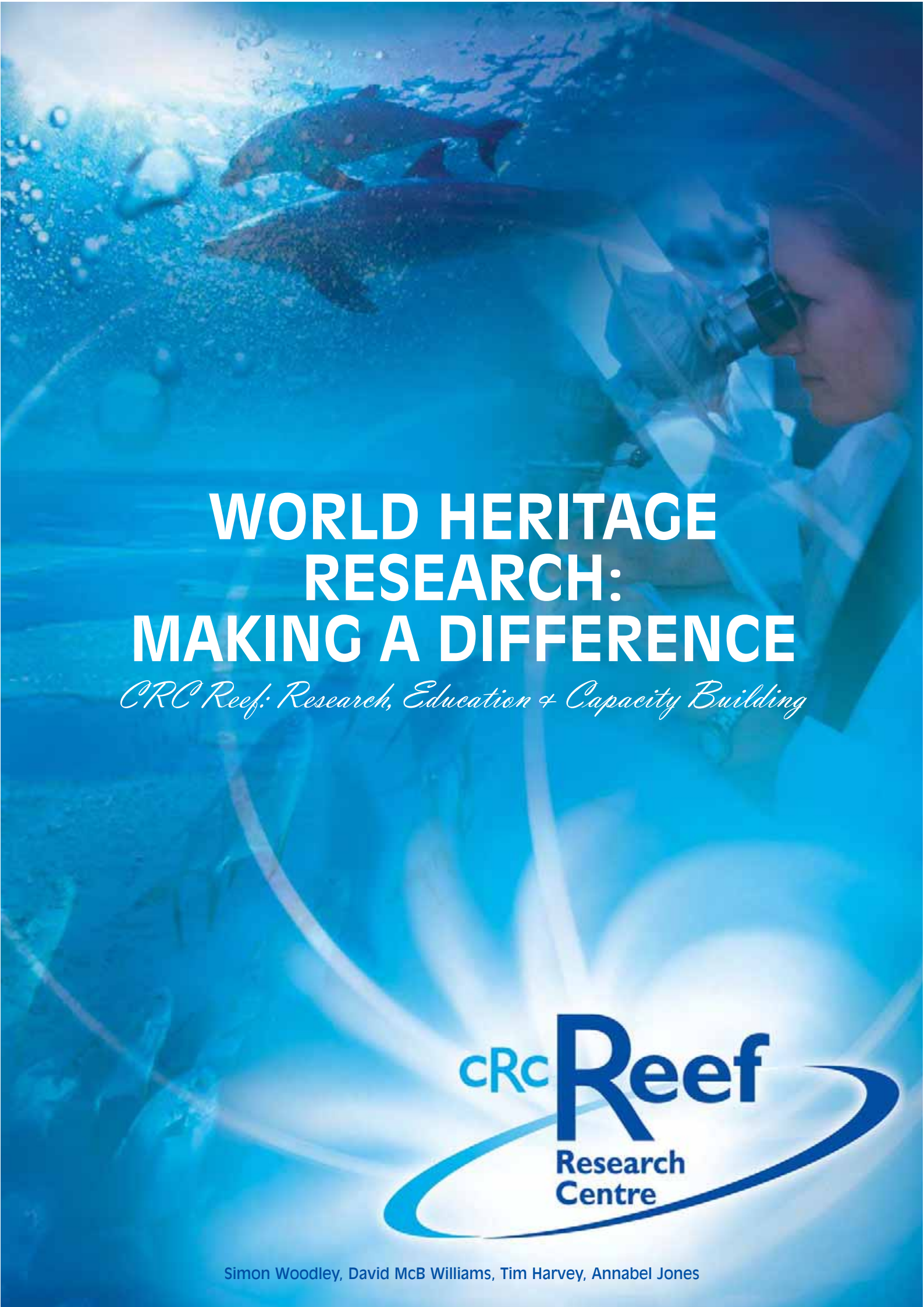
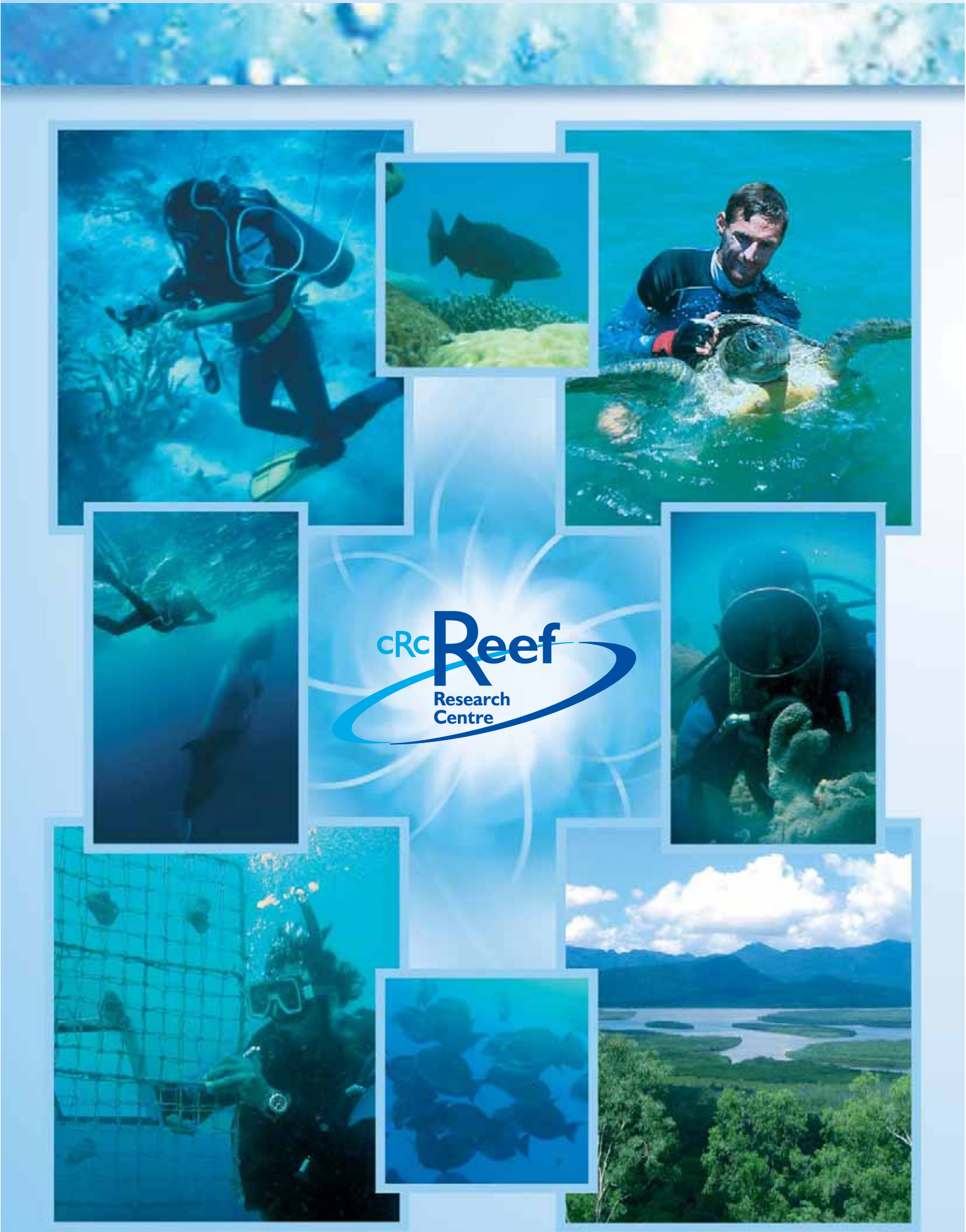


WORLD HERITAGE RESEARCH: MAKING A DIFFERENCE

CRC Reef: Research, Education & Capacity Building

CRC Reef Research Centre

Simon Woodley, David McB Williams, Tim Harvey, Annabel Jones


CRC Reef
Research
Centre

World Heritage Research: Making a Difference

CRC Reef: Research, Education and Capacity Building 1999-2006

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CRC Reef Research Centre

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Foreword

The Cooperative Research Centre for the Great Barrier Reef World Heritage Area was formed in 1999 out of the previous CRC for the Ecologically Sustainable Development of the Great Barrier Reef. The goal and aims of the new Centre broadened significantly to cover the whole of the Great Barrier Reef World Heritage Area, with new partners and new programs formed to support reef managers, tourism and fishing industries and other end users of research information. The ports and shipping industry became a new major purchaser of Centre research.

The CRC Reef has been very successful and has transformed the way in which research and research education is done on the World Heritage Area. Research programs have directly informed major issues facing reef managers and industry, such as improved biodiversity conservation, emerging tourism and recreation pressures, global warming effects, physical forces that affect reef based structures, the effects of fishing on reef ecosystems and water quality issues arising from land use adjacent to the Great Barrier Reef. This issue based research has been complemented by collaborative research programs to understand better the ecological and physical nature of the World Heritage Area and key species for conservation and use. Research into understanding people and their values, cultures, perceptions and behaviour has provided a further base for sound management and business decisions.

All of this effort has been to ensure as far as possible that the Great Barrier Reef World Heritage Area, as an icon for conservation and reasonable use in the world, is managed and used wisely for future generations.

Two new partners joined the CRC Reef after commencement - the Great Barrier Reef Research Foundation (an initiative of the CRC Reef Board), and the University of Queensland. Two major new programs were added in 2003. The first expanded the scope of the research into Torres Strait to address sustainable use of marine resources with Torres Strait Islanders. The second combined reef and rainforest research into a concerted effort to develop new protocols and tools to address water quality issues from land use.

The results have been: outstanding, high quality research focused on current and emerging issues, transmitted in ways that end-users can understand and utilise; highly productive and well trained graduates in applied research; scientists who go beyond the data to provide expert opinion and are able to form consensus views on major issues; and a network of research providers, research users, educational institutions and communities that understand each other and work towards common goals.

The Cooperative Research Centre for the Great Barrier Reef World Heritage Area concluded in 2006. The Reef and Rainforest Centre (RRRC) was formed in 2006 to build on the knowledge base created by the CRC Reef. The new Centre is implementing the Australian Government's Marine and Tropical Sciences Research Facility in North Queensland, which relies heavily on the extensive research capacity and partnerships created by the CRC Reef and the Rainforest CRC.

It has been a privilege to be part of this venture. I sincerely thank all those who contributed to the success of the Centre for their dedication and effort. For those who continue this excellent work I wish them every success.

Sir Sydney Schubert
Chairman of the Board CRC GBRWHA
Chairman of the Board CRC Torres Strait

Acknowledgements

This publication is a sequel to "Making a Difference", a major publication summarising the results of the Cooperative Research Centre for Ecologically Sustainable Development of the Great Barrier Reef (1993-1998) which was conceived and written by the late Associate Professor Vicki Harriott

This report is based on the hard work and achievements of many people who have been part of the CRC Reef since 1999. Thanks in particular go to the following people who helped to guide the development of the report, compile information and critique the drafts: Members of the Boards of the CRC Reef and CRC Torres Strait, particularly Sir Sydney Schubert (Chairman) and Professor Norman Palmer from James Cook University; Dr David Williams, Tim Harvey, Dr Annabel Jones, Dr Russell Reichelt of CRC Reef; Program and Project Leaders or researchers (Prof Helene Marsh, Dr Gianna Moscardo, Prof Tom Hardy, Dr Peter Doherty, Ms Anne Clarke, Dr Rob Coles, Dr Britta Schaffelke, Dr Terry Done, Dr Kerry Neil, Dr Katherina Fabricius), staff of the Great Barrier Reef Marine Park Authority (Dr David Wachenfeld, Dr Laurence McCook, Hugh Yorkston, Dr Kirstin Dobbs, Dr Adam Smith and Jon Day), Stephanie Slade from Queensland Department of Primary Industries and Fisheries; Sue English from Australian Institute of Marine Science and Floris van der Leest from James Cook University. Every effort has been made to capture the detail of this complex endeavour over the past seven years; any omissions and errors are the responsibility of the authors.

Simon Woodley
S & J Woodley Ptd Ltd

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AIMS - Australian Institute of Marine Science
GBRMPA - Great Barrier Reef Marine Park Authority
DPIF - Qld Department of Primary Industries & Fisheries
JCU - James Cook University
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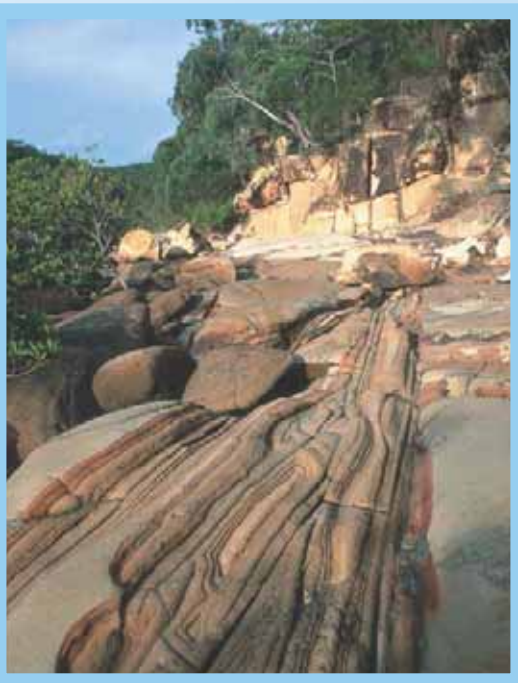
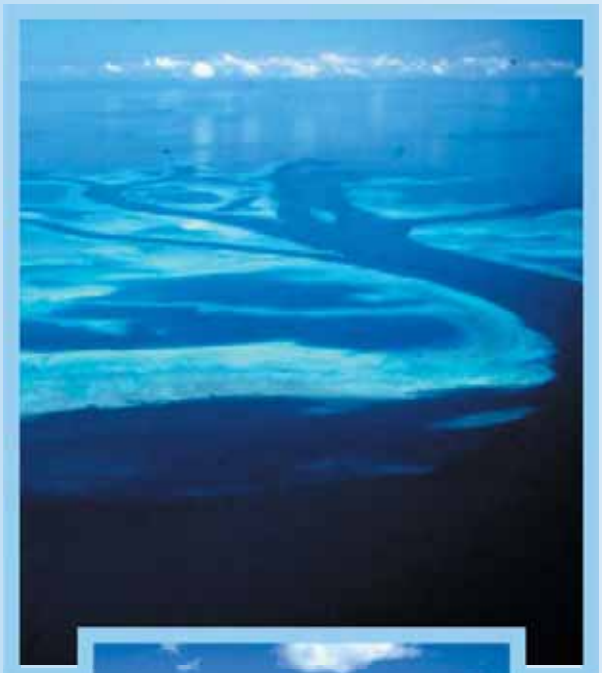
Tsv Bulletin - Townsville Bulletin





Introduction

This report describes the major contributions of the Cooperative Research Centre for the Great Barrier Reef World Heritage Area (CRC Reef) to the understanding, management and sustainable use of the Great Barrier Reef World Heritage Area (GBRWHA) over the period 1999-00 to 2005-06. The key messages and outcomes from the research programs, and the impact of research training and capacity building undertaken by the Centre are presented as well as how the Centre has made a difference to the way science is done on the GBRWHA.

Corporate Structure

The CRC Reef was an incorporated cooperative joint venture (CRC Reef Research Centre Limited) established in 1999 by an Agreement between CRC Reef members: Association of Marine Park Tourism Operators (AMPTO); Australian Institute of Marine Science (AIMS); Great Barrier Reef Marine Park Authority (GBRMPA); James Cook University (JCU); Queensland Seafood Industry Association (QSIA); the State of Queensland through its Department of Primary Industries and Fisheries (DPI&F); Sunfish Queensland Inc; and an Agreement with the Commonwealth of Australia. The Great Barrier Reef Research Foundation (GBRRF) became a member in 2001-02. The University of Queensland (UQ) became an associate member in August 2004.

In 2003, CRC Reef received support from the Commonwealth ($3 million over three years) to establish a new research, education and extension program in Torres Strait. The program brought together the main resource management agencies, research institutions and stakeholders in Torres Strait as well as the Torres Strait community. The members of the newly established incorporated entity CRC Torres Strait Ltd were Torres Strait Regional Authority (TSRA), Commonwealth Scientific and Industrial Research Organisation (CSIRO), Geoscience Australia (GA), National Oceans Office (NOO) and the Australian Fisheries Management Authority (AFMA). These institutions also became associate members of CRC Reef Research Centre Limited.

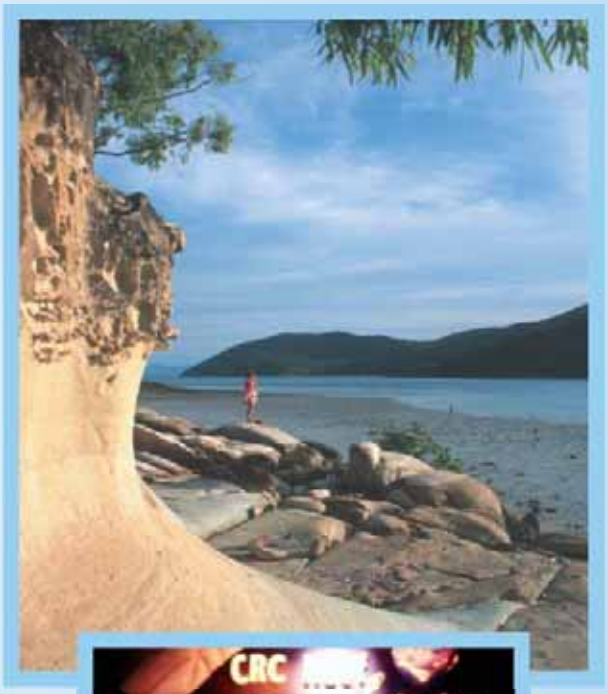
Goal and Aims

The goal of the CRC Reef was to support and promote the ecologically sustainable development and management of the GBRWHA, Torres Strait and tropical reef ecosystems.

The main strategy was to conduct an integrated program of applied research and development, education, training and extension to enhance the viability of reef-based industries and to provide an improved basis for reef management and regulatory decision making. Key factors in this strategy were:

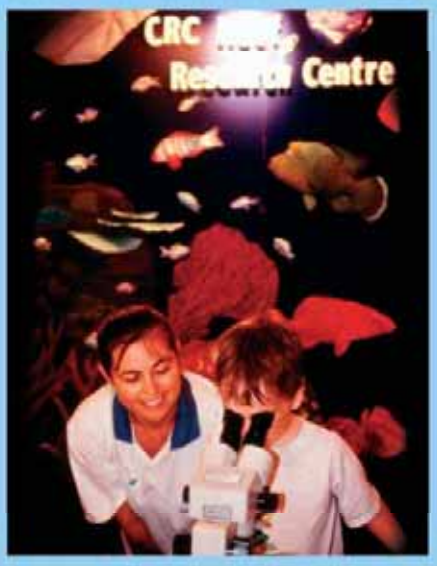
- collaboration between research institutions to enhance existing research and improve research results;
- collaboration with industry and management partners to ensure relevance and effective outcomes for research users;
- commercial and international activities that capitalise on research findings and educational training; e longer-term.

- research that is multi-disciplinary, across both the natural and social sciences;
- well supported research student training programs; and
- innovative technology transfer systems and products.



The specific aims of CRC Reef were:

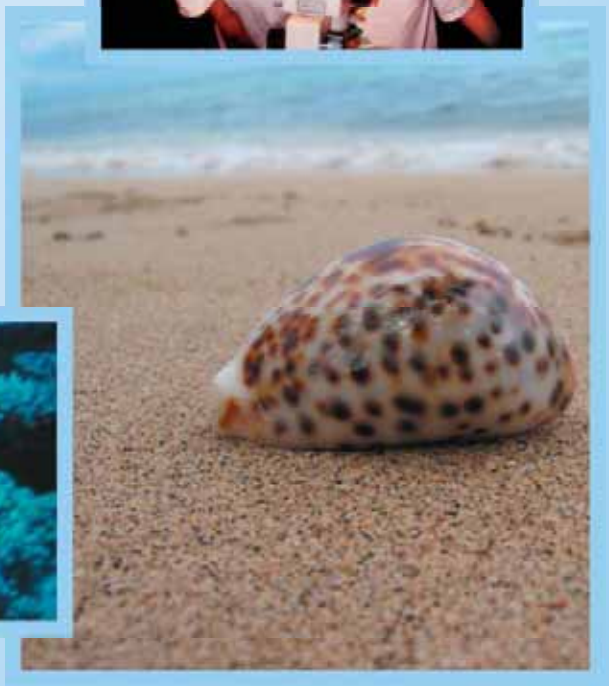
- to provide innovative technology, information, tools and advice to resource managers, industries and other stakeholders so that in the GBRWHA, human activities are ecologically sustainable with long-term benefits to Australia, industries are profitable and promote world's best practice for ecologically sustainable operations; and GBRWHA values are protected;
- to provide exciting and innovative education and training programs for future leaders in research, industry and management in Australia and overseas;
- to continue the collaborative and cooperative culture created by the first CRC Reef Research Centre between researchers, industry, stakeholders and resource managers; and
- to develop alternative sources of support and income which will sustain the Centre in the future.



The specific aims of CRC Torres Strait were:

- to meet identified end-user needs through a coordinated and integrated research program;
- to support the sustainable development of marine resources and minimise impacts of resource use in Torres Strait;
- to enhance the conservation of the marine environment and the social, cultural and economic well being of all stakeholders, in particular the Torres Strait peoples; and
- to contribute to effective policy formulation and management decision making.

The achievements of the CRC Reef in research, education and capacity building for the period 1999-2006 are presented by project within programs. The information for this report comes mainly from published sources. Highlights have been summarised into broad themes. Selected case studies illustrate how high quality research was directed to end-user issues and combined with effective technology transfer, education and extension to produce effective outcomes. The report also describes the unique contribution of a successful Cooperative Research Centre to Australia.



Context

Great Barrier Reef World Heritage Area

The Great Barrier Reef World Heritage Area (GBRWHA) contains one of the richest and most diverse natural areas on Earth. As the world's largest coral reef ecosystem, the Great Barrier Reef (GBR) is a critical global resource. It also contains an extraordinary variety of other plant and animal communities, habitats and associated ecological processes, ranging from fringing coastal reefs, mangroves, seagrass beds, sand and coral cays, sandy or muddy bottom communities to continental islands and deep open ocean areas. The GBR was declared a World Heritage Area in 1981, internationally recognised for its outstanding natural values, and only one of a few areas ever nominated and listed for all four natural criteria.

Integrated management for the GBR is provided by the Australian and Queensland Governments, through agencies including the Great Barrier Reef Marine Park Authority (GBRMPA), Queensland Environmental Protection Agency (QEPA) and the Queensland Department of Primary Industries and Fisheries (DPI&F).
The Great Barrier Reef Marine Park (GBRMP) is unique in size, covering approximately 344,000 Km^2, and extending more than 2,300 km along the Queensland coast. The GBRWHA extends to the low water mark on the mainland coast, and includes all islands under both Commonwealth and Queensland jurisdiction and all waters within the outer boundaries of the Marine Park.

The Marine Park , allows a range of ecologically sustainable uses with an overriding conservation objective; all of the Marine Park is protected, through a zoning plan and management systems to minimise impacts. Most human activities are allowed, within designated zones.

The GBR contributes around $5.8 billion annually to the Australian economy. This includes $5.1 billion from the tourism industry, $610 million from recreational activity and $149 million from commercial fishing. This economic activity generates about 63,000 jobs, mostly in the tourism industry, which brings over 1.9 million visitors to the Reef each year. About 69,000 recreational vessels are registered in the area next to the Reef (GBRMPA 2006)

Torres Strait

Torres Strait is a region of national and international significance, ecologically, culturally, strategically and economically. Torres Strait links Australia to Papua New Guinea and has been the home of the traditional peoples of Torres Strait for many centuries. It joins the Arafura and Coral Seas, and contains significant tropical marine ecosystems and populations of important marine species. The region contains significant fisheries and is a major international shipping lane for transit to Australia and between the Indian and Pacific Oceans. At its southern boundary, Torres Strait joins the GBRWHA and the GBR Marine Park.

Torres Strait consists of over a hundred islands and reefs with 20 islands currently inhabited by communities spread across six areas: eastern, central, near western, top western, inner islands and northern Peninsular.
The population of both the Australian and Papua New Guinea sectors of Torres Strait is predominantly Torres Strait Islanders of Melanesian origin. These peoples and those of Aboriginal origins have strong seafaring traditions and customs that link them to their maritime environment. The peoples of Torres Strait also include those of Asian, Caucasian or other origins. The cultural identity of Torres Strait traditional inhabitants is expressed and maintained through Ailan Kastom that covers a range of customs, languages, traditions, observances and beliefs in their social organisation.

The Torres Strait Treaty entered into by Australia and Papua New Guinea in 1985 is concerned with sovereignty and maritime boundaries in the area, the maintenance of the way-of-life and livelihood of traditional inhabitants and the protection of the marine environment. The Treaty establishes the Torres Strait Protected Zone (TSPZ), within which each country exercises sovereign jurisdiction for swimming fish and sedentary species in their areas. Administration of the TSPZ is coordinated between the Commonwealth, Queensland and the Torres Strait people by the Protected Zone Joint Authority (PZJA), comprising the Commonwealth and Queensland Ministers for Primary Industries and the Chair of the Torres Strait Regional Authority (TSRA). The TSRA was established in 1994 as a Commonwealth statutory authority in recognition of the need for greater autonomy of Torres Strait peoples in managing their affairs. The Island Coordinating Council (ICC), comprised of the leaders of all island communities, plays an important role in coordinating the affairs of Torres Strait peoples.

Overview of CRC Reef Research Centre 1999-2006

The ultimate measure of success for an organisation like CRC Reef is to evaluate the outcomes of its programs i.e. what has changed because of what has been done? What have been the benefits to end-users and the general public? Have CRC Reef partners, researchers and students gained from exposure to the CRC Reef system?

CRC Reef has been a catalyst for changing the way that much of the research on the GBRWHA has been done. Multi-disciplinary, multi-institutional projects solving specific problems, within specific timeframes and with defined products are part of this change. The linking of scientists and research information users in the process of developing research tasks and building ownership of the final products has been a fundamental change in the way research is done on the GBR. The Centre has actively linked those who do the research with those who need the results to look after the Great Barrier Reef and has redefined the relationships between research providers and information users for the GBRWHA.

CRC Reef has been an excellent example of a "public good" CRC that provides tangible and intangible benefits to the Australian and Queensland communities. An incorporated private sector model with good corporate governance practices and a philosophy of continual improvement has been central to effective management.
CRC Reef has been highly productive in the quality of research, quantity of publications and other products, education and extension activities undertaken and students supported.

Research has shifted from being predominantly discipline focused and researcher driven to integrated research that addresses management and industry issues. As management information needs became more clearly specified, the research projects became more focused on those issues. Better understanding of science by managers, and of management and policy imperatives by scientists, increased. While the production of published papers and reports has continued to be important, the growing provision of expert scientific advice, opinion and consensus on complex subjects about the sustainable use of the Reef has been an increasingly important role of the CRC Reef.

Significant investments have been made in strategies for effective information brokerage. Research information produced in an accessible way and utilised by management and industry enhances the "public good" value of the research. Improved access to data and information has been a key initiative and active extension programs targeting particular user needs have also been important.

The development of well supported education programs for research students including training in transportable skills has been a hall mark of the CRC Reef. A new type of research student inculcated with the values of collaborative, user-focused research have completed study through the CRC Reef system. All have gone on to apply their expertise and knowledge on interesting projects.

Over the life of the CRC Reef 1999-2006, and its predecessor, there have been fundamental shifts in attitudes towards and understanding about science and the value of research for the sustainable development of the GBRWHA. The CRC Reef has been central to addressing key integrated research/industry/management issues in the GBRWHA, such as biodiversity conservation, water quality, species protection, global warming and coral bleaching, impacts of ports and shipping, fishing and fisheries, understanding the values and attitudes of key stakeholder groups, and sustainable reef based tourism.

The CRC Reef has also been central to the development of a unique community of expertise and knowledge about the GBRWHA, its natural systems, the social, cultural and economic values that drive its uses and the management and policy issues that challenge decision makers. This community will be one of the lasting legacies of the CRC Reef Research Centre.

Views of CRC Reef Institutional Partners

The partnership of research providers, tertiary education institutions, industry bodies and reef management agencies that characterised the CRC Reef was effective and robust. The corporate governance arrangements established for CRC Reef Research Centre Ltd and CRC Torres Strait Ltd were consistent with best business practices (majority of Board members from end-users, incorporated private sector model with continual improvement) and stood the test of time. Strong leadership by Sir Sydney Schubert, Chair of the Boards of the two companies and by the two CEOs, Dr Russell Reichelt (CRC Reef) and Dr David Williams (CRC Torres Strait) respectively was a key factor in the success of the companies. The expectation of CRC Reef partners is that the benefits of these partnerships will continue beyond the life of the Centre.

Achievement of Goal and Aims

The partners in the CRC Reef Research Centre have been almost unanimous in their views that the CRC has achieved its mission and its goal and aims at a high level.

