ARC Centre of Excellence
Coral Reef Studies

2009 ANNUAL REPORT

2009

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ARC CENTRE OF EXCELLENCE FOR CORAL REEF STUDIES

ANNUAL REPORT

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 management and policy.

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 and Community Linkages
Transfer and exchange 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
The ARC Centre, through its networks and activities nationally and internationally, represents 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 ARC 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, the ARC Centre partnership includes the Australian Institute of Marine Science, the Australian National University, the Great Barrier Reef Marine Park Authority, the University of Queensland, and the University of Western Australia which formally joined the Centre in 2009. The Centre has collaborative links to 345 institutions in 52 countries.

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

DIRECTOR'S REPORT

Welcome to our 2009 annual report. A key outcome for the year has been our commitment to organize and host the next International Coral Reef Symposium (ICRS) in Australia. Almost 3000 delegates attended the 11th ICRS in Fort Lauderdale, Florida, in 2008. The ICRS is the world's largest and premier forum for the dissemination and discussion of coral reef science, management and conservation. The ARC Centre made a major contribution to the 11th symposium, presenting 124 talks and posters during the 5-day event. We look forward to co-hosting the 12th ICRS with James Cook University in the tropical city of Cairns in July 2012 (see p.47).

The Centre's publication output continued to grow rapidly this year, doubling since 2006. Our 224 publications in 2009 were co-authored by colleagues from 345 institutions in 52 countries, reflecting our extensive activities around the world. Among this year's publications is a provocative multi-national study on planetary tipping points published in *Nature*, and a *Policy Forum* article in *Science* magazine on missing institutions for coping with trans-boundary issues such as climate change and oceanic fisheries (see p.24). These trans-disciplinary studies will be developed further by research programs 5, 6 and 7 in 2010. A new ISI Web of Science analysis of journal publications and citations identifies our ARC Centre of Excellence as the premier climate change research institution in Australia, with James Cook University ranked 2nd in the world for citation impact (p.54).

The ARC Centre's fieldwork in 2009 was undertaken in 23 tropical countries, with a major ongoing focus in the Coral Triangle region to the north of Australia. The Centre expended over $3 million this past year to support fieldwork in the Philippines, Indonesia, Papua New Guinea and the Solomon Islands. Our website features a new list of links to 134 of the Centre's publications featuring science undertaken within the Coral Triangle (*www.coralcoe.org.au/events/ctiworkshop/pubscticountry10.pdf*). In May, we provided expertise and advice at the World Ocean Conference in Manado, Indonesia, where the six Coral Triangle nations launched an accord for sustainable management of coral reefs across the region. During the year, the Centre provided briefings in Townsville on Coral Triangle research and on our capacity-building activities to the Ambassadors and Consular Generals of Indonesia, Papua New Guinea, the Solomon Islands, Timor-Leste, and the USA.

We've had a very busy year providing advice and services to governments, agencies and Non Government Organisations (NGOs) around the world. In February, Deputy Director Malcolm McCulloch and I joined colleagues from National Academies of Australia and nine other countries to write an Inter-Academy statement on ocean acidification. The statement, timed in advance of the Copenhagen United Nations Framework Convention on Climate Change (UNFCCC) negotiations, summarizes the current state of the science, and is aimed at policy-makers. Deputy-Director Ove Hoegh-Guldberg was involved in Intergovernmental Panel on Climate Change (IPCC) workshops in Venice and Geneva, and provided UNFCCC briefings in Barcelona and Canberra. In September, I delivered a plenary talk in Stockholm, at an international conference of environmental policy-makers, held under the auspices of the Swedish Presidency of the European Union. In Australia, Centre members drafted sections of the national Climate Change Research Plan for marine biodiversity and resources. The Plan provides a framework to guide research funding decisions for developing effective adaptation strategies. In November,

the Centre was a major contributor to a briefing on emission reduction targets, provided to Australian Members of Parliament and Senators, in Parliament House, Canberra. The Centre's research program summaries on pp.16-32 provide many more examples of similar activities in many countries throughout 2009.

Outreach activities during the year included our annual symposium, further website development, and extensive media uptake. This year's 2-day symposium, entitled *Securing Coral Reef Futures – linking ecosystems, societies and economies* was held in Brisbane in August, and was eloquently launched by Her Excellency, Ms Penelope Wensley, the Governor of Queensland. Video recordings of 35 talks, including a public forum, are posted at *www.coralcoe.org.au /events/symposium09/program.html*. In October, members of the Centre met with Israeli marine scientists affiliated with the *Inter-University Institute for Marine Sciences*, at a joint workshop hosted in Eilat by Professor Yossi Loya. Our next coral reef symposium will be held in the Shine Dome in Canberra on 7th-8th October, 2010, in conjunction with the *Australian Academy of Science* and *The Royal Society* – as part of *The Royal Society's* 350th anniversary (see p.49).

Interest in the Centre's website reflects our growing interaction with the broader community, with 4.5 million hits in 2009 compared to 680,000 in 2006. In February, researchers from the Centre contributed scientific information and underwater images to the global launch of a new ocean version of Google Earth – which is designed to enable internet users worldwide to explore more fully the two thirds of the planet covered by water. The Centre's media coverage has continued to grow rapidly during 2009 – well over two thousand stories featuring the Centre's research activities were published or broadcast around the world in the past year (p.44).

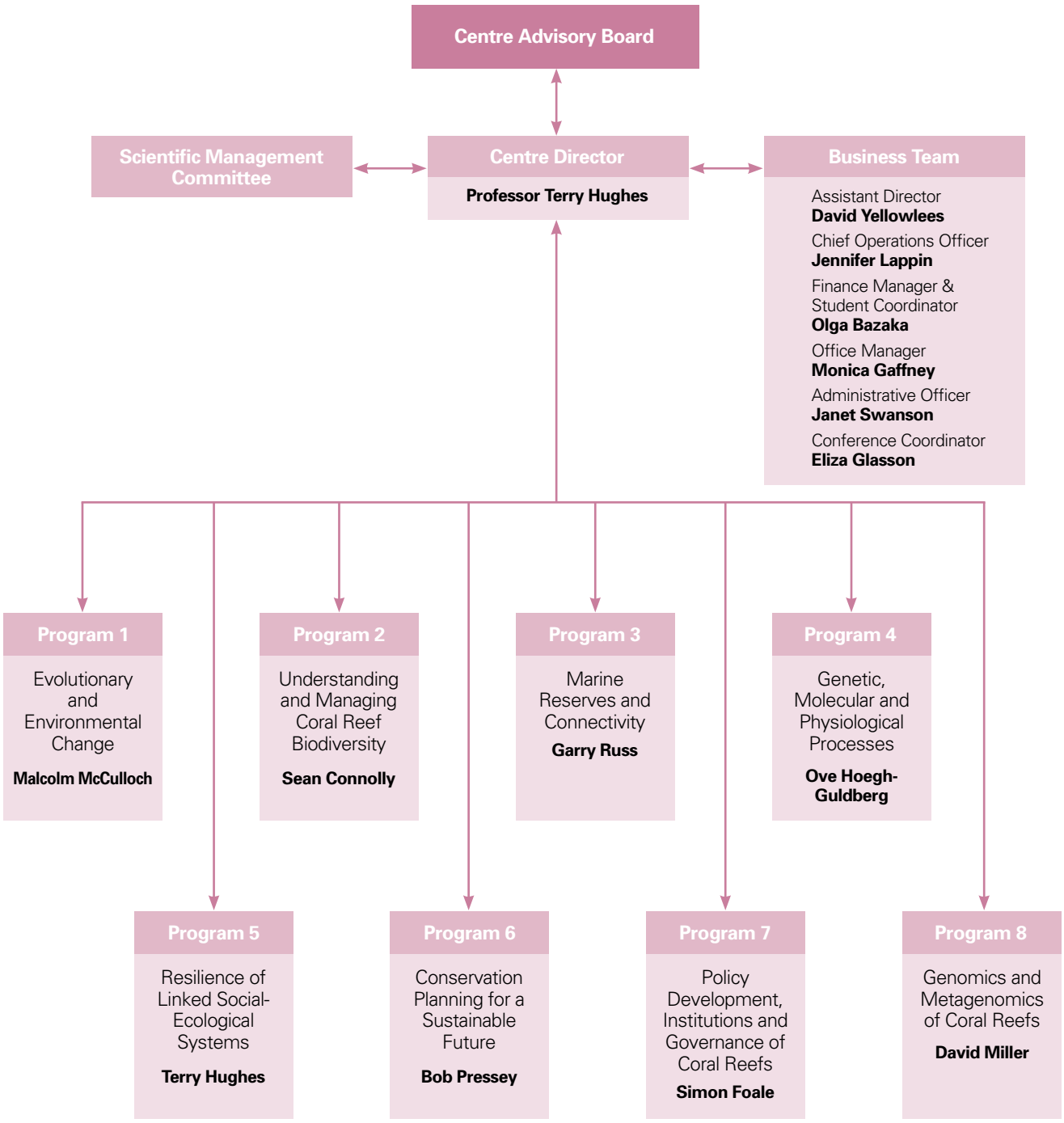
The Centre welcomed a new node in 2009, the University of Western Australia, following Deputy Director Malcolm McCulloch's move there from Canberra to take up a prestigious Western Australian Premier's Fellowship. We've retained our node at the Australian National University, and recruited Chris Fulton as a new Chief Investigator. Membership of the Centre has been further enhanced by the award of five prestigious ARC Fellowships during 2009 – two ARC Australian Postdoctoral Fellowships (Natalie Ban, Nick Graham), two Future Fellowships (Glenn Almany, Andrew Baird) and an ARC Laureate Fellowship (Peter Mumby, see p.33). At the end of 2009, the Centre's membership stands at 21 Chief and Partner Investigators, 36 full-time Research Fellows and 159 graduate students (from 39 countries, see pp.34-43). A further highlight of 2009 has been the launch of the Centre's new Programs 7, *Policy development, institutions and governance of coral reefs,* and 8, *Genomics and metagenomics of coral reefs* (pp.28-32).

The membership of our Centre's Advisory Board will change in early 2010, coinciding with the retirement from the Board of Professors Mandy Thomas, Chris Cocklin and Max Lu (respectively, the Deputy- and Pro-Vice Chancellors for Research at the Australian National University, James Cook University, and University of Queensland). I'd like to thank them all very much for their marvelous support. Sadly, one of our inaugural Board members, the Hon. Virginia Chadwick died in 2009. A great champion for the Great Barrier Reef, Virginia led the Great Barrier Reef Marine Park Authority from 1999-2007. In Virginia's honour we have established the "*The Virginia Chadwick Awards*", in recognition each year of five outstanding publications written by ARC Centre of Excellence graduate students. Please read our tribute to Virginia on p.9.

Lastly, I'd like to express my gratitude to our many other friends around the world for their contributions to a fourth outstanding year, especially my University colleagues, the Centre's Advisory Board, and our partners from the *Australian Institute for Marine Science, The Nature Conservancy, WWF and the Great Barrier Reef Marine Park Authority*. I am especially grateful to the Centre's administrative team – Jenny Lappin, David Yellowlees, Olga Bazaka, Monica Gaffney, Janet Swanson and Eliza Glasson – for their unseen support that underpins the Centre's performance.

Terry Hughes
Director

MANAGEMENT STRUCTURE



GOVERNANCE

The Centre's governance structures involve stakeholders in planning and management processes. The chart opposite illustrates the current governance structure and relationships. Programs 7 and 8 commenced during 2009 and the Centre's governance structures were revised to incorporate these two new research programs.

James Cook University is the administering organisation with the Centre Director, Terry Hughes reporting 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, the University of Queensland and the University of Western Australia which joined the Centre this year. 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 (UWA).

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, government agencies, research institutions and the wider community. From 2010 the focus of the Board will be more global, reflecting the Centre's increasing international engagement. The Centre Director and Chief Operations Officer provide the operational and management link between the Advisory Board and the Centre. The Board met formally in Canberra in April 2009.

In 2009, the ARC Centre of Excellence Review Panel recommended that the Centre vary the representation of its Advisory Board to match the Centre's demonstrably strong global research activities and international linkages. In conjunction with this change to Advisory Board membership, the Review Panel also recommended that the terms of reference for the Board be revised to take account of the Centre's international profile and its focus on sustainable management of coral reefs. In response to this, the terms of reference of the Advisory Board have been updated, and several new members have been recruited for next year. The first meeting of the new board will be in March 2010.

We have been privileged to have access to the expertise and experience of our departing university Board members and would like to thank Professors Chris Cocklin, Max Lu and Mandy Thomas for their advice and contribution to the Centre.

In 2009, the Advisory Board's membership was:

Dennis Trewin (Chair)
former Australian Statistician

Professor Chris Cocklin
Deputy Vice-Chancellor (Research and Innovation)
James Cook University

Professor Max Lu
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

Andrew Skeat
General Manager
Great Barrier Reef Marine Park Authority

Honourable Virginia Chadwick
former Chair
Great Barrier Reef Marine Park Authority

Professor Terry Hughes
ARC Centre Director and Federation Fellow

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 Centre's eight Research Programs, and the Director of the Knowledge Management Group from the Great Barrier Reef Marine Park Authority, 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, developing international collaborations and engagements, recruiting high-

GOVERNANCE

quality postdoctoral fellows, planning professional development programs, undertaking an effective communications strategy and reviewing processes for engaging with the Centre's many end-users around the world. The Committee met 3 times in 2009, in February (videoconference), April (Townsville) and October (Israel).

Priorities for the SMC in 2009 included responding to the ARC review, continuing to expand the Centre's international engagement, particularly in the Coral Triangle region, developing the Centre's outreach program and responding to the Australian Government's new research fellowship initiatives. The trans-disciplinary nature of the Centre's research was further developed during 2009 with the establishment of two new research programs: Program 7: *Policy development, institutions and governance of coral reefs* (see p.28) and Program 8: *Genomics and metagenomics of coral reefs* (see p.30).

Scientific Management Committee Members are:

Professor Yossi Loya (Chair)
Professor of Marine Biology
The Raynor Chair for Environmental Conservation Research
Tel Aviv University
Israel

Dr David Wachenfeld
Director, Knowledge Management Group
Great Barrier Reef Marine Park Authority

Professor Malcolm McCulloch
Leader, Research Program 1
University of Western Australia

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

Dr Simon Foale
Leader, Research Program 7
James Cook University

Professor David Miller
Leader, Research Program 8
James Cook University

HONOURABLE VIRGINIA CHADWICK

1944 – 2009

Sadly, Virginia Chadwick died on 19th September 2009 after a long and determined battle with cancer. She was a supporter of the ARC Centre from its inception, commencing with an enthusiastic letter of support for our initial application in 2004. As Chair of the Great Barrier Reef Marine Park Authority (GBRMPA), she became an Advisory Board member of the ARC Centre on its establishment in mid 2005 and was a major contributor to the strategic direction of the Centre. She remained as a Board member following her retirement and relocation to NSW. Her insight into how the ARC Centre could contribute to management of coral reefs and to policy was invaluable in the Centre's success. Her significant contribution was recognized by James Cook University by the award of an Honorary Doctorate, which she received in a ceremony in Townsville on 28th March 2009. Her counsel and support will be sorely missed within the ARC Centre. In Virginia's honour the Centre of Excellence has established ***"The Virginia Chadwick Awards"***, in recognition each year of five outstanding publications written by ARC Centre of Excellence graduate students.

Virginia Chadwick served the people of Queensland and Australia with distinction through her contribution to conserving the marine environment, as Chair and CEO of the Great Barrier Reef Marine Park Authority (1999 – 2007). Before moving to Townsville, she had a distinguished political career in New South Wales, including a term as the State's Education Minister.

Upon taking up the position, Virginia led The Authority in a visionary plan to enhance the level of protection for the Great Barrier Reef - The Great Barrier Reef Marine Park Representative Areas Program (RAP). This program has been the most comprehensive and innovative marine conservation and biodiversity program ever to occur in world marine conservation. The program will significantly enhance the resilience of the Great Barrier Reef (GBR) in the face of mounting environmental pressures, and will assist industry, particularly tourism and fisheries, to achieve increased levels of environmental sustainability and financial security.

The Great Barrier Reef Marine Park Zoning Plan, the statutory instrument giving effect to the Representative Areas Program, was tabled in Federal Parliament on 3 December 2003, and passed through all legislative stages during early 2004. The Zoning Plan took effect on 1 July 2004.

Under Virginia Chadwick's direction and leadership, officers of the GBRMPA convened panels of independent natural and social scientists. Their aim was to develop planning principles on how to best protect the reef, while minimising impacts for those who depend on the reef for their livelihood. After arranging for peer review of the principles, Virginia directed a major program of bioregional mapping for the GBR, using the best scientific advice, and ground-breaking applied spatial data technology.

In 2002, Virginia Chadwick and her team directed and conducted the most extensive community consultation process ever conducted in Australia. The first phase of community consultation with stakeholders and local communities in Queensland involved hundreds of meetings with thousands of people in coastal Queensland. Over 10,500 submissions were received as a result of phase 1 and a further 20,000 in phase 2. The result was the issue of the Great Barrier Reef Marine Park Zoning Plan, which has minimized, as far as possible, impacts on users of the Marine Park, while maximizing the level of biodiversity protection. Because of the level of co-operation from local communities, the GBRMPA has been able to access local knowledge, and significantly reduce impacts on existing users.

The success of this very sizeable consultation process, and the timely tabling of the Zoning Plan in December 2003, was due substantially to the outstanding professional and personal contribution made by Virginia.

These works have made a very significant contribution to fostering international awareness of sophisticated environmental conservation initiatives, and have served to enhance Australia's international marine conservation reputation. The RAP initiative has been recognized by nine major awards - three international and six national - and set a new global benchmark for marine conservation. This outcome would not have been possible without Virginia's drive and vision.

MEMBERSHIP

Researchers

Professor Terry Hughes
Centre Director and ARC Federation Fellow, Program 5 leader
James Cook University

Dr Tracy Ainsworth
ARC Australian Postdoctoral Fellow
James Cook University

Dr Glenn Almany
ARC Future Fellow
James Cook University

Dr Kenneth Anthony
Chief Investigator
University of Queensland

Dr Andrew Baird
ARC Future Fellow
James Cook University

Dr Natalie Ban
ARC Australian Postdoctoral Fellow
James Cook University

Dr Line Bay
Queensland Smart State Fellow
James Cook University

Professor David Bellwood
Chief Investigator
James Cook University

Dr Joshua Cinner
ARC Australian Postdoctoral Fellow
James Cook University

Professor Sean Connolly
ARC Australian Professorial Fellow and Program 2 leader
James Cook University

Debora De Freitas
Research Associate
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Dr Guillermo Diaz-Pulido
Research Fellow
University of Queensland

Dr Maria Dornelas
Research Fellow
James Cook University

Associate Professor 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
ARC Australian Postdoctoral Fellow
James Cook University

Dr Pedro Fidelman
Research Fellow
James Cook University

Dr Simon Foale
Research Fellow and Program 7 Leader
James Cook University

Professor Carl Folke
Partner Investigator
Stockholm University

Dr Sylvain Forêt
Research Fellow
James Cook University

Dr Christopher Fulton
Chief Investigator
Australian National University

Dr Nick Graham
ARC Australian Postdoctoral Fellow and Queensland Smart Futures Fellow
James Cook University

Dr 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

Professor Ronald Karlson
Partner Investigator
University of Delaware

Professor Michael Kingsford
Chief Investigator
James Cook University

Dr Johnathan Kool
Research Fellow
James Cook University

Dr Bill Leggat
Chief Investigator
James Cook University

Dr Janice Lough
Partner Investigator
Australian Institute of Marine Science

Dr Jennie Mallela
Research Fellow
Australian National University

Dr Laurence McCook
Partner Investigator
Great Barrier Reef Marine Park Authority

Dr Mark McCormick
Chief Investigator
James Cook University

Professor Malcolm McCulloch
Deputy Director, Western Australia Premier's Fellow and Program 1 Leader
University of Western Australia

Dr Mark Meekan
Partner Investigator
Australian Institute of Marine Science

Professor David Miller
Chief Investigator and Program 8 Leader
James Cook University

Professor Philip Munday
ARC Queen Elizabeth II Fellow
James Cook University

Professor John Pandolfi
Chief Investigator
University of Queensland

Dr Serge Planes
Partner Investigator
University of Perpignan

Dr Morgan Pratchett
ARC Australian Research Fellow
James Cook University

Professor Bob Pressey
Research Fellow and Program 6 Leader
James Cook University

Professor Garry Russ
Chief Investigator and 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

Dr David Williamson
Research Fellow
James Cook University

Professor Bette Willis
Chief Investigator
James Cook University

Professor David Yellowlees
Chief Investigator
James Cook University

Resident International Scholars

Dr Tatjana Good
Swiss National Foundation, Switzerland

Dr Cristina Linares
University of Barcelona, Spain

Professor Yossi Loya
Tel Aviv University, Israel

Dr Aurélie Moya
Marie Curie Fellow
University of Nice, France

Dr Lucie Penin
Marie Curie Fellow
University of Perpignan, France

Adjunct Researchers

Dr Alison Green
The Nature Conservancy

Dr Alexander Kerr
University of Guam, USA

Professor Janice Lough
Australian Institute of Marine Science

Professor Yossi Loya
Tel Aviv University, Israel

Dr Tim Lynam
CSIRO

Dr Laurence McCook
Great Barrier Reef Marine Park Authority

Dr Madeleine van Oppen
Australian Institute of Marine Science

Professor John Tanzer
Environmental Pathways and Solutions

Dr David Wachenfeld
Great Barrier Reef Marine Park Authority

Graduate Students

(see page 34)

Technical Staff

Lewis Anderson
James Cook University

Mary Boyle
James Cook University

Paul Costello
James Cook University

Maria Gomez
University of Queensland

Mizue Hisano
James Cook University

Paulina Kaniewska
University of Queensland

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Australian National University

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James Cook University

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James Cook University

Graham Mortimer
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Nela Rosic
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Maya Srinivasan
James Cook University

Jenn Tanner
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Sharon Wismer
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Lianne Cook
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Monica Gaffney
Office Manager and KPI Officer
James Cook University

Eliza Glasson
ICRS Conference Coordinator
James Cook University

Janet Swanson
Administrative Assistant
James Cook University

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 a Professor in the School of Earth and Environment at the University of Western Australia, Perth, and a newly appointed Western Australian Premier's Fellow (2009-2013). 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 marine 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 2009 he was awarded the *Jaeger Medal in Earth Sciences* by the Australian Academy of Science. Malcolm holds an Honorary Doctorate from Curtin University, and he is an *ISI Highly Cited Researcher*. His 240 scientific papers have been published in leading international journals including 23 articles in *Science* or *Nature*.

