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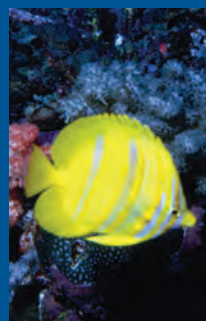


Commonwealth Environment Research Facilities

Marine and Tropical Sciences Research Facility



MTSRF Annual Report 2009-2010





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Great

Austra

North Queensland

Reef and Rainforest

Queensland

Girringun Aboriginal C

Central Queensland U

Australian Museum

Private Res

University of Alberta

Association

Griffith University

Reef Check

Powerlink

Consortium Partners

A word cloud shaped like a stylized map of Australia, featuring the names of various consortium partners. The text is arranged in a way that some names are larger and more prominent than others, reflecting their relative importance or size. The colors of the text range from dark blue to light yellow, matching the background colors of the map.

Sunfish
Queensland Health
Queensland Seafood Industry Association
Australian Centre for Tropical Freshwater Research
World Wildlife Fund
Australian Fisheries Management Authority
Charter Fishers
CSIRO
University of New South Wales
University of Melbourne
FNQ ROC
Biotropica
Fish Collectors
Commercial Fishers
Southern Cross University
Ports Corporation of Queensland
University of Queensland
Australian Defence Force Academy
Tourism Tropical North Queensland
Alliance for Sustainable Tourism
James Cook University
Additional Owners
Queensland Department of Natural Resources and Water
Great Barrier Reef Marine Park Authority
Australian Institute of Marine Science
Climate Alliance
Reef Water Quality Partnerships
Australian Maritime College
t Research Centre
Environmental Protection Agency
Department of Primary Industries and Fisheries
Corporation
Surf Lifesaving Australia
University
Torres Strait Regional Authority
Queensland Canegrowers Association
Wet Tropics Management Authority
n of Marine Park Tourism Operators
Great Barrier Reef Foundation
Island Councils
Department of Agriculture Forestry and Fishing
Queensland Department of Main Roads
Australian National University



Foreword

This report summarises the outcomes of the research of the Marine and Tropical Sciences Research Facility, funded through the Commonwealth Environment Research Facilities. Over four years the Marine and Tropical Sciences Research Facility has tackled some of the key challenges facing a unique part of Australia; the Great Barrier Reef, Cape York's tropical rainforests and the Torres Strait.

This report also highlights approaches to maintain the water quality and ecosystem services we all depend on for clean water and air, and fertile soil.

Australia's north-eastern coastal river catchments—from the forests to the reefs—are increasingly under threat from climate variation, species migration, coral decline and nutrient redistribution. It is crucial to maintain good water quality and manage coastal catchments for the long-term health of our communities and the iconic Great Barrier Reef.

The Marine and Tropical Sciences Research Facility, as part of a larger \$100 million Commonwealth commitment in environmental research, formed strong ongoing collaborations across Australia's research institutions. It shared world-class research and informed local communities on tropical reef ecosystems knowledge. It has, and will continue to inform government decisions on biodiversity, sustainable use of natural resources and ecologically sensitive tourism. It has also produced environmental monitoring and evaluation programs, which are valuable both locally and to the wider community.

The Department congratulates the Marine and Tropical Sciences Research Facility researchers, our co-investing partners and stakeholders, the program's administrator and the wider research community for supporting the work of this facility. We look forward to seeing this innovative research continue to provide a basis for better management of these natural resources in the coming years.



Ms Alex Rankin

First Assistant Secretary

Information Management Division

Department of Sustainability, Environment, Water, Population and Communities



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About the Marine and Tropical Sciences Research Facility (MTSRF)

The largest research portfolio currently managed by the RRRC, the \$A40 million MTSRF is part of the Australian Government's Commonwealth Environment Research Facilities program. This year ~300 scientists from 14 research organisations have been working on projects designed to solve specific management and policy problems faced by end users across at least 38 government, industry and community organisations.

Goals and research strategy

The vision of the MTSRF is to plan, fund and coordinate the highest quality, cross-disciplinary research for public good, to:

- ensure the protection, conservation, sustainable use and management of the environmental assets of the Great Barrier Reef and its catchments, tropical rainforests including the Wet Tropics World Heritage Area and the Torres Strait;
- foster an understanding of the interactions of north Queensland's natural environment with the social and economic aspects of north Queensland's communities;
- support the adoption of science-based knowledge in policies and practices for ecologically sustainable management; and
- facilitate capacity-building for sustainable environmental management and environmental management research, in partnership with the community, environmental managers, research institutions, industry and policy-makers.

The MTSRF's Research Investment Strategy¹ guides investment across five major themes:

- Status of the Ecosystems,
- Risks and Threats to the Ecosystems,
- Halting and Reversing the Decline of Water Quality,
- Sustainable Use and Management, and
- Enhancing Delivery.

Cooperation for better outcomes

Effective delivery and adoption of research results relies on a close link between research providers and the end users of the research. Engagement between providers and end users is essential through all stages of development of the MTSRF's research programs, from commencement when research problems are specified, during research activity in order to keep projects on track, and finally to facilitate end user uptake of research results such that management, policy, or practice is changed for the better. Without engagement, there would be a high risk that this considerable public investment in research would not lead to a more sustainable future for north Queensland. Engagement between researchers and end users has been built into the very structure of the MTSRF, through active membership by key research and end user groups in the MTSRF's internal Operations and Steering committees.

¹ <http://www.environment.gov.au/about/programs/cerf/publications/pubs/mtsrf-ris.pdf>

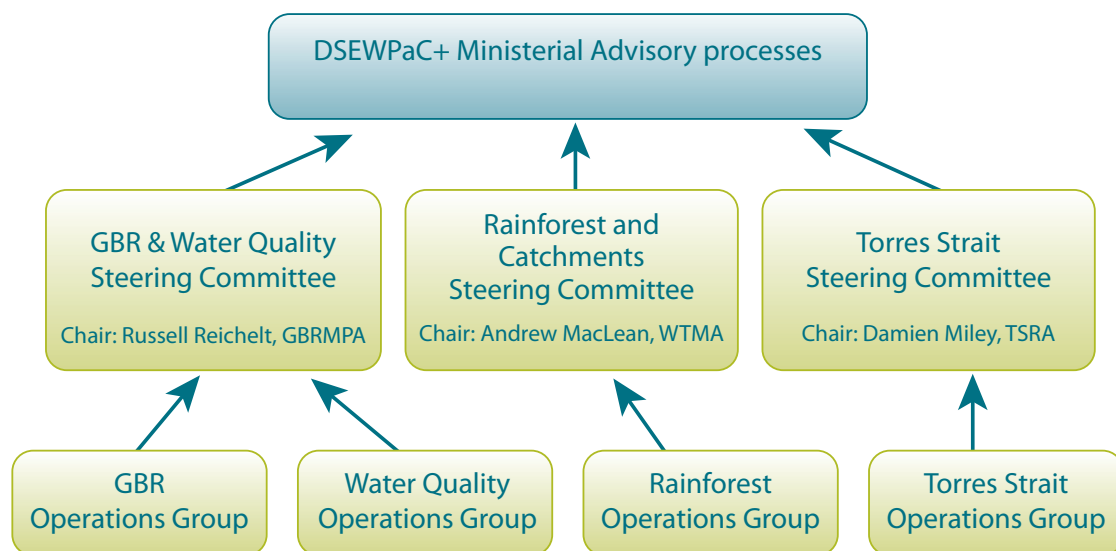


Figure 1. The MTSRF governance model including the relationship between Operations and Steering committees. Fundamental to the success of the model is the involvement of end users and research providers at all levels.

Annual Research Plan for 2009/10 (ARP4)

The MTSRF's fourth Annual Research Plan², covering financial year 2009/2010, was contracted in September 2009. The Plan covers all five themes in the MTSRF's Research Investment Strategy (Figure 2), supported by \$A7.6 million in MTSRF funds combined with cash and in-kind contributions from partners of a further \$A0.6 million and \$A10.6 million respectively. This represents \$A18.8 million of investment in the final ARP of the MTSRF's operation. Please see the financial summary on page 57 for more details.

² http://www.rrrc.org.au/publications/downloads/arp_2009_2010.pdf

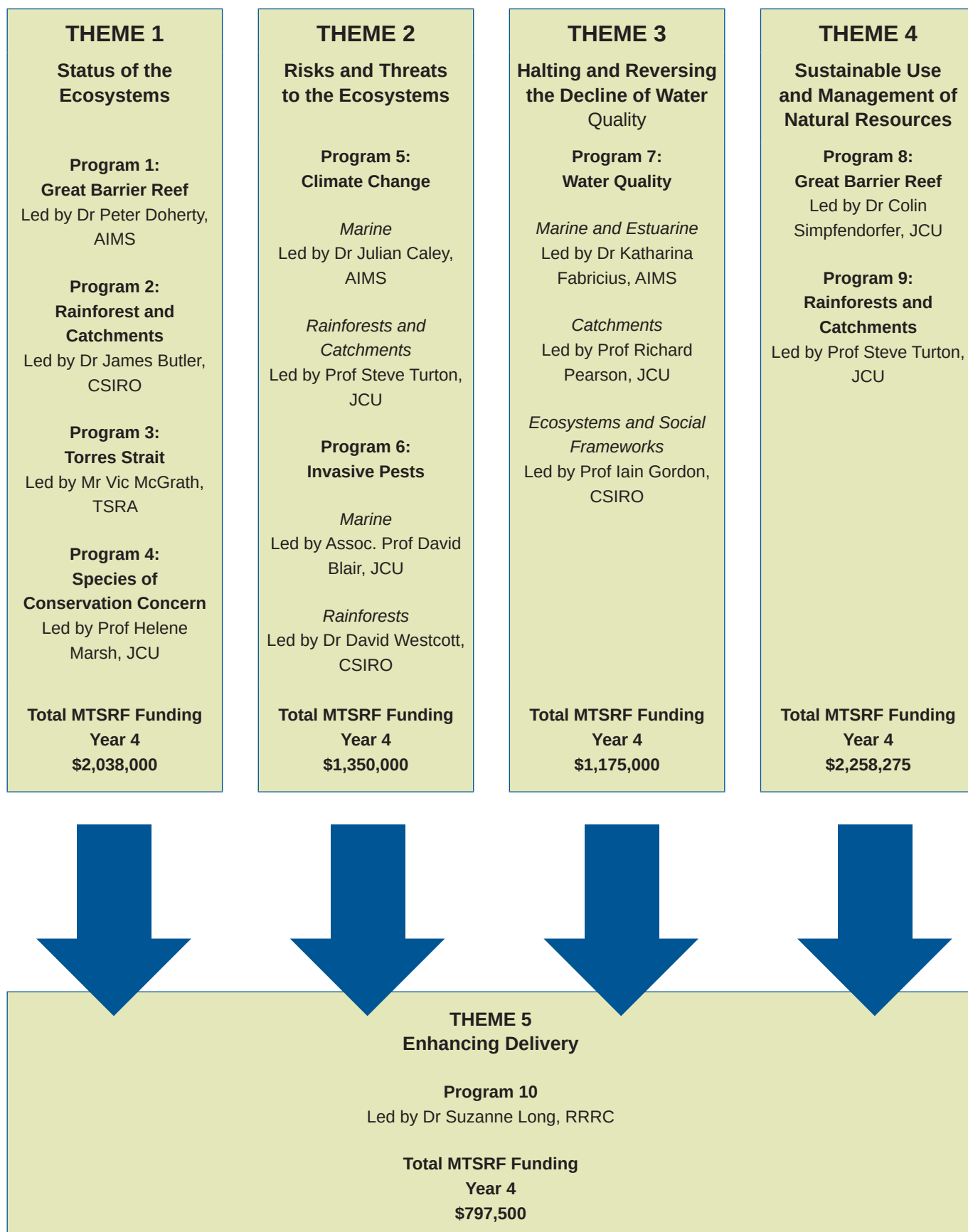


Figure 2. Outline of the MTSRF Research Program structure.

Major achievements for 2009/2010





Status of the Ecosystems (Theme 1 of the MTSRF)

This Theme contains research projects that aim to increase our understanding of the condition of and interdependencies between the environmental assets of north Queensland – the Great Barrier Reef and its catchments, the Wet Tropics rainforests and the Torres Strait. Spread across four major Programs, [Theme 1](#) projects seek to assist management by developing methods for effective long-term monitoring and reporting on trends in the condition of tropical environmental assets. Please see [Appendix 1](#) for the full list of research programs and projects conducted under this theme in 2009/2010. Some of this Theme's major achievements for this year are highlighted below.

Program 1: Status and Trends of Species and Ecosystems of the Great Barrier Reef

[This Program](#) is led by Dr Peter Doherty, who is the Research Director at the Australian Institute of Marine Science. Peter has many years experience in the field with a focus on research such as the ecology and genetics of coral reef fishes, emphasizing processes driving the connectivity, and replenishment and dynamics of their populations. Peter is a member of the Management Group sharing responsibility for transforming AIMS into Australia's Tropical Marine Research Agency and is also a member of other significant scientific collaborations such as the Antarctic Research Assessment Committee of which he is the chair.



Dr Peter Doherty, AIMS

Large-scale patterns in distribution of herbivorous fishes across the Great Barrier Reef ([Project 1.1.1](#))

Project leader: Dr Hugh Sweatman, AIMS

MTSRF funding has permitted analyses of an extremely detailed 17-year dataset compiled by the AIMS Long-term Monitoring Program, revealing meaningful patterns of richness and abundance of herbivorous fish species (parrotfish, surgeonfish and rabbitfish) in a standard habitat (the northwest reef face) on 93 reefs spread across the Great Barrier Reef. These patterns were observed both in terms of individual species and also in terms of functional groups of herbivores (scrapers, excavators, grazers/detritivores, algal grazers). Distinct cross-shelf patterns in total species richness were evident but these patterns were not consistent along the entire Great Barrier Reef: the highest total species richness in each shelf position was recorded in the Cooktown-Lizard Is sector, where total species richness varied little across the shelf, whereas in other sectors total species richness was generally least on the inner shelf reefs. Distinct cross-shelf patterns in total species abundance were evident but again, these patterns were not consistent for all sectors. Cross-shelf patterns in species richness and abundance varied among the functional groups of herbivorous fishes, but there was a consistent pattern in that each functional group was less abundant and less diverse on inshore reefs in the central Great Barrier Reef. There was also clear evidence of cross-shelf variation in the abundance and diversity of taxa performing certain functional ecological roles. This permitted the identification of shelf regions and sectors that appear to have low redundancy in functional



ecological roles, and therefore potentially reduced resilience to change, namely the inner-shelf reefs of the Cairns, Townsville and Whitsunday sectors. By contrast, this analysis indicated that the Cooktown-Lizard Island sector appeared to have the strongest sector-wide functional resilience, with maximal functional richness and highest Reef-wide values for functional redundancy, species richness and abundance of almost all functional groups.

Green zone gains for coral trout complicated by cyclone impacts and spawning behaviour ([Project 1.1.2](#))

Project Leader: Dr Hugh Sweatman, AIMS

Previous MTSRF-funded research by this project demonstrated spectacular increases in coral trout abundance inside green (no-take) zones compared with similar blue-zoned (fished) reefs. However, the results of this year's surveys were complicated by the impacts of Cyclone Hamish on survey sites on the central and southern Great Barrier Reef. This was particularly evident in the Swains and Capricorn-Bunker regions, where previously, coral trout were most abundant and the difference between fished (blue) and no-take (green) reefs was greatest. Thus, when viewed across all 28 matched pairs of reefs across five Reef regions, no consistent differences in relative numbers or relative biomass of coral trout were detectable six years after the rezoning. An additional complicating factor was the timing of the survey – reefs in the Swains and Capricorn-Bunker regions were surveyed in October and January, and there was evidence that the coral trout on some reefs were spawning. Spawning occurs around the new moon in summer months, and involves coral trout moving from their normal ranges and aggregating at particular sites on the reef, which may result in them being “missed” by standard sampling techniques.

Seagrass meadows in decline ([Project 1.1.3](#))

Project Leader: A/Prof Michelle Waycott, JCU

While the condition of seagrasses in the Great Barrier Reef region in general is currently considered to be fair, MTSRF-funded research into trends in condition indicate that the region's coastal seagrass meadows are declining. Reef-wide surveys show that 38% of sites exhibit shrinking meadow area, a large number of sites have ongoing trends of reduced seagrass abundance, and many sites have limited or no sexual reproduction (ie no seeds are being produced that would enable rapid recovery). There is evidence that light limitation is the primary driver of seagrass abundance at most sites, and that improved water quality (= increased light availability) would improve their status. While the declines observed at some sites will naturally reverse due to climatic fluctuation, others appear to be on a consistent trajectory towards decreased seagrass diversity and abundance. Increasing temperatures, sea-level rise and increasing frequency of disturbance regimes – projected to occur due to climate change – will add to the stressors on coastal seagrass meadows in the Great Barrier Reef region. While no single indicator of seagrass meadow condition appears sufficient to interpret causes of change, ongoing measurement of the following parameters is recommended:

- Long-term increases in seagrass tissue nutrient content (as integration of environment nutrient loads)
- Elemental ratios of tissue nutrients (indicative of the relationship between nutrient and light availability at that site)
- Plant morphology (alters as a result of light stress)
- Chlorophyll concentration (declines under heat and light stress)
- Variation in rate of production of sexual reproductive structures (decreases under stress).

The [Reef Rescue Marine Monitoring Program](#) (incorporating Seagrass-Watch) presently supports the ongoing collection of information on changing meadow size, seagrass abundance, morphology, nutrient and reproductive status, providing direct evidence of coastal meadow status and resilience for more than 20 seagrass meadows in the Great Barrier Reef.



