CRC REEF RESEARCH CENTRE TECHNICAL REPORT NO. 41

Making a difference.

Achievements of the Coooperative Research Centre for the Ecologically Sustainable Development of the Great Barrier Reef. 1993-2000.

Compiled by Vicki J. Harriott

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The CRC Reef Research Centre was established and is supported under the Australian Government's Cooperative Research Centres Program. CRC Reef provides strategic information, education and training to enhance reef-based industry and management of the Great Barrier Reef World Heritage Area. 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 Industry
- Queensland Seafood Industry Association
- Sunfish Queensland Inc.

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FOREWORD

The CRC for the Ecologically Sustainable Development of the Great Barrier Reef (CRC Reef) was established in 1993 as an unincorporated group committed to promoting research in support of the ecologically sustainable development of the Great Barrier Reef. The CRC Program approved and supported the Centre's establishment and coral reef research entered a new phase on the Great Barrier Reef.

The concept for the Centre came from Graeme Kelleher (GBRMPA), Joe Baker (AIMS) and Ray Golding (JCU) who saw an opportunity for a 'northern' marine CRC. Much of the work to design, bid and establish the Centre was done by Don Kinsey, the CRC's Interim Director, with strong scientific support from Terry Done (AIMS), Helene Marsh (JCU) and Archie Johnson (JCU). From the outset, Kinsey ensured the Centre's programs were driven by the users of the research results. Chris Crossland became the Director soon after the Centre was established and led it successfully for five years, during which it established a solid scientific reputation.

With Sir Sydney Williams as the Chairman, and Don Kinsey, Chris Crossland and later, Simon Woodley, in leadership roles, the Centre produced a formidable volume of scientific information to support the sustainable use and conservation of the reef.

The partnership of industry, government and researchers has proved an effective way to focus research on users' priorities and increase adoption of the results once the research is completed.

Since 1999, the CRC Reef has been incorporated as the CRC Reef Research Centre and is continuing the work begun in 1993, building even stronger partnerships between science and the users of research results.

As Chairman of the CRC Reef Research Centre, I am pleased to endorse this summary of the results of the 'first' CRC Reef, which represents a major contribution to the world's knowledge of coral reef ecosystems, and to understanding how people can use coral reefs in a sustainable way, while protecting them for future generations.

Sir Sydney Schubert
Chairman
CRC Reef Research Centre

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INTRODUCTION

The Cooperative Research Centre for the Ecologically Sustainable Development of the Great Barrier Reef operated from 1993 to 1999. Following a successful bid for refunding, the final year of projects for the first CRC Reef were completed during 2000 under the new CRC Reef program. Over the seven-year period, the Centre spent $20 million on research over 110 research tasks. The Centre aimed to provide world-class research and education programs that were relevant to end-users, including industry and management agencies.

The present Cooperative Research Centre for the Great Barrier Reef World Heritage Area began in 1999 and is built on the strong foundations established by the first CRC Reef. It is timely to collate and assess the achievements of the first CRC Reef, at a time when returns from national investment in research and development are being examined more closely than ever before.

For this report, CRC Reef researchers were contacted for updated information about the outcomes from their CRC Reef work and for a list of resulting publications. About 80% of researchers provided information for this report. Publications for other researchers were derived from annual reports submitted throughout the period of research funding. Research achievements are presented by topic. There is a brief description of the major research findings and a list of publications resulting from the work.

This report includes a list of all research projects supported by CRC Reef between 1993 and 1999. It includes information about the investigator, their institution, and the duration of the research.

The report shows that CRC Reef has been outstandingly successful in doing research that is relevant to industry and management and, at the same time, producing many scientific publications. Research from postgraduate students has made a valuable contribution to CRC Reef achievements. The report also demonstrates the success of the integrated approach to applied research inherent in the strategies of the national Cooperative Research Centres Program.

I am sure this report will help improve access by industry and management agencies and researchers to the extensive work supported by CRC Reef.

Dr Vicki Harriott
Program Leader, Education and Communication
CRC Reef Research Centre
August 2001

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THE COOPERATIVE RESEARCH CENTRE FOR THE ECOLOGICALLY SUSTAINABLE DEVELOPMENT OF THE GREAT BARRIER REEF

The Cooperative Research Centre for the Ecologically Sustainable Development of the Great Barrier Reef (CRC Reef) was an unincorporated joint venture established in 1993 by an Agreement between the Centre Parties:

?? The Association of Marine Park Tourism Operators (AMPTO);
?? The Australian Institute of Marine Science (AIMS);
?? The Great Barrier Reef Marine Park Authority (GBRMPA);
?? James Cook University (JCU); and
?? The State of Queensland through its Department of Primary Industries.

The Centre objectives were to undertake an integrated program of applied research and development, training and extension aimed at enhancing the viability of, and expanding sustainable Reef-based industries and economic activity. The Centre placed a particular emphasis on tourism and providing an improved scientific basis for reef management and regulatory decision-making.

The CRC Reef was established under the Commonwealth Government's Cooperative Research Centres Program. The program was launched in 1990 to bring together researchers and research users from universities, the public sector and business. Cooperative Research Centres undertake long-term collaborative research and development ventures of a substantial quality and size that contribute to national objectives. The objectives of the program are:

?? to enhance the contribution of long-term scientific and technological research and innovation to Australia's sustainable economic and social development;
?? to enhance the transfer of research outputs into commercial or other outcomes of economic, environmental or social benefit to Australia;
?? to enhance the value to Australia of graduate researchers; and

?? to enhance collaboration among researchers, between researchers and industry or other users, and to improve the efficiency in the use of intellectual and other research resources.

One of the best measures of the success of the Cooperative Research Centre for the Ecologically Sustainable Development of the Great Barrier Reef was that it was successful in gaining a second round of funding as the Cooperative Research Centre for the Great Barrier Reef World Heritage Area, despite fierce competition from other new and continuing Centres. The strength of the support of the Centre partners for the goals of the program was crucial to the successful funding bid.

In this document, the research projects supported by CRC Reef between 1993 and 2000 are compiled for the first time (Table 1). Research expenditure and number of projects are collated by broad topics such as water quality, coral bleaching, sustainable fishing, etc. (Table 2). A brief summary of the major findings are presented for each topic, followed by a bibliography of research publications which were outputs of CRC Reef research tasks. An index is provided to improve access to information on specific topics. This report is intended to provide a resource to users of research on coral reefs, to support the goal of the CRC Program to enhance the transfer of research outcomes.