Professor Sean Connolly

ARC Professorial Fellow Sean Connolly, from James Cook University, 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 38 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, from the School of Marine and Tropical Biology at James Cook University, 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 his applied research involves population and community dynamics of reef fish of commercial significance. 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 Queen's 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 new Global Change Institute 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 Global Environment Facility/World Bank Working Group on *Coral Bleaching and Related Ecological Disturbances*, one of three expert groups within the Intergovernmental Oceanographic Commission 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 160 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 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 James Cook University in 1990. Terry was elected a Fellow of the Australian Academy of Science in 2001 in recognition of "a career which has significantly advanced the world's store of scientific knowledge". 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 leading conservation biology journals. Bob was awarded *The Royal Botanic Gardens'* Eureka Prize for Biodiversity Research, in 2002 and the inaugural (2008) *Australian Ecology Research Award* from the Ecological Society of Australia. His most recent recognition (2009) was the title of James Cook University Distinguished Professor for excellence in scholarly activities.

PROGRAM LEADERS

Dr Simon Foale

Senior Research Fellow Simon Foale leads the ARC Centre's Program 7: *Policy development, institutions and governance of coral reefs*. He joined the Centre in late 2006, after a postdoctoral fellowship at the Australian National University's Resource Management in Asia Pacific Program. Simon is a marine biologist who, since his PhD. was awarded in 1998 at the University of Melbourne, has been increasingly engaging with the social sciences in an attempt to address pressing fishery management issues in the Pacific, particularly in the Solomon Islands and Papua New Guinea. Simon has very broad applied experience in the Pacific, having worked for non-government conservation organisations, mining companies, regional agencies, governments and aid agencies. He publishes in a wide range of journals spanning the natural and social sciences. Simon's current research examines political, social and economic aspects of fishery use and management in Melanesia, with a particular emphasis on developing locally relevant and culturally appropriate educational resources for improving coral reef fishery management.

Professor David Miller

Professor David Miller is Leader of Program 8: *Genomics and metagenomics of coral reefs*. David studies the molecular biology of corals and other "simple" marine animals. His research interests span a broad range of topics from marine biology to genomics, and include the biochemistry and molecular biology of coral symbioses, the evolution of developmental mechanisms ("evo-devo"), immune system evolution, and the molecular bases of coral responses to stressors such as disease, ocean acidification and climate change. David obtained his PhD in genetics and biochemistry from the University of Kent (UK). He subsequently undertook post-doctoral research at the University of Bristol (UK) and then the University of Adelaide. David moved to James Cook University from Adelaide in 1984 and is currently a Professor in molecular genetics and genomics. David's main claim to fame is the discovery that "simple" animals such as corals have genomes as complex as those of man and other vertebrates, and in highlighting the role of gene loss in shaping animal genomes. He plays a leading role in a number of genome projects on various lower animals, including the first coral genome project and the first all-Australian whole genome project, and is a regular commentator on animal genome evolution for a number of high profile journals.

BUSINESS LEADERS

Professor David Yellowlees

Professor David Yellowlees is the Assistant Director of the ARC Centre of Excellence and a Chief Investigator in Programs 4 and 8. Trained as a biochemist, he has undertaken extensive research on the symbiosis between coral reef organisms, particularly in corals and tridacnid clams since the mid 1980s. His major interests have centred on the metabolic relationship between the symbiotic partners. His research on the acquisition of inorganic carbon, its photosynthetic fixation and the transfer of this to the animal host forms the basis of much of our understanding of these organisms at the metabolic level. David has published over 80 papers in international journals. He has had a long career at James Cook University commencing in the Department of Chemistry and Biochemistry in 1971. After resigning as Head of the School of Pharmacy and Molecular Sciences at the beginning of 2007, he joined the staff of the Centre in a part time capacity as its Assistant Director. He now applies many of these skills learned as Head of School to assisting with the running of the Centre.

Jenny Lappin

Jenny Lappin is the Chief Operations Officer of the ARC Centre of Excellence. Jenny has a Bachelor of Commerce degree from the University of Queensland and is a member of the Australian Society of Certified Practicing Accountants. She has over 20 years of senior management experience with responsibilities for strategic planning, finance management, human resources, communications, business process engineering, change management and policy development. Starting work as an accountant in Townsville she progressed her career in Sydney, Melbourne and London before returning to Australia. She started as an academic in the Department of Commerce at James Cook University in 1988, moving to general financial management positions soon after. Following various leadership positions in finance, research, foreign aid projects and as an executive officer at JCU, she moved in October 2005 to the Centre of Excellence to oversee, with the Centre Director, its establishment. She enjoys the diversity and challenges of a rapidly growing and vibrant research Centre of Excellence.

RESEARCH

Program 1: Evolutionary and Environmental Change

Researchers

- **Malcolm McCulloch** *Program Leader*
- **Sean Connolly** *Research Fellow*
- **Ove Hoegh-Guldberg** *Research Fellow*
- **Terry Hughes** *Research Fellow*
- **Jennie Mallela** *Research Fellow*
- **Michael Kingsford**
- **Janice Lough**
- **John Pandolfi**
- **Robert Steneck**
- **Benjamin Walther** *Research Fellow*

Understanding how coral reefs are responding to the ongoing effects of both climate and environmental changes is the major objective being addressed by Program 1. A multi-faceted approach is being followed, not only using direct observations from modern reefs but also examining how reefs have evolved and changed over timescales ranging from a few decades and years to many thousands of years. 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, the latter from rapidly rising levels of atmospheric CO_2. Even if the most optimistic outcome is achieved from global cooperation on greenhouse gas emissions, and increases in global temperatures are kept at < 2°C, levels of atmospheric CO_2 will almost certainly exceed 450 ppm in the coming decades.

Global warming and ocean acidification are already changing the physiology, ecology and geology of coral reefs, in ways that are still poorly understood. In order to meet these growing challenges, researchers in Program 1 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. In a major new development, in mid-2009 a new node of the Centre was established at the University of Western Australia, following the award of the WA Premier's Fellowship to Malcolm McCulloch. This expansion will allow us to significantly expand on the Centre's existing activities on the west coast (in Programs 1, 2, 3 and 6).

In 2009, McCulloch and colleagues published their initial findings of the long-term influence of ocean acidification on Arlington Reef, an oceanic coral reef system offshore from the Great Barrier Reef. This study is using novel geochemical tools based on boron isotopic variations in long-lived coral cores. Results indicate that the long-term pre-industrial variation of seawater pH in this region is partially related to the decadal–interdecadal variability of atmospheric and oceanic anomalies in the Pacific. Importantly, from the 1940s to the present-day, there is a general overall trend of increasing ocean acidification, with pH decreasing by about 0.2–0.3 pH units. Boron and carbon isotopes indicate that the increasing trend towards ocean acidification over the past 60 years in this region is clearly the result of enhanced dissolution of CO_2 derived mainly from fossil fuel burning.

Research Fellow Jennie Mallela is using novel geochemical techniques based on direct measurements of phosphorus concentration in coral skeletons to assess how both land-based runoff (e.g. nutrients) together with climate change have influenced coral reefs and reef growth on the Great Barrier Reef, as well as in Tobago in the Southern Caribbean. In 2009, she commenced a new study on the effects of runoff into the key tourist areas of Dunk Island and Mission Beach located in the central Great Barrier Reef between Cairns and Townsville.

A major research program is yielding exciting insights into the long-term history of nearshore Great Barrier Reef and Moreton Bay (south east Queensland) coral reef communities. Led by John Pandolfi, the research uses precise chronological measures and paleoecological analysis to show dramatic shifts in nearshore coral communities that can be attributed to European colonization of Queensland. The work is providing reef managers with a new perspective on what was natural on the Great Barrier Reef prior to modern human influences.

John Pandolfi and Malcolm McCulloch are continuing their ongoing paleontological and geochemical studies of the regional dynamics of biodiversity in coral reefs under differing past climates. One major focus is the fossil reefs that grew along the Western Australian coastline ~125,000 years ago during the last interglacial period, 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, given sufficient time, to the effects of a global warming ocean, and that they migrated southwards into sub-tropical areas when the temperature increased. However, history may not repeat itself under the current anthropogenic climate change regime due to the added complexity of ocean acidification.

7000 year old corals of Moreton Bay tell their story

The 7000-year-old coral communities of Moreton Bay are telling a curious tale, expanding when sea-levels rise or water quality improves, then declining when current circulation becomes more restricted.

Intriguing new insights into the behaviour of corals and fish under changing climatic conditions will be presented by leading marine researchers at a public forum in Brisbane this coming Friday.

Professor John Pandolfi from the University of Queensland and ARC Centre of Excellence for Coral Reef Studies and his team have been dating the corals of Moreton Bay and finding they have undergone surges of growth, probably triggered by subtle changes in sea level and water conditions.

"We've found coral communities up to 7000 years old showing these curious growth episodes – the last one started about 400 years ago. When coral reef growth slows or stops in the Bay, it appears to correspond with a decline in the current circulation and an increase in turbidity."

The team has also found clear evidence of changes in the types of corals in the Bay from the delicate staghorns to more massive forms, coinciding with European settlement and possibly resulting from declining water quality as nearby catchments were altered.

These and many other aspects of the future of Australia's corals will be explored at a scientific symposium and public forum in Brisbane this week.

The scientific symposium Securing *Coral Reef Futures* will take place on August 6 and 7 at the Brisbane Customs House. It will be followed by the Public Forum on the future of the coral reefs worldwide at 6.00pm, Friday 7 August at the Brisbane Convention and Exhibition Centre. Media are welcome to attend both.

"Coral reef scientists and managers are worried about the future, and with good reason," Prof. Hughes says. "The world is on a conveyor belt driven by population growth, rising consumption and climate change - yet most governments and agencies are focused on maintaining the status quo, while many conservation groups would like to return to a pristine past. In a rapidly changing world, standing still or going backwards is simply not an option. The trick is to actively steer forward to a sustainable future that recognizes the importance of healthy ecosystems for human well-being."

At the symposium eminent environmental scientists will release an international communiqué on the future of coral reefs and the human communities which depend on them under climate change. A media conference will be held at 10.40am on Thursday, August 6, at The Customs House Reid Room, where CoECRS head Professor Terry Hughes, Professor John Quiggin (UQ) and Dr Josh Cinner (JCU) will be available to answer questions.

Communiqué at ***www.coralcoe.org.au/news_stories/brisstatement.html***

RESEARCH

Program 2: Understanding and Managing Coral Reef Biodiversity

Researchers

- **Sean Connolly** *Program Leader*
- **Glenn Almany** *Research Fellow*
- **Andrew Baird** *Research Fellow*
- **David Bellwood**
- **Guillermo Diaz-Pulido** *Research Fellow*
- **Maria Dornelas** *Research Fellow*
- **Toby Elmhirst** *Research Fellow*
- **Chris Fulton**
- **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**

Coral reef biodiversity underpins the critically important functions and services performed by reef ecosystems, such as sustaining the productivity of fish stocks on which many tropical nations depend for their food security and future development. 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.

Program 2 research in 2009 provided several key breakthroughs in understanding how coral reefs respond to overfishing and climate change, and importantly how management can mediate those responses. For example, Phil Munday, Geoff Jones and their graduate students published several papers in 2009 detailing the effects of ocean acidification on coral reef fish larvae and juveniles, including impairment of their abilities to home in on reef habitat, and to identify and avoid predators (see p.55). Toby Elmhirst, Sean Connolly and Terry Hughes developed mathematical models of ecosystem dynamics, which predict that the supply of new coral juveniles to overfished reefs from nearby protected areas does not enhance their resilience to collapsing into seaweed-dominated states. However, spill-over of larvae can facilitate the reversal of those collapses back to coral-dominated states. This study highlights the importance of good management outside no-take areas for preventing coral reef collapse, but also shows how no-take areas can provide an insurance policy in the event that collapses do occur. New work by John Pandolfi and colleagues investigating ecological baselines over centennial time scales on the Great Barrier Reef shows convincing evidence for human-induced shifts in species composition associated with European colonization. This work provides the first key evidence for shifting baselines on the Great Barrier Reef, and will aid managers in setting appropriate management goals.

Program 2 researchers also made numerous important contributions in 2009 to coral reef policy issues at State, Commonwealth, and international levels. Future Fellow Glenn Almany is working with *The Nature Conservancy* and local communities in Papua New Guinea to establish new Marine Park Areas for managing overfishing and the effects of climate change. Nick Graham is providing advice to the *Great Barrier Reef Foundation* on the development of indicators of coral reef resilience.

Program 2 researchers also continue to interact with Commonwealth agencies and other relevant parties on the proposed re-zoning of the Coral Sea.

Program 2 researchers were granted numerous awards and honours in 2009. Program Leader Sean Connolly received the *Fenner Medal* from the *Australian Academy of Science*; this award recognizes outstanding research in biology by a scientist under the age of 40. Andrew Baird was awarded an ARC Future Fellowship, and Nick Graham received an Australian Postdoctoral Fellowship and a Queensland Smart Futures Fellowship. In addition, Joana Figueredo (PhD, University of Lisbon) has been awarded a postdoctoral fellowship from the Portuguese *Fundação para a Ciência e a Tecnologia*, and will be joining Program 2 as a Visiting Research Fellow in 2010. John Pandolfi was appointed Vice-President of the *Australian Coral Reef Society*, the world's oldest professional association of coral reef scientists. Program 2 researchers, with other Centre colleagues, received ARC infrastructure funding to establish the *Marine Climate Change Experimental Facility* at JCU, which will be used to substantially enhance the ARC Centre's capacity for further study of the effect of global warming and ocean acidification on reef organisms.

In addition to the award of new ARC research fellowships to Andrew Baird and Nick Graham, a new Chief Investigator, Chris Fulton from the Australian National University, also joined the ARC Centre in 2009. Chris has already forged strong links with colleagues in Program 2, and adds an extensive record of research into the effects of flow on organism performance to the Centre's portfolio of expertise.

Corals raise hopes for survival

Hope that some of the world's corals may be able to escape destruction under climate change has emerged from a study by an international team of scientists working in French Polynesia in the Pacific. The researchers found that corals off Moorea, in the central Pacific, have rebounded on five occasions despite sustaining heavy damage from four bleaching events and one cyclone in the past 18 years.

In particular, they were able to recover even after the reef had been swamped by weeds, says team member Dr Lucie Penin of the ARC Centre of Excellence for Coral Reef Studies, James Cook University and the Université de Perpignan.

"We conclude from this that coral reefs may not completely disappear as a result of climate change – as some people fear they might," she says. (In the Earth's past history corals have become either nearly or totally extinct on five separate occasions, and some researchers warn that conditions under global warming may prove similar to those previous events.)

However, Dr Penin notes that the corals studied lie on the outer reef slope of an island that is not heavily populated, and that the main human impact on them is fishing. "The lack of human pressure on the reef makes it more resilient," she says. "This research suggests that, if left alone, coral reefs have the possibility to recover and re-grow."

Researcher Loïc Thibaut, James Cook University and Université Pierre et Marie Curie adds "One of the salient features of this reef is that the fish community, and in particular herbivorous fishes have remained at high levels of abundance throughout the study. This might well explain why the coral community recovered so quickly despite the catastrophic events it had to face."

Dr Penin said the Tiahura Outer Reef Sector of Moorea had been closely studied for four decades by scientists, and the corals' responses to natural disturbances were now well understood. The five major disturbances had reduced coral cover at the time from over 50% of the area to as little as 22% while, in the early nineties sea weeds known as turf algae had taken over more than half of the area in the wake of cyclone and bleaching. However key coral species were able to re-colonise the reef in subsequent years.

"Our results support the idea that a rapid recovery from a weed-dominated reef to a coral dominated one is possible – but it will depend on what other pressures the corals are facing," Dr Penin says. "It also shows that a fast recovery, in just a decade, is possible under the right conditions."

However since the study was completed the Tiahura reef has come under a new threat – Crown of Thorns starfish have mounted a severe attack on the corals, slashing coral cover to as little as two per cent in some areas.

"We are keeping a very close eye on this outbreak. Right now the reef is in a very bad condition, but there are signs of recovery and we are hoping it will come back from this as it has from the damage caused by bleaching and cyclones," she says.

Adjeroud, M, Michonneau, F, Edmunds, P, Chancerelle, Y, de Loma, T, Penin, L, Thibaut, L, Vidal-Dupiol, J, Salvat, B and Galzin, R (2009). Recurrent disturbances, recovery trajectories, and resilience of coral assemblages on a South Central Pacific reef. *Coral Reefs* 28(3): 775-780

6 July 2009

RESEARCH

Program 3: Marine Reserves and Reef Connectivity

Researchers

- **Garry Russ** *Program Leader*
- **Glenn Almany** *Research Fellow*
- **Andrew Baird** *Research Fellow*
- **David Bellwood**
- **Sean Connolly** *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*
- **David Williamson** *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.

In 2009, Program 3 researchers, together with colleagues from France and the USA, published a set of six articles in a Special Theme section of the journal *Coral Reefs*. The papers reviewed and synthesized information on biological connectivity on coral reefs, while also providing updated recommendations for the design of marine protected area networks (e.g., size and spacing) to protect connectivity. These papers formed the core output from an international workshop entitled "*Connectivity and population resilience – sustaining coral reefs during the coming century*" co-hosted in Townsville in 2008 by the ARC Centre and Global Environment Fund.

Program 3 continues to lead the world in the development and application of techniques for tagging and tracking marine larvae. Geoff Jones and colleagues used larval tagging and genetic studies to reveal the export of larvae from marine reserves in Papua New Guinea. They showed that larval dispersal connected fish populations in a network of marine protected areas over scales of 30km. This ground-breaking research was published in 2009 in *Proceedings of the National Academy of Science*. This year, for the first time, we also applied these novel larval tracking techniques, combined with detailed larval dispersal modeling, to Australia's iconic Great Barrier Reef Marine Park.