> *"The CRC Reef's mission is "to plan, fund and manage world-leading science for the sustainable use of the GBRWHA". At this broad level, CRC Reef has demonstrated considerable success…..The CRC Reef has been largely successful in achieving its aims, but was not successful in developing alternative sources of support and income that will sustain the Centre in the longer-term".*

> *"ongoing research is still needed in some areas to finalise results but its aim to form partnerships between industry and science has been met and this is demonstrated by the significant funding received from industry."*

> *"the CRC has been extraordinarily successful in meeting its goal and aims. The supplementary funding for the Torres Strait and Catchment to Reef programs meant that the scope of the CRC was significantly expanded. The CRC has been successful in accessing additional funding for contract research such that its overall budget has grown significantly over the lifetime of the CRC."*

Overall Operations and Activities

In relation to those aspects of the Centre's operations that have been done well and those that could have been better, partners have made many comments, which are summarised below:

"The CRC Reef has done well in the following ways:

- *brought together scientists, industry and managers to develop a common vision for the science needed to help manage the GBR so that it is sustainable. This has generated science that is trusted and respected, such as the Effects of Line Fishing Program;*
- *developed strong links between managers and scientists to develop a collaborative relationship based on mutual understanding;*
- *established itself as a reliable source of independent science knowledge;*
- *provided sound scientific opinions to management when requested;*
- *used collaboration very effectively;*
- *provided students with significant projects that contributed to the knowledge base;*
- *developed good links with industry to ensure strong end-user support; and had an excellent focus on environmental and biological research."*

Partners have commented that despite these outstanding results there was room for improvement. CRC Reef could have done better in the following ways:

- *"played a stronger role in examining the links from catchment to reef, with improved engagement with land based decision making groups;*
- *provided better high-level synthesis across research areas and projects;*
- *developed a range of social science capacity and leadership to support the delivery of social and economic research for Marine Park management;*
- *paid more attention to task associates in adding value to the work and more effective engagement by many researchers; and*
- *undertaking better proactive and systematic engagement with aboriginal communities in the GBRWHA was needed."*

Education, Extension and Capacity Building

Particular views were sought from partners about the education, extension and capacity building activities. These views are summarised below:

- *"Particularly effective extension work was conducted for the marine tourism industry;*
- *Education of students resulted in many going on to significant projects.*
- *While scientific publications were excellent, the material generally did not get high penetration levels where the industry was the end target.*
- *use of end-user communication networks could have been better.*
- *James Cook University has derived great benefits from CRC Reef support of postgraduate research students. Over the lifetime of both CRCs, over 100 PhD and Masters by Research students have been supported at JCU by the CRC Reef. The benefits have been twofold:*
  1. *a significant contribution to University funding; and*
  2. *the creation of a new type of postgraduate research student. The focus has been on stakeholder engagement and as a consequence graduates have been better prepared in terms of industry liaison, communication and other skills. Time will tell but it may be that the CRC Reef education program will have a significant capacity building for marine NRM research in the northern Queensland region over time.*
- *Overall, the education, extension and capacity building programme of the CRC Reef has been successful. The primary mechanism through which the CRC Reef developed capacity was its research student programme. Many of these students have gone on to begin successful careers in science or environmental management.*
- *The series of 'Current State of Knowledge' brochures provided excellent syntheses of information on particular subjects.*
- *The series of stakeholder 'Fishing and Fisheries' workshops was a very successful communication initiative.*
- *The extension program lacked an overall strategic focus in terms of identified target audiences and messages. The program could have been better linked with the community engagement capabilities of GBRMPA. In particular, better use could have been made of the Authority's Local Marine Advisory Committees and Reef Advisory Committees.*
- *In relation to fisheries management, one of the greatest benefits has been the inclusion of fishery participants in the research and the extension of research results and other information to fishers which has resulted in a better understanding of the need to manage fisheries resources."*

Benefits and Outcomes of being a Partner in CRC Reef
Partner's responses to this question are as follows:

- *"The benefits for JCU have been in part financial in terms of project funding but more importantly because of the partnerships the CRC has created for our researchers and the environment it has established through stakeholder engagement for postgraduate research students. JCU has been the home for the Fishing and Fisheries Group based in the School of TESAG. The University's view is that this ambitious large scale project is one of the major success stories of the CRC. This research group is now well established and will continue at JCU under the auspices of the MTSRF and as a consequence one example of the CRC Reef outcomes for JCU is that it has led to significant capacity building in fisheries research relevant to the region. In a similar vein, Helene Marsh and colleagues research on species of conservation concern has led to significant capacity building. One of the weaknesses regarding research in the northern Queensland region prior to the advent of the Reef and Rainforest CRCs was the lack of critical mass in research areas relevant to NRM management and planning. Both the Rainforest and Reef CRCs have had a major impact in this respect and from our perspective represent one of the major specific outcomes from the CRC Reef program."*

- *"The two greatest benefits to the GBRMPA have been the formation of partnerships between managers, Reef users and scientists and the delivery of scientific information to help inform management decisions. Of course, these benefits are linked, as it has been the quality of the partnerships that have helped to deliver the scientific outcomes. Most of the major management achievements of the last few years have benefited strongly from CRC Reef science. The highlights of these include: the 2003 Zoning Plan, the Reef Water Quality Protection Plan and the Fisheries (Coral Reef Fin Fish) Management Plan 2003. These Australian and Queensland Government initiatives have been based on the best available science, and much of that science has come from the CRC Reef."*

- *"Recognition of the significance of recreational fishing within the GBR; research projects addressing recreational fishing issues and priorities; and a greater understanding of the role of research and the use of research findings; replacement of anecdotal with factual information in management decisions in the GBR; improved understanding of regional variability within the GBR; improved level of knowledge among recreational fishers."*

- *"The DPI&F have gained significant benefit from the research conducted by the CRC Reef, in particular, from that generated by the Fishing & Fisheries Project. A number of the research projects undertaken … have had direct relevance to the management of the Queensland coral reef fin fish fishery and the Queensland east coast Spanish mackerel fishery, with results from those projects continuing to feed into management arrangements for Queensland's line fisheries. CRC Reef … has provided high quality, relevant, industry-based research outcomes on the coral reef fin fish fishery. Those outcomes have facilitated the development of management arrangements to ensure that the fishery continues to operate in a sustainable manner."*

- *"The principle benefit of being a partner has been to be able to help set research priorities and ensure that individual research tasks have dealt with the marine tourism industry in a fair and equitable manner. The research showing that marine tourism is sustainable and has a minimal effect on the GBR has been important for correcting public perception and for working with government. COTS research has played a very important role helping us obtain support for the COTS Control program and this has resulted in $4.5 million in funding. Showing the link between water quality and over fishing to COTS outbreaks was also very useful. The health of the sites used by high numbers of visitors such as Quicksilver's sites, has demonstrated the ability for operators to look after their sites and present them in better condition than the surrounding reef. More research is needed here but at the moment it looks like a fully sustainable operation is possible for high visitation sites as long as the operator takes basic steps to protect the reef. The science underpinning the RAP was in the main generated by the CRC and this may turn out to be the most positive environmental initiative in our lifetimes. "*

CRC Reef as a Model for Integrated end-user Driven Research

The views of partners on the CRC Reef as a model for between research institutions, tertiary education providers, industry and reef management agencies are set out below:

- *"The CRC Reef is one of a number of CRCs that Sunfish has had some interaction and because of the partnership approach used it has been the most effective. This partnership approach and involvement of users has lead to more practical research that can be used by industry. The networking resulting from the partnerships has created opportunities that would not otherwise have been available or would have been more difficult to accomplish."*

- *"The CRC Reef has been the most effective CRC (that JCU has been involved with) in establishing partnerships between research institutions, tertiary education providers and management and user organisations. This partnership has expressed itself at the level of researchers, through postgraduate research students and at the level of the Governing Board. The real test of how effective the partnership is, is whether it will continue beyond the CRC Reef."*

- *"The development of (the) partnerships over its life has been one of the most positive outcomes of the CRC Reef. These relationships hopefully will continue beyond the life of the CRC Reef as all parties have increased their understanding of each other's needs and have come to respect the importance of such collaborative efforts."*

- *"In the main the CRC model has been effective. It has certainly managed to get all the parties talking and allowed us all to understand the differing perspectives, even if we did not totally accept them. This will continue to produce dividends long after the CRC Reef is only a memory."*

- *" PCQ chose DPI&F to do … projects as they were considered independent, highly credible and well recognised in the scientific community. The projects undertaken through CRC were always undertaken in a highly professional manner. PCQ has been extremely pleased with the excellent quality of work."*

Highlights

The following highlights illustrate the effectiveness of CRC Reef in delivering high quality research for end-users. Major integrated achievements are shown in a series of case studies.

Supporting Marine Policy and Planning

Collaboration and assistance to research and management agencies in Australia and overseas has been a core component of CRC Reef's success. The benefits of developing these partnerships and networks should be felt for many years after the formal end of CRC Reef. The provision of expert advice and information for policy and planning have been substantial.

Advice to GBRMPA for the Representative Areas Program added significant value to the program by providing expertise and scientific consensus that was vital to the subsequent policy and management decisions. (see Case Study #1). Advice about marine mammals and reptiles (e.g. the response of dugong to boat traffic supporting a go-slow campaign for recreational vessels) has been important for policy development and decision making. CRC researchers have either been members of Reef Advisory Committees (conservation, tourism, water quality, fisheries) or have provided expert advice for their consideration.

The Queensland Government has received important advice and information, particularly for application in fishing and fisheries policy and management. Advice has been given for fisheries Management Advisory Committees (harvest, spotted mackerel, Spanish mackerel, coral reef fin fish). CRC Reef was a source of research on Torres Strait fisheries (e.g. fin fish, rock lobster). Other policy and management issues for the Queensland Government were assisted by CRC Reef advice on the movement of dugongs to aid in planning for the Great Sandy Marine Park, jellyfish biology through membership the Queensland Government's Irukandji Taskforce, marine biotechnology through membership of Queensland Biotechnology Advisory Council and on Queensland's seagrass resources for the Queensland State of the Environment report.

Internationally, CRC Reef provided advice and assistance to the United Nations Environment Programme for use by the IUCN as the basis for a re-evaluation of the global status of the dugong, to the International Whaling Commission concerning draft sustainability indicators for dwarf minke whale tourism. Nationally, CRC Reef provided advice to the Department of the Environment and Heritage (DEH) about research on coastal dolphins. This resulted in a set of recommendations for cetacean research and conservation priorities in Australian waters. Other advice to DEH was give in relation to:

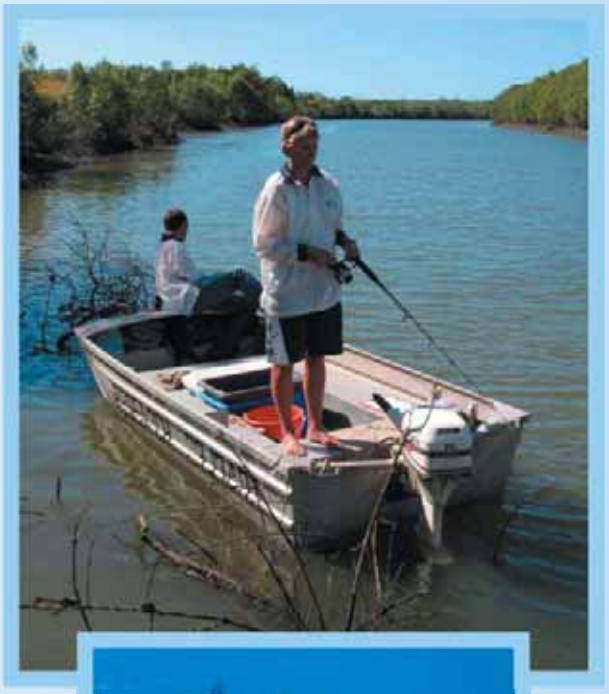
- Queensland's seagrass resources for the State on the Global Seagrass Monitoring Program which was expanded to develop collaborative partnerships between science and community-based teams in the western Pacific;
- the biological status of Elizabeth and Middleton Reefs Marine National Nature Reserve;
- the links between roseate terns in Australia and Japan has led to the listing of this bird on the Japan- Australia Migratory Bird Agreement (JAMBA) to ensure this species is managed across national boundaries;
- Bioregionalisation strategies as member of Australia's State of the Environment Committee and the National Bioregionalisation Working Committee; and
- a strategy for monitoring marine protected areas managed by the Commonwealth.

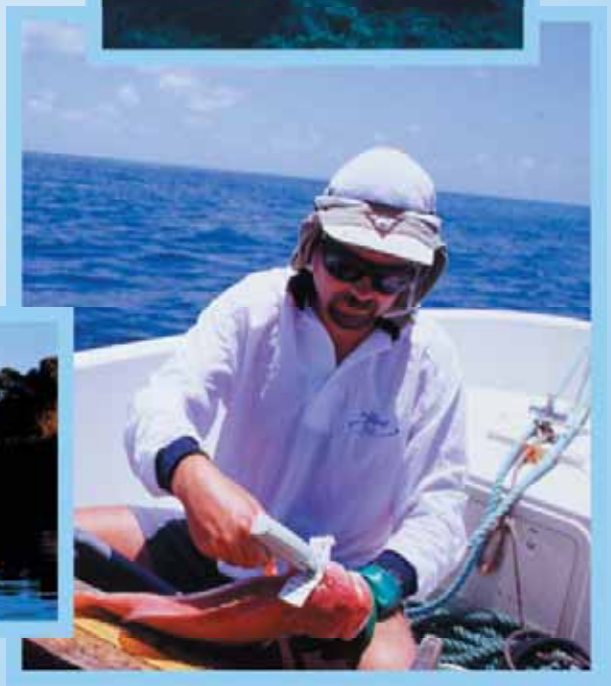
Ports Corporation of Queensland (PC) was assisted with expertise and advice through attendance at Dredging Technical Advisory Consultative Committees (ports of Weipa, Karumba and Mackay). Finally, the National Oceans Office (NOO) Northern Marine Planning Area was assisted by a study detailing the description and data gaps of key marine species in the Northern Planning Area.

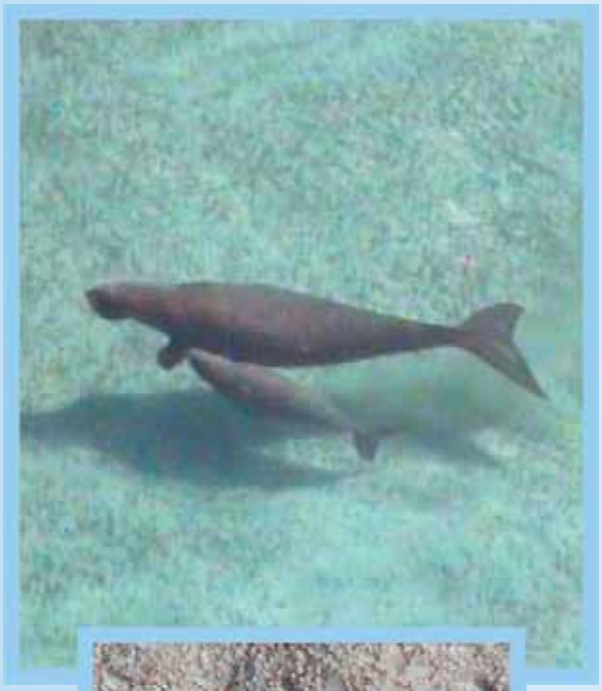
Monitoring Status and Trends in Biodiversity

The GBRWHA was inscribed on the World Heritage list because of its unique biodiversity. CRC Reef research into biodiversity was crucial to better management and protection of this internationally significant natural heritage. Public debate and policy development for use and protection of the GBRWHA should be well informed about the status and trends of ecosystems. However, there have been few historical benchmarks against which to measure change and few agreed performance indicators of ecosystem health. Detecting anthropogenic impact in this situation is challenging because it takes place in a highly variable natural environment and often results in slow chronic changes. Highlights were:

- Completion of the Great Barrier Reef Seabed Biodiversity Project, a large multi-agency task involving four research providers (AIMS, CSIRO, DPI&F, Queensland Museum (QM) supported by CRC Reef, Fisheries Research and Development Corporation (FRDC) and NOO (see Program C Project C1 for a more complete description and also the website - http://www.reef.crc.org.au/resprogram/programC/seabed/index.htm).
- Important understanding of status and trends of key indicators of reef health through extensive monitoring by the AIMS Long-Term Monitoring Team of the condition of reefs and other habitats over the life of the CRC Reef such as:
    - Inshore reefs can have diverse coral communities and high coral cover, although many of these reefs are currently not in this condition due to multiple disturbances including storms, crown-of-thorns starfish outbreaks, and recent coral bleaching in addition to land run-off.
    - Preliminary results from surveys of a sample of offshore reefs show that coral trout populations are already greater than 50% more abundant in the new 'no take' zones after two years of protection from line fishing following the introduction of the new GBRMP Zoning Plan in 2003.
    - Better understanding of outbreaks of crown-of-thorns starfish by tracking the spread of COTS, while also reporting on global patterns in coral cover, fish abundance and coral disease.
    - Reef corals that change zooxanthellae partners as a result of coral bleaching suffer a 30% reduction in calcification rates, which indicates slower reef growth for species tough enough to survive the immediate effects of future heat shocks from climate change.
- Results from Seagrass-Watch, a community-based program that monitors condition and trend in seagrass meadows at 70 sites throughout coastal Queensland were provided to management agencies to assist with managing dredging proposals, algal blooms, coastal developments and marine parks.







Marine Wildlife Conservation

The GBRWHA and Torres Strait are globally important habitats for many species of marine wildlife. More than 30 species of marine mammals visit or are resident in these regions. Six of the world's seven species of marine turtles, 17 species of sea snakes and more than two million seabirds of at least 22 species are found in the area. At least 14 species of these marine mammals, birds and reptiles found in the Great Barrier Reef and Torres Strait are listed as threatened globally or under Australian and/or Queensland legislation.

In the GBRWHA, threatened species management results from Australia's international obligation to ensure the Area's protection, conservation and transmission to future generations and national obligations to protect the species. Some species are explicitly included as part of the rationale for the World Heritage listing. Success in managing threatened species is a key indicator of the success of management of the GBRWHA.

In Torres Strait, the management focus is different. The Torres Strait Treaty signed in 1985 provides for protection of the way of life and livelihood of its traditional inhabitants. The focus of managing marine wildlife, especially dugongs and green turtles is as target species for traditional fisheries rather than threatened species.

The challenges to managing the populations of marine wildlife in the Great Barrier Reef and Torres Strait are many. They arise from the complex cross-jurisdictional regimes, the need for maintenance of traditional lifestyles, Native Title claims over inshore waters, the high cultural value of marine wildlife to both Indigenous and non-Indigenous Australians and conservation campaigns about specific aspects of the World Heritage Area. In addition, most marine wildlife species are long-lived, slow breeding and dependent on specialist habitats. Some species are currently seriously depleted as a result of multiple human impacts which are difficult to disaggregate from each other and natural change. Highlights have been:

- Better insight into the behaviour and biology of dugongs and impacts from human activities (a detailed description of the research for conservation of dugong can be found at Case Study #3).
- The most comprehensive study of Australia's first endemic species of cetacean, the Australian snubfin dolphin (formerly known as the Irrawaddy dolphin) was completed.
- Investigations into the sustainable management of sea turtle by-catch in prawn trawls in the GBRWHA indicated that the regulations requiring trawlers to use Turtle Excluder Devices (TEDs) are warranted. The results of this work contributed to the re-zoning of the GBR Marine Park and assisted fisheries managers in designing cost-effective programs to monitor the use of TEDs by trawler skippers.
- Investigations into vessel collisions with turtles showed that turtles are vulnerable to collisions and mortality from vessels at moderate and high speeds (> 6 and > 10 knots) respectively. Collision risk is also higher in turbid water and at night (when turtles are less likely to sense approaching vessels) and in shallow water with insufficient vertical clearance between vessel hulls and turtles foraging or resting on the substrate.
- Analysis of the genetic relationships among roseate terns established two lineages of roseate tern from individuals in the Atlantic and Indo-Pacific Ocean basins. This study highlighted the need for roseate terns to be managed across all relevant Australian and international jurisdictions. The roseate tern has now been listed on the Japan-Australia Migratory Bird Agreement (JAMBA).

Molecular analysis of the olive sea snake and the spine-bellied sea snake (2 of about 17 species that occur in the GBRWHA) showed very different evolutionary origins. The olive sea snake occurs on coral reefs from the southern GBR to Shark Bay in Western Australia in highly variable densities. In contrast, the spine-bellied sea snake occurs in inter-reefal habitats and has an extensive geographic range, which extends from the Persian Gulf, through the Indo-West Pacific and the South China Sea, to the northern coastal regions of Australia.

Crown-of-Thorns Starfish

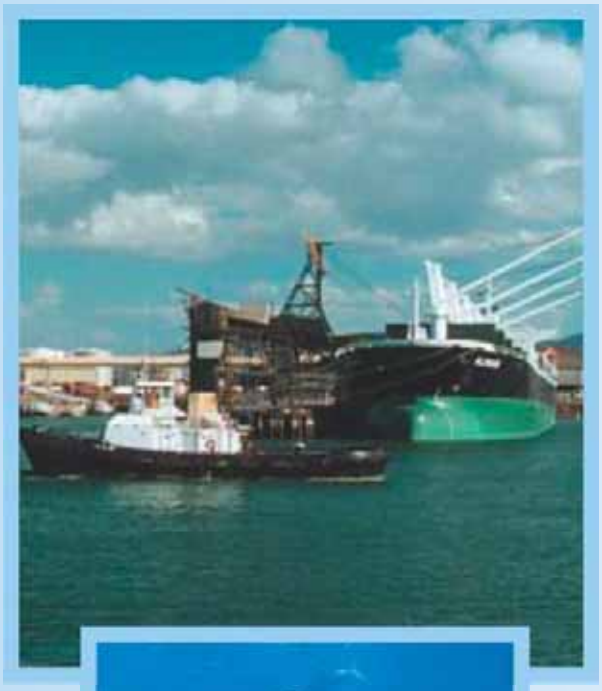
Outbreaks of crown-of-thorns starfish have been one of the major issues confronting the Great Barrier Reef over more than 40 years. The perceived threat to the GBR from outbreaks was one factor in public concern that lead to the establishment of the GBR Marine Park in 1976. Research into crown-of-thorns starfish outbreaks was part of the CRC Reef program since its first inception in 1992. Understanding outbreaks and predicting their timing and passage has been important to the reef tourism industry. Highlights of research were:

- Long-term monitoring of crown-of-thorns starfish outbreaks since 1985.
- Fine-scale monitoring to detect juvenile crown-of-thorns starfish before outbreaks occur.
- Development with the tourism industry of environmentally sound methods to control crown-of-thorns starfish before outbreaks occur on key tourist reefs.
- Funding support from the Great Barrier Reef Research Foundation and the Commonwealth Government for site specific eradication.
- A collaborative multi-disciplinary modelling study of potential causes of crown-of-thorns outbreaks considerably strengthened the case for run-off of nutrients from the land being a significant factor

Irukandji Research

Cubozoan or box jellyfish have long been recognized as a serious potential risk to swimmers in north Queensland. *Chironex fleckeri* has caused fatalities around northern Australia. The irukandji, *Carukia barnesi*, although not known to have caused a fatality, has been responsible for the hospitalization of many people with very painful symptoms known as irukandji syndrome. *C. barnesi* is generally found in relatively nearshore waters, and stings usually occur close to beaches. In the 2001-02 summer, two tourists died with irukandji syndrome in offshore waters. Consequently, CRC Reef initiated a major priority setting workshop leading to an integrated irukandji research program with significant funding from the Great Barrier Reef Research Foundation and both the Queensland and Federal governments. Highlights have been:

- Coordination of a Status of Knowledge document that highlighted priority information needs.
- Molecular and morphological research that identified three distinct groups of irukandji, including two distinct groups of dangerous irukandji jellyfish. The two distinct dangerous groups coincide with the anecdote-based hypothesis of two different classes of irukandji syndrome, one including *Carukia*, the other including offshore, potentially fatal species.
- Hospital trials set up to better determine a formal definition of the syndrome and its physiological progression and optimal treatment, including a trial of the effectiveness of magnesium treatment which has been demonstrated in some cases to relieve pain.
- Construction of cDNA libraries for the proteins in the nematocysts (which deliver the poison) of two species that cause irukandji syndrome (*C. barnesi* and an offshore pseudo-irukandji).
- Coordination of focussed collecting programs, both offshore and nearshore for the supply of irukandji specimens to all research teams.
- Much improved coordination, funding and focus of research efforts and delivery to those responsible for prevention and response strategies.



Impacts of Ports and Shipping

Many ports and marinas operate in, or adjacent to, the GBRWHA and thousands of ships traverse the waters of the World Heritage Area annually, often carrying cargoes that would threaten the environment if released in an accident. These activities are vital to the normal social and economic function of Queensland (the value of trade through ports operated by the Ports Corporation of Queensland alone is $68 billion per year) but pose potential risks to the environment. Environmental risks in shipping channels and in ports principally occur through accidents and unintentional introduction of exotic pest species. CRC Reef was contracted by Ports Corporation of Queensland as preferred supplier of research information necessary for environmental management. See Case Study # 6 for more detailed description.

Sustainable Tourism

Tourism on the Great Barrier Reef is a major industry in local, regional, national and international terms, worth more than $5.1 billion p.a. GBR tourism depends on a healthy reef and CRC Reef researchers have contributed information and knowledge about the health of the reef, threats (e.g. COTS), water quality, tourist profiles, attitudes, preferences and travel patterns, wildlife tourism and information for visitors and operators. The GBR tourism industry has been a major partner in the CRC Reef and has contributed substantial resources, both cash and in-kind to the research program. Highlights of research have been:

- Successful collaboration between CRC Reef researchers and the dive tourism industry to research dwarf minke whales and develop industry standards for swim-with-whales tourism. The expectations, perceptions and behaviours of visitors on live-aboard dive charter vessels and those seeking interactions with dwarf minke whales off the northern GBR were key components of this research.
- Information and training kit developed to aid operators and others in the provision of interpretive guided tours of GBR destinations.
- A study into understanding how SCUBA divers value coral reef environments made valuable contribution to the dive tourism industry and reef management. This study has provided the first detailed insight into the different types of certified SCUBA divers taking part in diving trips, and the specific biophysical attributes that contribute and detract from their experiences.
- Close collaboration between researchers and the tourism industry in the detection and tracking of crown-of-thorns starfish outbreaks and the development of effective eradication techniques for reef tourism sites.
- Development of extensive marine tourism databases to answer management questions, provide market intelligence to reef tour operators and to develop conceptual models for better understanding of tourist behaviour.

Innovative Engineering Solutions

The need to understand the physical forces that occur on the GBR under normal and extreme conditions is essential for reef management and industry, particularly tourism and shipping. It is also important for understanding the physical influences on reef ecology. Design inputs and design techniques that will reduce environmental impacts and improve the economics and structural integrity of reef structures are one of the important results of this research. Highlights of research have been:

- Completion of the Atlas of Cyclone Waves that simulates winds during approximately 20,000 simulated tropical cyclones. This tool provides capability to develop wind statistics from available wind data which can be used to help understand the quality of synthetic cyclone wind statistics. Unlike historical data, available at a limited number of unevenly spaced weather observation stations, the synthetic cyclone statistics provide data over the entire GBR.

- Completion of Guidelines for Investigations into the use of modelling to better understanding coral bleaching incidents. This collaborative project coupled thermodynamic and hydrodynamic models that offer interesting explanations of differences in coral mortality at Scott Reef (off northwest Australia) during the 1998 bleaching event.

- Provision of research and consulting advice to Woodside Energy Ltd to model waves produced by different tropical cyclones of Arafura, Timor and Northwest Shelf regions to determine the 1 in 10,000 year wave conditions.

- Collaboration with Systems Engineering Australia in the development of storm surge models for the Northern Territory and northeastern Western Australia, to be used to simulate storm surge during tropical cyclones, to improve forecasting during a storm and for regional development planning.

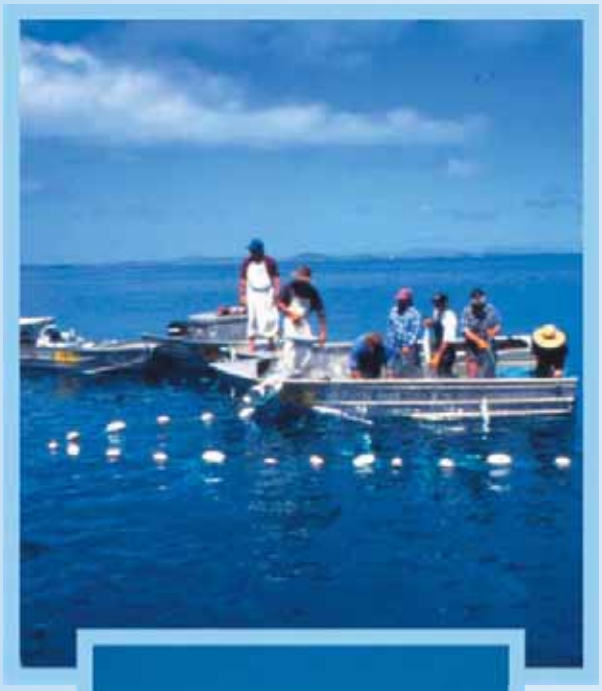
- Completion of a hydrodynamic circulation model for the entire GBR and Torres Strait operating at a 1.5 km grid-scale, allowing the detailed modelling of water flows around individual reefs and representation of the effects of the complex reef structure on transport of water-borne particles. This work provided critical information for assessing the connectivity of marine populations between reefs and, hence, the likely effectiveness of closure regimes as refuges from which populations elsewhere can be replenished.

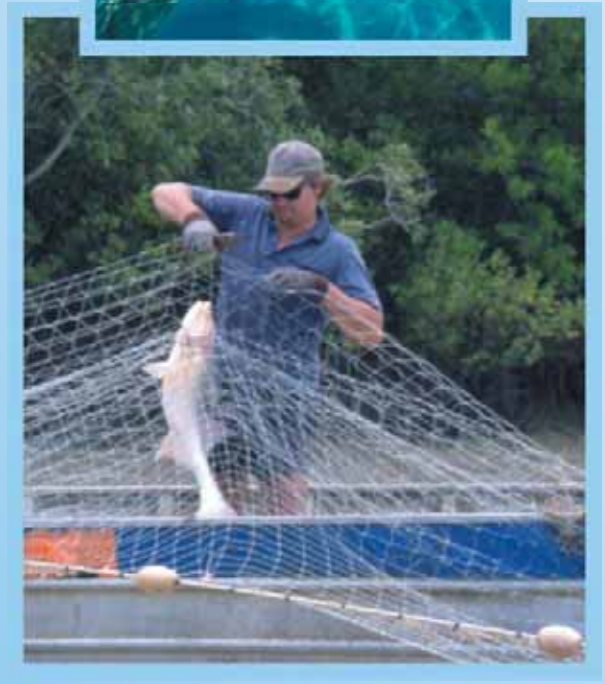
- Completion of Reef Infrastructure Guidelines; tourist pontoons to guide reef management and the tourist industry in the construction, permitting, installation and operation of reef based infrastructure.

- Development of fine-scale modeling to assist wave prediction in and around coral reefs, to reduce design loads at tourist pontoon sites and to assist reef management decision-making; extension of fine-scale current modeling to include the entire GBR and the influences of the East Australian Current on water-borne processes in the GBR, including larval and pollutant transport.

- Development of best-practice mooring and pontoon design to facilitate the design of mooring configurations and optimize the balance between cost and strength of moorings for reef tourism pontoons.

- Extensive modelling and field studies of the feasibility of using island resort wastewater as irrigation to reduce the flow of wastewater nitrogen from islands into surrounding GBR waters.





Understanding People

Sustainable use and effective management of the GBR depends on understanding the impacts of human use on natural systems and on other people. It also depends on understanding the social, economic and cultural values of people and their perceptions about such things as the health of the Reef and the effectiveness of management. Case Study # 4 contains more detailed highlights of CRC Reef research in this important field.

Sustainable Fisheries

Commercial fishing is an important industry in the Great Barrier Reef World Heritage Area and is worth about $149 million a year (GBRMA 2006). In addition, about 198,000 recreational fishers live in the catchments adjacent to the GBRMP (DEH 2006). CRC Reef research provided information to ensure commercial, recreational and Indigenous fisheries are sustainable. The Fishing and Fisheries Project involved several inter-related research tasks focused on important commercial, charter, recreational and Indigenous fisheries of the GBR and Torres Strait. Data and information from these tasks have been used in the development of State fisheries management plans; for AFMA, DEH and DPI&F stock assessment and monitoring requirements; and the CapReef community monitoring program in central Queensland. Highlights of research have been:

- Completion of the 11 year GBR-wide Effects of Line Fishing Experiment (ELF). The final report plus the computer modelling support and data sets that have been developed will provide reef and fisheries management agencies with powerful tools to assist in making more informed decisions. Refer to Case Study # 5 for more details on the ELF Project.
- Expert advice was provided to DPI&F about:
  - developing management plans for the Coral Reef Fin Fish Fishery (CRFFF), the east coast Spanish mackerel fishery, and Queensland Inshore fishery;
  - risk assessment for tropical east coast shark;
  - distribution of sea snakes to help assess and mitigate seasnake bycatch in Australia's northern prawn trawl fisheries;
  - biological characteristics of three coral trout species that led to changes to legal size limits; and
  - red bass life history to support the decision to protect this species.
- Development of an individual transferable catch quota model for the CRFFF of the GBR.
- Expert advice on post-release survival (a project funded by the FRDC) provided valuable information for the National Strategy for the Survival of Released Line Caught Fish.
- Modelling of multi-species targeting of fishing effort in the CRFFF.
- Determination of management units for grey mackerel fisheries in Queensland and the Northern Territory.
- Compilation of a website for managers, researchers and the general public about the trawl, reef line, harvest, inshore fin fish and crab fisheries (catch, critical issues, management, and environmental accreditation for 22 target species) from Queensland's east coast:
  http://www.reef.crc.org.au/research/fishing_fisheries/statusfisheries/index.htm
- The Third International Symposium on Fish Otolith Research and Application, coordinated by the CRC Reef Fishing and Fisheries team, attracted more than 300 delegates from 35 countries.

Global warming and climate change effects

One of the greatest threats to the Great Barrier Reef is considered to be global warming.

CRC Reef research has improved understanding and assisted better management of possible future scenarios of global warming and climate change. An early warning system for coral bleaching was created by CRC Reef in collaboration with AIMS and National Oceanographic and Atmospheric Administration (NOAA) with daily updates for GBRMPA to know when sea temperatures are conducive to coral bleaching.