Risk analysis and reporting for Great Barrier Reef seagrass meadows **([Project 1.1.3](#))**

Project Leaders: A/Prof Michelle Waycott, JCU, & Mr Len McKenzie, DEEDI

While most seagrass habitats in the remote Cape York region of the Great Barrier Reef are classified as low risk, almost two-thirds of coastal seagrass habitats along Queensland's urbanised coastline are at high or medium risk from multiple anthropogenic threats. Twelve 'hot spots' were identified as priority for conservation actions. Reducing the risk to coastal seagrass habitats in these 'hot spots' will require: (1) improving the quality of terrestrial water that enters the Great Barrier Reef lagoon; (2) mitigating the impacts of urban and port infrastructure development and dredging; and (3) addressing the hazards of shipping accidents and recreational boat damage. Risk analysis outputs include the development of a spatially-explicit predictive model of coastal seagrass distribution, estimation of risk to deepwater seagrass habitats from the Queensland East Coast Otter Trawl Fishery, and the estimation of the risk of coastal seagrass habitats from multiple anthropogenic threats. Community and agency monitoring of intertidal seagrass meadows (Seagrass-Watch) along the Queensland coast has established a dataset indicating that intertidal seagrasses have declined in abundance at more sites than expected during the last 10 years. Seagrass-Watch newsletters (magazines) containing updates on monitoring results were produced throughout the year and have been distributed to participants (also available for general public download via the [Seagrass-Watch website](#)).

New information about the likely impacts of climate change on seagrasses **([Project 1.1.3](#))**

Project Leader: A/Prof Michelle Waycott, JCU

Experiments demonstrated that seagrasses are strongly negatively affected by low light levels (which occur under conditions of poor water quality) and short-term spikes in water temperature to 43 °C (temperatures that have already been recorded occurring in the field). In addition, experiments investigating the interaction between light intensity and water temperature indicated that seagrasses experiencing low-light conditions - as occurs with poor water quality - will be more negatively impacted by high temperatures than those in high-light conditions. This is good news, because it indicates that improvements in water quality could reduce and delay some of the impacts of climate change on coastal seagrasses. Different seagrass species are likely to respond differently to climate change, leading to shifts in species composition of seagrass meadows. Interestingly, experiments showed that the northern Australian population of *Halodule uninervis* appears to exist well within its optimal temperature range, meaning that this species could continue to thrive in the Great Barrier Reef region and potentially even expand its southward range as mean sea temperatures increase. In contrast, *Zostera muelleri* currently exists near its upper thermal threshold, and a temperature hike of 3°C by 2100 is likely to result in the contraction of this species from the tropical Australian coastline. This could have ecologically significant ramifications, as *Z. muelleri* is often the only seagrass species able to inhabit muddy habitats.

Shifting baselines on the Great Barrier Reef: major changes in inshore coral communities since European settlement **([Project 1.1.4](#))**

Project Leader: Dr Jian-Xin Zhao, UQ

Using a novel uranium/thorium method that permits precise dating of the year of death from coral fragments, this study has shown for the first time that European modification of Queensland catchments corresponded with a shift in both the health and composition of inshore coral communities. The observed shift in community structure included the loss of previously dominant *Acropora* corals, and has been attributed to the synergistic impacts of increasing sediment runoff and climatic factors. Detailed results from over 40 sediment cores from Pandora and Havannah Reefs suggest that coral communities exist in stable states for extended periods (> 400 yrs) punctuated by periods of instability, and that once established, stable states persist for longer periods than unstable communities. Comparison of mortality frequency distribution patterns across sampling sites from the



central and southern Great Barrier Reef shows that there have been three common recent peaks in inshore coral mortality (despite local variability), likely correlating with the early phase of European settlement (1850-1890) and warm phases of the Pacific Decadal Oscillation (1930-1940 and 1980-2000). If borne out by further sampling, this implies the presence of large-scale common stressors or more likely 'triggers' driving coral mortality in inshore reef areas since European settlement. In a classic local example of the globally-recognised shifting baselines phenomenon, these results clearly indicate that management of inshore coral reef communities should not aim to maintain present-day condition. While achievement of a pre-disturbance condition for these reefs is probably not a useful management objective either, managers can use these results to make more informed decisions about condition targets for the inshore Great Barrier Reef.

Program 2: Status and Trends of Species and Ecosystems in the Wet Tropics Rainforests

Program 2 is led by Dr James Butler at CSIRO Ecosystem Sciences. James' current research interests involve social-ecological systems research, and the utility of adaptive co-management, social-ecological networks and payments for ecosystem services as tools for internalising externalities, mitigating conflict and evaluating trade-offs in sustainable livelihoods, particularly with regard to community adaptation and transformation strategies in response to climate and global change.



Dr James Butler, CSIRO

Ongoing development of the Interactive Key to Australian Rainforest Plants (Project 1.2.1a)

Project Leader: Prof Darren Crayn, ATH

Having previously developed the comprehensive Interactive Key to Australian Rainforest Plants, a world first for a Wet Tropical rainforest, this project focused this year on training informed members of the Wet Tropics community in plant identification skills (including weed and orchid identification) and the use of the Interactive Key to Australian Rainforest Plants. A draft of the Introduction to the Rainforest Key training materials has been reviewed by the workshop development team, and improvements to the layout and content have been made. The final draft of the Introduction to the Rainforest Key module is complete, and will be presented with the beta-test version of the Rainforest Key when it becomes available. Preparation of the Advanced use of the Rainforest Key and Weed Identification modules is well advanced. Workshops are planned for delivery in Cairns, Mareeba, Atherton, Paluma and Townsville. Additionally, Commonwealth funding (Environment Research Facilities Project Transition Funding) has been received to deliver these workshops 'On Country' to Wet Tropics rangers as part of their Natural Resource Management Cultural and Land Management training programs including Queensland Parks and Wildlife Service Rangers and 'Working On Country/Indigenous Protected Area rangers from Mandingalbay Yidinyi, Girringun Aboriginal Corporation, Jabalbina Aboriginal Organisation and the Central Wet Tropics Institute for Country and Culture Aboriginal Corporation...These four organisations represent all 18 Traditional Owner groups in the Wet Tropics bioregion.



Biodiversity monitoring for climate change ([Project 1.2.1b](#))

Project Leader: Prof Steve Williams, JCU

The extensive field data collection funded through this project has included:

- Microclimate data collected from a region-wide network of 25 weather stations for the period 2006-2010. These data are being used to develop more realistic estimates of microclimate exposure for the region, and to identify cool landscape refugia and major microhabitat features that buffer exposure to extreme temperatures.
- The addition of another 917 standard surveys and approximately 55,000 individual records to the vertebrate fauna dataset. These data have been used to evaluate vulnerability or resilience of species to extinction, evaluate the biodiversity values of climate change refugia, and improve niche models.
- Invertebrate data has contributed to status and trends of insect diversity (MTSRF Project 1.2.1d) and has provided the foundations for several PhD projects. We also identify key data sets that will be useful for the detecting change in the status of species in the future.

Surveys of rainforest birds in Cape York and central Queensland ([Project 1.2.1b](#))

Project Leader: Prof Steve Williams, JCU

MTSRF-funded researchers have substantially extended the baseline dataset on rainforest bird diversity and abundance in the Australian Wet Tropics, to include almost the full altitudinal and latitudinal gradient of rainforests in northeastern Australia. Eight separate expeditions surveyed sites from sea level up to the highest peaks in the McIlwraith and Iron Ranges (Cape York), and in the Clarke and Conway Ranges (central Queensland), making 4483 individual records of 163 species. Preliminary analyses indicate that this surveying effort has been sufficient to capture a snapshot of the patterns of diversity and abundance of rainforest bird fauna across the altitudinal gradient of both regions. These data are an invaluable baseline that will enable analysis of the influence of climate, and climate change, on rainforest bird community structure, and will contribute to DSEWPaC's implementation of the EPBC Act.

A prototype Wet Tropics report card ([Project 1.2.1c](#))

Project Leader: Dr James Butler, CSIRO

MTSRF-funded researchers from CSIRO have worked closely with the Wet Tropics Management Authority and Terrain NRM to develop a prototype report card for the status and trends of biodiversity, soils and landscapes in the Wet Tropics. Preliminary estimates of the present status and condition of these environmental assets were made based on expert opinion and long term datasets, enabling priorities for natural resource management actions to be further identified both at the catchment and subregional scale. Despite considerable advances towards conservation of natural resources over the past few decades, these results show that the Wet Tropics region is still under pressure, and policy responses to date have been insufficient to halt a general decline in condition. Analysis of the condition indicators for biodiversity suggests that the overall score for the region is 'good', though it is clear that fragmentation of native vegetation, weeds and feral animals remain problematic. Urban sprawl and intensification of use of previously cleared land are putting increasing pressure on natural and semi-natural areas, particularly in the Mulgrave catchment. The report card is a response to the need for long-term, consistent assessment of status and trends in the Wet Tropics, and it should inform the policies, plans and activities of a wide range of organisations, both public and private. This is the first step towards long-term, ecologically meaningful reporting and monitoring of the status and trends of the Wet Tropics region's natural assets.



Increased understanding of beetle abundance and biodiversity patterns in the Wet Tropics ([Project 1.2.1d](#))

Project Leader: Prof Nigel Stork, UniMelb

Beetles are highly speciose and play important ecological roles. Increasing our understanding of variations in their abundance and diversity across the Wet Tropics is important in estimating the resilience of these ecosystems to environmental change, including climate change. While flight intercept trap data indicate that beetle abundance generally increases with altitude in the Wet Tropics (probably driven by increases in abundance of beetle taxa associated with leaf litter), abundance within six beetle families examined to species level showed the opposite trend (ie, abundance of these species decreased with altitude). Ordination of species-level data for these six families suggests that the lower-altitude fauna is just as distinct as the upland fauna. While many of the more abundant species have significant modal altitudes, most of them appear to have at least a natural range of at least 900 m (equivalent to 4.5°C natural temperature range if we assume that the temperature changes by 0.5°C every 100 m in altitude). These data have contributed significantly to other MTSRF projects and at least 17 research publications to date.

Program 3: Torres Strait – Status, Use and Trends

[This Program](#) is led by Mr Vic McGrath, TSRA. Vic is the Community Liaison Officer which is co-funded by MTSRF and the TSRA, and based at the TSRA offices on Thursday Island. Vic's involvement and support for MTSRF research projects in the region continues to ensure appropriate communication with Torres Strait Island communities and also to maintain partnerships and knowledge transfer with supporting agencies in the region. Vic is also accomplished artist and is a scrimshawer and carver of pearl shells, dugong bone and turtle shell. McGrath's shell objects were featured in the 2001 Brisbane exhibition "Gatherings, Contemporary Aboriginal and Torres Strait Islander Art from Queensland, Australia".



Vic McGrath, TSRA

Traditional knowledge facilitating climate change adaptation in the Torres Strait ([Project 1.3.1](#))

Project Leaders: A/Prof Kevin Parnell and Dr Karen McNamara, JCU

Torres Strait Islanders are experiencing inundation events, high tides, less predictable winds and currents, increase in disease vectors, loss of cultural sites, and reduced fresh water supplies. MTSRF-funded researchers have been working closely with Elders and Aunties on Erub Island to document traditional knowledge systems and their capacity to facilitate present-day climate change adaptation. Traditional ecological knowledge emerges through Islanders' ongoing and direct interaction with the land- and seascape, and while it has been established and refined through generations, it is still continually being built upon. Elders were largely concerned with observed deviations from expected seasonal patterns in winds and tides, and the increasing challenges these environmental deviations pose for *Ailan Kastom* (Island Custom). Loss to or changes in personal and cultural identity were also reported as a consequence of changes in climate and land- and seascape. Researchers have now drafted a report on how the Torres Strait traditional knowledge and information systems are constructed (*Different Way of Knowing*). This process should help to safeguard the invaluable traditional knowledge supplied by community Elders of the Torres Strait, and allows culturally appropriate adaptation methods to be identified and developed.

Continuing research support for the Kailag sponge farm in the Torres Strait: aspects of sponge ecology and life history ([Project 1.3.2](#))

Project Leader: Dr Chris Battershill, AIMS

Following on from decades of research through a number of agencies, including the MTSRF, a commercial sponge farm was established in early 2009 at Masig Island, growing *Coscinoderma* sponges for harvest. Further studies of the natural distribution and abundance patterns of the farmed sponge *C. matthewsi* in the vicinity of Masig Island suggest that previously recommended seed stock guidelines would support the harvest of at least 700 donor sponges per year. This would mean that Kailag's current farming operation could be sustained by the existing sponge population. Investigations of the reproductive and larval ecology of *C. matthewsi* revealed that the species is viviparous, releasing tufted parenchymella larvae during daylight hours over an extended period in the summer (December 2009). Larvae swam at the surface for 18-24 h, and settlement to the substrate was enhanced on established biofilms, with 80% of larvae settled after 42 h. Coupled



with Torres Strait's strong current profiles, these behavioural observations suggest that this species is capable of broad-scale distribution through larval dispersal. Genetic analyses support a high degree of connectivity between *C. matthewsi* populations from central and eastern Torres Strait reefs, indicating that any farming-related translocation between these areas would be low-risk for wild populations. While post-settlement mortality and growth rates are yet to be investigated, artificial larval production and selective settlement onto farming structures could potentially be a more efficient way to stock the sponge farm than the present method of harvesting wild sponges. The Torres Strait Regional Authority provided additional funding to conduct a series of experiments into the effects of a range of collection and handling methods on *C. matthewsi* explants, with the aim of optimizing explant survival and growth and streamlining sponge farm operations.

Continuing research support for the Kailag sponge farm in the Torres Strait: interactions with hawksbill turtles ([Project 1.3.2a](#))

Project Leader: Dr Mark Hamann, JCU

Surveys were conducted in August 2009 in response to concerns about possible interactions between foraging hawksbill turtles and the Kailag sponge farm on Masig Island. Relatively small numbers of hawksbills were observed on the reefs around the Island, and while stomach samples revealed that the turtles were feeding on siliceous sponges, no evidence was found suggesting the turtles ate the non-siliceous *Coscinoderma* spp. It was concluded that it is unlikely that there will be any significant interaction between hawksbills and the sponge farm, although repeated future surveys are recommended to detect any increases in turtle numbers or potential diet-switching behaviour to more easily available sponge species.

Bilateral framework to support the sustainable management of marine turtles and dugongs in the Western Province, Papua New Guinea ([Project 1.3.3a](#))

Project Leaders: David Roe, STF, & Sheriden Morris, RRRC

Development of an effective Sea Turtle and Dugong Awareness Program for the northern Torres Strait and Western Province of Papua New Guinea (PNG) requires an extensive participatory consultation process. The MTSRF funded a workshop held at the New Century Hotel, Daru on 10 June 2010 which brought together representatives from the 13 Treaty villages in Western Province, as well as PNG representatives from the PNG Department of Environment and Conservation (PNG DEC), the PNG Fisheries Department, the PNG Treaty Chairman, the PNG Border Liaison Officer, and the Department of the Environment, Water, Heritage and the Arts (DEWHA), the Department of Foreign Affairs and Trade (DFAT), Sea Turtle Foundation and the Reef and Rainforest Research Centre. The findings from this development workshop are being used to help ensure that communities learn about sea turtle and dugong conservation, traditional values, sustainable harvest practices, and are engaged in conservation activities.

Monitoring and communicating marine ecosystem health in the Torres Strait ([Project 1.3.5](#))

Project Leader: Dr James Butler, CSIRO

Currently there is no formal marine ecosystem health (MEH) monitoring or reporting system in the Torres Strait. This MTSRF-funded project addresses the need to involve Torres Strait Islander communities in the dissemination and collection of ecosystem management and research information, and to establish an integrated system of MEH reporting which is of relevance to agencies and communities. Expert workshops in 2007 and 2008 had previously developed a list of 21 potential indicators of MEH in the Torres Strait. This year, we reviewed the data available for each indicator, finding that only four had established biological thresholds of concern (tropical rock lobster, tiger and endeavour prawns and sandfish), and there was high data confidence and scientific and management knowledge for only 27% of marine fishery species. We derived a standardised method of classifying the condition of indicators as 'healthy', 'unhealthy' and 'vulnerable' based on trends where known



thresholds of concern did not exist. Data utility was complicated by the inconsistent temporal and spatial nature of its availability. Examples of regional-scale report card formats were developed, using heat maps for trends and spider diagrams for current status. A prototype MEH Index was also developed, which showed that for 9 indicators with available data MEH was 'moderate' in 2009. The usefulness of single-species fact sheets in communicating MEH with local communities was trialled through consultations on Warraber and Darnley Islands. Communities responded that their favoured media for receiving information was fact sheets and DVDs or videos. Communities also expressed their desire to be involved in MEH monitoring and reporting, but only if the schemes were of direct benefit to them, for example through fisheries co-management schemes. Communities also listed indicators of MEH which would be relevant to their livelihoods, most of which were also identified in the original list of 21. Researchers proposed a nested framework for linked community and regional monitoring and reporting of MEH, integrating regional scientific knowledge with local and traditional knowledge, to be coordinated by the Torres Strait Regional Authority.

Program 4: Species and Communities of Conservation Concern

This Program is led by Prof Helene Marsh, JCU. Helene is currently Dean of Graduate Research Studies and Professor of Environmental Science at JCU. The focus of her research has been dugong population ecology with an emphasis on life history, reproductive ecology, population dynamics, diet, distribution, abundance and movements. The policy outcomes of her research include significant contributions to the science base for the Dugong Sanctuary established in Torres Strait; dugong management in the Great Barrier Reef Marine Park, especially the Dugong Protected Areas and no-take areas to protect dugongs in various zoning plans; and the establishment of a Commonwealth Ministerial Taskforce to Investigate the Sustainability of Indigenous Hunting of Dugongs and Turtles.