Program 3 continues to make breakthroughs in understanding of larval biology. Mark McCormick and colleagues completed a synthesis of how the physiological state of parents (particularly mothers) during gametogenesis affects offspring success. This novel research shows that successful recruitment to the next generation of breeding fish is strongly influenced by parental condition. Phil Munday and colleagues showed that ocean acidification impairs the innate ability of fish larvae to avoid their predators. 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, fisheries sustainability and connectivity patterns of populations and networks of marine reserves.

In the Philippines, Garry Russ and colleagues undertook a national-scale assessment of the current extent, conservation efficacy and gaps in coverage of Marine Protected Areas (MPAs), using a newly compiled GIS database with records for more than 1000 marine reserves. The analysis shows that the current extent and distribution of MPAs does not adequately represent biodiversity in the Philippines. At present, only 2.8% of coral reef area in the Philippines is protected within no-take zones, and 88% of MPAs are smaller than 1km^2. However, spacing distances between MPAs are such that larval connectivity between sites is likely, providing opportunities to develop regional-scale MPA networks. The results indicate that, even if adopted universally, community-based MPAs will not be sufficient to meet national goals. A dual approach to MPA implementation was recommended, whereby continued efforts to increase the number of community-based MPAs are supplemented by the designation of additional large no-take areas with a conservation focus.

Many of the research projects within Program 3 are designed to actively engage with local stakeholders. For example, work on the Great Barrier Reef in 2009 required assistance from several recreational fishing groups, including the major recreational fishing body in Queensland, SUNFISH. In the Philippines, Garry Russ's long-standing colleague, Angel Alcala, continues to work closely with Philippine fishing communities to set up marine reserves. In PNG and the Solomon Islands, Future Fellow Glenn Almany and others work closely with The Nature Conservancy to test and design new Marine Protected Area networks.

Research on the design and implementation of marine reserve networks, as outlined above for the Great Barrier Reef, Papua New Guinea, the Solomon Islands and the Philippines, represents a significant contribution by Program 3 to the scientific knowledge underpinning the Coral Triangle Initiative (see also p.26, 28, 50).

Photo by Ashley Frisch

Media Release

Proof that marine parks work

New evidence supports the growing view that a network of marine reserves is more effective for maintaining a diversity of fish and other marine species than a single, isolated park or no-fishing area.

An international research team has found that networks of marine protected areas (MPAs) can play a big role in protecting threatened coral reef fish and other marine species from local extinction. In a world-first experiment, the researchers used DNA fingerprinting to show that baby orange clownfish have remarkable homing abilities, with many finding their way back to home reefs after being swept out to sea as hatchlings.

In the process they discovered some baby clownfish had travelled to reefs as much as 35 kilometres distant from the reef where they were spawned – a spectacular feat considering they were only a few millimetres in length. The research was carried out in Kimbe Bay, New Britain in Papua New Guinea, a region of relatively pristine coral reefs where it is proposed to set up a network of marine reserves.

"Using their parent's DNA to identify where they had come from, we have been able to show that about 40 per cent of baby clownfish that settle in a marine reserve are those that have returned home. In addition, the parents within one marine reserve can explain up to 10 per cent of the baby fish settling in reserves 20-30km away", says Prof Geoff Jones of the ARC Centre of Excellence for Coral Reef Studies.

"This shows not only how effective a marine protected area can be for conserving the breeding stock on a particular reef – but also how important it is to have a network of protected reefs at the right distance which can help to re-stock one another."

In another first, the team has demonstrated the power of parental DNA analysis for measuring the health and viability of fish populations in marine protected areas.

Because orange clownfish live in sea anemones and because the locations of all the anemone clumps around Kimbe Island were known, the team was able to collect DNA from 506 adult clownfish living around the island – which they believe to be its entire population.

They then tested juvenile fish which had recently returned from the open sea and settled on the reef in order to establish their parentage, finding that about 40 per cent were locally-bred while the remainder had come from other reefs.

"This level of recruitment to the home reef was remarkably stable over time. It shows both the value of having a protected area to maintain the local fish population – and also the importance of having a network of protected areas within a range that allows them to replenish one another's fish populations," Professor Jones says.

"Given the mounting evidence worldwide that populations of many small reef fish are under threat, we think parental DNA analysis offers a new tool to help protect them."

Planes, S, Jones, GP and Thorrold, SR (2009). Larval dispersal connects fish populations in a network of marine protected areas. *Proceedings of the National Academy of Sciences* 106(14): 5693-5697.

25 March 2009

RESEARCH

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*
- **Bill Leggat**
- **David Miller**
- **Madeleine van Oppen**
- **Bette Willis**
- **David Yellowlees**

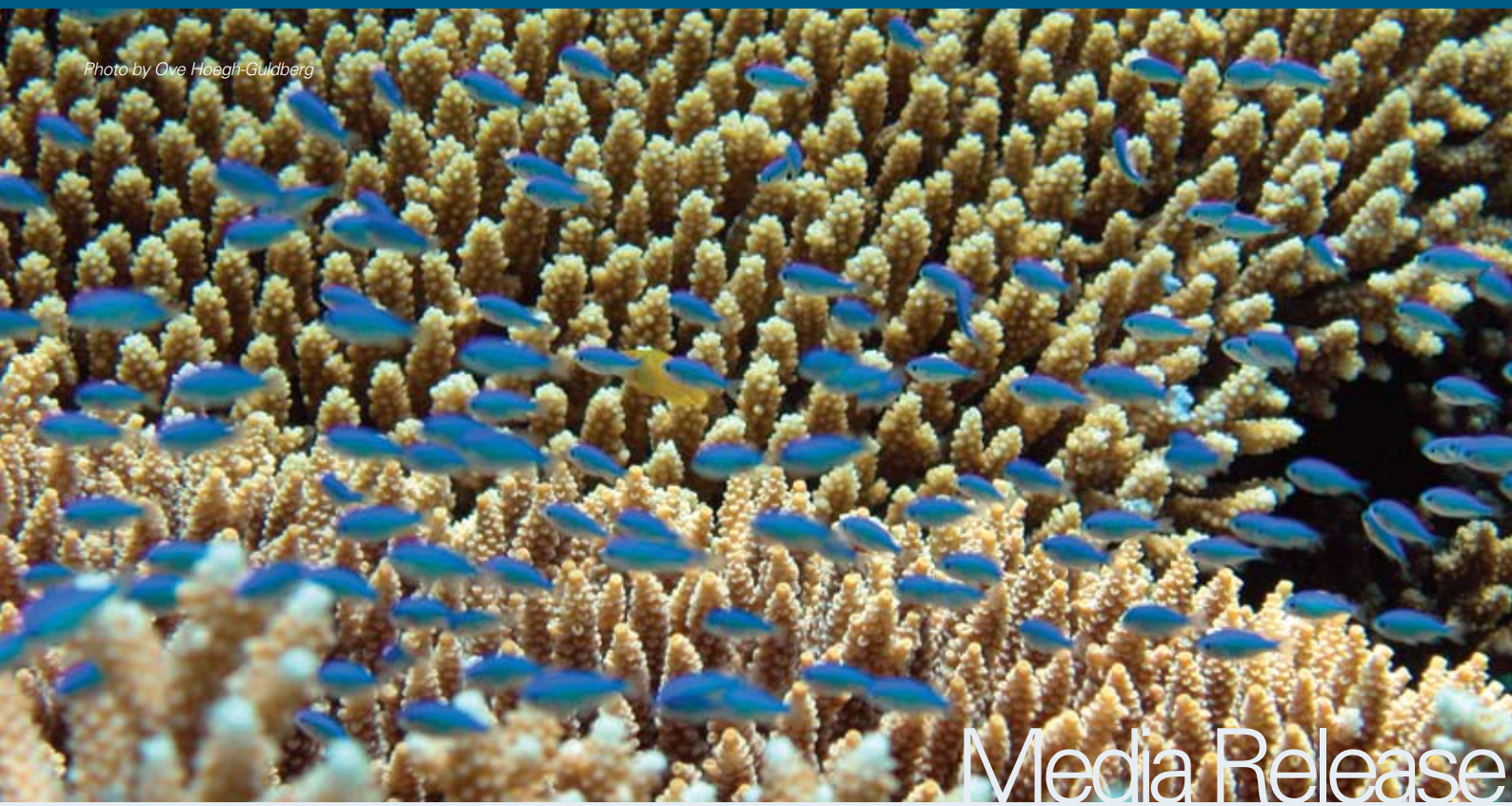
Program 4 researchers continued in 2009 to investigate the relationships between the coral animal and their symbiotic microalgae, and microbial associates – both as beneficial partners and disease agents. A major focus within the Program has been determining the impact that environmental factors – including global climate change – have on these relationships, and particularly on an array of projects that address the mechanisms of coral bleaching triggered by thermal stress. These studies greatly increase our knowledge of these symbioses, providing a broader understanding of how and why corals respond in certain ways to different stressors.

Eugenia Sampayo in the Hoegh-Guldberg and Dove laboratories have analysed eight ecologically distinct *Symbiodinium* spp and showed that there was a strong correlation between phylogenetically independent lineages and ecological and physiological attributes. The Willis and van Oppen laboratories, in studying the relationship between the coral host and zooxanthellae, have now shown that it can take up to 3 years to establish adult patterns of algal endosymbioses. This is a remarkable finding, with important implications for how reefs recover from recurrent bouts of bleaching. Along with the work of PhD students David Abrego and Jos Mieog, these studies have revealed fresh insights into the complexity of the symbiosis between these partners. Interestingly, they have shown more clearly than any previous studies that the fitness of this relationship is influenced by interactions between the symbiont type and the environment.

The impact of climate change on the symbiotic association is a major focus of all researchers in Program 4, across both the UQ and JCU/AIMS nodes, with a wide range of important research questions being addressed. PhD student Rachael Middlebrook demonstrated that heating rate is an important parameter when determining thermal susceptibility of corals. The shuffling or switching of symbionts (the "adaptive bleaching" hypothesis) came under scrutiny when PhD student Michael Stat and co-workers found no evidence for switching in ten coral species 12 months after a thermal stress event on the Great Barrier Reef. Gene expression studies, led by Queensland Smart State Fellow Line Bay, have revealed evidence of major phenotypic plasticity in gene expression levels in response to environmental change. Line and co-workers' ongoing studies are exploring the genetic basis of trait variation, to assess the potential for adaptation by corals in response to climate change and to potentially find genetic markers associated with the tolerance of corals to climate change. Also of relevance to global warming was the 2009 study by Mia Hoogenboom which showed that, contrary to conventional thinking, the optimal light regimes for coral growth and energetics are below the maximum observed light levels of coral reefs.

Simon Dunn, Sophie Dove, Bill Leggat and Tracy Ainsworth have been exploring the involvement of cell death pathways in thermal stress and breakdown of the symbiosis between corals and their dinoflagellates. This has led to the identification of a series of key genes that control the fate of cells affected by rapid changes in sea temperature.

Research into causative agents of coral diseases by Program 4 researchers is adding to the toolbox available to reef managers. A study by PhD student Yui Sato is the first to describe the seasonal dynamics of an outbreak of black band disease on the Great Barrier Reef, which highlights the increasing susceptibility of corals to rising sea temperatures. Early successional changes in bacterial communities that facilitate development of black band disease were identified and will aid in early detection of the disease. A complementary study of the natural bacterial communities in corals, by Tracy Ainsworth showed that they too are significantly altered during thermal stress. Landmark studies by PhD student Meir Sussman identified *Vibrio coralliilyticus* as a causative agent of white syndromes, a group of damaging Indo-Pacific coral diseases, and showed that photoinactivation of algal endosymbionts by zinc-metalloproteases contributes to its virulence. These studies lay the groundwork for developing assays that will provide important management tools for detecting future disease outbreaks.



Reef boom beats doom

Marine scientists say they are astonished at the spectacular recovery of certain coral reefs in Australia's Great Barrier Reef Marine Park from a devastating coral bleaching event in 2006.

That year high sea temperatures caused massive and severe coral bleaching in the Keppel Islands, in the southern part of the Great Barrier Reef. The damaged reefs were quickly smothered by a single species of seaweed – an event that can spell the total loss of the corals.

However, a lucky combination of rare circumstances meant the reefs were able to achieve a spectacular recovery, with abundant corals re-established in a single year. Dr Guillermo Diaz-Pulido explains that "Three factors were critical. The first was exceptionally high re-growth of fragments of surviving coral tissue. The second was an unusual seasonal dieback in the seaweeds, and the third was the presence of a highly competitive coral species, which was able to outgrow the seaweed."

"It is rare to see reports of reefs that bounce back from mass coral bleaching or other human impacts in less than a decade or two," said Dr Diaz-Pulido. "But this also all happened in the context of a well-protected marine area and moderately good water quality," he adds.

"The exceptional aspect was that corals recovered by rapidly regrowing from surviving tissue. Recovery of corals is usually thought to depend on sexual reproduction and the settlement and growth of new corals arriving from other reefs. This study demonstrates that for fast-growing coral species asexual reproduction is a vital component of reef resilience" says Dr Sophie Dove.

"Coral reefs globally are increasingly being damaged by mass bleaching and climate change, and their capacity for recovery from that damage is critical to their future," explains Prof. Ove Hoegh-Guldberg. "Our study suggests that managing local stresses that affect reefs such as overfishing and declining water quality can have a big influence on the trajectory of reefs under rapid global change."

"Clearly, we need to urgently deal with the problem of rising carbon dioxide in the atmosphere, but managing reefs to reduce the impact of local factors can buy important time while we do this," he says.

Understanding the different mechanisms of resilience is critical for reef management under climate change. "Diversity in processes may well be critical to the overall resilience and persistence of coral reef ecosystems globally," Dr Laurence McCook, from the Great Barrier Reef Marine Park Authority, says.

"This combination of circumstances provided a lucky escape for the coral reefs in Keppel Islands, but is also a clear warning for the Great Barrier Reef. As climate change and other human impacts intensify, we need to do everything we possibly can to protect the resilience of coral reefs," he adds.

Diaz-Pulido, G, McCook, LJ, Dove, S, Berkelmans, R, Roff, G, Kline, DI, Weeks, S, Evans, RD, Williamson, DH and Hoegh-Guldberg, O (2009). Doom and boom on a resilient reef: climate change, algal overgrowth and coral recovery. *PLoS ONE* 4(4): e5239

22 April 2009

RESEARCH

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**
- **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.

In February, Program 5 leader Terry Hughes and Rodrigo Bustamante from CSIRO, co-hosted the latest of the ARC Centre's series of international working group meetings on marine social-ecological systems, focussing this time on the Galapagos Islands. The group examined how climate change, tourism, global markets, migration, and introduced pests have all changed the nature and scale of the social-ecological dynamics of the Galapagos archipelago, with the co-evolution of an emerging system of governance. The next meeting will be held in June 2010 in the Baltic Sea, addressing the challenges of trans-boundary governance in the ocean.

In June, Terry Hughes joined the inaugural Science Committee responsible for developing a 10-year global research project of ICSU, the *International Council for Science*. The project, entitled *Program on Ecosystem Change and Society* (PECS), will focus on both human development and sustainability of natural resources at regional to global scales. PECS aims to link science and environmental management to society, policy and human well-being. The PECS Science Committee will meet twice a year in Paris to develop a social-ecological research agenda that is closely aligned to the ARC Centre's Programs 5, 6 and 7. PECS is co-sponsored by UNESCO, and will complement existing global environmental change programs and international partnerships.

Two of the ARC's high-profile articles in 2009, published in *Science* and *Nature*, are at the interface of Programs 5 and 7. The first argues that coping with global changes requires new institutions and a global system of governance that is currently missing. Energy, food and water crises, climate change, declining world fisheries, emerging diseases and antibiotic resistance are all examples of intertwined global challenges that are outpacing the capacity of existing institutions (see p.29). The *Nature* paper proposes ten earth-system boundaries which should not be exceeded to avoid crossing dangerous tipping points. These include the rate of species extinction, the amount of nitrogen and phosphorus in fertilisers, use of fresh water, the clearing of land, ozone depletion, aerosol pollution of the atmosphere and chemical contamination. These two studies reflect the ARC Centre's ongoing links to the Resilience Alliance, the Beijer Institute for Ecological Economics, and the Stockholm Resilience Centre. Other major publications during the year included a cutting-edge theme section in the journal *Coral Reefs*, on larval connectivity and ecological resilience (see Program 3 summary), compiled and edited by Geoff Jones, Garry Russ, Peter Sale and Bob Steneck.

Senior Fellow Simon Foale was contracted by The Nature Conservancy (TNC) to review the extent to which TNC have applied the ecosystem approach to fisheries in their Melanesian projects. ARC Australian Postdoctoral Fellow Josh Cinner and colleagues undertook a regional analysis of the role of socioeconomic development in sustaining coral reefs in the Indian Ocean. The study, published in *Current Biology*, was also presented by Josh at the 2009 meeting of the American Association for the Advancement of Science, in Chicago. Research Fellow Toby Elmhirst and colleagues presented the results of a novel modelling study in the December issue of *Coral Reefs*, which examines the reliance of highly-protected areas on larval input from the surrounding seascape. Most research in large scale connectivity has emphasized spill-over from no-take areas. Toby's work predicts that the ecological resilience of no-take areas can be undermined by degradation at larger scales, requiring a seascape approach to marine resource management beyond the conventional focus on networks of no-take areas.

Gear bans "can help save reefs"

An international team of scientists led by Dr Josh Cinner of the ARC Centre of Excellence for Coral Reef Studies has proposed that bans on fishing gear - like spear guns, fish traps, beach seine nets, and gill nets – could aid in the recovery of reefs and fish populations hard hit by coral bleaching events.

Research carried out in Kenya and Papua New Guinea has shown that certain types of gear are more damaging to corals, to coral-dependent fish and to the key species of fish that are needed to help reefs recover from bleaching or storm damage.

"This is creating a double jeopardy for both the corals and certain types of reef fish. They are already on the edge because of the overfishing – and the additional impact caused by a bleaching event can push them over" Dr Cinner explains. The result can be an accelerated decline of the reef, its fish populations and their ability to sustain local people.

"From an ecological perspective, the best response to bleaching is to close reefs to fishing entirely. But that is not feasible everywhere and is a particularly hard sell among the impoverished fishers in developing countries" says co-author Dr. Tim McClanahan of the Wildlife Conservation Society. "In areas where fishery closures are impractical, managers don't have many options and haven't been able to do much but watch the reef die and often not recover."

The team investigated the effects of five main types of gear on different types of fish: spear guns, traps, hook and line, beach seine nets and gill nets.

"Spear guns target a high proportion of species that help maintain the resilience of coral reefs, but also can result in a surprising amount of damage to the corals themselves. When a fish is shot with a spear gun, it often hides in the reef, so some fishermen break the corals in their attempts to get it." Dr Cinner says.

But in developing countries, spear guns can be the fishing tool most used by the poorest fishers because they are cheap to make and the yield can be high, so they are an important source of income for poor fishers.

"You can't simply impose an arbitrary ban on their use – you need to consider issues like compensation, other fishing options, or alternative livelihoods for the affected fishers," says co-author Dr. Shaun Wilson of the Western Australian Department of Environment and Conservation. "One key issue may be educating fishers about the importance of reef habitat and the species that help to maintain reef quality – and the need to be selective in what they shoot. This would mean fishers could still use this cheap and effective fishing tool without necessarily damaging habitat and reef resilience."

Cinner, JE, McClanahan, TR, Graham, NAJ, Pratchett, MS, Wilson, SK and Raina, J-B (2009). Gear-based fisheries management as a potential adaptive response to climate change and coral mortality. *Journal of Applied Ecology* 46: 724-732

18 June 2009

RESEARCH

Program 6: Conservation Planning for a Sustainable Future

Researchers

- **Bob Pressey** *Program Leader*
- **Glenn Almany** *Research Fellow*
- **Natalie Ban** *Research Fellow*
- **Debora de Freitas**
- **Tatjana Good** *Visiting Research Fellow*
- **Johnathan Kool** *Research Fellow*
- **Laurence McCook**

Program 6, established in 2008, focuses on spatial solutions to resource management problems, involving the design of conservation areas that are managed to promote the persistence and sustainable use of natural resources, and implemented with local communities and other stakeholders. During 2009 our number of PhD students grew to nine and further growth is planned for 2010, with the recruitment of two additional Research Fellows.