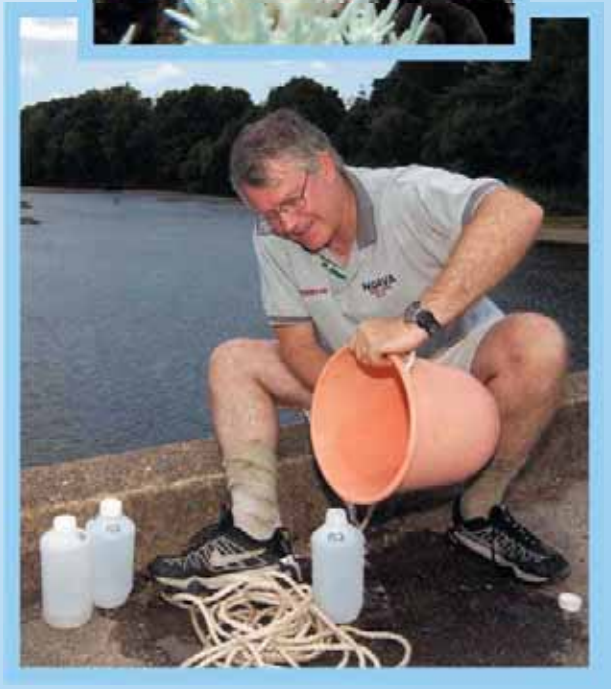
Highlights of research have been:

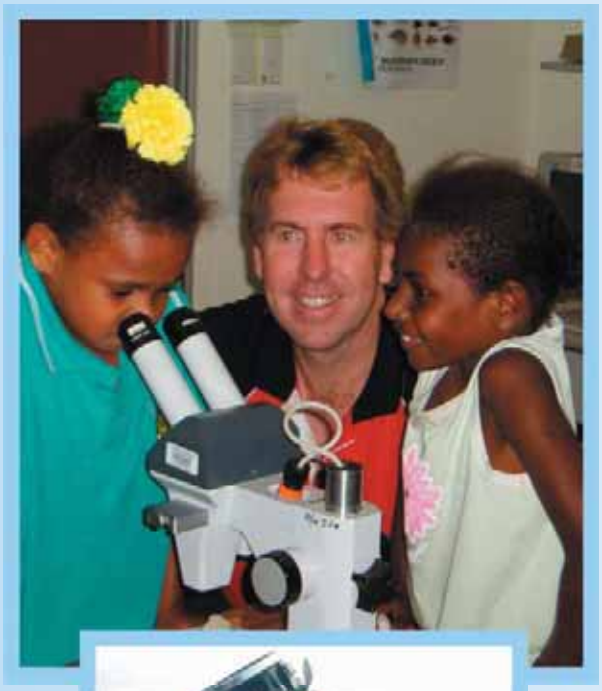
- Continued experiments into the potential for corals to survive further warming of the ocean. Daily processing of maps of Sea Surface Temperature (SST) collected by orbiting satellites are posted on the AIMS website and transmitted to other science agencies (CSIRO, NOAA) for inclusion in global assessments.
- The launch of a new Reef State mathematical model on the Reef Futures website (www.reeffutures.org) which demonstrates the benefits for the Great Barrier Reef of lower rates of global warming and good management. The system includes an interactive capacity for web users to explore future scenarios for coral reefs of the Great Barrier Reef.
- Reporting to the State of Queensland Greenhouse Taskforce on the potential effects and strategies to mitigate global climate change and coral bleaching on the Great Barrier Reef.
- Provision of information about storm surges to the Australian Bureau of Meteorology (BOM) and the QEPA to assist future planning for Hervey Bay and the Sunshine Coast. The work won a Queensland Safer Communities Award in 2004.

Water Quality

The effects of land use on the water quality and integrity of the GBRWHA has become one of the most pressing issues for reef and catchment management in the past decade. The Commonwealth and Queensland Governments have developed a Reef Water Quality Protection Plan (2003) with the aim of halting the decline in water quality flowing to the Reef. Research into water quality issues has been a feature of CRC Reef research since 1992.

A major new research project by CRC Reef in collaboration with Rainforest CRC, called Catchment to Reef, began in 2004. The program featured cooperative linkages between scientists and stakeholders to deliver tools to help improve the quality of water flowing to the Reef. See Case Study #2 for more detailed description.





Torres Strait

The Torres Strait program brought together the main resource management agencies, research institutions and stakeholders in Torres Strait as well as the TSRA, representing the Torres Strait community in a collaborative approach to marine issues in Torres Strait. Highlights of research have been:

- Researchers collaborated with Torres Strait Islander communities in developing mutual understanding of harvest fisheries such as sandfish, dugongs and turtles.
- Potential aquaculture ventures were tested through experimental sponge culture trials of a species of *Coscinoderma*. These were begun near Masig Island in collaboration with the Yorke Island Council. High survival was logged, and over 100% growth of cultured sponges in the first six months.
- A community dugong catch-monitoring program on Hammond Island was commenced.
- Training of local participants and community members in turtle tagging, measuring, and the collection of skin samples for DNA analysis as well as being shown turtle laparoscopy techniques, and being trained in identifying sex of turtles from gonads.
- A survey in Thursday Island Harbour Port that yielded comprehensive, semi-quantitative, collections of flora and fauna and found no introduced marine species. Information from the survey contributed to the Australian Quarantine Inspection Service (AQIS) National Decision Support Systema risk-based assessment system used to manage international ballast water.
- Mapping of shipping lanes showed a diverse range of habitats in intertidal areas in Torres Strait. The dominant habitats adjoining the Prince of Wales Channel and in the Port of Thursday Island are seagrass meadows and coral reefs. Information was supplied to port and shipping management agencies to aid in oil spill response planning and for incorporation into the Oil Spill Response Atlas for the region.
- Seabed habitats and benthos were sampled at more than 180 sites throughout Torres Strait with towed-video, digital still cameras, epibenthic sleds and a sediment scoop.
- Changes in the position and orientation of sand waves were surveyed in monsoonal and trade-wind seasons to assess the seasonal migration rates of sand waves and infer their possible impacts on seagrass beds.
- Students participating in *Seagrass-Watch* monitoring gained an insight into the transition from education to employment and roles in future decision making about Torres Strait marine resources.
- Seagrass was mapped in detail on a major reef complex (Orman Reefs), in Torres Strait for the first time. Species distribution, seasonal abundances, growth, nutrients and photosynthesis of seagrass were analysed and the implications for primary productivity quantified. This is providing important information on the link between seagrass distribution and abundance and dugong and other marine organisms.

Education and capacity building

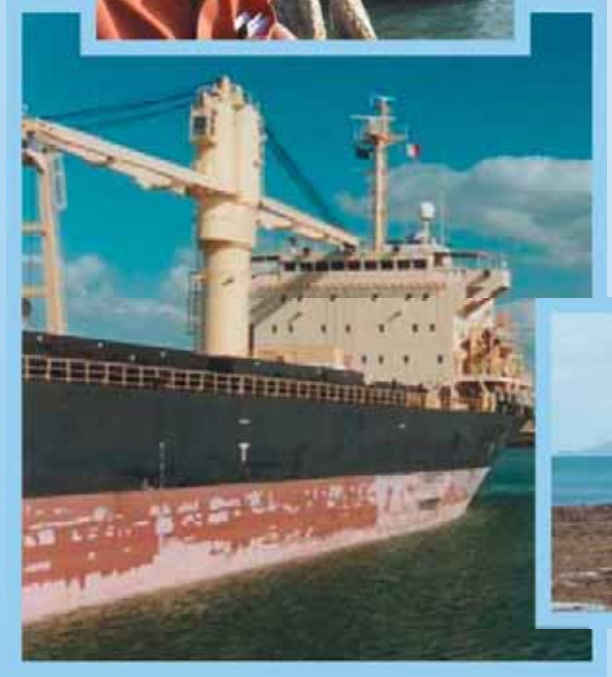
A group of highly motivated and productive research students has been a cornerstone of CRC Reef success. 188 students (105 PhD, 31 Masters, 52 honours) were supported by the Centre. CRC Reef students were recruited across a wide range of disciplines including marine biology, earth sciences, oceanography, anthropology and archaeology, social sciences and economics, resource management, spatial analysis, environmental studies and engineering. Highlights have included:

- High rates of completion - of the 48 scholarship students supported by CRC reef, 34 completed their degrees, one suspended and one had withdrawn. The remaining students are expected to complete their degrees in 2006-07. This completion rate is well above the national average.
- CRC Reef students produced 32% of the CRC Reef publications and 43% of the refereed journal articles on 9% of the total CRC Reef Research budget.
- Students were supported with dedicated staff resources and skills training in a wide range of technical and personal skills to enhance their capacity to apply their knowledge in new employment (see Program E for full details):
- Co-supervision with government management and research agencies was provided for many students and was of significant advantage to students.
- Involvement of many students in national and international collaborative projects.
- Student organisation and participation in four large research workshops with key stakeholder groups.

Technology transfer

A key program in the CRC Reef was the Reef Futures Program with the objective of synthesizing research information into useful products and to develop web-based tools that supported reef management and industry. Highlights have been:

- Compilation of information about monitoring programs in the Great Barrier Reef World Heritage Area which is now available on the Reef Futures website www.reeffutures.org
- Development of a new Reef Futures website, on which visitors can visualise automatic weather station data in real time as well as temperature fluctuations from long-term monitoring across the GBR. Researchers can download these fine scale data directly from http://www.reeffutures.org/topics/bleach/stations.cfm.
- The Production of a comprehensive web 'brochure' about the Queensland's east coast fisheries, which includes status, trend and value of catch by species, with maps showing location of fishing effort: http://www.reef.crc.org.au/research/fishing_fisheries/statusfisheries/index.htm
- Showcasing the Seabed Biodiversity Project with information about the project, its aims and objectives, the team members, vessels, dates of voyages, and descriptions of the tools see http://www.reef.crc.org.au/resprogram/programC/seabed/index.htm.
- Publication of over 870 CRC Reef publications via a web-accessible searchable reference database: http://www.crcreef.webmetrix.com.au/publications/
- Development of ReefState modelling tools and a framework to explore how management interventions might benefit GBR coral reefs under future climate change.
- Undertaking of sophisticated statistical analyses of long-term monitoring datasets that contributed to the development of monitoring programs to evaluate change in GBR water quality and ecosystems under the Reef Water Quality Protection Plan (RWQPP), and to evaluate the effectiveness of the GBR Representative Areas Program.
- The completion of two management-focused future 'scenario models' to explore the efficacy of existing (and proposed) GBRWHA management strategies.



Commercial and international

The expertise of Centre members is sought throughout Australia and overseas and attracted significant additional funds. Highlights of this activity have been:

- The level of commercial contracts has increased from approximately $250,000 in the 1999-2000 financial year to $3.4m in the 2005-06 financial year. A total of $11.05m was obtained by CRC Reef from commercial contracts over the period 1999-2006.
- The Marine Modelling Unit JCU was awarded a major research and consulting project from Woodside Energy Ltd totalling more than $350,000 to model waves during cyclones in the Arafura and Timor Seas and northwest shelf regions to determine the 1 in 10,000 year wave conditions.
- Funding was obtained from the National Heritage Trust of $0.247 million to develop and test a pilot plant for treating ships' ballast water to prevent the introduction of marine pests. A consortium of port authorities, government and private sector partners joined CRC Reef to undertake this project (see - http://www.reef.crc.org.au/resprogram/programB/B1-5.html).
- JCU and CRC Reef established a company, Ballastech P/L, as a vehicle for promoting more commercial development of ballast water treatments. JCU became the sole partner in Ballastech P/L as part of the CRC Reef winding-up operations.
- The Fishing and Fisheries Research team attracted over $2 million in extra funding from external funding sources.
- The Ports and Shipping projects attracted significant additional funding of $1.4 million from Queensland port authorities to map the biodiversity of their port environments and conduct surveys for introduced marine pests.
- CRC Reef established a company International Marine Projects Centre (IMPAC) to promote external activities, particularly internationally. This was an effective vehicle for attracting external funding and hosting interns and other agencies. For example, in 2005-06 IMPAC received $400,000 from AusAID under the Public Sector Linkages Program for activities in Thailand.

Case Studies

Case Study #1: Representative Areas Program

The Issues

In the 1990's the GBRMPA became aware that the current level of protection from Marine National Park ('no-take') zones in the GBRMP was inadequate to "ensure protection of the entire range of marine biodiversity in the park." (Fernandes et al 2005). There was growing concern about increasing pressures on the biological systems from human use within the Park, from onshore activities in the GBR catchment and from climate change. Only 4.5% of the Marine Park was contained within 'no-take' zones. These were largely confined to coral reefs and, other than the large cross-shelf transect in the Far Northern Section of the Marine Park, virtually all of them were small and of limited value for biodiversity protection. Almost none were located in inshore areas.

The 25 Year Strategic Plan for the GBRWHA released in 1994 contained an objective "to protect representative biological communities throughout the Area to act as source areas, reference areas, and reservoirs of biodiversity and species abundance". The GBRMPA initiated the Representative Areas Program (RAP) in 1999 and decided to use a bio-regionalisation approach as the basis for protecting representative examples of biodiversity. The entire GBRMP was rezoned in 2003 on the basis of increased protection of representative bioregions.

The Role of CRC Reef

The advice and opinion of reef scientists, many of them from CRC Reef, was sought to help define the problem, collate data sets, map the reef and non-reef bioregions and set planning principles.

Scientists played a major role in mapping the biodiversity of the GBR into 30 reef and 40 non-reef bioregions. The data for the classification phase were scattered through published and unpublished material over 50 years or so. More than 70 scientists and experts were surveyed to identify the information and data on spatial patterns in the distribution and diversity of both biota and physical parameters. The respondents were from relevant disciplines in private industry, academia, research, and management institutions. Over 60 datasets were collated.

Spatial patterns of diversity were further described using multivariate regression tree (MRT) analysis on the most comprehensive datasets (soft corals, hard corals, reef macroalgae, reef fishes, epibenthos, algae, sediments, benthos and deepwater seagrasses). The analyses spatially clustered reef and non-reef components of the GBRWHA. The second component of the Classification Phase describing the biological patterns of the GBRWHA drew upon these analyses, other existing regionalisations and the data gathered in the scientific surveys. In a series of workshops organised by the GBRMPA, experts combined these analyses and data with their detailed knowledge to produce a map of bioregions for the GBRWHA (Fernandes et al 2005).

An independent Scientific Steering Committee with expertise in GBR ecosystems and biophysical processes helped define operational principles to guide the development of a comprehensive, adequate and representative network of no-take areas in the Marine Park (Fernandes et al 2005). The operating principles (11 biophysical principles and 4 socio-economic principles) were designed to achieve the objectives of RAP.

It proved difficult to develop a strong scientific statement in support of a specific percentage of protected habitat based on evidence because "*there have been relatively few ecosystem scale scientific studies to support or 'prove' the amount of insurance that will be provided.*" (Fernandes et al 2005). However, it was sufficient to support a minimum level of protection, judged to be at least 20%. One of the critical developments in the scientific support for this program was to use scientific expertise to form a consensus on the following important points:

- Highly protected areas of sufficient size and in a dispersed configuration are likely to provide some "insurance" that helps maintain resilience of the GBR ecosystem.
- Highly protected areas do not operate in isolation and external pressures must also be managed.
- Highly protected areas are important as points of reference when assessing reef status, particularly in providing a benchmark for comparison with other areas where protection levels are lower and human disturbance may be causing changes in the system.

Other important scientific input into RAP included:

- Independent review by the CEO of the CRC Reef, of the scientific and technical aspects of the 'classification' phase of the RAP.
- Assistance in interpreting commercial fisheries log-book data.
- Expert knowledge of fishing patterns - used to fit zones around patterns of use, minimising impacts on commercial fishers.
- Provision of information on socio-economic aspects of commercial and recreational fishing.
- Application of mathematical models showing the movement of larvae between reefs used to identify key 'source' reefs as well as likely 'sink' reefs which may be more readily replenished.
- Particular advice on the value of 'no-take' areas for replenishment of adjacent areas through 'spill-over' and larval recruitment effects from no-take areas.

The provision of scientific data, expertise, opinion and consensus much of it from the CRC Reef provided a strong basis for the process and the final socio-political outcome. *"Independent experts greatly assisted in the development of GBR-specific bioregions, reserve design software and operational principles relevant to biodiversity protection objectives. Collectively, over 30 experts contributed to forming the foundations of the re-zoning of the Great Barrier Reef Marine Park. The bioregions and principles were made public prior to development of any maps of new zoning. These "products" were powerful due to their independent status and their wide availability for discussion and critique early in the planning process"* (Fernandes et al 2005).

Lessons Learned

1. The existence of an organisation like the CRC Reef with strong partnerships between research providers and research information users provided an excellent vehicle for organising the scientific input to the RAP process.
2. Familiarity with GBR management needs and issues from many years of collaboration between scientists and managers was important to the RAP process.
3. Early involvement of all relevant scientists in the process of determining the scope of the issues, the range and location of bioregions and the operating principles was essential to success.
4. Making clear the role of science i.e. as the foundation on which the planning, public consultation and political processes would be based, was important.
5. The use of careful facilitation of the processes of developing scientific advice and consensus was critical to success.

Case Study#2: Water Quality in the GBRWHA

The Issues

The 25 Year Strategic Plan for the GBRWHA published in 1994 identified as a major issue, the potential effects of land-based pollution on the integrity of the GBRWHA. The need for integrated management and research strategies to evaluate the effects was included in the objectives for this Strategy. Water quality was identified by GBRMPA as one of four key issues that would be the focus of activities from 1994 onwards.

The Role of CRC Reef

Prior to 2001, GBRMPA, AIMS and CRC Reef scientists had collaborated in undertaking important water quality research to quantify issues such as the GBR nutrient budget, fluxes to the GBR from the variety of sources including delivery mechanism such as flood plumes, initial investigation of impacts of nutrients and sediments on coral communities and some of the first sampling in the marine environment for agricultural pesticides.

Much of this research information was then used to produce two important syntheses:

1. *Review of Impacts of Terrestrial Run-off on the GBRWHA* by Dr David Williams of CRC Reef prepared for information of the CRC Board.
2. *Great Barrier Reef Water Quality: Current Issues* (Haynes et al 2001.) released by the GBRMPA in September 2001. This document provided an overview of current issues and in particular identified the overall increases in pollutants entering the GBR.

The *Current Issues* paper generated significant discussion in the science community about the veracity of the science and of the synthesis. The CRC Reef was commissioned to prepare a consensus statement on water quality. This was done by bringing together principle research science leaders across a number of disciplines to set out the current scientific basis for understanding the perceived threats (Williams et al 2002). This statement concluded by saying:

"on the basis that:

- *post-European land use had significantly increased runoff and sediment associated nutrient and contaminant delivery to near-shore regions of the GBRWHA;*
- *runoff has had clear detrimental impacts on freshwater aquatic systems; and*
- *there is significant risk that this impact is currently or may in future damage areas of high exposure along the wet tropical and central Queensland coasts of the GBRWHA, there is a continued urgency to work towards a reduction in the runoff of sediments, nutrients, herbicides and other pollutants into the Great Barrier Reef World Heritage Area."*

This scientific consensus statement played a significant role in allowing the policy debate to move forward and this in turn led to the development of the joint Commonwealth and Queensland Government Reef Water Quality Protection Plan 2003. (RWQPP 2003).

Assessing land based threats and impacts was a key project of the CRC Reef from 1999. In 2002 the CRC Reef joined with the Rainforest CRC in making a successful bid for a new program "Catchment to Reef". This program lifted the focus in research effort to support the policy work being done by the GBRMPA to develop and implement RWQPP. The research program started to address gaps in knowledge, refocused some of the research effort to further quantify impact of sediments, nutrients and pesticides and began to explore links between catchments and the Reef.

One of the strengths of CRC Reef was its capacity to coordinate the science providers and manage partnerships. This was demonstrated by its successful tendering for management of the GBRMPA's Reef Plan Marine Monitoring Program, the only comprehensive monitoring program assessing the outcomes of the implementation of the RWQPP. Other highlights were:

- A conference 'Catchment to Reef: Water Quality Issues in the Great Barrier Reef Region' was organised in March 2004. This conference attracted 170 people, and began charting new directions for improving water quality under the RWQPP
- A plausible link between rainfall, water quality and outbreaks of the crown-of-thorns starfish on reefs adjacent to the Wet Tropics coastline of the GBRWHA was demonstrated. The study highlights the potential benefits of improving water quality in the GBR.
- The strongest link yet between coastal development and the state of coral reefs was discovered using epidemiological methods. The study again highlights the benefit of improving water quality for the GBR.

Lessons Learned

1. CRC Reef has undertaken critical scientific research to support management of the impacts of water quality on the GBR.
2. Most of the research has been in the physical and biological sciences. Socio-economic research has had to be commissioned separately.
3. The partnerships generated between science and management through the CRC Reef governance and program structure has facilitated the production of relevant science for policy and management decisions.
4. Integration of the research strands has been undertaken by scientists and managers within GBRMPA.
5. The development of a consensus statement from CRC Reef and other scientists is another example of the value of collaboration between science and management.

Case Study #3: Conservation of Dugong.

The Issues

The GBRWHA and Torres Strait are globally important habitats for many species of marine wildlife. More than 30 species of marine mammals visit or are resident in these regions including the dugong, a species of cultural and dietary significance to Indigenous Australians and of intrinsic value to many non-Indigenous Australians.

In the GBR Region, threatened species management results from Australia's international obligation to ensure the World Heritage Area's protection, conservation and transmission to future generations and obligations under national legislation. The significance of the Region for dugongs was a reason for its World Heritage listing. The dugong is listed as vulnerable to extinction by IUCN and Queensland. Management agencies are therefore committed to paying special attention to such species and the success in managing threatened and protected species is a key indicator of the success of management of the Area.

Because the dugong is a long-lived slow breeding species, the total mortality from human impacts must be extremely low (1-2% p.a.) for numbers to be maintained. It is also essential to protect the coastal seagrass meadows which are critical habitats for dugongs. Dugongs can undertake movements of hundreds of kilometres in a few days but movements are individualistic and unpredictable. The ecologically relevant scale for dugong management is hundreds of kilometres rather than culturally relevant, more local scales. Dugongs live and travel in areas that are within different jurisdictions.

The relative importance of the various causes of the long-term decline in dugong numbers along the urban coast of Queensland cannot be quantified and probably varies in both space and time. The likely causes include the commercial dugong industry (now stopped), traditional hunting, poaching, incidental drowning in nets (commercial gill nets as well as shark nets set for bather protection), vessel strike, and habitat loss.

The Role of CRC Reef

CRC Reef contributed to better understanding of the life history, population estimates and specialist habitat requirements for dugong. Highlights include:

- Statistical analysis of the bycatch of dugongs in shark nets set for bather protection on the urban coast of Queensland. These analyses have shown that this coast supports far fewer dugongs than in the 1960s, the first date for which any reliable indices of dugong abundance are available for this region.
- Assessment of the responses of dugong to acoustic alarms ("pingers") on fishing nets, showed that these are unlikely to reduce dugong mortality.
- Completion of a study into the responses of dugong to disturbance and strikes by boat movements, which showed that dugongs are particularly vulnerable to boats travelling fast and that speed restrictions for boats may be necessary in important dugong areas.
- Analysis of data from dugong fitted with GPS transmitters and dive computers showed that dugongs track the bottom when they go on long distance movements and use inshore areas more at night than during the day.
- Spatial risk assessment of the 2003 GBRMP Zoning Plan, the adjacent Queensland Great Barrier Reef Coast Marine Park Zoning Plan and other current management arrangements, for their combined capacity to protect the GBRWHA's significant populations of the dugong. Overall, 96% of high conservation value dugong habitats in the GBRWHA are now highly protected from anthropogenic impacts, a significant improvement over the previous management arrangements.

This research has changed the understanding of the impacts of human activities on dugong and has informed major changes in management measures by both the Commonwealth and Queensland Governments to protect dugong such as:

- Declaration of Dugong Protection Areas in both Commonwealth and State waters which include the removal of net fishing from some significant dugong habitat.
- Inclusion of key dugong habitat in 'no-take' and limited fishing zones of the GBRMP Zoning Plan 2003.
- Introduction of voluntary vessel lanes and/or speed restrictions to protect dugongs from vessel strikes in prime dugong habitat (e.g. Hinchinbrook Island).
- Development of mutually acceptable legal agreements with Traditional Owners for the management of traditional hunting in local areas.
- Replacement of shark nets with drum lines at most locations where bather safety is an issue.
- A review of the use of the herbicide *diuron*, which has been detected in both dugong tissues and the sediments associated with seagrass beds.
- Organisation of a collaborative marine wildlife carcass salvage program.
- Provision of evidence to the Natural Resource Management Ministerial Council about Indigenous harvest of dugongs in the northern GBR and Torres Strait, that led to the establishment of the national partnership approach to the harvest of marine turtles and dugongs in Australia in 2005.

Lessons Learned

1. Long-term monitoring of populations of slow-growing mammals is essential to begin to understand life history parameters and make management decisions that provide for recovery and/or maintenance of populations.
2. Expert biological advice is essential input to the development of management systems for the protection of endangered species.
3. The importance of developing cross-jurisdictional objectives for management at ecosystem scales, and of coordinating management at ecologically and culturally relevant scales.
4. Assumptions about the effectiveness of strategies used elsewhere on different species need to be evaluated in the GBR context for their relevance to dugong conservation.

Case Study #4: Understanding People

The Issues

Sustainable use and effective management of the GBR depends on understanding the impacts of human use on natural systems and on other users. It also depends on understanding the social, economic and cultural values and perceptions of people about the health of the Reef and the effectiveness of management.

The Role of CRC Reef

1. Language matters. Research into dugong and turtle hunting, planning and management, showed clear differences in perspectives or discourses between the Hope Vale community near Cooktown and the management agencies GBRMPA and QEPA. Hope Vale community members prioritised community and cultural needs over the biodiversity and animal rights needs of the species, focused on process rather than content, and did not separate the issue of hunting management from an overall discourse about social justice and Indigenous rights for self-determination. Management agencies sought to understand how many green turtles and dugongs were being hunted, whereas Hope Vale participants prioritised hunting management as an issue of cultural survival and assertion of their Indigenous knowledge and culture. This work showed how important it is for management agencies and stakeholders to share a common understanding of each others' priorities.

2. Community participation in management decision making processes. Natural resource management agencies such as GBRMPA are under increasing pressure to consult with their constituents and include them in the decision-making process. In the recent re-zoning of the GBRWHA, management agencies used a range of techniques including public meetings and formal submission programs to solicit public input and enhance public involvement in fisheries and marine park management decisions.

The largest and most comprehensive survey of the social values of recreational fishers in Queensland provided a baseline against which change can be measured. This work provided new insights into the factors that predict participation by recreational fishers in public consultation programs, and investigated differences in opinions and beliefs between participants and non-participants. 28% of the 765 respondents to this survey reported participating in public consultation programs regarding recreational fisheries issues. 72% of fishers who attended a meeting and 75% of fishers who made a formal submission reported doing so over the issue of re-zoning the GBRMP.

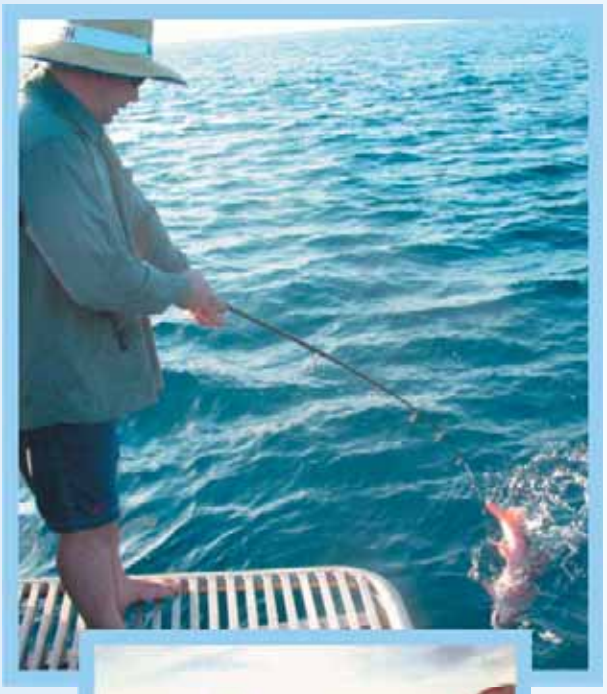
Participation in consultation programs was positively related to a number of factors: age, enthusiasm for fishing, centrality of fishing to lifestyle, and membership in fisheries-related organisations. There was no effect of gender, income, or years of fishing experience. Participants and non-participants differed significantly in their level of agreement with 12 of 20 belief statements about fisheries management, issues and threats facing recreational fisheries, and the effects of recreational fishing on fish populations, and in their level of approval of four of eight fishing regulations. Non-participants were generally more supportive of the management restrictions than participants. Results suggested that recreational fishers who participated in public consultation programs may not be representative of the wider recreational fisher population.

3. Resilience of commercial fishers to change. A CRC Reef study of the resilience of commercial fishers to changing management arrangements in the GBRWHA showed that dependency on fishing is a function of both attitudinal and financial flexibility. The fishers most vulnerable to change tend to be very attached to their lifestyle, and have low employability and a small operation. The research showed that fishers who participate in the process of change by attending public meetings or making submissions are more likely to be negative about the change than those who don't participate, a finding parallel to the finding about recreational fishers. However, if fishers are meaningfully involved in the process of change they are more likely to be positive. This work showed that public participation, especially for the most vulnerable groups of fishers, is not just about how many fishers participate in public consultation programs, but about how meaningfully they are involved.

4. Other contributions to understanding people.

- Development and implementation of an *Indigenous Engagement Strategy* to develop partnerships with Traditional Owners and provide opportunities for involvement of Indigenous groups in research.
- Development of *Guidelines for ethical and effective communication for researchers working in Torres Strait* for contact and communication by researchers with Torres Strait communities and to raise cross-cultural awareness.
- Completion of Town-Resource Cluster Analysis of commercial fishing communities along the Queensland coast to provide insights into the possible social and economic consequences of natural resource management decisions

Case Study #5: Effects of Line Fishing Experiment



The Issues

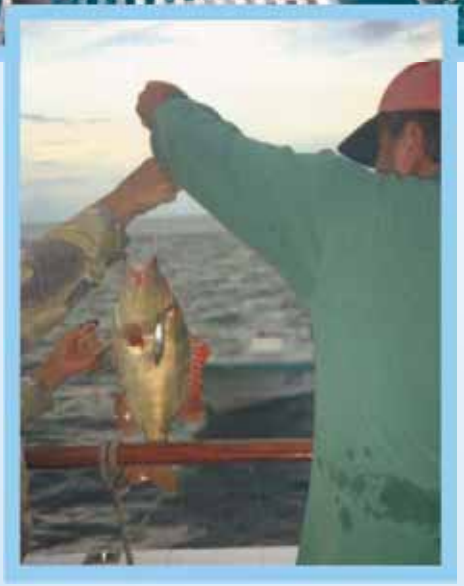
Fishing for reef fish has been a commercial and recreational activity on the GBR since well before the establishment of the GBRMP in 1975. Fishing was considered to be consistent with the multiple-use concept for the Marne Park, providing that the impacts were sustainable.

In the 1970's and 1980's the levels of fishing were considered to be acceptable, although there was little data on which to base fisheries and marine park management decisions. The design of a large-scale long-term experiment on the Effects of Line Fishing (ELF) commenced in 1988. The need for data for management became more acute as fishing pressure increased (e.g. commercial line fishing effort doubled between 1994 and 2002) at the same time as the need for much higher levels of protection of representative habitats became apparent (see Case Study #1 Representative Areas Program).

The Role of CRC Reef

The CRC Reef provided the collaborative research framework for the conduct of this ambitious experiment. The early design of the program took several years to develop, before a large-scale manipulative experiment was agreed on. The initial design objectives were:

- To understand the level of fishing that existing fish stocks and reef communities can sustain via:
- Investigations of demographic characteristics of target and non-target species;
- Experimental manipulations of fishing effort; and
- Monitoring responses of target and non-target species to changes in fishing pressure, including responses of selected benthos and prey of target species.
- To evaluate the efficacy of current management practices, including zoning strategies, with respect to the ecologically sustainable management of the Marine Park and tropical reef line fishing.
- To evaluate quantitatively potential management strategies for the future regulation of fishing such that fish stocks, ecosystem function, and yields to fisheries will be conserved.



