIRO. Seventy of the ARC Centre's students were also funded to attend international symposia in 2008. Sixty participated in the quadrennial International Coral Reef Symposium held in Fort Lauderdale, Florida in July. Also in July, five new PhD students from Program 6 travelled to Chattanooga, Tennessee where they presented their research to the annual meeting of the Society for Conservation Biology.

The Centre actively involves students through a Student Committee which manages a $40,000 annual budget for student mentoring activities, internodal visits and student awards. In 2008 they also organised a successful student workshop in September entitled "*When do conservation plans work?* Best practice for implementation and evaluation of conservation planning". Five $1,000 prizes for the ARC Centre's Best Student Papers for 2008 were awarded to David Abrego, Danielle Dixson, Charlotte Kveneffors, Rachael Middlebrook and Mia Hoogenboom

Many of our students participated in the quadrennial International Coral Reef Symposium held in Fort Lauderdale, Florida in July. Students selected by the organising committee to present their research at the conference had their travel costs supported by the Centre. In all 45 students received a total of $65,000 towards their participation in the symposium. Also in July, five of our students travelled to Chattanooga, Tennessee where they presented their research to the annual meeting of the Society for Conservation Biology.

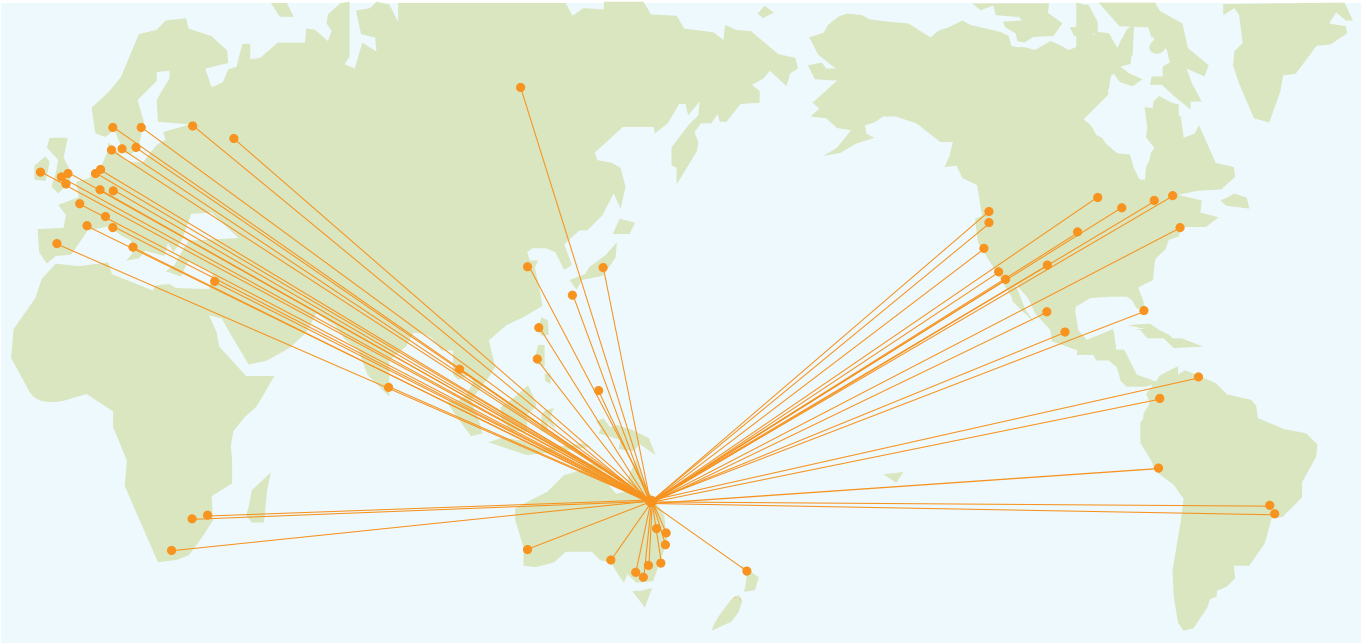
We thank our 2008 student committee: Paulina Cetina-Heredia (JCU/AIMS), Mike Fabinyi (ANU), Stephanie Januchowski (JCU) Rachael Middlebrook (UQ), George (Jez) Roff (UQ) and Marcelo Visentini Kitahara (JCU) for their important contribution to the Centre.

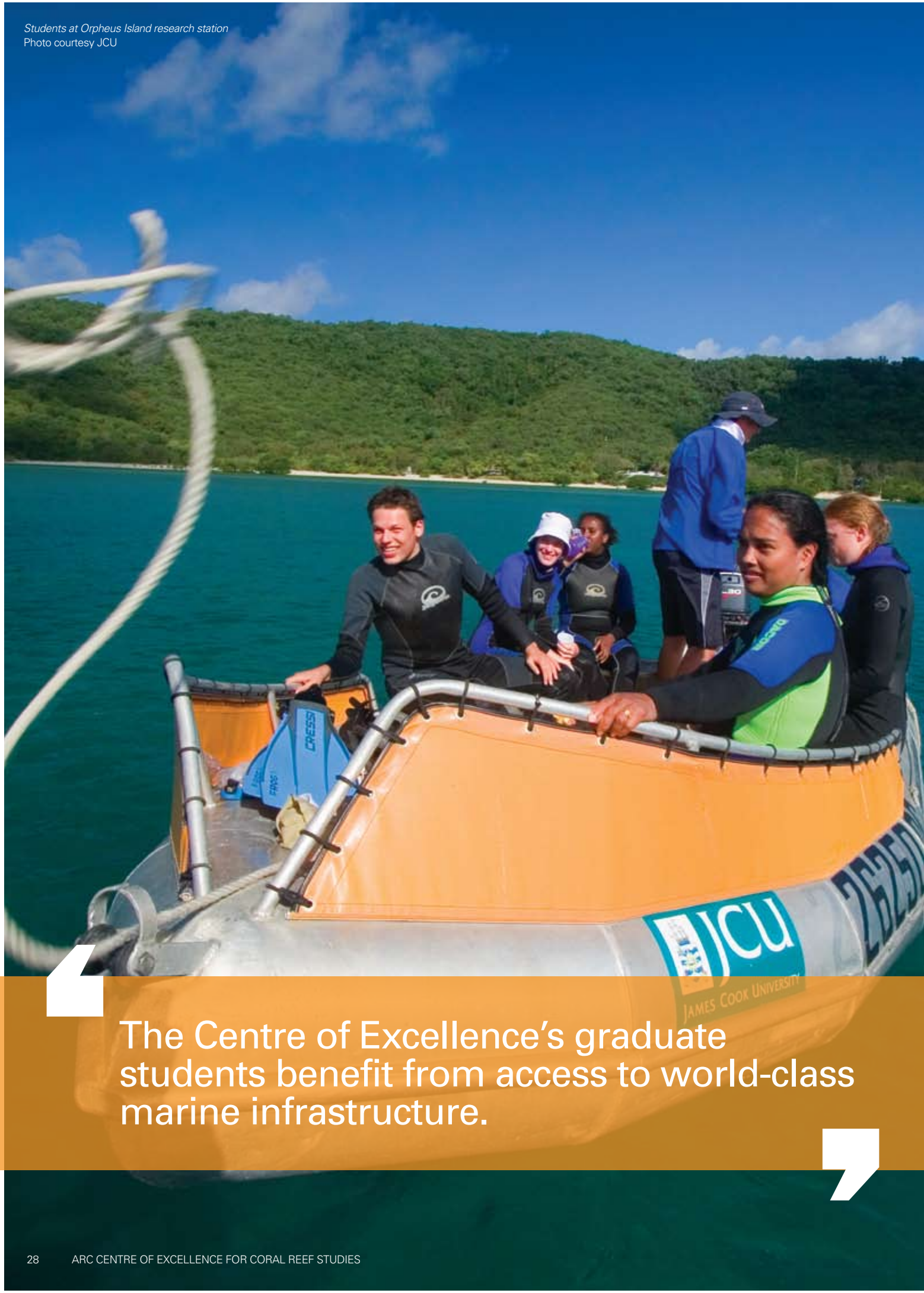
↓ *Trends in the ARC Centre's training activities 2005 to 2008*



A unique feature of the Centre is the high percentage of international students enrolled in graduate research programs. The 151 graduate student members of the ARC Centre come from 37 countries around the globe and many are funded by grants from their government's agencies. The map below illustrates the geographic diversity of students.

↓ *The ARC Centre's international network of graduate students. In 2008, ninety-nine overseas students, representing half of the Centre's current enrolments, came to Australia from 37 countries.*





Students at Orpheus Island research station
Photo courtesy JCU

> The Centre of Excellence's graduate students benefit from access to world-class marine infrastructure.

2008 STUDENT MEMBERS OF THE ARC CENTRE OF EXCELLENCE

Student	University	Country of Origin	Thesis Title	CoE Supervisor/s
Rene Abesamis	JCU, Silliman University	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, Prof S Connolly, Dr M van Oppen
Vanessa Adams	JCU	USA	Incorporating economic factors into systematic conservation planning. (PhD)	Prof R Pressey, Prof T Hughes
Siham Afatta	UQ	Indonesia	Resilience indicators for reefs of the Karimunjawa Marine Park. (MSc)	Dr K Anthony, Prof O Hoegh-Guldberg
Tracy Ainsworth	UQ	Australia	Disease and stress in reef building corals. (PhD awarded)	Prof O Hoegh-Guldberg
Jorge Alvarez-Romero	JCU	Mexico	An integrated land-sea approach to design of marine protected areas in the Gulf of California. (PhD)	Prof R Pressey, Prof T Hughes
Shelley Anthony	JCU, AIMS	USA	White Syndrome Disease and colony mortality in captive Indo-Pacific corals. (PhD)	Prof B Willis
Jacquelyn Barba	JCU	USA	Effects of fishing on the life history dynamics of reef fishes in Guam. (MSc)	Prof G Russ
Lissa Barr	UQ, JCU	Australia	Measuring the effectiveness of marine protected areas. (PhD)	Prof R Pressey
Christopher Bartlett	JCU	USA	Marine conservation in Vanuatu. (PhD)	Dr J Cinner
Brian Beck	UQ, JCU	USA	Palaeoecological dynamics of coral communities along a disturbance gradient, Solomon Islands. (PhD)	Prof J Pandolfi, A.Prof S Connolly
Roger Beeden	JCU	New Zealand	How healthy is the Great Barrier Reef in a warming world? (PhD)	Prof B Willis
Maria Beger	UQ, JCU	Germany	Models and framework that enhance systematic planning for coral reefs. (PhD awarded)	Prof G Jones
Dorothea Bender	UQ, University of Bremen	Germany	Effects of macroalgae on the regeneration of coral tissue. (MSc awarded)	Dr G Diaz-Pulido, Dr S Dove, Prof O Hoegh-Guldberg
Rose Berdin	ANU	Philippines	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	Resilience of reef-based tourism to climate change and disturbance. (PhD)	Prof T Hughes, Dr J Cinner
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 W Leggat, Prof D Yellowlees
Roberta Bonaldo	JCU	Brazil	The ecosystem role of parrotfishes. (PhD)	Prof D Bellwood, Prof S Connolly
Olga Bondarenko	JCU, AIMS	Ukraine	Import of plankton to reefs and the influence of oceanography. (MAppSc awarded)	Prof M Kingsford
Pim Bongaerts	UQ	Netherlands	Ecological significance of deep, light-dependent coral communities. (PhD)	Prof O Hoegh-Guldberg, Dr M Rodriguez-Lanetty