Prof Helene Marsh, JCU

Vulnerability of sea turtles to climate change ([Project 1.4.1](#))

Project Leader: Dr Mark Hamann, JCU

A vulnerability assessment framework was developed and used to assess the cumulative impact of various climatic processes on the nesting grounds used by the northern Great Barrier Reef (nGBR) and Torres Strait green turtle population. The variables from this framework were manipulated to investigate how mitigating different climatic processes individually or simultaneously influenced the vulnerability of the nesting grounds. The results indicate that nesting grounds closer to the equator - such as Bramble Cay and Milman Island - are the most vulnerable to climate change. In the short-term (by 2030), sea level rise will cause the most impact on the nesting grounds used by the nGBR green turtle population. However, in the longer term (by 2070), sand temperatures will reach levels above the upper thermal threshold for egg development, and cause relatively more impact on the nGBR green turtle population. Thus, in the long term, a reduction of impacts from sea-level rise may not be sufficient, as rookeries will start to experience increasing susceptibility to increased temperature. Therefore, reducing the threats from increased temperature may provide a greater long-term return on conservation investment than mitigating the impacts from other climatic processes. These results indicate that mitigation of the impacts of increased temperature on rookeries will reduce the vulnerability of almost all nGBR and Torres Strait rookeries from high to low.



Geomorphological studies at Raine Island ([Project 1.4.1](#))

Project Leader: Dr Mark Hamann, JCU

Raine Island, in the northern Great Barrier Reef Marine Park, is the world's largest remaining green turtle rookery. However, declines in numbers of nesting turtles have been observed. In response to concerns that this could be related to apparent changes in the island's beach morphology, this MTSRF-funded project reconstructed a 40-year shoreline history using both historical data and modern 3D terrain modeling. Over this time period swale-width has decreased at a linear rate of ~ 0.30 m/yr to the northeast, accreting at a rate of 0.54 m/yr to the southwest. The most accurate estimates of volumetric change over the past 9 years are a net sediment budget gain of $\sim 45,200$ m³, predominantly (55%) to the north and northwest, while over the past 40 years, net sediment gain ($\sim 14,000$ m³) has been reduced by episodes of erosion to the northeast, southeast and west. Southwest Raine Island has experienced the bulk of net sand accumulation (~ 40 m³). In effect, the island appears to be undergoing both a slow change in shape and a slow east-to-west migration. Significant episodes of accretion and erosion to the west appear to coincide with periods of strong El Niño and La Niña respectively. This study has provided a useful initial stage in modelling shoreline behaviour, response to climate change, and potential ecological vulnerabilities and management implications at Raine Island.

Participatory monitoring of turtle ecology and nesting success in the Torres Strait ([Project 1.4.1](#))

Project Leader: Dr Mark Hamann, JCU

Nesting beach studies undertaken by the Queensland Government indicate that the northern Great Barrier Reef turtle population is showing early warning signs of decline. Torres Strait islanders are one of the major stakeholders in the management of these populations, because of their strong cultural associations and links with turtles. To both improve scientific understanding such that it can inform management initiatives, and also to raise awareness among Torres Strait islanders about turtles and their research and monitoring, MTSRF-funded researchers involved Islanders from several communities in the collection of marine turtle population demographic data, and trained local people about turtle monitoring techniques. The data showed that shallow water reef flats are important habitats for juvenile green and hawksbill turtles; recruitment of juvenile turtles into the Torres Strait is low ($\sim 2\%$); green turtle fibropapilloma is an emerging issue; and that there are migratory links between turtle populations in the northern Great Barrier Reef and Torres Strait. Researchers also investigated Islanders' thoughts and aspirations regarding marine turtle management. They considered community-based management processes to be important, especially the application of cultural norms to achieve compliance and enforcement within the community, and consensus-based decision-making with regard to the use of more formal management rules. The need for cooperation with other communities and stakeholders across scales was also recognised, particularly with regard to enforcement. The outcomes suggest that co-management will be a more appropriate approach than either community-based management or ecosystem-based management for green turtles in the Torres Strait.

Robust and cost-effective indicators of the status of dugong populations ([Project 1.4.2](#))

Project Leader: Prof Helene Marsh, JCU

Dugong abundance and distribution in the GBRWHA have been systematically monitored by JCU using aerial surveys since the mid-1980s. The dugong population estimates from aerial surveys have not varied significantly over time in the remote Cape York region. However, aerial surveys along the urban coast documented a distinct decline in the dugong population between 1986 and 1994. The results of the 1999 survey of the urban coast showed that dugong abundance returned to their pre-1992 levels, probably due to a combination of factors including dugong movements between surveys. This MTSRF-funded project has sought to overcome these potential problems through the development of a series of robust and cost-effective indicators of the status of dugongs in the Great Barrier Reef World Heritage Area (GBRWHA), by:

- developing a time-series of spatially explicit dugong population models and assessing their value as an indicator of change in dugong distribution and relative risk;
- critically evaluating the strengths and weaknesses of the various dugong monitoring tools (dugong aerial surveys, dugong aerial surveys using unmanned aerial vehicles, spatial models and risk assessments, broad scale seagrass surveys and seagrass watch, Catch Per Unit Effort data, and Queensland Marine Strandings Database) to provide information on the status of dugongs and their habitats; and
- identifying appropriate dugong performance indicators for the GBRWHA at an expert workshop.

The major outcome of the technical workshop was the recognition of the applicability and validity of all of the monitoring tools. Furthermore, it was acknowledged that there is not a 'one size fits all' monitoring solution; a combination of all the dugong monitoring tools are required to effectively inform management in the remote Cape York region and urban coast. A report card for dugongs – linked to water quality and seagrass report cards - would provide an integrated assessment of the performance of management actions in the GBRWHA by taking into consideration the outputs of multiple monitoring tools.

Effects of fragmentation and associated threats to native wildlife in a spatial and temporal context (Project 1.4.3)

Project Leader: Dr Dan Metcalfe, CSIRO

This MTSRF-funded project has been primarily focused on how fragmentation of lowland communities impacts on native species and ecosystem processes, and what an understanding of these processes can tell us about longer-term declines in more extensive areas of native vegetation. An analysis of the distribution of rain forest Regional Ecosystems (REs; Queensland Government Environmental Protection Agency, 2005) in the target area (i.e. Tully, Murray and Johnstone Rivers occurring below 100 m asl) identified 46 separate types, of which 22 appeared to be lacking any full vascular plant surveys from the Bioregion. Survey methodologies were agreed with Queensland Herbarium, with whom survey and collection data were shared. The first year of work filled many of these data gaps, and so provided a baseline dataset for the coastal lowlands from which an appropriate fragmented community could be selected. The selected study RE was scheduled as an endangered habitat (mesophyll vine forest on moderately to poorly-drained alluvial plains, of moderate fertility; Regional Ecosystem 7.3.10a) and fragments of the RE were common in the target area. Twenty such fragments were surveyed, and contextualized in terms of size, age and distance from continuous native vegetation. For the community and context surveyed, time since isolation and size had no effect, but that isolation distance impacted significantly on species composition of the fragments. This suggests that seed dispersers are less willing to cross larger distances to more isolated fragments. In terms of regeneration trajectory, more isolated fragments were more similar in species composition than fragments closer to extensive forest, when sapling recruits were considered. Again, disperser preferences and handling abilities may be restricting the species composition of recruits able to reach the more isolated fragments. From a functional perspective, we also considered the services provided by species in fragments, and analyses suggested that in fragments close to extensive tracts of forest there is a gradual homogenization of community traits, as early successional species are recruited out of the extensive forest and come to dominate the fragment communities. However, weeds were not driving this trend, as weeds make little contribution to functional diversity, as they tend to convey the same traits as native species. Together, these data suggest that all fragments are at risk of declining value in terms of biodiversity and ecosystem services, with remote fragments losing rare species and becoming dominated by a small group of well-dispersed species, and less remote fragments being swamped with early successional species at the risk of rarer species. These results have been reported to managers via the Wet Tropics Building Restoration Knowledge workshop and are the subject of a manuscript in preparation.

Risks and Threats to the Ecosystems (Theme 2 of the MTSRF)

Research projects within [Theme 2](#) are increasing our understanding of the processes threatening the ecosystems comprising north Queensland's key environmental assets. These research projects aim to improve the long-term sustainability of these assets by using science to develop options for mitigating and managing risks and threats. Please see [Appendix 1](#) for the full list of research projects conducted under this theme in 2009/2010. Some of this Theme's major achievements for this year are highlighted below.

Program 5i: Climate Change – Understanding the Threat, Ecosystem Impacts and Mitigation for the Great Barrier Reef

[This Program](#) is led by Dr Julian Caley, Principal Research Scientist at the Australian Institute of Marine Science. Julian studies population and community ecology, macroecology, and evolutionary biology using many different model organisms. Most of Julian's recent work has concentrated on the ecology and evolutionary biology of reef fishes, while maintaining active research interests focused on other taxa. In general, his research explores ecological and contemporary evolutionary processes that generate and maintain biodiversity and how this knowledge can be used for effective conservation and resource management.



Dr Julian Caley, AIMS

Development of a whole-of-Reef 3D hydrodynamic model ([Project 2.5i.1](#))

Project Leader: Dr Andreas Schiller, CSIRO

Hydrodynamic models simulate the advection and mixing of water, processes fundamental in controlling the fate and impact of freshwater, sediment, nutrients and pesticides delivered from catchments into the receiving waters of the Great Barrier Reef lagoon. A robust and validated 3-dimensional hydrodynamic model is seen as a necessary precursor to the development of water quality and ecological response models that can be applied generically in catchments, estuaries and the lagoon. This MTSRF-funded project has developed a hydrodynamic model of the entire Great Barrier Reef that includes all of the important factors affecting currents, mixing, temperature and salinity within the lagoon and exchanges with the adjacent Coral Sea. A pilot 4-km resolution regional model has been established, including river inflows for a number of real-time gauged rivers, and is running in near-real-time. Inter-comparison between observed and predicted tidal sea levels, which drive the general circulation, are a powerful verification of a model's performance, and the general agreement of both magnitude and phasing of tidal water level fluctuations at coastal stations throughout the Great Barrier Reef gives confidence in the accuracy of the model's simulation of a dominant hydrodynamic process. Qualitative assessment of a pilot 2009 wet season hindcast of this model indicates general agreement in extent and timing of the predicted surface fresh water plume and the remotely sensed plume distribution. Predicted and observed sub-surface salinities also show good agreement. A pilot 1-km resolution model is currently undergoing preliminary evaluation for computational performance.



Implications of mixotrophy for coral health ([Project 2.5i.2](#))

Project Leader: Prof Ove Hoegh-Guldberg, UQ

Although photosynthetic rates and bleaching status are typically used as indicators to describe the “health” of corals, corals can also obtain organic carbon heterotrophically, through capture of plankton, ingestion of suspended particulate matter and uptake of dissolved organic matter. This MTSRF-funded study investigated the relationship between rates of photosynthesis, heterotrophy and growth in *Acropora millepora* colonies on reefs at Heron (southern Great Barrier Reef) and Lizard (northern Great Barrier Reef) islands. Coral colonies were monitored for two years, during which period maximum mean monthly maximum sea surface temperatures were breached during both summers (but by less than the NOAA Bleach Watch trigger of 1°C). Lizard Island colonies proved to be highly susceptible to whole-colony mortality, with a loss of 2 of 5 colonies monitored, while Heron Island colonies proved to be more robust, with no whole-colony mortality observed in monitored colonies. Greater rates of linear extension (growth) were observed in winter in the Heron Island colonies, than in summer in Lizard Island colonies. Interestingly, this occurred despite the fact that Heron Island colonies had relatively high levels of heterotrophy over winter. In summary, during the two years of this study, Heron Island colonies appeared to maintain their weight (as measured by areal lipid concentration) and growth (positive linear extension) despite a potential reliance on heterotrophy, while Lizard Island colonies appeared to struggle despite high rates of photosynthesis. Greater appreciation and understanding of the mixotrophic lifestyle of corals is needed to generate a more complete picture of coral health.

Heritability and genetics of thermal tolerance in corals ([Project 2.5i.2](#))

Project Leader: Dr Madeleine van Oppen, AIMS

The adaptive potential of corals is complicated by the complex evolutionary dynamics of two or more interacting genomes – that of the coral host and that of its symbiont(s). This MTSRF-funded project used the proportion of the variance in thermal tolerance that has a genetic basis (ie heritability) as an empirical proxy for adaptive potential in the coral *Acropora millepora*. High heritabilities were found for functional key traits of algal symbionts, which along with their short clonal generation time and high population sizes, could allow for rapid thermal adaptation. However, the low overall heritability of the four coral host traits investigated, along with corals’ relatively long generation time (≥4 yrs for fast growing, early maturing species such as acroporids or pocilloporids, ~20 yrs for the majority of corals), raise concern about the capacity for timely adaptation of the coral-algal symbiosis in the face of continued rapid climate warming (although further investigation of other important host traits may reveal significant heritability adaptive potential). However, there are at least two other theoretical and so far untested ways in which the coral-algal symbiosis could adapt more quickly to increasing temperatures. As most corals also reproduce asexually through fragmentation or other means, there is the potential for asexual propagation of somatic mutations within a sexual generation; in other words, it may be possible for adaptation to higher temperatures to occur via somatic mutation within the time period of a coral sexual generation. Additionally, new somatic mutations arising within symbiotic algal cells could be selected upon and, if beneficial, the new mutant could theoretically displace most of the original genotype(s) within the coral colony.

Diversity of naturally-occurring coral symbionts on the Great Barrier Reef ([Project 2.5i.2](#))

Project Leader: Dr Ove Hoegh-Guldberg, UQ

Relatively little is known about the characteristics of coral symbionts (*Symbiodinium* spp.), despite their important role in the complex responses displayed by corals to environmental disturbances, such as high sea temperatures. This MTSRF-funded project has compiled one of the most extensive *Symbiodinium* genetic datasets in existence worldwide. Five different *Symbiodinium* clades (A, B, C, D and G) were identified in 3082 samples from 65 locations on the Great Barrier Reef. The majority of samples (97%) contained clade C *Symbiodinium*, and ~90% of the sampled hosts contained a single detectable symbiont type rather than a mixture. Some patterns in distribution of different clades and host taxa are detectable – for example, a higher association of host species with clades



C1 and D in the warmer Northern sector of the Great Barrier Reef – but the picture remains relatively incomplete at present, with sampling skewed towards particular locations and hosts. While these data are a good start, our current knowledge of *Symbiodinium* distribution patterns across the Great Barrier Reef, in combination with the uncertainties involved in host-symbiont flexibility in terms of acquiring more temperature-tolerant types, remains inadequate to postulate meaningful predictions concerning the health and diversity of coral reefs in the future.

Early warning of bleaching events: upwellings and intrusions ([Project 2.5i.2](#))

Project Leader: Dr Scarla Weeks, UQ

This MTSRF-funded investigation of the oceanography of the Great Barrier Reef has linked the intensity and persistence of upwelling with anomalously warm summers and coral bleaching events. The usefulness of a number of metrics - such as 'upwelling days' (the number of days of upwelling, inferred from erratic temperature variability) and diurnal variation in subsurface temperature (max-min, 20 m depth) - for describing the duration and intensity of shelf-break upwelling events in the central Great Barrier Reef were assessed. The results show, somewhat paradoxically, that even though upwelling is associated with cold water being brought near the surface, it is linked to positive thermal anomalies on the Great Barrier Reef, both locally and regionally. Summers (December to February) with strongest upwelling occurred during the Reef-wide bleaching events of 1997-1998 and 2001-2002. Upwelling in the Great Barrier Reef is enhanced during doldrum conditions, which were a feature of these summers. During these conditions the poleward-flowing East Australian Current flows faster, lifting the thermocline closer to the surface and thus spilling more sub-thermocline waters onto the shelf. Doldrum conditions also result in intense local heating, stratification of the water column and, when severe, coral bleaching. Upwelling intrusions are spatially restricted (central Great Barrier Reef), generally remain subsurface, and are often intermittent, allowing Reef-wide bleaching to occur despite conditions resulting in enhanced upwelling. Intense upwelling events precede anomalous seasonal maxima by up to 2 months and bleaching by 1-3 weeks, leading to the prospect of using upwelling activity as a seasonal forecasting index of unusually warm summers and widespread bleaching risk.

Impacts of climatic variability on seabird foraging patterns and nesting success ([Project 2.5i.2](#))

Project Leader: Dr Brad Congdon, JCU

The foraging ecology of seabirds such as wedge-tailed shearwaters (*Puffinus pacificus*) is highly dependent on oceanographic dynamics. This project has sought to increase our understanding of how these dynamics will change over the coming decade and century, and to provide insight into how seabird populations will fare as the climate changes. Preliminary analyses combining satellite foraging position data, bathymetry data and meso-scale oceanographic information for the East Australian coast and Coral Sea region highlighted potential links between shearwater foraging activity and specific ocean frontal systems, currents, bathymetry and upwelling phenomena. They also identified potential overlap between shearwater foraging areas and blue-water billfish and tuna fishing activities. Further analyses combining temperature/depth foraging data from wedge-tailed shearwaters with satellite and hydrodynamic information at local inter-reef scales in the Capricorn-Bunker Group suggested that shearwaters feeding chicks foraged primarily in surface waters at temperatures below mean background levels available. This implies that shearwater foraging habitat has a restricted spatial and temporal distribution, and that sea surface temperature satellite imagery can be used to identify and map changes in the distribution of preferred foraging habitat relative to changes in oceanography. In addition, analysis of subsurface temperature changes during a thermal stress event demonstrated that decreases in the availability of both preferred foraging habitat and food availability can be linked to cold-water oceanic intrusions onto the Great Barrier Reef platform at depths >35m. These incursions appear to suppress mixing of cooler waters into near-surface layers, which traps warm water at the surface and presumably affects the distribution of shearwater prey. The delicate balancing act that is apparent within populations of nesting seabirds within the Capricorn Bunker Group suggests a high degree of vulnerability to the impacts of climate change.