The Great Barrier Reef and the Coral Triangle region are both a major focus of Program 6, and Bob Pressey and colleagues have already built close links with local governments, state governments, Australian government departments, Natural Resource Management (NRM) boards, international conservation NGOs, International Union for Conservation of Nature (IUCN - the World Conservation Union) and the United Nations Environment Program. During 2009, Pressey established new collaborative links with two NRM Boards in north Queensland. With Allan Dale, CEO of Terrain (Wet Tropics), the NRM Boards, and Debora de Freitas, Pressey is designing a research project to provide managers of coastal catchments with the tools to make effective trade-offs between the many objectives they have to balance. A keynote presentation by Pressey at the inaugural Island Arks symposium led to a major funding application to the Federal government in collaboration with Derek Ball, Operations Manager of Reef Catchments (Mackay Whitsundays) NRM.

Natalie Ban and Bob Pressey contributed to two working groups of the Great Barrier Reef Foundation to discuss the importance of dynamics such as coral bleaching and pelagic productivity for planning multiple-use reef zones. This involvement led to Natalie's successful application for the Foundation's inaugural Bommies Award, shared with Eddie Game of The Nature Conservancy. They will use the award funding to hold a scientific workshop on how to incorporate patch dynamics into conservation planning for the Great Barrier Reef region. Research Fellow, Johnathan Kool, who is co-funded by the Australian Institute of Marine Science (AIMS), has begun work on the extensive CSIRO-AIMS seabed biodiversity data set for the Great Barrier Reef. He is analysing these data to help inform marine classification and conservation objectives.

Program 6 has launched a number of new projects in the Coral Triangle and the south-west Pacific. For instance, in 2009 Johnathan Kool completed a unique model of ocean circulation in the Coral Triangle region. Johnathan also leads a new project in the Solomon Islands, in collaboration with The Nature Conservancy, identifying marine and terrestrial bioregions as a basis for a gap analysis of protected areas and identification of preliminary additional protected areas that link catchments and inshore waters. In Fiji, Program 6 has initiated a project with one of our former postdoctoral fellows, Stacy Jupiter of the Wildlife Conservation Society, to estimate the opportunity costs to local communities of establishing marine protected areas in inshore waters. In Papua New Guinea, Natalie Ban has developed her research project on patch dynamics and conservation planning within the Bismarck Sea and the Great Barrier Reef. Natalie also led a consultancy for the Pew Foundation to estimate the management costs of complete no-take and partial no-take scenarios for the proposed Coral Sea Marine Reserve.

The Program had a busy and productive 2009. As well as her award from the Great Barrier Reef Foundation, Natalie received an Australian Postdoctoral Fellowship from the ARC. Bob Pressey and Helene Marsh were awarded an ARC Linkage grant entitled "Innovative systematic conservation planning for indigenous land and sea country: Torres Strait as a case study". The grant will fund a new Research Fellow for three years to combine Indigenous knowledge with software tools for participatory planning of harvesting restrictions in Torres Strait.

Program 6 researchers and PhD students attended national conferences in Alice Springs, Brisbane, Canberra, Newcastle and the Whitsunday Islands and international conferences in China, the Czech Republic, Fiji, Indonesia (two meetings), Portugal, Tahiti, and the USA (two meetings). Attendance at these conferences involved a total of 36 presentations, including three invited keynotes.

The Great Barrier Reef as seen from space
MODIS satellite image (http://visibleearth.nasa.gov)
Photo courtesy NASA

Media Release

Rules proposed to save the world's coral reefs

An international team of scientists has proposed a set of basic rules to help save the world's imperiled coral reefs from ultimate destruction.

Their proposal is being unveiled at the World Ocean Conference 2009 in Manado, Indonesia, where leaders of six regional governments plus Australia and the United States are meeting to declare the largest-ever marine reserve in world history, the Coral Triangle Initiative.

"The catastrophic decline in the world's coral reefs demands urgent management responses on two fronts," say the researchers from the ARC Centre of Excellence for Coral Reef Studies, The Australian Museum, Woods Hole Oceanographic Institution, James Cook University, University of Perpignan, the United Nations University and The Nature Conservancy.

These are the "...reduction of immediate direct threats such as climate change, over-fishing and water pollution, and actions to protect or enhance the resilience of reef ecosystems in the face of existing and unavoidable future threats," they say.

The key to saving threatened coral ecosystems is to maintain the links (connectivity) between reefs allowing larvae to flow between them and re-stock depleted areas, the team led by Pew Fellow Dr Laurence McCook of Australia's Great Barrier Reef Marine Park Authority argues.

The researchers propose six 'rules of thumb' for keeping coral ecosystems viable, based on the results of research carried out in the Philippines, Australia, and Papua New Guinea.

These rules are:

1. allow margins of error in extent and nature of protection, as insurance against unforeseen threats;
2. spread risks among areas;
3. aim to create networks of protected areas which (a) protect all the main types of reef creatures, processes and connections, known and unknown; (b) achieve sufficient protection for each type of reef habitat type, and for the whole region; (c) achieve maximum protection for all reef processes (d) contain several examples of particular reef types to spread the risk;
4. protect whole reefs where possible; place buffer zones around core areas;
5. allow for reef species to spread over a range of distances, especially 20–30 km; and
6. use a range of conservation approaches, including marine protected areas.

The rules are designed to operate in a range of situations, including where detailed scientific knowledge of local coral reefs and their species is sparse, the team says in a review article in the journal *Coral Reefs*.

"The Coral Triangle Initiative is one of the most important marine conservation measures ever undertaken anywhere in the world and the first to span several countries. It involves Indonesia, the Philippines, Malaysia, Papua New Guinea, East Timor and the Solomon islands, and is as much about nation building and food security as it is about reef conservation" says Professor Terry Hughes, Director of the CoECRS, attending the Coral Triangle meeting today in Manado, Indonesia.

McCook, L, Almany, G, Berumen, M, Day, J, Green, A, Jones, G, Leis, J, Planes, S, Russ, G, Sale, P and Thorrold, S (2009). Management under uncertainty: Guide-lines for incorporating connectivity into the protection of coral reefs. *Coral Reefs* 28(2): 353-366.

11 May 2009

RESEARCH

Program 7: Policy Development, Institutions and Governance of Coral Reefs

Researchers

- **Simon Foale** *Program Leader*
- **Joshua Cinner** *Research Fellow*
- **Pedro Fidelman** *Research Fellow*
- **John Pandolfi**
- **Terry Hughes** *Research Fellow*

Program 7, launched in 2009 and led by Senior Research Fellow Simon Foale, addresses the multi-faceted challenges of improving coral reef governance. Because it is people, rather than fish or coral that must be managed, this multi-disciplinary research program covers cultural, political, historical, and economic aspects of coral reef management at multiple scales. While Program 7's activities include a focus on the Great Barrier Reef, they are global in scope (see press release). In 2009, most of the Program's projects were directed at the rapidly evolving coastal resource management and governance challenges in the Indo-Pacific region, in particular in Melanesia and the Coral Triangle. Program 7 addresses the global political and economic drivers of resource-use at several scales, and aims to understand the cultural, social and political dimensions of coral reef tenure systems and resource use, both contemporary and historical. Program 7 is already involved in capacity-building activities in many countries, working with NGOs and national governments.

This new program is rapidly ramping up with the recruitment late in 2009 of two additional post-doctoral fellows Louisa Evans and Mike Fabinyi, who will commence in May 2010. Louisa's Ph.D. at the University of East Anglia focussed on governance and marine systems in Kenya and she is currently a research fellow at WorldFish in Malaysia. Mike is an anthropologist currently at the Australian National University working on social equity and marine resource regulation in the Philippines. These two new recruits will provide a greater geographic spread of expertise and projects in Program 7.

Other research fellows with a role in Program 7 include Josh Cinner and Pedro Fidelman. In 2009 Josh held a workshop on fisheries co-management in La Reunion, gave a keynote talk on governance at the Western Indian Ocean Marine Science Association (WIOMSA) Conference, participated in a WIOMSA research priority-setting round table on climate change and gave talks at a number of research institutions in the USA with governance or policy-related themes. Pedro presented a paper at the Earth System Governance Project (part of the International Human Dimensions Programme on Global Environmental Change) on the institutional dimensions of environmental governance, and was admitted as a fellow of the Earth Systems Governance Project. He also commenced collaborations with the Stockholm Resilience Centre on research into governance of large marine ecosystems, and with CSIRO and the University of Georgia, USA on the institutional dimensions of climate change.

In the Solomon Islands and Papua New Guinea, Program 7 is undertaking social and ecological research on how to develop locally relevant and culturally appropriate educational resources for improving coral reef fishery management. During the latter half of 2009, Simon consolidated a productive working relationship with key personnel in the Curriculum Development Centre of the Department of Education in Solomon Islands. This work with Education Departments on high school science curricula addresses the need for training in the biology and ecology of over-fishing and reef ecosystem degradation and is essential for the future leaders of the community. Other aspects of this three year research project address the social, political and economic aspects of coral reef fishery governance at various levels.

In July and August the Centre completed a long-term consultancy with the AusAID-funded Community Sector Program in Solomon Islands – a program led by Simon Foale, which has provided valuable research material on community-based sustainable development and capacity building. In October, Simon and colleagues at the Australian Institute of Marine Science organised a workshop addressing the challenge of developing sustainable livelihoods in the Indo-Pacific region as part of the Global Environment Facility's International Waters conference in Cairns.

In 2010, Program 7 researchers will host three working groups, on sustainable artisanal fisheries (led by Simon Foale in collaboration with WorldFish, in Townsville), trans-boundary governance in the sea (Terry Hughes, in Stockholm), and on legal frameworks for incorporating ecological knowledge (John Pandolfi, in Washington DC).

Photo by Simon Foale

Media Release

Missing institutions for dealing with global crises

The world faces a compounding series of crises driven by human activity, which existing governments and institutions are increasingly powerless to cope with, a group of eminent environmental scientists and economists has warned. In today's issue of the leading international journal *Science,* the researchers say that nations alone are unable to resolve the sorts of planet-wide challenges now arising.

Pointing to global action on ozone depletion (the Montreal Protocol), high seas fisheries and antibiotic drug resistance as examples, they call for a new order of cooperative international institutions capable of dealing with issues like climate change – and enforcing compliance where necessary.

"Energy, food and water crises, climate disruption, declining fisheries, ocean acidification, emerging diseases and increasing antibiotic resistance are examples of serious, intertwined global-scale challenges spawned by the accelerating scale of human activity," say the researchers, who come from Australia, Sweden, the United States, India, Greece and The Netherlands.

"These issues are outpacing the development of institutions to deal with them and their many interactive effects. The core of the problem is inducing cooperation in situations where individuals and nations will collectively gain if all cooperate, but each faces the temptation to free-ride on the cooperation of others."

"There are few institutional structures to achieve co-operation globally on the sort of scales now essential to avoid very serious consequences", warns lead author Dr Brian Walker of Australia's CSIRO.

While there are signs of emerging global action on issues such as climate change, there is widespread inaction on others, such as the destruction of the world's forests to grow biofuels or the emergence of pandemic flu through lack of appropriate animal husbandry protocols.

"Knowing what to do is not enough," says Dr Walker. "Institutional reforms are needed to bring about changes in human behaviour, to increase local appreciation of shared global concerns and to correct the sort of failures of collective action that cause global-scale problems."

"We are not advocating that countries give up their sovereignty," adds co-author Professor Terry Hughes, Director of the ARC Centre of Excellence for Coral Reef Studies. "We are instead proposing a much stronger focus on regional and worldwide cooperation, helped by better-designed multi-national institutions. The threat of climate change to coral reefs, for example, has to be tackled at a global scale. Local and national efforts are already failing."

"The major powers must be willing to enforce an agreement – but legitimacy will depend on acceptance by numerous and diverse countries, and non-governmental actors such as civil society and business," they add.

"To address common threats and harness common opportunities, we need greater interaction amongst existing institutions, and new institutions, to help construct and maintain a global-scale social contract," the scientists conclude.

Walker, B, Barrett, S, Polasky, S, Galaz, V, Folke, C, Engstrom, G, Ackerman, F, Arrow, K, Carpenter, S, Chopra, K, Daily, G, Ehrlich, P, Hughes, T, Kautsky, N, Levin, S, Maler, K-G, Shogren, J, Vincent, J, Xepapadeas, T and de Zeeuw, A (2009). Looming global-scale failures and missing institutions. *Science* 325(5946): 1345-1346

11 September 2009

RESEARCH

Program 8: Genomics and Metagenomics of Coral Reefs

Researchers

- **David Miller** *Program Leader*
- **Tracy Ainsworth** *Research Fellow*
- **Line Bay** *Research Fellow*
- **Simon Dunn** *Research Fellow*
- **Sylvain Forêt** *Research Fellow*
- **Lauretta Grasso** *Research Fellow*
- **Ove Hoegh-Guldberg**
- **Bill Leggat**
- **Aurélie Moya**
  Visiting Research Fellow
- **Madeleine van Oppen**

The establishment of Program 8 in 2009 recognises the growing importance of genomics in coral reef research and the Centre's growing expertise and leadership in this field. The new research program is based around the structure and function of the genomes of corals, their dinoflagellate symbionts and associated bacterial and viral communities, known as the "holobiome". The long-term aim of Program 8, in association with Program 4, is to understand how the "holobiome" functions under normal and stressed conditions.

The major research highlight of 2009 was the selection of the coral *Acropora millepora* as the first animal to undergo whole genome sequencing and assembly by an all-Australian team. Rapid advances in sequencing technology and the new ground-breaking partnership between the ARC Centre, The Australian Genome Research Facility and Illumina Inc, (see opposite) has made this project possible. A key factor in the decision was the extensive transcriptome data accumulated by David Miller at James Cook University and his collaborators at the Australian National University. These data have proven to be an invaluable resource, making *Acropora millepora* the coral of choice for molecular and cell biology research by most scientists in the coral research community.

In Program 8's first year, David Miller and his group have made significant progress with a novel, comprehensive analysis of the coral transcriptome. This project has been assisted by the recruitment of Dr Sylvain Forêt, a bioinformatician and the first postdoctoral fellow in the Program, co-funded by the Australian Institute of Marine Science. Sylvain collaborated previously with the Miller group on the coral transcriptome project while on the staff at ANU and is now a key participant in the *A. millepora* genome assembly team. The first iteration of the genome assembly has been completed and the team members are looking forward to the second run which will be available in the second quarter of 2010.

Program 8 researchers are also engaged in unravelling the unique nature of the transcriptome of the coral's photosynthetic dinoflagellate symbionts. In addition to obtaining a more comprehensive coverage of the transcriptome, they have provided an interesting insight into the evolution of these organisms through characterisation of the light-harvesting gene complement of the dinoflagellate symbionts. The research of PhD student, Lynda Boldt, in Bill Leggat's group has shown this to be the most complex repertoire of such proteins identified in any organism to date.

Research on the virome was greatly assisted by the visit of Rebecca Vega-Thurber (Florida International University) and two of her group from the US during the 2009 coral spawning period on the Great Barrier Reef. This collaboration enabled the collection of material for characterisation of the viral component associated with the coral *Acropora millepora*. The analyses of the virome, along with screening the coral genome for genes of viral origin, is underway.

Other research highlights in 2009 included major advances towards the establishment of stable cell lines from coral (Alejandro Reyes-Bermudez) and the identification of more members of a unique group of genes that encode key components of the organic matrix of corals (Reyes-Bermudez & Zhiyi Lin). David Miller analysed the homeobox gene repertoire in the genome of *Schistosoma japonicum*, while Sylvain Forêt was a member of the team that analysed the genomes of three *Nasonia* species. Both resulted in authorship of *Nature* papers.

PhD student Marcelo Kitahara was an invited participant at the FAO workshop on the identification of deep-sea species, held in Rome in December. He subsequently prepared the Global List of Cold Water Corals to be used as the basis for a series of identification guides that will be the global reference on the subject. Marcelo was also an invited participant at a 5-day workshop entitled *Systematics and evolution of scleractinian corals* at the National Museum of Natural History of the Smithsonian Institution in Washington DC, held in June. The workshop was sponsored and funded by the Encyclopaedia of Life (EOL), with additional support from the Treatise on Invertebrate Palaeontology (TIP).

Article in Discovery Newsletter: Spring 2009 reproduced with thanks to the Australian Research Council

Australia's first full genome project gets green light

Coral in the Soloman Islands. Photo courtesy of Dr Simon Foale

One of the corals that form the backbone of the Great Barrier Reef will be the first animal to have its genes fully explored in Australia.

The program to sequence the entire genome, or genetic information, of *Acropora millepora*—a branching coral whose 'staghorn' shape and beautiful colours are familiar to millions of visitors to the Great Barrier Reef—marks a major milestone in Australian biotechnology: it will be the first animal genome to be fully sequenced and assembled in Australia.

The staghorn coral may look like a simple animal, but its genome is surprisingly large and complex. In fact, *Acropora millepora* has around 20 000 genes—about the same number as a human. Why such apparently simple animals as corals should require as many genes as humans is still unclear; but it was this coral which provided the first hints of how genetically complex simple animals can be.

While they don't much resemble humans, corals lie deep on the ancestral tree of all animals and share many of our genes, says Professor David Miller, head of the Genomics Program at the Australian Research Council (ARC) Centre of Excellence for Coral Reef Studies, based at James Cook University.

Professor David Miller. Photo courtesy of the ARC Centre of Excellence for Coral Reef Studies

"*Acropora millepora* is already the best-characterised coral at the molecular level and has yielded important insights into the evolution of all animals", explains Professor Miller who, together with Dr Eldon Ball of the Australian National University (ANU), will lead the *Acropora millepora* genome sequencing program.

"Corals are among the simplest animals and may reflect the ancestral animal condition and reveal important features of genome evolution", says Professor Miller.

The project is expected to provide significant insights into the mechanisms that underlie the evolution of life on Earth, including the genetic branch leading to the higher animals and humans.

As to why a coral has been chosen as the first Australian animal to be gene-mapped by Australian scientists, Professor Miller explains: "Corals have iconic significance for Australia. We have the best-preserved coral reef system in the world and the Great Barrier Reef is a cornerstone of a $6 billion a year tourism industry. As reefs elsewhere in the world decline, this value will grow if we can keep our reefs healthy and intact."

Continued on page 7…

"As the world's largest reef and one of the most important marine ecosystems on earth, the Great Barrier Reef is one of Australia's greatest natural assets and national icons."

Continued from page 6…

"This gene mapping project has both practical and scientific significance. It will help us to understand how corals build reefs, and why they fail to do so when they are under stress.

"It will enable us to predict, with much greater confidence, how corals are likely to respond to changes in the oceans such as warming, acidification, the spread of coral diseases, and various forms of pollution."

The mapping of the coral genome is a joint undertaking by the ARC Centre of Excellence for Coral Reef Studies and the Australian Genome Research Facility, in collaboration with the ANU, The Walter and Eliza Hall Institute, and The University of Queensland.

"This is a fabulous example of a multi-nodal collaboration among many players, creating a new world-class research program in coral reef genomics", says Centre Director and ARC Federation Fellow, Professor Terry Hughes.

The sequencing project builds on earlier collaborations between the ANU and James Cook University, sponsored by the ARC Special Research Centre for the Molecular Genetics of Development under the Directorship of Professor Robert Saint.

Future plans for the Centre include mapping the genome of the coral's symbiotic partner, the dinoflagellate *Symbiodinium*—a primitive marine plant, with its associated microbes. *Symbiodinium* is essential for coral growth because it carries out photosynthesis and provides the coral with carbohydrates and energy.

A bacterial community is also important for the health of the coral animal. Only by understanding all community interactions, and how they change under conditions of stress, will we be able to understand how the entire coral organism functions.

For more information contact Professor Terry Hughes at terry.hughes@jcu.edu.au or on + 61 7 4781 4000.

Great Barrier Reef corals. Photos courtesy of the ARC Centre of Excellence for Coral Reef Studies

RESEARCHER PROFILE

Professor Peter Mumby

The ARC Centre welcomes new member Professor Peter Mumby, who will be moving to Australia from the UK in early 2010, following the award of a prestigious Laureate Fellowship. Peter's award brings the number of senior fellows in the Centre to four – following the earlier awards of a Federation Fellowship (Terry Hughes, 2007-2012), Queensland Premier's Fellowship (Ove Hoegh-Guldberg, 2008-2012) and Western Australian Premier's Fellowship (Malcolm McCulloch, 2009-2013). In 2009, the Centre also hosts nine other full-time ARC Fellows, ranging across the entire spectrum of career stages.