The initial broad design objectives were refined into the following central objectives:

1. to quantify how target and non-target fish species are impacted by line fishing in the GBR;
2. to examine the recovery of target and non-target fish species when reefs are closed to fishing;
3. to measure impacts on fisheries of changes in abundance of target and non-target fish species species;
4. to compare different methods of monitoring changes in density of target and non-target fish species; and
5. to provide key parameters for evaluating management strategies.

The ELF experiment involved the manipulation of fishing pressure in four groups of six reef 'clusters' spread over >1500 km of the GBR from Lizard Island in the north to Storm Cay in the south. Four of the reefs in each cluster had been closed as 'no-take' during the 1980's when the GBRMP was first zoned. The other two reefs in each cluster had historically been open to fishing and zoned accordingly. By opening and closing sets of reefs within each cluster, the effects of both protection and fishing pressure were able to be measured.

The first surveys to measure fish stocks prior to experimental changes of fishing pressure began in 1995. Over the following 10 years the manipulative experiment continued, as well as a suite of other fisheries related research to support the ELF experiment. Reefs were surveyed annually using structured line fishing surveys and underwater visual surveys.

A significant aspect of this research was the degree of cooperation between researchers, management agencies and fishers in the conduct of the research and dissemination of results; without such co-operation, particularly of the fishing communities, this experiment would not have been successful.

The quality of the research program attracted significant additional funding ($6.5m since 1993) as competitive research grants and consultancies from a wide variety of Commonwealth and Queensland Government agencies.

Post-graduate student projects have also had a significant contribution to the ELF project. 19 post-graduate students either completed their degrees by 2006 or are expected to in 2007. All of the research was collaborative and much of it was multi-disciplinary in nature. This has provided these students with skills and experience not normally acquired from post-graduate studies.

The Results

This program was not without controversy. Opening and closing reefs to fishing required a change to the GBRMP Zoning Plan and this was opposed by some political parties. There was intense debate about the ethics of allowing experimental fishing in 'no-take' zones within the Marine Park. The decision to allow the zoning changes was only narrowly passed by the Senate. The experiment was reviewed by the Federal Government after the first round of manipulation to ensure that it was meeting its objectives.

A wealth of information of importance for fisheries and marine park management was generated from this program. The ELF experiment was a significant source of information used in the rezoning of the GBRMP in 2003 (see Case Study #1). Many of the fisheries management practices of the Queensland Government have been changed after research results from ELF were known. The development of decision support tools (ELFSim) to conduct Management Strategy Evaluations of options for managing populations of target fish species in the reef line fishery on the GBR was a major product of the research. The continued maintenance of this tool should ensure its value for future use as an important fisheries and Marine Park management tool.

Some key findings from this experiment have been:

- closed reefs have larger and more abundant target fish than open reefs;
- stocks of target fish on reefs newly opened to fishing decline rapidly to the levels in surrounding open reefs;
- fish stocks recover when reefs are closed; however fish stocks on reefs with a long history of fishing pressure may recover more slowly than reefs that were only opened for short periods;
- more large fish on closed reefs have a greater spawning capacity than populations on surrounding open reefs; and
- increased fishing pressure on coral trout may cause these fish to change sex earlier and at smaller sizes that could affect the reproductive capacity of the species.

Lessons Learned

1. Community participation is essential for successful experiments where the results are likely to affect people's livelihoods and values.
2. Political sensitivities need to be addressed and managed where there are large-scale manipulations of natural populations.
3. Studies to fully understand the effects of a complex set of pressures on fish stocks need to be conducted at large spatial and temporal scales.
4. Excellent cost-effective research can be generated by well supported research students engaged on relevant and interesting research topics.
5. The continued maintenance of the ELFSim models that allow managers to conduct 'what if' testing of alternative management strategies is essential if the continued value of this program is to be maintained.
6. The successful conduct of large-scale long-term collaborative research projects requires a sustained orginisational framework such as that provided by CRC Reef.

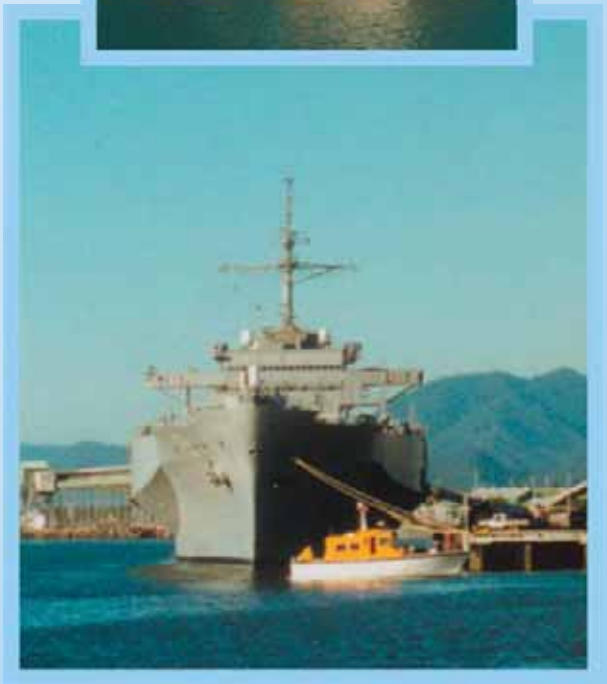
Case Study #6: Impacts of Ports and Shipping Activities

The Issues

Many ports and marinas operate in, or adjacent to, the GBRWHA and thousands of ships traverse the waters of the GBRWHA annually, often carrying cargoes that would threaten the environment if released in an accident. These activities are vital to the normal social and economic function of Queensland (the value of trade through ports operated by the PCQ alone is $68 billion per year) but pose potential risks to the environment. Environmental risks in shipping channels and in ports principally occur through accidents and unintentional introduction of exotic pest species. CRC Reef was contracted by PCQ as preferred supplier of research information necessary for environmental management.

The Role of CRC Reef

- A coordinated program was organised and conducted over the seven years with the following results:
- Surveys completed of all major ports in tropical Queensland to map natural habitats and search for exotic pests.
- Early detection of an invasive exotic species, the Asian green mussel, in Trinity Inlet, Cairns through port survey.
- Mapping of marine habitats in sections of two major shipping channels, Margaret Bay and Hydrographers Passage, identified as at high risk from shipping accidents.
- Marine surveys in the Ports of Hay Point and Abbot Point to enable planning of an environment framework for essential port infrastructure improvements.
- Provision of expertise to develop detailed circulation and sediment transport models for major ports. These models were used to explore the likely infestation pathways for Asian green mussels in Cairns Port, to explore the major risks from accidental spills in ports, and the most efficient designs for port dredging and development works.
- International recognition for work on invasive pest species through invitations to attend specialist international working groups and advise on the detection of introduced pests in tropical waters.
- Development of tests to detect exotic pests based on biochemical or genetic signals rather than labour-intensive visual searches. These methods will increase the efficiency and reliability of pest detection.
- Testing a portable pilot plant for an efficient method of 'cleaning' shipboard ballast water to remove or kill all larvae of exotic marine species in the ballast water so that they will not be released into Australian seas. The pilot plant was developed with external funding from government and industry and is now ready for onboard ship testing. This technology has the potential to provide state-of-the-art biosecurity to the international shipping industry and to significantly reduce the risks of exotic pest introductions via ballast water.



Research Quality and Impact

CRC Reef has acquired a deserved reputation for high quality collaborative research directed at end-users needs and delivering outcomes of benefit to the sustainable use of the GBRWHA. Research **quality** can be measured in a number of ways through recognition by peers, volume of outputs, reputation of journals publishing papers, prestigious awards to key researchers, citations, collaboration and co-funding. Quality control is a function of effective research project management systems.

Research **impact** is ultimately the degree to which the application of useful information in decisions produces effective outcomes for the GBRWHA, and its sustainable use. Figure 1 is a conceptual framework for effective research outcomes.

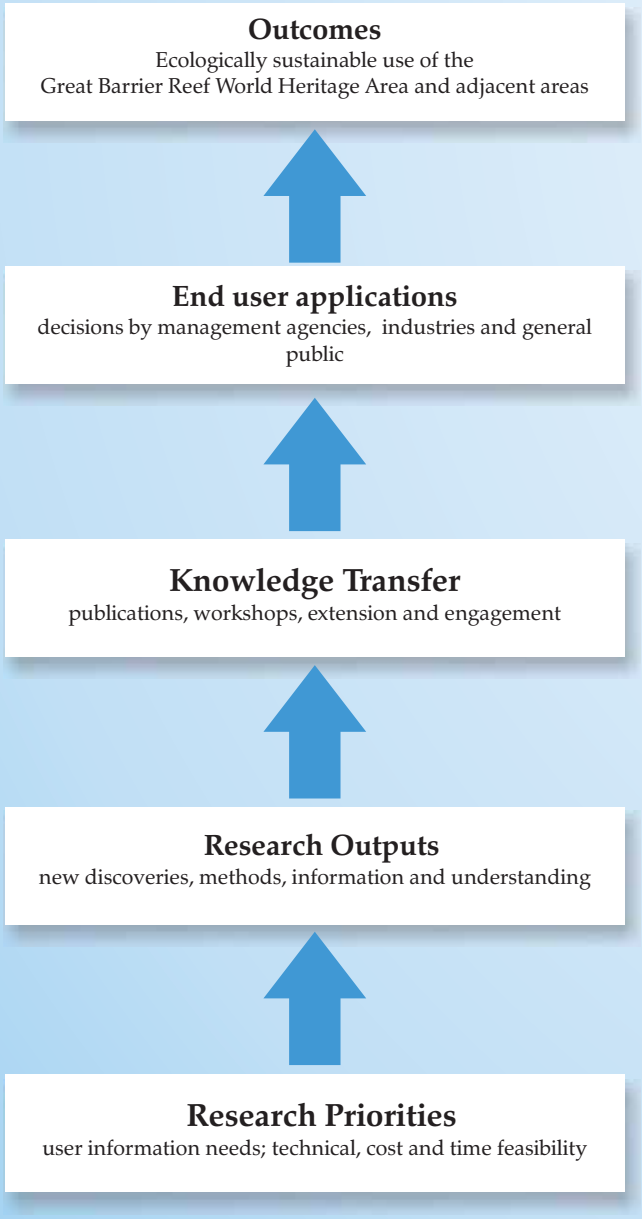


Figure 1 Effective Research Outcomes

Quality control systems

- Quality control of CRC Reef research has been ensured by careful planning and oversight of research tasks to ensure that researchers deliver useful products on time and in formats that are readily able to be used. The CRC Reef **Board** has insisted on effective systems to manage resources contributed to CRC Reef. Processes undertaken in the development and approval stages of research tasks ensured that they were scientifically rigorous and relevant to end-users:
- A **Scientific Advisory Committee** (SAC) provided scientific and technical advice to the Board through the CEO and Task Review Committee on the research and technology transfer aspects of programs.
- The **Task Review Committee** (TRC) ensured that end-users were involved in the formulation of research proposals after scientific evaluation by the SAC and before consideration by the Board.
- A **Task Associate Program** (TAC) promoted better understanding between researchers and end-users from industry and management agencies, by assigning one or more associates from an end-user organisation to each research task.
- Where projects were large and complex or issue-specific, a **Steering Committee** was formed to assist cooperation and integration in research programs and tasks e.g. Effects of Fishing Steering Committee, Seabed Biodiversity Steering Committee, Catchment to Reef Steering Committee, Water Quality and Ecosystem Monitoring Programs Management Steering Committee.
- An **Intellectual Property Committee** (IPC) provided advice to the Board through the CEO on the identification, protection and proper utilisation of Intellectual Property.

Ultimately the **Board,** whose members were predominately made up of end-users, approved the research tasks after advice from the SAC and TRC. All research tasks were reviewed each year in December (checking progress) and in June/July (full review of progress and achievements against milestones). All research students were reviewed annually and six-monthly as part of the task reviews.

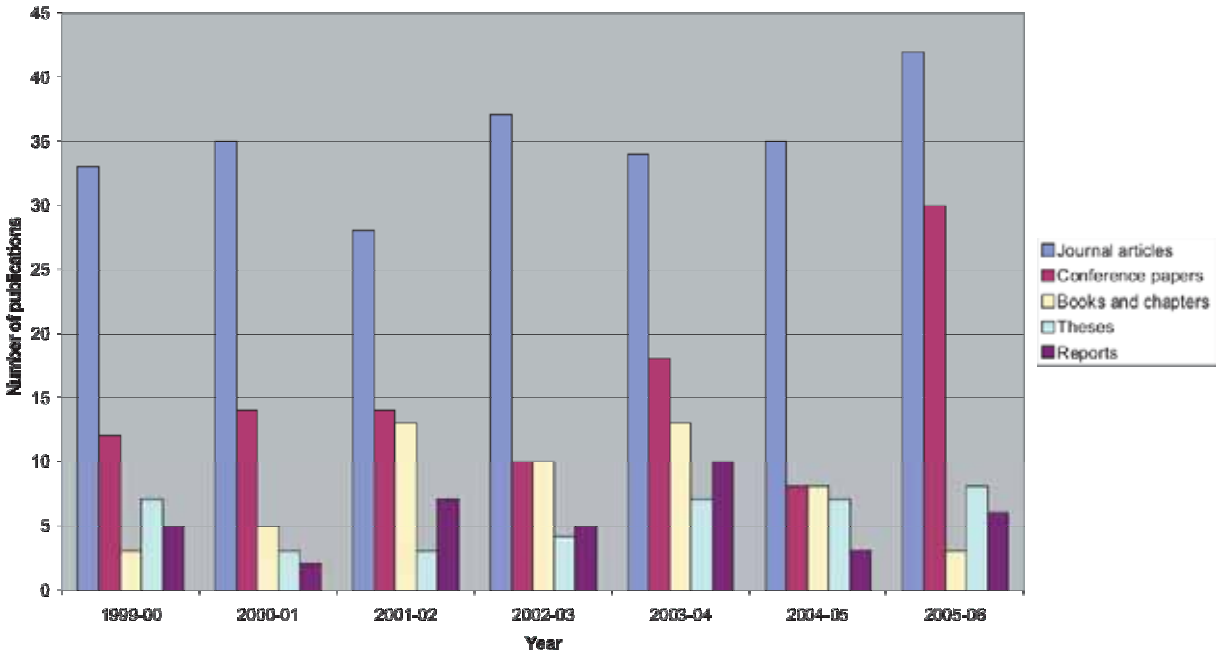
Quantitative Indicators

Table 1 is a summary of the quantitative indicators for research quality for the period 1999-2006.

Indicator	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	Total (Target)
INPUTS								
Research program resources $m p.a. (cash)	8.3	9.9	9.7	10.07	16.6	17.8	20.1	93.0 (53.3)
Research program resources (in-kind)$m p.a.	4.9	5.3	5.5	5.7	8.85	9.4	9.2	48.9 (32.1)
Commercial contracts $m p.a.	0.25	0.46	0.6		2.1		7.6	15.3 (2.35)
OUTPUTS								
Refereed journal articles	33	35	28	37	34	35	42	274 (15 p.a.)
Conference papers (international)	10	8	7	7	8	4	10	54 (10 p.a.)
Conference papers (national)	2	6	7	3	10	4	20	52 (20 p.a.)
Books and chapters	3	5	13	10	13	8	3	55 (5 p.a.)
Technical Reports	5	2	7	5	10	3	6	38 (10 p.a.)
Current Research Students (Scholarship) p.a.	28	21	22	25	22	22	14	Av. 22 p.a.
Current Research Students (Associate) p.a.	54	63	66	58	62	52	33	Av. 55 p.a.
Theses completed	7	3	3	4	7	7	8	39
PEER RECOGNITION								
Advisory groups and steering committees	6	4	5	5	7	8	11	46 (10)
Invitations to speak (plenary/keynote)	3	4	6	3	2	2	3	23 (3 p.a)
DELIVERY OF RESEARCH OUTCOMES TO END USERS								
Publications	5	19	36	18	36	32	30	176 (70)
Newsletters	7	5	5	7	5	6	1	36 (28)
Industry Seminars	32	67	61	68	102	96	80	72 (50)
COLLABORATION								
Between researchers (=2 per task)	82%	67%	82%	100%	100%	100%	100%	Average 90% (80%)
With Australian research institutions (tasks p.a.)	26	22	24	35	29	82	83	43 (25)
With Overseas research insititutions (tasks p.a.)	45	48	56	67	50	51	45	52 (25)

Table 1 and Figure 2 show the publications for CRC Reef over the review period and indicate the maintenance of a strong and consistent level of output. A total of 688 publications were recorded in the seven year period. A further 23 manuscripts from Program T: Torres Strait are in preparation for publication in a special edition of Continental Shelf Research 2006-07. Lists of publications can be found in each of the Project Summaries.

Figure 2: CRC Reef publications 1999-2006



Citation analysis

A general indication of research quality is the international standing of the main research institutions of CRC Reef in relevant fields. ISI Essential Science Indicators (ISI ESI) released a Special Topics report on Coral Reef Ecology in 2004 covering the period 1994-2004. The three major research providers for the Reef CRC in Coral Reef Science (JCU, AIMS and UQ) were ranked 1, 2 and 15 in the world respectively for citations in coral reef ecology. Their collective citations (6,523) are almost 4 times higher than any other institution worldwide. Although these data are derived from all researchers at JCU, AIMS and UQ, not only those in CRC Reef programs, the survey established that the three key research providers for the CRC Reef in coral reef science are amongst the top ranked institutions in the field worldwide.

A similar global approach to institutional research quality is provided by the ISI ESI database on citations in specific fields. In the field of Ecology/Environment, one of the most relevant fields to coral reef science, JCU, UQ and AIMS are ranked 66, 89 and 367 in the world for citations. Their collective citations (16,645) for the 10-year period 1996-2006 would rank them collectively 19th in the world for citations in the field. Again this is strong evidence of the general quality of the research institutions from which CRC Reef has derived much of its research outputs in coral reef science.

Publication of scientific research in prestigious international peer-reviewed journals is another indicator of research quality. An analysis of 87 CRC Reef papers from 2004-05 shows that 60% have been published in the top 20 ISI journals by Impact Factor in the research field of Marine and Freshwater Biology. The main journals in this field are Coral Reefs, Marine Ecology Progress Series, Marine Pollution Bulletin, Journal of Experimental Biology and Ecology, Marine and Freshwater Research and the Canadian Journal of Fisheries and Aquatic Sciences. Given that citations are a lagging indicator, publications in High Impact Journals are widely recognised as measures of research quality.

Collaboration between researchers

Collaboration with other researchers was a deliberate and effective strategy to bring intellectual, financial and in-kind resources to bear on large projects. A target to have at least 80% of research tasks with 2 or more researchers was met and exceeded each year for the life of the CRC Reef. For the years 2002-03 to 2005-06 inclusive, collaboration was 100% (Table 1). Collaboration between CRC Reef research providers and other researchers was significant, averaging 43 tasks p.a. in Australia and 52 tasks p.a. overseas.

Peer Recognition

During the life of the CRC Reef 1999-2006, outstanding contributions by CRC Reef researchers have been recognised by peers in their fields in various ways. This has been through awards, holding office in professional bodies, invitations to deliver keynote and plenary speeches at conferences and invitations to provide expert advice to government and industry for policy and other decision making. These are all ways of recognising scientific standing, integrity and capacity.

The most notable of those reported for the seven year period were:

- Dr Terry Done - President of the International Coral Reef Society.
- Dr Russell Reichelt - National Oceans Advisory Group (chair), Great Barrier Reef Consultative Committee (chair) and CSIRO Wealth from Oceans Flagship Advisory Committee.
- Dr Terry Done keynote speaker at UNEP workshop on Information Management and Decision Support for Biodiversity Preservation and Human Welfare Townsville, December 1999.
- Dr David Barnes plenary address at the XIV Pacific Science Congress Sydney, July 1999.
- Dr Rob Coles - awarded Public Service Medal 2001 for outstanding service in the protection and management of coastal habitat in Queensland and the Asia-Pacific region.
- Dr Rob Coles elected inaugural secretary of the World Seagrass Association
- Prof Helene Marsh, James Cook University awarded Pew Fellowship
- Dr Laurence McCook, GBRMPA - awarded Pew Fellowship.
- Dr Bruce Mapstone plenary address to the International Conference on Scientific and Technical Bases of Sustainable Fisheries Florida USA November 2001.
- Dr Russell Reichelt (keynote speaker), Dr David Williams and Dr Miles Furnas (plenary speakers) 2nd National Conference on Aquatic Environments Townsville, November 2001.
- Dr Bruce Mapstone plenary address at UNESCO International Conference on World Heritage Venice, Italy November 2002.
- Dr Katherina Fabricius plenary address at International Society for Reef Studies Conference - Cambridge, UK September 2002.
- Prof Helene Marsh plenary speaker at international symposium on dugong, Japan October 2002.
- Prof Helene Marsh keynote address at Pew Fellowship Program Annual Meeting Florida USA, 2004.
- Dr Britta Schaffelke plenary lecture at International Seaweed Symposium Norway, June 2004.
- Dr Katherina Fabricius invited speaker at World Parks Congress Durban, September 2003.
- Dr Jamie Seymour plenary address at International Society of Toxicology Adelaide, 2004.

Resources allocated to key research areas identified by end-users

The resources allocated for research were significant ($92.47m) and comprised approximately 84% of the total resources for the CRC Reef. Allocations to programs were varied during the life of the CRC Reef depending on changing priorities. New programs were added in 2003 with additional funding - Torres Strait and Catchment to Reef $3.0m and $ 2.25m respectively.

Co-investment

Co-investment is another indicator of research quality. The amount of co-investment from research providers totaled $48.85 million (plus 177.88 FTE's) over the seven year period. External earnings from commercial contracts totaled $11.85 million over the seven-year period.

External periodic review of program

The CRC Reef was reviewed twice in the period 1999-2006; firstly in 2000 and then a major review in the 5th Year of operation was conducted by Dr Don Kinsey in 2004. Dr Kinsey commented:

> "CRC Reef has an outstanding performance record. It is appropriately entrepreneurial and has developed expanding operating horizons. It has an entirely output/product based focus and has now reached a point of achieving real products….."
>
> "The great value of this CRC lies in that it is able to offer immediately available, applicable, and well packaged products to all …. The preparedness to offer products which are timely but may still be speculative is a major achievement in the conservative world of scientific research."

Dr Kinsey went on to say:

> "Most CRC researchers have a very satisfactory understanding of, and enthusiasm for, their product-based output targets. Nevertheless, the CRC has been very successful in creating an environment where the researchers are very comfortable whether or not they individually have a commercial focus. Graduate students with a strong output focus are relatively rare and the CRC has an outstanding record in achieving this."

Research Impact

The contribution of CRC Reef research to the ecologically sustainable use of the GBRWHA is the subject of this report. Uptake of research information by end-users is described in the Highlights, Case Studies and Project Summaries sections of the report. The capacity building aspects are described in Program E - Education. Benefits to core participants are described in the section on Institutional Views.

In summary the CRC reef has been very successful in producing high quality research of value to end-users. The end-users have applied the new information in many different ways for the benefit of the World Heritage Area and the people who value and use it.

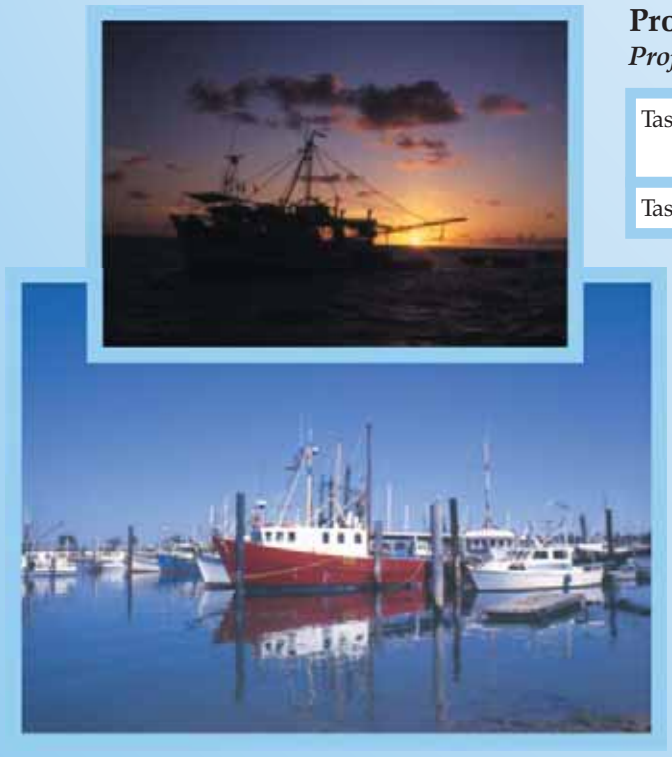
Program and Project Summaries

Program A: Conserving World Heritage Values

Program Leader Prof. Helene Marsh JCU

The objectives of this program were to enable policy makers and environmental managers to use all relevant information, including the different values of various stakeholder groups, in decision making for the use and conservation of the GBR region in accordance with its World Heritage Values. Uses and values were examined in a number of ways to help understand the perceptions and views of key interest groups and users. By understanding the potential effects of conservation based management decisions on key groups of people communication between resource users and policy makers should improve.

Projects	Leaders	Year
A1. Social, Cultural and Economic Values	Dr Mark Fenton	1999 - 2001
A2. Decision Support for Managers	Prof. Stephen Crook	1999 - 2001
A3. Informing the Management Process	Dr Barbara Kennedy	2000 - 2001
A3. Use and Value of the World Heritage Area	Prof. Stephen Crook 2001 - 02 Prof. Malcolm Waters 2002 - 04 Prof. Bruce Prideaux 2004 - 06	2001 - 2006
A4. Species Conservation	Prof. Helene Marsh	1999 - 2006



Project A1: Social Cultural and Economic Values

Project Leader Dr Mark Fenton, JCU

Task Leaders	JCU - Dr Mark Fenton, CRC Reef - Dr Leanne Fernandes
Task Associates	GBRMPA, QSIA, AMPTO

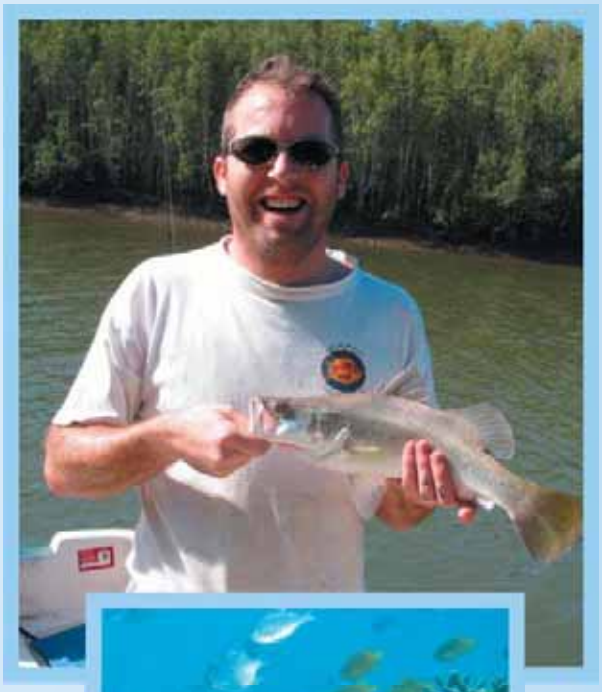
Achievements, Outcomes and Utilisation

Identifying the social impacts of potential changes in access to, and use of, Queensland's fisheries resources - Dr Mark Fenton, JCU

Dr Mark Fenton and Dr Nadine Marshall studied the social and economic links between Queensland's commercial fishing resource and communities along the coast. Telephone interviews with 1,544 fishers living between Karumba and Southport provided information about the fishing business, the location of home ports, years of operation in business, number and size of boats and type of timing of fishing activities, number of employees, and business spending as well as information about families and household spending. This provided a snapshot of how Queensland coastal communities use and depend on Queensland's seafood industries.

This study enhanced the capability of managers to: (a) assess the net economic and social benefits to commercial fishing; and (b) understand the potential socio-economic impacts of management decisions on fishers. This information helped to understand and predict the social and economic impacts associated with potential changes in policy and management and was used to evaluate alternative conservation strategies in the re-zoning of the GBRMP in 2003.

Towards integrating social, cultural and economic concerns into management of the GBRMPA -
Dr Leanne Fernandes, CRC Reef
The social, economic, ecological and cultural management objectives held by people who use and manage the GBRMP needed to be identified to evaluate management options. Stakeholders prioritised their main objectives to enable managers to explicitly consider the likely impact of their decisions on different groups. A user-friendly decision support system combined this information on objectives and priorities to help staff at the GBRMPA conduct structured, systematic assessments of the likely impacts of any decision.



As a result of this task, which involved interviewing over 220 people, GBRMPA now has a clearer view of its objectives from the perspectives of their staff and all major stakeholder groups including the general public resident on the coast adjacent to the region, as well as Brisbane and Sydney.

Project A2: Decision Support for Managers
Project Leader Prof. Stephen Crook

Task Leaders	GBRMPA - Dr Zena Dinesen; JCU - Dr Elisabeth Dinsdale, JCU, Dr Cheryl
Task Associates	GBRMPA, AMPTO

Achievements, Outcomes and Utilisation
Performance indicators for the GBRWHA - Dr Zena Dinesen, GBRMPA
Various models that have been developed to evaluate management effectiveness were tested to find suitable indicators for management effectiveness evaluation in the GBRWHA context. The models tested included the framework developed by IUCN/WCPA to evaluate the management of protected areas, methodologies used in State of the Environment Reporting, and indicators for ecologically sustainable fishing.

Developing indicators of coral reef health - Dr Elizabeth Dinsdale, JCU
This research sought to identify environmental indicators that describe the condition of coral reefs to assist in the evaluation of effectiveness of management. Peoples' perceptions of healthy coral reefs were tested using ecological indicators. Initial results suggested that some ecological measurements were useful to describe coral condition and others were not. Effective evaluation of coral condition requires the careful selection of indicators. The research has identified requirements for planning processes in the GBRWHA: These requirements are:

- to have clear, specific objectives (and preferably agreed targets) against which to evaluate progress and success;
- to disaggregate broad, high-level goals or objectives and to divide them into clear measurable objectives;
- to involve stakeholders as well as managers of natural resources in identifying what should be monitored and evaluated.

Project A3: Informing the management process
Project Leader: Dr Barbara Kennedy, JCU
This project was moved to Program D Project D2 Information Synthesis.

Project A3: Use and value of the World Heritage Area
Project Leaders: 1999-2001 Pro.f Stephen Crook, JCU, 2002-2004 Pro.f Malcolm Waters and 2005-2006 Prof. Bruce Prideaux, JCU

Task Leaders and Research Staff	JCU - Prof Helene Marsh, Dr Cheryl Hercus, Dr Celmara Pocock, Dr David Roe, Mr Geoffrey Muldoon Dr Barbara Breen, Dr Melissa Nursey-Bray, Dr Stephen Sutton, Dr Nadine Marshall Dr Shelley Greer, Dr Celmara Pocock, Dr Jane Harrington; UQ - Prof Helen Ross; GBRMPA Mr James Innes, Ms Melissa George.
Task Associates	GBRMPA - Dr Leanne Fernandes, Mr James Innes, Mr D Cameron, Ms Melissa George; Mr Col McKenzie (AMPTO), Mr Vern Veitch (Sunfish), Mr Duncan Souter (QSIA)

Achievements, Outcomes and Utilisation

Determinants of stakeholder compliance and non-compliance in the GBRWHA - Dr Cheryl Hercus, JCU

88 recreational anglers from Cairns, Townsville and Agnes Waters/Town of 1770 were interviewed to determine their perceptions, experiences and actions towards compliance and management issues. The participants valued recreational fishing as a cultural practice. Their love of fishing shapes their perceptions of issues of communication, protection and enforcement. Most participants are positively oriented towards fishing regulations, even though they might be critical of certain regulations. Most recreational anglers recognised the importance of conservation but they wanted the social and recreational importance of recreational fishing recognised. Most fishers considered the enforcement of Marine Park and fishing regulations was inadequate and they wanted to see stronger enforcement measures for the minority who break the rules so that the majority who comply can continue to enjoy fishing.