Spatial connectivity of coral and *Symbiodinium* populations on the Great Barrier Reef ([Project 2.5i.3](#))

Project Leaders: Prof Terry Hughes, JCU & Dr Julian Caley, AIMS

Increasing understanding of patterns of spatial connectivity within and between reefs of the Great Barrier Reef – effectively, the capacity for replenishment of reefs following patchy disturbance - is important if the Reef is to be managed for resilience. This MTSRF-funded project has provided insights into how populations of the ubiquitous brooding coral *Seriatopora hystrix* are related between exposed and sheltered habitats at small spatial scales within the Palm and Lizard Island groups. Exposed-habitat populations were found to be more closely related between the two Island groups (which are ~500 km apart), than were corals from sheltered and exposed habitats within each Island group (1-10 km apart). These preliminary results suggest that there may be high rates of self-recruitment and population inbreeding in sheltered habitats within protected bays, indicating that genotypes in these habitats may be particularly vulnerable to disturbance and extinction. In other surveys, the *Symbiodinium* strain hosted by the coral *Acropora millepora* was found to be constant through space and time within the Palm Island group. More than 99% of coral colonies sampled (n = >400) hosted exclusively *Symbiodinium* strain C2 (*sensu* van Oppen) regardless of whether they were healthy or bleached. However, the population-level genetic composition of *Symbiodinium* C2 at seven reef sites differed significantly between sampling years and between healthy and bleached sub-populations. These population genetic shifts could potentially be attributed to genetic drift in asexually maintained populations, sexual recombination, acquisition of new *Symbiodinium* genotypes from the external environment, and/or natural selection. Elucidating the causal mechanism(s) requires further research into the basic life history characteristics of *Symbiodinium*, including the timing and location of sexual reproduction.

Sea water heating rate and host density are critical precursors for coral disease outbreaks ([Project 2.5i.3](#))

Project Leaders: Dr Julian Caley, AIMS & Prof Bette Willis, JCU

Links have been made between anomalously high summer temperatures and outbreaks of the group of coral diseases known as White Syndrome on Indo-Pacific reefs. However, further advances in understanding their aetiologies and in developing management actions to mitigate their impacts are hampered by not knowing where or when outbreaks will occur. Before 2009, the only known outbreaks of White Syndrome on the Great Barrier Reef were documented in 2002. Outbreak sites tended to experience high values of heating rate (a metric developed as a measure of thermal stress) and also had high cover of corals within the genus *Acropora*, the primary hosts. MTSRF funding enabled the development of an empirical regression model that explains 93% of the variation in the abundance of White Syndrome observed during 2002, and suggests that abundance of White Syndrome increases exponentially as both heating rate and host cover increase. We used the model to hindcast the likelihood of outbreaks on Australian reefs for 2002 and each following summer (combining data from 45 sites surveyed from 2003 to 2008), producing no false negative or false positive predictions during this period. The model identified reefs with high heating rates in 2009 and forecast high outbreak likelihood in both the north-central and southern Great Barrier Reef. Targeted surveys to evaluate the efficacy of the model detected greatest abundance of White Syndrome at a site with high heating rate but medium host cover. The imperfect fit of the forecast with survey data highlights the need to reconsider host density threshold requirements for outbreaks. This work has shown that forecasting coral disease outbreaks in an era of changing climate is feasible (at least for selected disease syndromes) and requires integration of biological and physical data. The predictive tools being developed through this project are already helping managers of Australian reefs to target research and monitoring to enable informed responses to future outbreaks of coral disease.



Quantifying levels of herbivory in macro-algal phase shifts ([Project 2.5i.3](#))

Project Leader: Prof Terry Hughes, JCU

Inshore reefs are increasingly showing their susceptibility to human-induced changes. The vulnerability of marginal systems has been highlighted by one algal species, *Lobophora*, a brown leathery alga which appears to be highly resistant to grazing. As a result, this species may have the capacity to dominate inshore reefs regardless of herbivore presence, and surveys have shown that it was this species that drove recent algal outbreaks in the Keppel Islands and other inshore areas of the Great Barrier Reef. Further analyses identified extensive spatial variation in the capacity for algal removal. In the north (Cairns - Low Isles region), algal removal by herbivores from inshore reefs was strong, with good prospects for continued coral development. By contrast, just 5% of that effective herbivore activity was observed at the Keppel Islands, due to low herbivore numbers and low feeding rates. Our observations suggest that southern reefs, and the Keppels in particular, are more likely to become dominated by macro-algae, and once in place the algae are likely to remain. While protection of herbivorous fishes is a clear and logical management priority, this may not be sufficient, as herbivore effectiveness depends on both fish abundance and fish behaviour. The ongoing challenge is to understand the environmental factors that moderate herbivore activity on inshore reefs.

Evaluating long term recovery and resilience of reef fish communities to climate change ([Project 2.5i.3](#))

Project Leader: Prof Terry Hughes, JCU

Climate change poses a major threat to the Great Barrier Reef, and the most immediate threat comes from sustained and ongoing increases in sea surface temperatures. The future of coral reef ecosystems is heavily dependent upon the rate at which populations and communities can recover from successive disturbances associated with periodic temperature extremes. Ongoing monitoring of fishes and corals has been conducted in the central Great Barrier Reef following significant coral bleaching and associated habitat degradation in 2001-02. Significant bleaching and subsequent coral mortality reduced coral cover to <5% across several reefs in this region, and cover has generally remained low for the subsequent eight years. Even at locations where there has been spectacular recovery of coral cover, the structure of coral assemblages is markedly different in the aftermath of the 2001-02 bleaching event. These changes in cover and composition of reef-building corals have had significant effects on fish communities. Most notably, coral-feeding butterflyfishes all but disappeared following extensive coral loss, and recovery has been very slow and highly variable among species. Directional shifts in the structure of butterflyfish assemblages have been strongly influenced by changes in the structure of coral assemblages. These results suggest that there is limited resilience among fish and coral assemblages in the central Great Barrier Reef, and that further increases in the frequency and/or severity of warm water bleaching will cause major (potentially catastrophic) changes in the structure of local reef assemblages. Even if reef assemblages are resilient, and simply require more than eight years to become re-established, it seems unlikely that contemporary reef assemblages could be sustained in the face of future global warming. Further research is urgently required to assess what factors are limiting the resilience of reef assemblages in the central Great Barrier Reef.

Effective local management actions can enhance reef resilience in the face of climate change ([Project 2.5i.4](#))

Project Leader: Dr Scott Wooldridge, AIMS

This MTSRF-funded work has provided quantitative insight into many of the management response problems (e.g., 'what type?', 'how much?', 'where?', and 'by when?') that presently face coral reef managers tasked with maintaining reef resilience in the face of climate change. The benefit of 20%, 40%, 60% and 80% reductions in end-of-river dissolved inorganic nitrogen (DIN) concentrations in raising the thermal tolerance (i.e. bleaching 'resistance') of inner-to-mid-shelf reef sites on the Great Barrier Reef was modelled alongside two alternative global CO₂ emission scenarios: (a) No mitigation ('business-as-usual'), and (ii) CO₂ mitigation leading to atmospheric stabilisation of CO₂



concentrations at 450 ppm early in the 22nd century. The 'ReefClim' software package was used to develop regional-scale sea surface temperature (SST) patterns for the Great Barrier Reef till 2100. The dominant feature of the projected SST warming from all climate models tested was a proportionately higher rate of warming in the central-southern Great Barrier Reef. Simulated reductions in end-of river DIN loads appear to offer considerable improvements in the future survival prospects of locally-impacted reefs. The model projections demonstrated that in the area between Cardwell and Bowling Green Bay, an 80% reduction in DIN permits the maintenance of the coral-dominated reef state for an additional ~50 years beyond current projections for the 'business-as-usual' (no mitigation) warming scenario. Moreover, when coupled with the CO₂ mitigation ('stabilisation at 450 ppm') warming scenario, the enforcement of ~50% reduction in DIN is sufficient to ensure the long-term persistence of the impacted reefs.

Extrapolation of the modelling framework across the entire flood-impacted Great Barrier Reef domain enabled a projection of the likely timeframe (yr) for the loss of viable reef communities given the *No mitigation* and *CO₂ Mitigation* warming scenarios. Results show that:

- In the absence of any DIN reduction, the viability of a large proportion of inshore reef area is already marginal (in 2010), owing to the fact that the present day (2010) disturbance frequency experienced by many inshore reef communities is already likely to exceed their long-term capacity to maintain reef-building capacity; and
- Local reductions in DIN loads of ~50% and global atmospheric CO₂ stabilisation below 450 ppm are needed to ensure the long-term persistence of impacted reefs.

The outcomes of this work demonstrate that both local and global strategies are needed to prevent the imminent mortality risk and loss of resilience that currently characterises the inner-to-mid-shelf reefs of the Great Barrier Reef.

How will reef degradation affect the tourism industry? ([Project 2.5i.4](#))

Project Leader: Dr Scott Wooldridge, AIMS

To help quantify the impacts of future degradation in the health of the Reef on Queensland's lucrative marine tourism industry, MTSRF-funded researchers have developed a prototype model that quantifies the relationships between tourist perceptions, reef condition and economic and enjoyment valuation of reef trips. The model shows clear relationships between changes in reef condition and tourist visitation, financial valuation and satisfaction of reef trips. Reefs in excellent condition have the capacity to achieve twice the income as degraded reefs (i.e. reef states that are likely under unmitigated climate change), however variability is large. At this stage it is unclear from the data whether the drivers of this change result directly from changes in tourist demand for higher quality reefs, or from operators' decisions about which reefs they will visit, and thus requires more investigation. While tourists are able to rate reef aesthetics quite accurately, they are less skilled at rating reef quality, implying that tourists may recognise the effects of climate change as aesthetic but not as ecological losses. Climate change impacts on the tourist industry are likely to happen through their enjoyment of the reef experience rather than their valuing the loss of ecosystem services. For example, the model shows that tourists visiting top condition reefs during bad weather are more likely to perceive the reef to be of poorer quality than those visiting top condition reefs in good weather. If climate change also brings more good weather periods, then the impact of climate change on tourist satisfaction may be diminished, and vice versa. These results from the prototype model imply that while the tourism industry has some capacity to overcome potential financial losses due to reef degradation, this capacity is limited; however, it has the capacity to realize greater financial benefits from high quality reefs. These results were produced using ecological and visitation statistics for four reefs, and trends may change as more reefs are added.

Program 5ii: Climate Change – Understanding the Threat, Ecosystem Impacts and Mitigation for the Wet Tropics Rainforests

[This Program](#) is led by Prof Steve Turton, JCU. Steve's research interests include climatology, rainforest ecology, urban and road ecology, adaptation of tourism and forestry to climate change, Indigenous cultural and natural resource management and environmental management. He particularly focuses on sustainable use, planning and management of tropical forest landscapes in north Queensland, particularly in relation to land-use and climate change.



Prof Steve Turton, JCU

Best available climate change projections for the MTSRF region ([Project 2.5ii.1](#))

Project Leader: Dr Penny Whetton, CSIRO

The best estimates and low and high ranges of climate change projections based on 23 global climate models are given as the 50th, 10th and 90th percentiles. Projections indicate that the inland areas of the MTSRF region will warm faster than the coastal areas. Under a medium emissions scenario, the best-estimate regional annual average temperature increase by 2030 is 0.8°C, with a range of uncertainty of 0.6 to 1.1°C. Higher increases are projected for 2050 and 2070. Rainfall changes show increases and decreases. The best estimate of regional average annual rainfall change for 2030 is -1%, with a range of uncertainty of -8 to +6%. Larger ranges are projected for 2050 and 2070. Percentage changes in Dry season and Transitional season 2 rainfall are greater than those for Wet season and Transitional season 1 rainfall. This project has delivered the best available climate change projections for the MTSRF region, and the results are already being used by other MTSRF projects, as well as state government agencies.

Increased process-based understanding of the likely impacts of climate change on Daintree lowland rainforest performance ([Project 2.5ii.2](#))

Project Leader: Dr Michael Liddell, JCU

MTSRF funding has permitted the continuation of atmospheric flux studies at Cape Tribulation, building a nine-year dataset that can now be analysed. During this period a drought event in 2002-2003 allowed the influence of water stress on the carbon balance of the forest to be assessed, leading to the conclusion that wet season recharge is essential in maintaining photosynthetic productivity. Without at least 2 m of rainfall in the wet season full photosynthetic activity cannot be maintained throughout the year. Analyses of differences in cloud cover (= available solar radiation) indicates that a future increase in wet season cloud cover would result in a decrease in forest productivity. Although trace emissions of volatile organic compounds have been detected from the forest, and there are major aerosol formation events in the vicinity, the origin of these formation events has yet to be determined. Nonetheless they are undoubtedly important for ensuring cloud formation. Cyclonic damage to the ecosystem measurably increased forest respiration rates over the period 2000 - 2004. A predicted mean annual temperature increase of 3.6°C for the Daintree (CSIRO CMAR) and reduced rainfall in the wet season will place the rainforest in a highly stressed



situation by 2080. Our field data show that mean annual temperature at the Cape Tribulation site has increased by 0.6°C over the past nine years.

Below-ground fluxes in water and carbon in lowland rainforest ([Project 2.5ii.2](#))

Project Leader: Dr Michael Liddell, JCU

Despite a growing body of knowledge about the hydrology of tropical rainforests, little is known about temporal and spatial patterns of water uptake and carbon fluxes in soil. Water uptake will be an important factor in the response of forests to climate change. This MTSRF-funded project aimed to determine water uptake rates and identify some of the factors controlling them in lowland rainforest in the Daintree region. Soil water content and potential were measured at depths of 0.1, 0.75 and 1.5 m, over a two-year period. Water uptake was calculated from the change in soil water content during periods with no rainfall. Water uptake ranged from 0 to 12 mm d⁻¹, and was closely related to mean soil profile water potential. These researchers also investigated carbon fluxes through the soil at the same location. Soil carbon content and fertility were measured by analysing topsoil (0-0.1 m) samples from across the site (5 x 5 grid across 1 ha, corresponding with litter collection traps) and samples to 1.5 m depth from a pit. Topsoil properties varied considerably across the site, and canopy cover was spatially correlated with soil fertility and depth/rockiness, as estimated by apparent electrical conductivity. Soil carbon was found to have a turnover rate of approximately 5% per year. Carbohydrate was the most abundant component of soil organic matter, but its concentration relative to other components decreased with depth. The rate of carbon cycling through the soil at this site is likely to be sensitive to perturbations in rainfall.

Long-term monitoring of flowering and fruiting in Wet Tropics rainforests ([Project 2.5ii.2](#))

Project Leader: Dr Michael Liddell, JCU

MTSRF funding has permitted the commencement of a long-term project monitoring phenological shifts in rainforest flowering and fruiting in response to climatic variability. Two sites are being monitored: the Australian Canopy Crane Research Facility at Cape Tribulation (where presence/absence data are scored visually from the gondola of the crane) and in association with the SkyRail Rainforest Cableway near Smithfield (at which a d-SLR camera is used to continuously collect high-resolution images along both sides of the gondola carriageway; images are analysed later and species showing an event are identified). One year of data has been collected at both sites. Preliminary analyses of these new datasets, in combination with historical data from the SkyRail transect, indicate that these methods will enable us to successfully track changes in flowering/fruiting phenology in response to climatic variability.

Understanding the climate change threat to tropical forests ([Project 2.5ii.3](#))

Project Leader: Dr David Hilbert, CSIRO

MTSRF-funded researchers used an artificial neural network classifier to investigate the large expansions, contractions and spatial shifts of the environments of structural forest types in the Wet Tropics bioregion over the last 18-20,000 years, as well as likely changes due to future warming. In the worst-case scenario (IPCC A1FI: rapid warming (5 °C) accompanied by reduced rainfall (-23%) by 2080), results indicate that there will be substantial changes - mostly decreases - in the areas suitable for many rainforest types. As mean annual temperature increases, forest basal area decreases and tree species endemism decreases, although tree species richness and tree density do not change along the temperature/altitudinal gradient. While it is not possible to say exactly where and when changes in forest structure and plant species composition will occur, the region's forests will be in a substantial disequilibrium with their environment. Large changes in the ecological environments of the bioregion will stress existing forest communities and ecosystems. Some areas may remain suitable for a certain vegetation type despite rather large changes in regional climate, due to physical features such as soils and landforms. Our results indicate that these climate refugia



are not likely to be important at regional scales in the A1FI scenario, except for some areas of Mesophyll Vine Forest ecosystems in the central Wet Tropics.

These observations suggest a number of likely responses to global warming in the Wet Tropics' forests, including reduced basal area (carbon stocks) and possible expansion of generalist lowland species with concomitant decreases in more cool-climate adapted upland endemics. Our preliminary analysis indicates that relatively few Wet Tropics tree species (~10%) are altitudinal generalists; many species may be restricted to narrow altitudinal ranges (200 m, which is equivalent to a 1°C range of mean annual temperature). This suggests that, as the climate changes, many Wet Tropics tree species will rapidly be exposed to mean annual temperatures that are beyond their normal tolerances.

Climate change and avian malaria ([Project 2.5ii.3](#))

Project Leader: Dr David Hilbert, CSIRO

Mosquitoes are important vectors of wildlife and human diseases – how will their distribution and disease vectoring capacity be affected by climate change? To begin to answer this question, MTSRF-funded researchers captured mosquitoes and birds at a range of different altitudes in the Wet Tropics, at three heights relative to the forest canopy and in three seasons over three years. They found that both the abundance and diversity of mosquitoes increased with estimated mean annual temperature. Genetic tests identified the presence of avian malaria in the most common lowland mosquito that was captured, *Coquilleltidia crassipes*. This genus was recently reported to be a vector of avian malaria in Africa but had not previously been implicated as a vector in Australia. DNA analyses of bird blood samples showed that *Haemoproteus* was a more common haemosporidian infection than *Plasmodium*, and peak infection rates were observed at intermediate temperatures and elevations. By contrast, infection rates of avian malaria (*Plasmodium relictum*) were highest in the warmer sites and declined to an average of ~3% at mean annual temperatures below about 22.5°C.