GRADUATE TRAINING

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
Madeleine Bottrill	UQ, JCU	United Kingdom	Evaluating the effectiveness of conservation planning: when do plans work? (PhD)	Prof R Pressey
Daniel Breen	JCU	Australia	Systematic conservation assessments for marine protected areas in New South Wales, Australia. (PhD awarded)	Prof G Jones
Tom Brewer	JCU, UQ	Australia	Socioecological systems and institutional hierarchies in conservation planning. (PhD)	Prof R Pressey, Dr J Cinner, Prof J Pandolfi
Kate Bromfield	UQ, CSIRO	Australia	Neogene corals of the Indo-Pacific. (PhD)	Prof J Pandolfi
Rohan Brooker	JCU	New Zealand	The diet of coral-commensal gobies. (GDipResMeth)	Dr P Munday, Prof G Jones
Neal Cantin	JCU, AIMS	Canada	Effects of the herbicide diuron on coral reproduction and larval competency. (PhD awarded)	Prof B Willis
Michael Cappo	JCU, AIMS	Australia	Spatial patterns of demersal vertebrate assemblages in inter-reef waters. (PhD)	Prof M Kingsford
Nicoletta Cariglia	JCU, University of Newcastle	Italy	The influence of marine reserves and habitat variables on holothurian distribution in the Seychelles. (MSc)	Dr S Wilson
Alexandra Carter	JCU	Australia	The effects of no-take zoning, region and year on reproductive output of the common coral trout, *Plectropomus leopardus*. (PhD)	Dr M McCormick, Prof G Russ
Paulina Cetina-Heredia	JCU, AIMS	Mexico	Modelling physical and biological processes driving larval transport and supply in reef systems. (PhD)	Prof S Connolly
Rowan Chick	JCU	Australia	Reseeding for the enhancement of abalone stocks in NSW. (PhD)	Prof M Kingsford
Chia-Miin Chua	JCU	Malaysia	Effects of elevated temperature and increased acidity on the early life history of coral. (PhD)	Dr A Baird, Dr W Leggat, Prof T Hughes
Tara Clark	UQ, AIMS	Australia	Dating and mapping historical changes in Great Barrier Reef coral communities. (PhD)	Prof J Pandolfi
Darren Coker	JCU, DEC in WA, AIMS	New Zealand	Responses of coral-dwelling fishes to host coral bleaching and collapse (displaced damsels). (PhD)	Dr M Pratchett, Prof T Hughes, Dr P Munday, Dr S Wilson
Andrew Cole	JCU, DEC in WA	Australia	The effect of chronic fish predation on scleractinian corals. (PhD)	Dr M Pratchett, Prof G Jones, Dr S Wilson
Timothy Cooper	JCU	Australia	Coral bioindicators of environmental conditions on coastal coral reefs. (PhD awarded)	Prof M Kingsford
Melissa Cowlishaw	JCU	Australia	Determinants of home range and territorial behaviour in coral fishes. (PhD)	Prof G Jones, Dr M McCormick
Peter Cowman	JCU	Ireland	Dating the evolutionary origins of trophic novelty in coral reef fishes. (PhD)	Prof D Bellwood
Alicia Crawley	UQ	Australia	The synergistic effect of rising ocean temperature and acidification on coral reef ecosystems. (PhD)	Dr S Dove, Dr S Dunn
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 awarded)	Prof M Kingsford
Kathryn Danaher	JCU	Australia	Oceanography and the condition of plankton. (PhD)	Prof M Kingsford

Student	University	Country of Origin	Thesis Title	CoE Supervisor/s
Andrea de Leon	ANU	Australia	Palaeoceanographic records of the Southern Ocean: insights from the boron composition of biogenic silica. (PhD)	Prof M McCulloch
Jeffry Deckenback	UQ, JCU, Monash	USA	Maturation, turn-over, oligomerization, and transport of pocilloporins. (PhD awarded)	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 P Munday, Dr M Pratchett
Juan Pablo D'Olivo	ANU	Mexico	Environmental and climate variability in seawater pH reconstructed from B isotopes in corals from the Pacific Ocean. (PhD)	Prof M McCulloch
Jennifer Donelson	JCU, CSIRO	Australia	Climate change and the future for coral reef fishes: impacts and adaptation. (PhD)	Dr P Munday, Dr M McCormick
Maxi Eckes	UQ	Germany	How do coral reef fish protect themselves from solar ultraviolet radiation? (PhD)	Dr S Dove
Udo Engelhardt	UQ	Australia	Community-level ecological responses of coral reef biota to mass coral bleaching events. (PhD)	Prof O Hoegh-Guldberg
Richard Evans	JCU	Australia	Effects of marine reserves: ecology and reproductive connectivity. (PhD)	Prof G Russ, Prof G Jones
Michael Fabinyi	ANU, JCU	Australia	Fishing for fairness: poverty, morality and marine resource regulation in the Calamianes Islands, Philippines. (PhD)	Dr S Foale
Pepito (Sonny) Fernandez	ANU, JCU	Philippines	Political engagements in MPA governance in northeastern Liloilo, Philippines. (PhD)	Dr S Foale
Rebecca Fox	JCU	United Kingdom	Ecosystem function of rabbitfishes (*Siganidae*) on the Great Barrier Reef, Australia. (PhD)	Prof D Bellwood
Matthew Fraser	JCU	Australia	Dynamics of egg predation at tropical fish spawning sites. (PhD)	Dr M McCormick, Prof G Jones
Ashley Frisch	JCU	Australia	Population biology and fishery ecology of the painted crayfish, *Panulirus versicolor*, on the Great Barrier Reef, Australia. (PhD awarded)	Dr M McCormick
Naomi Gardiner	JCU	Australia	Habitat specialization, co-occurrence and resting site fidelity in cardinalfish on coral reefs. (PhD)	Prof G Jones
Christopher Goatley	JCU	United Kingdom	The ecological role of sediments in coral reefs. (PhD)	Prof D Bellwood
Alonso Gonzalez-Cabello	JCU	Mexico	Cryptobenthic reef fish ecology in the Great Barrier Reef, Australia. (PhD)	Prof D Bellwood
Erin Graham	JCU	USA	Energetics of coral larvae and its implications for dispersal. (PhD)	Prof B Willis, Prof S Connolly, Dr A Baird
Lauretta Grasso	ANU, JCU	Australia	Microarray analysis of coral development. (PhD)	Prof D Miller
Jessica Haapkyla	JCU, AIMS	Finland	Impacts and drivers of coral disease in Indo-Pacific Reefs. (PhD)	Prof B Willis
Andrew Halford	JCU	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

GRADUATE TRAINING

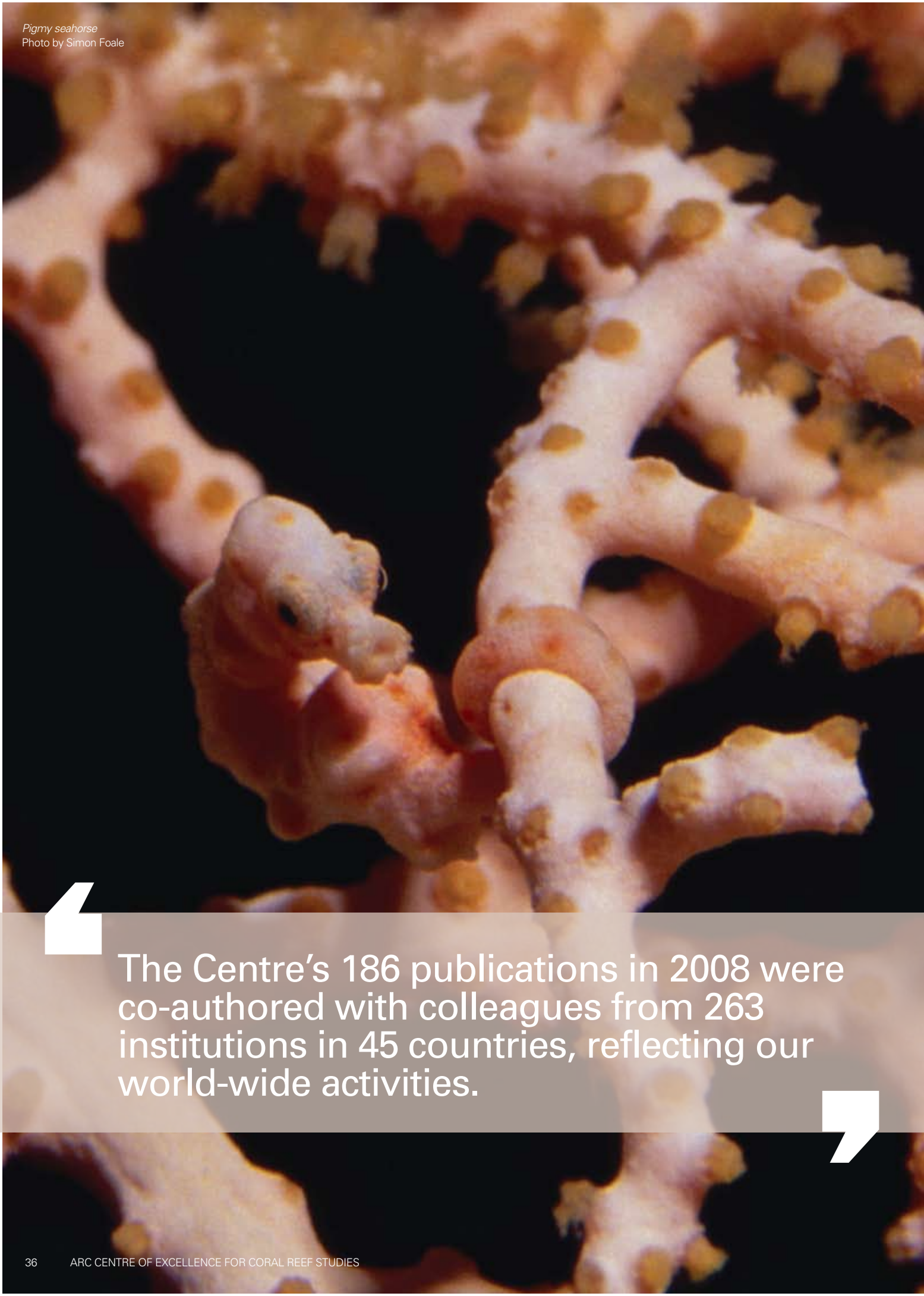
Student	University	Country of Origin	Thesis Title	CoE Supervisor/s
Hugo Harrison	JCU	France	Larval recruitment dynamics and the genetic structure of coral reef fish populations in marine protected networks. (MSc)	Prof G Jones
Meegan Henderson	UQ	Australia	Microbial ecology of coral disease: the use of 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 awarded)	Prof G Jones
Andrew Hoey	JCU	Australia	Algal-fish interactions on coral reefs. (PhD)	Prof D Bellwood, Prof G Russ
Thomas 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 awarded)	Prof S Connolly, Dr K Anthony
Emily Howells	JCU, AIMS	Australia	Genetic resilience of *Symbiodinium* populations: the role of coral endosymbionts in reef adaptation to climate change. (PhD)	Prof B Willis, Dr L Bay, Dr M van Oppen
Alec Hughes	JCU	Solomon Islands	Life history and population biology of the squaretail coral-grouper (*Plectropomus areolatus*) in Solomon Islands. (MSc)	Prof G Russ
Stephanie Januchowski	JCU	USA	Towards stream classifications for conservation planning: a Wet Tropics region case study. (PhD)	Prof R Pressey
Jacob Johansen	JCU	Denmark	Energetics of habitat choice in planktivorous coral reef fishes. (PhD)	Prof G Jones, Prof D Bellwood
Jung Ok Kang	ANU	Korea	Anthropogenic increase of atmospheric carbon dioxide and ocean acidifying and global warming: implications for long-term changes in the calcification rate of coral reefs. (PhD)	Prof M McCulloch
Brent Knack	JCU	Australia	Cell adhesion factors in Cnidarians. (PhD)	Prof D Miller, Dr W Leggat
Valeriya Komyakova	JCU	Russia	Habitat characteristics as the determinants of the local diversity and structure of coral reef fish communities. (MSc)	Prof G Jones, Dr P Munday
Narinratana Kongjandtre	UQ	Thailand	The taxonomy and systematics of the genus *Favia* from Thai waters. (PhD)	Prof O Hoegh-Guldberg, Dr M Rodriguez-Lanetty
Charlotte Kvennefors	UQ, JCU	Sweden	Host-microbe interactions in reef-building corals. (PhD)	Dr W Leggat, Prof O Hoegh-Guldberg
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
Rebecca Lawton	JCU, WHOI	New Zealand	Geographic variation in the ecology of butterflyfishes and resilience to large scale disturbances. (PhD)	Dr M Pratchett, Prof T Hughes, Dr L Bay
Helene Le Grand	JCU, AIMS	France	Development of coral bioindicators to detect changes in water quality on inshore reefs of the Great Barrier Reef. (MAppSc)	Prof B Willis
Anne Leitch	JCU, CSIRO	Australia	Social resilience to climate change: the adaptive capacity of local government. (PhD)	Prof T Hughes
Kimberley Lema	JCU, AIMS	France	Recovery of the coral holobiont after injury stress. (MSc)	Prof B Willis