Table 1. PROJECT LIST, CHIEF INVESTIGATORS, INSTITUTIONS, YEAR FUNDING STARTED AND FINISHED

Task No.	Task Title	Chief Investigator	Start	Finish
Program 1				
1.1.1	Biological oceanography	Furnas (AIMS)	7/93	7/00
1.1.2	Long-term monitoring of the Great Barrier Reef	Sweatman (AIMS)	7/93	7/00
1.1.3	Cyclone hindcasting	Done (AIMS)	7/95	9/97
1.1.4	Long-term monitoring of sea temperature on the Great Barrier Reef	Berkelmans (GBRMPA)	10/95	7/00
1.2.1	Regional circulation modelling	Bode (JCU) / Burrage (AIMS)	1/94	7/97
1.2.2	Circulation and fish dispersal	Doherty (AIMS)	10/93	6/96
1.2.3	Guidelines for oceanographic research approaches and application	Wilkinson (AIMS)	7/94	8/95
1.3.1	Sediment accumulation / dynamics	Woolfe (JCU)	1/94	7/00
1.3.2	History of sediment accumulation	Brunskill (AIMS)	1/94	7/97
1.3.3	Biomarkers – corals and clams	Barnes (AIMS)	1/95	8/97
1.3.4	Response of fringing reefs along a gradient of riverine discharge: an examination of historic and contemporary processes	Blake (ANU)	1/94	12/95
1.3.5	Accumulation rates and depositional history of organochlorine pesticide residues in mangrove and coastal sediments.	Brunskill (AIMS)	8/95	6/99
1.3.6	Determining and distinguishing anthropogenic and natural mercury abundance	Walker (JCU)	7/95	6/97
1.3.7	Assessment of the spatial and temporal variability of terrestrial impacts on the Great Barrier Reef using coral fluorescent banding	Barnes (AIMS)	8/97	6/00
1.4.1	Coral reefs	Done (AIMS)	1/94	6/00
1.4.2	Seagrass beds	Coles (DPI)	1/94	6/00
1.4.3	Coral 'tumours'. Phase 1: evaluation	Kahn / Johnstone (Reef Biosearch)	5/94	11/94
1.4.4	Effects of experimentally enhanced nutrients on inshore seagress beds in the Great Barrier Reef region	Mellors (JCU)	7/94	12/97
1.4.5	Mangrove forests – oil effects	Duke (AIMS)	7/95	6/98

Task No.	Task Title	Chief Investigator	Start	Finish
1.4.6	Baseline survey of seagrass resources, Dunk Island to Cape Cleveland (spring 1996)	Coles (DPI)	9/96	8/97
1.4.7	Growth responses of macroalgae to different forms of nutrients from natural or anthropogenic sources	Klumpp / Schaffelke (AIMS)	2/97	8/98
1.5.1	Science modelling	Done (AIMS)	7/94	7/00
1.5.1/2	Impact of river plume on the Central Great Barrier Reef	Wolanski (AIMS)	9/95	9/97
1.5.1/3	Modelling the effects of sediment on corals	Stafford-Smith (AIMS)	5/96	6/97
1.5.2	Spatial systems to support planning for ecologically sustainable use of the Great Barrier Reef at regional scales	Lewis (JCU / AIMS)	1997	2000
1.5.3	Book on science for management of the Great Barrier Reef beyond 2000	Done (AIMS)	1997	1999
1.6.1	Fine-scale surveys of crown-of-thorns starfish in the Cairns Section of the Great Barrier Reef Marine Park	Engelhardt (GBRMPA)	7/94	6/00
1.6.2	Development of environmentally friendly techniques for the conduct of local-scale controls of crown-of-thorns starfish	Engelhardt (GBRMPA)	7/94	12/95
1.6.3	Background and event-associated variations in concentration of Dissolved Free Amino Acids (DFAA) in the Cairns Section	Ayukai (AIMS)	8/94	12/95
1.6.4	Crown-of-thorns starfish: public information and extension program	Engelhardt (GBRMPA)	7/94	6/00
1.6.6	Dynamics of potentially incipient crown-of-thorns starfish outbreaks in the Northern Great Barrier Reef	Stump (GBRMPA)	2/95	6/96
1.6.7	Development of cost-effective local crown-of-thorns starfish control strategies	Fisk (GBRMPA)	9/95	8/96
	Phase 2	Fisk (GBRMPA)	8/96	9/97
1.6.8	Genetic determination of sources of *Acanthaster planci* recruitment	Benzie (AIMS)	12/95	12/96
1.7.1	Irukandji research	Hore (Reef Biosearch)	12/97	6/98

Task No.	Task Title	Chief Investigator	Start	Finish
Program 2				
2.1.1	A review of environmental impact monitoring of pontoon installations	Mapstone (GBRMPA)	8/94	12/95
2.1.2	Review of visitor use patterns	Valentine (JCU)	10/93	12/94
2.1.3	An annotated bibliography of monitoring programs in the GBR Marine Park	Inglis / Yaman (JCU)	9/94	5/95
2.1.4	Development of preliminary social impact assessment guidelines	Valentine (JCU)	10/93	7/94
2.1.5/1	The effects of diving activities on reef benthos	Inglis / Rouphael (JCU)	2/94	3/97
2.1.5/2	Effects of anchors on benthos	Inglis / Marshall (JCU)	1/95	12/99
2.1.6	Spatial allocation of resource use	Marsh / Breen (JCU)	2/94	7/97
2.1.6/2	Decision Support System for reef visitors	Marsh / Breen (JCU)	8/94	3/98
2.1.7	Impact of pontoons on fish assemblages	Sweatman (JCU)	11/93	1/95
2.1.8	Socially and ecologically acceptable levels of use	Shafer / Inglis (JCU)	11/93	6/97
2.1.8/2	Socially and ecologically acceptable levels of use (phase 2)	Inglis (JCU)		
2.1.9	An evaluation of time-lapse video techniques to monitor site use in the Great Barrier Reef Marine Park	Abbott (JCU)	8/94	7/95
2.1.10	The effects of natural and human disturbance on seabirds in the Swains Reefs	O'Neill (QDE)	4/94	6/96
2.1.11	The feasibility of constructing coral-viewing platforms on underwater observatories by transplanting coral fragments	Inglis / White (JCU)	12/93	12/97
2.1.12	Socio-economic implications of the Bramble Reef re-opening	Innes (GBRMPA)	3/95	12/97
2.1.13	Investigation of mechanisms for allocation of reef sites and arrangements for commercial use in the GBRMP	Dinesen (GBRMPA)	10/95	6/96
2.1.14	Reefwatch monitoring	Inglis (JCU)	1/96	2/97
2.1.15	Local values and local usage of the Capricorn Section of the Great Barrier Reef Marine Park	Jennings (CQU)	7/96	12/96
2.1.16	Towards integrating social, cultural and economic concerns into management of the Great Barrier Reef	Fernandes (JCU)	11/96	6/00