Assessment of climate change vulnerability for Wet Tropics vertebrates ([Project 2.5ii.4](#))

Project Leader: Prof Steve Williams, JCU

This MTSRF-funded project has made significant advancements in our understanding of the relative extinction proneness and vulnerability of Wet Tropics vertebrate species to climate change. First, researchers have developed a single unified framework for assessing vulnerability that incorporates all major factors contributing to vulnerability, including elements relating to both sensitivity and exposure. Second, researchers have vastly improved our knowledge of the sensitivity and exposure of individual species to climate change. Specifically, researchers have employed improved modelling techniques to estimate geographic range size, incorporated uncertainty in projections from seven different global climate models, and used field measurements of abundance to generate estimates of relative change in population size. Researchers compiled detailed information of ecological characteristics of species to estimate the capacity of species to resist or bounce back from environmental perturbations, and catalogued microhabitat use that can influence exposure to stressful environmental conditions. Third, researchers have integrated all of this information into a single vulnerability assessment to identify a priority list of species most threatened by climate change. This has been a particularly high-profile MTSRF-funded project, generating eighteen scientific publications (with twelve more in review), seven articles in magazines and newspapers, 30 conference presentations and four workshops, as well as significant media coverage.



Physiological tolerances of arboreal mammals ([Project 2.5ii.4](#))

Project Leader: Prof Steve Williams, JCU

How vulnerable are the arboreal mammals of the Wet Tropics to increases in temperature? MTSRF-funded researchers measured responses to changing ambient temperatures in three species – lemuroid, Herbert River and green ringtail possums. In lemuroid and green ringtails, body temperature rose linearly at temperatures above a certain threshold. The threshold temperature at which lemuroids allowed their body temperature to start rising was 28.5°C, and the rate at which their temperature rose was ~25% faster than green ringtail possums. The observed variations in the rate of temperature rise and threshold temperature between species match well with researchers' expectations based on the differences in the altitudinal ranges occupied by each species. These rainforest ringtail possums are likely to be limited by temperature extremes and negatively impacted by increases in the frequency and severity of those extremes.

Inclusion of biotic interactions in species distribution models improves predictions under climate change: the northern bettong, its food resources and a competitor ([Project 2.5ii.4s2](#))

Project Leader: Prof Steve Williams, JCU

A MTSRF Student Scholarship enabled this study of the influence of biotic interactions on predicted current and future distributions of an endangered marsupial, the northern bettong (*Bettongia tropica*). Climatic models were developed independently for each of the northern bettong, two of its food resources, and a likely competitor. To determine how the inclusion of biotic interactions altered predicted distributions, northern bettong models were augmented by including estimates of climate suitability for the food resources and competitor, and then compared with those of the climate-only model. Differences in predictions were quantified with a 'global' metric to test whether predictions were significantly different, and a 'local' metric to identify where they differed. Inclusion of biotic interactions improved model performance and provided the most ecologically realistic distributions. Below 3.0 °C increase in climatic warming, predicted northern bettong models differed only in the margins of their predicted distribution, but beyond this level, predictions of models that incorporated biotic interactions diverged from those which did not.

Program 6: Understanding Threats and Impacts of Invasive Pests on Ecosystems

[This Program](#) is led by Prof David Blair from JCU and Dr David Westcott from CSIRO.

Professor David Blair is a specialist in both parasitology and genetics at James Cook University. David's research interests include the evolution and phylogeny of Australian fauna and population and conservation genetics of mammals and reptiles. Significant projects include the population genetics and phylogeography of the dugong and tracing the movements and population biology of a vulnerable species of flying fox.

Dr David Westcott is a Principal Research Scientist for Tropical Landscapes at CSIRO's Atherton Laboratory. Dr Westcott is currently studying patterns of seed and weed dispersal in tropical rainforests and the influence that landscape change has on this process. His research interests include the evolution of communication systems, and the ecology of conservations management of endangered species such as the southern cassowary and the spectacled flying fox. David is also a subject editor for the journal *Biotropica* and *Biodiversity and Conservation* and is an Adjunct Senior Lecturer at James Cook University.



Prof David Blair, JCU, Dr David Westcott, CSIRO

Distribution and abundance of toxic microalgae on the central Great Barrier Reef ([Project 2.6.1](#))

Project Leaders: Prof David Blair & Dr Kirsten Heimann, JCU

Climate change-induced increases in natural disturbance events are predicted to lead to phase shifts to macroalgal dominance on coral reefs world-wide. Macroalgae, dead corals and coral rubble serve as substrates for toxic epiphytic and benthic dinoflagellates, known to cause ciguatera (CFP), paralytic (PSP), diarrhetic (DSP), and amnesic shellfish poisoning (ASP). Hence, as substrate availability increases, toxic dinoflagellates are likely to expand their ranges simultaneously with substrate availability. Information on benthic toxic dinoflagellate abundance patterns and community composition for the Great Barrier Reef is sparse. There is an urgent need to collect and collate these data in order to evaluate the impact of climate change on these toxin producers, as they affect human health. This MTSRF-funded project collected preliminary data on abundance patterns and community composition of epiphytic toxic dinoflagellates in coastal, inshore and mid-reefal habitats of the central Great Barrier Reef. Three sites in the Orpheus Island seasonal study (Lodestone Reef, Pioneer Bay and John Brewer Reef) were examined over three seasons. Preliminary results in November 2008 showed relatively high abundance of dinoflagellates, followed by a decrease in March 2009, with numbers increasing again in August 2009 at these sites. No clear patterns in community structure have yet emerged, although *Prorocentrum* spp dominated the community structure at all three sites in November 2008, and at all seasons at Lodestone Reef. *Ostreopsis* was the predominant genus at Pioneer Bay in March 2009, but by August *Prorocentrum* again dominated the toxic microalgal community there. Differences in community structure and species richness may be related to environmental conditions, as Pioneer Bay is tidal inshore, whilst Lodestone and John Brewer Reefs are submerged sites. During November 2008 inshore reefs appear to be dominated by *Prorocentrum*, whereas *Ostreopsis* prevailed at submerged reef sites. Sites at Magnetic



Island showed the same pattern. *Gambierdiscus* spp were present, but not prevalent, at all sites in November with the highest number (14%) recorded at John Brewer Reef. These findings are being compiled into an Atlas of Marine Microalgae for the Great Barrier Reef, which also contains descriptions of 22 species of toxic dinoflagellate and 15 substrate macroalgal species.

Ciguatera fish poisoning on the Great Barrier Reef ([Project 2.6.1](#))

Project Leader: Dr Kirsten Heimann, JCU

Although the Great Barrier Reef is a global hotspot for ciguatera fish poisoning (CFP), a human illness caused by the ingestion of food contaminated by toxins produced by benthic dinoflagellates, very little is known about the diversity, distribution and abundance of the causative microalgae in our waters. Baseline data are necessary both to establish current levels of risk, and to permit recognition of any future invasions of new toxic microalgae. MTSRF-funded researchers have established cultures of potentially toxic strains isolated from central Great Barrier Reef waters, and identified them using a combination of molecular phylogenetics, scanning electron microscopy and light microscopy. Species belonging to the genera *Gambierdiscus*, *Prorocentrum*, *Amphidinium*, *Ostreopsis* and *Coolia* were identified, including two apparently new species of *Coolia*. Some of these species are suspected principal agents of CFP. Researchers also developed molecular probes which can be used to monitor the presence of such organisms in environmental samples. The use of these molecular probes will allow investigation of the ecology of toxic dinoflagellates to an extent that would be impossible based on standard microscopy. This will provide managers with vital information about patterns of abundance and distribution of toxic microalgae, and a baseline to recognize future invasions of toxic species. Another part of this project gathered information about the frequency and severity of CFP in the Great Barrier Reef region. Preliminary results indicated that one in ten local people surveyed had suffered from CFP at some point. All local sufferers reported neurological rather than gastrointestinal symptoms, in line with observations from other Pacific locations.

Dissolved oxygen tolerance of exotic freshwater fish species in north Queensland ([Project 2.6.2](#))

Project Leader: Dr Damien Burrows, JCU

Exotic fish species have become increasingly established and dominant in north Queensland freshwater ecosystems in recent years. Research has shown that exotic species have become most abundant in degraded aquatic habitats, in which naturally low levels of dissolved oxygen (DO) have typically further declined. Earlier work funded through this MTSRF project (Webb 2008) showed that the greater tolerance of exotic fishes to water quality variables such as low DO and high temperature were major contributors to the invasion success of exotic species that had established breeding populations in north Queensland freshwaters. Researchers tested tolerance to low DO in a range of exotic species from those that have established in freshwaters of north Queensland, those that have been found in freshwaters in north Queensland (though not established) and those that are regularly sold in aquarium shops and may thus be released into the environment in the future. Species tested were from four fish families that are freshwater-derived taxa, that is, they have very long evolutionary histories in freshwater, where low DO is more prevalent, compared to most Australian native fish families, which mostly have relatively recent marine ancestry. Fish from the families tested in this study are also commonly used as aquarium fish (the main source of introduced fish species). As expected, it was found that the exotic fishes had significantly greater DO tolerances than most native fish species they would be likely to encounter in north Queensland's aquatic ecosystems. In addition, we have identified several new species that threaten to invade north Queensland from Papua New Guinea, which are from the families Anabantidae (eg, climbing perch), Channidae (eg, snakeheads) and Osphronemidae (eg, gouramis), all of which are capable of breathing oxygen directly from the air and can stay out of water for considerable periods. Their pre-adaptation for tolerating very low DO confers a considerable risk for their establishment in north Queensland.



A new method for estimating cassowary population size ([Project 2.6.2](#))

Project Leader: Dr David Westcott, CSIRO

We know surprisingly little about southern cassowaries (*Casuarius casuarius*), including even the most basic parameters required for management of this iconic but endangered species. Arguably the most basic data needed to assess the conservation status of a species and its management requirements is an estimate of population size and trends. With the support of the Wet Tropics Management Authority and the Australian Rainforest Foundation, researchers have been developing a monitoring methodology based on DNA fingerprinting of cassowary dung samples. Researchers can now identify and sex individual cassowaries by amplifying DNA from dung samples collected from a variety of locations in the Wet Tropics region. The method makes scientifically rigorous estimation of population size possible, and provides a cost-effective process for community involvement in monitoring of key cassowary populations. Faecal-DNA monitoring methods can be used in two monitoring contexts for cassowaries. The first is in broad-scale surveys of large geographical areas, e.g. the Wet Tropics or the species' Australian range, with the purpose of population estimation and monitoring of long-term population trends at these scales. The second is as part of intensive population studies of relatively small geographic areas where sampling occurs regularly, effectively resulting in monitoring of the individuals and their use of the local area. In the latter context, community involvement in local-area sample collection has the potential to not only increase the temporal and spatial resolution of monitoring, but to increase the engagement of local communities in conservation activities.

Halting and Reversing the Decline in Water Quality (Theme 3 of the MTSRF)

In recognition of the fundamental importance of water quality to the health of north Queensland's aquatic, estuarine and marine ecosystems, including the Great Barrier Reef, projects in [this Theme](#) aim to build a comprehensive understanding of the causes and effects of changing water quality and water resource use patterns. Results from these projects are already helping to develop management options for improving practices, reducing risks and mitigating impacts, as well as methods for measuring the effectiveness of management efforts. Please see [Appendix 1](#) for the full list of research projects conducted under this theme in 2009/2010. Some of this Theme's major achievements for this year are highlighted below.

Program 7: Halting and Reversing the Decline in Water Quality

[This Program](#) is jointly led by Dr Katharina Fabricius, Principal Research Scientist at the Australian Institute of Marine Science, Prof Richard Pearson, Head of Zoology and Tropical Ecology and James Cook University, and Prof Iain Gordon, Theme Leader at CSIRO.

Dr Katharina Fabricius is a Principal Research Scientist at AIMS. Her research aims to better understand the role of natural and anthropogenic disturbances in shaping coral reef communities. Specific topics Katharina has worked on include studies on drivers of biodiversity and resilience in response to terrestrial run-off and climate change. Currently, her research aims at understanding the effects of organically enriched sediments, marine snow and light, on coral biodiversity, coral recruitment and reef calcification. Katharina is also an advisor to the Great Barrier Reef Marine Park Authority and other Government Bodies on water quality and climate change issues.

Professor Richard Pearson is the Head of Zoology and Tropical Ecology at JCU. His research interests lie in community ecology, especially of stream and wetlands; river health and water quality monitoring; biodiversity; bird ecology. Richard has more than 30 years research experience in tropical biology and is widely recognized for his achievements including most recently a Cassowary Award for his commitment to conservation in the Wet Tropics World Heritage Area.

Professor Iain Gordon led CSIRO's Biodiversity Theme: Building Resilient Australian Biodiversity Assets, during the MTSRF period. His research interests include providing the tools and knowledge to help halt biodiversity decline; and involving local communities in developing countries in wildlife management. Iain is an Editorial board Member on some prestigious journal and a board member on the Tropical Landscapes Joint Venture at JCU among others. Iain has recently returned to Scotland to take up a position as The Chief Executive of Scotland's new Research Institute.



Dr Katharina Fabricius, AIMS, Prof Richard Pearson, JCU, and Prof Iain Gordon, CSIRO



Measuring the impact of poor water quality on inshore coral reefs ([Project 3.7.1](#))

Project Leader: Dr Katharina Fabricius, AIMS

This MTSRF project has considerably furthered our understanding how poor water quality from river runoff affects a wide range of attributes of coral reef, seagrass and estuarine communities. Research quantifying the responses of corals and other reef-associated organisms to changing nutrients and sediments permitted the development of a set of indicators that is currently being tested within the Marine Monitoring Program for the Great Barrier Reef. Research results from this project have:

- been published in 28 peer-reviewed scientific papers and 10 student theses
- formed the basis for the Great Barrier Reef Marine Park Authority's Water Quality Guidelines
- substantially contributed to and underpinned the Consensus Statement on Water Quality
- substantially contributed to GBRMPA's first Outlook Report
- informed the Reef Rescue initiative as well as the Queensland Government's Reef Regulations.

Perhaps most importantly, this MTSRF research project has contributed to a more informed and less confrontational public debate on this highly controversial issue, helping to build community consensus for better environmental management.

Using coral reef organisms as indicators of water quality and ecosystem condition ([Project 3.7.1](#))

Project Leader: Dr Katharina Fabricius, AIMS

This MTSRF-funded project has confirmed that decreases in water quality cause profound multi-faceted trophic shifts (from phototrophic to heterotrophic communities) and community shifts (from reef-building coral dominated communities to sites dominated by macroalgae and abiotic substrata) on the inshore Great Barrier Reef. Twenty-six environmental variables are strongly and specifically related to water quality conditions on the inshore Great Barrier Reef, and their potential usefulness as indicators of water quality for monitoring programs were investigated. Turbidity was by far the best predictor of biota and should be the first priority for monitoring water quality on the inshore Great Barrier Reef. For example, colonies of massive *Porites* corals are darker in colour, and the density of macrobioeroders on living surfaces is higher, on reefs which experience higher turbidity and river-influenced waters. Less diverse symbiont-bearing benthic foram communities are also observed on these reefs, and the ratio of phototrophic to heterotrophic foram taxa declines. In contrast, total macroalgal cover steeply increases from almost none in clear-water reefs to >50% cover in turbid water. Both total cover and the cover of specific genera of hard corals and octocorals declines as turbidity increases, and so does the taxonomic richness and juvenile densities and richness in both hard corals and octocorals. In cases where direct turbidity measurements are impractical or too expensive, bioindicators may be a cost-effective alternative for monitoring changes in water quality. This research project has delivered a final list of 11 bioindicators useful for water quality monitoring on the Great Barrier Reef: *Porites* brightness, macro-bioeroder density in massive living *Porites*, Foram Index, macroalgal cover, *Acropora* cover, *Acropora*/Hard coral cover ratio, *Turbinaria* cover, juvenile hard coral density and richness, and juvenile soft coral density and richness. Additionally, Secchi depth readings taken every visit serve as a 12th indicator for water quality. A new multivariate approach to synthesising and integrating across multiple and unrelated indicators into one comprehensive and easy to use indicator system is now being tested. This new technique is derived from the indicator work conducted in this MTSRF project over the last four years, and if successful could become widely applicable for ecological indicator initiatives around the world.



Development of marine biofilms as indicators of changes in water quality ([Project 3.7.1](#))

Project Leaders: Dr Katharina Fabricius & Dr Sven Uthicke, AIMS

As part of a larger project investigating the usefulness of a range of biological indicators of water quality, MTSRF-funded researchers have identified the organism groups in marine biofilms (bacterial biofilms on sediments, microphytobenthos layers on sediments, and foraminifera on sediment and other reef substrata) that consistently change along water quality gradients. The effects of light and nutrients on growth, mortality and photosynthesis were tested for several foraminiferan species both in laboratory experiments and in the field (through sampling under the Reef Rescue Marine Monitoring Program and experimental field transplants). Both foraminiferal growth rates and carbon/nitrogen ratios are reflective of local water quality conditions. Analyses of the influence of various stressors on foraminiferan distribution have improved our understanding of the thresholds of potential concern for pollutant exposure for individual organism groups and biofilm communities generally. Further experiments investigating interactions between water quality and climate change suggest that for at least one foram species, additive effects of the two stressors exist, and foram growth rates can be negatively affected by increased nutrient concentrations and increased temperature. Most species tested are clearly susceptible to bleaching at temperatures only slightly above current summer maxima, and thermal thresholds have been established for several foraminiferan species. The results of this project have been published in an easy-to-use web-based foraminiferan guide, a Standard Operational Procedure for foram sampling, a major step towards facilitating the use of foraminifera in water quality monitoring programs. In an immediate novel application of this new monitoring tool, these researchers have received MTSRF transition funding to investigate changes in water quality over the past 200 years by analysing changes in foraminiferan communities in dated sediment cores.