Cultural heritage of the GBRWHA -Dr Celmara Pocock, JCU

Research into understanding Indigenous and non-Indigenous cultural heritage values of the GBR was undertaken by synthesising existing material, collecting additional data and consulting extensively with communities of interest. The ways in which social values are established, transformed, continued and lost over time were explored, as well as notions of social value and attachment to place through the experiences of tourists and tour operators. The complexities of understanding heritage values and their management in local, regional, national and global communities of interest were examined through a case study approach, with field information from the Whitsundays and Cairns regions of the GBRWHA. Particular emphasis was placed on the advancement of key cultural heritage concepts.

The outcome was a theoretical context for understanding heritage in the GBR region. This study provided insight into how the GBRWHA was experienced by visitors and how their knowledge of the region was framed, communicated and transformed through time. Both technology and social change have affected the way both the landscapes and underwater world is valued, presented and experienced.

Indigenous practices relating to land and seascapes at Yarrabah, NQ - Dr Shelley Greer; Dr David Roe, JCU

Two Indigenous Traditional Owner groups, the Gurabana Gunggandji and the Guru Gulu Gunggandji were involved in this research. The investigations sought to understand Indigenous practices in relation to the marine environment which would serve as a basis for the development of useful and appropriate management practices. Research results showed that Traditional Owners have broad concerns about protection and management of the marine environment, and these concerns are linked to concerns about community sustainability and employment. Other concerns related to current practices of community members and outsiders, and the recording and use of traditional knowledge in management processes. The research showed that in any given situation, cultural practices will only be revealed by utilising a broad range of methods specific to the history, circumstances and expertise of the researcher.

Latent effort in the live fish trade - Mr Geoffrey Muldoon, JCU

This research reviewed the global and emergent Australian live fish trade and examined the impact of the live reef fish trade on the structure and operation of the GBR reef line fishing fleet. The study also explored the bio-economic implications arising from economic incentives to increase capital investment through simulation modelling. Results indicated:

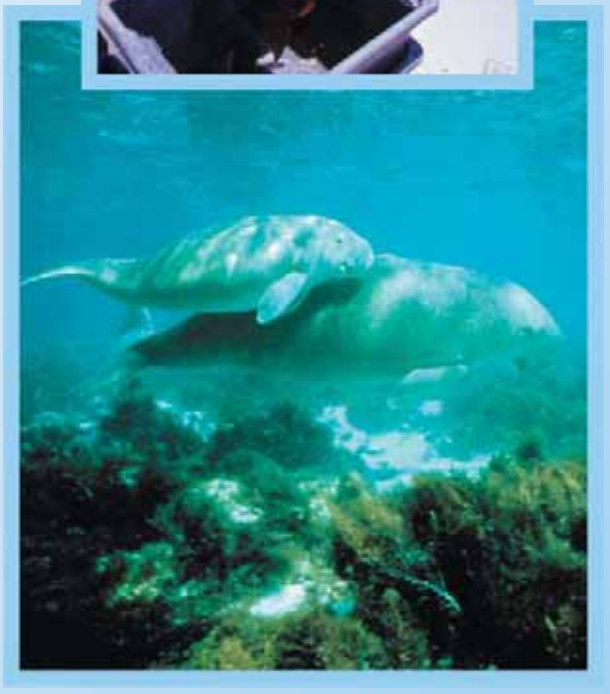
- substantial fleet-wide shifts toward supply of catch for overseas live fish markets;
- an increasing dependence on Australian-sourced product to meet demand for selected species;
- 'live' operations generated substantially higher returns to capital than did 'frozen' operations;
- the determinants of investment in live fishing technology were both economic (value of product, cost of conversion to live fishing) and operational (size of vessel, number of tenders); and
- the importance of Australia to global live fish trade issues through both the volume of fish supplied and its ability to contribute to improving the conduct of the live fish trade.

Resilience of commercial fishers to changing management arrangements and access to resources - Dr Nadine Marshall, JCU

This study showed that dependency on fishing is a function of both attitudinal and financial flexibility. The fishers most vulnerable to change tend to be very attached to their lifestyle, and have low employability and a small operation. Fishers who participate in the process of change by attending public meetings or making submissions are more likely to be negative about the change than those who don't participate. However, this study showed that if fishers are meaningfully involved in the process of change they are more likely to be positive. This work shows that public participation, especially for the most vulnerable groups of fishers, is not just about how many fishers participate in public consultation programs, but about how meaningfully they are involved.

Towards co-operative management of Indigenous hunting by a remote community in the GBRWHA - Dr Melissa Nursey-Bray, JCU

Developing a capacity for co-operative management of Indigenous resources in the GBRWHA requires an understanding of the social, cultural and economic values that Indigenous people place on marine resources. Dugongs and turtles are traditional foods with the highest value for the Indigenous communities which use the GBRWHA. The development of co-operative arrangements for turtle and dugong hunting is a significant step towards Indigenous communities managing their land and sea country, as well as contributing towards effective strategies for species' management. This research investigated the social, economic and cultural importance of turtle and dugong hunting in the Aboriginal communities of Hope Vale and Yarrabah in the context of community hunting management programs over a 2-year period. By seeking to understand the discourse or perspectives about hunting among Indigenous and non-Indigenous groups, the implications for co-operative hunting management initiatives in the future could be better understood.



Clear differences in perspectives or discourses about dugong and turtle hunting, planning and management, were shown between Hope Vale community near Cooktown and the management agencies GBRMPA and QEPA. Hope Vale community members prioritised community and cultural needs over the biodiversity and animal rights needs of the species, focused on process rather than content, and did not separate the issue of hunting management from an overall discourse about social justice and Indigenous rights for self-determination. Management agencies sought to understand how many green turtles and dugongs were being hunted, whereas Hope Vale participants prioritised hunting management as an issue of cultural survival and assertion of their Indigenous knowledge and culture. This work showed how important it is for management agencies and stakeholders to share a common understanding of each others' priorities.

Supporting Development of co-management by GBRMPA with Indigenous and other stakeholders - Dr Helen Ross, UQ, Mr James Innes, GBRMPA and Ms Melissa George

The research project used a case study approach to work with Indigenous communities to provide information and support mutual learning, towards the best possible design and implementation of future co-management arrangements between Indigenous peoples and the managers of the GBRWHA. They concluded that the opportunities for solving both Indigenous and non-Indigenous management and access desires in the GBRWHA probably lie in some combination of area, species and multi-purpose agreements. A co-management arrangement starts, rather than finishes, when the agreement is reached. The parties therefore need to keep goodwill in working together, and to work hard at resolving problems as they arise. This can be helped by: shared goals; shared commitment and a belief that cooperation offers better prospects than political or legal conflict; a fair and efficient decision-making structure and processes, adequate resourcing, sense of progress, through successful implementation via a series of steps, maintaining positive personal relationships and regular reviews to check how the arrangements are working (both in terms of process and outcomes).

Understanding the effects of management changes in the GBR on the recreational fishing community - Dr Stephen Sutton, JCU

Social assessment of recreational fishing in Queensland has provided new insights into the factors that predict participation by recreational fishers in public consultation programs. Strong differences have been found in opinions and beliefs between participants and non-participants in public consultation programs. Only 28% of the 765 respondents to a CRC Reef survey reported participating in public consultation programs regarding recreational fisheries issues. 72% of fishers who attended a meeting and 75 % of fishers who made a formal submission reported doing so over the issue of re-zoning the GBRMP. Participation in consultation programs was positively related to age, enthusiasm for fishing, centrality of fishing to lifestyle, and membership in fisheries-related organisations. There was no effect of gender, income, or years of fishing experience. Participants and non-participants in public consultation programs differed significantly in their level of agreement with 12 of 20 belief statements about fisheries management, issues and threats facing recreational fisheries, the effects of recreational fishing on fish populations, and in their level of approval to four of eight fishing regulations. Non-participants were generally more supportive of the management restrictions than participants. Results suggested that recreational fishers who participated in public consultation programs may not be representative of the wider recreational fisher population.

Species conservation (Project A4)

Project Leader: Professor Helene Marsh (JCU)

Task Leaders and Research Staff	JCU - Prof. Helene Marsh, Dr Vimoksalehi Lukoschek, Mr Darren Grover, Dr James Sheppard, Dr Guido Parra, Dr Ivan Lawler, Dr Donna Kwan, Ms Julie Robins, Dr Julia Hazel, Ms Alana Grech, Dr Anna Lashko, Dr Amanda Hodgson; GBRMPA Dr Kirstin Dobbs
Task Associates	GBRMPA - Dr Kirstin Dobbs, Dr Leanne Fernandes, Mr Malcolm Turner.

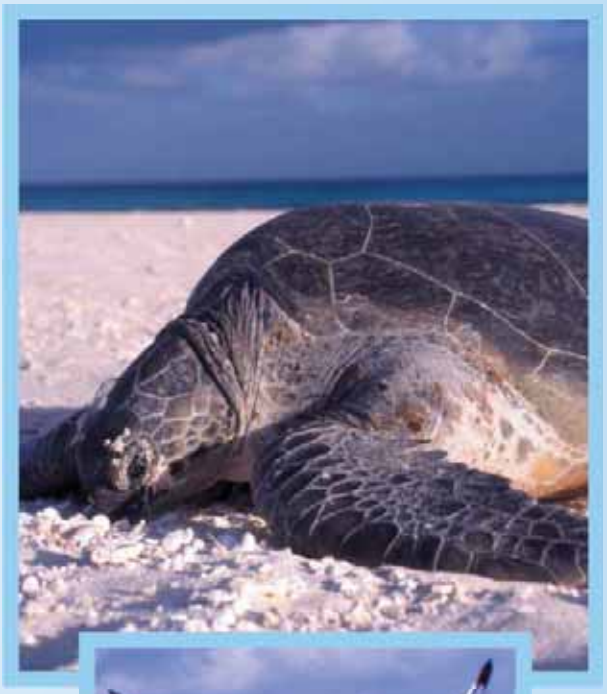
Achievements, Outcomes and Utilisation

Ownership of genetic resources in the GBRWHA, its ecotone and the Exclusive Economic Zone - Dr Merrilyn Wasson, ANU

This project was moved to Project D4 Reef Futures.

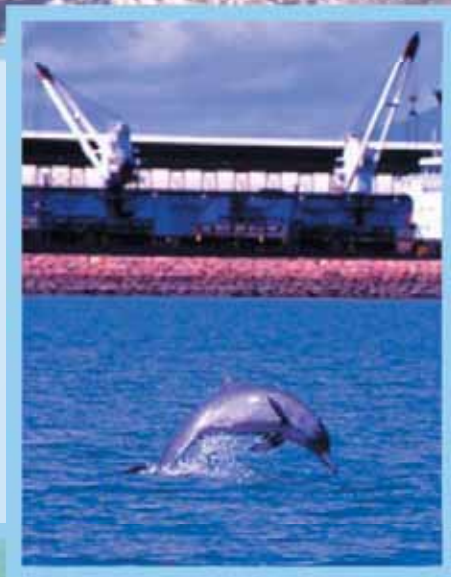
Survivorship of sea turtles after capture in trawls - Ms Julie Robins, JCU

This study contributed to the sustainable management of sea turtle by-catch in prawn trawls in the GBRWHA by developing a comprehensive approach to understanding the interaction between prawn trawling and sea turtles. Estimated numbers and species composition of sea turtles caught and killed in the Queensland East Coast Trawl Fishery, combined with estimates from other trawl fisheries in northern Australia, indicates that the regulations requiring trawlers to use Turtle Excluder Devices (TEDs) are warranted. A spatially explicit strategy was developed for monitoring the compliance of fishers to the regulations about the use of TEDs and their effectiveness in meeting by-catch reduction targets by integrating predicted sea turtle density and fishing effort. The results of this work contributed to the re-zoning of the GBR Marine Park and assisted fisheries managers in designing cost-effective programs to monitor the use of TEDs by trawler skippers.



Ecology and conservation biology of coastal dolphins - Dr Guido Parra, JCU

Coastal dolphins including the Australian snubfin and humpback dolphins are among the most threatened species of cetaceans. The Australian snubfin dolphin (formerly known as the Irrawaddy dolphin) has recently been recognised as Australia's only endemic cetacean. Both species occur in the GBRWHA in very small, spatially isolated populations in inshore waters, thus making them extremely vulnerable to anthropogenic mortality and rapid population declines. Cleveland Bay, near Townsville, is a hotspot for both speciesespecially around the Port of Townsville. Despite considerable overlap in their space use patterns, snubfin and humpback dolphins show different habitat preferences. Snubfin dolphins prefer shallow (0-2 m) waters with seagrass meadows closer to river mouths. Humpback dolphins prefer slightly deeper waters (2-5 m deep), shallow waters (1-2 m deep) with no seagrass, and dredge channels (5-15 m deep). These differences in habitat preference are thought to be important factors promoting the co-existence of the two species. Dr Parra's work has been used by the GBRMPA as the basis for the conservation management of the two species in the GBRWHA.



Spatial models of dugong and seagrass distribution for habitat management - Ms Alana Grech and Prof. Helene Marsh, JCU

Spatial analysis was used to evaluate the 2003 GBRMP Zoning Plan, the associated re-zoning of the adjacent Queensland Great Barrier Reef Coast Marine Park and other current management arrangements, for their combined capacity to protect the GBRWHA's significant populations of the dugong, *Dugong dugon*. The researchers used expert knowledge and a Delphi technique to identify and rank activities which are potentially threatening to dugongs and their seagrass habitats: netting, trawling, Indigenous hunting, vessel activity and terrestrial runoff. GIS and spatial modelling was used to quantify the protection afforded by the new arrangements. Overall, 96% of high conservation value dugong habitat in the GBRWHA now have a high level of protection from all identified threatening anthropogenic activities, a significant improvement over the previous management arrangements.

Population genetic structure of roseate tern populations in Australia - Dr Anna Lashko, JCU
Roseate terns are seabirds which nest on tropical and temperate islands in the Atlantic, Indian and Pacific Oceans. They are considered endangered in North America, Europe and South Africa. Australia has more than 60,000 birds breeding on islands between Lady Musgrave Island in the GBRWHA and Fremantle in Western Australia. Analysis of the genetic relationships among roseate terns established two lineages of roseate tern globally, representing a historic separation between individuals in the Atlantic and Indo-Pacific Ocean basins. This study highlighted the need for roseate terns to be managed across all relevant Australian and international jurisdictions. The roseate tern has now been listed on the Japan-Australia Migratory Bird Agreement (JAMBA) as a protective measure.

Enhancing the ecological basis for managing dugong in the GBRWHA Prof. Helene Marsh, Dr Ivan Lawler and Dr Donna Kwan, JCU
The sustainable management of dugong hunting is a challenge because of the tension between the obligations to protect both the species and a sustainable hunting culture and the complex and dynamic ecological, legal, socio-economic, cultural and management context.In collaboration with researchers in the USA and the Australian National University, CRC Reef researchers investigated the sustainability of the dugong harvest in the northern GBR and Torres Strait. Modelling based on the current estimates of the annual dugong harvest and population size indicated that the current harvest of dugong in Torres Strait and the northern GBR Region is unsustainable. In addition, any Indigenous hunting on the urban coast of Queensland is unsustainable given the decline in dugong numbers in this region and the other impacts on these species. Because dugongs move across jurisdictions and because of the different statutory environment in different regions, a nested series of national, regional and local initiatives is required to conserve dugongs. The greatest challenge will be at the local community level.

Enhancing the ecological basis for conservation management of dugongs using innovative satellite tracking techniques - Dr James Sheppard; Dr Ivan Lawler, Prof. Helene Marsh, JCU.
Seventy dugongs were fitted with satellite PTTs and/or GPS transmitters in sub-tropical and tropical waters of Queensland and the Northern Territory, Australia. Twenty-eight of the 70 dugongs were also fitted with time-depth recorders. The dugongs were tracked for periods ranging from 15 to 551 days and exhibited a large range of individualistic movement behaviours; some relatively sedentary (moving <15 km) while others made large-scale movements (>15 km) of up to 560 km from their capture sites. Male and female animals, including cows with calves, exhibited large-scale movements (>15 km). Body length of travelling dugongs ranged from 1.9 to 3 m. At least some of the movements were return movements to the capture location, suggesting that such movements were ranging rather than dispersal movements. Large-scale movements included macro-scale regional movements (>100 km) and meso-scale inter-patch local movements (15 to <100 km) and were qualitatively different from tidally-driven micro-scale commuting movements between and within seagrass beds.

Tracked dugongs rarely travelled far from the coast. Dive profiles from the time-depth recorders suggest that dugongs make repeated deep dives while travelling rather than remaining at the surface, increasing their likelihood of capture in bottom set gill nets. Some animals caught in the high latitude limits of the dugongs' range on the Australian east coast in winter apparently undertook long distance movements in response to low water temperatures, similar to migrational movements by Florida manatees. The findings that dugongs frequently undertake macro-scale movements have implications for management at a range of scales, and strengthen the aerial survey and genetic evidence for management and monitoring at ecological scales that cross jurisdictions. A major outcome of this research was the confirmation that dugong management has to be coordinated across different jurisdictions. The research has informed the process of re-zoning the Great Sandy Strait Marine Park, the review of the Queensland inshore fin-fish fisheries, and the ongoing management of dugongs in the GBRMP.

The impacts of anthropogenic noise on coastal marine mammals: dugong and dolphins - Dr Amanda Hodgson, JCU

The potential risk of boat disturbance and boat strikes was assessed by studying the behaviour of the dugongs in an area used by recreational boats during experimental trials. A video camera mounted on a blimp tethered to a vessel was used to study the responses of dugongs to boats. Observations of boats passing opportunistically at different speeds showed that dugongs have a delayed response to boats and are particularly vulnerable to being hit by boats travelling fast. There was no link between the distance of the boat from the focal animal and the duration, distance or direction of its subsurface behaviour. The percentage of time spent feeding and travelling by dugongs was unaffected by the boat's passing, the number of passes by the boat made, or the focal dugong's position in the herd relative to these two factors. Therefore, any response to the boat was delayed and short. These results supported the use of speed restrictions for boats in important dugong areas.

Dugong behaviour and the effect of boats and pingers - Dr Amanda Hodgson, JCU

Incidental by-catch in fishing nets is a global cause of incidental mortality of marine mammals. Two classes of approaches attempt to mitigate this impact: (1) approaches which change the behaviour of the fisher (e.g. closures and gear modifications) and (2) approaches which attempt to change the behaviour of the by-catch species (e.g. acoustic alarms or pingers). Even though the effectiveness of pingers has been established for very few by-catch species, pingers are now mandatory in many fisheries throughout the world. Pingers are being trialled in commercial gill net fisheries in tropical Australia to reduce the by-catch of three species of coastal dolphins and the dugong, despite an absence of robust assessments of: (1) their effectiveness in reducing by-catch or (2) the likelihood of alienating by-catch species from critical habitats.

Replicate experiments were conducted to test the behavioural responses of dugongs to 4 and 10 kHz pingers in an array simulating a net. Each experiment comprised three sequential 10 min treatments in which two pingers were: (1) inactive, (2) active, and (3) inactive. The rate of decline of the number of dugongs within the focal arena did not change significantly while pingers were activated. Dugongs passed between the pingers (where a net would be located) irrespective of whether the alarms were active or inactive, fed throughout the experiments, and did not change orientation to investigate pinger noise or their likelihood of vocalising. The research indicates that: (1) pingers are unlikely to displace dugongs from critical habitats or reduce dugong mortalities in fishing nets, and (2) by-catch mitigation strategies relying on changing animal behaviour, such as pingers, should only be used after rigorous testing on all likely by-catch species.

Conservation genetics of sea snakes (Family Hydrophiidae) in Australian waters, with emphasis on the GBRWHA - Dr Vimoksalehi Lukoschek, JCU

Sea snakes are a very important component of Australia's tropical marine biodiversity and the GBRWHA supports about 17 species. Molecular techniques were used to study the evolutionary relationships of Australia's sea snake fauna. The data are consistent with the hypothesis that the present situation reflects historical sea level fluctuations that isolated populations and promoted speciation. The olive sea snake occurs on coral reefs from the southern GBR to Shark Bay, Western Australia. Population densities of this sea snake are highly variable, with dense aggregations at some reef locations, and few or no snakes at other reef locations that appear to be ecologically similar. The population structure of the olive sea snake was investigated at several spatial scales across its range. Findings imply recent population expansions into the GBR Region as the sea level gradually rose after the last glacial maximum, about 18 thousand years ago, high levels of male-mediated gene flow, and low levels of female-mediated gene flow. In contrast to the olive sea snake, the spine-bellied sea snake occurs in inter-reefal habitats and has an extensive geographic range, which extends from the Persian Gulf, through the Indo-West Pacific and the South China Sea, to the northern coastal regions of Australia. Most of the genetic variation in this species is accounted for by differences between Australia and Thailand, rather than between populations within Australian waters. Thus, population genetic structure occurs at different spatial scales for these two species and reflects the scale of their respective geographic distributions. The implications of this research for management of marine biodiversity are being investigated.

Turtle-Vessel Interactions Ms Julia Hazel, JCU

Vessel collisions contribute to the anthropogenic mortality of marine turtles and other threatened species, but data on the circumstances of collisions are lacking. A field experiment was conducted to evaluate green turtles' behavioural responses to a vessel approaching at slow, moderate or fast speed (respectively 2, 6 and 10 knots). The study used a 6 m research vessel to simulate transits by recreational boat traffic in shallow water (< 5 m) along the north-eastern margin of Moreton Bay, Queensland, Australia. Data were recorded for a total of 1890 encounters with turtles sighted within 10 m of the research vessel's track. The proportion of turtles that fled to avoid the vessel decreased significantly as speed increased. Turtles that fled from moderate and fast approaches did so at significantly shorter distances from the vessel than turtles that fled from slow approaches. Response characteristics suggested that turtles relied on visual cues to detect approaching vessels and preferred to flee towards deeper water. Findings imply that a vessel travelling at 2 knots (slow idling speed) is very unlikely to collide with a turtle. However, vessel operators travelling at 6 knots or faster cannot expect that a turtle in their track will avoid them. Higher collision risk is expected in turbid water and at night (when turtles are less likely to sense approaching vessels) and in shallow water with insufficient vertical clearance between vessel hulls and turtles foraging or resting on the substrate.

Funding

Project	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	Total
A0		$45,000	$50,000	$45,000	$55,000	$60,000	$45,000	**$300,000**
A1		$129,000						**$129,000**
A2		$15,770						**$15,770**
A3		$86,320	$117,271	$336,909	$272,581	$131,900	$303,200	**$1,248,181**
A4		$87,395	$154,779	$126,681	$83,432	$144,701	$250,124	**$847,112**
Total		**$363,485**	**$322,050**	**$508,590**	**$472,282**	**$275,332**	**$598,324**	**$2,540,063**

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All CRC Reef Technical Reports are available online at:
http://www.reef.crc.org.au/publications/techreport/

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Program B: Sustainable Industries

Program Leader: Dr Bruce Mapstone, JCU 1999-2003; Ms Anne Clarke, DPI&F 2003-06

The objective of this program was to provide critical information for and about the key uses of the GBRWHA that is needed to manage those uses. The program sought to:

- provide key industry-level information for management of the GBRWHA;
- assess the operational characteristics, needs, constraints and potential impacts of the major industry sectors in the GBRWHA;
- where appropriate, seek innovative technologies to allow ecologically and economically sustainable development; and
- develop tools to reduce uncertainty in the management of key uses for their ecologically sustainable development.

A practical and thorough understanding of the industries, their needs and impacts was the focus of this Program. Information was collected to support regulation and best practiceso that commercial uses do not threaten key World Heritage values of the region, and that industries can remain economically and socially viable.

Aspects of the two major industries that rely on the GBRWHA (tourism and fisheries) and one industry that must co-exist with it (port and shipping activities) to provide services to a multitude of land-based industries, were researched.

Project	Leaders	Year
B1. Ports and Shipping	Dr Rob Coles	1999 - 06
B2. Sustainable Tourism (1999-01) B2. Tourism (2001-06)	Dr Gianna Moscardo	1999 - 01 2001 - 06
B3. Innovative engineering (1999-01) B3. Engineering and environmental control (2001-06)	Prof Tom Hardy	1999 - 01 2001 - 06
B4. Fishing and Fisheries	Dr Bruce Mapstone Dr Gavin Begg	1999 - 03 2003 - 06

Project B1: Ports and shipping

Project Leader: Dr Rob Coles, DPI&F

Task Leaders and Researchers	DPI&F - Ms Anne Clarke, Dr Rob Coles, Mr Len McKenzie, Dr Michael Rasheed, Dr Kerry Neil, Mr Ross Thomas, Ms Skye Mckenna, Ms Helen Taylor, Mr Heath Stafford, Ms Cassandra Rose, Dr Jane Mellors; Australian Museum - Dr Pat Hutchings; JCU - Dr David Blair, Dr Oliver Floerl, Prof. Tom Hardy, Dr Michelle Waycott, Mr Steve Hillman, Dr Phil Schneider, Dr Frank Hoedt.
Collaborators	Taxonomic staff from museums in Australia, NIWA New Zealand, DAFF, QEPA, DEH, Biosecurity New Zealand, URS Perth, GHD, School of Engineering JCU
Task Associates	Cairns Port Authority, Townsville Port Authority, Ports Corporation of Queensland, Central Queensland Port Authority

Achievements, Outcomes and Utilisation

Introduces Marine Pest Port Surveys - Dr Kerry Neil, DPI&F

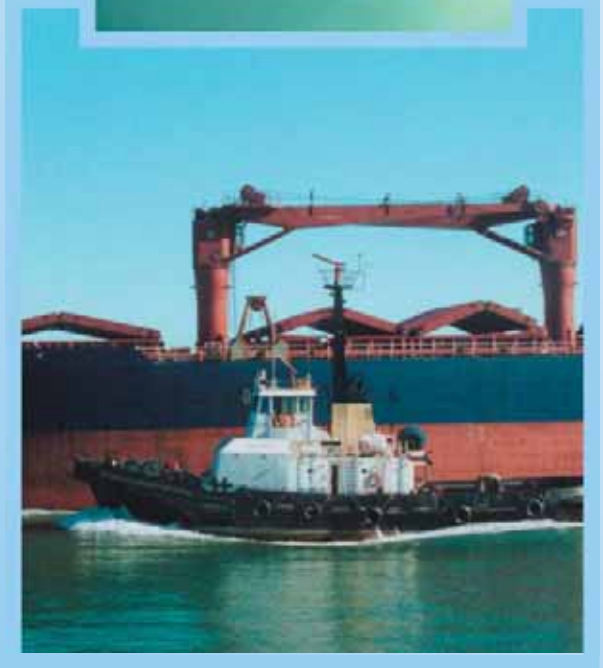
Identification and monitoring of habitat critical to the GBRWHA in or adjacent to shipping lanes and coastal ports - Dr Michael Raheed, DPI&F

Many ports and marinas operate in or adjacent to the GBRWHA, and thousands of ships traverse the waters of the World Heritage Area annually, often carrying cargoes that would threaten the environment if released in an accident. These activities are vital to the normal social and economic function of Queensland (the value of trade through ports operated by the Ports Corporation of Queensland alone is $68 billion per year) but pose potential risks to the environment.

These projects were one of the most successful aspects of CRC Reef research and generated information of significant utility to the ports and shipping industry:

- All major ports in tropical Queensland were surveyed under contract to the PCQ, Cairns Port Authority, Mackay Port Authority and the Central Queensland Port Authority. Natural habitats were mapped and searched for exotic pests. Sections of two major shipping channels, Margaret Bay and Hydrographers Passage, identified as at high risk from ship groundings/oil spills, were mapped to identify any environmental issues. The environment issues in the Ports of Hay Point, Mackay and Abbot Point were also mapped to enable planning of port infrastructure improvements.
- A network of long-term monitoring sites for habitats at risk in Queensland ports was established in partnership with the Queensland port authorities. Results of this are used by the port authorities to assess the environment of their ports and have been instrumental for management agencies in ensuring port development and maintenance activities have had minimal effect on the marine environment.

- CRC Reef's work on invasive pests in tropical waters contributed to the implementation of Australia's marine pest monitoring and management program and received international recognition. Further research focused on developing tests to detect exotic pests based on biochemical or genetic signals rather than labour-intensive visual searches. These methods will increase the efficiency and reliability of pest detection and support management options to mitigate impacts from pests.
- CRC Reef researchers participated in six Technical Advisory Consultative Committees for Queensland ports, providing a major source of environmental advice for Queensland port managers. They also participated in two National Advisory Consultative Committees for Marine Pest Monitoring and Management, ensuring critical issues regarding marine pest risks for tropical regions, particularly the GBRWHA, were incorporated into the development of national management and monitoring programs.



Ballast water treatment pilot study - Dr Phil Schneider, JCU

CRC Reef, together with joint venture partners, investigated an efficient method of 'cleaning' shipboard ballast water to remove or kill all larvae in the ballast water so that they will not be released into Australian seas. A portable pilot plant for treatment was developed and is now ready for onboard ship testing. This technology has the potential to provide state-of-the-art biosecurity to Australia and to significantly reduce the risks of exotic pest introductions via ballast water.

Hydrodynamic, sediment and dredge modelling of ports Prof. Tom Hardy JCU

Collaboration with the Engineering and Environmental Control Project enabled development of models to explore the likely infestation pathways for Asian green mussels in Cairns Port, to explore the major risks from accidental spills in ports, and the most efficient designs for port dredging and development works.

Project B2: Tourism
Project Leader: Dr Gianna Moscardo, JCU

Task Leaders and Researchers	JCU - Dr Gianna Moscardo, Prof. Phillip Pearce, Dr Alistair Birtles, Mr Dean Miller, A/Prof. Peter Valentine; MTQ - Dr Peter Arnold; GBRMPA Mr James Innes; QDPI&F Dr Kerry Neil
Task Associates	Mike Ball Dive Expeditions, AMPTO, CHROA

Achievements, Outcomes and Utilisation

Understanding tourist use of the GBRWHA - Dr Gianna Moscardo, JCU;

GBR: Destination image and competitiveness Prof. Phillip Pearce, JCU

Visitor strategic response project - Dr Gianna Moscardo, JCU

The main achievements of this project have been the creation of three of the first and most extensive marine tourism data bases in the world. These databases were used for analyses to answer management questions, to provide market intelligence to reef tour operators and to develop a number of conceptual models that have subsequently been internationally recognised as making major contributions to the broader theoretical understanding of tourist behaviour: The databases were:

- Time series survey data collected from passengers on commercial reef tour operations. This included information on reef visitor characteristics, reef travel behaviour and activity participation, visitor evaluations of reef experience features and reef visitor decision making processes. The data were used to develop a series of market intelligence reports in response to reef tour operator requests, and to analyse issues raised by GBRMPA. Management issues included understanding changing patterns in the types of reef visitors, understanding the factors that contribute to reef experience evaluations, and changes in regional distributions of reef visitation. Conceptual models relevant to understanding a number of key issues in tourism were also developed. A paper on this model won a best paper award at the 2004 Asia Pacific Tourist Association conference
- Time series telephone survey data from reef region and eastern capital city residents.
- These data were collected to directly address management questions put forward by the GBRMPA and includes data on a range of issues including patterns of recreational use of the reef, awareness of threats to the reef and perceptions of management strategies to respond to threats. This data has been incorporated into management information systems at the GBRMPA. A recent example of its use is an analysis contrasting the impacts of actual reef visitation and reef information source usage on awareness of threats to the GBR.
- Data were collected from wildlife based tourism participants in a joint research exercise with the Rainforest and Sustainable Tourism CRCs. More than 5,000 cases from a range of study sites were collected. The data have been used to develop models to explain participant satisfaction and attitudes towards wildlife conservation.

The results of this project have revealed that trends in repeat visitation are continuing and that new Australian markets are emerging. Fewer tourists seek solitude or interactions with wildlife and 'wilderness' experiences compared with those who seek more social, experiential activities such as diving and 'resort style' holidays. This shift in expectations has management implications. It may reflect a change in the demographics of tourists visiting the GBR, in that many tourists who would previously have visited international resorts in south-east Asia are choosing tropical Australian holidays in the wake of terrorist threats overseas.