Before embarking on a research career, Peter Mumby spent two years designing marine reserves in Belize where he experienced, first hand, the limited scientific basis for such planning. This experience was highly influential in defining and driving his research, which has been dedicated to conducting applied science in support of the management of coral reefs. In 1997, he obtained his PhD in coral reef remote sensing and then used two post-doctoral fellowships to broaden his expertise into empirical reef ecology and ecological modeling. Today, Peter uses remotely-sensed data to scale up ecological models so that they are spatially-realistic and able to inform conservation decisions directly.

Peter's research has responded to the challenge of obtaining credible evidence of human impacts at appropriate scales. Using remote sensing and field survey, he designed a study across Belize and Mexico that allowed his team to test hypotheses on the effects of mangroves on reef fish community structure. An absence of mangroves caused local extinction of the largest herbivorous fish in the Atlantic, and caused profound reductions in the biomass of many fish species.

Peter and colleagues have also studied the impacts of marine reserves on Caribbean reefs and discovered that the direct effects of protecting fish can have profound indirect effects on the ecosystem. For example, a recovery of parrotfish inside a well-managed reserve led to a reduction of macroalgae and concomitant increase in coral recruitment. Thus, while the reserve benefits fish directly, the resulting trophic cascades also benefit the corals and therefore help ensure the delivery of reef-based ecosystem services.

Peter has recently developed mechanistic ecological models of coral reefs that integrate reef dynamics, conservation actions and disturbance, including climate change. So far, the models have provided insight into the consequences of conserving herbivorous fishes, reducing nutrient runoff, conserving mangroves, and restoring urchin populations. These results have influenced reef management policy and led to new fisheries regulations.

Peter's move to the University of Queensland early in 2010 will allow him to forge new collaborations in Australia. His work aligns closely with the ARC Centre's Programs 2 and 6.

GRADUATE TRAINING

In 2009, one hundred and fifty nine graduate students were supervised by the ARC Centre's senior researchers, making the Centre the world's largest provider of graduate training in coral reef science. This commitment to postgraduate training entails a large investment in support of student research projects, conservatively costed at 25% of our annual budget. In addition, the Centre has a major early-career development program. As part of this, we actively involve students through a student committee. The Centre provides intellectual, organisational and financial help for student mentoring activities, student awards, inter-nodal supervision and visits by postgraduate students. The inaugural recipients of the "*The Virginia Chadwick Awards*", are David Abrego, Peter Cowman, Andrew Hoey, Ruth Reef and Alejandro Reyes. The five prizes of $1000 are made each year for outstanding publications written by ARC Centre of Excellence graduate students.

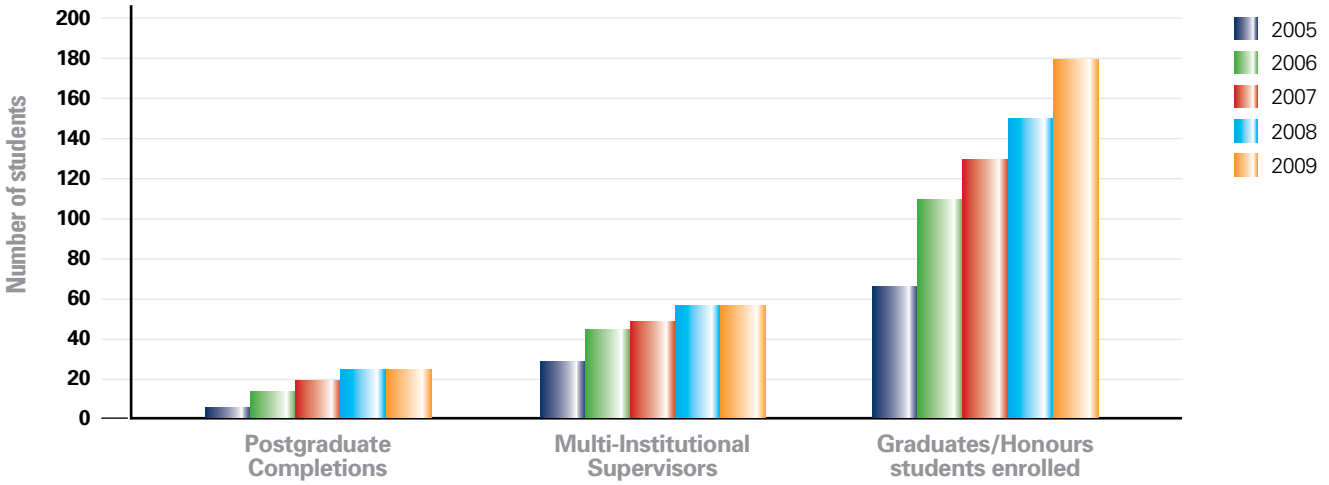
In 2009, the ARC Centre again organised and sponsored a National Mentoring Day for student delegates attending the annual Australian Coral Reef Society meeting. This year the mentoring day was held at the Novotel Hotel in Darwin at the end of September. The graduate students who attended came from James Cook University, University of Queensland, Victoria (NZ), Murdoch, Southern Cross, Sydney and NSW universities. An exit survey of the students revealed the success of the workshop with a rating of 3.89 from a possible 4. In Brisbane, earlier in the year at the Centre's annual Symposium, 17 graduate students participated in a workshop entitled *Talking science with the media*, organised by the Centre's Student Committee. The workshop was presented by Econnect Communications Pty Ltd., who have for the past 15 years run workshops on communicating science via the media.

The success of the ARC Centre's graduate program can be seen through the national and international recognition the students attracted in 2009:

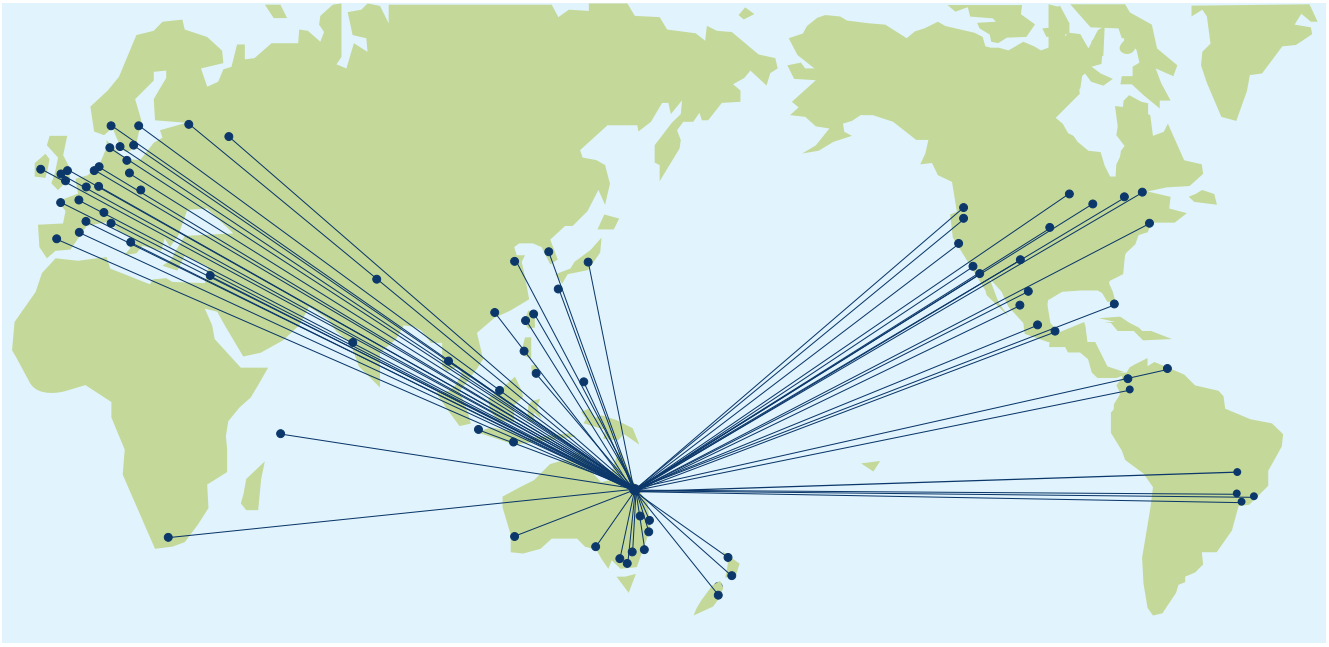
- Vanessa Adams was awarded the Sir Keith Murdoch Fellowship of $25,000 from the American Australian Association. In addition she received the Ecological Society of Australia *The Nature Conservancy Applied Conservation Award* for 2009.
- Darren Coker, Rebecca Lawton, Andrew Cole and Alexander Vail were all granted John Glover Travel Awards by the Australian Society for Fish Biology. Darren also won an AIMS@ JCU conference Travel Prize.
- Stephanie Januchowski received three grants for conference travel and research, including $33,000 from Biosecurity Queensland for research associated with her PhD studies.
- Alexander Vail won the Michael Hall Award for Student Innovation and the Gilbert Whitley Memorial Student Award (junior) at the Indo Pacific Fish Conference in Freemantle in June.
- Andrew Cole was awarded the University Centenary Student Grant for 2009 by the Wildlife Preservation Society of Australia,
- Rebecca Fox was awarded the Australian Coral Reef Society's Terry Walker Prize for 2009.
- At the annual Australian Coral Reef Society Meeting in Darwin, Rebecca Lawton was awarded the Danielle Simmons Award for 2009, while Emily Howells won the Vicki Harriott Memorial Student Prize for the best student presentation. Yui Sato, Rebecca Fox and Colin Wen also won student presentation prizes at the meeting.
- Andrew Cole, Rebecca Lawton and Alexandra Carter received research support from the PADI Foundation.
- Alexandra Carter received the GBRMPA Science for Management Award for 2009.
- Felipe Gusmao was awarded the Peter Holloway Oceanography Prize for his presentation at the Australian Marine Science Association conference in Adelaide.
- Christopher Doropoulos was awarded a Queensland Government Smart State PhD Scholarship.
- Rebecca Fox and Alicia Crawley were both awarded Lizard Island Doctoral Fellowships.

The Centre is indebted to the 2009 Student Committee for their energy and input. They, along with student co-ordinator, Olga Bazaka, make an invaluable contribution to the success of the ARC Centre of Excellence. Members of the committee during the year were Alicia Crawley (UQ), Anne Leitch (JCU/CSIRO), Juan Pablo D'Olivo (ANU), Paulina Cetina Heredia (JCU/AIMS), Rachael Middlebrook (UQ), Stephanie Januchowski (JCU) and Tom Brewer (JCU).

Trends in the ARC Centre's training activities 2005 to 2009



The ARC Centre's international network of graduate students. In 2009, 102 overseas students, representing half of the Centre's current enrolments, came to Australia from 39 countries.



2009 Student members of the ARC Centre of Excellence for Coral Reef Studies

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	Temporal and environmental influences on the early establishment and maintenance of coral-*Symbiodinium* symbioses. (PhD awarded)	Prof B Willis, Dr M van Oppen, Prof S Connolly
Vanessa Adams	JCU	USA	Incorporating economic factors into systematic conservation planning. (PhD)	Prof R Pressey, Prof T Hughes
Siham Afatta	UQ	Indonesia	Human impacts, resilience and management challenges for Indonesian coral reefs: Karimunjawa National Park case study. (MSc)	Dr K Anthony, Prof O Hoegh-Guldberg
Campbell Allen	UQ	Australia	Australian eco-informatic tools for coral reef ecology. (MSc)	Prof O Hoegh-Guldberg
Jorge Alvarez-Romero	JCU	Mexico	Cross-system threats and competing values in coastal and marine conservation planning: an integrated land-sea approach to prioritize conservation actions in the Gulf of California. (PhD)	Prof R Pressey, Dr N Ban, Dr J Kool
Shelley Anthony	JCU, AIMS	USA	White Syndrome Disease and colony mortality in captive Indo-Pacific corals. (PhD)	Prof B Willis
Stephen Ban	JCU	Canada	Investigating resilience and spatial responses of coral reef ecosystems to climate change and associated stressors. (PhD)	Prof R Pressey, Dr N Graham, Prof S Connolly
Lissa Bar	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, Prof S Connolly
Roger Beeden	JCU	New Zealand	How healthy is the Great Barrier Reef in a warming world? (PhD)	Prof B Willis
Victor Beltran-Ramirez	JCU	Mexico	Molecular aspects of the fluorescent protein homologues in *Acropora millepora*. (PhD)	Prof D Miller
Dorothea Bender	UQ	Germany	Impacts of climate change on macroalgae and their interactions with coral reef organisms. (PhD)	Dr G Diaz-Pulido, Dr S Dove
Rose Berdin	ANU	Philippines	Late Quaternary Palaeoclimate history of the northern Indo-Pacific warm pool from raised coral reefs in the Philippines. (PhD awarded)	Prof M McCulloch
Duan Biggs	JCU, CSIR South Africa, Emory University USA, University of Canterbury NZ	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

Student	University	Country of Origin	Thesis Title	CoE Supervisor/s
Pim Bongaerts	UQ	Netherlands	Ecological significance of deep, light-dependent coral communities. (PhD)	Prof O Hoegh-Guldberg
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
Tom Brewer	JCU, UQ	Australia	Linking sociological perspectives to coral reef resources across scales. (PhD)	Prof T Hughes, Prof R Pressey, Dr J Cinner, Dr S Foale, Prof J Pandolfi
Kate Bromfield	UQ, CSIRO	Australia	Neogene corals of the Indo-Pacific. (PhD awarded)	Prof J Pandolfi
Rohan Brooker	JCU	New Zealand	Reproduction and ecology of the harlequin filefish, *Oxymonacanthus longirostris*, and the implications of climate change. (MSc)	Prof G Jones, Prof P Munday
Michael Cappo	JCU, AIMS	Australia	Spatial patterns of demersal vertebrate assemblages in inter-reef waters. (PhD)	Prof M Kingsford
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 laval transport and supply in reef systems. (PhD)	Prof S Connolly
Neil Chan	JCU, UQ	Malaysia	Modelling the effects of pH, temperature and flow on calcification of reef corals. (PhD)	Prof S Connolly, Dr K Anthony
Rowan Chick	JCU	Australia	Stock enhancement of local populations of blacklip abalone *Haliotis rubra* in New South Wales, Australia. (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
Philippa Cohen	JCU	Australia	The contribution of locally-managed marine areas to food security of Solomon Islands. (PhD)	Dr S Foale, Prof T Hughes
Darren Coker	JCU, DEC in WA, AIMS	New Zealand	The role of live coral in moderating key ecological processes for coral reef fishes. (PhD)	Dr M Pratchett, Dr N Graham
Andrew Cole	JCU, DEC in WA	Australia	The effect of chronic fish predation on scleractinian corals. (PhD)	Dr M Pratchett, Prof G Jones
Melissa Cowlishaw	JCU	Australia	Determinants of home range and territorial behaviour in coral fishes: roles of body size, habitat structure and population density. (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)	Dr A Baird, Dr M van Oppen, Prof T Hughes
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
Brynn Devine	JCU	USA	Effects of ocean acidification on habitat selection in fish. (MSc)	Prof P Munday, Prof G Jones
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	Use of olfactory cues for settlement site selection in coral reef fishes. (PhD)	Prof P Munday, Prof G Jones, Dr M Pratchett
Juan Pablo D'Olivo	ANU	Mexico	Environmental and climate variability in seawater pH reconstructed from Boron 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)	Prof P Munday, Dr M McCormick
Christopher Doropoulos	UQ	Australia	Climate change effects on the recruitment and succession of algae and corals from the Great Barrier Reef. (PhD)	Dr Guillermo Diaz-Pulido
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	No-take marine protected areas: abundance, biomass, batch fecundity and genetic connectivity of target species on the Great Barrier Reef. (PhD awarded)	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 awarded)	Dr S Foale
Kar Hei (James) Fang	UQ	China	The synergistic effects of ocean warming and acidification on growth and bioerosion capacity of the marine sponge *Cliona orientalis*, on the Great Barrier Reef, Australia. (PhD)	Dr S Dove, Prof O Hoegh-Guldberg
Pepito (Sonny) Fernandez	ANU, JCU	Philippines	Political engagements in marine protected area governance in northeastern Liloilo, Philippines. (PhD)	Dr S Foale
Rebecca Fox	JCU	United Kingdom	Ecosystem function of rabbitfishes (F: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
Irene Fuertes Jerez	JCU	Spain	Characterization of microsatellite loci for *Epinephelus quoyanus* (epinephelinae): preparing to measure connections from no-take to fished areas of the Great Barrier Reef. (MAppSc)	Prof G Russ, Prof G Jones
Naomi Gardiner	JCU	Australia	Habitat specialization, co-occurrence and resting site fidelity in cardinalfish on coral reefs. (PhD)	Prof G Jones
Chris Goatley	JCU	United Kingdom	The ecological role of sediments on coral reefs. (PhD)	Prof D Bellwood

Student	University	Country of Origin	Thesis Title	CoE Supervisor/s
Alonso Gonzalez-Cabello	JCU	Mexico	Cryptobenthic reef fish ecology in the Great Barrier Reef, Australia. (PhD)	Prof D Bellwood
Luis Gonzalez Reynoso	JCU, Griffith University	Mexico	Mechanisms of stress inhibition of reproduction in fish. (PhD)	Dr M McCormick
Lauretta Grasso	ANU, JCU	Australia	Transcriptome analysis of development, with a focus on metamorphosis, in the coral *Acropora millepora*. (PhD awarded)	Prof D Miller
Erin Graham	JCU	USA	Energetics of coral larvae and its implications for dispersal. (PhD)	Prof B Willis, Prof S Connolly, Dr A Baird
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
Hugo Harrison	JCU, University of Perpignan	France	Larval recruitment dynamics and the genetic structure of coral reef fish populations in marine protected networks. (PhD)	Prof G Jones, Prof G Russ, Dr S Planes
Meegan Henderson	UQ	Australia	Microbial ecology of coral disease: the use of molecular techniques in understanding bacterial community shifts. (PhD awarded)	Prof O Hoegh-Guldberg
Christina Chemtai Hicks	JCU	United Kingdom	The interplay between economic values and societal settings in coral reef governance. (PhD)	Prof T Hughes, Prof R Pressey, Dr J E Cinner
Jean-Paul Hobbs	JCU	Australia	Isolation, endemism and the structure of coral reef fish communities on islands. (PhD)	Prof G Jones, Prof P Munday
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
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
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
Charlotte Johansson	JCU, AIMS	Sweden	Managing coral reefs - the importance of working with functional groups to conserve ecosystem resilience. (PhD)	Prof D Bellwood
David Jones	JCU	Australia	Predicting the distribution of two venomous cubozoans (*Carukia barnesi* and *Chironex fleckeri*) using population genetic structure. (PhD)	Prof M Kingsford, Prof G Russ
Jung Ok Kang	ANU	Korea	Anthropogenic increase of atmospheric carbon dioxide and ocean acidification and global warming: implications for long-term changes in the calcification rate of coral reefs. (PhD)	Prof M McCulloch
Rucha Karkarey	JCU	India	Using northern and southern Great Barrier Reef green turtle (*Chelonia mydas*) nesting data as a proxy to estimate abundance of the remote Coral Sea nesting population. (MAppSci)	Prof S Connolly
Brent Knack	JCU	Australia	Cell adhesion factors in Cnidarians. (PhD)	Prof D Miller, Dr W Leggat