Identification of key pollutant sources in Great Barrier Reef catchments ([Project 3.7.2](#))

Project Leader: Jon Brodie, JCU

The key findings from this MTSRF-funded project are:

- Elevated concentrations of dissolved inorganic nitrogen in streams are clearly linked to the runoff of fertiliser residues in areas of intensive cropping (particularly sugarcane and bananas).
- Some specific soil types may also contribute a disproportionate phosphorus load.
- Grazing lands of the Dry Tropics (i.e Burdekin and Fitzroy) contribute the vast majority of the suspended sediment load to the Great Barrier Reef lagoon.
- Pesticides detected in streams are sourced to intensive cropping lands, with the exception of tebuthiuron which is sourced to grazing land use.

The total key pollutant loads from each region have been calculated based on a combination of long-term monitoring data and recent SedNet/ANNEX model outputs. 'Hot spot' areas or catchments have been identified, as well as the key land uses in each region which would benefit from further management consideration. An overall risk assessment of pollutant runoff from each basin of the Great Barrier Reef catchment area (Wet Tropics, Burdekin, Mackay Whitsunday, Fitzroy and Burnett Mary) was conducted using current 'anthropogenic loads' (current load minus pre-European settlement load), reef condition score and reef exposure score, to produce an 'overall relative risk score'. This risk assessment rates the Mackay Whitsunday and Wet Tropics regions as the areas with the highest overall risk. The Burdekin and Fitzroy regions are ranked as medium-high, while the relative risk to the Burnett Mary region is medium. Results from this project have been instrumental in the development of regulatory thresholds for water quality on the Great Barrier Reef.



Connectivity and risk: tracing contaminants from the catchment to the reef **([Project 3.7.2](#))**

Project Leader: Jon Brodie, JCU

This MTSRF-funded project has been successful in tracing materials, particularly sediment and pesticides, from the terrestrial environment to the marine environment through the processes of generation, transport, transformation, trapping and risk. Inshore-offshore sediment transport in the Wet Tropics has also been investigated by identifying the relationships between sediment input and transport and regional turbidity regimes. Researchers have shown that the movement of sediment from the Burdekin catchment is dependent on the size and also the location of flood events. The Burdekin Dam plays an important role in trapping a high proportion of incoming suspended sediment, with the bulk of the suspended sediment delivered to the Great Barrier Reef lagoon coming from the lower catchments below the Dam (Bowen/Bogie catchment). The project has now started to produce data on suspended sediment behavior in flood plumes by describing the pathway of the finer sediment and its potential impacts on the reef. This exciting work has shown that the finer sediment signature is still present in secondary flood plume waters (though masked through organic flocculation processes), and further work can potentially start to connect plume behaviour and potential impacts with specific soil types/sources in the sub-catchments of the Burdekin River. Geochemical records from coral cores have been successfully used as proxies to demonstrate long-term changes in catchment sediment loads, and to develop long-term histories of regional trends in agricultural and urban activities. Finally, the sediment budget work in the Tully and Cleveland Bay areas has been successful in developing our understanding of the sediment pathways, and the long-term impact of increased sediment supply. Sediments sourced during high flow events are deposited in the bay, and are re-suspended during the dry season through the trade winds. This has the effect of increasing the long-term turbidity of the bay, with consequences for local coral and seagrass ecosystems. Science-based sediment reduction rates which may potentially promote seagrass and reef growth in this area have been proposed.

Freshwater indicators and thresholds of concern ([Project 3.7.3](#))

Project Leaders: Prof Richard Pearson, JCU & Prof Angela Arthington, GU

This project sought to measure and understand the ecological processes, linkages and interdependencies that govern the condition, health, trend and resilience of rivers and their floodplain wetlands in Great Barrier Reef catchments, as a basis for development of cost-effective biophysical monitoring tools to help sustain these habitats and their dependent environmental assets. Researchers produced a conceptual biophysical model that identified the appropriate indicators of wetland health, and probable thresholds of concern, in terms of contaminant concentrations, ecological processes and biodiversity. The major indicators identified are related to pressures including types of land use, general water quality and contaminants, hydrological regime and connectivity, channel and habitat structure, riparian vegetation condition and alien species of plants and fish. Stressor-response relationships along gradients of disturbance (supported by data from laboratory trials and the literature) have helped to identify 'thresholds of concern', i.e. points along each disturbance gradient where ecological changes of scientific or management concern become apparent. The most serious factors currently affecting health in Wet Tropics streams and wetlands are changes to habitats, including flow modification, invasion by exotic weeds and loss of riparian vegetation, which can cause major changes to waterway morphology, habitat complexity, food availability, gas exchange with the atmosphere and, therefore, biodiversity. Dry tropics streams and wetlands are impacted by similar influences but due to varying land uses and a dominance of cattle grazing, are generally more exposed to issues related to sedimentation. Many dry tropics rivers cease to flow in the dry season, contracting to isolated lagoons, which provide refugia for the biota. The gradient of flow regime from mid-Wet Tropics to Dry Tropics is very clearly reflected in their biodiversity, with even the smaller rivers of the Wet Tropics supporting many more fish species than the large Dry Tropics systems. Flow regime has a high influence on fish populations. The relationship between the structure and dynamics of the larval fish assemblage in lowland riverine Wet Tropics habitats and the underlying variability of the habitat and its condition are shaped primarily by the prevailing flow regime. The fauna in the wetlands of the Tully-Murray floodplain and in streams of the Russell-Mulgrave



catchment is in moderate to good condition. It appears that the fauna is resistant to the immense changes in land use that have taken place across the floodplains in the last century, mostly because of perennial flows. Less well-flushed systems (e.g. on the Herbert floodplain) do not fare so well. Potential indicators of ecosystem health, such as abundance and diversity of zooplankton and benthic invertebrates, tend to correlate very closely with habitat changes, which themselves are quite straightforward to monitor (e.g., floods, riparian condition, alien species and weeds). Fish provide a robust indication of lagoon condition and, importantly, connectivity, while fish and especially invertebrates are good indicators of condition in streams.

Wetlands and floodplains: Connectivity and hydrological function ([Project 3.7.4](#))

Project Leader: Prof Jim Wallace, CSIRO

This MTSRF-funded project successfully quantified the role of over-bank floods on the transport of sediments and nutrients and their transport across floodplains in the Wet Tropics. This work was instrumental in the prediction of how the hydrological response and connectivity of floodplain wetlands are affected by land use and water management. Researchers have shown that the nutrient loads being delivered during flood events from the Tully-Murray catchments to the Great Barrier Reef lagoon have been significantly underestimated: over bank flood contributions were found to increase the mean annual loads of phosphorus and nitrogen loads by 30-50% above previous river-based estimates. Model simulations provided a means of identifying the degree of connectivity of different wetlands, ranging from those wetlands that are more permanently connected with streams and drains, to those that are connected only when there are large over-bank floods. This information has been integrated into the biological indicator work to help understand movement of freshwater fish. Understanding of the ecological functions of wetlands has been enhanced by this improved knowledge of over-bank flow and the reoccurrence of connectivity between wetlands. Variations in wetland connectivity could affect the movement of aquatic biota during floods, and the variability of habitat and biodiversity of individual wetlands. Knowledge of the appropriate corridors and links will be instrumental in any future management of wetlands and/or selection for rehabilitation and restoration.

Socio-economic constraints to and incentives for the adoption of land use and management options for water quality ([Project 3.7.5](#))

Project Leader: Dr Martijn van Grieken, CSIRO

This study has provided an economic assessment of instruments promoting adoption of land management practices (MPs) by landholders for the Tully Murray catchment in the Wet Tropics. More specifically, the objectives of this study were to determine the private economic consequences of MP adoption, determine the effectiveness of MPs adoption in reducing nutrient supply, and assess the effectiveness of taxes and subsidies to promote the adoption of MPs. Researchers combined a financial analysis of MPs in sugarcane, beef cattle production, banana cultivation and production forestry at the paddock scale and a farm household modelling approach for various types of producers at the farm scale. The results showed that improved nutrient, pesticide and soil management in the sugarcane industry would lead to increased productivity benefits, but at a significant investment cost. Improved practices (ie reduced stocking rates) in the grazing industry would cause a loss of productivity, although in some cases, reductions in stock rates may lead to benefits (through increased gross margins). Researchers then made some predictions about how different types of farmers, or farming agents, will respond to different policy interventions, by developing a typology of farmers in the study area. This has permitted qualitative and quantitative estimation of regional socioeconomic and environmental consequences of implementing a specific policy in terms of local income, employment and nitrogen runoff. The conclusion of this work is that while financial motives are important in explaining adoption of management practices, there are a wide range of other nonfinancial factors explaining the current non-adoption of management practices by a significant number of farmers.



More reliable and accurate estimates of pollutant loads entering the Great Barrier Reef lagoon ([Project 3.7.7](#))

Project Leader: Dr Petra Kuhnert, CSIRO

This MTSRF-funded project has generated a four-step methodology – the Loads Regression Estimator (LRE) - which allows better estimates of load through the calculation of the uncertainty associated with load data. The first step involves 'regularising' the flow, a process whereby a loess smoother, capturing peak flows, is used to predict flow at regular time intervals (e.g. hourly) and infill any gaps in the flow monitoring data. The second step in the methodology fits a generalised additive model to concentration (on the log-scale) to model the relationship between concentration and a series of flow terms that attempt to mimic key hydrological processes of the system with the aim of reducing knowledge uncertainty. The third step involves the estimation of the load, which is the result of multiplying the regularised flow by the concentration predicted at each regularised flow value, which is then summed over the water year. The fourth step involves the construction of the variance around the estimate of the load. The variance is structured so it not only incorporates errors in the concentration but errors in the flow rates (measurement and spatial). The LRE has been applied to twelve monitored rivers and nine pollutants to estimate annual loads with uncertainties. These estimations were then used to calculate more reliable and accurate long-term loads of pollutants being delivered to the Great Barrier Reef lagoon. The LRE has already been adopted by water quality monitoring programs and is being used to report on the status of, and trends in, pollutant loads in Queensland catchments.

Sustainable Use and Management (Theme 4 of the MTSRF)

Projects within [this Theme](#) aim to increase our understanding of the current and future ways in which north Queensland's key environmental assets are being used by industries and communities. Results from these projects are helping managers optimise the use of resources for sustainability, and minimise adverse impacts where they occur. Please see [Appendix 1](#) for the full list of research projects conducted under this theme in 2009/2010. Some of this Theme's major achievements for this year are highlighted below.

Program 8: Sustainable Use and Management of Marine Resources of the Great Barrier Reef

[This Program](#) is led by Assoc Prof Colin Simpfendorfer, Director of the Fishing and Fisheries Research Centre at James Cook University. His research has focused on the elasmobranch fishes (sharks and rays), and his research interests include fisheries of the GBRWHA; habitat use of sharks and rays, and analysis of acoustic monitoring data and his current projects include sustainability of Queensland's east coast shark population, and resiliency of coral reef fin fish species.



A/Prof Colin Simpfendorfer, JCU

No-take (green) zones replenish fish populations in fished (blue) zones in the Great Barrier Reef Marine Park ([Project 4.8.1](#))

Project Leader: Prof Terry Hughes, JCU

Understanding patterns in larval dispersal – connectivity between reefs and the capacity to replenishment stocks - is a major challenge in both marine ecology and fisheries management. Other MTSRF-funded work has shown that green (no-take) zones in the Great Barrier Reef Marine Park promote the abundance, size and reproductive potential of exploited fishes within their boundaries, but an important question remained unanswered: does the reproductive output of fish living within no-take areas contribute to the replenishment of populations in fished areas, particularly for sought after species such as coral trout? This MTSRF project investigated this question in two ways: by developing a detailed model for larval dispersal between reefs in the Great Barrier Reef Marine Park, and by extensive parentage analyses of targeted reef fish species inside and outside green (no-take) zones. The model results indicated that more than half of the larvae produced within green (no-take) zones on the Great Barrier Reef were likely to be exported to other zones. Seeking confirmation in the field, researchers enlisted the help of local recreational fishers in obtaining DNA samples from a large number of adult and juvenile coral trout living on reefs in the Keppel Group. Preliminary genetic analyses have determined that 85 of the sampled juveniles were produced from adults living in green (no-take) zones. Over two-thirds of these identified juveniles were sampled in blue zones; that is, they had dispersed from their parental green (no-take) zones into blue (fished) zones. Observed dispersal distances ranged from 100 m to 24 km, with an average of 6-8 km. This research has demonstrated empirically for the first time that fish protected within green (no-take) zones in the Great Barrier Reef Marine Park make a positive contribution to stocks in adjacent (blue) zones where fishing is permitted. Green (no-take) zones not only promote ecosystem resilience through larval connectivity, but improve the sustainability of fishing in adjacent blue zones.



The impacts of the rezoning of the Great Barrier Reef Marine Park on southern deep water reef-associated fish populations ([Project 4.8.2](#))

Project Leaders: Dr Peter Doherty, AIMS & A/Prof Garry Russ, JCU

In the first-ever examination of the fauna associated with large, discrete deep water reef bases in the southern Great Barrier Reef (Pompeys, Swains and Capricorn-Bunker groups), MTSRF-funded researchers surveyed 16 reef pairs (one zoned green and one blue) using baited remote underwater video stations (BRUVS) up to ~60 m depth. A diverse fauna (~360 species) comprised of fish, sharks, rays and sea snakes was revealed, demonstrating the importance of these deeper water habitats for biodiversity conservation and fisheries sustainability in the region. The primary outcomes of the survey were:

- Zoning had a minor but detectable effect on the maximum number of fish (maxN) observed, but this was detectable only in habitats dominated by corals.
- The maxN for unfished and bycatch species was generally similar around blue (fished) and green (no-take) reefs within reef groups.
- Coral trout, red emperor and red-throat emperor – species particularly prized in both recreational and commercial fisheries - were 1.05, 0.28 and 5.74 individuals (per BRUVS set) more abundant on coral-dominated reefs in green (no-take) zones, than in blue (fished) zones.
- Grey reef sharks (which are taken as bycatch) were more abundant in coral-dominated, open sand and rubble habitats on green (no-take) reefs compared with blue (fished) reefs, particularly in the Swains and Pompeys.
- Target and bycatch species generally had lowest maxN around the Capricorn-Bunker reefs, and white-tip reef sharks were not recorded there in green (no-take) zones.

The consistency of the response of most species targeted by fisheries strongly suggests a positive effect of zoning, although the magnitude of the response - particularly for coral trout - is less than that recorded in shallower habitats of these reefs. Data on spatial and temporal variation in fishing effort in the deep habitats around reef bases were not available, and for this reason these results should not be extrapolated regionally or throughout the Great Barrier Reef Marine Park. It is plausible that fishing around the deep reef bases in these remote southern reefs occurs at such a low level that zoning has negligible effects on local fish abundance in areas already under little to no fishing pressure.

Lost fishing line in green (no-take) zones indicates breakdown in compliance ([Project 4.8.2](#))

Project Leaders: Dr Peter Doherty, AIMS & A/Prof Garry Russ, JCU

Recreational fishers regularly get “snagged” when fishing in coral reef habitats, losing fishing tackle when it becomes entangled on the reef. While most non-stainless steel fishing hooks corrode rapidly, monofilament nylon fishing line can remain in place on the reef for many years. Researchers took advantage of this unfortunate occurrence, using the amount of entangled fishing line sighted during underwater fish surveys as a proxy for relative fishing effort. No significant differences were detected in the amount of discarded fishing line sighted in green (no-take) and blue (fished) zones within any island group in 2009. This lack of difference between zones was most pronounced in the Palm Islands, northeast of Townsville, where the amount of fishing line present in green (no-take) zones was just ~20% less than that observed in the blue (fished) zone. This is particularly concerning given that the vast majority of the fishing line observed in the Palm Islands in December 2009 had accumulated in just two years (volunteer divers from Reef Check Australia removed all lines from two of the three sites within green zones, and one of the three fished zone sites during December 2007), and closely mirrors a documented decline in green-zone coral trout abundance at this location over the same time period. Sites located on the western side of Orpheus Island (in relatively close proximity to the Orpheus Island Research Station and the Orpheus Island Resort) were those in which the lowest amounts of fishing line were located and removed. It is suggested that ‘passive surveillance’ from both the research station and the resort is having a significant effect



on the locations in which fishers are choosing to illegally fish. These results suggest that rates of non-compliance with zoning regulations are surprisingly high within the Great Barrier Reef Marine Park. More effective enforcement of zoning regulations and more effective community education programs are needed if the Marine Park's multiple-use zoning plan is to successfully achieve its objectives of conserving biodiversity and long-term sustainable use.