Student	University	Country of Origin	Thesis Title	CoE Supervisor/s
Tove Lemberget	JCU	Norway	Importance of body condition and growth to larval survival of a Caribbean lizardfish. (PhD)	Dr M McCormick, Prof G Jones
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
Adrian Lutz	JCU, AIMS	Switzerland	Coenzyme Q and plastoquinone redox balance as a physiological determinant of oxidative stress in coral algal symbiosis. (PhD)	Prof D Miller, Dr M van Oppen
Matt Lybolt	UQ	USA	Causes of change in coastal ecosystems: past, present and future. (PhD)	Prof J Pandolfi
Thomas Mannering	JCU	United Kingdom	Do marine reserves augment recruitment in nearby fished areas? (MSc)	Prof G Jones
Dominique McCowan	JCU	USA	Bleaching susceptibility of corals: a hierarchy of causes and consequences. (PhD)	Dr M Pratchett, Dr A Baird, Prof T Hughes
Ewen McPhee	JCU	Australia	Coastal confusion: the maritime cultural heritage of the Great Barrier Reef. (PhD)	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, University of Perpignan	France	Causes and consequences of declining fish biodiversity in coral reefs. (PhD)	Prof G Jones, Dr P Munday
Rachael Middlebrook	UQ	Australia	Determining thermal threshold dynamics and variability in reef building corals. (PhD)	Dr S Dove, Dr K Anthony, Prof O Hoegh-Guldberg
Morena Mills	JCU	Brazil	Implementation opportunity in systematic conservation planning. (PhD)	Prof R Pressey, Prof T Hughes
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. (PhD)	Prof J Pandolfi
Stephan Neale	JCU	Australia	Impacts of water quality on recruitment of corals. (GDRM awarded)	Prof B Willis
Chooi Fei Ng	JCU	Malaysia	Statolith of Cubozoans: taxonomic tool for species identification. (MAppSc awarded)	Prof M Kingsford
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 polymorphisms of a common reef-building coral, *Acropora millepora*, on the Great Barrier Reef, Australia. (MSc)	Prof B Willis, Dr M van Oppen
Caroline Palmer	JCU, Newcastle University	United Kingdom	The basic biological mechanisms of scleractinian immune defenses involved in wound healing and disease mitigation. (PhD)	Prof B Willis
Christine Pam	JCU	Australia	Social responses to change on small islands in Micronesia. (PhD)	Dr S Foale
Joe Pollock	JCU , AIMS, College of Charleston (SC, USA)	USA	Phylogeography of the coral pathogen, *Vibrio coralliilyticus*, and the development of a qPCR-based diagnostic assay for its detection. (MSc)	Prof B Willis

GRADUATE TRAINING

Student	University	Country of Origin	Thesis Title	CoE Supervisor/s
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-Quartenary climate in the Indo-Pacific warm pool reconstructed from the raised coral reefs of Sumba, Indonesia. (PhD awarded)	Prof M McCulloch
Jean-Baptiste Raina	JCU, AIMS	France	Coral-associated bacteria and their role in the biogeochemical cycle of sulphur. (PhD)	Prof B Willis
Charmaine Read	JCU	Australia	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 awarded)	Prof O Hoegh-Guldberg, Dr W Leggat, Dr S Dove
Claire Reymond	UQ, AIMS	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, Prof B Willis, Dr M van Oppen
Alma Ridep-Morris	JCU	Palau	Dynamics of a black band disease outbreak in Palau. (MAppSc awarded)	Prof B Willis
Maria Rodriques	JCU	Mozambique	Effects of herbivory on coexistence of coral and algae. (PhD awarded)	Prof T Hughes, Dr A Baird
George Roff	UQ	United Kingdom	Historical ecology of coral communities from the inshore Great Barrier Reef, Australia. (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	Sex-specific growth dynamics in protogynous hermaphrodites. (MSc awarded)	Dr M McCormick, Dr P Munday
Armagan Sabatien	JCU	New Zealand	Investigating the population dynamics of commercially important reef fish species. (PhD awarded)	Prof G Jones
Aleksey Sadekov	ANU	Russia	Distribution of trace elements within foraminiferal tests as the proxy for paleoclimatology and foraminiferal biology. (PhD awarded)	Prof M McCulloch
Pablo Saenz-Agudelo	JCU, University of Perpignan	Colombia	Demography and connectivity in coral reef fish populations as revealed by parentage analysis. (PhD)	Prof G Jones
Yui Sato	JCU, AIMS	Japan	Dynamics of a black band disease outbreak. (MSc)	Prof B Willis
Jessica Scannell	JCU	USA	Influence of habitat degradation in mortality of fishes. (MAppSc awarded)	Dr M McCormick
Shio Segi	ANU, JCU	Japan	Living under threat: depletion, development and MPAs in the lives of small-scale fishers in the Philippines. (PhD)	Dr S Foale
Francois Seneca	JCU, AIMS, ANU	Monaco	The molecular stress response in a model scleractinian coral: *Acropora millepora*. (PhD)	Prof D Miller, Dr M van Oppen
Michael Short	JCU	Australia	The recovery of coral reefs following ship grounding disturbances. (MSc)	Prof B Willis, Prof G Jones
Luke Smith	JCU	Australia	Coral bleaching in Western Australia. (PhD awarded)	Prof T Hughes
Jessica Stella	JCU, Australian Museum	USA	Climate impacts on non-coral reef invertebrates. (PhD)	Prof G Jones, Dr M Pratchett, Dr P Munday
Meir Sussman	JCU, AIMS	Israel	A molecular approach to the study of coral diseases. (PhD)	Prof B Willis

Student	University	Country of Origin	Thesis Title	CoE Supervisor/s
Jill Sutton	ANU	Canada	Southern ocean nutrients and climate change: insights from isotopic and elemental signatures of diatoms and sponges. (PhD)	Prof M McCulloch
Chun Hong Tan	JCU	Malaysia	Environmental controls and evolutionary constraints on growth and reproduction in corals. (PhD)	Dr M Pratchett, Dr L Bay, Dr A Baird
Michelle Templeman	JCU	Australia	The role of jellyfish in cycling contaminants in the marine environment and their utility as biomonitors. (PhD)	Prof M Kingsford
Loic Thibaut	JCU, Université Pierre et Marie Curie	France	Resilience in coral reef and model ecosystems. (PhD)	Prof S Connolly, Prof T Hughes
Lubna Ukani	JCU	India	Characterisation of DNA methylation systems in *Acropora* and other lower animals. (PhD)	Prof D Miller, Dr W Leggat
Svetlana Ukolova	JCU	Russia	Signalling molecules in coral development. (PhD)	Prof D Miller, Dr W Leggat
Annamieke Van Den Heuvel	UQ, JCU	Australia	Characterisation of genes, proteins, and the regulatory pathways involved in nitrogen uptake and the assimilation in *Acropora aspera* and its symbiont *Symbiodinium* sp. (PhD)	Dr S Dove, Dr W Leggat, Prof D Yellowlees
Cameron Veal	UQ	Australia	Meso-and micro-scale light fields around shallow coral reefs. (PhD)	Prof O Hoegh-Guldberg, Dr K Anthony, Dr S Dove
Ana Villacorta Rath	JCU	Peru	Selective mortality and productivity of sprats. (MSc)	Dr M McCormick, Dr M Meekan
Piero Visconti	JCU, University La Sapienza, Rome, Italy	Italy	Incorporating biodiversity processes and dynamic threats in systematic conservation planning. (PhD)	Prof R Pressey
Marcelo Visentini-Kitahara	JCU, Smithsonian Institute	Brazil	Taxonomic and phylogenic trends among azooxanthellate corals, using morphological and molecular aspects. (PhD)	Prof D Miller
Stefan Walker	JCU	Australia	The socio-biology of life history transitions and lifetime fecundity in a tropical haremic reef fish. (PhD)	Dr M McCormick, Dr P Munday
Patricia Warner	JCU, AIMS	USA	Reproductive ecology and population genetic approaches to assessing connectivity of the brooding coral, *Seriatopora hystrix*. (PhD)	Prof B Willis, Dr M van Oppen
Rebecca Weeks	JCU	United Kingdom	Systematic marine reserve network design in the Philippines. (PhD)	Prof G Russ, Prof G Jones
Yvonne Weiss	JCU	Germany	The immune system of *Acropora millepora*: identification and characterisation of candidate genes. (PhD)	Prof D Miller, Dr W Leggat, Dr T Ainsworth
Colin Wen	JCU	Taiwan	Are increased predatory fishes in the No Take Marine Reserves susceptible or sustainable: consequences of the coral deteriorating from climate change. (PhD)	Prof G Jones, Dr M Pratchett
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	United Kingdom	Simulation frameworks for investigating spatially-explicit modelling of competition and coexistence in coral assemblages. (MAppSc awarded)	Prof S Connolly
Marion Wong	JCU, Centre for Science, Spain	United Kingdom	The evolution of animal societies: monogamy, group living and conflict on coral-dwelling fish. (PhD awarded)	Dr P Munday, Prof G Jones
Huibin Zou	JCU	China	The characterisation of selenium containing protein families in coral *Acropora millepora*. (PhD)	Prof D Miller, Dr T Ainsworth



Pigmy seahorse
Photo by Simon Foale

> The Centre's 186 publications in 2008 were co-authored with colleagues from 263 institutions in 45 countries, reflecting our world-wide activities.

NATIONAL AND INTERNATIONAL LINKAGES

The Centre is recognised as a world leader in coral reef research and in the provision of science for the sustainable management of coral reefs. Our exceptional international standing has resulted in literally hundreds of recent collaborations and interactions with international researchers and their institutions. This can be illustrated through the Centre's co-authorships, workshops, visits, and editorial board memberships (KPI Tables, pp.62-65), in addition to activities such as international research exchanges, new memorandums of understanding, and joint funding of research and research fellows.

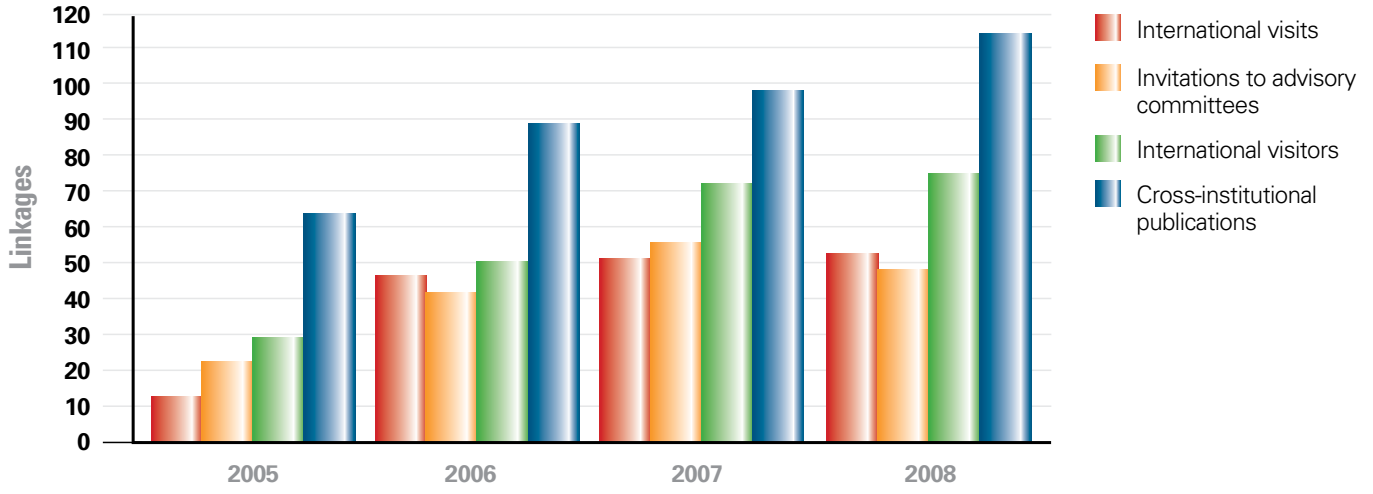
In 2008, the ARC Centre produced 115 publications (out of a total of 186) with cross-institutional co-authorship (39 more than 2005). These publications involved researchers from 263 institutions in 45 countries. The ARC Centre hosted 75 international visitors from 23 countries, and Centre personnel traveled to 26 countries. The ARC Centre participated in or hosted 16 international working groups during 2008. Centre personnel are members of editorial boards for 14 international journals.