Task No.	Task Title	Chief Investigator	Start	Finish
2.1.17	Socio-economic impacts	Young / Fenton (JCU)		
2.2.1	Analysis of Great Barrier Reef visitors: their attitudes, motivations, socio-demographic profiles and activity preferences	Pearce (JCU)	1 / 94	6 / 98
2.2.2	Towards ecotourism: developing quality tourism in the special interest tourism sector	Birtles (JCU)	1 / 94	12 / 97
2.2.3	Evaluation and design of Great Barrier Reef interpretation	Pearce (JCU)	7 / 95	6 / 00
2.3.1	Restoration of coral habitats: pilot study	Kaly (JCU)	1 / 94	6 / 94
2.3.2	Restoration ecology Phase 2	Kaly / Pratt (JCU)	8 / 94	9 / 97
2.4.1	Evaluation of methods for effective sampling of reef fish populations	Brown (DPI)	1 / 94	6 / 94
2.4.2	Reproductive strategies of the common coral trout on the Northern GBR	Samoilys (DPI)	9 / 93	6 / 97
2.4.3	Monitoring the replenishment of coral trout populations in the Cairns Section of the Great Barrier Reef	Doherty (AIMS)	9 / 93	6 / 96
2.4.4	Size and sex structure of coral trout populations on coral reefs closed and open to fishing in the Central Great Barrier Reef	Russ (JCU)	9 / 93	12 / 94
2.4.5	Use of otolith weight-for-age determination of fish populations	McPherson (DPI)	1 / 94	6 / 94
2.4.6	Design of experimental investigations of the effects of line and spear fishing in the Great Barrier Reef	Mapstone (GBRMPA)	3 / 94	10 / 94
2.4.7	Review of the information needs from recreational fishing and boating activities and design of sampling strategies to collect appropriate data	Mapstone (GBRMPA)	2 / 94	11 / 94
2.4.8	Zoning changes on fish: handline	Brown (DPI)	3 / 94	6 / 96
2.4.9	Effects of fishing phase 2	Mapstone (JCU)	5 / 94	12 / 94
2.4.10	Effects of fishing liaison and coordination	Mapstone (JCU)	7 / 94	6 / 00
2.4.11	Effects of line and spear fishing on the Great Barrier Reef: part 1 – establishment	Mapstone (JCU)	8 / 94	12 / 98
2.4.12	Effects of fishing experiment: part 2 – implementation	Mapstone (JCU)	9 / 94	6 / 00
2.4.12 / 1	Fleet dynamics and determinants of fishing efforts and catch in the reef line fishery of the Great Barrier Reef region	Mapstone / Davies (JCU)	9 / 95	7 / 00

Task No.	Task Title	Chief Investigator	Start	Finish
2.4.12/2	The use of experimental stock manipulations to compare stock assessment techniques and examine the effects of line fishing on reef fish stocks in the Great Barrier Reef	Mapstone/ Davies (JCU)	6/94	7/00
2.4.12/3	Visual surveys of experimental reef clusters	Williams (AIMS)/ Ayling	8/95	7/00
2.4.12/4	Use of age-structure data to measure effects of fishing, growth, mortality and recruitment of target and some non-target species of reef fish	Russ (JCU)/ Brown (DPI)	9/95	7/00
2.4.12/5	Assessment of size selectivity in samples of the common coral trout *Plectropomus leopardus* taken by line fishing for age-structure analysis	Welch/ Davies/ Mapstone (JCU)	6/95	7/00
2.4.12/6	Modelling and evaluation of management strategies	Smith (CSIRO Marine Research)/ Mapstone (JCU)	7/94	7/00
2.4.13	Spear-fishing on the Great Barrier Reef	Nakaya/ Mapstone/ Inglis (JCU)	6/94	3/97
2.4.14	Recreational boating – Townsville model	Higgs/ Mapstone (JCU)	1/95	12/97
2.4.15	Bramble Reef re-opening: fisheries dynamics	Mapstone/ Davis/ Higgs (JCU)	5/95	4/97
2.4.16	Fisheries management models: options and development	Robertson (GBRMPA)	4/95	6/00
2.4.17	Fisheries databases – QFMA	Mapstone/ Davis/ McKinlay (JCU)	5/95	6/00
2.4.18	Interview / liaison with industry: effects of fishing	Mapstone/ Jones (JCU)	5/95	6/00
2.4.19	Rezoning for effects of line fishing experiment	McGinnity (GBRMPA)	1/96	6/97
2.4.20	The economic management of multispecies fisheries and the commercial collection of aquarium fisheries on the Great Barrier Reef	Kung/ Mapstone (JCU)	6/97	1/99
2.5.1	Strategies to reduce the impact of gill-netting on dugongs in the GBR Region	Marsh (JCU)	1/96	7/98
2.5.2	The ecological impacts of visitors on seabird populations	Gyuris (JCU)	7/95	7/98
2.5.3	The survivorship of sea turtles after capture in trawls	Marsh/ Robins (JCU)	7/95	7/98
2.5.4	Impacts of humans on seabirds	Gyuris (JCU)	7/98	6/99

Task No.	Task Title	Chief Investigator	Start	Finish
Program 3				
3.1	Design waves and water levels in the Great Barrier Reef	Hardy (JCU)	1/94	6/00
3.2	The influence of groundwater and surface water discharges on the water quality of the Great Barrier Reef lagoon	Volker (JCU)	1/94	6/00
3.3	Engineering guidelines: design, construction and operation	Massel (AIMS)	1/94	6/00
3.4	Engineering design for the Great Barrier Reef	Johnston (JCU)	6/94	6/00
3.4.1	Great Barrier Reef shipping study – inner/outer route risk assessment	Johnstone (JCU)	11/93	6/94
3.4.2/1	Dynamic response of a tourist pontoon in a coral reef lagoon	Britton (JCU)	1/94	12/97
3.4.2/2	Ballast water discharge	Oemcke (JCU)	6/95	12/98
3.4.2/3	Investigation of load capacities of mooring anchoring systems	Greensill (JCU)	1/95	9/95
3.4.2/4	The hydrodynamics of a coral reef flat	McCorkell (JCU)	1/97	12/99
Program 4				
4.1	Diver awareness	Queensland Dive	5/94	6/00
4.3.1	Dive course materials	GBRMPA	10/94	3/95
4.3.2	Marine interpretive/ training matter	GBRMPA	1/95	6/95
4.3.3	HIT training course development	CRC Reef/TAFEs/Industry	7/96	12/97
Program 5				
5.2.1	Endangered species education program	West (QFITC)	11/97	3/98
5.2.2	Tourism industry training needs	MCT (Mackay)	9/96	6/97
5.5.1	The role of suspended sediment in coral energy budgets	Anthony (JCU)	2/95	3/98
5.5.2	Coral settlement patterns and the behaviour and ecology of coral larvae	Baird (JCU)	1/95	12/95
5.5.3	The chemical ecology of the soft coral / zooxanthellae interaction	Michalek-Wagner (JCU)	9/95	9/98