Management implications of the life history characteristics of serranid fish species on the Great Barrier Reef ([Project 4.8.3](#))

Project Leader: Dr Colin Simpfendorfer, JCU

Sustainable management of fisheries requires sound scientific understanding of the biology and ecology of targeted species. This MTSRF-funded project addressed key gaps in our knowledge of important life history parameters such as growth, length and age at sex change, and longevity for 18 species within five different genera of serranid fishes (groupers) on the Great Barrier Reef. Wide variations in these parameters were observed across all species, precluding any attempt to manage them effectively as a single group. Three species (*Epinephelus fuscoguttatus*, *E. polyphekadion* and *Cephalopholis cyanostigma*) had maximum ages greater than 40 years, some of the oldest epinepheline serranids aged to date. The peak spawning period for a number of species appeared to be in the austral spring and summer, from October to January. Some species were monandric protogynous hermaphrodites (in which individuals are first female, with some mature females later changing sex to function as males), with large overlaps in the size and age of males and females suggesting that the cue for sex change in these species is not based solely on an endogenous developmental schedule – exogenous mechanisms such as the maintenance of a threshold sex ratio within the population could influence the timing of sex change. *E. fuscoguttatus* and *E. polyphekadion* changed sex very late in life (age at 50% sex change greater than the 90th percentile in age) and at very large size (846 mm and 550 mm respectively). However, whilst evidence indicates monandric protogyny for *E. fuscoguttatus*, *E. polyphekadion* males may develop via two pathways (diandry), from immature and mature females. The current management arrangements for these two species on the Great Barrier Reef include both minimum (500 mm) and maximum (700 mm) size limits, affording some protection to the larger *E. fuscoguttatus*, but none at all to large female and male *E. polyphekadion*. While none of the eighteen species reviewed in this project are specifically targeted by fishers on the Great Barrier Reef, there are many instances in which existing regulations and gear selectivity lead to the exclusive harvest of older large males and large mature females, which may not be a desirable management outcome. The results generated by this study are the first available information for some species, and are already helping to improve the sustainability of management of coral reef fisheries, both in the Great Barrier Reef and other parts of the Indo-Pacific.

Shark life histories and their implications for Great Barrier Reef fisheries management ([Project 4.8.4](#))

Project Leader: Dr Andrew Tobin, JCU

This project has made significant steps towards addressing critical knowledge gaps about important life history traits of nine shark and ray species that interact with the East Coast Inshore Finfish Fishery (ECIFF) within the Great Barrier Reef World Heritage Area. The major findings were:

- Maximum age and length demonstrates varied species-specific biological profiles. Extremes are represented by the small and short-lived milk shark and the large and long-lived great hammerhead shark, with maximum length and age recorded at 930 mm and 4.5 years and 4400 mm and 22 years respectively. These extremes are also represented in the growth rates of these sharks, with male milk sharks exhibiting the most rapid growth ($k = 0.94$) and great hammerheads the slowest ($k = 0.04$ and 0.085 for female and male sharks respectively)
- Australian blacktip and spot tail sharks, which dominate the elasmobranch harvest within the ECIFF, display medium maximum sizes (1800 mm and 1310 mm respectively) and longevity (13.9 and 13.6 years respectively).

- Modeled von Bertalanffy growth profiles further reinforce the variation between the age, growth and longevity characteristics of individual species. The smallest and youngest species, the milk shark, grows quickly towards a relatively sharp asymptote; the medium sized Australian blacktip and spot tail sharks grow less quickly with stronger asymptotic tendencies for the smaller spot tail than for the Australian blacktip; while scalloped and great hammerhead sharks have a slower overall growth rate that shows very little tendency to reach an asymptote.
- Male Australian blacktip, spot tail, milk and great hammerhead sharks tend to grow faster, but females tend to have greater longevity and larger maximum lengths than males.
- Male milk, spot tail, Australian blacktip and great hammerhead sharks mature at smaller lengths than their female partners. Only the milk and spot tail sharks matured at lengths less than 1 m, while great hammerhead sharks exhibited the longest length-at-50% maturity at 2284 mm and 2258 mm for females and males respectively.
- Pupping season was the most consistent life history trait between species. All species investigated pup during the warm summer months, with the exception of milk and great hammerhead sharks, which pup aseasonally.

Some of the species (such as milk sharks and spot tail sharks) display life history traits that confer a relatively high resilience to fishing. The primary shark species harvested within the ECIFFF is the Australian blacktip shark, and, based on the new information generated by this project, this species is likely to be less resilient to fishing impacts (relative to milk and spot tail sharks) owing to its slower growth rate, longer lifespan and larger size at maturity. The scalloped and great hammerhead sharks display a mix of biological traits, with some conferring resilience while others suggest vulnerability. Large maximum size and large length at maturity suggest low resilience while very large litter sizes ($n > 20$) is a resilient character. This new information has been incorporated into an ecological risk assessment for inshore species that are targeted by commercial and recreational fishing.

Impacts of the rezoning of the Great Barrier Reef Marine Park on commercial inshore net fishers ([Project 4.8.4](#))

Project Leader: Dr Andrew Tobin, JCU

The impacts of the July 2004 rezoning of the Great Barrier Reef Marine Park on patterns of fishing effort and catch within the inshore commercial net fishery were examined through the analysis of commercial logbook data recorded between 1988 and 2008. Over the period examined, the annual landings within this fishery have increased by over 600%, with 360 t of shark and finfish product harvested in 1988 compared with 2210 t of shark and finfish product landed in 2008. The largest annual catch of 2708 t was recorded in 2003, driven largely by increased activity (effort and catch) within the inshore shark fishery, with slight increases also being recorded for barramundi and threadfins. The period 2000 to 2008 was distinctly different from previous years, showing strong similarity for the targeting (days fished) and harvesting (kg landed) of tropical inshore shark.

Subsequent analyses compared the catch landed and days (fished) during the four years prior to the rezoning and the four years since, for each of the five main target species of the fishery (namely shark, grey mackerel, barramundi, threadfin salmon and garfish) for the whole Great Barrier Reef World Heritage Area, and within each of the five sub-regions (Far North, Cairns, Townsville, Mackay and Capricorn). Results showed that:

- The effort (days fished) within the fishery tends to increase post-rezoning, while catches show slight decreases, although neither trend was statistically significant. Only shark showed a significant decline in landed catch, while grey mackerel showed a significant increase in effort that is likely to be attributable to improvements in gear that allows fishing even in poor weather.
- Within sub-regions, no clear differences between pre- and post-rezoning were evident in either catch or effort of commercial net fishers in the Far North, Cairns or Townsville regions. In the Mackay region, there was no clear difference in effort between pre- and post-rezoning, but there was a difference in catch composition attributable to a decrease in shark catches post-rezoning.



The Capricorn region showed an increased presence of shark in the catches post-rezoning, which corresponded to increased effort targeting shark post-rezoning.

- Overall, only slight changes in effort and targeting behaviours of the commercial fishing fleet were detectable, particularly for shark and grey mackerel.

The commercial inshore net fishery appears to have considerable adaptive capacity that allows individual fishers to catch a range of potential target species depending on seasonal presence, market price, weather, and participation in other fisheries (most commonly crab and line).

Impacts of the 2004 rezoning of the Great Barrier Reef Marine Park on commercial line, trawl and charter fishers ([Project 4.8.5](#))

Project Leader: Dr Steve Sutton, JCU

Commercial line, charter, and trawl fishers were interviewed face-to-face in 2008 and 2009 to investigate their attitudes and perceptions regarding the 2004 Great Barrier Reef Marine Park Zoning Plan, the effects of the plan on their fishing activity and fishing business, their beliefs about the zoning plan and management of the Great Barrier Reef, and their resilience to changes in Great Barrier Reef fisheries. The study aimed to understand (a) fishers' perceptions of the costs and benefits of the zoning plan, and (b) the redistribution of commercial fishing effort in response to the increase in no-fishing areas within the Park. The study concluded that:

- Despite positive attitudes towards environmental protection, most commercial fishers did not believe the 2004 zoning plan was necessary for biodiversity protection in the Park, and most report being unsupportive of the Plan five years after its implementation.
- The reasons underlying fishers lack of support for the 2004 Zoning Plan are related primarily to (a) their perception that they were not meaningfully engaged or consulted in the process of developing and implementing the zoning plan, and (b) the impacts that the zoning plan has had on fishers and their fishing businesses.
- Commercial fishing effort has been concentrated in remaining open areas of the Marine Park since implementation of the Zoning Plan, which has potentially resulted in increased crowding and competition among fishers, and increased impacts of fishing in localized, high-effort areas.

Despite the impacts that commercial fishers have experienced, most fishers reported that they have adapted their fishing activity and fishing business at least moderately well to the new zoning plan in the five years since its implementation. These results suggest that many of the impacts experienced by fishers are likely to be short-term and will decline over time as fishers continue to adapt to the new zoning system. More research is necessary to better understand the strategies that fishers use to adapt to change and the social and economic factors that facilitate or constrain their capacity to adapt to changing environmental or management conditions. The results of this study contribute to our understanding of the overall costs and benefits of the Plan and will be useful as a basis for further monitoring of social impacts on commercial fishing industries in the Park.

Importance of marine wildlife for the Great Barrier Reef tourism industry ([Project 4.8.6](#))

Project Leader: Prof Bruce Prideaux, JCU

This MTSRF-funded socioeconomic study of the importance of marine wildlife to the Great Barrier Reef tourism industry is the first to robustly differentiate between visitor spending per se, and visitor spending that can be directly attributed to this type of tourism. Research on the social and economic values of key marine wildlife species has so far established the regional economic contribution of the live-aboard scuba dive tourism industry in Cairns and Port Douglas as greater than \$16 million per annum, and has identified a range of key marine animals to which this regional expenditure can be directly attributed. For example, calculations based on mean expenditure figures indicate that dwarf minke whale tourism contributed \$20 million to the regional economy during the 2008 season. Surveys of visitor satisfaction revealed that the opportunity to interact with a wide variety



of marine wildlife species scored highest overall, and tourists on Far Northern live-aboard trips reported highest satisfaction with interactions with marine turtles, sharks and rays, and dwarf minke whales (on the limited number of winter trips during which dwarf minke whales are in the region, as 90% of sightings occur in June-July). Tourists' satisfaction with their wildlife experiences is affected by frequency of sightings; tourists reported relatively low satisfaction levels when marine wildlife sightings were less frequent. For example, comparison of survey data across years shows that visitors reported relatively low satisfaction with turtle sightings in 2007, compared to very high levels of satisfaction in 2006 and 2008. This corresponds with the observation that there were unusually low numbers of turtle sightings in the Far Northern region in 2007, compared to other years. The results from this project demonstrate that marine wildlife tourism makes a substantial and important contribution to the Far North Queensland economy. It is not just the transport (boating) sector that benefits: the accommodation, transport, retail and finance, property and business service sectors are significant beneficiaries of the incomes generated by wildlife tourism in the region. These are clear economic reasons – in addition to intrinsic and ecological values – to preserve and protect the marine wildlife of the Great Barrier Reef.

Increased understanding of marine stinger risk ([Project 4.8.7](#))

Project Leader: Prof Michael Kingsford, JCU

In response to concerns about the impacts of marine stingers (jellyfish) on the Great Barrier Reef tourism industry, this MTSRF-funded project has substantially increased our understanding of temporal and spatial changes in distribution patterns of some of the stinger species known or suspected to be associated with irukandji syndrome. Two hundred and sixty-three cubozoan jellyfish were sampled using light traps (they are attracted to lights at night) during the summer months across different habitats and different locations in the northern half of the Great Barrier Reef. While no cubozoan jellyfish were found offshore at any latitude, capture records indicated that, at least in the case of *Carukia barnesi* (the chief causative agent of irukandji syndrome), populations were very localized at small spatial scales, such as bays, from the mainland to mid-shelf reefs. In 2007/8 relatively high numbers of many kinds of jellyfish were observed, suggesting that conditions acting at scales of hundreds of kilometers affect jellyfish abundance, including that of cubozoans. The results from this project indicated that the highest risk of envenomation for swimmers occurs on reefs from the mainland to mid-shelf, especially if granitic islands are present. The period of greatest risk is from October to December, especially if rainfall has been low that season.

Motivation to comply with the Great Barrier Reef Marine Park zoning plan ([Project 4.8.8](#))

Project Leader: Dr Steve Sutton, JCU

The success of the zoning plan for the Great Barrier Reef Marine Park in terms of increasing reef resilience, biodiversity conservation and sustainable fisheries management is wholly dependent on compliance by users. This MTSRF-funded pilot project investigated the motivations of recreational and commercial fishers to comply with the zoning plan. Fisheries Queensland provided inspection and compliance rate data for recreational and commercial finfish fisheries on Queensland's east coast from 2004-2009. Regulations for compliance included both fisheries and marine park regulations. These data provided an opportunity to compare compliance rates between sectors, fisheries, regions, and years. In particular the comparison between sectors and fisheries provides some insight into potential for the differing drivers affecting compliance rates. Researchers then conducted a more general literature review into compliance drivers, motivations, attitudes and resulting behaviours of both recreational and commercial fishers, including potential methods available to investigate these compliance motivations and behaviours. This is a difficult topic to discuss with resource users, and must be approached with care. However, improved knowledge of compliance behaviour and why fishers choose to comply with regulations has important implications for overall sustainability of fisheries and the success of the zoning plan for the Great Barrier Reef Marine Park.

Program 9: Sustainable Use, Planning and Management of Tropical Rainforest Landscapes

[This Program](#) is led by Prof Steve Turton, JCU. Steve's research interests include climatology, rainforest ecology, urban and road ecology, adaptation of tourism and forestry to climate change, Indigenous cultural and natural resource management and environmental management. He particularly focuses on sustainable use, planning and management of tropical forest landscapes in north Queensland, particularly in relation to land-use and climate change.



Prof Steve Turton, JCU

Identification of linked cultural and biophysical indicators for the Wet Tropics World Heritage Area ([Project 4.9.1](#))

Project Leader: Prof Steve Turton, JCU

If current plans to nominate the Wet Tropics World Heritage Area for formal designation as a Cultural Landscape are successful, the management agency will be required to report on the status of the region's cultural values, in addition to the status of the natural values for which the Area is already recognised. Identification of appropriate and meaningful indicators for the cultural status of the Rainforest Aboriginal Peoples who have shaped the Wet Tropics Cultural Landscape over thousands of years has been the focus of this MTSRF-funded project. The eighteen linked cultural and biophysical indicators that have been identified fall into six categories:

1. Recognition of rights and interests;
2. Participation in management;
3. Socioeconomic benefits;
4. Heritage and spiritual values;
5. Understanding history; and
6. Climate change.

The regional indicators are designed to reflect changes in Rainforest Aboriginal Culture (positive or negative) and are measurable attributes that Indigenous communities feel are acceptable and appropriate to measure and include in routine monitoring programs. The categories and indicators have been presented within a 'spider's web' framework, acknowledging that for any action on country there will be consequences felt throughout country. In addition to routine regional monitoring and reporting, these cultural indicators can be included in joint management initiatives/proposals; used in country-based management plans; support participation of Traditional Owners in cultural heritage management; support cross-cultural development, understanding and conflict resolution; and can provide a pathway for integration into future decision-making processes. Improving representations of Indigenous Culture in formal reporting frameworks remains a significant challenge...



Drivers, trends and management tools for tourism in Wet Tropics rainforests **([Project 4.9.2](#))**

Project Leader: Prof Bruce Prideaux, JCU

This MTSRF-funded project investigated aspects of the visitor experience at ten sites across the Wet Tropics World Heritage Area. Specific elements of the visitor experience include socio demographic characteristics of visitors, the facilities used, activities undertaken, visitor perceptions of the environmental quality of sites and suggestions for improvements. The most popular activities undertaken varied between sites but generally included observing the scenery, short walks, swimming where available, photography and relaxing. Respondents were very positive about their experiences and few problems were identified. In summary the results were a positive endorsement of the standards of visitor sites in the Wet Tropics World Heritage Area. This project has also given rise to the first-ever Tour Guide Handbook to the Wet Tropics Rainforests, a training resource aimed at providing local rainforest tour guides with accurate, relevant information about the region and its World Heritage values, which they can then use to further enhance visitor experiences.

Managing and remediating impacts on north Queensland rainforests **([Project 4.9.3](#))**

Project Leader: Prof Steve Turton, JCU

Monitoring funded through this MTSRF project shows that while the habitat quality of remnant and riparian vegetation in the Mission Beach region is still affected by the aftermath of Tropical Cyclone Larry (March 2006), recovery is occurring. Extensive field studies including vegetation and microclimate assessments and bird surveys showed that, due to the patchy nature of the impact, even small forest remnants and riparian rainforest strips along watercourses appeared to retain levels of biodiversity similar to areas of continuous forests that suffered severe damage in the cyclone. It appears that normal species-area relationships do not necessarily apply after such a severe cyclone, which makes rapid assessment of habitat quality problematic. These observations reinforce the need to conserve even small areas of forest in the fragmented landscape, so that there are a wide range of areas of forest - in terms of size and position in the landscape - that can act as "sources" of rainforest species after such large natural disturbances. This project has also investigated ways to remediate human impacts, such as those associated with roads, on sensitive rainforest habitats. The scientific results from this project have been compiled into two volumes - *Roads in Rainforest: Best Practice Guidelines – Planning, Design and Management* and the accompanying *Roads in Rainforest: Science behind the Guidelines* – which have already been adopted by Queensland Transport and Main Roads throughout the State, as well as by local governments maintaining and constructing roads and assessing road applications in rainforest habitat. Other government departments and entities including DERM and WTMA will also be able to apply these documents within their management regimes.