Student	University	Country of Origin	Thesis Title	CoE Supervisor/s
Valeriya Komyakova	JCU	Russia	Habitat characteristics as the determinants of the local diversity and structure of coral reef fish communities. (MSc awarded)	Prof G Jones, Prof P Munday
Narinratana Kongjandtre	UQ	Thailand	The taxonomy and systematics of the genus *Favia* from Thai waters. (PhD)	Prof O Hoegh-Guldberg
Charlotte Kvennefors	UQ, JCU	Sweden	Host-microbe interactions in reef-building corals. (PhD awarded)	Dr W Leggat, Prof O Hoegh-Guldberg
Joleah Lamb	JCU	USA	Effects of offshore tourist pontoons on coral disease prevalence in the Cairns and Whitsunday sectors of the Great Barrier Reef Marine Park. (MAppSc)	Prof B Willis
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, Dr S Dove
Rebecca Lawton	JCU, KAUST	New Zealand	Geographic variation in the ecology of butterflyfishes and resilience to large scale disturbances. (PhD)	Dr M Pratchett, Dr L Bay, Prof T Hughes
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
Carine Lefevre	JCU	France	The ecology of cryptobenthic reef fishes. (PhD)	Prof D Bellwood
Anne Leitch	JCU, CSIRO	Australia	Social resilience to climate change: the adaptive capacity of local government. (PhD)	Prof T Hughes
Anais Kimberley Lema	JCU, AIMS	Mexico/ France	Nitrogen fixing bacteria associated with corals of the Great Barrier Reef. (MSc)	Prof B Willis
Tove Lemberget	JCU	Norway	Importance of body condition and growth to larval survival of a Caribbean lizardfish. (PhD)	Dr M McCormick, Prof G Jones
Vetea Liao	JCU	French Polynesia	Direct effect of temperature on growth and body condition of the coral reef fish *Acanthochromis polyacanthus*. (MAppSc)	Dr M Pratchett
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 awarded)	Prof G Jones
Jeffrey Maynard	U. Melbourne, UQ	USA	Climate-change processes affecting coral reef ecology. (PhD)	Dr K Anthony
Dominique McCowan	JCU	USA	Bleaching susceptibility of corals: a hierarchy of causes and consequences. (PhD)	Dr M Pratchett, Dr A Baird, Prof T Hughes
Amelie Menchenin	JCU	France	Early life history of *Epinephelus quoyanus*. (MAppSc)	Prof G Jones, Prof G Russ
Luiz- Felipe Mendes-de-Gusmao	JCU, AIMS	Brazil	Studies on secondary production of zooplankton in tropical seas and aquaculture. (PhD)	Prof M Kingsford
Vanessa Messmer	JCU, U. Perpignan	France	Causes and consequences of declining fish biodiversity in coral reefs. (PhD)	Prof G Jones, Prof P Munday

Student	University	Country of Origin	Thesis Title	CoE Supervisor/s
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
Gabrielle Miller	JCU	Australia	Impact of pH on fish development. (PhD)	Prof P Munday, Dr M McCormick
Morena Mills	JCU	Brazil	Implementation opportunity in systematic conservation planning. (PhD)	Prof R Pressey, Dr N Ban, Dr S Foale
Matthew Mitchell	JCU	United Kingdom	Antipredator defence through chemical alarm cues - how common amongst tropical marine fishes? (PhD)	Dr M McCormick
Roshni Narayan	UQ	Canada	Holocene to recent changes in the benthic foraminifera communities of subtropical Moreton Bay, Queensland and potential indicators for monitoring sediment/water quality in estuarine environments. (PhD)	Prof J Pandolfi
Crystal Neligh	JCU	USA	Links between metabolism, growth and performance (MSc)	Dr M McCormick
Daisie Ogawa	JCU	USA	Synergistic effects of ocean acidification and elevated temperature on carbon-concentrating mechanisms and energy transfer in the coral holobiont. (PhD)	Dr W Leggat, Prof D Yellowlees
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 awarded)	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 defences 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	USA	Phylogeography of the coral pathogen, *Vibrio coralliilyticus*, and the development of a qPCR-based diagnostic assay for its detection. (MSc)	Prof B Willis
Mary Portwood	JCU	USA	Influence of marine protected areas on invertebrate communities. (MAppSc)	Prof G Jones
Eneour Puill-Stephan	JCU, AIMS	France	Self-nonself recognition and chimerism in *Acropora millepora*. (PhD)	Prof B Willis, Dr M van Oppen
Paola G. Rachello-Dolmen	UQ	Italy	Constructing long-term proxy records of historical changes in marine mollusc assemblages in tropical and subtropical Queensland region (Australia). (PhD)	Prof J Pandolfi
Jean-Baptiste Raina	JCU, AIMS	France	Coral-associated bacteria and their role in the biogeochemical cycle of sulphur. (PhD)	Prof B Willis
Ana Redondo-Rodriguez	UQ, AIMS	Spain	Implications of climate change for the oceanography of the Great Barrier Reef ecosystem. (PhD)	Dr K Anthony, Prof O Hoegh-Guldberg
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

Student	University	Country of Origin	Thesis Title	CoE Supervisor/s
Alejandro Reyes	JCU	Colombia	Cellular mechanisms of coral calcification. (PhD)	Prof D Miller
Catalina Reyes	UQ	Colombia	The role of elevated CO2 scenarios on bioerosion of coral reef ecosystems. (PhD)	Dr S Dove, Dr G Diaz-Pulido, Prof O Hoegh-Guldberg
Maria Catalina Reyes-Nivia	UQ	Colombia	Effects of climate change on bioerosion of reef carbonates. (PhD)	Dr S Dove, Dr G Diaz-Pulido
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 coral diseases on Palauan reefs and the role of marine protected areas in mitigating their impacts (MSc)	Prof B Willis, Prof G Jones
Jairo Rivera Posada	JCU	Colombia	Pathogenesis in crown-of-thorns starfish (*Acanthaster planci*). (PhD)	Dr M Pratchett, Prof T Hughes, Dr T Ainsworth
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
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
Shio Segi	ANU, JCU	Japan	Living under threat: depletion, development and marine protected areas 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
Jennifer Smith	JCU	Canada	Influence of patch dynamics on coral reef fishes on the southern GBR. (MSc)	Prof G Jones, Dr M McCormick
Jessica Stella	JCU, Australian Museum	USA	Climate impacts on non-coral reef invertebrates. (PhD)	Prof G Jones, Dr M Pratchett, Prof P Munday
Meir Sussman	JCU, AIMS	Israel	A molecular approach to the study of coral diseases. (PhD awarded)	Prof B Willis
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 A Baird, Dr M Pratchett, Dr L Bay
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

Student	University	Country of Origin	Thesis Title	CoE Supervisor/s
Lucija Tomljenovic	JCU	Croatia	Charcterisation of the TTC4 gene family. (PhD awarded)	Prof D Miller
Gergely Torda	JCU, AIMS	Hungary	Assessment of ecological connectivity in corals: implications for their recovery from major perturbations and their potential to adapt to climate change. (PhD)	Dr M van Oppen, Prof B Willis
Mélanie Trapon	JCU	France	Ongoing disturbances and further shifts in community structure among coral assemblages at Moorea, French Polynesia. (MAppSc)	Dr M Pratchett, Dr L Penin, Prof G Jones
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	Characterisations 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 Cecilia Villacorta Rath	JCU	Peru	Selective mortality during early life stages 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, Prof 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
Christine Weaver	JCU	USA	Competition between two damselfishes. (MAppSc)	Dr M McCormick
Rebecca Weeks	JCU	United Kingdom	Approaches to designing marine protected area networks in the Philippines. (PhD)	Prof G Russ
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	Recruitment hotspots and their role in the ecology and management of large exploited predatory fishes. (PhD)	Prof G Jones, Dr M Pratchett, Dr G Almany
Amelia Wenger	JCU	USA	Effects of sedimentation and turbidity on planktivorous fishes. (MSc)	Prof G Jones, Dr M McCormick
David Williamson	JCU	Australia	Fishery effects and benefits of marine protected areas within the Great Barrier Reef Marine Park. (PhD awarded)	Prof G Russ, 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

MEDIA AND PUBLIC OUTREACH

The ARC Centre seeks to inform the wider community of its research outcomes through the media and through public awareness activities. In 2009, Centre personnel participated in 45 public outreach programs, reaching audiences locally, nationally and internationally. Examples include:

- Researchers from the ARC Centre of Excellence teamed with Google to populate the GBR section of *Google Earth's Ocean* with information about the reef and human impacts on it.
- The Centre hosted its 2-day national symposium and public forum in Brisbane on the 6th – 7th August
- Under the Queensland *Scientists in School* program, Line Bay, hosted an information booth about threats to the Great Barrier Reef at the Mundingburra State School 125th year anniversary fete.
- At the invitation of the Royal Australasian College of Surgeons, John Pandolfi presented a lecture *Countdown to extinction: Can coral reefs survive?*
- Terry Hughes presented a public lecture in Brisbane on coral reef resilience, part of a lecture series run by the National Climate Change Adaptation Facility, at Griffith University.
- In association with the Queensland branch of the Australian Academy of Science, the Centre hosted a public forum in Townsville, with presentations from six Fellows of the Academy, including Terry Hughes and Academy medallist Sean Connolly, to showcase the growing international profile of Queensland scientists.
- Malcolm McCulloch presented a lecture *Shaping the Future Climate Change: Sceptics Denial* as part of the University of Western Australia's public lecture series.
- During October and November, Mike Kingsford gave a series of public lectures at the University of Bergen (Norway), University of Copenhagen (Denmark) and the University of Uppsala (Sweden).
- Ove Hoegh-Guldberg participated in a Q&A session at the international launch in Copenhagen of the movie documentary *A Sea Change: imagine a world without fish.*
- In Kimbe Bay, Papua New Guinea, Glenn Almany led a series of discussions with local communities that own, manage and depend on coral reefs about climate change, overfishing and the value of marine protected area networks in mitigating their impacts and the importance of understanding connectivity to design a resilient network.
- In April, Josh Cinner participated in a public forum on *Beyond the obituaries: success stories in marine conservation* at the Smithsonian Institute in Washington DC.

As part of our communications strategy the Centre has developed a robust media strategy in consultation with Julian Cribb, our media advisor. Julian converts sometimes esoteric science into everyday language and delivers our research findings to a diverse Australian and international audience.

In 2009, the ARC Centre produced 39 media releases, generating 2190 media stories that reached local, national and international audiences. Five hundred and eighty-four news articles and commentaries were on the web, in addition to 71 television and 296 radio reports, 1073 newspaper and 166 magazine articles. The Centre's research in the Coral Triangle region attracted considerable media coverage during the World's Ocean Conference in Manado, Indonesia in May 2009. Over 900 media stories were generated during the week long conference (see p.46).

The Centre's website caters for multiple audiences, providing information, access to resources, research services, and downloads of research, teaching and educational tools. The site received 4.5 million web hits in 2009, a six-fold increase over the past 4 years. It ranks first of 20.2 million websites found in a Google search for "coral research".

In 2009, the Centre's educational resources web pages were further developed to cater for the demand by school children for information on coral reefs. In collaboration with the Australian Academy of Science, a new NOVA topic, *Science for sustainable reefs,* was developed and launched on the Academy's website. This resource provides the latest science on coral reefs in a format readily accessible for secondary school teachers, students and parents. The Centre's highly popular webinar series continued in 2009 with the addition of 35 new talks under the theme, *Securing the Future of Coral Reefs.* These videos range from short, highly topical presentations on issues of interest to a general audience to longer videos showcasing the latest, leading-edge science for a scientifically informed audience. The Centre also developed a new website for the 2012 International Coral Reef Symposium which will be launched in March 2010. During 2010, the Centre's website will be redesigned to enhance access to our research services and information, and to improve navigability.

Examples of the Centre's 2,190 media hits in 2009 include:

New Scientist, *Acid oceans no laughing matter for clownfish*, 2/2/09, P. Munday

BBC News, *Australian scientists have found a new, unexpected impact of ocean acidification*, 4 /2/09, P Munday

Australian Story, ABC television. *The heat of the moment,* 9/2/09, O Hoegh-Guldberg

The Australian, *Barrier Reef lands in Google Net,* 11/2/09, D Bellwood

CNN.com/Asia, *Beating poverty would save coral reef fish*, 9/2/09, J Cinner

Bush Telegraph, ABC Radio National, *Fat corals make better survivors interview*, 10/3/09, K Anthony

Conservation Magazine, *Saving Nemo,* 24/3/09, G Jones

Lateline, ABC television, *interview with Margot O'Neill*, 30/3/09, O Hoegh-Guldberg

The Guardian, UK, *Damaged Barrier Reef coral makes 'spectacular' recovery*, 22/4/09, G Diaz Pulido

Discovery Channel, *Stress gives fish wonky ears*, 28/4/09, M McCormick

Solomon (Islands) Star, *Markets deplete fish stocks here*, 29/4/09, T Brewer

ABC local and national news, *Coral can't escape the heat*, 7/5/09, M McCulloch

The Jakarta Post, *Oceans key in climate change battle,* 14/5/09, O Hoegh-Guldberg

The Reef and Marine Aquarium magazine, *The Lazarus Reef: rebounding bleached Acropora corals recorded off* Australia, May/June 09, K Anthony, M Hoogenboom, R Middlebrook

Sydney Morning Herald, *Scientists warn acid is killing oceans*, 2/6/09, T Hughes

The Hindu, *Failed policies, corruption leading to overfishing*, 23/6/09, J Cinner

World News, *World's corals face danger as global warming whips up powerful storms,* 24 June 2009, J Mallela

Africa Geographic, *On the social scale*, July 09, J Cinner

Townsville Bulletin, *Happiness doesn't have to cost the Earth,* 11/7/09, S Foale

Australian Geographic, *News: turf wars*, 14/7/09, L Penin

ScienceBlog, *Humans 'damaging the oceans'*, 30/7/09, M Kingsford

The Age, *Scientists to unlock Great Barrier Reef genome*, 30/7/09, D Miller

BayJournal, *Moreton Bay corals get the spotlight*, 6/8/09, J Pandolfi

Sunday Mail, *Scientists find Nemo all at sea*, 9/8/09, P Munday

Courier Mail, *'TimTams' of the reef go missing*, 25/8/09, D Bellwood

Cairns Sun, *$14m reef forum coup*, 26/8/09, ARC Centre

Malaysia Sun, *Man-made crises outrunning our ability to deal with them*, 12/9/09, T Hughes

Australian R&D Review, *World at a tipping point*, October 2009, T Hughes

7.30 report, ABC TV, *Feature- coral calcification*, 10/10/09, J Lough, A Crawley, S Dove

Townsville Bulletin, *Bullied to death*, 7/11/09, M McCormick

Reuters, *Great Barrier Reef survival 'requires 25% CO_2 cut'*, 17/11/09, T Hughes

ARD German public radio network, *interview with Bernd Musch Borowska*, 2/12/09, O Hoegh-Guldberg

Seoul Times, *Scientists call for 'ocean parks' to protect seas*, 8/12/09, B Pressey

Photo by Pim Bongaerts

Australian News

AUSTRALIA: Scientist Pushes For Coral Triangle Action

Written by Stephen de Tarczynski

MELBOURNE, Jul 7 (IPS) - While Australia remains committed to playing an ongoing role in assisting the six nations of the Coral Triangle Initiative (CTI) to protect their marine environments, a leading scientist here says that an Australian-style of management in the triangle will not work.

"There is no single recipe for how to manage a reef well and the Great Barrier Reef model is not exportable to a poor country," says Professor Terry Hughes, director of the highly-regarded Australian Research Council Centre of Excellence for Coral Reef Studies. The Centre is a partnership of several leading universities and statutory bodies - located at James Cook University in Townsville.

"Australia is very much the lucky country when it comes to having the resources to manage reefs and to pay for science and reef management," he says.

"There's a huge contrast between Australian investment in science and reef management compared to almost anywhere else in the world because most coral reef countries in the tropics are developing countries and just don't have the resources that we do," he adds.

But the signing of the declaration of the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security at the CTI summit in Manado, Indonesia in May indicates that where the political will exists, less-affluent nations can also undertake action to protect their marine environments for the benefit of current and future generations.

Indonesia, Malaysia, the Philippines, East Timor, Papua New Guinea and the Solomon Islands - the so-called Coral Triangle Six (CT6) - have committed to cooperate to preserve the biologically diverse yet highly-populated Coral Triangle, an area which covers some 5.7 million square kilometers in Southeast Asia and Melanesia.

Australia is currently involved in researching marine environments in the triangle and in the Pacific region, with the ARC Centre of Excellence for Coral Reef Studies working already in the Philippines, Indonesia, the Solomon Islands and Papua New Guinea.

"The initiative is new and it's wonderful to see it, but Australian scientists see this as an opportunity to ramp-up an existing engagement. It's not as if we're starting from scratch," says Hughes.

Additionally, of the Centre's current batch of 155 PhD students, 95 are from the immediate region. Australia was quick to pledge an initial AUD$2 million to fund critical projects within the CTI - part of the USD$300 million to be provided by the Global Environment Facility, the Asian Development Bank, the United States and other partners. The Rudd government describes the first phase of this as an "ongoing plan" to back the CT6.

"This investment will focus on areas where we can make the greatest contribution by sharing our knowledge and directly supporting capacity building in marine biodiversity conservation, sustainable fisheries, protecting vulnerable marine species and community empowerment," said Peter Garrett, the country's environment minister.

Australia's role as a supporter of the CT6 stems from a request sent to it by Indonesian President Susilo Bambang Yudhoyono at a CTI meeting in Bali in Dec. 2007. He asked for Australian technical expertise to aid in protecting the triangle.

Hughes told IPS that Australia is compelled to act. "Australia has a capacity that, in my opinion, obligates it to be a major player in the Coral Triangle region," he said.

While he supports the view that the threat faced by the inhabitants of the triangle's coastal areas requires a multilateral approach, the diversity of marine environments within the Coral Triangle means that a one-size-fits-all solution to management is not viable.

"You need to tailor-make the management style to what will work on the ground in the different regions," says Hughes. Written by Stephen de Tarczynski

Article extract, reproduced with thanks to Australian News website www.australia.to

The ARC Centre and James Cook University are honoured to have been invited by the International Society for Reef Studies to host the 12th International Coral Reef Symposium (ICRS) in Australia in 2012. The ICRS is the world's largest and most important coral reef meeting, bringing together coral reef scientists, educators, graduate students, resource managers and policy makers. The 12th ICRS is expected to attract approximately 2,500 delegates from 80 countries to the Cairns Convention Centre, from 9th–13th July 2012. A First Announcement was made in 2009 to inform potential delegates of the dates and venue for the next ICRS and also to direct them to the Symposium's new website, at *www.icrs2012.com*.

ICRS 2012 will provide the international science community with a platform to increase global knowledge and interest in coral reefs, as well as the opportunity to showcase innovative science, and the latest developments in coral reef conservation and management. Close to 2,000 talks and posters will be presented on major themes including climate change, reef ecology, conservation planning, fish and fisheries, genomics, management tools, the Coral Triangle Initiative and the human dimension of coral reefs.

Activities at ICRS 2012 will include a comprehensive science program, a trade exhibition, and field trips both before and after the Symposium to the Heron Island, Lizard Island and Orpheus Island Research Stations. Exciting and culturally significant Australian social events and the Symposium banquet will provide additional networking opportunities for delegates to develop collaborations and partnerships to increase international capacity in coral reef research, education and environmental management. ICRS 2012 will attract an extensive international media contingent, and the ARC Centre expects to host some 100 journalists, whose stories will increase awareness of coral reef science across the world.

In developing ICRS 2012, the ARC Centre has established an Executive Committee (chaired by the Symposium Convenor, Terry Hughes), linked to sub-committees responsible for fundraising (led by David Yellowlees), and developing the scientific program (chaired by Terry Done). Two other sub-committees for overseeing the proceeding publications and for field trips will be established in 2010. The committee membership, listed on the Symposium website, is global. We sincerely thank everyone who has volunteered their expertise and support.

Our objective is for ICRS 2012 to be carbon-neutral, and we are actively pursuing innovative ways to reduce carbon emissions.