Task No.	Task Title	Chief Investigator	Start	Finish
5.5.4	Injury and regeneration in reef-crest corals	Hall (JCU)	9 / 95	12 / 96
5.5.5	Modelling spatial and temporal change in benthic reef communities	De'ath (JCU)	8 / 96	7 / 99
5.5.6	Spatial and temporal variation in the population dynamics and life history traits of the tropical snapper *Lutjanus carponotatus* on the Great Barrier Reef	Kritzer (JCU)	1 / 97	12 / 97
5.5.7	Effects of fishing and regional variation on the sexual structure of *Plectropomus leopardus* and *P. laevis* populations on the Great Barrier Reef	Adams (JCU)	3 / 97	3 / 00

Table 2. RESEARCH TASKS 1993 – 2000

Research Tasks which provided information about the listed topics within the Cooperative Research Centre for Ecologically Sustainable Development of the Great Barrier Reef, 1993-2000. Total expenditure on research during this period was $20,101,000.

Topic	Number of tasks[1]	Total funding 1993-2000 [1]	Research Task Numbers[2]
Coral bleaching and climate change	3	$826,000	1.1.2; 1.1.4; 5.5.3
Crown-of-thorns starfish	9	$1,852,000	1.1.2; 1.6.1; 1.6.2; 1.6.3; 1.6.4; 1.6.5; 1.6.6; 1.6.7; 1.6.8
Water quality / pollution	16	$2,295,000	1.1.1; 1.2.3; 1.3.3; 1.3.4; 1.3.5; 1.3.6; 1.3.7; 1.4.4; 1.4.5; 1.4.7; 1.5.1; 1.5.2; 1.5.3; 1.5.4; 1.5.3; 5.5.1
Conserving biodiversity / introduced species	9	$797,000	2.1.10; 2.3.1; 2.3.2; 2.5.1; 2.5.2; 2.5.3; 2.5.4; 3.4.2 / 2; 5.2.1
Sustainable fishing	30	$3,737,000	2.1.12; 2.1.17; 2.4.2; 2.4.3; 2.4.4; 2.4.5; 2.4.6; 2.4.7; 2.4.8; 2.4.9; 2.4.10; 2.4.11; 2.4.12; 2.4.12 / 1; 2.4.12 / 2; 2.4.12 / 3; 2.4.12 / 4; 2.4.12 / 5; 2.4.12 / 6; 2.4.13; 2.4.14; 2.4.15; 2.4.16; 2.4.17; 2.4.18; 2.4.19; 2.4.20; 2.4.21; 2.4.23; 5.5.6
Sustainable tourism	28	$4,475,000	2.1.1; 2.1.2; 2.1.4; 2.1.5 / 1; 2.1.5 / 2; 2.1.6; 2.1.6 / 2; 2.1.7; 2.1.7; 2.1.8 / 2; 2.1.9; 2.1.11; 2.1.13; 2.1.15; 2.2.1; 2.2.2; 2.2.3; 3.1; 3.2; 3.3; 3.4; 3.4.2 / 1; 3.4.2 / 3; 4.1; 4.3.1; 4.3.2; 4.3.3; 5.2.2
Oceanography and physical processes	14	$3,380,000	1.1.1; 1.1.3; 1.1.4; 1.2.1; 1.2.2; 1.2.3; 1.3.1; 1.3.2; 1.3.4; 1.5.1 / 2; 1.5.1 / 3; 1.5.2 / 4; 1.5.2; 3.4.2 / 4
Biological processes and monitoring	22	$4,447,000	1.1.2; 1.1.3; 1.1.4; 1.2.2; 1.3.3; 1.3.7; 1.4.1; 1.4.2; 1.4.3; 1.4.6; 1.4.7; 1.5.1; 1.5.1 / 3; 1.7.1; 2.1.3; 2.3.1; 2.3.2; 5.5.1; 5.5.2; 5.5.3; 5.5.4; 5.5.5
Marine park management research	7	$1,313,000	1.5.3; 2.1.6; 2.1.8; 2.1.15; 2.1.16; 2.1.17; 3.4.1

1 Where research tasks address more than one topic (e.g. coral bleaching and crown-of-thorns starfish, or water quality and oceanography), the projects are listed and expenditure included under each of the topics.

2 For detailed information on the title, chief investigator and duration of projects, refer to Table 1.

SIGNIFICANT ACHIEVEMENTS AND PUBLICATIONS

1. Coral Bleaching and Climate Change

Coral bleaching has become a significant public issue, nationally and internationally. There are major concerns about the possibility that humans are contributing to coral bleaching through global warming. There is also concern about the impact of coral bleaching on the future of the Great Barrier Reef. Understanding the potential for coral reefs to survive bleaching episodes, which may be more frequent and widespread in the future, requires a clear understanding of the capacity of corals to survive temperature changes.

Significant achievements and major findings

?? An aerial survey technique was used for the first time to document the extent and intensity of coral bleaching during the 1998 coral bleaching event on the Great Barrier Reef (GBR). This survey technique was an efficient and cost-efficient way of getting a GBR-wide overview of bleaching. Importantly, the information was available quickly and was used to satisfy an urgent public and political demand for an update on the bleaching event.

?? A novel approach was used to define time and temperature thresholds for coral bleaching. These time-temperature threshold curves indicate that considerable thermal adaptation has taken place in coral communities which correlate with latitude, but more specifically with local temperature regimes. These threshold curves are an important part of a current project which is providing a risk assessment of climate change impacts on the GBR. The threshold curves will also provide an automated early warning system for coral bleaching using the AIMS/GBRMPA network of automatic weather stations on the GBR.

?? An experimental investigation defined the upper thermal limits of three coral species on the inshore central GBR. The results confirm the precarious balance between tolerable and intolerable thermal conditions for some coral species. Bleaching thresholds for these species are 2-4°C higher than mean summer

temperatures and within 1°C of average daily temperatures for considerable periods each summer.

?? The broadscale long-term monitoring project by AIMS enhanced the capacity of the scientific community to make authoritative statements about the limited extent of coral mortality on the GBR following the severe global bleaching event of summer 1998.

?? The first detailed study of bleaching in soft corals provided new insights into photoprotective mechanisms and the role of specific secondary metabolites in protecting soft corals against bleaching. It showed that bleaching has the potential to disrupt the reproductive output of soft corals for up to two years after a bleaching disturbance. This work provides one of the first pieces of evidence for the longer-term effects of bleaching on reef communities.