Towards ecologically sustainable dwarf minke whale tourism - Dr Alistair Birtles, JCU

The little known dwarf minke whale (*Balaenoptera acutorostrata)* was only discovered in GBR waters during the 1980s, and research into its biology and ecology has only recently begun. During the 1990s live-aboard dive tour operators in the Cairns section of the GBR began reporting in-water interactions with these whales along the Ribbon Reefs during the winter months. The needs of this emerging wildlife tourism venture were addressed in a collaborative research project between CRC Reef researchers and live-aboard dive tourism operators. This work has resulted in the development of a Code of Practice for swimming with whales and engagement of CRC Reef researchers with the International Whaling Commission, concerning draft sustainability indicators for dwarf minke whales. In addition, an information and training kit was developed to aid operators and others in the provision of interpretive guided tours of GBR destinations. This research has been significant in informing the development of policies for management of cetaceans in the GBRWHA.

Towards sustainable environmental experiences for the live-aboard diving industry on the GBR -Mr Dean Miller, JCU

The values that certified SCUBA divers of different skill levels place on diving experiences were examined. Different groups ('beginner', 'intermediate', 'enthusiast' and 'specialist') were interviewed to determine which coral reef attributes are most important in contributing and detracting from divers' experiences. The study showed that each group was distinct from others, and as divers increase their level of diving and coral reef history from 'beginner' to 'specialist', they also increase their level of environmental specialization reflected by knowledge, and a keen interest in acquiring more knowledge about that environment. These differences allow comparisons to be made regarding diving experiences. This information has been invaluable to the dive tourism industry.

Project B3: Engineering and environmental control

Project Leader: Prof. Tom Hardy, JCU

Task Leaders and Researchers	JCU - Prof. Tom Hardy, Dr Peter Ridd, Dr Phil Schneider, Dr Lou Mason, Dr Lance Bode, Mr Ross Kapitzke.
Task Associates	Systems Engineering Australia Pty Ltd, Woodside Australia Energy. GBRMPA.

The need to understand the physical forces that occur on the GBR under normal and extreme conditions is essential for reef management and industry (tourism and shipping). It is also important for understanding the physical influences on reef ecology. Design inputs and design techniques that will reduce environmental impacts and improve the economics and structural integrity of reef structures are one of the important results of this research.

Achievements, Outcomes and Utilisation

The completion of the Atlas of Cyclone Waves that simulates winds during approximately 20,000 simulated tropical cyclones was a major research contribution to understanding these forces. This tool provides capability to develop wind statistics from available wind data which can be used to help understand the quality of synthetic cyclone wind statistics. Unlike historical data, available at a limited number of unevenly spaced weather observation stations, the synthetic cyclone statistics provide data over the entire GBR.

A series of collaborative projects applied the learning from the Wave Atlas project to other tropical areas of Australia. *Guidelines for Investigations into the use of modelling to better understand coral bleaching incidents* coupled thermodynamic and hydrodynamic models that offer interesting explanations of differences in coral mortality at Scott Reef (off northwest Australia) during the 1998 bleaching event. Research and consulting advice was provided to Woodside Energy Ltd to model waves produced by different tropical cyclones of Arafura, Timor and Northwest Shelf regions to determine the 1 in 10,000 year wave conditions. Collaboration with Systems Engineering Australia developed storm surge models for the Northern Territory and northeastern Western Australia, to be used to simulate storm surge during tropical cyclones, to improve forecasting during a storm and for regional development planning.

Another significant achievement was to complete a hydrodynamic circulation model for the entire GBR and Torres Strait operating at a 1.5 km grid-scale, allowing the detailed modelling of water flows around individual reefs and representation of the effects of the complex reef structure on transport of water-borne particles. This work provides critical information for assessing the connectivity of marine populations between reefs and, hence, the likely effectiveness of closure regimes as refuges from which populations elsewhere can be replenished.

The completion of the project on *Reef Infrastructure Guidelines; tourist pontoons* to guide reef management and the tourist industry in the construction, permitting, installation and operation of reef based infrastructure, was of significant value to GBRMPA.

> *"A challenge for all projects is to successfully integrate science and management. I believe that we have been very successful in this objective because of good communication between industry, science and management. The Reef Infrastructure Guidelines will form the basis of the GBRMPA's policy for structures in the GBRMP. The guidelines have been designed to provide new and existing operators, designers and managing agencies a 'World's Best Practice' framework and protocol to develop tourist pontoon projects from the concept phase, through feasibility, design and installation, to monitoring and operation. The guidelines are a lengthy, detailed document and GBRMPA will be directly involved in communicating their importance to the tourism industry and the broader community."*
>
> Dr Adam Smith, Manager, Environmental Impact Management, GBRMPA

Collaboration with the Ports and Shipping Project provided expertise to develop detailed circulation and sediment transport models for major ports. These models were used to explore the likely infestation pathways for Asian green mussels in Cairns Port, to explore the major risks from accidental spills in ports, and the most efficient designs for port dredging and development works.

This project also developed fine-scale modeling to assist wave prediction in and around coral reefs, to reduce design loads at tourist pontoon sites and to assist reef management decision-making. Extension of fine-scale current modeling to include the entire GBRWHA and the influences of the East Australian Current on water-borne processes in the GBR, including larval and pollutant transport was another important application.

Finally, extensive modelling and field studies of the feasibility of using island resort wastewater as irrigation to reduce the flow of wastewater nitrogen from islands into surrounding GBR waters was undertaken.

Project B4: Fishing and fisheries

Project Leader: Dr Gavin Begg, JCU

Task Leaders and Research Staff	JCU - Prof. Bruce Mapstone, Dr Gavin Begg, Dr Bridget Green, Dr Annabel Jones, Dr Ashley Williams, Dr Stephen Sutton, Dr Renae Tobin, Prof. Howard Choat, Dr Ross Marriot, Mr Amos Maplestone, Mr Ameer Abdulla, Dr Rachel Pears, Mr Geoffrey Muldoon, Dr Campbell Davies, Mr Chad Lunow, Dr Michaela Bergenius, Ms Janelle Eagle, Dr Lou Dong Chun, Prof Garry Russ; CRC Reef Dr David Williams; DPI&F - Mr Rod Garrett, Dr Ian Brown, Dr Brigid Kerrigan, Mr David Welch; UQ - Dr Daryl McPhee
Collaborators	CSIRO, DPI&F, AIMS, QSIA, GRBMPA, Sunfish Qld, Sunfish NQ, FRDC
Task Associates	GBRMPA, UQ, DPI&F, FRDC, ANU, QSIA, AIMS

Commercial and recreational (including charter) fishing is a major use of the Marine Park. There are 17 commercial fisheries that operate within the GBRMP. The value of the commercial fishing operations within the Marine Park has been estimated at $130 million per annum in Gross Value of Production terms (PDP Australia 2003). The East Coast Otter Trawl and Coral Reef Fin Fish Fishery constitute 82 per cent of this value (DEH 2006).

Around 198,000 recreational fishers (National Recreational and Indigenous Fishing Survey 2003) live in the catchments adjacent to the Great Barrier Reef. The annual catch of recreational fishers throughout Queensland is around 8,500 tonnes of seafood. In some cases the recreational catch is larger than the commercial catch (e.g. coral trout). Around 55% of recreational fishing occurs from the shore. Recreational fishing in Queensland has been trending downwards at 1% per annum since 1996. There are around 120 charter fishing vessels operating in the Marine Park (DEH 2006).

Annual expenditure by recreational fishers in the catchment is estimated at between $80 and $201 million. The Queensland Department of Primary Industries and Fisheries has estimated expenditure on recreational boat fishing in the Marine Park at around $100 million for 2004 (DEH 2006).
CRC Reef research provided information to help ensure commercial, recreational and Indigenous fisheries are sustainable. The Fishing and Fisheries Project involved several inter-related research tasks focused on important commercial, charter, recreational and Indigenous fisheries of the GBR and Torres Strait. The centre piece of this program was the large long-term experiment into the effects of line fishing in the GBR. Data and information from these tasks have been used in the development of State fisheries management plans for coral reef fin fish, Spanish and spotted mackerel and east coast shark; for AFMA, DEH and DPI&F stock assessment and monitoring requirements; and the CapReef community monitoring program in central Queensland.

Achievements, Outcomes and Utilisation
Completion of the 11 year GBR-wide Effects of Line Fishing (ELF) Experiment attracted widespread interest from stakeholders. The research outcomes plus the computer modelling support and data sets that have been developed has provided reef and fisheries management agencies with powerful tools to assist in making more informed decisions. Refer to Case Study # 5 for more details on the ELF Project.

The expertise of the Fishing and Fisheries staff has been provided to Queensland DPI&F to assist in:

- developing management plans for the Coral Reef Fin Fish Fishery (CRFFF), the east coast Spanish mackerel fishery, and Queensland Inshore fishery;
- risk assessment for tropical east coast shark;
- distribution of seasnakes to help assess and mitigate seasnake bycatch in Australia's northern prawn trawl fisheries;
- biological characteristics of three coral trout species has led to changes to legal size limits; and
- red bass life history to support the decision to protect this species.

A major achievement of this project has been the compilation of a website for managers, researchers and the general public about the trawl, reef line, harvest, inshore fin fish and crab fisheries (catch, critical issues, management, and environmental accreditation for 22 target species) from Queensland's east coast http://www.reef.crc.org.au/research/fishing_fisheries/statusfisheries/index.htm
The Third International Symposium on Fish Otolith Research and Application, coordinated by the CRC Reef Fishing and Fisheries team, attracted more than 300 delegates from 35 countries.

The project has received funding from the FRDC for four major tasks: development of an individual transferable catch quota model for the CRFFF of the GBR; development of a national strategy for increasing the survival of released line-caught tropical reef fish; modelling of multi-species targeting of fishing effort in the CRFFF; and determination of management units for grey mackerel fisheries in Queensland and the Northern Territory. A novel experimental apparatus was also developed to estimate absolute short-term mortality rates in fish species likely to be susceptible to barotrauma.
Outcomes from these research projects and others have contributed directly to the management, assessment and long-term monitoring requirements for Queensland's valuable coral reef fish, mackerel and tropical east coast shark fisheries and cement the project's role as a major supplier of fisheries management advice in Queensland.

Funding

Project	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	Total
B0					$37,500	$62,500	$50,000	**$150,000**
B1		$346,285	$462,282	$583,528	$621,082	$474,718	$621,823	**$3,109,717**
B2		$295,250	$221,359	$304,107	$178,529	$28,489	$5,500	**$1,033,234**
B3		$102,241	$76,200	$206,417	$196,698	$125,490	$367,235	**$1,074,281**
B4		$837,946	$992,559	$1,032,882	$1,165,216	$1,311,995	$2,147,214	**$7,487,812**
Total		**$1,581,722**	**$1,752,400**	**$2,126,934**	**$2,199,025**	**$2,003,192**	**$3,191,772**	**$12,855,044**

Publications

Technical Reports:
All CRC Reef Technical Reports are available online at:
http://www.reef.crc.org.au/publications/techreport/

Project - B1
All (Ports & Shipping pests & habitat) reports produced by QDPI&F in collaboration with
CRC Reef are available at http://www.reef.or.au/publications/techreport/DPIFreports.htm

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Marine tourism on the Great Barrier Reef (June 2003)
http://www.reef.crc.org.au/publications/brochures/marine%20tourism_web.pdf

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http://www.reef.crc.org.au/publications/brochures/line_fishing_12-12-02.pdf
Coral Trout species of Queensland
http://www.reef.crc.org.au/publications/brochures/documents/CoralTroutFlyer_000.pdf
Fisheries of Queensland's East Coast
http://www.reef.crc.org.au/research/fishing_fisheries/statusfisheries/index.htm

Reef Futures:
Sustainable Fisheries: http://www.reeffutures.org/topics/susfish.cfm

Program C: Maintaining Ecosystem Quality

Program Leader: Dr Peter Doherty, AIMS

The GBRWHA was inscribed on the World Heritage list because of its unique natural biodiversity. CRC Reef research into biodiversity is crucial to better management and protection of this internationally significant natural heritage. Public debate and policy development for use and protection of the GBRWHA should be well informed about the status and trends of ecosystems. However, there are few historical benchmarks against which to measure change and few agreed performance indicators of system health. Detecting anthropogenic impact in this situation is challenging because it takes place in a highly variable natural environment and often results in slow chronic changes.

The objective of this program was to generate critical information, relevant products and useful advice that will assist users, interested members of the Australian public, industry operators, and natural resource managers to know the status and trends of marine ecosystems within the GBRWHA, through development of benchmarks and performance indicators.

Project	Leaders	Year
C1. Conserving Biodiversity C1. Biodiversity: Status and trends	Dr Peter Doherty Dr Peter Doherty	1999 - 01 2001 - 06
C2. Assessing land-based threats and impacts C2. Water quality(moved to Program W 2004-05)	Dr Miles Furnas Dr Miles Furnas	1999 - 01 2001 - 04
C3. Predicting the Physical Environment	Dr. Janice Lough	1999 - 01
C4. Climate change and coral bleaching	Dr Janice Lough	2001 - 06
C5 Crown-of-thorns starfish	Dr David Williams	1999-2003
C6. Irukandji	Dr David Williams	2003 - 06
C7. Catchment to Reef (moved to Program W 2004-05)	Dr Richard Pearson	2003 - 04

Project C1: Biodiversity: status and trends

Project Leader: Dr Peter Doherty, AIMS

Task Leaders and Research Staff	CSIRO - Dr Roland Pitcher; DPI&F - Dr Neil Gribble, Mr Len McKenzie, Dr Rob Coles, Dr Jane Mellors; AIMS - Dr Peter Doherty, Dr Chris Battershill, Ms Elisabeth Evans-Illidge, Mr Will Oxley, Dr Hugh Sweatman, Dr David Williams, Dr John Veron; QM - Dr John Hooper ; JCU Prof. Helene Marsh, Prof. Howard Choat, Prof. Bruce Prideaux, Ms S Anthony; Access Economics - Mr G Carmody
Task Associates	QSIA - Mr Duncan Souter, Mr Barry Ehrke; DPI&F - Dr Brigid Kerrigan; Sunfish - Mr Vern Veitch, GBRMPA - Dr Kirstin Dobbs, Dr David Haynes, Dr Dorothea Huber, Dr Laurence McCook, Dr Kirstin Michalek-Wagner; CRC Reef - Dr David Williams. FRDC, NOO, GBRRF, DEH, Univ of New Hampshire, Qld Health

Achievements, Outcomes and Utilisation

The **Great Barrier Reef Seabed Biodiversity Project**, a large multi-agency task involving four research providers (AIMS, CSIRO, DPI&F, QM) mapped seafloor habitats and associated biodiversity over the whole of the GBRMP to:

- assess whether trawl fisheries in the World Heritage Area are ecologically sustainable activities;
- assist the GBRMPA to determine how well its new zoning plan meets the objectives of comprehensive, adequate and representative protection of seafloor biodiversity, and
- provide baseline data for monitoring changes arising from the new zoning of the Park.

Queensland's seagrass resources were also mapped and monitored through a state wide program (with extensions to the western Pacific) that combined assistance from community volunteers with scientific advice and analysis. Findings from this project have provided state-wide resource assessment advice for decisions on fisheries and coastal management.

Ten voyages by research vessels from AIMS and DPI&F since 2003 have delivered information from 1,787 sampling sites in the form of 2,400 hrs of video, 17,935 biological samples, 1,187 sediment samples, and 140 G of acoustic data. Many of the more than 7,000 types of organisms found are new records for Australia or undescribed new species. The bulk of this information has been processed and is being analysed. The initial outputs will be maps of habitats and biodiversity values (species richness, biomass) that will be used to assess the uniqueness of the GBR bioregions recognised by GBRMPA's Representative Areas Program and to assess the performance of the GBR Zoning Plan (2003) to deliver comprehensive, adequate, and representative protection to benthic biodiversity in non-reef habitats. The maps of biomass distribution will also be used as the basis for a risk-analysis to test whether current levels of otter trawling in the World Heritage Area are ecologically sustainable. Results can be viewed at www.reef.crc.org.au/resprogram/programC/seabed/index.htm .

The AIMS **Long-Term Monitoring Project** (LTMP) is one of the largest coral reef monitoring programs in the world. It has been monitoring the health of coral reef ecosystems in the GBRWHA for over a decade, by surveying fish, corals, crown-of-thorns starfish, and coral disease. As well as surveying reefs, the team has developed survey methods and reports on the status of the Great Barrier Reef. These are a critical part of the State of the Reef Report
http://www.gbrmpa.gov.au/corp_site/info_services/publications/sotr.

In 2005/06 the program started to measure the impact of the GBR Zoning Plan (2003) upon reef biodiversity. Over six voyages, the LTMP counted fish and corals on 26 reefs closed to fishing by the rezoning and 25 matched reefs that remained open to fishing, representing five geographic regions adjacent to coastal communities between Cairns and Gladstone. Although 5 reefs in the Townsville region will not be surveyed until September 2006, preliminary results from the offshore reefs have shown that the most valuable fish species, coral trout, is already greater than 50% more abundant in the new 'no-take' Green zones after two years of protection from line fishing.

In 2004-05 the LTMP surveyed the condition of inshore coral reefs in areas not covered by the reef-wide program. This snapshot of 29 reefs in the coastal zone potentially most affected by human activities showed that reefs in turbid waters can support a high cover and diversity of reef corals. However, a number of these near-shore reefs are not currently in this state as the result of multiple recent disturbances including storms, crown-of-thorns starfish, coral bleaching, and regional impacts of terrestrial run-off as reported elsewhere. A detailed description of the LTMP and its results can be found at http://www.aims.gov.au/pages/research/reef-monitoring/projinfo.html.

Seagrass-Watch is a non-destructive seagrass assessment and monitoring program that started in Australia in 1998. It monitors sites throughout Queensland and the western Pacific.
The project aims to raise awareness of the condition and trend of nearshore seagrass ecosystems and to provide an early warning of major coastal environment changes. Seagrass-Watch monitoring efforts are vital to assist with tracking global patterns in seagrass health, and to assess the human impacts which have the potential to destroy or degrade these coastal ecosystems. Responsive management based on adequate information will help to prevent any further significant areas and species being lost. The goals of the project are:

- to educate the wider community on the importance of seagrass resources;
- to raise awareness of coastal management issues;
- to build the capacity of local stakeholders in the use of standardised scientific methodologies;
- to conduct long-term monitoring of seagrass and coastal habitat condition;
- to provide an early warning system of coastal environment changes for management; and
- to support conservation measures which ensure the long-term resilience of seagrass ecosystems.

This project supported extensive community-based monitoring of seagrasses at 73 sites across 11 regions of coastal Queensland, and at 38 sites across nine other countries in the Western Pacific, as a contribution to the Global Seagrass Monitoring Network. Based on these assessments, a major status report on seagrass resources was published showing that seagrass meadows in the GBR and elsewhere remain in fairly good condition because negative impacts are generally localized: only four locations showed decline. Low rainfall as a result of El Niño events was the most likely reason for healthy seagrass cover in Queensland, as this reduces the potentially damaging loads of sediments and pollutants carried from the land to the sea. Results from each of the regions and locations covered by the domestic and international monitoring are now available on a new website (www.seagrasswatch.org).

This seagrass work has been extremely proactive and productive, with presentations to international conferences, quarterly newsletters, technical reports, peer-reviewed publications, training workshops, support for graduate students, and regular advice to managing agencies on the impacts of proposals for coastal development (including dredging)

Sponge aquaculture for Indigenous communities was a new initiative to test the feasibility of sponge aquaculture for development/commercialisation at the Palm Islands near Townsville, examining various production models. It involved identification of commercial species, quantification of their distribution and abundance, stock assessment for seed supply, development of sustainable seed production protocols, preliminary identification of high growth promoting locations and/or conditions, and assessment of environmental impacts of seed generation, translocation, and aquacultured sponge grow-out at feasibility scales.

Project C2: Assessing Land Based Impacts 1999-01, Water Quality 2001-06
Project Leader: Dr Miles Furnas, AIMS
This project was transferred to Program W Healthy Country, Healthy Reef in 2004. See Program W for a description of the project and for publications post-2004.

Project C3: Predicting the Physical Environment 1999-01
Project Leader: Dr Janice Lough, AIMS
This Project was transferred to Project C4 in 2001.

Project C4: Climate change and coral bleaching
Project Leader: Dr Janice Lough, AIMS

Task Leaders and Research Staff	AIMS - Dr Janice Lough, Dr Ray Berkelmans; JCU - Mr S Lewis; UQ Prof. Ove Hoegh-Guldberg, Dr Ron Johnstone, Dr Maoz Fine
Task Associates	Dr Paul Marshall (GBRMPA), Ms Simona Trimarchi (PCQ)

Achievements, Outcomes and Utilisation
The enhanced greenhouse effect is warming global and regional temperatures in the air, on the land, and in the sea. Reef-building corals are very sensitive to changes in their thermal environment and are known to lose their algal symbionts (zooxanthellae) and bleach with a 1°C rise in the maximum sea temperature. As a result, coral reefs have been highlighted as a 'unique and threatened ecosystem' by the Intergovernmental Panel on Climate Change (IPCC).

There was widespread coral bleaching on the GBR in the summers of 1998 and 2002 on the GBR that triggered public concern about the long-term future of the Great Barrier Reef. In response, CRC Reef researchers with others (AIMS, NOAA) have created an early warning system forGBRMPA to detect sea temperatures conducive to bleaching, while continuing experiments into the potential for corals to accommodate further warming of the oceans. High-resolution monitoring of the physical environment of the GBRWHA was achieved through real-time satellite remote sensing, validated by an extensive network of *in situ* temperature loggers, oceanographic moorings, and the AIMS automated weather station network. Maps of sea surface temperature (SST) collected by orbiting satellites were processed daily, posted on the AIMS internal website and transmitted to other science agencies (CSIRO, NOAA) for inclusion in global assessments. Since 2000, GBRMPA has been updated twice weekly on the bleaching risk factor. Daily updates were provided when a mild bleaching event was detected for the GBR. The SST maps are being validated by direct monitoring of bulk sea temperatures at 45 sites on the GBR. These records have shown that bleaching can be predicted with an accuracy of 70% from the maximum 3-day SST value for each pixel in the satellite image. Based on this relationship, an increase of just another degree above the temperatures seen during the last two bleaching episodes is predicted to result in bleaching on >80% of reefs in the GBRWHA. Coral bleaching thresholds that were developed from controlled laboratory experiments have proven to be robust when tested in the field and have been translated into more important coral mortality thresholds from sites that suffered >50% morbidity during recent events. Disturbingly, mortality thresholds were found to be just 0.5-1.0°C higher than the bleaching threshold indicating the knife-edge stability of the coral-algal symbiosis.

Other activities directed at understanding this phenomenon have been:

- Applying data from remote sensing monitoring of sea temperatures to investigate the potential of this technique to detect levels of water column chlorophyll.

- Investigating the biology of the coral-algal symbiosis to understand the potential of reef corals to adapt to future rises in sea temperatures. Experimental work showed that corals with more heat-tolerant varieties of zooxanthellae develop reduced calcification rates compared with the current symbiosis. At the least, this suggests that reef building will be slower by modern corals that are able to survive in significantly warmer waters.

- Laboratory studies on the physiology and biochemistry of coral-algal symbioses were supplemented by careful and limited transplantation of non-breeding reef corals between parts of the GBR to forecast how they will respond to warmer temperatures. One set of corals transplanted from the Keppel Islands (23°S) to Magnetic Island (19°S) survived bleaching with a different strain of symbionts from their original state. While this change of partners gave the corals from the Keppel Islands the same thermal properties as native corals from Magnetic Island, the increased tolerance is likely to be limited to 1-2°C which is at or below the predicted rate of future warming.

Project C5: Crown-of-Thorns Starfish
Project Leader: Dr David Williams, AIMS/ CRC Reef

Task Leaders and Research Staff	AIMS - Dr Hugh Sweatman, AIMS Long Term Monitoring Team Dr Udo Engelhardt.
Task Associates	GBRRF, GBRMPA, AMPTO

Crown-of-Thorns starfish (COTS) research has involved both fine-scale and large-scale monitoring of the progression, intensity and impacts of the most recent outbreak. The information gained from COTS survey programs and advice from CRC Reef staff provided the basis for a successful case to the Federal government by the tourism industry for a $4.5 million local site control program of COTS around important tourism sites on the GBR. A collaborative multi-disciplinary modelling study of potential causes of crown-of-thorns outbreaks considerably strengthened the case for run-off of nutrients from the land being a significant factor. A very successful Status-of-Knowledge brochure on COTS was prepared and distributed to tourists, the tourism industry, reef managers and researchers to provide a common grounding in the status of informed knowledge concerning COTS
(http://www.reef.crc.org.au/publications/brochures/COTS_web_Nov2003.pdf).

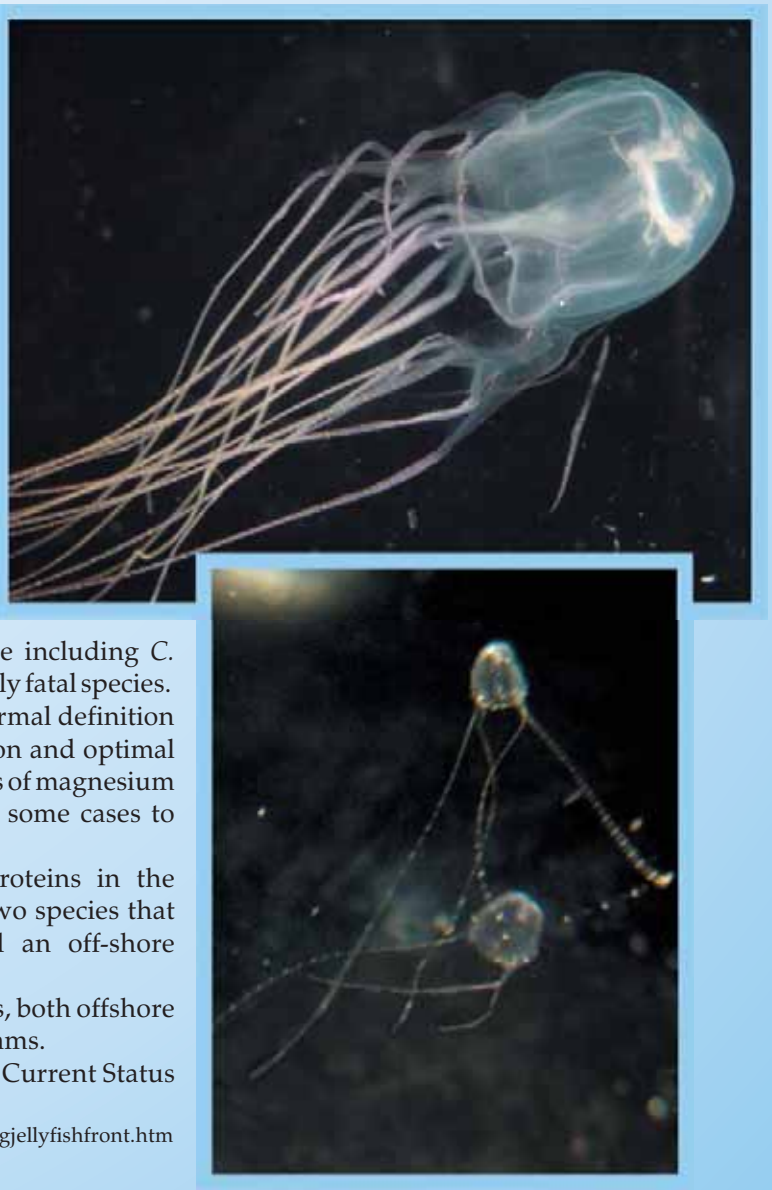
Project C6: Irukandji
Project Leader: Dr David Williams, AIMS/ CRC Reef

Task leaders and Research Staff	JCU - Dr Jamie Seymour, Prof. Jim Burnell, Dr Lisa-ann Gershwin, Ms G Avila Soria, Ms D Brinkman; AIMS - Dr Madeleine Van Oppen; Quicksilver - Mr Russell Hore
Task Associates	GBRRF, QLD Health, AMPTO

Achievements, Outcomes and Utilisation

Cubozoan or box jellyfish have long been recognized as a serious potential risk to swimmers in north Queensland. *Chironex fleckeri* has caused fatalities around northern Australia. The irukandji, *Carukia barnesi*, although not known to have caused a fatality, has been responsible for the hospitalization of many people with very painful symptoms known as irukandji syndrome. *C. barnesi* is generally found in relatively nearshore waters, and stings usually occur close to beaches. In the 2001-02 summer, two tourists died with irukandji syndrome in offshore waters. Consequently the CRC Reef initiated a major priority setting workshop and managed an irukandji research program with significant funding from the GBRRF and both the Queensland and Federal governments.

The CRC effort led to much improved coordination, funding and focus of research efforts and delivery of the best available information to those responsible for prevention and response strategies.



The main results were:

- Provision of research representation on Queensland's inter-departmental Irukandji Taskforce and its Prevention and Response Working Group and Research Working Group (chair).
- Coordination of a Status of Knowledge document that provided critical background for the priority setting of the Taskforce.
- A combination of molecular and morphological research that identified three distinct groups of irukandji, including two distinct groups of dangerous irukandjis. The two distinct dangerous groups coincide with the anecdote-based hypothesis of two different classes of irukandji syndrome, one including *C. barnesi*, the other including offshore, potentially fatal species.
- Hospital trials set up to better determine a formal definition of the Syndrome, its physiological progression and optimal treatment, including a trial of the effectiveness of magnesium treatment which has been demonstrated in some cases to relieve pain.
- Construction of cDNA libraries for the proteins in the nematocysts (which deliver the poison) of two species that cause irukandji syndrome (*C. barnesi* and an off-shore pseudo-irukandji).
- Coordination of focussed collecting programs, both offshore and nearshore for the supply of all research teams.
- Production of the CRC Reef's most requested Current Status of Knowledge Brochure
  http://www.reef.crc.org.au/publications/brochures/Stingingjellyfishfront.htm

Project C7: Catchment to Reef

Dr Richard Pearson, JCU

This project commenced in 2003-04 and was transferred to Program W, Healthy Country, Healthy Reef in 2004-05. See Program W for description and publications

Funding

Project	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	Total
C0		$60,000	$48,750	$71,250	$60,000	$60,000	$60,000	**$360,000**
C1		$600,360	$616,370	$666,596	$1,343,879	$1,182,606	$1,862,071	**$6,278,229**
C2		$515,576	$518,034	$426,371	$292,647			**$1,752,628**
C3		$62,834						**$62,834**
C4		$155,500	$163,382	$138,213	$166,064	$192,460	$204,950	**$1,020,569**
C5		$77,273	$6,818					**$84,091**
C6				$78,595	$103,646	$115,053	$229,132	**$526,426**
Total		**$1,000,967**	**$881,954**	**$954,654**	**$1,677,589**	**$1,550,119**	**$2,356,153**	**$8,427,783**

Publications

Technical Reports:
All CRC Reef Technical Reports are available online at:
http://www.reef.crc.org.au/publications/techreport/

Project - C1

All (Seagrass) reports produced by QDPI&F in collaboration with CRC Reef are available at
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Program D: Reef Futures

Program Leaders: Dr Terry Done, AIMS 1999-04/ Dr Britta Schaffelke, AIMS2004-06

The objective of this program was to improve the management and use of information within CRC Reef, to catalyse and participate in integrative projects, and to facilitate knowledge transfer among CRC Reef's partners, and between CRC Reef and its key client groups.

Project	Leaders	Year
D1. Information Systems	Dr Jamie Oliver Dr Adam Lewis	1999 - 00 2000 - 01
D2. Information Synthesis	Dr Terry Done	1999 - 01
D3. Knowledge Exchange	Dr Terry Done Dr Britta Schaffelke	2002 - 03 2003 - 06
D4. Exploring Reef Futures	Dr Terry Done	2002 - 06

Project D1: Information Systems

Project Leader: Dr Jamie Oliver, GBRMPA 1999-00; Dr Adam Lewis GBRMPA 2000-01

Task Leaders and Research Staff	GBRMPA Dr Jamie Oliver, Dr Adam Lewis AIMS Dr Britta Schaffelke,
Task Associates	GBRMPA

Achievements, Outcomes and Utilisation

This project was developed through consultation with CRC Reef members and provided the technical basis for CRC Reef's administration and outreach. The creation of a web-page portal provided direct access to the visions, goals, philosophies and organisational structures of the Centre and its research outcomes. It also had a knowledge synthesis component, which was later carried into other projects. The main results were:

- Development of CRC Reef's Project management and reporting systems.
- Development and maintenance of CRC Reef, CRC Torres, IMPAC and Reef Futures websites.
- Major reviews about the sustainability of coral harvest fishery and marine tourism impacts.