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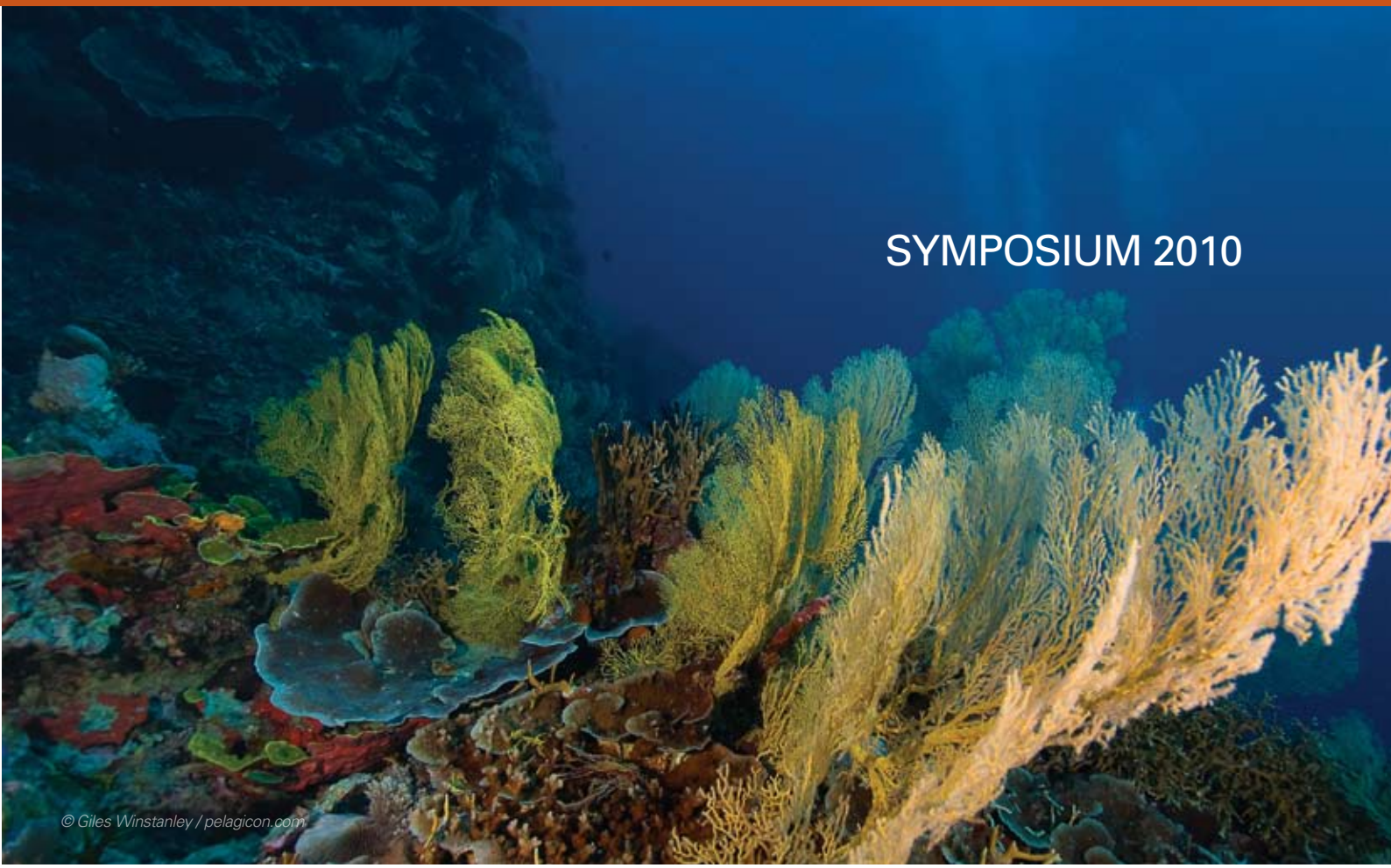
"The ARC Centre, too, is highly ambitious... in its determination to remain at the cutting edge of world science... and its commitment to drive forward the national and international agenda on the sustainable use and management of coral reefs."

Her Excellency, Ms Penelope Wensley, the Governor of Queensland. Opening the ARC Centre's annual symposium, *Securing Coral Reef Futures*, Brisbane, August 2009.



SYMPOSIUM 2010

A highlight of the ARC Centre's 2010 calendar will be hosting an inter-academy symposium on coral reefs, at the Shine Dome in Canberra on October 7-8th. The Centre's annual symposia are an important feature of our outreach activities. 2010 will be a particularly special event as we will be presenting the conference in partnership with the Australian Academy of Science and The Royal Society, which is celebrating its 350th anniversary. The Canberra symposium will incorporate presentations by members of both national academies and the ARC Centre of Excellence for Coral Reef Studies, to celebrate the birth, development and emergence of coral reef sciences.

The Royal Society has a long history of involvement with research on the Great Barrier Reef. In 1928 they sponsored C. M. Yonge to lead an expedition to the Lowe Isles in northern Queensland. This was the world's first detailed scientific study of coral and coral reefs. Less than 100 years later, Australian coral reef science and reef management are among the most developed in the world, and every year close to 200 international scientists travel to the Great Barrier Reef to pursue their research.

2010 is also the International Year of Biodiversity. It is therefore fitting that The Royal Society is taking the opportunity to recognize the special importance of the world's coral reefs as part of its 350th anniversary. Celebrations will comprise four major events: the 2-day symposium, a public forum and an exhibition at the National Museum of Australia in Canberra, and a Frontiers of Science meeting to be held in Perth.

The Public Forum will be held in the National Museum of Australia on the evening of 7th October. It will be hosted by a science celebrity, with researchers presenting short talks to a general audience. The National Museum of Australia will host a special commemorative exhibition to coincide with the Public Forum and Symposium. The exhibition will feature artifacts from The Royal Society's collection from Captain James Cook's exploration of Australia, as well as historic items of significance to marine science from Australian museums and private collections.

Following the Canberra events, a UK-Australia *Frontiers of Science* meeting sponsored by The Royal Society and the Australian Academy of Science will be held in Perth, from 13th-19th October. Future leaders in marine science will present the latest advances in their fields, learn from each other about research developments in other marine science disciplines and explore opportunities for collaboration. Early career researchers from the ARC Centre of Excellence, Australian Postdoctoral Fellows Tracy Ainsworth and Natalie Ban, have been selected by the Australian Academy of Science to represent Australia on the organising committee for this international meeting.

NATIONAL BENEFIT CASE STUDY

Case Study 1: Improved protection for the Coral Sea

The Coral Sea is bounded to the south by the 24th parallel, by New Caledonia, Vanuatu and the Solomon Islands to the east, Papua New Guinea and Solomon Islands to the north, and Queensland to the west. It has a very rich biodiversity and is one of the few places remaining on Earth where large pelagic fishes (tuna, billfish and sharks) have not yet been severely depleted. Importantly, it also provides a refuge for some critically endangered species including the Hawksbill and Green turtles. It therefore constitutes an extremely valuable resource with outstanding conservation values. Consequently, the ARC Centre of Excellence for Coral Reef Studies supports the establishment of the Coral Sea as one of the world's largest marine protected areas.

Researchers in the ARC Centre have recommended to the Federal Government that the whole Coral Sea should become a no-fishing area to protect its immense environmental and heritage values from escalating overfishing and climate change. There is overwhelming evidence, generated by the ARC Centre and elsewhere, that the world's marine ecosystems have been seriously degraded by overfishing, pollution and global warming. Eleven percent of land habitats have been designated as parks to conserve their biodiversity and the ecosystem services they provide to people. In contrast, less than 0.1 per cent of the world's oceans are fully protected.

In a media interview published worldwide in 2009, ARC Centre researcher John Pandolfi stated that "Fishing activities in the Coral Sea contribute to significant declines of sharks, turtles and seabirds. A single large no-take zone is the best approach for protecting these pelagic and migratory species because they cannot be protected inside small reserves." The practicality of this statement was confirmed by economic research undertaken by members of the Centre's Program 6 on Conservation Planning (p.26). Consideration of management costs is important for several reasons. First, resources must be available for effective, long-term management to ensure effective conservation. Second, costs of management can be considerable, and should therefore be explicitly addressed in the site design and selection process. Third, current management budgets are rarely sufficient to achieve all their objectives. Incorporating management costs from the outset of any planning exercise is critical.

In collaboration with Queensland National Parks and Wildlife Service, Bob Pressey, Vanessa Adams and Natalie Ban addressed a key question that had not been considered – here or elsewhere – of whether there was a significant difference in the estimated management cost for different zoning proposals for the Coral Sea. Specifically, what is the difference in management costs between multiple use zones versus a single large no-take area?

The Centre's researchers developed two novel approaches for estimating the management costs for a Coral Sea Marine Protected Area (MPA). They first examined the current operational budgets for existing Commonwealth MPAs to identify key indicators of management costs. The second approach identified management requirements for the Coral Sea, and estimated costs for these activities based on expert interviews and on the existing operating costs for the Great Barrier Reef Marine Park. The resulting management estimates for the Coral Sea indicate that a single large marine reserve is less expensive to manage than multiple-use areas of equivalent size with a 30% no-take component. Regardless of the method used, the difference between the costs of a 30% versus 100% no-take scenarios is the same: it is about 1.6 times more expensive to manage a multiple-use area than the same area with 100% protection.

In May 2009, the Coral Sea was declared as a Conservation Zone by the Hon. Peter Garrett, the Federal Minister for the Environment, Heritage and the Arts. The new Conservation Zone constitutes 972,000 km^2 of Australian waters and seabed from directly east of the Great Barrier Reef Marine Park out to the edge of Australia's Exclusive Economic Zone. Minister Garrett said that "The Coral Sea Conservation Zone will protect this environmentally significant area from increasing pressures while the national marine bioregional planning process is undertaken, with a final plan scheduled for completion in 2010".

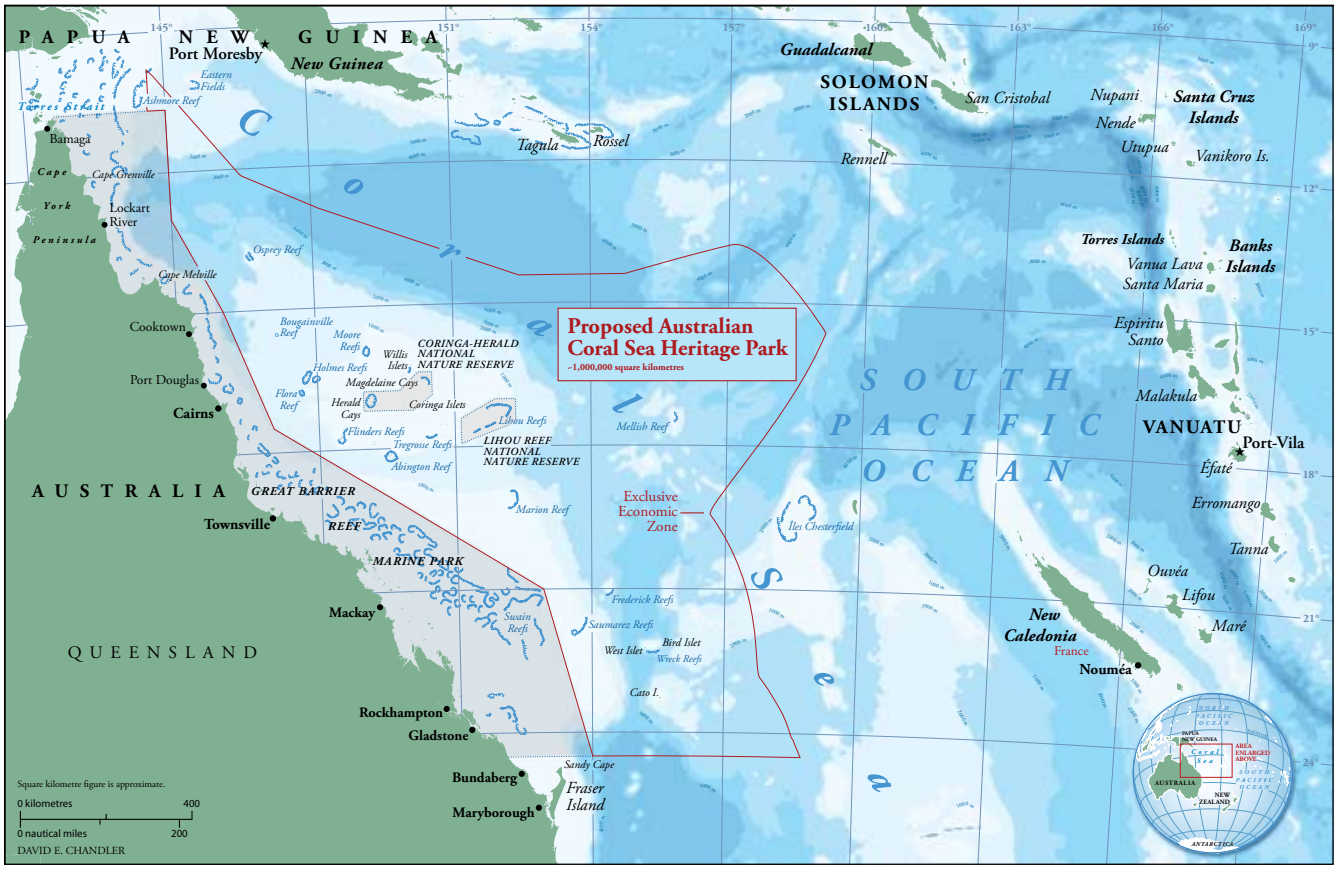
Sample publications:

Almany, G, Connolly, S, Heath, D, Hogan, J, Jones, G, McCook, L, Mills, M, Pressey, R and Williamson, D (2009). Connectivity, biodiversity conservation and the design of marine reserve networks for coral reefs. *Coral Reefs* 28(2): 339-351.

Calvo, E, Marshall, JF, Pelejero, C, McCulloch, MT, Gagan, MK and Lough, JM (2007). Interdecadal climate variability in the Coral Sea since 1708 A.D. *Palaeogeography, Palaeoclimatology, Palaeoecology* 248(1-2): 190-201

Game, ET, Grantham, HS, Hobday, AJ, Pressey, RL, Lombard, AT, Beckley, LE, Gjerde, K, Bustamante, R, Possingham, HP and Richardson, AJ (2009). Pelagic protected areas: The missing dimension in ocean conservation. *Trends in Ecology & Evolution* 24(7): 360-369.

Hughes, TP (2009). Seascape patterns and dynamics of coral reefs. pp 482-487. In *The Princeton Guide to Ecology*. S. A. Levin (Ed.). Princeton Press, Princeton.



Map reproduced with thanks to the Pew Foundation

Photo by Simon Foale

Media Release

Scientists call for 'ocean parks' to protect seas

An international team of scientists has called for the creation of marine protected areas in the open oceans to protect the world's sea life from growing damage and loss caused by overexploitation, pollution and other human impacts.

"Pelagic ecosystems now face a multitude of threats including overfishing, pollution, climate change, eutrophication, mining and species introductions," the researchers warn in the journal *Trends in Ecology and Evolution* (TREE). These threats can act together to cause far greater damage to marine food chains, fish stocks and ecosystems.

"Mobile pelagic species also suffer from the cumulative impact of sublethal stressors. Chronic exposure to chemical and acoustic pollution from shipping, military activities or oil and gas exploration and exploitation can lead to immunosuppression and reproductive failure in marine mammals," they add.

The high seas provide almost 80 per cent of humanity's fish supplies, carry out half the photosynthesis (conversion of solar energy to sustain life) that takes place on the planet and, through their ability to absorb CO_2, are a dominant influence over the speed and extent of climate change.

"It is clear from declines in many species that there is inadequate protection for pelagic biodiversity and ecosystems," the researchers from Australia, South Africa and Poland say.

"Fewer protected areas exist in the open ocean than in any other major ecosystem on Earth," explains Professor Bob Pressey of the ARC Centre of Excellence for Coral Reef Studies, a co-author of the article.

"Although there is growing support for the idea of marine protected areas in the open oceans, critics have argued they would be difficult and costly to enforce and manage in the ever-changing ocean environment.

"However my colleagues and I consider that recent advances in conservation science, oceanography and fisheries science can provide the necessary evidence, tools and information to operate these 'ocean parks' for the conservation of marine species that live in the high seas.

The scientists argue ocean protected areas should be seen as simply another form of marine protected area, except that they will extend in three dimensions – across the surface and deep into the water itself.

They note that on the high seas, there is no single global body with the authority to establish protected areas or to regulate access to and use of an area for more than one purpose. However they say progress can be made through Regional Fisheries Management Organizations, the International Maritime Organisation and by individual countries doing more to protect the outer parts of their 200 mile sovereign territories.

By reducing the cumulative impact of human activities on the world's oceans, MPAs can help to mitigate the severity of particular threats that cannot be directly controlled: "We believe that pelagic MPAs have now come of age as an important tool in the planet's last frontier of conservation management."

Game, ET, Grantham, HS, Hobday, AJ, Pressey, RL, Lombard, AT, Beckley, LE, Gjerde, K, Bustamante, R, Possingham, HP and Richardson, AJ (2009). Pelagic protected areas: The missing dimension in ocean conservation. *Trends in Ecology & Evolution* 24(7): 360-369.

19 October 2009

A new ISI Web of Science analysis of journal publications and citations identifies the ARC Centre of Excellence for Coral Reef Studies as the premier climate change research institution in Australia, with three Centre researchers ranked among the top 20 researchers in the world for total number of citations on climate change papers.

www.sciencewatch.com/ana/fea/pdf/09novdecFea.pdf

NATIONAL BENEFIT CASE STUDY

Case Study 2: Informing governments on responding to Climate Change

The 2009 United Nations climate change summit in Copenhagen attracted >100 world leaders, including the Prime Minister of Australia. The ecological, social and economic consequences of climate change for coral reefs in Australia and throughout the tropics are critical issues that pervade all of the ARC Centre's research programs. The Great Barrier Reef alone contributes $5.4 billion annually to the Australian economy – $5.1 billion from the tourism industry; $153 million from recreational activity; and $139 million from commercial fishing.

The ARC Centre of Excellence for Coral Reef Studies is a global leader in climate change research, producing so far well over 500 papers since 2005 on this broad inter-disciplinary topic. In 2009, *ISI Web of Science* analysed 28,000 journal articles on climate change research published world-wide over the past decade. From this vast data-set, *Web of Science-Science Watch* identified the most-cited institutions and authors globally. Among the leading institutions, James Cook University – headquarters of the ARC Centre of Excellence for Coral Reef Science - is ranked 2nd in the world in terms of impact, measured as citations per paper in climate change research. Among the top papers of the decade, the most highly-cited climate-change publication led by an Australian author is a 2003 *Science* paper by Centre Director, Terry Hughes and colleagues, entitled "*Climate Change, Human Impacts, and the Resilience of Coral Reefs*". According to *Web of Science*, three Australians rank among the top 20 researchers in the world for the number of citations their climate change papers have received - ARC Centre members Ove Hoegh-Guldberg, Terry Hughes and John Pandolfi.

The ARC Centre engages with many end-users of climate change research, in Australia and globally. For example, Australian Academy of Science Fellows Malcolm McCulloch and Terry Hughes joined colleagues from Brazil, Canada, China, Germany, New Zealand, Mexico, Japan, and Sweden in 2009 to produce an Inter-Academy statement on ocean acidification. The statement, timed in advance of the Copenhagen United Nations Framework Convention on Climate Change (UNFCCC) negotiations, summarizes the current state of the science, and is aimed at policy-makers. In September, Deputy Director, Ove Hoegh-Guldberg provided Congressional briefings on climate change and ocean acidification, in Washington DC. In October, the ARC Centre's Director provided a plenary talk on climate change, adaptation and coral reefs, at the 2009 ASEAN Conference on Biodiversity in Singapore, preceding the ASEAN Ministerial Meeting on the Environment.

In Australia, the Federal and Queensland environment ministers acknowledged the key research provider role of the ARC Centre, the Australian Institute of Marine Science, and the Commonwealth Scientific and Industrial Research Organization, in their formal response to the *2009 Great Barrier Reef Outlook Report*. The report is a legislative requirement, presented every 5 years to both Houses of the Australian Parliament. The inaugural 2009 report provides a summary of many of the ARC Centre's research findings, and will inform policy and management decisions. In Western Australia, Deputy Director Malcolm McCulloch provided a series of briefings to the Western Australian Department of Environment and Conservation. In November, the Centre was a major contributor to a briefing on emission reduction targets and the Great Barrier Reef, provided to Australian Members of Parliament and Senators, in Parliament House, Canberra. The ARC Centre's Director and two Deputy Directors, along with Partner Investigator, Janice Lough from the Australian Institute of Marine Science, contributed to the briefing, under the auspices of the *Federation of Australian Scientific and Technological Societies.*

The ARC Centre contributed senior personnel to the team that drafted the *National Climate Change Adaptation Research Plan for Marine Biodiversity and Resources*. Subject to Ministerial approval, the national plan provides a framework to guide research funding decisions, and identifies the research required over the next 5-7 years to inform policy development and management of marine resources. The plan focuses on aquaculture, commercial and recreational fisheries, conservation, and tourism.