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2. Crown-of-Thorns Starfish

Outbreaks of crown-of-thorns starfish *Acanthaster planci* have been a major issue on the Great Barrier Reef and other Indo-Pacific reefs for nearly 40 years. The outbreaks have generated great concern among the community and considerable debate among scientists. Despite 30 years of research effort on this complex research problem, and the commitment of millions of dollars on research over the last 15 years, the ultimate causes of the outbreaks are still not clear. However, there is now a much greater understanding of the biology of the starfish, the nature of the outbreaks and the pattern of recovery of the reefs.

Significant achievements and major findings

?? A system of intensive, fine-scale surveys, capable of locating populations of juvenile crown-of-thorns starfish, were developed and used on the Great Barrier Reef (GBR) between 1994 and 2000. The surveys aimed to detect crown-of-thorns starfish outbreaks in their earliest stages, and thus help with forward planning by the marine tourism industry. The surveys increased understanding of population dynamics of the crown-of-thorns starfish, particularly in the critical juvenile stages. An impending outbreak was detected in the Cairns area in 1994-95. For the first time, this outbreak was followed from its earliest stages through time. By 2001, populations of crown-of-thorns starfish in the Cairns area were almost gone and the first starfish populations were recorded in the Townsville and Whitsundays regions.

?? Researchers worked closely with the tourism industry to develop training for local controls of crown-of-thorns starfish populations and on developing the capacity to identify the early stages of starfish outbreaks. CRC Reef provided scientific support to the tourism industry in their requests for government funding to support local crown-of-thorns starfish controls.

?? The Long-Term Monitoring program regularly surveyed reefs along the length of the GBR using manta tow surveys and video transects. This provided a large-scale picture of the location and intensity of outbreaks of adult crown-of-thorns starfish. During the 1990s, crown-of-thorns starfish populations were initially recorded in the northern GBR and subsequently on reefs further south. This indicated that the pattern of this third outbreak was similar to that of the previous two outbreaks.

?? Patterns of genetic connectedness between populations of the crown-of-thorns starfish on the GBR were examined. The results indicated that the populations of crown-of-thorns starfish in the outbreak during the mid-1990s were derived from the same genetic source, and not from separate outbreaks. The outbreaking starfish in 1996 were also genetically similar to those from the 1980s indicating that the sources of both populations were similar.

?? Local control techniques for crown-of-thorns outbreaks were trialed in the Lizard Island region. Starfish regularly move into areas which have been previously cleared, so that effective local control of starfish populations requires ongoing effort over long periods. The relative merits of high and low intensity efforts were compared. Each situation requires close monitoring and continual evaluation of the most effective strategy.

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3. Water Quality and Pollution

Nutrients and sediment run-off in to the Great Barrier Reef World Heritage Area as a result of land use is estimated to have increased four-fold since European settlement. In addition, about 80% of wetlands adjacent to the reef have been drained or filled. These wetlands are a natural filter of run-off in to the GBRWHA.

The impact of land use and associated run-off on the GBRWHA are not yet clear but there is growing concern about changes to inshore marine communities caused by altered land use practices.

CRC Reef research has improved our understanding of water quality and pollution in the Great Barrier Reef World Heritage Area.

Significant achievements and major findings

?? Work by CRC Reef researchers has made a significant contribution to understanding nutrient flow near the coast and its implications for reef systems. Studies demonstrated differences in nutrient export between 'wet' and 'dry' catchments, and differences between rivers in the contribution of upper and lower catchments as nutrient sources. Data from these studies have been used by management agencies to set guidelines for catchment discharges.

?? The first comprehensive nitrogen and phosphorus budgets have been prepared for the central Great Barrier Reef. Estimates have been made of the significance of upwelling in contributing the nutrient inputs to the central Great Barrier Reef via the Coral Sea. Links have been established between water quality, nutrient inputs and phytoplankton community structure for the Great Barrier Reef.

?? Changes to river nutrient status in Queensland related to land use have been quantified, allowing system-scale estimates of the input of terrestrial sediment and nutrient from runoff to the Great Barrier Reef. These results have contributed greatly to the debate on water quality and its management in the GBRWHA.

?? A computer simulation model and risk assessment software have been developed to better quantify the influence of river plumes under current and future catchment management and water allocation regimes. Simulation of flood discharge shows the potential impacts of fresh water on near-shore coral communities. The simulations correlated with historical flood events revealed by analysis of coral skeletons.

?? Surveys of 1,500 sites on the Great Barrier Reef indicate considerable disturbance in the inshore reef communities of the wet tropical region that is exposed to elevated nutrient and sediment levels from adjacent land use. Abundance and richness of hard corals and octocorals (i.e. soft corals) are low. This appears to be due to a combination of bleaching, crown-of-thorns and reduced water quality. In contrast, there are few signs of disturbance on inshore reefs further north where inputs from human land use are low.

?? The number of coral recruits on these wet tropical inshore reefs is low compared with other regions investigated. This implies that the potential for recovery of these reefs is low.

?? Surveys showed that high water turbidity (which can be caused by flood plumes and sediment resuspension) is related to low octocoral biodiversity.

?? Experimental work by CRC Reef researchers has improved knowledge about the ways that terrestrial runoff might affect coral populations and reef status. In contrast to the widely accepted view, algae is unlikely to overgrow corals as a result of enhanced nutrients from runoff except where herbivores are naturally or anthropogenically scarce. The abundance of benthic algae is largely (but not completely) explained by herbivory.

?? Abundant macroalgae are not evidence for (or against) degradation of inshore reefs of GBR. On reefs with abundant herbivorous fish, a shift in the trophic balance of the reef may not be noticed because the fish will quickly eat the algae and mask an increase in algal growth rate. In contrast, high algal growth rates

will be visible where there are few herbivorous fishes such as areas subject to overfishing or GBR inshore reef flats (which usually have naturally low herbivore populations).

?? A manipulative study by CRC Reef assessed short-term and long-term effects of commonly transported oils and methods for their bioremediation or treatment in tropical Australian mangrove and salt marsh habitats. Longer-term effects were assessed from spill incidents which occurred around Australia over the last 30 years. Dispersion of spilled oil before it reaches mangroves is an important strategy to reduce the long-term impact of oil on mangrove habitats.

?? Experiments by CRC Reef researchers showed that oxygen helps the rapid degradation of oil. These studies have been used to improve guidelines and recommendations for the protection, clean-up, and restoration of oiled mangrove habitats around Australia and elsewhere. This research has helped the Australian petroleum industry determine the usefulness of chemical dispersants and the interdependence of plants and animals in mangrove habitats. Queensland port authorities are also better prepared to respond to possible crude oil spills near the coast.

?? Cadmium and mercury were found to be above background concentrations in nearshore sediments in parts of the Herbert and Burdekin River estuaries (Hinchinbrook Channel, Bowling Green Bay). This metal enhancement is probably related to 50 years of phosphatic fertiliser and organomercurial fungicide usage in Herbert River floodplain sugar cane agriculture, and gold mining activities between 1874 and 1920.