Project D2: Information Synthesis

Project Leader: Dr Terry Done AIMS 1999-01

Task Leaders and Research Staff	AIMS Dr Terry Done, Dr Britta Schaffelke, Dr Ben Radford, Dr David Williams
Task Associates	GBRMPA

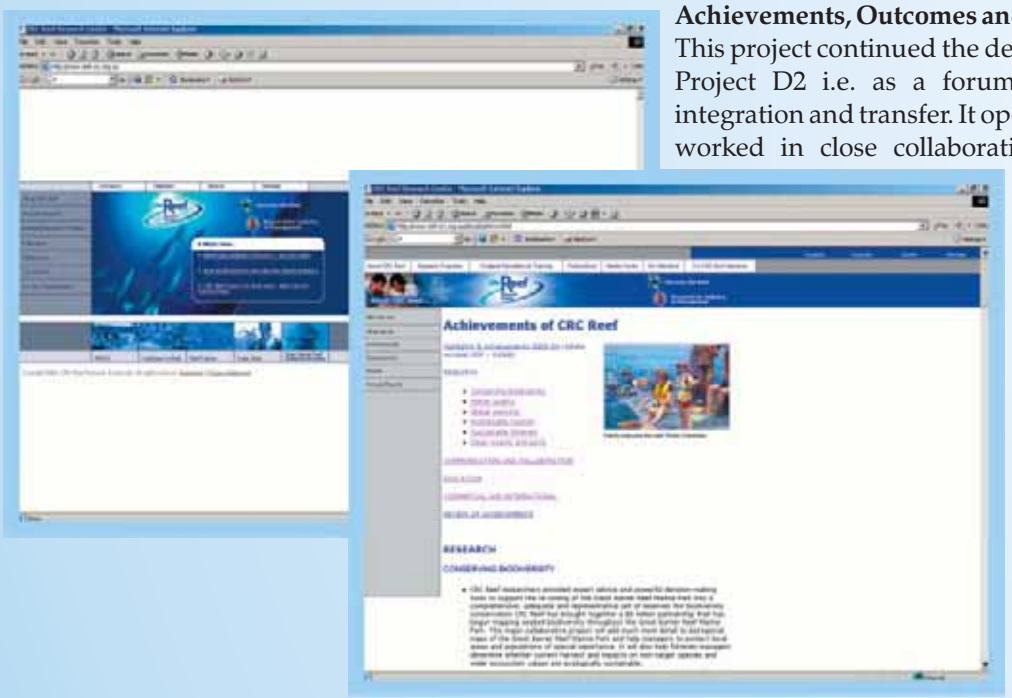
Achievements, Outcomes and Utilisation

This project was developed as a forum for knowledge compilation, integration and transfer which was later carried into other projects. The main results were:

- publication of a review about the impacts of water quality on the GBR, which supported development of the RWQPP;
- co-organisation of "Sustaining Aquatic Environments" conference in Townsville 2001, published in 2003;
- major scientific contributions to GBRMPA RAP processes - see Case Study #1; and
- completion of a PhD thesis by Ben Radford about assessments of cross-shelf coral reef biodiversity to support selection of protected areas.

Project D3: Knowledge exchange
Project leader: Dr Britta Schaffelke, JCU/AIMS

Task Leaders and Research Staff	AIMS Dr Britta Schaffelke
Task Associates	GBRMPA



Achievements, Outcomes and Utilisation

This project continued the developments commenced under Project D2 i.e. as a forum for knowledge compilation, integration and transfer. It operated across research tasks and worked in close collaboration with the Communication Program and the Exploring Reef Futures team. The project made major contributions to the development and upgrading of the CRC Reef and Reef Futures websites and the development of web-based knowledge exchange products. These allowed more flexibility to represent information, were able to be regularly updated and were well-received by users. Products from this project included:

- Production and updates of eleven CRC Reef 'Current State-of-Knowledge' brochures, available online and in print, on current issues, e.g. 'Stinging jellyfish in tropical Australiacurrent state of knowledge' and 'Coral bleaching and global warming. Current state-of-knowledge'.
- A comprehensive online 'web brochure' about Queensland's east coast fisheries, which compiled from various sources detailed information about fisheries in the GBR region into summary pages for each fished species. The pages included statistics about status, trend and value of catch by species, with maps showing location of fishing effort.
- Website pages to showcase the Seabed Biodiversity Project with information about the project, its aims and objectives, the team members, vessels, dates of voyages, and descriptions of the tools. Visitors can use interactive maps to do a virtual tour of each site sampled during the Project, and see underwater video (information about site depth, and which vessel sampled it), as well as charts which illustrate the composition of the seabed fauna: http://www.reef.crc.org.au/resprogram/programC/seabed/index.htm
- Web-based CRC Reef Review of Monitoring Programs in the GBRWHA a database that summarised monitoring activities in the GBR region.
- A website database of all CRC Reef publications making CRC Reef outputs available to all members and the general public.
- CRC Reef 'Research and Implications Briefings' as a further knowledge exchange tool.
- Co-organisation of a 3-day conference 'Catchment to Reef: Water Quality Issues in the Great Barrier Reef Region'. The conference proceedings were published as a special issue in Marine Pollution Bulletin (Vol 51, 2005), and were a benchmark of the current state of knowledge on GBR water quality.
- A review of the state of knowledge of water quality effects on marine plants. While information about water quality responses of marine plants is scarce, highlighting the need for further ecological studies on habitat-forming coastal marine plants, there are clear indications that declining water quality negatively affects these plants and their communities.

Project D4: Exploring Reef Futures
Project leader: Dr Terry Done, AIMS

Research Staff	AIMS - Dr Terry Done, Dr Britta Schaffelke, Dr Stuart Kininmonth, Dr Scott Wooldridge, Dr Glenn De'ath; JCU - Dr Barbara Kennedy
Task Associates	GBRMPA

Achievements, Outcomes and Utilisation
The project contributed to CRC Reef goals in four main areas:

- exploring future environmental and management scenarios;
- understanding the major pressures of terrestrial run-off and crown-of-thorns starfish;
- statistical support for design and analysis of research tasks; and
- further development of an advanced knowledge management system.

A major aim was making data, information and knowledge broadly and readily available for public access. This was achieved by development of the Reef Futures website to give access to web-maps, reports and real time data. In particular the use of multimedia tools such as video, dynamic graphs, pictures and webmaps has significantly improved the capacity of CRC projects like C1 Biodiversity: Status and Trends to disseminate research findings. Technical products to showcase CRC Reef research included:

- Information about the sea temperature monitoring program conducted by AIMS. Visitors to the Reef Futures website can visualise temperature fluctuations across the GBR while researchers can download the fine-scale data directly. Complementary to this facility is the visualisation of the AIMS automatic weather station data in real time. As the data stream into AIMS, graphs are automatically generated and updated representing e.g. long-term average temperatures and temperature thresholds for coral bleaching.
- Continued development of the ReefState modelling framework, based on use of Bayesian belief networks, allowed us to explore how successful management interventions might benefit coral reefs in the central GBR during the period of climate warming that is expected in coming decades. Even under optimistic (low) rates of future warming, the modelling evidence suggests that the persistence of hard coral-dominated reefscapes beyond 2050 will depend on two things: firstly the ability of corals to increase their thermal bleaching tolerance by approximately 0.1° C per
- decade and secondly the management regimes that constrain excessive algal biomass proliferation during inter-disturbance intervals. The ReefState modelling approach generated international interest (from the National Institute for Space Research, INPE, Brazil).

This project developed 'management focused' scenario models to assess the consequences of existing (e.g. water quality), and perceived future threats (e.g. climate change), on the long-term resilience of coral reefs within the GBR. The integration of various long-term datasets in the modeling approach has proven very useful to improve understanding of whole-system dynamics.

For example, an examination of the subtle interactions between environmental stressors and other drivers of GBR coral community structure, in order to improve the ability to distinguish and predict patterns of bleaching and mortality applied an analysis of relationships between major long-term datasets of e.g. bleaching impacts, physical oceanography, bathymetry, chlorophyll a concentrations and sea surface temperatures. Spatial maps outlining 'risk-of-bleaching' predictions for the GBR were used as input into the draft Zoning Plan under the RAP to ensure that the risk of biodiversity loss due to coral bleaching was spread across as many 'low-risk' areas as possible.

In addition to exploring future ecological scenarios, the project also made major contributions to the improved understanding and monitoring of key pressures to the system, two of which are terrestrial run-off and crown-of-thorns starfish. The data mining activities in this project centred on monitoring for the RWQPP and the effects of terrestrial run-off. A framework based on statistical and epidemiological methods was developed and used to assess the effects of run-off on coral reefs by comparing reefs of the Wet Tropics (a high-risk area) with Princess Charlotte Bay (a low-risk area). Crown-of-thorns starfish outbreaks were linked to increasing nutrient levels, resulting in enhanced larval survival. Models were developed to investigate this link, and showed that increased chlorophyll could account for a shift from infrequent outbreaks to a chronic state whereby reefs fail to fully recover. Spatial and temporal analysis of a 10-year chlorophyll data set showed large spatial but weak temporal changes. These analyses were extended to a number of available long-term and large-scale datasets from programs that will be used as a baseline for the RWQPP Marine Monitoring Program, coordinated by GBRMPA. providing a snapshot of current status of measured parameters and long-term trends. Performance of the methods used to assess temporal change was investigated, and suggested improvements to sampling strategies were made.

A statistical review of data from various reef fish and reef benthos surveys was undertaken as part of a feasibility study for monitoring the effectiveness of the RAP. Recommendations on the design of a monitoring program were made to GBRMPA.

The Project also provided statistical design and analysis support for several CRC Reef tasks including investigation of water quality pollution and genetic expression of stress, the seabed biodiversity project and further development of methods to analyse large complex data sets.

Informing the management process - ***Dr Barbara Kennedy, JCU***
The 25 Year Strategic Plan for the GBRWHA was published in 1994 and included agreement by the Stakeholders to a review process at five-yearly intervals. This project was the first review. It aimed to identify:

- progress made toward 5- and 10-year objectives;
- perceptions of the ongoing relevance and utility of the Plan;
- stakeholder interest in participating in a formal process to update the vision, objectives and strategies of the Plan; and
- stakeholder perceptions of how the Plan could have been better structured or implemented.

The 25 Year Plan is the major strategic planning document for the GBRWHA and the Review sought to provide direction for the future use and/or redevelopment of the Plan and its application in strategic planning by stakeholder organisations. The review also provided the opportunity to provide some data on the effectiveness of the 25 Year Plan as an approach to facilitated joint planning among a group of stakeholders diverse in their goals, objectives, values and operations.

Project	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	Total
D2		$22,136	$141,654	$52,358	$8,667	$8,667	$13,366	**$246,848**
D3		$50,160	$50,160	$22,700	$42,000	$58,063	$76,188	**$299,271**
D4		$119,000	$67,500	$492,268	$421,478	$539,299	$595,915	**$2,235,460**
Total		**$191,296**	**$259,314**	**$567,326**	**$472,145**	**$606,029**	**$685,469**	**$2,781,579**

Publications

Technical Reports:
All CRC Reef Technical Reports are available online at:
http://www.reef.crc.org.au/publications/techreport/

Project - D1

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Program E: Education and Training

Program Leaders: A/Prof. Vicki Harriott 1999 - 2002; Prof. Helene Marsh, JCU 2002-2006

The CRC Reef Education and Training Program had the following goals:

- to maintain standards of scientific excellence in education;
- to guide students to employment; and
- to enable students to contribute to the strategic development of Australian and international marine sciences, and Torres Strait.

The main objective was to provide scholarships, funding, training and a supportive educational environment for post-graduate students within an integrated research program. In 2003, a further objective was established for CRC Torres Strait Education and Training Program: to provide training and education opportunities and support at a variety of secondary, tertiary and post-graduate levels specifically for Torres Strait islanders.

Resources

The resources committed to education and training of post-graduate research students totalled $3.495 million over the period 1999-2006. The CRC Reef recruited 27 new scholarship students (24 PhD; 3 Masters) between 1999 and 2004, adding to those students continuing from the previous CRC Reef. No new scholarships were given after 2004. During the life of the CRC Reef, 190 students were supported, 48 of whom were scholarship students. A further 142 were Student Associates, who had an association with CRC Reef or CRC Torres Strait through their project or supervisor, or through the receipt of financial support other than a scholarship. Table 2 shows further detail of the students supported over the period 1999-2006.

Table 2: Students supported by CRC Reef Research Centre 1999-2006

POST-GRADUATE STUDENTS 1999-2006			
Degree	**Scholarship Students**	**Student Associates**	**Total**
PhD	43	62	105
Masters Degree	5	26	31
Honours/ Grad Dip		52	52
Other		2	2
Total	**48**	**142**	**190**

CRC Reef students conducted research in a wide range of disciplines, reflecting the integrated and collaborative nature of the issues that required research information. These included studies in the natural sciences disciplines such as marine biology and ecology, geography, natural resource management, earth sciences, GIS/spatial analysis and oceanography. Social sciences disciplines included anthropology and archaeology, sociology and economics. Other disciplines included tourism, environmental studies and engineering. The application of statistics was integral to all studies.

Student Support

A feature of CRC Reef Education program has been the support provided to students either through scholarships, grants, travel funds or through structured mentoring, management and skills development programs.

Mentoring and scholarship management programs were first developed in the previous CRC Reef and further enhanced in the CRC Reef from 1999 onwards. These proved to be of great benefit to CRC students particularly in areas of project management, seminar presentations and scientific writing. Features of the academic and mentoring support were:

- The initiation of a comprehensive annual half-day induction program for new post-graduate students to introduce them to the benefits and responsibilities of belonging to the CRC. As part of the induction, students were surveyed about their training needs to assist in planning of training opportunities.
- The development of tutoring and training courses in a wide variety of skills necessary for better quality research and enhanced employment prospects.The initiation of performance reviews, conducted in conjunction with university supervisory staff, for students identified as being at risk of not completing their degrees within a reasonable time-frame. These students were encouraged to develop realistic project management timelines and were monitored regularly.
- The development of a student agreement, in conjunction with JCU, that clarified issues about intellectual property and contractual obligations of CRC Reef scholarship students. All new students from 2001 onwards were required to sign the agreement.
- The placement on the CRC Reef web-site of extensive information about the post-graduate education program, including documentation for scholarships and summaries of all student projects.
- The development of up-to-date student induction materials, including the CRC Post-graduate Information Booklet that contained information on intellectual property, training and grant opportunities and guidelines for funding student proposals.
- The provision of continuing high quality statistical advice for CRC students in a shared financial arrangement with James Cook University. The scheme provided both individual consultation time with a statistical advisor and several short courses in topics of interest. It was extremely well supported by students, especially in the final stages of their projects when support for data analyses was greatest.
- The provision of targeted training in generic skills useful to industry, plus the opportunity to undertake industry placement during their training.

Skills training

Each year training needs of CRC Reef students were identified and where possible training courses were developed in response to those needs. Initially, there was a focus on assisting students from the former CRC to complete their degrees, recruiting new students into the research programs of the current CRC, and maintaining the balance between tertiary and industry training. Training offered by the CRC included courses in multivariate analysis, scientific writing, GIS skills and application, social assessment research methods, intellectual property implications of research, conflict resolution skills (VETEC accredited), negotiation skills, understanding the relationship between policy development and science, writing funding proposals, presentation and media skills and in project management.

Students were encouraged and supported to collaborate with education and training programs from other CRCs. Selected students were sponsored to attend conferences to explore opportunities for collaboration in design and delivery of student training programs. In addition, students were supported to attend the CRC Career Development and Leadership program. This highly successful and popular program was hosted by CRC Reef in Townsville in 2000 in collaboration with CRC Rainforest, CRC Sugar and CRC Savannas. All students reported that they received extremely valuable outcomes from course participation in terms of their career development.

In collaboration with a private company, *Babel-sbf*, CRC Reef developed a course on Science-Business Fusion, designed to teach scientists about commercialisation of science and working productively with business. The course included the principles of project management and addressed some of the issues that can arise in cultural clashes between science and business.

The first three-day course was run at CRC Reef in December 2000 and was subsequently marketed to other CRCs and centres on a profit-sharing basis with *Babel-sbf*.

Outcomes

This program has been one of the outstanding features of the CRC Reef. The following comment by Dr Don Kinsey, Chair of 5th Year Review Panel 2004, captures the quality of this program:

> *"This Program has always been a highlight of the CRC. The 78 graduate student relationships associated with the CRC represent 17% of the total research students at JCU. I have now been exposed to more than half the PhD students associated with the current CRC during its 5 year life. Without exception, these students not only have been totally comfortable to be involved in research with an anticipated applied outcome but have enthusiastically embraced the association with the CRC and its user driven philosophy. The 113 publications already arising from* that *student research, notwithstanding that most of them are yet to finalise their PhD requirements, is outstanding and indicates a degree of career orientation that I believe is exceptional."*

James Cook University has enrolled and supported most of the students attached to the CRC Reef. Professor T. Norman Palmer, Pro-Vice-Chancellor (Research and Innovation), has commented that:

> *"James Cook University has derived great benefits from CRC Reef support of postgraduate research students. Over the lifetime of both CRCs, over 100 PhD and Masters by Research students have been supported at JCU by the CRC Reef. The benefits have been twofold:*
>
> - *a significant contribution to University funding; and*
> - *The creation of a new type of postgraduate research student. The focus has been on stakeholder engagement and as a consequence graduates have been better prepared in terms of industry liaison, communication and other skills. Time will tell but it may be that the CRC Reef education program will have a significant capacity building for marine NRM research in the northern Queensland region over time."*

The record of completions of students supported by CRC Reef has been outstanding. Of the 48 Scholarship Students supported over the seven years, 34 had completed their degrees by June 2006 and one had withdrawn. Thirteen students who were still enrolled at the end of June 2006 are expected to complete their studies in 2006-07. Of the 142 Student Associates supported, 113 had completed their degrees and six had withdrawn by June 2006. The remainder are expected to complete their studies by the end of 2007. The majority of the CRC Reef students were enrolled at JCU.

Collaboration

Students were actively encouraged to communicate research results, using new communication skills. Several students gained considerable experience with the media through press releases, and interviews for newspaper, radio and television about their work with CRC Reef. Many students presented conference papers at CRC Reef Research Days, providing experience in presentation skills in an informal environment.

Students either organised or were an important component in the organisation and delivery of four highly successful workshops during the life of the CRC Reef.

1. The **CRC Reef Fishing & Fisheries Team** held two student/stakeholder workshops in 2001 and 2004. The workshops were organised entirely by the students and were extremely well-received. The aim was to broadcast results of the students' research and discuss issues raised by the stakeholder representatives at the workshop to benefit the sustainable management of fisheries on the east coast of Queensland and the Torres Strait.
2. The **CRC Reef Student Megafauna Workshop** held in February 2004, generated a series of 'Research Outcomes and Implications Briefings' produced by students. These short, plain-English research summaries make current scientific knowledge available to policy-makers and people affected by policy changes.
3. The Workshop **Forging Partnerships to meet the challenge of conserving marine wildlife in the Great Barrier Reef and Torres Strait** conducted in July 2006. This workshop provided an update on the marine wildlife conservation projects supported by CRC Reef and CRC Torres Strait since 1999. Many of the presentations were the result of CRC Reef student research.

Outcomes - Student employment

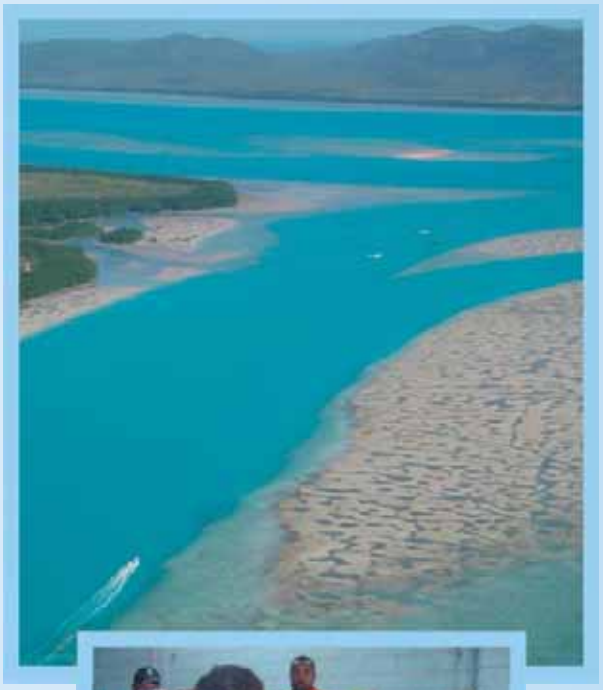
The success of the CRC Reef mentoring and skills development training programs, together with the high quality and motivation of the students themselves, has produced graduates who have been actively sought by industry, government, non-government organisations and research institutions. All of the students have gone on to successful employment in a variety of government, industry, non-government organisations and research institutions.

Publications

Publications by CRC Reef students are included in the relevant program/project summary. Theses written by CRC Reef Scholarship students are shown at Appendix 1.

Program T: Torres Strait

Program Leader: Dr David Williams, CRC Reef/AIMS



This program brought together the main resource management agencies, research institutions and stakeholders in Torres Strait as well as the Torres Strait Regional Authority (TSRA), representing the Torres Strait community. The participants brought substantial resources (over $13 million over three years) to the Program as well as scientific and management expertise and are combining their efforts into a single, integrated, multi-disciplinary research, education and communication program, directed towards the identified needs of stakeholders and end-users. Their expertise derives from considerable experience in Torres Strait and the adjacent GBRWHA. The core participants were AFMA, AIMS, CSIRO Marine Research, CRC Reef, GA, JCU, NOO, DPI&F and the TSRA. Supporting participants were GBRMPA, GBRRF and QSIA.

The objectives of this program were:

- to provide information on key ecological processes in Torres Strait that will improve understanding of the sustainability of the Torres Strait marine ecosystem and conservation of threatened marine species;
- to provide information on status and trends of fisheries and other economically and culturally important natural resources of Torres Strait necessary for effective coordinated and integrated natural resource management;
- to assist in the development and implementation of marine strategies for Torres Strait;
- to provide information to support regional marine planning in Torres Strait and northern Australia;
- to assess the impacts of resource exploitation on the Torres Strait marine environment;
- to provide tools for the evaluation of the consequences of alternative management strategies on Torres Strait stakeholders, marine resources, communities and cultural values;
- to create innovative systems to make available to Torres Strait peoples and other end-users data and information, either existing or generated by the program;
- to identify candidate species for new aquaculture from the natural resources of Torres Strait that are compatible with the aspirations and lifestyles of Torres Strait peoples, and to develop the technology and knowledge base to support sustainable production in new Torres Strait based aquaculture industries;
- to develop education and extension programs to enhance the involvement of Torres Strait peoples in research and development opportunities in Torres Strait;
- to improve the capacity of Torres Strait communities to understand and utilise research results for enhanced economic and social development; and
- to improve the capacity of researchers to engage with Torres Strait communities in the design and conduct of research and in the transfer of research results.

Project	Leaders	Year
T1. Sustaining the harvest of marine resources	Dr Gavin Begg	2003 - 06
T2. Understanding ecosystem processes	Dr Alan Butler	2003 - 06
T3. Evaluating management strategies and risk	Dr Rob Coles	2003 - 06
T4. Education	Prof Helene Marsh	2003 - 06
T5. Extension	Dr Annabel Jones	2003 - 06

Project T1: Sustaining the harvest of marine resources
***Project Leader: Dr Gavin Begg, JCU*Achievements, Outcomes and Utilisation**

Task Leaders	DPI&F - Dr Rob Coles, Mr Clive Turnbull, Mr C Robertson; JCU Dr Gavin Begg, Dr Ashley Williams, Ms S Busilacchi, Ms A Pritchard, Ms J Grayson; AFMA Mr S Taylor; CSIRO Mr Yimin Ye, Mr Tom Skewes; AIMS Dr Alan Duckworth, Ms Elisabeth Evans-Illidge
Task Associates	TSRA - Mr P Yorkston, Ms R Maxwell; AFMA - Mr J Prescott, Mr S Taylor, Mr J Marrington; DPI&F - Dr J Kung; Torres Strait Prawn Entitlement Holders - Ms R Millwood; NQIAWG - Mr D Mosby

Achievements, Outcomes and Utilisation

Marine resources in Torres Strait support several important commercial and traditional fisheries including prawn, tropical rock lobster, Spanish mackerel, reef fish, sea cucumber, dugong and turtle. However, for most of these fisheries ecologically sustainable harvest rates are not known, and the information upon which these rates are estimated is limited. However, this project continues to provide the fundamental baseline data required for understanding the sustainability of these key marine species in Torres Strait. In addition, the project has identified candidate marine species and opportunities for aquaculture that will enhance the economic wellbeing of Torres Strait Islanders.

Research focused on the commercial and traditional harvest patterns of eastern Torres Strait reef fish through the completion of observer surveys on non-Islander commercial vessels and implementation of voluntary logbooks at each of the main fishing communities of Murray (Mer), Darnley (Erub) and Yorke (Masig) Islands. A monitoring program involving school students from each of these islands was also established to provide detailed harvest information on traditional fishing practices, while increasing the awareness of marine resource sustainability issues in the communities. Likewise, a voluntary non-Islander fisher logbook program was established to provide baseline monitoring data for assessment of the Torres Strait Spanish mackerel fishery.

Abundance surveys were conducted for the tropical rock lobster, prawn and sea cucumber (or sandfish) fisheries, with stock assessments completed for the latter two fisheries. Although tropical rock lobsters and prawns are harvested by both Islander and non-Islander fishers, the sea cucumber fishery is almost exclusively an Islander-only fishery. Assessment of the Warrior Reef sandfish fishery indicated that the species is still heavily depleted due to low recruitment and/or illegal fishing with no signs of stock recovery. Community workshops conducted on Murray, Darnley and Yorke Islands to disseminate information on the monitoring and assessment of sea cucumbers in Torres Strait provided an opportunity to increase understanding about the species' current resource status, and related research activities.

Community workshops were also held on Hammond and Thursday Islands to discuss conservation issues and the establishment of catch monitoring programs for marine turtles and dugongs. Monitoring of these important traditional species commenced following extensive consultation with the respective communities. Training of community members on each of the Islands in turtle tagging and measuring, collection of biological samples for genetic analysis, and other monitoring activities will enable the ongoing and long-term monitoring of these key species.

Opportunities for aquaculture in Torres Strait were explored following completion of a comprehensive sponge survey in the region that identified a suitable species in high abundance adjacent to Masig Island. Subsequent experimental culture trials to examine the suitability of the species for large-scale aquaculture production commenced with strong community engagement and support. Significant extension activities were also carried out throughout the Torres Strait assisting in various aquaculture opportunities such as pearl farming on Saibai and prawn farming on Badu Island.

Project T2: Understanding ecosystem processes
Project Leader: Dr Alan Butler, CSIRO

Task Leaders	CSIRO - Dr Alan Butler, Dr Roland Pitcher; GA - Dr Andrew Heap; DPI&F - Dr S Campbell, Dr R Coles
Task Associates	TSRA - Mr P Yorkston; NOO - Dr V Nelson, Mr S Jackson; PCQ

Achievements, Outcomes and Utilisation
It is essential to manage the marine environment, the marine resources and the conservation values of Torres Strait on a regional, ecosystem basis. This project aimed to provide information about key ecological patterns and processes in Torres Strait that would improve the understanding of the dynamics of the Torres Strait marine ecosystem and would provide sound scientific support for coordinated and integrated management.

Two benthic surveys to map and characterise key biotic and physical attributes of the Torres Strait ecosystem were completed in March-April 2005. The first survey concentrated on demersal, motile animals that are sampled by a modified prawn trawl. The second concerned sessile benthic animals (using towed video, benthic sled and other devices). Processing of the samples commenced in 2005.

Two surveys to understand biophysical processes in the Torres Strait marine ecosystem using high-resolution swath sonar survey and detailed sampling were completed in September 2004. In addition, seagrass survey work was done. This enabled an assessment of the seasonal migration of sandwaves and possible impacts on seagrass beds. Modelling work was expanded to include tidal and wind-driven currents, and the representation of sandwave movements. Preliminary work suggested that sediments causing high turbidity during spring tides come from locally re-suspended bottom material, and not from plumes of Fly River sediment.

Understanding distribution and abundance, and growth and nutrient availability of seagrass habitats are key factors for modelling ecological processes in Torres Strait. These factors were assessed through two baseline surveys of the Orman Reef complex. Detailed information from this project has highlighted deficiencies in knowledge of energy transport and ecosystem connectivity.

Project T3: Evaluating management strategies and risk
Project Leader: Dr Rob Coles, DPI&F

Task Leaders	DPI&F - Dr Rob Coles, Dr Kerry Neil, Dr Michael Rasheed; CSIRO Dr Francis Pantus; Dr Dermot Smyth; Dr Judy Fitzpatrick, Dr Donna Kwan
Task Associates	TSRA - Mr P Yorkston; AFMA - Mr J Prescott; NOO - Dr V Nelson, Mr S Jackson; PCQ - Mr B Brunner, Ms S Trimarchi

Achievements, Outcomes and Utilisation
The aim of this project was a better understanding of the dynamics of Torres Strait seagrasses and insight into the reasons for past changes, particularly declines in the seagrass meadows. Two detailed seagrass mapping surveys were completed around reefs in the region to the north east of Mabuiag Island. Experimental studies of growth and the effects of light were completed at Mabuiag and Thursday Island.

The first two years of mapping and quantifying marine habitats at risk adjacent to the Prince of Wales (March 2004) and Adolphus (March 2005) Shipping Channels were completed. In addition, a baseline survey of marine habitats within the Port of Thursday Island (Port Kennedy) port limits and a long-term monitoring strategy for seagrasses within the port were completed. The data from these tasks supported the development of indicators for managing traditional marine resources and for commercial fishery management strategy evaluation.

Project T4: Education
Project Leader: Professor Helene Marsh

Task Leaders	DPI&F - Dr Jane Mellors; JCU Prof. Helene Marsh, Dr Gillian Brodie, Dr Donna Kwan, A/Prof. Kevin Parnell
Task Associates	Thursday Island High School Mr Tony Considine; Torres Strait Islanders Regional Education Council Inc.- Mr Tony Ghee.

Achievements, Outcomes and Utilisation
A strong education program is essential for effective outcomes in Torres Strait. The challenge for CRC Torres Strait was to develop a program which was relevant, effective and culturally appropriate for Torres Strait Islanders.

The Torres Strait Prestige Research Scholarship was awarded to Mr Frank Loban to undertake a Masters degree at JCU to investigate the prospects for Islanders to become involved in fisheries management, especially enforcement. Dr Jane Mellors instigated and continued a very successful Seagrass-Watch community-based monitoring program in Torres Strait, in partnership with Thursday Island High School. The program involved fieldwork and classroom-based training. Two students from Thursday Island visited Townsville under the program.

Project T5: Extension
Project Leader: Dr Annabel Jones **Achievements, Outcomes and Utilisation**

Task Leaders	JCU - Dr Annabel Jones; CRC Reef Ms Bryony Barnett
Task Associates	TSRA - Mr T Nakata

Feedback from stakeholders indicated that the success of research in Torres Strait depended on the relationships developed between researchers and Torres Strait Islanders. Extension and liaison activities played an essential role in developing these relationships, and were therefore vital to the overall success of CRC Torres Strait.

The role of the Marine Research Liaison Officer (Mr Toshio Nakata) was a vital part of the ongoing success of the research program. This role was essential for efficient planning of research tasks, facilitating visits by researchers and communication activities.

The role of Indigenous Aquaculture Liaison Officer (Mr Stanley Lui) was also extremely beneficial for effective research, through involvement with the North Queensland Indigenous Aquaculture Working Group and the Sponge Aquaculture task.