Since its establishment in 2005 there has been a steady growth in the engagement of the ARC Centre's researchers with their international colleagues (see figure, below). The Centre's profile is increasingly attracting overseas postgraduate students who, in 2008, come from 37 different countries around the world (see p27).

Nationally, the Centre is represented at the Australian Academy of Science by two Fellows, Terry Hughes and Malcolm McCulloch. In 2008, the Centre's Director assisted the Department of Climate Change as a member of the drafting team for the Marine Biodiversity and Resources National Adaptation Research Plan for 2009-2012. The ARC Centre of Excellence, along with AIMS, was invited by the Department of the Environment, Water, Heritage and the Arts to contribute to the organisation and content of an international forum on management and conservation of coral reefs, in November 2008. This was the first practical step in the Australian Government's commitment to support the *Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security* (see p.48). The ARC Centre is Australia's leading research agency in the Coral Triangle region, with a long-term commitment to projects in Indonesia, Papua New Guinea, The Philippines, and the Solomon Islands (see 2008 publication list).

Official visitors to the ARC Centre in the past year included the new Prime Minister, Federal Minister for Innovation, Industry, Science and Research, Federal Minister and shadow Minister of Education, and the US Ambassador to Australia. Knowledge transfer from the ARC Centre of Excellence to industry and governments included new technologies that can better predict coral bleaching, enhanced understandings of reef responses to climate change, and improvement in the efficiency of conservation planning. The Centre also provided training to conservation and resource management projects, and to governments and NGOs around the world. The Centre's researchers were major contributors to intergovernmental organisations such as the International Union for the Conservation of Nature (IUCN), the World Bank, UNESCO, and the Intergovernmental Panel on Climate Change, all of which are involved in key global declarations, World Heritage designations, and endangered or threatened species status decisions.

↓ *The Centre's international linkages in 2005 to 2008.*



Our major international collaborations include:

- The Beijer Institute for Ecological Economics – an international research institute under the auspices of the Royal Swedish Academy of Sciences
- The Resilience Alliance
- The Stockholm Resilience Centre
- The World Bank Global Coral Reef Targeted Research (CRTR) Program
- The Nature Conservancy
- The Coral Triangle Initiative (see p.48)

The Stockholm Resilience Centre

www.stockholmresilience.org

The Stockholm Resilience 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. 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 ARC Centre Director, Terry Hughes, is a Fellow and Board member of the Beijer Institute. 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. As part of the agreement, Senior Research Fellow Jon Norberg spent a sabbatical visit at JCU in early 2008, while APD Fellow Josh Cinner visited Stockholm on a 6 week exchange (co-funded by the Australian Academy of Science). In January 2008, Terry Hughes convened a joint working group on adaptive management of fisheries, in Santiago, Chile, involving researchers from the ARC Centre (Hughes and Simon Foale), the Stockholm Research Centre (Carl Folke, Per Olsson) and elsewhere. Four ARC Centre members visited Stockholm in April 2008. A range of other joint activities have been established, including additional working groups jointly funded by both organizations. The next one will take place in the Galapagos Islands, Equador, in February 2009.

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 2008, the Centre is represented on three 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, (Co-Chair). Contributions from Centre members in 2008 included several major workshops in Australia and overseas. Bette Willis led a team from the ARC Centre and the CRTR Program who produced a guide to coral health and diseases for use both by scientists and by lay people. This educational tool is in the form of a ring-bound 24-page waterproof guide to coral diseases and their symptoms, which is designed for easy reference under water. It is accompanied by a 120-page booklet on how to assess, monitor and manage coral disease.

The Nature Conservancy

www.nature.org

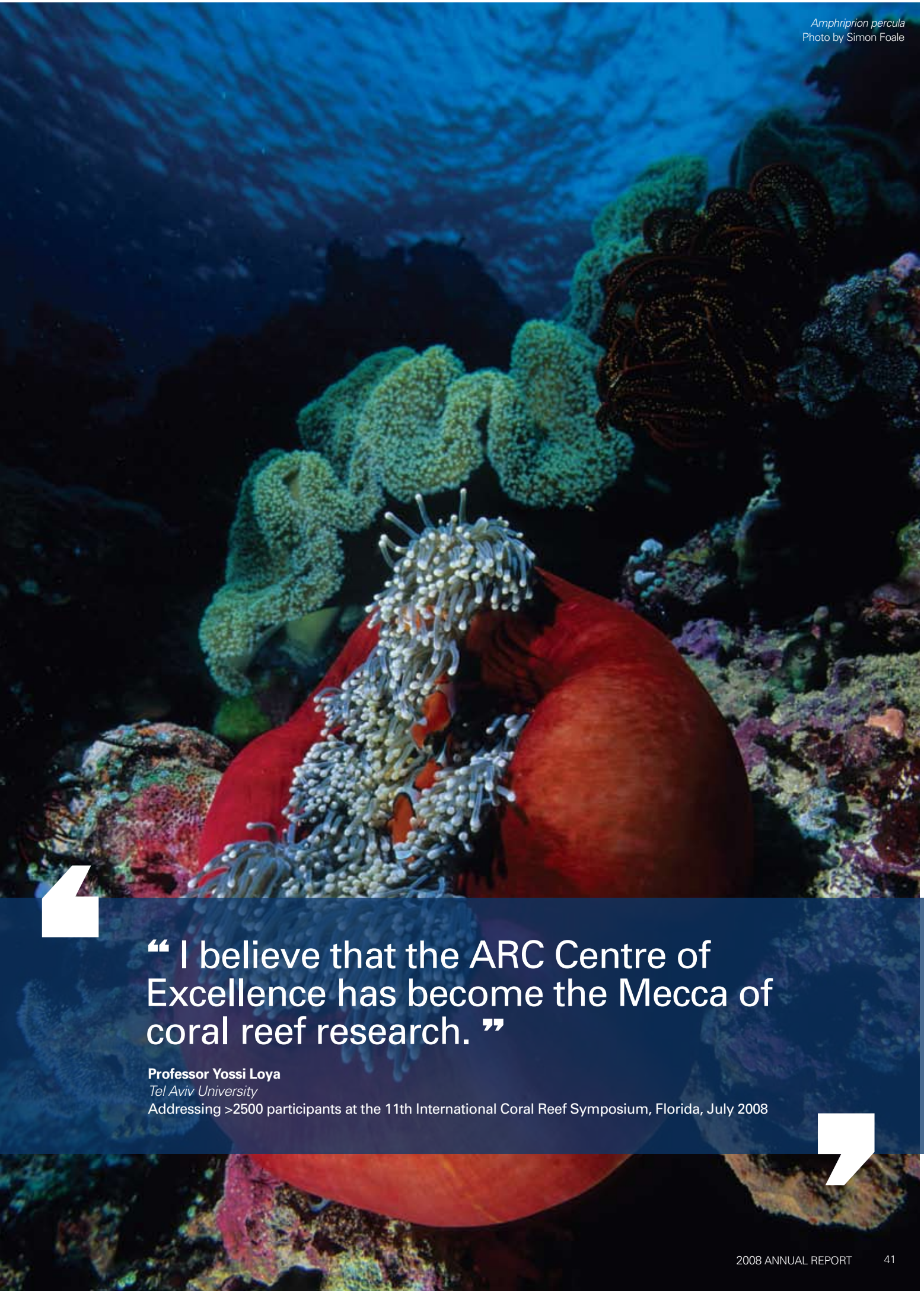
The Nature Conservancy, the world's largest non-profit conservation organisation, and the ARC Centre, signed a Memorandum of Understanding in 2008. It cements a growing level of engagement between the two organisations involving projects in numerous countries. The TNC depends on sound scientific knowledge to accomplish its mission, and works closely with the Centre on many fronts. In 2008, Centre Fellow Glenn Almany was seconded to TNC's Brisbane office to work with TNC researcher Alison Green and her teams in Melanesia on reef connectivity and the design of networks of coral reef marine protected areas in the Coral Triangle region. The TNC and Program 6 Leader, Bob Pressey, also initiated a set of new collaborations in 2008, focusing on conservation planning and seascape approaches to coastal management in the Bismark Sea and elsewhere in the Coral Triangle. Senior Fellow Simon Foale is working with TNC to review the social component of their ecosystem-based management of fisheries in Papua New Guinea, the Solomon Islands, and Vanuatu.

OVERSEAS VISITING RESEARCHERS

In 2008, 75 visitors were hosted by one or more nodes of the ARC Centre, or attended working group meetings organized by the Centre:

- **Professor Johan Bell**
  Secretariat of the Pacific Community
  New Caledonia
- **Dr Michael Berumen**
  Woods Hole Oceanographic Institution
  USA
- **Professor Thomas Bosch**
  University of Kiel
  Germany
- **Associate Professor John Bruno**
  Duke University
  USA
- **Dr Scott Bryan**
  Kingston University
  United Kingdom
- **Governor Felix Perez Camacho**
  Guam
  USA
- **Professor Juan Carlos Castilla**
  Pontificia Universidad Catolica de Chile
  Chile
- **Professor Anne Chao**
  National Tsing Hua University
  Taiwan
- **Professor Robert Colwell**
  University of Connecticut
  USA
- **Professor David Currie**
  University of Ottawa
  Canada
- **Dr Omar Defeo**
  Universidad de la Republica
  Uruguay
- **Dr Al (Alfred) Duda**
  GEF Secretariat
  USA
- **Professor Rob Dunbar**
  Stanford University
  USA
- **Professor Evan Edinger**
  Memorial University
  Canada
- **Professor Johnathan Erez**
  The Hebrew University of Jerusalem
  Israel
- **Dr Gene Feldman**
  NASA
  USA
- **Associate Professor Miriam Fernandez**
  Pontificia Universidad Catolica de Chile
  Chile
- **Professor Carl Folke**
  Stockholm University
  Sweden
- **Dr Stefan Gelcich**
  Pontificia Universidad Catolica de Chile
  Chile
- **Professor Ed Gomez**
  Philippines University
  Philippines
- **Associate Professor George Graff**
  University of Connecticut
  USA
- **Associate Professor Lance Gunderson**
  Emory University
  USA
- **Professor Drew Harvell**
  Cornell University
  USA
- **Dr Austin Hendy**
  Yale University
  USA
- **Professor Sally Holbrook**
  University of California Santa Barbara
  USA
- **Dr Danwei Huang**
  Scripps Institution of Oceanography
  USA
- **Professor Roberto Iglesias-Prieto**
  Universidad Nacional Autonoma de Mexico
- **Dr Tsuyoshi Iizuka**
  Tokyo University
  Japan
- **Dr Yi-Huei Jiang**
  National Tsing Hua University
  Taiwan
- **Dr Jamaluddin Jompa**
  Ministry of Marine Affairs and Fisheries, Indonesia
- **Dr Stacy Jupiter**
  Wildlife Conservation Society
  Fiji
- **Dr Alexander Kerr**
  University of Guam
  USA
- **Justine Kimball**
  Stanford University
  USA
- **Matthias Lopez Correa**
  Erlangen University
  Germany
- **Dr Syamsul Maarif**
  Ministry of Marine Affairs & Fisheries
  Indonesia
- **Dr Husni Manggabarani**
  Ministry of Marine Affairs & Fisheries
  Indonesia
- **Associate Professor Mikhail Matz**
  University of Texas
  USA
- **His Excellency, Robert McCallum Jnr.**
  US Ambassador to Australia
  USA
- **Dr Monica Medina**
  University of California
  USA
- **Janot-Reine Mendler de Suarez**
  GEF International Waters: Learn
  USA
- **Dr Paolo Montagna**
  ICRAM
  Italy
- **Dr Michael Morgan**
  Berry College
  USA
- **Professor David Morse**
  University of Montreal
  Canada