?? Organochlorine pesticide residues (DDT, dieldrin, etc, which are now banned from use) were found in sugar cane field soils and some wetlands of the Herbert and Burdekin River floodplains. However, these long-lived pesticides could not be detected in the estuarine sediments of Hinchinbrook Channel and Bowling Green Bay. These ecological poisons were probably lost to the atmosphere by volatilisation, or degraded by photochemical and microbiological reactions.

?? Relatively high concentrations of an unusual form of dioxin (usually considered to be a toxic anthropogenic contaminant) were found in coastal soils and sediments. Analysis of radiochemically dated sediment cores from Hinchinbrook Channel and Bowling Green Bay shows that this unusual dioxin is present in sediment deposited before 1800, which suggests that there must be a natural source of this dioxin.

?? The concentration of herbicides and pesticides in sediments and seagrass collected between Torres Strait and Moreton Bay were typically low. Contaminants were mainly detected in samples collected in subtidal muds along the high rainfall, tropical coast between Townsville and Port Douglas. Of the contaminants detected, diuron and dieldrin were found in concentrations that were high enough to present an environmental risk to local biota. Polychlorinated dibenzo-p-dioxins (PCDDs) were also detected in sediments from five GBR sites sampled for dioxins. These results were unexpected and provide evidence that an unidentified source for higher chlorinated dioxins exists along the Queensland coast.

?? Experiments by CRC Reef researchers found that exposure to herbicide concentrations present in nearshore Queensland sediments present a potential risk to seagrasses and, as a consequence, an indirect risk to dugongs. Tissue samples of liver and blubber were salvaged from fifty-three dugong (*Dugong dugon*) carcasses stranded along the Queensland coast between 1996-2000, and higher than normal concentrations of some pollutants were found. The contamination of the coast by pollutants will have important consequences for GBR dugong populations. The dioxins are likely to be bioaccumulated by the dugongs and the herbicides could impact nearshore seagrasses on which the dugongs feed.

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4. Conserving Biodiversity / Introduced Species

Marine species which have been introduced into Australian waters can become pests and threaten native biodiversity and commercial aquaculture industries. CRC Reef is committed to conserving biodiversity of the reef and protecting Australia from the threat of introduced marine species.

CRC Reef projects have also provided important information about endangered species conservation (dugongs and turtles), seabirds and inshore seagrass communities.

Significant achievements and major findings

?? An assessment of dugong populations has led to government strategies to reduce the impact of gillnetting on these animals. This includes the establishment of sixteen new Dugong Protection Areas and regional training courses for commercial fishers by the Queensland Seafood Industry Association.

?? Surveys of dugong feeding grounds in Hervey Bay before and after a major flood event showed a decline in seagrass abundance. These results have implications for dugong feeding and survival patterns.

?? CRC Reef researchers investigated the treatment of ballast water to reduce the transport of introduced marine species. Ultraviolet (UV) irradiation and filtration could potentially be used to treat ballast water, depending on the regulatory regime which is yet to be established. UV irradiation did not affect dinoflagellate cysts.

?? The conditions in ballast water tanks had a considerable impact on the treatment. Sediments affect the efficiency of ballast exchange because organisms will remain in the tanks during exchanges. Sediments and corrosion will affect the efficiency of oxidising biocides because they have a reductive effect on the disinfectants.

?? CRC Reef supported extensive surveys of benthic communities in both reef and inter-reefal areas. The results of these surveys in combination with the expertise of the researchers, provided valuable information about habitats which have been used in the Representative Areas Program run by Great Barrier Reef Marine Park Authority. The project aims to select all significant marine habitat types so they can be protected during rezoning of the marine park.

?? The Seagrass Watch project supported by QDPI researchers gained considerable community support. The project evaluates the health of seagrass communities along the Queensland coast.

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5. Sustainable Fishing

CRC Reef has committed a significant proportion of funding to research to enhance our understanding of the sustainability of fishing in the Great Barrier Reef. Research has stressed both biological information on target species, and assessment of fishers, including the dynamics of fishing fleets and socio-economic evaluation of fishing communities. This information is used in management of fisheries and the natural resources on which the fisheries rely.

Significant achievements and major findings

?? Extensive socio-financial data has been collected that thoroughly describes the commercial fishing industry in Queensland. For the first time, links have been made between areas of the marine resource that are fished; the profile of the people that fish there; and the social and financial networks that these people have with the local and broader community.

?? The data has been presented in a user-friendly way that allows both managers and industry to access the information. The data is presented as an interactive database on CD-ROM. This data is especially useful for managers, since it enables potential social impacts associated with changes in fisheries and marine policy to be assessed. The data allows proposed policy change scenarios to be tested in advance. This data is useful for both managers and industry in assessing the current status of commercial fishing in Queensland.

?? CRC Reef researchers are examining the effects of line fishing on a range of reef fish. The project is developing tools to evaluate and fine-tune management strategies for the line fishing industry before they are implemented.

?? The Effects of Line Fishing (ELF) experiment has successfully implemented one the largest manipulative experiments ever undertaken to address explicitly the dynamic impacts of fishing on target and non-target species.

?? CRC Reef and CSIRO researchers have developed a world-leading set of dynamic simulations that allow quantitative assessments of the strengths and weaknesses of harvest strategies and their potential to meet a range of stakeholder objectives. The models are spatially structured to capture the complexity of the Great Barrier Reef (GBR). They allow simulation of a complex array of population dynamics of target species, dynamics of fishing fleets, and range of spatial, temporal and harvest management strategies.

?? A range of stakeholders have been engaged in the development of research objectives. A key focus for the ELF research has been operational objectives for management of the line fishery, and terms of reference for management strategy evaluations.

?? CRC Reef researchers completed the first comprehensive descriptive analyses of the commercial reef line fishery, allowing more informed decisions about relevant performance indicators for management.

?? New information about the age, growth and reproductive biology of a range of harvested target and by-catch reef fish have been gathered and provided to management and industry stakeholders to assist with management of the reef line fishery, for example by setting appropriate size limits for harvest.

?? Comprehensive analyses of the social and motivational characteristics have been made of spear fishers on the GBR.

?? The social, economic and motivational characteristics of the marine aquarium fish fishers have been analysed for on the GBR.

?? The effects of the growing trade in live food fish on the operational dynamics and catch rates of the commercial reef line fishery has been documented.

?? CRC Reef researchers were appointed to the key management advisory committees for the reef line fishery (ReefMAC, QFMA) and fisheries in the GBR

Marine Park (Fisheries RAC, GBRMPA). These positions ensured significant transfer of information from research into policy forums.

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6. Sustainable Tourism

Tourism on the Great Barrier Reef contributes around two billion dollars to the Australian economy each year. CRC Reef research has been involved in assessing the needs of both tourists and the tourism industry to ensure the reef is protected and the industry is sustainable.