This project was successful in delivering relevant products to the Torres Strait communities, management agencies and researchers, such as:

- CRC Torres Strait website (www.torres.com) - an effective communication vehicle that provided a calendar of upcoming visits to aid researchers in planning research activities in Torres Strait.
- Several articles including information about CRC Torres Strait research published in local media including the Torres News, the TSRA News and radio 4MW. All of these were distributed widely throughout Torres Strait and were efficient methods for disseminating research information.
- A series of school activities about sponge aquaculture conducted by CRC Reef Extension Manager, Ms Bryony Barnett with AIMS researchers Dr Alan Duckworth and Mr Carsten Wolff, were highly successful as was a public presentation for the community. Local divers were also trained and employed to conduct research, providing a legacy of vocational training, and building capacity in the community.

- Production of *Guidelines for ethical and effective communication for researchers working in Torres Strait* collating communication media and activities for researchers working in Torres Strait.
- A workshop bringing together key researchers, associates and stakeholders in Townsville, in March 2005, was highly useful for developing synergistic relationships between research projects, for communication of research findings, and identifying key areas of interest to stakeholders.

Funding

Project	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	Total
T1					245,897	773,030	934,382	**1,953,309**
T2					591,552	686,503	586,558	**1,864,613**
T3					243,894	191,414	514,511	**949,819**
T4					87,446	187,921	172,189	**447,556**
T5					21,998	21,998	94,000	**137,996**
Total					**1,190.787**	**1,860,866**	**2,301,640**	**5,353,293**

Publications

In preparation for Torres Strait Special Edition of Continental Shelf Research 2007

Begg GA, Chen C, O'Neill MF, Rose D, Helmke S. Assessment of the Spanish mackerel fishery in Torres Strait.
Busilacchi S, Begg G. A. Harvest patterns of the traditional reef line fishery in the eastern Torres Strait.
Daniels J. et al. Sandwave movement and impact on seagrass beds
Duckworth AR, Wolff CWW, Evans-Illidge E, Whalan S. Spatial variability of *Dictyoceratid* sponges across Torres Strait, Australia.
Harris P T, Butler A, Coles R. Biophysical processes and environmental management in Torres Strait.
Heap AD, Sbaffi L. Sources of seabed and suspended sediments in north central Torres Strait.
Hemer, M. Hughes, M. et al Dynamics of sediment movement.
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Margvelashvili N, Saint-Cast F, Condie S. Modelling sediment transport in Torres Strait.
Marsh H and Hamann M. Environmental variation in Torres Strait: implications for the management of the dugong and turtle fisheries.
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Neil K M, Chalmers S, Stafford H. Risk analysis of the introduction of non-indigenous marine species to the Torres Strait: Vectors and areas of high risk.
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Skewes TD, Dennis DM, Ye Y, Taylor S. Stock assessment of commercial holothurians in Torres Strait.
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Program W: Healthy Country, Healthy Reef

Program Leader: Ms Sheriden Morris, CSIRO

The decline of water quality from catchment to reef, is widely recognized as one of Australia's most pressing and challenging environmental issues. The Australian and Queensland Governments have jointly established a long-term plan for improving water quality in the GBR lagoon, the Reef Water Quality Protection Plan (Reef Plan) which requires effective tools for monitoring the status and trends of water quality of rivers entering the GBRWHA and in the GBR kagoon and of marine ecosystem health.

In 2002, CRC Reef and Rainforest CRC were awarded a joint Supplementary Grant from the CRC Program for three years to develop new protocols and tools to identify, mitigate water quality problems, and to assess the health of aquatic ecosystems in the Wet Tropics and GBR World Heritage Areas. This integrated program, '**Catchment to Reef**' recognised the downstream effects of agriculture and the need to improve the ecosystem health of the GBR lagoon and its feeder catchments. While new institutional arrangements and policy frameworks were required to bring about effective changes in coastal and marine ecosystems, new tools were also needed by landholders, industry and other stakeholders to both improve the quality and ecological integrity of terrestrial and aquatic systems and to monitor the effects of land use changes and restoration on water quality.

In 2004, CRC Reef was awarded the contract for the management of the monitoring under the Reef Plan and a new program W: Healthy Country, Healthy Reef was established for this purpose. The related water quality projects in Program C - C7 Catchment to Reef and C2 Water Quality - were transferred from Program C to complement the new Reef Plan monitoring initiative and provide one coordinated home for the CRC Reef projects related to GBR water quality. The Healthy Country, Healthy Reef Program aimed to integrate and develop tools to assess the status of water quality and its impacts on marine ecosystems. It also sought solutions for water quality issues and provided information to inform public debate.

The Reef Plan Marine Monitoring Program (Reef Plan MMP) for water quality and ecosystem health in the GBR lagoon was designed to assess the long-term effectiveness of the Reef Plan by measuring key ecosystem and water quality indicators at selected river mouths and inshore reef locations. The GBRMPA is responsible for the implementation and reporting of the Reef Plan MMP in the GBR. CRC Reef led and coordinated the Reef Plan MMP consortium of organisations that all undertake water quality monitoring. The consortium included AIMS, UQ, DPI&F, DNR&M, QEPA, SeaResearch and CSIRO. CRC Reef coordinated five key sub-programs of the Marine Monitoring Program including river mouth water quality monitoring, marine water quality monitoring, marine biological monitoring (coral and seagrasses) and bioaccumulation monitoring. The GBRMPA also coordinated a socio-economic monitoring component of the Program.

The objective of the Healthy Country, Healthy Reef program was to provide critical information of relevance to industry and management in relation to the following problems:

- The export of nutrients, sediments and other contaminants into near coastal waters and the GBR lagoon. This export has increased substantially since European settlement, with severe impact on the viability and condition of marine ecosystems and the industries that depend on them. Approximately 200 nearshore reefs adjacent to the wet tropics and around the Whitsunday Islands are under immediate, direct pressure.
- Run-off of excess nutrients, sediments and agricultural chemicals is also severely impacting the river catchments and wetland ecosystems that feed into the GBR lagoon and threatens the ecology of these systems, their biodiversity and their capacity to cleanse water entering the sea.

Project	Leaders	Year
W1. Clean Water for the GBR	Ms Sheriden Morris	2004 - 06
C2. Water Quality (transferred from Program C)	Dr Miles Furnas	2004 - 06
C7. Catchment to Reef (transferred from Program C)	Prof Richard Pearson	2004 - 06

Project W1: Clean water for the GBR
Project leader: Ms Sheriden Morris, CSIRO

Task Leaders	CSIRO - Ms Sheriden Morris, Dr Arnold Dekker; AIMS - Dr Britta Schaffelke; DPI&F - Mr Len McKenzie; SeaResearch - Dr Tony Ayling; DNR&M - Mr Peter Gilbey; UQ - Prof Jochen Mueller; Mr Munro Mortimer
Task Associates	Steering Committee

Achievements, Outcomes and Utilisation
Overall, the implementation of the Reef Plan MMP has been a success. This has included substantial effort from the monitoring consortium partners to engage community groups and tourism operators in monitoring activities. This has resulted in the implementation of a comprehensive community monitoring component of the program. Other highlights of the program to date have been:

- Reporting of the current status and trends of water quality and important ecosystems of the GBRWHA based on available long-term large scale datasets relevant to the tasks in the Reef Plan MMP.
- Establishment of a community-based water-sampling program a eight priority rivers; including flood sampling of river water in three rivers in 2004-05 and nine rivers in 2005-06, and delployment of passive samplers for pesticide monitoring in six rivers.

- Collection of turbidity (by automated instrumentation) and river discharge data from seven rivers in 2004-05 and 10 rivers in 2005-06.
- Twice- yearly lagoon water quality monitoring in conjunction with inshore reef sampling at 38 sites in 2004-05 and 2005-06.
- Long-term chlorophyll monitoring along nine cross-shelf transects and 11 coastal monitoring sites.
- Trial and deployment of automated chlorophyll and turbidity loggers at two lagoon sites.
- Further development of algorithms to enable remote sensing of chlorophyll and turbidity concentrations in the GBRWHA.
- Temperature monitoring at 16 established sites; deployment of new temperature loggers at 12 sites
- Deployment of passive samplers for pesticide monitoring at eight island sites, assisted by tourism operators
- Establishment and monitoring of coral reef benthos at 28 inshore locations.
- Monitoring of seagrass cover and composition at 11 locations.
- Sediment sampling for herbicides in seagrass meadows at eight locations.
- Mudcrabs sampledfor measurements of bioaccumulation of pesticides and other toxicants from 10 rivers in 2004-05.

Project C2: Water quality
Project Leader: Dr Miles Furnas, AIMS

Task Leaders	AIMS - Dr Miles Furnas, Dr Dan Alongi, Dr Katharina Fabricius; Dr Miles Furnas; Dr Kirstin Heimann, Dr Britta Schaffelke, Dr Andrew Negri; JCU - Mr Jon Brodie, Dr Sea Rotmann; CRC Reef - Dr David Williams: DPI&F - Dr Jane Mellors
Task Associates	GBRMPA; Sunfish

Achievements, Outcomes and Utilisation
The increase in run-off of sediment and nutrients following European development of the land is one of the greatest human impacts on the GBR. Most of this increase is due to land clearing and intensive agriculture in catchments adjoining the GBR. Heightened awareness of the export of materials from land to sea has generated significant community and policy debate.

The aims of this project have been:
- to create a nutrient budget for today's coastal system, which means quantifying land-sea connections and understanding the transport and transformation of nutrients once they have entered the coastal domain; and
- to understand and to measure the biological impact of excess nutrients upon important subsystems, especially on the resilience of inshore coral reefs.

Terrestrial inputs to coastal seas come from catchment conditions which range from nearly pristine to highly modified. Historically, most attention has been paid to factors affecting nutrient exports from the latter category. In order to produce a balanced picture, a major review was finalised of exports from pristine or semi-pristine systems in north and central Queensland. This summary showed that waters draining pristine rainforest and woodlands in north-eastern Australia have low to moderate exports of nitrogen and phosphorus except where there is significant discharge of groundwater.

These baseline estimates were used in scenario-modelling designed to inform the RWQPP. Project staff also produced benchmark estimates of suspended sediment logger records from the ends of six major rivers draining into the GBR, representing a range of catchment uses from cattle grazing to intensive agriculture and/or urban development in both high and low rainfall ares..

Research was undertaken into the transport and transformation of terrestrial materials once they reach the marine environment. Most of the terrestrial exports are deposited in a band within 20 km of the coast, confirming that run-off is mainly a problem for inshore areas of the GBRWHA. Estimates of nutrient burial rates (sequestration) in the sediments were made to determine whether this was a significant sink. In addition, the Marine Modelling Unit at JCU developed a depth-integrated hydrodynamic model covering the continental shelf from PNG to Fraser Island and simulated particle transports in the coastal zone using seven years of historical weather records. This model will play a central role in the final synthesis of inputs and biogeochemical processes to develop a GBR-wide budget for nutrients.

A comparison of the condition of inshore coral reefs near agricultural catchments in the Wet Tropics and relatively pristine ones on Cape York was undertaken with two years of intensive field work followed by experimental work in the laboratory to support the observations from the intensive field phase. This task produced six peer-reviewed scientific papers and two completed doctoral theses. The publications included comparisons of coral reef biodiversity in different coastal regions, the impacts of sediment upon coral recruitment, and the impacts of herbicide residues upon coral recruits and crustose coralline algae. In addition, a new method to assess causality in ecological studies was published in the international journal Ecological Applications.

Clear gradients in water quality were found within and between these two study regions. The diversity of soft corals and the abundance of four major families of hard coral decrease along these gradients, while the diversity of red algae and the abundance of green algae increase in the opposite direction. This evidence of potential impact prompted research to continue into the transport and transformation of land-based pollutants, especially the major nutrients (phosphorus, nitrogen) controlling plant growth, once they reach the marine environment.

Other achievements of this project were:

- Monitoring seven important and representative rivers draining into the Marine Park (continued under W1).
- Monitoring chlorophyll levels in the Park especially in coastal waters adjacent to developed catchments (continued under W1).
- Collaboration with Coastal CRC to assist its modelling work in Keppel Bay, and also with Queensland EPA and CSIRO Land & Water to validate a remote sensing project as part of a water quality initiative by the Douglas Shire.
- Collaboration with AIMS to review and assess the likely linkage between water quality and outbreaks of crown-of-thorns starfish on the GBR. The major finding was that higher loads of bio-available nutrients in flood plumes coming from rivers in the Wet Tropics Region (between Hinchinbrook Island and Cooktown) have the potential to enhance the survival of larval starfish, which may lead to more frequent starfish outbreaks.

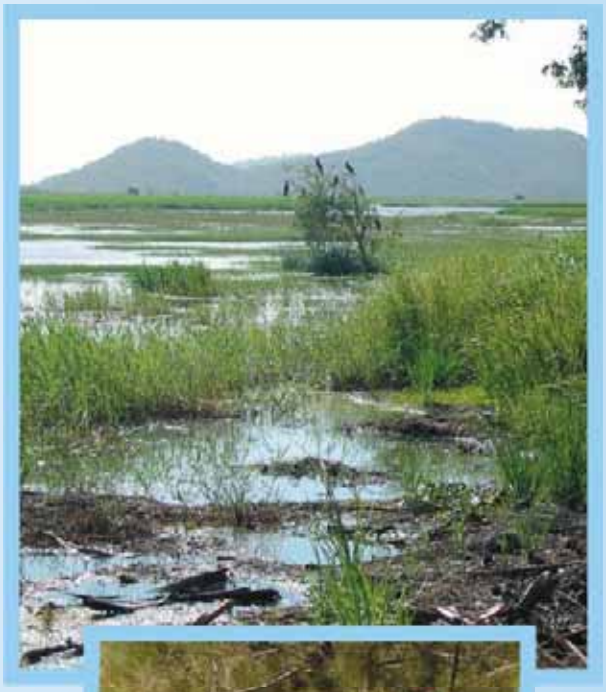
- Assessment of the incidence and cause of nuisance outbreaks of a benthic microalga affecting the amenity of major of offshore tourism sites. After initial high abundance blooms declined at all severely affected reef but sporadic blooms have been reported throughout the GBR. Warm temperatures, presence of viable cells, and suitable substrate (available especially after coral mortality due to bleaching or crown-of-thorns starfish impact) appear to be the drivers of successful colonisation of this nuisance alga, rather than elevated nutrient levels.
- A major review of the biological impacts of reduced coastal water quality ('*Effects of terrestrial runoff on the ecology of corals and coral reefs: review and synthesis*') was published in Marine Pollution Bulletin. Many related contributions were published in a subsequent special issue of the Bulletin that was dedicated to results from the conference held in 2004: "Catchment to Reef: Water Quality Issues in the Great Barrier Reef Region".
- Publication of the book "Catchments and corals: terrestrial runoff to the Great Barrier Reef" by the Australian Institute of Marine Science, Townsville.

Project C7: Catchment to Reef
Project Leader: Dr Richard Pearson, JCU

Task Leaders	AIMS - Dr Miles Furnas , Dr Katharina Fabricius
Task Associates	GBRMPA; Sunfish

Achievements, Outcomes and Utilisation

The Catchment to Reef Project aimed to develop new tools to assess and monitor the health of catchments and aquatic systems in the Wet Tropics and GBR World Heritage Areas. These tools should enable landholders and stakeholders to better understand and manage the effects of human activities on water quality and ecosystem health, and to connect changes in downstream receiving areas with changes in land use practices in terrestrial catchments. CRC Reef was responsible for two tasks: advanced technologies for monitoring coastal water quality, and new tools for measuring the health of benthic ecosystems.



Passive samplers suitable to detect trace concentrations of many pollutants have been further developed to suit deployment in marine tropical environments. The deployment of these samplers provided the first data on pesticide exposures around coral reefs. Ways to better use remote sensing to monitor water quality conditions within the naturally turbid waters of the GBRMP have also been tested. Once operational, the chlorophyll concentrations in large bodies of water will become measurable from space.

The project also aimed at developing and validating new tools to detect sub-lethal stress in key organisms living in nearshore habitats of the GBR in relation to changes in water quality. The research focused on microbes growing in biofilms on sediments (e.g. bacteria, algae, foraminifera) and on corals and seagrasses. An experimental facility was built to control and manipulate water quality settings. First potential indicators in biofilms and in corals have been tested along a water quality gradient in the Whitsundays, and in the laboratory. Experiments have shown that the saturation of colour increases when corals are moved from clear to turbid waters, indicating that coral pigmentation could provide a useful and rapid measure of changes in water quality on nearshore reefs. A field study to test the suitability of remote sensing to monitor and map sparse tropical intertidal seagrasses was also completed by UQ and CSIRO.

Funding

Project	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	Total
W1						$880,918	$1,846,768	**$2,727,686**
C2						$332,324	$438,137	**$770,461**
C7					$416,829	$486,872	$372,284	**$1,275,985**
Total					**$416,829**	**$1,700,114**	**$2,657,189**	**$4,774,132**

Publications

Technical Reports:

All CRC Reef Technical Reports are available online at:
http://www.reef.crc.org.au/publications/techreport/

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Abbreviations

AFMA = Australian Fisheries Management Authority
AIMS = Australian Institute of Marine Science
AMPTO = Association of Marine Park Tourism Operators
ANU = Australian National University
AQIS = Australian Quarantine Inspection Service
AusAID = Australian Agency for International Development
BOM = Bureau of Meteorology
CEO = Chief Executive Officer
COTS = crown-of-thorn starfish
CPA = Cairns Port Authority
CRC = Co-operative Research Centre
CRC Reef = Cooperative Research Centre for the Great Barrier Reef World Heritage Area
CRFFF = Coral Reef Fin Fish Fishery
CSIRO = Commonwealth Scientific and Industrial Research Organisation
DAFF = Department of Agriculture Fisheries and Forestry
DEH = Department of Environment and Heritage
DNR&M = Department of Natural Resources and Mines
DPI&F = Queensland Department of Primary Industries & Fisheries
ELF = Effects of Line Fishing
ELFSim = ELF Simulation model for Management Strategy Evaluations
FRDC = Fisheries Research & Development Corporation
FTE = Full-time Equivalent (staff)
GA = Geoscience Australia
GBR = Great Barrier Reef
GBRMP = Great Barrier Reef Marine Park
GBRMPA = Great Barrier Reef Marine Park Authority
GBRRF = Great Barrier Reef Research Foundation
GBRWHA = Great Barrier Reef World Heritage Area
GCRMN = Global Coral Reef Monitoring Network
GIS = Geographic Information System
ICC = Island Coordinating Council
IMPAC = International Marine Project Activities Centre
IPC = Intellectual Property Committee
IPCC = Inter-governmental Panel on Climate Change
ISI ESI = ISI Essential Science Indicators
IUCN = World Conservation Union
JAMBA = Japan - Australia Migratory Bird Agreeement.
JCU = James Cook University
LTMP = Long Term Monitoring Program
MMP = Marine Monitoring Program
MPA = Marine Protected Area
MTQ = Museum of Tropical Queensland
NOAA = National Oceanic and Atmospheric Administration, USA
NOO = National Oceans Office
NRM = Natural Resource Management
PCQ = Ports Corporation of Queensland
PNG = Papua New Guinea
PZJA = Protected Zone Joint Authority
PTT = Platform Transmitter Terminal
QEPA = Queensland Environmental Protection Agency
QM = Queensland Museum
QPWS = Queensland Parks and Wildlife Service
QSIA = Queensland Seafood Industry Association
RAP = Representative Areas Program
RWQPP = Reef Water Quality Protection Plan
SAC = Scientific Advisory Committee
SSI = Scuba Schools International
SST = Sea Surface Temperature
Sunfish = Sunfish Queensland Inc
TAC = Task Associate Program
TED = Trawl Excluder Device
TRC = Task Review Committee
TSPZ = Torres Strait Protected Zone
TSRA = Torres Strait Regional Authority
UNEP = United Nations Environment Programme
UQ = University of Queensland
WCPA = World Commission on Protected Areas

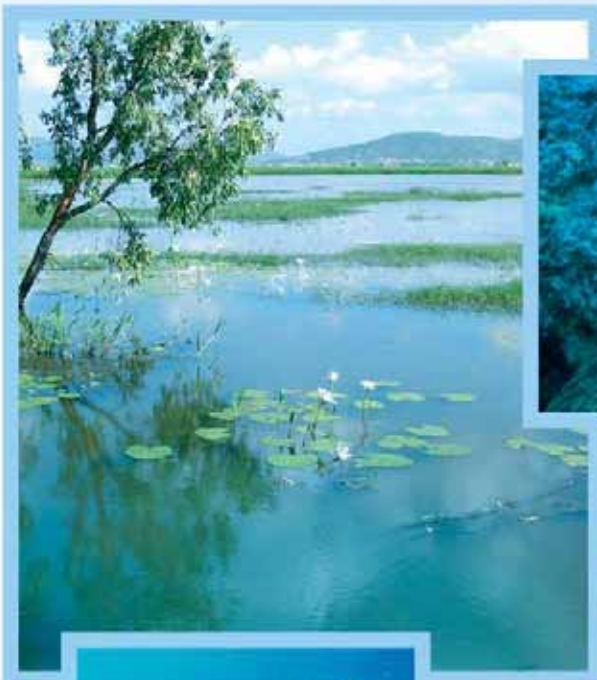
Appendix 1: Scholarship Students 1999-2006

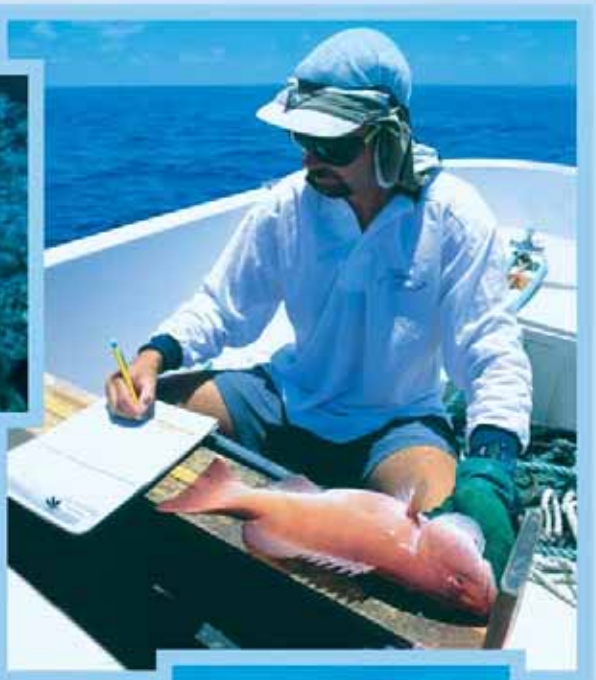
(incl completion dates where appropriate)

Name	Degree	Thesis Title
S Adams	PhD 3.10.03	The Reproductive biology of three species of *Plectropomus (Serranidae)* and responses to fishing.
K Anthony	PhD	The role of suspended sediments in coral energy budgets.
S Anthony	PhD	Physiological tolerances, growth limiting factors, and sources of stress for corals in a large-scale aquarium.
W Bailey	MEngSc	Numerical modeling of the sediment transport in the GBR region.
M Bergenius	PhD	Stock structure of common coral trout in the GBR.
B Breen	PhD 13.05.06	Spatial allocation of resource use in the Cairns Section of the GBRMP.
N Crosbie	PhD 05.05.00	Environmental and ecological controls on in situ population growth rates of Great Barrier reef phytoplankton
G De'ath	PhD 03.02.00	Modelling spatial and temporal change in benthic reef communities
E Dinsdale	PhD 14.05.05	Measuring the success of conservation strategies to protect scleractinian corals on the GBR.
M Dommisse	PhD 11.05.01	Detritus and its influences on water quality in the Great Barrier Reef: quality and quantity
J Eagle	PhD	Larval accumulation areas: a tool for predicting reef fish population dynamics and connectivity.
R Fisher	PhD 28.03.03	The behavioural capabilities of tropical reef fish larvae: implications for dispersal during the pelagic phase.
D Grover Withdrawn	MSc	The role of environmental factors in the distribution of breeding seabird populations in the GBRWHA.
J Harrington	PhD 08.04.05	Valuing a place; how do communities identify cultural heritage significance? A comparative study in two World Heritage areas.
A Heap	PhD	Sedimentology of the Whitsundays.
A Hodgson	PhD 09.04.05	Impacts of anthropogenic noise on dugongs and coastal dolphins.
J Kritzer	PhD 23.03.02	Spatial and temporal variation in the population dynamics and life history traits of the tropical snapper Lutjanus *carponotatus* on the GBR.
L Lambeck	MSc 21.04.01	Sphere of influence of northern rivers
A Lashko	PhD	Genetic diversity in the relationship between nesting and feeding aggregations of seabirds in the GBRWHA.

Name	Degree	Thesis Title
S Lewis	PhD 13.05.05	Climatic and Oceanographic change from high-resolution records in large fossil Porites coral heads, Magnetic Island, Queensland.
V Lukoschek	PhD	Conservation genetics of sea snakes (Hydrophiidae) in Australian waters, with emphasis on the GBRWHA.
R Marriott	PhD 07.10.05	An investigation into aspects of reproduction and regional variation in growth for populations of red bass, *Lutjanus bohar.*
N Marshall	PhD 13.05.06	Social resilience and resource-dependency in Queensland's commercial fishing industry
P Marshall	PhD 21.04.01	Physical impacts to corals: implications for community structure and management
K Michalek-Wagner	MEngSc	The chemical ecology of the soft coral *zooxanthellae* interaction
D Miller	PhD	Towards sustainable use of ecologically important natural resources by an economically important tourism industry in the GBRMP.
M Nursey-Bray	PhD	Conflict, co-operation or co-management: eating our words? Towards Indigenous hunting management in north Queensland.
D Oemcke	PhD 15.04.00	Modelling spatial and temporal change in benthic The treatment of ballast water discharges to ports in the Great Barrier Reef region
A Orpin	PhD 15.04.00	Fate of riverine sediment entering the GBR lagoon from the Burdekin Delta
R Pears	PhD 23.03.06	Comparative demography and life history features of cods and gropers: implications for fisheries and conservation management.
C Pocock	PhD 08.04.05	Management of cultural heritage values in the GBRWHA.
B Radford Withdrawn 2004	PhD	Effects of water quality on the distribution of corals on coastal reefs: development of tools for environmental assessment and risk management.
M Rasheed	PhD 15.04.00	Investigations of recovery and succession in North Queensland tropical seagrass communties
J Robertson	PhD	Ecological and economic implications of conservation management strategies intended to minimise the impacts of fishing on the GBR.
J Sheppard	PhD	Enhancing the ecological basis for conservation management of dugongs, using innovative satellite tracking technologies.
R Tobin (Partridge)	PhD	The perceived and actual differences in recreational line catch trends in estuaries open and closed to commercial gillnet fishing in north Queensland.
S Rotmann	PhD 13.05.05	Assessment of the use of coral tissue thickness as a monitor of reef health and performance.
D Welch	MSc 11.05.02	Development of techniques that minimise size selectivity for sampling populations of the common coral trout *Plectropomus leopardus* for age structure analysis.
A Williams	PhD 03.04.04	Population structure of *Lethrinus miniatus* on the GBR.

Notes:





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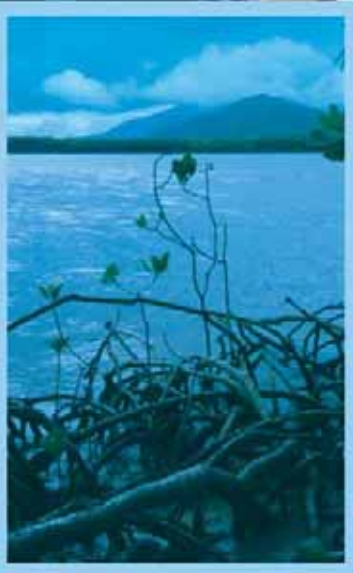

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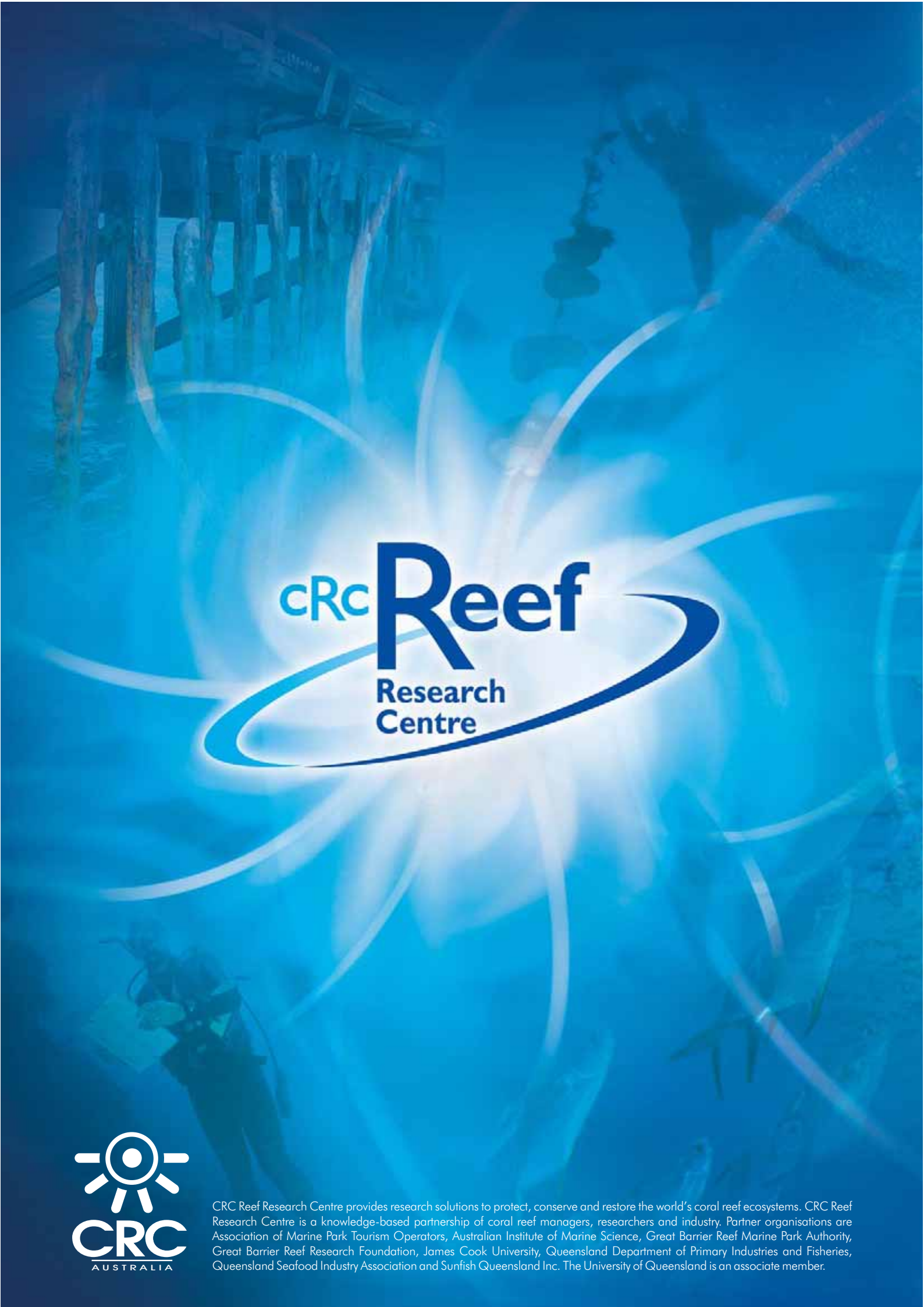

CRC AUSTRALIA

CRC Reef Research Centre provides research solutions to protect, conserve and restore the world's coral reef ecosystems. CRC Reef Research Centre is a knowledge-based partnership of coral reef managers, researchers and industry. Partner organisations are Association of Marine Park Tourism Operators, Australian Institute of Marine Science, Great Barrier Reef Marine Park Authority, Great Barrier Reef Research Foundation, James Cook University, Queensland Department of Primary Industries and Fisheries, Queensland Seafood Industry Association and Sunfish Queensland Inc. The University of Queensland is an associate member.