- **Dr David Mouillot**
  University of Montpellier
  France
- **David Mucciarone**
  Stanford University
  USA
- **Professor Peter Mumby**
  University of Essex
  United Kingdom
- **Dr Sanivalati Navuku**
  World Wildlife Fund
  Fiji
- **Dr Jon Norberg**
  Stockholm University
  Sweden
- **Dr Jamie Oliver**
  WorldFish Center
  Malaysia
- **Dr Esben Olsen**
  University of Oslo
  Norway
- **Dr Per Olsson**
  Stockholm University
  Sweden
- **Dr Emily Pidgeon**
  Conservation International
  Global Marine Team
  USA
- **Professor Steven Quistdad**
  University of California Santa Barbara
  USA
- **Dr Thiago Rangel**
  University of Connecticut
  USA
- **Dr Robert Redmond**
  University of Hawaii
  USA
- **Associate Professor Brendan Roark**
  Texas A&M
  USA
- **Dr David Roberts**
  Harvard University/ Kew Gardens
  USA/UK
- **Dr Andres Ruggeberg**
  University of Kiel
  Germany
- **Dr Didi Sadili**
  Ministry of Marine Affairs & Fisheries
  Indonesia
- **Professor Marten Scheffer**
  University of Wageningen
  Netherlands
- **Professor David Schiel**
  University of Canterbury
  New Zealand
- **Professor Russell Schmitt**
  University of California Santa Barbara
  USA
- **Dr Sergio Silenzi**
  ICRAM
  Italy
- **Professor Howard Spero**
  University of California Davis
  USA
- **Professor Bob Steneck**
  University of Maine
  USA
- **Professor Fred Taylor**
  University of Texas at Austin
  USA
- **Professor Ulrich Technau**
  University of Vienna
  Austria
- **Dr Anna Tengberg**
  United Nations Development Program
  Sweden
- **Dr Mark Tupper**
  WorldFish Center
  Malaysia
- **Dr Egbert van Es**
  University of Wageningen
  Netherlands
- **Dr Ken Vance-Borland**
  Oregon State University
  USA
- **Dr Rebecca Vega Thurber**
  Florida International University
  USA
- **Professor Peter Vize**
  University of Calgary
  Canada
- **Dr Tonny Wagey**
  CTI Secretariat
  Indonesia
- **Dr Marian Wong**
  McMaster University
  Canada



Amphriprion percula
Photo by Simon Foale

“ I believe that the ARC Centre of Excellence has become the Mecca of coral reef research. ”

Professor Yossi Loya
Tel Aviv University
Addressing >2500 participants at the 11th International Coral Reef Symposium, Florida, July 2008

MEDIA COVERAGE

Mandarin Fish Synchiropus splendidus
Photo by Simon Foale

The ARC Centre of Excellence seeks to deliver news of its research outcomes through the media, where the vast majority of the general public learn about science and technology. In consultation with our media adviser, Julian Cribb we have developed a robust media strategy to convert sometimes esoteric science into everyday language and deliver our research findings to a diverse Australian and international audience. In 2008, we continued with this strategy and distributed 36 media releases generating 1391 media stories in newspapers, magazines online, on radio and television.

Considerable media coverage was generated in July by the Centre's presentations at the International Coral Reef Symposium in Florida, USA. Keynote addresses by Malcolm McCulloch and Terry Hughes as well as presentations by Ove Hoegh-Guldberg and Andrew Baird generated more than 100 media stories during the week long conference, principally across the United States and Australia.

The Centre's media policy also allows us to give the Centre's graduate students opportunities to promote their research and gain invaluable experience in the media spotlight. In 2008, 8 media releases included the research of Centre students. One of them, *Bikini corals recover from atomic shock*, based on research by Centre student Zoe Richards, attracted huge international media attention. Over 275 media stories were reported in more than 14 countries including coverage in outlets as diverse as The Guardian, Los Angeles Times, New York Times, Fox News, BBC world service, National Geographic, New Scientist, The Seoul Times, the Malaysian Sun, ABC (Australia) radio and television and numerous regional newspapers.

The 1391 media stories that feature the ARC Centre in 2008 included 641 on the web, 71 television reports, 268 on radio, 334 in newspapers, and 77 magazine articles (see the article in *Outcomes: Results of research in the real world*, p.44).

Media releases are promoted through the Centre website which has greatly enhanced the ARC Centre's international visibility. The website caters for multiple audiences, providing information, access to resources, research services, and downloads of research and teaching tools. In 2008 the site attracted 4.13 million web hits, more than double the number in 2007. It is the most visible of >14,100,000 websites found in a Google search for "ARC Centre", ranking 1st. Ninety-six percent of the Centre's web hits are from outside Australia.

In 2008, we expanded the Centre's web site to include a *Research Tools* page, designed to pursue our goal of making the "products" of the Centre's research available to users worldwide. As part of the International Year of the Reef (IYOR) the Centre produced a web seminar series which provided over 20 video presentations focussing on the latest science that supports the sustainable management of the world's coral reefs. These webinars are enormously popular attracting over 20,000 viewers in the first six months. In addition, the Centre's website provides extensive information in support of the Coral Triangle Initiative (p.48). During 2009 the website will be further developed to promote the Centre's students, to enhance access to the research services we provide, and to improve navigability to >600 research publications produced by the Centre since 2005.

Highlights of the Centre's 1391 media hits in 2008 include:

TV Denmark, *Interview with ROJ* (Havin Guneser), 8/1/08, O. Hoegh-Guldberg

The Science Show, Radio National, *Coral Reef Futures*, 12/1/08, G. Almany, D. Bellwood, S. Connolly, J. Lough, G. Russ

Reuters Hong Kong, *Starfish destroy reefs in Asia*, 16/1/08, A. Baird

Australian R&D Review, *Fish Talk*, 21/2/08, D. Bellwood

AAP wire service, *Corals might get too hot to trot*, 9/7/08, A. Baird

The New York Times, *Coral Flourishing at Bikini Atoll Atomic Test Site*, 15/4/08, Z. Richards

Time Magazine, *Coral Reefs face Extinction*, 11/7/08, Z. Richards

US News and World Report, *Nemo sniffs his way home*, 29/8/08, D. Dixson, G. Jones, P. Munday

Voice of America, *Search for answers to coral reef decline*, 25/3/08, A Baird

Sydney Morning Herald, *Corals might migrate south: scientists*, 1/1/08, J Pandolfi

ABC Radio AM and FM Weekend News, *Corals Not Doomed – 'If We Do the Right Thing'*, 13/7/08, T.Hughes

Informationsdienst Wissenschaft, Germany, *New Governance thinking efficient cure for global coral crisis*, 8/7/08, T. Hughes

IPS News wire service, *Cutting CO_2 could save dying reefs*, 12/7/08, T Hughes

Australasian Science, *Gobies Beat the Queue Jumpers*, 30/4/08, M. Wong, G Jones, P. Munday

India News, *Symbiotic relationship between corals and algae faces threat from climate change*, 25/3/08, D. Yellowlees, B. Leggat

New Scientist, *Reef fish rebound in No-Take zones*, 25/6/08, G. Russ

Innovations Report, *Butterfly fish 'may face extinction'*, 25/2/08, M. Pratchett

The Age, *Starving fish killing Great Barrier Reef*, 23/6/08, M. Pratchett

Seoul Times, *Coral Decline hits rich and poor*, 15/7/08, O. Hoegh-Guldberg

ABC Bush Telegraph Radio, *Reef impact from agriculture and in particular cane growers*, 24/9/08, M. McCulloch

BBC TV News, *Fish key to reef climate survival*, 25/3/08, T. Hughes

Business Acumen Queensland journal, *Supercomputing reefs, weather, mummies*, 1/10/08, S. Connolly

Cambodian Times, *Pioneer fish could save coral reefs*, 1/10/08, L. Bay

Cyber Diver News Network, *Climate change, fishing killing Fiji's coral reefs*, 24/11/08, N. Graham, S. Wilson, M. Pratchett

Cosmos magazine (and online), *Secrets of sex-changing fish in their ears*, 2/12/08, M. McCormick, S Walker

RIA Novosti, Russia, *Chemical war of seaweeds against coral*, 2/9/08, B. Willis

The Tech Herald, Australia, *World's coral reefs face serious risk of degradation*, 22/7/08, J. Cinner

Channel 10 TV News, *Coral Confusion*, 9/7/08, A. Baird

Los Angeles Times, *Reef building corals most vulnerable to extinction*, 10/7/08, Z. Richards

Oman Daily Observer, *Corals mate with other species to survive*, 23/10/08, D. Miller

Queensland Country Hour ABC Radio, *Tougher steps needed to save sharks*, 29/4/08, S. Connolly, H. Choat, W. Robbins, M. Hisano

ABC Radio, ABC Bush Radio, ABC Science Online; ABC Catalyst, *Hopping marine hotspots linked to geology*, 1/8/08, J. Pandolfi, W. Renema, D. Bellwood

Nippon Housou Kaisha, Japan TV, Interview, part of a 1 hr special on coral reefs *"A journey of coral in the world"*, 13/2/08, D. Bellwood

Malaysian Sun, *Sanctuaries unable to protect Indian Ocean coral reefs*, 27/8/08, N. Graham, S. Wilson

Cairns Post, *Reef tour market in spotlight*, 12/8/08, D. Biggs

Townsville Bulletin, *Green zone win, Spectacular recovery in coral trout numbers*, 26/6/08, G. Russ

Video, Marian Koshland Science Museum of the National Academy of Sciences, Washington, DC, *Canary in the coal mine*, O. Hoegh-Guldberg

The following four pages are reproduced with thanks to Palamedia "Outcomes: Results of research in the real world". A talk based on this article was presented in Federal Parliament House by Terry Hughes in June 2008, as part of the ARC's Graeme Clarke Research Outcomes Forum.

PRESERVING THE WORLD'S CORAL REEFS

LED BY PROFESSOR TERENCE HUGHES, RESEARCHERS AT THE ARC CENTRE OF EXCELLENCE FOR CORAL REEF STUDIES ARE PROTECTING JOBS, THE ECONOMY AND THE ENVIRONMENT WITH THEIR KEY FINDINGS ABOUT CORAL REEF MANAGEMENT

Coral reefs are not only important for the environmental role they play, but for their social and economic value. Globally, the welfare of more than 200 million people is intricately linked to the goods and services provided by coral reefs. In Australia, tourism and fisheries on the Great Barrier Reef alone contribute A$6 billion annually to the nation's economy and provide employment for 60,000 people.

The ARC Centre of Excellence for Coral Reef Studies (CoECRS), led by director Professor Terence Hughes, is providing the scientific knowledge necessary to preserve the world's coral reefs. As a result, Australia has become an international leader is this field and is playing a key role in protecting reefs on a global scale.

IN A NUTSHELL

* RESEARCH AREA: Coral reef management, reef fisheries management and systematic conservation planning
* PRIMARY AUTHORS: Professor Terence Hughes, Director, and Professors Garry Russ and Robert Pressey, ARC Centre of Excellence for Coral Reef Studies, James Cook University
* KEY OUTCOME AREAS: Economic; Environmental; Policy and administration

THE PROBLEM OF 'PHASE-SHIFTS'

Reefs have long been under threat by fishing and pollution, but one of the biggest threats now is global warming. When water temperatures rise, coral bleaching occurs (a stress reaction that causes the coral to expel the algae that lives within its tissues) and the coral is overtaken by seaweed. "Once corals are replaced by weed – a process known as a 'phase-shift' – it is extraordinarily difficult, if not impossible, to bring them back again," says Hughes.