Significant achievements and major findings

?? The first comprehensive database about tourists to the Great Barrier Reef (GBR) was developed. It included their demographic and travel profiles; their motivations and expectations; and their satisfaction with existing operations. The resulting market profiles were used to develop promotional campaigns, adjust existing products and test new products.

?? Patterns of reef travel were examined, including repeat visitation. The research identified a trend for repeat reef visitors to move from larger to smaller boats. This has implications for future levels of reef use. The role played by commercial operations in providing access to the GBR for regional recreation was identified.

?? The researchers explored existing data and found trends in international ecotourism which suggested that the development of very small scale ecotourism ventures would not be a viable alternative to larger scale reef operations.

?? Factors that contribute to reef visitor satisfaction were identified, including the need for more and better quality interpretation; and more focus on reef and safety information for non-English speaking visitors.

?? The establishment of a baseline of visitor profiles, activity participation and destination choice is a valuable resource for longer-term studies of changing patterns of reef tourism.

?? Two interpretive products developed by GBRMPA were evaluated for use with reef tourists. Methods to improve these products were suggested.

?? Telephone surveys of Australian residents detailed public perceptions of the environmental status of the GBR; threats to its well being; and patterns of recreational and tourist use. The data provides a series of management performance indicators and a baseline to evaluate the effectiveness of educational and promotional campaigns run by GBRMPA or the reef tourism industry.

?? An understanding of recreational use of the GBR was identified as a major information need by both tourism industry and management stakeholders. Data was collected to address this need and is being used by GBRMPA in its Representative Areas Program.

?? The interactions between wildlife and tourists has been examined in a study that focusses on populations of dwarf minke whales. Researchers have worked closely with tourism operators to devise best-practice ways to allow satisfactory experiences for tourists without negative impacts on the whales. A range of interpretive material has been produced. Researchers have also collected biological information about minke whales and learnt about movement patterns and ecology of the species.

?? A Cyclone Wave Atlas and Pontoon Guidelines prepared by CRC Reef researchers will assist GBRMPA and the tourism industry to achieve world's best practice in optimising construction and mooring of offshore structures in the Great Barrier Reef World Heritage Area.

?? Studies of a new screw anchor mooring systems have assisted a Townsville marine company to install these eco-friendly anchor systems at popular spots within the Great Barrier Reef Marine Park.

?? Research on the environmental impacts of SCUBA divers on the Great Barrier Reef involved working collaboratively with the marine tourism industry to assist

social and ecological planning for tourism experiences. The results of the study have influenced Dive Queensland's scuba training programs and codes of practice used by dive operators, such as revised pre-dive briefings and instructor training programs.

?? Several island resorts have improved their recycled irrigation systems following the results of groundwater monitoring studies to track nutrients around their coastal gardens, lawns and golf courses.

?? The CRC Reef review of social impact assessment was a leading-edge publication which assisted managers and others develop a better appreciation of social impact assessment concepts and practices as they relate to the GBR.

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7. Oceanography, Geomorphology and Physical Processes

CRC Reef researchers have furthered our understanding of oceanography in the Great Barrier Reef and adjacent waters. This information will help biologists and managers to predict the movement of both organisms and pollutants in these waters. A knowledge of the most extreme ocean conditions that could be expected in reef waters is also vital to ensure that position and mooring of structures, such as tourism pontoons, are safe. A geological perspective on changes in the coastline and estuaries adjacent to the Great Barrier Reef enhances our understanding of the ways the humans have altered these environments.

Significant achievements and major findings

?? For about the last 6,000 years, sediments washed from the land into the Great Barrier Reef (GBR) lagoon have been retained close to the shoreline by the prevailing hydrodynamic regime of the GBR shelf. The sediments are stored in coastal depocentres north of the input, mostly in northward facing bays. There is no evidence for significant sedimentary deposits beyond the inner shelf (20 m depth contour) that are related to modern river discharge.

?? Three types of coastline have been delineated along the GBR shoreline: north-facing, low energy embayments favouring accumulation of sediments (to the exclusion of coral reefs); south-southeast facing, high-energy embayments where reefs can flourish despite high sedimentation rates because of good topographic relief enhancing regular flushing of the reef surface; and curvilinear north-south open coasts where coral reefs exist but lack significant topographic relief.

?? There is no documented threat to mid-shelf coral reefs from sedimentation associated with modern river input. River plumes which spread onto the middle GBR shelf contain relatively little sediment. Further, these coral reefs are unlikely to be under threat for many thousands of years because sediment supply to the coast is not a limiting factor in controlling turbidity or sediment accumulation at most coral reefs.

?? The lower reaches of many rivers on the GBR coast are estuarine and fringed by mangrove swamps. The sediment dynamics of these estuarine mangrove systems plays a primary role in controlling fluxes of sediment between the land and the sea. In some small systems, mud is trapped within the estuary during wet seasons, but sand is removed to the coastline by a strong ebb tide generated at 'overbank' spring tides. Other larger systems trap sand in the longer term because of their length. It is simplistic to view these coastal systems as conduits for sediment delivery into the GBR lagoon.

?? Many reefs of the GBR are in the nearshore zone, in highly turbid environments and associated with muddy sediments. These 'turbid-zone' coral reefs occur at these sites because sediments are in transit towards depocentres, and do not accumulate at the reefs for long enough to prevent coral growth. Such sites have probably been common throughout the 8,000-year duration of the GBR, probably as sites of coral reef formation and development.

?? For the past 6,000 years, sea levels have been high. The Whitsunday Islands and many other mid-shelf granitic island groups have been largely removed from the sedimentary system associated with the coastline. This is partly because of the along-shelf tidal currents, but also because of the along-shelf wind-driven current associated with the south-east trade winds. Sediment accumulation around some islands and in some of their inlets have probably been dominated by cyclones.

?? CRC Reef researchers have integrated data about the bathymetry of the GBR to give a better idea of its three-dimensional structure. The depths, volumes of water, slopes and roughness of the continental shelf, etc., was not previously available. Understanding that the GBR is, on average, only 34 metres deep leads to a greater appreciation of the fragility of this environment. Their research has produced a reference document that is useful for scientists and managers.

?? Three-dimensional models of the ocean floor are essential to scientists modelling current movements to try to understand connectivity between reefs in the GBR.

These models can now be used in navigation systems and will be potentially valuable to all mariners.

?? Wave information is needed on the GBR for engineering design and marine park management. A model capable of simulating tracks and central pressures of cyclones was used to generate an ensemble of 6,000 tropical cyclones representative of those in the GBR region. Wind speed and wave height models generated high-resolution information which is available from an Atlas of Waves on the GBR, stored on CD.