Sample 2009 publications:

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Cinner, JE, McClanahan, TR, Graham, NAJ, Pratchett, MS, Wilson, SK and Raina, J-B (2009). Gear-based fisheries management as a potential adaptive response to climate change and coral mortality. *Journal of Applied Ecology* 46: 724-732.

de Freitas, DM, Kininmonth, S and Woodley, S (2009). Linking science and management in the adoption of sensor network technology in the Great Barrier Reef coast, Australia. *Computers, Environment and Urban Systems* 33(2): 111-121.

McCook, L, Almany, G, Berumen, M, Day, J, Green, A, Jones, G, Leis, J, Planes, S, Russ, G, Sale, P and Thorrold, S (2009). Management under uncertainty: Guide-lines for incorporating connectivity into the protection of coral reefs. *Coral Reefs* 28(2): 353-366

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Photo by Simon Foale

Media Release

Nemo "won't be coming home"

Nemo, the lovable clownfish of movie fame, may be unable to find his way home as the world's oceans acidify due to human-derived carbon emissions.

Fish lose the sense of smell that guides them home when sea water becomes more acidic – with potentially devastating consequences for sea life, an international team of scientists has discovered.

Like many reef and coastal fish, Nemos are swept off their home reef into the open ocean as tiny babies and use their acute sense of smell to find their way back again.

The researchers tested clownfish raised in normal and slightly more acidic seawater to see what effect it had on their sense of smell. To their dismay they found that the fish, normally acutely sensitive to different smells in the water, became confused when the water they were raised in was more acidic than usual.

"This is a disturbing finding, because the tiny larvae of many coastal fish probably rely on scent cues in the water to help locate adult habitat. Any disruption to their ability to navigate could have far-reaching implications for the future of these fish populations." says lead author Prof Philip Munday of the ARC Centre of Excellence for Coral Reef Studies.

Ocean acidification, caused by the absorption of human-released carbon dioxide (CO_2) at the ocean surface, is now recognized as a serious threat to marine ecosystems, the researchers from James Cook, Moscow and Oslo universities say.

"Global ocean pH is estimated to have dropped by 0.1 units since preindustrial times and is projected to fall another 0.3-0.4 units by 2100 due to current and future CO_2 emissions."

"Orange clownfish – or nemos - mostly live on oceanic reefs surrounding vegetated islands and research has shown that baby fish can discriminate between seawater from reefs surrounding vegetated islands versus seawater from reefs without islands. This is what enables many of the baby clownfish to find their way back to the reef where they were hatched", says co-author Geoff Jones.

In normal sea water nemos are strongly attracted to scents from anemones on their home reefs and tropical rainforest trees on nearby land – but avoid the smell of swamp trees or tropical grasses.

Nemos reared in slightly more acidic water were attracted to a range of environmental smells, including those they normally avoided and that indicated a habitat less suited to their needs. Nemos reared in seawater at pH 7.6 showed no response to scent cues at all.

"Our results show for the first time that elevated CO_2 and reduced seawater pH can affect the behavioural decisions of marine organisms during critical stages of their life-history. In this case, acidification disrupted the olfactory mechanism by which clownfish larvae discriminate between cues that may be useful for locating suitable adult habitat and other cues that could lead larvae to unsuitable settlement sites.

"Disruption to this process would have significant consequences for the replenishment of adult populations and could lead to declines of many coastal species," they conclude.

Munday, PL, Dixson, DL, Donelson, JM, Jones, GP, Pratchett, MS, Devitsina, GV and Daving, KB (2009). Ocean acidification impairs olfactory discrimination and homing ability of a marine fish. *Proceedings of the National Academy of Sciences* 106(6): 1848-1852.

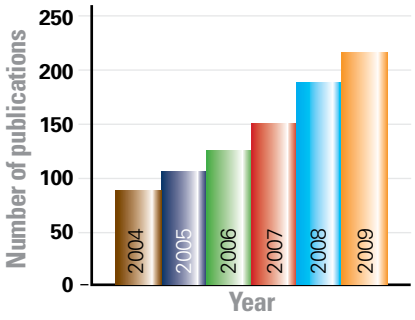
4 February 2009

PUBLICATIONS

The ARC Centre of Excellence for Coral Reef Studies produced 224 publications in 2009, continuing the rapid growth in output exhibited since 2004. According to *ISI Web of Science*, the ARC Centre remains the first-ranked institution globally for both the number of journal publications and citations in coral reef science. The average Impact Factor for all 203 journal articles published in 2009 was 4.2.

Fifty-three of the 2009 articles are in journals with Impact Factors greater than four, including top-tier journals such as *Science, Nature*, *PNAS* and *Current Biology*.

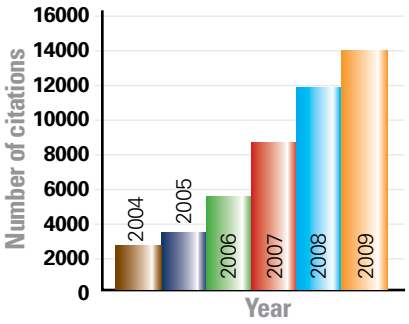
↓ *Number of publications by members of the ARC Centre of Excellence for 2004-2009*



The Centre's research outputs were published in a total of 90 journals, spanning many fields of research. For example, the titles of these journals refer to each of the following disciplines: archaeology, biochemistry, botany, conservation biology, ecology, evolution, fisheries, immunology, modelling, oceanography, paleobiology, petrology, photobiology, physiology, genomics, geochemistry, social science, systematics, and many more.

Citations of the Centre's publications continue to grow, increasing nearly 5-fold since 2004. Twenty-five researchers were each cited >200 times in 2009, nine of the Centre members had >500 citations, and three had >1000 citations in the 12-month reporting period.

↓ *Summed citations to members of the ARC Centre of Excellence each year for 2004-2009*



League table achievements in 2009 include:

- Three Program Leaders in the Centre are recognized by ISI as *Highly Cited Researchers* in Earth Sciences (Malcolm McCulloch) and Ecology/Environment (Terry Hughes and Bob Pressey).
- *The Faculty of 1000 Biology* highlighted six of the ARC Centre's publications for review in 2009.
- *ISI Essential Science Indicators* identified two of the Centre's recent articles as *Hot Papers*, which received an unusually high number of citations within 2 years of publication:
  - Hoegh-Guldberg, O, Mumby, PJ, Hooten, AJ, Steneck, RS, Greenfield, P, Gomez, E, Harvell, CD, Sale, PF, Edwards, AJ, Caldeira, K, Knowlton, N, Eakin, CM, Iglesias-Prieto, R, Muthiga, N, Bradbury, RH, Dubi, A and Hatziolos, ME (2007). Coral Reefs Under Rapid Climate Change and Ocean Acidification. *Science* 318: 1737-1742.
  - Pratchett MS, Munday PL, Wilson SK, Graham NAJ, Cinner JE, Bellwood DR, Jones GP, Polunin NVC, McClanahan TR (2008) Effects of climate-induced coral bleaching on coral-reef fishes - ecological and economic consequences. *Oceanography and Marine Biology: An Annual Review* 46:251-296
- *ISI Essential Science Indicators* identified four *Research Fronts* in 2009 that highlight the Centre's research. A research front is a group of highly cited papers, referred to as core papers, in an emerging topic defined by a cluster analysis. Seventeen core papers in these *Research Fronts* including 7 in *Science, Nature* and *PNAS*, were co-authored by G. Almany, D. Bellwood, C. Folke, N. Graham, O. Hoegh-Guldberg, T. Hughes, G. Jones, M. Kingsford, M. McCormick, S. Planes, M. Pratchett, B. Pressey, R. Steneck, S. Wilson, and D. Yellowlees.

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Books

[1] van Oppen, MJH and Lough, JM (2009). Coral bleaching: patterns, processes, causes and consequences 178pp. Springer, Berlin Heidelberg.

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[2] Cinner, JE, McClanahan, TR, Abunge, C and Wamukota, AW (2009). Human dimensions of conserving Kenya's coral reefs. In *Advances in coastal ecology: People, processes and ecosystems in Kenya*. J. Hoorweg and N. A. Muthiga (Eds.). African Studies Centre, Leiden, Netherlands.

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RECOGNITION OF EXCELLENCE BY CENTRE MEMBERS

The scientific achievements of many members of the *ARC Centre of Excellence for Coral Reef Studies* were recognised during 2009 through awards and peer-recognition. Examples include:

- The Australian Academy of Science recognised the achievements of two of the Centre's program leaders. Malcolm McCulloch was awarded the *Jaeger Medal for Research in Earth Science* for the contribution throughout his career to "the study of the solid earth and environmental issues". Sean Connolly won the *Fenner Medal for Research in Biology*. This is awarded for distinguished research by an early career researcher under the age of 40. Sean was recognised for his "research on the processes influencing population dynamics, ecological interactions and biodiversity".
- Australian Postdoctoral Fellow, Natalie Ban, won the inaugural Bommies Award of the *Great Barrier Reef Foundation* along with her associate Eddie Game from The Nature Conservancy. Her project is entitled "Conservation objectives to minimize the impacts of climate change on the Great Barrier Reef".
- The book *The Great Barrier Reef* edited by Ove Hoegh-Guldberg, Pat Hutchings and Mike Kingsford was awarded a Commendation Certificate for a Zoological Text at the 2009 Whitley Awards hosted by the Royal Zoological Society of New South Wales.
- Three of the Centre's Fellows were selected by the Australian Academy of Science for International Science Linkages – Science Academies Program funding. John Pandolfi (UQ), Tracy Ainsworth (JCU), Andrew Baird (JCU) will visit the University of California, University of Hawaii and Academia Sinica respectively under this scheme.
- Professor Peter Mumby was awarded one of the Australian Research Council's inaugural Laureate Fellowships in late 2009. Peter's move to Australia from the University of Exeter in the United Kingdom will allow him to forge new collaborations across the ARC Centre's nodes in Australia. Other successes in latest ARC Fellowship rounds include Glenn Almany, Andrew Baird (Future Fellowships), and Natalie Ban and Nick Graham (Australian Postdoctoral Fellowships).
- At James Cook University, several of the Centre's researchers were recognised within the University:
  - Terry Hughes and Bob Pressey were appointed as Distinguished Professors in September. This new title is bestowed on leading researchers who have achieved extraordinary levels in their chosen fields.
  - Morgan Pratchett won the *JCU Supervisor of the Year* award in the early career category.
  - Philip Munday, Morgan Pratchett and Nick Graham won the *JCU Vice-Chancellor Excellence Award for Research and Supervision*.

→ *Professor Sean Connolly was awarded the Fenner Medal for Research in Biology by the Australian Academy of Science*

Courtesy of the Australian Academy of Science © Irene Dowdy

Professor Malcolm McCulloch was awarded the Jaeger Medal for Research in Earth Science by the Australian Academy of Science

PERFORMANCE MEASURES

Research findings

Measure	Target 2009	Outcome 2009
Number of publications (p.56)	145	224
Publications in journals with an impact factor > 4	38	53
Number of citations (p.56)	6500	14194
Invitations to provide plenary addresses at international conferences	30	43
Invitations to provide review articles	35	42
Number and nature of commentaries about the Centre's achievements	850	2190
Awards, prizes or recognition (p.64)	17	26

Research training and professional education

Measure	Target 2009	Outcome 2009
Number of postgraduates enrolled (p.34)	120 over 5 years	159 enrolled in 2009
Number of postgraduate completions	70 over 5 years	25
Number of Honours students	60 over 5 years	15 enrolled in 2009
Number of professional workshops	14	18
Participation in professional workshops	20	37
Number and level of graduate student courses and workshops in the priority area(s)	10	16

International, national and regional links and networks

Measure	Target 2009	Outcome 2009
Number of international visitors	65	79
Number of national and international Working Groups	16	45 researcher participations in 20 working groups
Number of visits to overseas laboratories and research facilities	50	58
Membership of national and international boards and advisory committees	40	57
Number of cross-institutional publications	95	161
Number of multi-institutional supervisory arrangements of graduate students	50	57
Commercialisation: Number of internationally funded students Number of consultancies and contract research	 20 over 5 years 5	 57 23
Number of government, industry and business briefings	30	82
Number of Centre trained/ing personnel in knowledge / technology transfer and commercialization	5	5
Public awareness programs: Website hits Public awareness presentations	 1.5 million 12	 4.5 million 45

Organisational support

Measure	Target 2009	Outcome 2009
Annual cash contributions from Collaborating Organisations	$1.36m	$2.2m
Annual in-kind contributions from Collaborating Organisations	$3.2m	$5.7m
Number of new Organisations recruited to or involved in the Centre	5	5
Level and quality of infrastructure provided to the Centre	$1.07m	$1.1m
Annual cash contributions from other organisations	$0.26m	$2.3m

PERFORMANCE MEASURES

Governance

Measure	Target 2009	Outcome 2009
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 p.a. 4 Scientific Management Committee meetings p.a.	See page 7
Quality of the Centre strategic plan	The Centre's progress against the plan will be formally reported to the Advisory Board and be renewed in light of outcomes	Strategic Plan reviewed and endorsed by the Centre Advisory Board. Ongoing performance against plan reviewed at Scientific Management Committee meetings
Effectiveness of arrangements to manage Centre nodes	1. Meetings of the Scientific Management Committee where each node and program is represented 2. Monthly nodal leader phone or video conferences 3. Annual rotational visits to the nodes 4. Annual research retreats for all Centre participants 5. Annual research program planning meetings with cross-nodal attendance 6. Number of co-supervisory arrangements for students 7. Number of multi-nodal seminar and discussion groups	1. All nodes and research programs represented at Scientific Management Committee meetings 2. Regular nodal and program leader meetings held 3. There were 24 cross-nodal visits in 2009. Additionally, members travelled to Brisbane for the Centre's annual meeting and symposium. 4. Research planning meetings were held by each research program 5. Cross-nodal attendance at all research planning meetings 6. 57 7. 40
The adequacy of the Centre's Key Performance Measures	International benchmarking to research in top international marine research centres.	The Centre is ranked #1 in the world for citations and outputs in coral reef science

National Benefit

Measure	Target 2009	Outcome 2009
Measures of expansion of Australia's capability in the priority area(s)	100% increase on 2004 benchmark by 2010	2.5 times the number of publications in the 2004 benchmark 4.8 times the number of citations in the 2004 benchmark
	34 briefings to government, business and industry groups	82 briefings
	17 cross-nodal publications	30 cross-nodal publications
	90 cross-institutional publications	161 cross-institutional publications
Case studies of economic, social, cultural or environmental benefits	2 to be highlighted in the annual report and distributed to media agencies	39 Media Releases See page 50

FINANCIAL STATEMENT

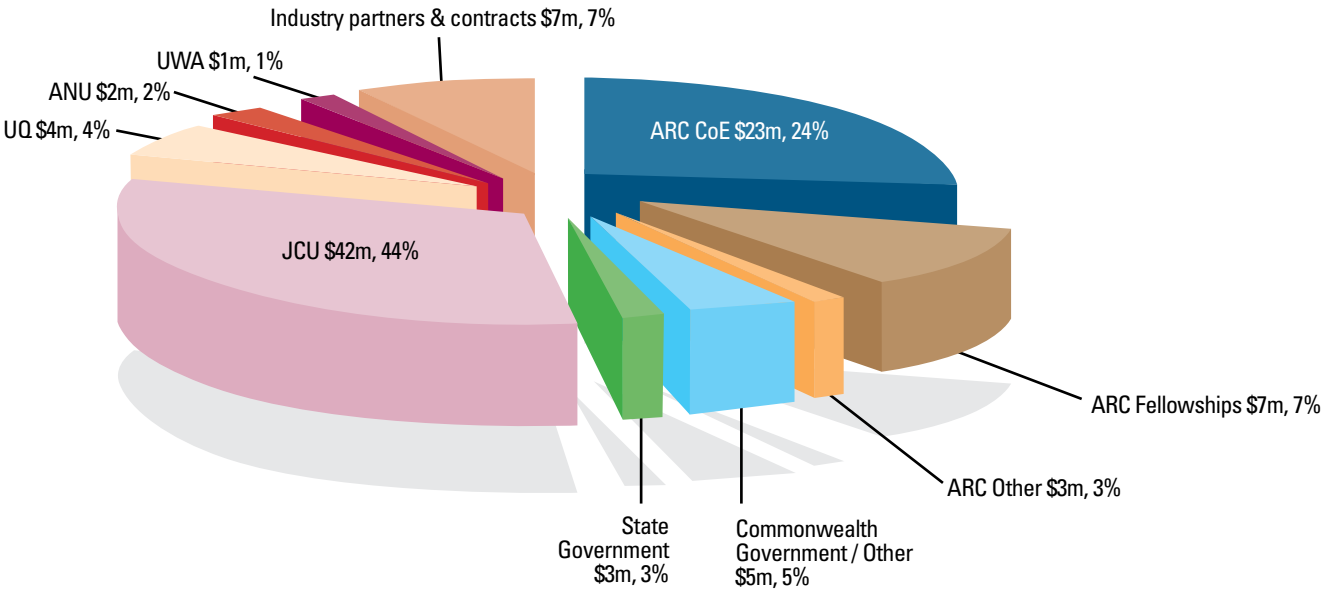
ARC Centre of Excellence for Coral Reef Studies
Statement of Operating Income and Expenditure for year ended 31 December 2009

	2008	2009
Income	**$**	**$**
ARC Centre Grant	$2,598,470	$2,651,090
ARC Fellowships	789,965	932,744
ARC Discovery		71,418
ARC Linkages		150,000
ARC Networks		30,000
Host Institutions cash support	1,709,282	2,266,972
Local Government		
State Government	117,000	119,965
Commonwealth Government other grants	356,000	408,423
International and other contracts	297,900	571,923
Total Income	**$5,868,617**	**$7,202,535**
Expenditure		
Salaries	3,710,607	3,829,430
Equipment	326,790	526,204
Travel	1,144,558	1,236,948
Research maintenance and consumables	1,133,984	1,087,630
Scholarships	54,112	153,077
Public outreach and administration	45,523	171,776
Total Expenditure	**$6,415,573**	**$7,005,065**
Surplus (Deficit)	**$(546,956)**	**$197,470**

Financial Status

With the announcement of the extension of the ARC Centre of Excellence to 2013 the operating cash and in-kind operating budget for the ARC Centre of Excellence for 2005-2013 currently totals $97m, more than triple the 2005 funding outlook. The chart below indicates the budgeted level of income from the various funding sources.

ARC Centre cash and inkind funding outlook 2005-2013 – Total funding $97m



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- American Australian Association
- Australian Academy of Science
- Australian Institute of Marine Science
- Australian Coral Reef Society
- Australian Geographical Society
- Australian Museum
- Beijer Institute for Ecological Economics
- Centre National de la Recherche Scientifique
- Conservation International
- Department of Environment, Water, Heritage and the Arts
- Ecological Society of Australia
- Environmental Futures Network
- European Commission
- German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
- Government of the Republic of Indonesia
- Great Barrier Reef Foundation
- Great Barrier Reef Marine Park Authority
- Griffith University
- Hassall and Associates Pty Ltd
- Ian Potter Foundation
- IDP Education Australia
- Lizard Island Research Station
- MacArthur Foundation
- Marine and Tropical Sciences Research Facility
- National Geographic Society
- Network in Genes and Environment in Development
- New Zealand Marsden Fund
- Packard Foundation
- PADI Foundation
- Project AWARE Foundation
- Queensland Conservation Council
- Queensland Department of Premier and Cabinet
- Queensland Department of Primary Industries
- Queensland Department of Employment, Economic Development & Innovation
- Queensland Parks & Wildlife Service
- Resilience Alliance
- Royal Swedish Academy of Science
- Stockholm Resilience Centre
- The Nature Conservancy
- United Nations University
- University of Delaware
- University of Maine
- University of Perpignan
- Western Australian Department of Commerce
- Western Australian Department of Environment and Conservation
- Western Indian Ocean Marine Science Association
- Wildlife Conservation Society
- Wildlife Preservation Society of Australia
- World Bank Global Environment Facility Coral Reef Targeted Research Program
- World Wide Fund for Nature

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