During a major heating event in the late 1990s, one-sixth of the world's corals were affected by coral bleaching, pointing to the potential scale of the impact of climate change on the natural environment. According to Hughes, it's only a matter of time before the next major bleaching event occurs. "For reefs to be able to withstand such events, they need to be resilient," he says. "A key focus of our work has been to determine ways of achieving this."

FISH ARE VITAL

Hughes and his team conducted an experiment in the Great Barrier Reef and discovered that healthy fish populations are vital to successfully managing coral reef resilience.

"We followed the recovery of corals that had been severely damaged by bleaching," he explains. "The corals were on a reef where fish populations were very abundant. 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."

Above: A Clown Anemonefish; healthy fish populations are vital to coral reef resilience.
Below: Coral reefs are threatened by global warming.

The team discovered the larger herbivorous fish – such as parrot fish and surgeon fish – were particularly important. "Our experiment showed 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," says Hughes. "This research indicates it is important to avoid overfishing of these herbivores at all costs."

BUILDING RESILIENCE

The team's findings have prompted reef management agencies around the world to build the resilience of reefs through initiatives such as 'no-take' zoning – the permanent closure of a designated marine area to all forms of extractive activity, including fishing – and policies for reducing water pollution.

It has also had an impact on policy and legislation worldwide. For example, in the US, Hughes was asked by Congressional advisors to provide a definition of 'coral reef resilience'. This has been incorporated into the *Coral Reef Conservation Amendments Act*, which was passed by Congress on 22 October 2007.

REZONING THE GREAT BARRIER REEF

One of the most significant outcomes has been the rezoning of the Great Barrier Reef. In late 2002, Hughes convened an international working group of researchers and reef managers in Townsville, Queensland, to discuss ways to minimise the impact of climate change on coral reefs. In particular, participants provided scientific input into the public debate surrounding proposed legislative changes to the management of the Great Barrier Reef.

The group produced a major synthesis paper to develop the concept of ecological resilience, which was published as a cover article in *Science* in mid-2003. A press conference to release these findings was broadcast to more than four million viewers around Australia. The recommendations were further highlighted in a public meeting broadcast nationally by ABC Radio National.

"The dissemination of our results to managers and the media contributed to the emergence of a consensus that at least 30 per cent of the Great Barrier Reef should be designated as no-take," says Hughes, who has since also contributed to the rezoning of Ningaloo reef in Western Australia.

The CoECRS team's findings have prompted reef management agencies around the world to build reef resilience through initiatives such as 'no-take' zoning.

REEF FISHERIES MANAGEMENT

No-take zones have also been important for reef fisheries management, another key focus of the CoECRS. Professor Garry Russ and his team have shown no-take reserves are critical for replenishing fish stocks, which in turn protects industry and the economy.

History has shown if we don't manage marine resources, we inevitably over-exploit them

"History has shown if we don't manage marine resources, we inevitably over-exploit them," says Russ. "But if you have a network of reserves where you can't go fishing, the fish build up in abundance in those areas, they spawn more effectively and tend to produce more larvae, and they export a lot of those new extra larvae out into the fished areas. So it's important for the conservation of the reef, but it's also important for the fisheries on the reef."

NEW TAGGING TECHNOLOGY

Russ's colleague Professor Geoff Jones has developed a revolutionary new tagging technology for tracking larvae, which is helping to design more effective networks of no-take reserves. The tag – a chemical stain made from stable isotopes of barium – is injected into the female fish, passing through to the egg and then to the new babies.

"For the first time, this allows marine ecologists to track larvae from where they were spawned to where they end up," says Russ. "If you know how far the larvae go, you can then work out the best size, placement and spacing of the reserves, and you can start to design proper networks so that the reserves are doing the job you want them to do."

SYSTEMATIC CONSERVATION PLANNING

The CoECRS also conducts research into the relatively new field of systematic conservation planning, and has produced a number of outcomes in this area. "Systematic conservation planning is a process of resolving conflicts between the conservation and use of natural resources," says Professor Robert Pressey.

In 1996, Pressey and his team developed a software tool called C-Plan, which allows practitioners to explore

different options for achieving conservation objectives. "The software shows them, on a map, the 'irreplaceability' of each area being considered," Pressey explains. "This is a measure of its relative importance for achieving objectives, or the number of other areas that could replace it. Effectively, this shows them where they have room to manoeuvre and where they don't. The system also allows them to develop alternative conservation and development scenarios, and to assess the trade-offs between them."

WORLDWIDE INFLUENCE

C-Plan has been used by hundreds of people around the world for conservation planning in terrestrial, marine and freshwater environments. In Australia alone, it has led to the establishment of around one million hectares of new reserves in eastern New South Wales.

Pressey is also leading the development of a guide to conservation planning, which will be published by the International Union for Conservation of Nature (IUCN). "The motivation for the guide was to cut through the confusion produced by the many alternative approaches to conservation planning being developed and promoted," he says. "It will be distributed to hundreds of IUCN members around the world and therefore influence their thinking about conservation planning, lead to follow-up case studies and workshops, and generally lift the effectiveness of planning worldwide."

The replenishing of fish stocks protects industry and the economy as well as the reef.

HELPING VILLAGERS IN THE PHILIPPINES

Professor Garry Russ's research into reef fisheries management has not only contributed to the establishment of no-take reserves in Australia, but also in small fishing villages in the southern Philippines. Since the early 1970s, he has collaborated with a local scientist, Dr Angel C. Alcala, to give the villagers some control over the way their marine resources are managed.

"Fisheries management used to be centralised in the big cities, so fishing companies would come to these villages, take all their fish and leave," says Russ. "Our work helped to set up no-take reserves and eventually led to legislation which gave villagers the power to co-manage their marine resources up to 15 kilometres from the shore."

Protecting the local coral reefs has also helped attract tourism, which is now bringing income into the villages. In a country where such a huge percentage of people live below the poverty line, this is of great economic benefit – an outcome of which Russ is very proud. "It's not often as a biologist that you get a chance to change the laws of a country for the benefit of local fishing communities and for the benefit of people who are disadvantaged," he says.

For further reading

Bellwood, D.R., T.P. Hughes, C. Folke, and M. Nyström. 2004. Confronting the coral reef crisis. Nature 429: 827-833.

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For a full list of published work, visit www.coralcoe.org.au

NATIONAL BENEFIT CASE-STUDY

CASE STUDY 1

SUPPORTING THE CORAL TRIANGLE INITIATIVE ON CORAL REEFS, FISHERIES AND FOOD SECURITY

The 5.7 million km^2 of the Coral Triangle is home to the highest diversity of marine life on earth. This region stretches across six countries (the CT6): Indonesia, the Philippines, Malaysia, Papua New Guinea, the Solomon Islands and Timor Leste. This extraordinary marine biological resource directly sustains the lives of over 200 million people and benefits millions more world-wide. Unfortunately, the marine-based natural resources of the CT and the economic and social benefits they generate are at risk, threatened by a range of factors that combined are causing a situation of crisis that only a transformational approach to marine resource management can resolve. The ARC Centre of Excellence for Coral Reef Studies undertakes research throughout the Coral Triangle region, leading to 80 publications over the past 5 years. The ARC Centre is also a major provider of graduate training for the region and globally, with students enrolled from 37 countries in 2008.

In August 2007, President Susilo Bambang Yudhoyono of Indonesia wrote to other country leaders proposing a new Coral Triangle Initiative (CTI) on Coral Reefs, Fisheries and Food Security. Responding positively, the six governments met in Bali in December 2007 agreeing to a framework for a "CTI Plan of Action" that has been developed during 2008 and adopted at the highest political levels. The CTI has a current global commitment projected to be at least $U.S. 500 million. Its Plan of Action includes 4 objectives, which align with several of the ARC Centre's research programs:

- Developing an ecosystem approach to fisheries management across the Coral Triangle
- Building a network of Marine Protected Areas across the region
- Developing Measures to help adaptation to climate change
- Protecting threatened marine species.

The Australian Government's Department of the Environment, Water, Heritage and the Arts (DEWHA), approached the ARC Centre and our colleagues at the Australian Institute of Marine Science to help plan and deliver a workshop in November 2008 for delegates from the CT6, with a focus on management and conservation of coral reefs. The workshop was attended by over 100 people, from the CT6, conservation NGOs (WWF, The Nature Conservancy, and Conservation International), research institutions, and by representatives from the Australian government, led by the Hon. Peter Garrett, Minister for the Environment (DEWHA).

BRIEFING PAPERS FOR THE CORAL TRIANGLE INITIATIVE

The ARC Centre of Excellence for Coral Reef Studies and the Australian Institute of Marine Science drafted 18 briefing papers in preparation for the Townsville workshop, many of which are co-authored by our colleagues from the CT6 countries. They are designed to stimulate and assist discussion between Coral Triangle countries, research providers, NGOs and other partners. Further participation through co-authorship, input and comment continues to be welcome, as these briefing papers are developed further. The ARC Centre received financial assistance from WWF and The Queensland Department of Tourism, Regional Development and Industry to help prepare these resources. The themes of the briefing papers are:

- The Coral Triangle: a regional ecosystem-based management approach
- Existing and potential non-spatial management options in the Coral Triangle
- Existing spatial management within the Coral Triangle
- Ecological resilience and "shifting baselines"
- Data sufficiency and dealing with uncertainty
- How human uses and values can matter for the Coral Triangle Initiative
- Participatory marine resource management planning
- Climate change threats to coral reefs in the Coral Triangle
- Threat of climate change to fish and fisheries
- Capacity building for marine resource management, including MPAs
- Objectives and multiple-use zoning for a network of MPAs for the Coral Triangle
- Connectivity and the design of MPA networks in the Coral Triangle
- Incorporating information about marine species of conservation concern and their habitats into a network of MPAs for the Coral Triangle region
- Designing a network of MPAs for the Coral Triangle
- Long-term biophysical monitoring of a network of MPAs in the Coral Triangle
- Human adaptation to climate change
- "At least do no harm": Coral Triangle Initiative contributing to livelihoods and poverty reduction
- Outbreaks of Crown-of-Thorns Seastars add to coral depletion in the Coral Triangle

The briefing papers are available for download from the ARC Centre's website at *www.coralcoe.org.au/events/ctiworkshop/ctimain.html*

Selected 2008 publications

Foale, S (2008). A preliminary exploration of relationships among fishery management, food security, and the Millennium Development Goals in Melanesia. *SPC Traditional Marine Resource Management and Knowledge Information Bulletin* 24: 3-8.

Foale, SJ (2008). Conserving Melanesia's coral reef heritage in the face of climate change. *Historic Environment* 21(1): 30-36.

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NATIONAL BENEFIT CASE-STUDY

CASE STUDY 2
GENOMICS: A WINDOW ON HOW CORALS FUNCTION

Scientists within the ARC Centre are recognised throughout the world as the pioneers of genomic approaches to coral biology. Their research, a component of Program 4, addresses genetic, molecular and physiological processes of corals and is increasingly focussed on the cause and implications of environmental stress. Following the Centre's ground-breaking initiatives, genomics and related technologies will, in the future, form the basis of "high-tech" approaches to planning and monitoring of marine protected areas in coral reefs.

David Miller initiated this approach and the large group he leads has, over the past 5 or 6 years, gained a unique insight into the genetic makeup of the coral *Acropora millepora*. The 18,000 genes so far identified represent a significant global resource to studying how corals function at a molecular level and how they respond to stress. David and his collaborators at the Centre for Molecular Genetics of Development at ANU have used these genes to construct a DNA microarray which is now being used by researchers in the ARC Centre and AIMS (David Miller, Madeleine van Oppen, Smart State Fellow Line Bay and others) to study thermal stress and a range of other important scientific questions in coral biology.