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8. Biological Processes / Monitoring

CRC Reef researchers have made significant contributions to a better understanding of the biology of many reef organisms. In particular, the ecology, distribution and classification of soft corals throughout the Indo-Pacific region is now much better known. Knowledge about the connectivity of species and populations is important to determine maximum distances and minimum sizes of an effective system of marine protected areas. An understanding of the interactions between corals and algae is important in evaluating whether reef communities will be damaged by the addition of nutrients and sediments into reef waters. The long-term monitoring program has provided a baseline of information on the status and health of the Great Barrier Reef against which natural and anthropogenic change can be measured.

CRC Reef researchers also increased knowledge about the coral bleaching and the crown-of-thorns starfish as listed in sections 1 and 2.

Significant achievements and major findings

?? Extensive surveys of 1,500 sites from all over the Great Barrier Reef (GBR) identified patterns of octocoral biodiversity. Diversity gradually decreases from north to south, with a biodiversity hot spot of soft corals on the mid-shelf on reefs between Cairns and Cooktown. The survey data contributed significantly to defining bioregions (biologically homogenous areas) within the Great Barrier Reef Marine Park.

?? The octocoral survey of the GBR also resulted in the production of the book *Soft Corals And Sea Fans*, the first guide to allow divers, reef researchers and aquarium owners to identify the soft corals and sea fans found on Indo-Pacific coral reefs.

?? The surveys revealed that cover of crustose coralline algae is low in areas of high sedimentation. These algae play an important role in the reef community, by triggering the settlement of coral recruits, and forming a protective layer over the reef substrate that may slow down erosion.

?? The genetic connectivity in the broadcast-spawning soft coral *Sinularia flexibilis* and a brooding soft coral species *Briareum* sp. is high along the length of the GBR. In another brooding species, *Clavularia* sp., populations are genetically more isolated, so it has less potential to recolonise an area after disturbance. Such knowledge of connectivity in a range of species and populations is important for determining maximum distances and minimum sizes of an effective system of marine protected areas.

?? The results of the study on growth responses of macroalgae to different forms of nutrients from natural or anthropogenic sources has improved our understanding of the mechanisms of nutrient utilisation that enable macroalgae to grow in abundance on GBR nearshore coral reefs. Inshore macroalgae (e.g. *Sargassum* spp.) acquire nutrients from three previously unrecognised sources which allow them to thrive in habitats with few inorganic nutrients available. Due to their high nutrient demand, these species are likely to be favoured by an increased nutrient supply caused by human activity. In contrast, macroalgae with a distribution on reefs across the shelf (e.g. turtle weed, *Chlorodesmis fastigiata*) were shown to be nutrient-sufficient in average inorganic water column nutrients and may not benefit from a higher nutrient availability.

?? Coral transplantation may be required to enhance rehabilitation of damaged coral reefs. Techniques to effectively enhance coral survival following transplantation were examined. In particular, methods to attach corals to the substrate were evaluated, with attachment of coral pieces using quick-setting cement proving to be the most effective.

?? Surveys of benthic algal distributions and abundance and environmental parameters on >130 reefs and > 1,000 surveys of the GBR, covering latitudinal, cross-shelf, small spatial and seasonal variability provide the first large-scale, quantitative descriptions of reef marine plant distribution, abundance and seasonality.

?? The algal surveys provide baseline descriptions of distributions, against which human impacts may be more easily detected. There is evidence that benthic algae make a large and important contribution to coral reef biodiversity and have potential for predictive bioindicators of reef status. Data on algal distribution contributed in a major way to the GBRMPA Representative Areas bioregionalisation program.

?? Coral-algal competition is widespread but highly variable in both mechanism and outcome. That variability can be understood in terms of a limited number of mechanisms by which corals and algae can affect each other. Benthic algae will not always outcompete or even inhibit healthy adult corals, even in poor water conditions. Corals are often replaced by algae when they are subject to external disturbance and killed. Macroalgae may be a consequence, rather than a cause of coral decline; but may also contribute by inhibiting recovery.

?? CRC Reef contributed to two long-term data sets by supporting AIMS researchers. CRC Reef support enabled coral and fish monitoring projects established by Done and Williams in 1980 to be continued.

?? CRC Reef researchers quantified the variability in coral settlement and recruitment between zones of coral reefs. This information underpins coral recovery following disturbance.

?? CRC Reef supported AIMS' Long-Term Monitoring Project and enabled world-class statistical analysis of the data which was reflected in five high quality reports about status of the GBR.

?? Research about the responses of corals to physical damage has provided an insight into the factors that influence recovery rates in corals that are damaged by anchors or in storms. Some corals can regrow damaged parts extremely rapidly, but corals that break most easily are not necessarily those are most able to recover. An understanding of the life-history strategies of corals can provide the basis for ecologically-based strategies for managing human uses of the reef.

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9. Research for Marine Park Management

Accurate information is crucial to wise management of a natural resource. CRC Reef has provided information about the scientific, cultural, social and economic aspects of the Great Barrier Reef to assist management of this valuable resource.

Significant achievements and major findings

?? A CRC Reef project enabled social, cultural and economic concerns to be incorporated into natural resource management. The research revealed that stakeholders, including Great Barrier Reef Marine Park Authority (GBRMPA) staff, acknowledged that GBRMPA has multiple and conflicting objectives. The main objectives are: maintain or enhance cultural and natural values; maintain or enhance economic benefit and social amenity and values; optimise institutional functioning; meet legal and other obligations and political requirements. While their priorities differ, all representative bodies recognise that maintaining natural values are a high priority but that GBRMPA has other priorities. The transparency of decision-making in resource management could be improved by using a structured decision-support tool. Such a tool was developed in this task.

?? CRC Reef researchers made a major contribution to the Representative Areas Program developed by GBRMPA, ensuring that examples of major habitat types are protected within the marine park. They provided input about natural fluctuation of reef biota, seagrass resources, decision support systems and socioeconomics.

?? Recommendations by CRC Reef researchers for diver interaction with whale sharks have been adopted by the Western Australian government.

?? A risk analysis undertaken by CRC Reef was used to modify shipping routes near the GBR.

?? CRC Reef researchers developed selection criteria and tools for use and protection of specific coral reefs based on values, risk and resilience.

?? Stakeholder perceptions of reef quality, crowding and patterns of use informed the Cairns Section Zoning Plan process.

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Abbreviations

AIMS – Australian Institute of Marine Science

CRC – Cooperative Research Centre

CQU – Central Queensland University

DPI – Department of Primary Industries

GBR – Great Barrier Reef

GBRMP- Great Barrier Reef Marine Park

GBRMPA- Great Barrier Reef Marine Park Authority

GBRWHA – Great Barrier Reef World Heritage Area

JCU – James Cook University

NOAA – National Oceanographic and Atmospheric Administration (USA)

QDPI – Queensland Department of Primary Industries

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