David Miller's group has pioneered the development and application of these genomic resources for examining the evolution of corals. Counter-intuitively, they discovered that these simple animals have more genes in common with man and other vertebrates than have the more complex and commonly-studied higher invertebrates. This approach has provided a novel perspective on metazoan evolution and has attracted considerable attention, as evidenced by radio, TV and global newspaper/magazine reports.

During 2008, the search for coral genes has entered a new phase, with the application of 'next generation' DNA sequencing methods by Miller and his team. These new technologies have delivered a mass of data that contains every gene present in the coral genome – the coral transcriptome. The Centre's primary goal now is to assemble these data into a complete, world-first database of *Acropora* genes.

Complementing the work on corals has been the preliminary analysis of 6000 genes of the coral's dinoflagellate symbiont, *Symbiodinium*, by Bill Leggat, David Yellowlees and Ove Hoegh-Guldberg. These unique photosynthetic organisms are related to *Plasmodium*, the malaria parasite, with which they share many genetic similarities. The pioneering publication describing this work provides the first analysis of the symbiotic dinoflagellate genome, and the first transcriptome from the unicellular component of a eukaryote-eukaryote symbiosis.

The combination of both coral and dinoflagellate genomic resources represents a major international resource not only for studying the biology of this iconic symbiosis, but will also inform conservation measures for the Great Barrier Reef and elsewhere. Central among these are the responses of corals to an increase in oceanic temperature, CO_2 concentrations and the consequent acidification of oceans. Studying experimental and longer-term changes in the expression of genes and associated physiology in response to these environmental challenges will inform reef managers as to whether all corals will respond equally and whether a change in dinoflagellate symbionts can improve the resilience of coral reefs.

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Coral reef Lizard Island
Photo by Terry Hughes

MEDIA RELEASE

Corals: more complex than you?

The humble coral may possess as many genes – and possibly even more – than humans do. And remarkably, although it is very distant from humans in evolutionary terms, it has many of the immune system genes that protect people against disease. In fact, it is possible some of these were pioneered by corals.

Corals are among the simplest animals in the world – yet they may possess a set of genes as large and complex as our own, says David Miller of the ARC Centre of Excellence for Coral Reef Studies.

"Four years ago researchers in this field were predicting that coral would be found to have about 10,000 genes – but we've found almost that many already and clearly have a long way to go. Based on the rate of gene discovery, we estimate that corals have as many as 25,000 genes, compared with the human complement of 20-23,000."

Why a simple creature should have such a huge genetic repertoire is a mystery, but scientists are excited by it because corals are near the root of the family tree of all living animals and can throw new light on the origin of such complex features as the nervous and immune systems of vertebrates.

Around 10 or 12 per cent of the known coral genes are in fact shared uniquely with vertebrates – these are genes that have been lost from all other animals so far examined. These include genes for the development of nerves, vision, DNA imprinting, stress responses and key immune system genes.

"We actually have quite a lot in common with corals, though it might not appear so," Miller says. "For example, we have been amazed at how many of the genes involved in innate immunity in humans are present in coral – and just how similar they are."

"The coral immune system is a black box at present. How corals cope with the worldwide upsurge in diseases, and the extent to which they are affected by other stresses caused by human activity are important questions. The similarity of the coral and human innate immune repertoires implies that they may function in similar ways, so the hope is that we can apply what we know about human health to better understand coral disease.

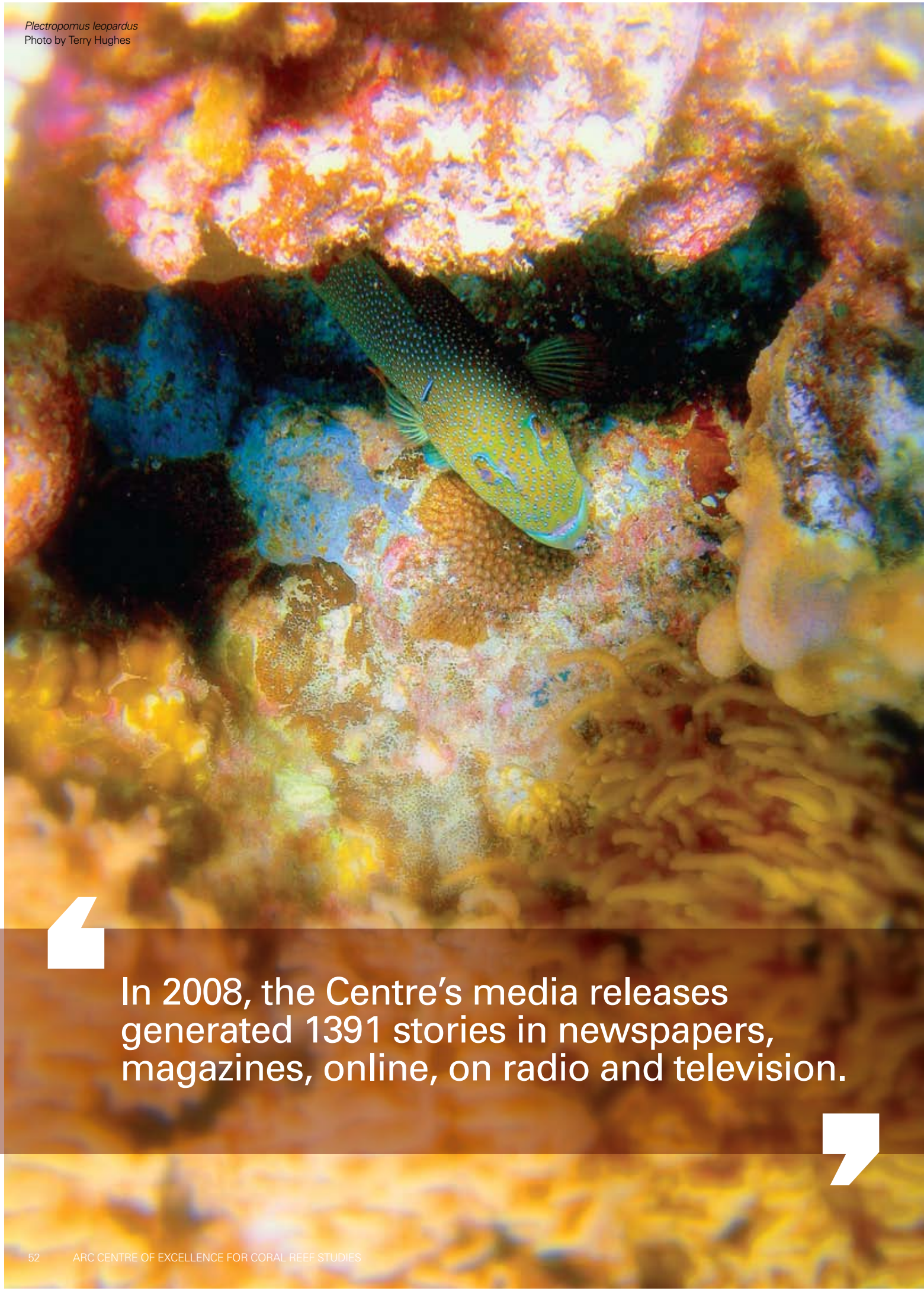
There may also be a direct payback, in the sense that, by exploring the ancestral immune genetic repertoire of corals and how it functions in a simple animal, we will gain new insights which will help in the battle against human disease, he adds.

The richness of the coral genome – unexpectedly loaded with genes, many of which were thought to have evolved much later– is also casting new light on evolution.

It appears that all animals lose genes during evolution; those with fast generation turnover times shed genes particularly fast. Corals which take at least 5 years to reach sexual maturity, and which have long and overlapping generation times, may thus be a living 'museum' of ancestral animal genes.

However corals use all those genes to produce only 12-14 types of body cells. Humans, on the other hand, have developed thousands of different cell types. A possible explanation for this, Miller believes, is that coral genes may interact with each other in far less complex ways. Humans, on the other hand, are the product of a continuous and complicated dialogue between thousands of genes.

"Sequencing a coral genome is a real contribution which Australia can make to human knowledge – with potential benefit to society, the environment and the economy."



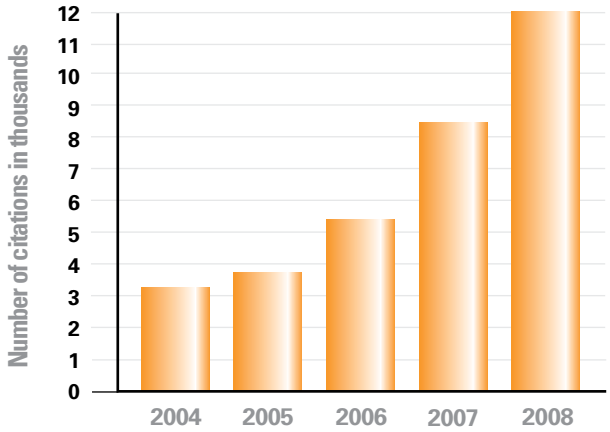
Plectropomus leopardus
Photo by Terry Hughes

> In 2008, the Centre's media releases generated 1391 stories in newspapers, magazines, online, on radio and television.

PUBLICATIONS

The ARC Centre of Excellence for Coral Reef Studies produced 186 publications in 2008, almost double the Centre's initial 2005 output. According to *ISI Web of Science*, the ARC Centre of Excellence for Coral Reef Studies is the first-ranked institution globally for the number of journal publications and citations in coral reef science. Forty-two 2008 articles were published in journals with Impact Factors greater than four, including eighteen papers in *Science*, *Nature*, *PNAS* and *Current Biology*. The average Impact Factor for all 160 journal articles in 2008 was 4.9.

↓ *Summed citations to members of the ARC Centre of Excellence each year for 2004-2008.*



Citations of the Centre members' publications grew rapidly in 2008, increasing by 47% in the past year, to 12,202. Twenty researchers were cited >200 times each in 2008, and nine of these had >500 citations in the 12-month reporting period. Three Program Leaders in the Centre (McCulloch, Hughes and Pressey) are recognized by ISI as **Highly Cited Researchers**, in the top half of one percent for citations in their field.

League table achievements in publications for 2008 include:

ISI Essential Science Indicators identified six **Research Fronts** in 2008 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. Eighteen core papers in these Research Fronts were authored by K. Anthony, A. Baird, D. Bellwood, S. Connolly, M. Dornelas, O. Hoegh-Guldberg, G. Jones, T. Hughes, N. Graham, J. Pandolfi, M. Pratchett, B. Pressey, B. Willis, and S. Wilson, and by Partner Investigators C. Folke, J. Lough, M. Van Oppen and R. Steneck.

The Faculty of 1000 Biology highlighted 5 of the ARC Centre's 2008 publications for review in 2008:

Ainsworth, TD, Fine, M, Roff, G and Hoegh-Guldberg, O (2008). Bacteria are not the primary cause of bleaching in the Mediterranean coral *Oculina patagonica*. *ISME Journal* 2(1): 67-73.

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BOOKS AND BOOK CHAPTERS

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Photo courtesy Lisa Hogben

Morgan Pratchett (right), Australian Research Fellow in the Centre, is presented with the 2008 American-Australian Association Fellowship by the Australian Prime Minister Kevin Rudd (left) and Rupert Murdoch AC, Chairman of News Corporation (centre).

RECOGNITION OF EXCELLENCE BY CENTRE MEMBERS

Many members of the *ARC Centre of Excellence for Coral Reef Studies* were awarded prizes and peer-recognition during 2008. Examples include:

The Centre's Director, Terry Hughes, was presented with the quadrennial Darwin Medal by the *International Coral Reef Society* in July for his outstanding contribution to marine and coral science and to the growing appreciation of the importance of the resilience of natural systems, a scientific view in which he is a leading player. In April, he was presented with a *Thomson Scientific Citation Awards* which recognizes the most pre-eminent researchers working in Australia, and their influence on international research. He also was awarded the prestigious Storer Lectureship at the University of California, Davis, USA in November 2008.

Both of the Centre's deputy directors were awarded prestigious Premier's fellowships in 2008. Ove Hoegh-Guldberg received the Queensland Premier's Smart State Fellowship, the State's top science prize. The Western Australian Premier's Research Fellowship for 2008 was awarded to Malcolm McCulloch, to boost Western Australia's research effort in climate change and biodiversity. Malcolm McCulloch's outstanding contributions to geology and geochemistry were also recognised this year by his appointment as a Fellow to both The Australian Geological Society and the Geochemical Society.

Professor Bob Pressey, a Professorial Fellow in the Centre and leader of Research Program 6, was awarded the inaugural *Australian Ecology Research Award* of the Ecological Society of Australia. This award recognizes excellence in ecological research, which Bob presented in an invited lecture at the Society's annual symposium.

Early career researchers Line Bay and Tracy Ainsworth also received awards this year. Line won the inaugural *Isobel Bennett Marine Biology Fellowship* at Lizard Island Research Station. Tracy received two early career researcher awards: one from the Australian Research Council and Australian Academy of Science and one from the Network for Genes and Environment in Development.

Australian Research Fellow Morgan Pratchett was awarded the American Australian Association Fellowship for trans-Pacific scientific collaborations and an Australian Academy of Science award for a scientific visit to the USA, which he will undertake in March and April 2009.

The Centre's graduate students also attracted national and international recognition:

- Rebecca Lawton and Emily Howells both won Queensland Government Smart State PhD scholarships, which are awarded to outstanding Australian Postgraduate Award Scholarship holders to undertake innovative research in Queensland.
- Joe Pollock is one of thirteen Americans to be granted a Fulbright Postgraduate Scholarship to study at JCU in Australia in 2008.
- The Danielle Simmons Prize from the Australian Coral Reef Society was awarded to Alicia Crawley, who also won a GBRMPA Science for Management award.
- All five of the 2008 AIMS@JCU PhD scholarships were awarded to students that are supervised by the Centre's Chief and Partner Investigators.
- Maxi Eckes was awarded an *Australia and Pacific Science Foundation Grant* to research the role of natural sunscreens for the control of ultraviolet radiation damage in reef fish. Maxi also received a grant from the *Sea World Research and Rescue Foundation* and the G&J Beirne Doctoral Scholarship.
- Five students were awarded International Coral Reef Society travel grants to attend the ICRS conference in Florida in July 2008.
- Jez Roff was awarded the *Mia J. Tegner Memorial Research Grant* in Marine Environmental History and Historical Marine Ecology for his research project on shifting baselines on the inshore Great Barrier Reef. Jez also won a *GBRMPA Science for Management Award*.
- Christopher Bartlett's work in the Nguna-Pele Marine Protected Area of Vanuatu won him the *2008 Equator Prize*, awarded by the United Nations Development Program to recognize and celebrate outstanding community efforts to reduce poverty through the conservation of biodiversity.

PERFORMANCE MEASURES

Research findings

Measure	Outcome 2007	Target 2008	Outcome 2008
Number of publications	149	140	186
Publications in journals with an impact factor > 4	29	36	42
Number of citations	8313	6000	12202
Invitations to provide plenary addresses at international conferences	29	30	28
Invitations to provide review articles	26	35	32
Number and nature of commentaries about the Centre's achievements	892	800	1391
Awards, Prizes or Recognition	18	16	26

Research training and professional education

Measure	Outcome 2007	Target 2008	Outcome 2008
Number of postgraduates enrolled	129	120 over 5 years	151
Number of postgraduate completions	22	70 over 5 years	25
Number of Honours students	23	60 over 5 years	16
Number of professional workshops	23	12	18
Participation in professional workshops	24	20	28
Number and level of graduate student courses and workshops in the priority area(s)	12	10	15

International, national and regional links and networks

Measure	Outcome 2007	Target 2008	Outcome 2008
Number of international visitors	72	60	75
Number of national and international Working Groups	18 Centre investigators participated in 17 working groups.	14	29 researchers participated in 16 working groups.

Number of visits to overseas laboratories and research facilities	53	50	54
Invitations to membership of national and international boards and advisory committees	56	40	50
Number of cross-institutional publications	101	90	115
Number of multi-institutional supervisory arrangements of graduate students	46	45	57
Number & nature of contractual arrangements ▪ increase the level of internationally funded students ▪ increase level of consultancies and contract research	 28 16	 20 over 5 years 5	 43 22
Number of government, industry and business briefings	36	27	75
Number of Centre trained/ing personnel in knowledge / technology transfer and commercialization	9	5	9
Public awareness programs ▪ Website hits ▪ Public awareness presentations	 1.96 million 31	 1.25 million 12	 4.13 million 25

Organisational support

Measure	Outcome 2007	Target 2008	Outcome 2008
Annual cash contributions from Collaborating Organisations	$1.46m	$1.3m	$1.71m
Annual in-kind contributions from Collaborating Organisations	$2.6m	$3.05m	$5.06m
Number of new Organisations recruited to or involved in the Centre	25	5	9
Level and quality of infrastructure provided to the Centre	$1.02m	$1.02m	$1.07m
Annual cash contributions from other new organisations	$1.1m	$0.22m	$1.9m

PERFORMANCE MEASURES

Governance

Measure	Outcome 2007	Target 2008	Outcome 2008
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 page 7
Frequency and effectiveness of Advisory Board meetings	2 Centre Advisory Board meetings held 4 Scientific Management Committee meetings held	2 Centre Advisory Board meetings p.a. 4 Scientific Management Committee meetings p.a.	See page 7
Quality of the Centre strategic plan	Strategic Plan reviewed and endorsed by the Centre Advisory Board. Ongoing performance against plan reviewed at Scientific Management Committee meetings	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	Meetings of the Scientific Management Committee where each node and program is represented	All nodes and research programs represented at Scientific Management Committee meetings
	Nodal leader discussions are continuous, occurring at least weekly	monthly nodal leader phone or video conferences	Monthly nodal and program leader meetings held
	Each Node leader visited the other nodes at least twice during 2007	Annual rotational visits to the nodes	In 2008, each node leader visited the other nodes at least three times
	In 2007 research planning meetings held for Centre and each research program	Annual research retreats for all Centre participants	In 2008, research planning meetings were held by each research Program
	Cross-nodal attendance at all research planning meetings	Annual research Program planning meetings with cross-nodal attendance	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

National Benefit

Measure	Outcome 2007	Target 2008	Outcome 2008
Measures of expansion of Australia's capability in the priority area(s)	46% increase in Publications over 2004 benchmark	100% increase on 2004 benchmark by 2010	127% increase in publications over 2004 benchmark 313% increase in citations over 2004 benchmark
	36 briefings	30 briefings to government, business and industry groups	75 briefings
	20 Cross-nodal publications	17 cross-institutional co-authored publications	22 Cross-nodal publications
	101 Cross-institutional publications	90 cross-institutional publications	115 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	36 Media Releases See page 42

FINANCIAL STATEMENT

ARC CENTRE OF EXCELLENCE FOR CORAL REEF STUDIES

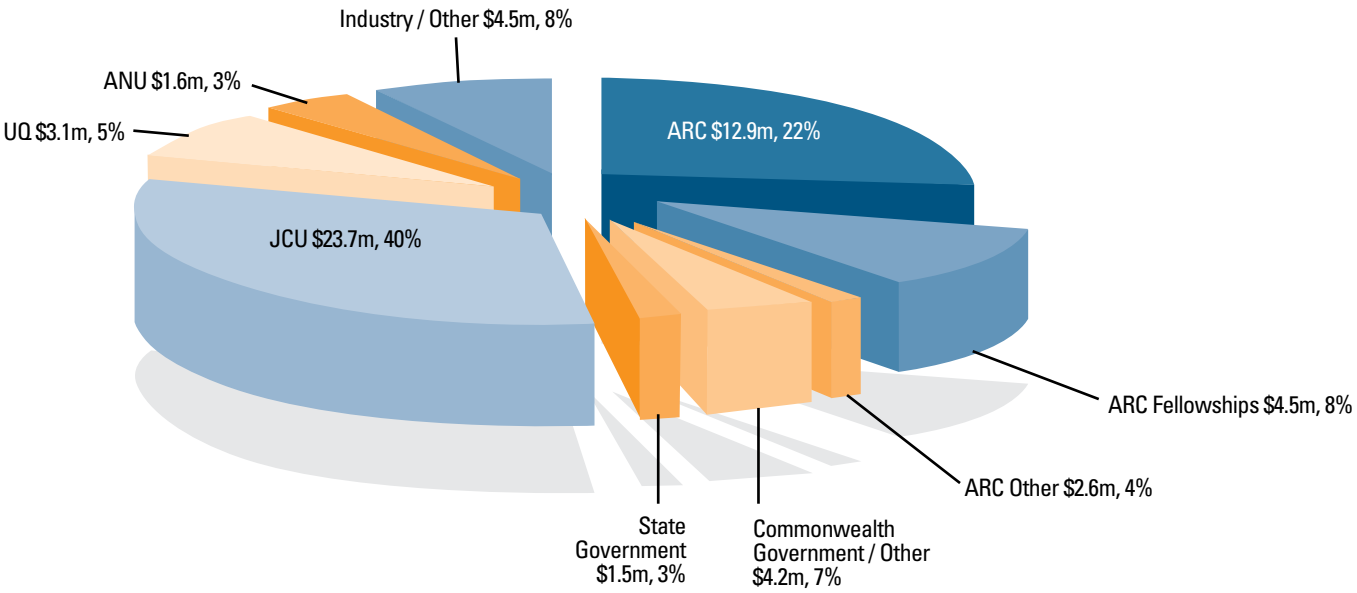
Statement of Operating Income and Expenditure for year ended 31 December 2008

	2007	2008
Income	**$**	**$**
ARC Centre Grant	$2,547,520	$2,598,470
ARC Fellowships	335,000	789,965
ARC Networks Program	30,000	
Host Institutions cash support	1,367,485	1,709,282
Local Government	40,000	
State Government	10,000	117,000
Commonwealth Government other grants	453,000	356,000
International income & other contracts	371,352	297,900
Total Income	**$5,154,357**	**5,868,617**
Expenditure		
Salaries	2,728,548	3,710,607
Equipment	239,633	326,790
Travel	956,282	1,144,558
Research Maintenance & consumables	863,505	1,133,984
Scholarships	167,544	54,111
Public Outreach and Administration	159,655	45,523
Total Expenditure	**$5,115,167**	**$6,415,573**
Surplus (Deficit)	**$39,191**	**$(546,956)**

FINANCIAL STATUS

The operating cash and in-kind operating budget for the Centre of Excellence for 2005-2010 currently totals $58.5m, an 85% increase from 2005 projections. The chart below indicates the budgeted level of income from the various funding sources.

↓ *ARC Centre of Excellence Cash and inkind Funding outlook 2005-2012*



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- The Australian Research Council
- James Cook University
- The Australian National University
- The University of Queensland
- Australian Institute of Marine Science
- Australian Coral Reef Society
- Australian Geographical Society
- Cairns City Council
- Centre for Marine Studies, UQ
- Conservation International
- Douglas Shire Council
- Great Barrier Reef Foundation
- Great Barrier Reef Marine Park Authority
- International Council on Monuments and Sites (ICOMOS)
- Lizard Island Research Station
- Mackay City Council
- Mackay-Whitsunday NRM Group
- Marine and Tropical Sciences Research Facility
- National Geographic
- Packard Foundation
- Project AWARE Foundation
- Queensland Parks & Wildlife Service
- Queensland Department of Tourism, Regional Development and Industry
- Research School for Earth Sciences, ANU
- Resilience Alliance
- School of Arts and Social Sciences JCU
- School of Marine and Tropical Biology, JCU
- School of Pharmacy and Molecular Sciences, JCU
- Stockholm Resilience Centre
- The Australian Academy of Science
- The Beijer Institute for Ecological Economics
- The Ecology Centre, UQ
- The Nature Conservancy
- United Nations University
- University of Delaware
- University of Maine
- University of Perpignan
- Western Australian Department of Environment and Conservation
- Western Indian Ocean Marine Science Association
- Wildlife Conservation Society
- Wildlife Preservation Society of Australia
- World Bank GEF Coral Reef Targeted Research Program
- World Wildlife Fund

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