Improving the rate of environmental practice change amongst Wet Tropics landholders **([Project 4.9.4](#))**

Project Leaders: Dr Nick Emtage & A/Prof John Herbohn, UQ

The adoption of recommended management practices on privately-owned rural lands in the catchments of the Great Barrier Reef is central to the strategy being employed by Australian governments to improve the health of terrestrial and aquatic environments in Queensland. The main strategy employed to date in effecting practice change has been to encourage landholders to voluntarily adopt best management practices. This MTSRF-funded project examined rural landholders' attitudes to practice change, management goals, communication behaviour and trust of others, in the Wet Tropics Natural Resource Management (NRM) region. Mail- and interview-based surveys were used to explore landholders' land and water management practices, attitudes to natural resource management issues, management objectives, use of information to support management decision making, trust of organisations and individuals and their socio-economic and demographic characteristics. Results showed substantial individual-level variation in the relative



importance of economic, environment and social goals for Wet Tropics landholders. On average, landholders considered generalist information sources (including media) and financial/family advice to be more useful than enterprise-based or environmental-based information sources, although significant differences were observed between landholder groups with differing primary purposes for land ownership and scales of operation. Government agencies did not score highly in terms of the trust expressed in them by rural landholders in the Wet Tropics, probably reflecting a widespread rural cynicism regarding government involvement in natural resource management. Many landholders lack trust and confidence in government appraisals of the causes and extent of 'environmental problems', a topic that was raised repeatedly during the interviews of landholders undertaken for this study. Some fear the dilution of their property rights and reject the idea that their activities are the primary cause of degradation in the marine environment. Participation in NRM programs to date has been biased towards those with larger-scale cropping and mixed farming enterprises. Participation in NRM programs was also found to be strongly related to participation in short training courses and the preparation of property management plans. Those wishing to engage the interest of a broad range of landholders in natural resource management programs in the Wet Tropics would be most likely to succeed if they adopt an integrated approach that combines education and awareness campaigns with financial and technical assistance programs.

Monitoring recovery of biodiversity in revegetated rainforest sites ([Project 4.9.5](#))

Project Leader: A/Prof Carla Catterall, GU

This MTSRF-funded project has sought to quantify and improve the success of rainforest revegetation projects in terms of both biodiversity recovery and carbon biosequestration, and many of its findings and products have already been adopted by practitioners in the Wet Tropics and further afield. This year, these researchers have delivered the third instalment of their very well-received *Monitoring Revegetation Projects in Rainforest Landscapes* toolkit – the bird survey module. As with previous modules, researchers have produced a relatively simple and time-efficient yet robust monitoring protocol that generates useful quantitative data and requires minimal specialist knowledge, and is appropriate for monitoring by community groups. The method permits comparison of bird species composition (as a proxy for general biodiversity recovery) between revegetated and reference sites. Although the toolkit survey methods have been designed specifically for monitoring the progress of revegetation projects, these protocols can also be used by non-specialists to assess the condition of remnant rainforest patches, and monitor changes over time.

Development and refinement of indicators for effective water quality governance: Applications in the Wet Tropics ([Project 4.9.6](#))

Project Leader: Dr Cathy Robinson, CSIRO

The achievement of water quality targets to halt the decline of water quality entering the Reef from diffuse sources relies on an effective system of governance capable of facilitating the necessary co-operation and coordination between multiple environmental decision-makers and their activities. This MTSRF-funded research project aimed to improve the management of natural resources and supply of ecosystem services on private land in the region, specifically, the governance arrangements needed to support natural resource management programs for water quality improvement in Great Barrier Reef catchments. Researchers identified the critical attributes that determine the success or otherwise of cooperative planning and implementation of environmental policy in this specific context, and developed a framework that uses knowledge indicators to evaluate collaborative governance performance. The validity and usefulness of this framework was then tested, with researchers using it to assess the implementation of the Wet Tropics Reef Rescue (Transition Year) Implementation Package, a component of the Australian Government's *Caring for Our Country* program. After the assessment was completed, information was promptly incorporated (within 4-8 weeks) back into the Wet Tropics Reef Rescue Grants Program. The assessment enabled modifications to processes and approaches to improve delivery for the remainder of Year 1, and further refinements for Year 2. These improvements involved more regular communications with partners, enhancing partner engagement in planning and priority setting, and further development of tools, processes, and



procedures to support efficient and effective program delivery. Within the 2009/2010 financial year alone this project has delivered a framework to assess water governance arrangements that has been used by Wet Tropic regional NRM and industry group stakeholders, and overall has provided consistent and strong solution based outcomes to improve Reef Rescue grant allocations and decisions.

Practical policy advice for environmental offset program implementation and refinement ([Project 4.9.6](#))

Project Leader: Dr Cathy Robinson, CSIRO

With considerable public and private effort focused on managing the impact of development on the Southern Cassowary in the Mission Beach region, this MTSRF-funded project looked at ways to plan and assess development offsets, with the aim of contributing to offset policy refinement under the *EPBC Act* 1999. Researchers also used this case study to analyse who bears the costs of this policy approach, and why. Some of their major conclusions were:

- Uncertainty surrounding what has to be done, who can do it, who can be included in negotiations, etc, increases the transaction costs to all parties but particularly the developers who must conduct offsets.

Offset requirements must be aligned with what is institutionally practical and possible to enable good outcomes at least possible costs to all parties...

- It is important to have a good understanding of the service of the impacted asset and what level of equivalence is required to truly offset this.
- There is more than one type of offset design. Different designs generate different extent and distributions of costs and benefits across participants. The design of the offset needs to be carefully matched with the participants and the overall offset objective.
- Transfer of responsibility can occur through a variety of mediums - it is important to consider these and choose the one most suitable for the offset and the desired outcome.
- Offsets that require highly specific configurations of inputs to be of value (for example, specific vegetation in specific arrangements across the landscape to be effective as habitat for cassowaries) have a significant impact on the transaction costs of the policy administrator, developers and offset suppliers. This spatial specificity means that transactors have to invest in information collection activities to determine the configuration of the required offset. Frequent transactions and learning could reduce information transaction costs (through formalisation of this learning into processes, systems, metrics etc).

Improving the effectiveness of community-based natural resource management ([Project 4.9.6](#))

Project Leader: Dr Ro Hill, CSIRO

The generally poor performance of community-based natural resource management (CBNRM) approaches mandated by national policy highlights the need to search for better models. MTSRF-funded researchers took a co-researching approach to develop, apply and test the transferability and effectiveness of a new model and tools for CBNRM in biodiversity conservation. Adaptive co-management, designed with specific communities and natural resources, recognized as linked to multi-scalar phenomena, is the new face of CBNRM. New tools used to achieve adaptive co-management include a collaborative focal species approach focused on the iconic southern cassowary, scenario analysis, science brokering partnerships, a collaborative habitat investment atlas and institutional brokering. An intermediate-complexity analytical framework was used to test the robustness of these tools and therefore likely transferability. The tools meet multiple relevant standards across three dimensions, namely empowering institutions and individuals, ongoing systematic scientific assessment and securing effective on-ground action. Evaluation of effectiveness using a performance criteria framework identified achievement of many social and



environmental outcomes. Effective CBNRM requires multi-scale multi-actor collaborative design, not simply devolution to local-scale governance. Bridging/boundary individuals and organisations are important to facilitate the process.

Understanding and monitoring social resilience in the Great Barrier Reef region ([Project 4.9.7](#))

Project Leaders: Prof Helen Ross, UQ; Dr Tim Lynam, CSIRO; Dr Margaret Gooch, JCU

MTSRF-funded researchers working on this project have sought to develop a framework and set of indicators that would enable regional natural resource management bodies or state government agencies to explore the likely impacts of interventions such as financial incentives or regulations on the adaptive abilities of society. The objective of this research was to develop, test, and refine a conceptual framework and indicators of regional-scale social resilience in the Great Barrier Reef region. A conceptual model of social resilience has been developed, as well as some preliminary indicators of social resilience. This provides potential users with sufficient information on the conceptual model and draft indicators to enable them to provide researchers with comments and critical feedback to improve both the model and the indicators. A two-stage process of data collection and analysis has identified the “current best” set of 20 indicators of social resilience to environmental and/or social change in the Great Barrier Reef region.

Enhancing Delivery (Theme 5 of the MTSRF)

The MTSRF aims to increase the sustainability of management and use of north Queensland’s key environmental assets – the Great Barrier Reef and its catchments, the Wet Tropics rainforests and the Torres Strait. Even at the outset it was clear that achieving this objective of increased sustainability would require not only targeted applied research projects that explicitly addressed the needs of end-users, but successful transfer of the new knowledge to end-users in appropriate and accessible forms. Strategic, adequately-resourced knowledge brokering and communications activities were therefore recognised as fundamental to the achievement of the hub’s objective.

Program 10: Enhancing Delivery of the MTSRF

[Program 10](#) is led by Dr Suzanne Long, Senior Scientist at the Reef and Rainforest Research Centre. The knowledge brokering activities conducted in this Program have helped bridge the science-policy gap through targeted synthesis and delivery of interpreted technical and scientific information to a wide range of stakeholders, including government ministers and their advisors, industry, NGOs, community and indigenous groups. Suzanne’s research interests include marine ecology, conservation biology and the evolving field of knowledge brokering.



Dr Suzanne Long, RRRC

The strategic knowledge brokering, engagement and communications activities conducted under this program had the explicit aim of enhancing delivery of the new information generated through MTSRF funding to end-users. This has not been a trivial task: although there is increasing recognition



of the need to bridge the gap between science and policy/practice, implementation continues to be problematic worldwide. However, the dedication of significant resources to this task within the MTSRF has permitted significant innovation and achievement in this area.

Activities conducted under this program were informed by both emerging global best-practices in knowledge transfer and understanding of local end-user needs, and included:

- collaborative definition of research questions (annual project brokering and planning)
- facilitation of sustained and meaningful engagement between researchers and end users (quarterly Steering and Operations Committee meetings, workshops, annual MTSRF conference)
- inclusion of end-users in the research process (annual research project brokering, quarterly Operations Committee meetings)
- the use of intermediaries who understand the perspectives, needs and motivations of both researchers and end-users (knowledge brokers)
- development, monitoring, evaluation and refinement of innovative mechanisms to enhance delivery (annual benchmarking survey, Pathways to Impact analysis, Essential Science sessions, web-based communication methods including Communiques and RSS feeds)

From the outset, the construction and maintenance of a functional and easy-to-use website has been a key focus of the Enhancing Delivery program. This was important because surveys showed that key end-users of MTSRF tended to turn to the internet first when they were looking for information, and additionally it ensured that all information generated through the MTSRF became publicly available in a timely fashion. Please see Appendix 2 for the full list of documents available for download from the website at June 2010. Large numbers of reports, fact sheets and publications are continuing to be produced and made available via the website beyond June 2010. Analyses of website statistics demonstrated that the most frequently visited and downloaded pages and documents were those that contain information synthesised across multiple projects, presented in plain English, rather than technical or research reports. This capacity to draw together information from projects across the entire scope of the MTSRF, such that the implications of the science are clear for users and managers, has been a major strength and achievement of Theme 5.

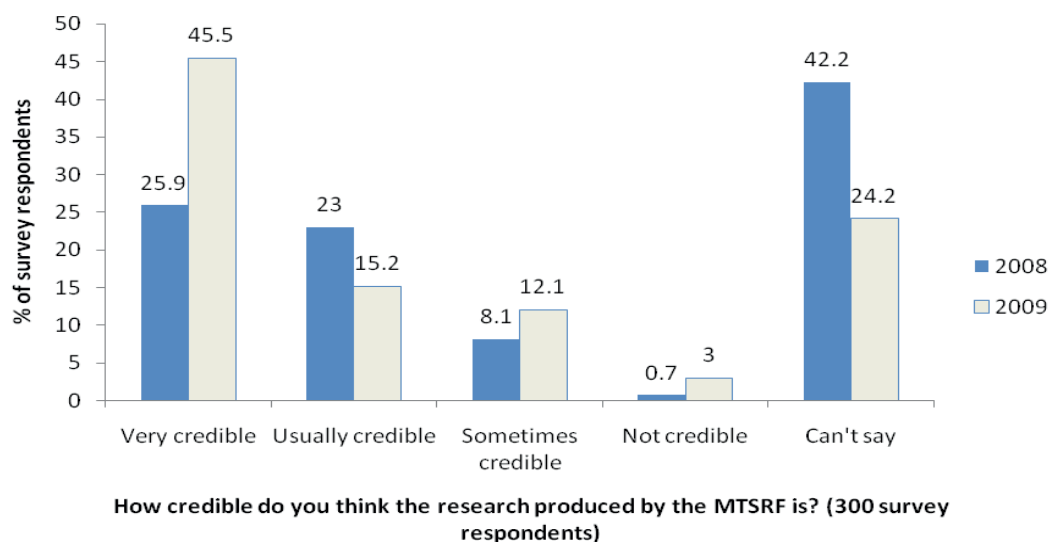
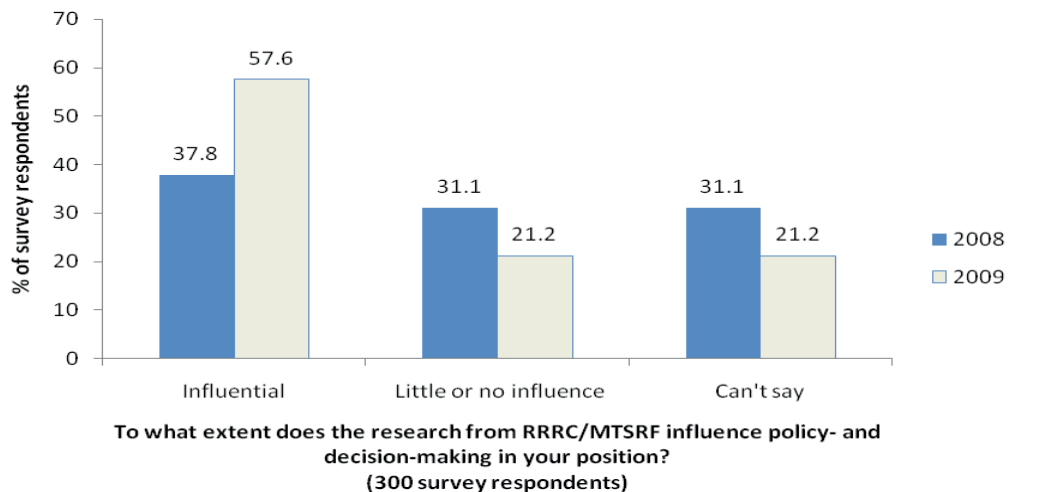
As 2009/2010 was the fourth and final year of the MTSRF, effort was also invested in evaluating the success of the activities conducted under Theme 5. Did the Enhancing Delivery program help the MTSRF achieve its objective of increasing sustainability of management and use? The size and complexity of the MTSRF meant that there was considerable scope for monitoring and evaluation of the success of enhancing delivery efforts. While conventional quantitative monitoring of proxies of delivery success – such as number of visitors to the website, number of document downloads, number of peer-reviewed publications, number of attendees at Essential Science Sessions – were indicative, they were considered inadequate measures of whether the MTSRF was achieving its objectives. As a consequence a more innovative approach to evaluating delivery success was developed. Three hundred individuals working in decision- or policy-making roles in the MTSRF's specified end-user organisations were surveyed in late 2008 and then again in late 2009, after 12 months of strategic enhancing delivery effort. Methodologies were identical between years, and wherever possible the same individuals were surveyed each year.³ A wide variety of questions were asked, aiming to uncover which particular communication mechanisms had been effective for particular end-users, and why.

Of particular interest were the compiled answers to two questions about the credibility and impact of information generated from the MTSRF (See figures below). The results show that the knowledge brokering and communications activities conducted under Theme 5 were effective in increasing both the perception of credibility and the perception of influence of information generated by the MTSRF, even over such a relatively short time period. While direct measurement of the impact of the

³ When individuals that were surveyed in 2008 were unavailable in 2009, the new occupants of their roles, or individuals occupying similar roles in similar organisations, were surveyed instead.



MTSRF on increasingly sustainable policy and practice is not yet possible⁴, the ~60% of end-users finding MTSRF-generated information influential in their positions bodes well for the eventual impact of the MTSRF in terms of increasing sustainability. It is also a clear indication of the capacity for strategically-driven, adequately-resourced knowledge brokers to maximise the return on investment in publicly-funded research.



The e-Atlas: An online knowledge management system for Australia's Tropical Lands and Seas

Why do we need an e-Atlas?

Managing our tropical lands and seas to enhance their resilience, particularly in the face of growing threats posed by climate change, declining water quality and unsustainable use, is a significant scientific, policy and management challenge. Effective collation, analysis, synthesis and communication of credible bio-physical and socio-economic information to policy makers, natural resource managers, scientists and the general public will be one of the keys to successfully meeting this challenge. The Australian Institute of Marine Science with funding from the MTSRF, Great Barrier Reef Foundation and Great Barrier Reef Marine Park Authority has developed the e-Atlas and is working with Dr David Souter to coordinate a substantial collaborative effort to populate the e-Atlas and increase its usefulness and useability (<http://e-atlas.org.au>).

⁴ But see the Impacts of the MTSRF booklet at http://www.rrrc.org.au/publications/downloads/mtsrfr_impacts.pdf for a work-in-progress.



What is the e-Atlas?

The e-Atlas is a new online knowledge management system that integrates a range of technologies to effectively use and share information in order to enhance evidence-based decision making for effective management and long-term sustainable use of the Great Barrier Reef and its catchments, the Wet Tropics Rainforest and Torres Strait. The e-Atlas is a portal providing access to the data and information handling, spatial mapping and analytical tools to collate, integrate, share and analyze the vast array of bio-physical and socio-economic information required to manage these environmentally, economically and culturally valuable systems effectively. The e-Atlas is also the knowledge repository for the entire \$40 million MTSRF program.

What will you find in the e-Atlas?

The e-Atlas currently holds a growing number of text pages that deliver syntheses of the latest scientific thinking on a wide range of issues facing the marine, freshwater and terrestrial environments of North Queensland. These syntheses have been derived from the latest scientific literature, much of which is founded on research conducted within the MTSRF program, and can be downloaded from the e-Atlas, along with images, meta-data, data and KML files for use in Google Earth. The e-Atlas now holds meta-data records for 38 datasets from 11 different national, state and local institutions or agencies. Twenty-seven of these datasets, many of which have been collected over decades and span large geographic areas (e.g. the entire Great Barrier Reef and Wet Tropics World Heritage Areas), have been incorporated into the e-Atlas mapping system to produce more than 600 maps, all of which can be viewed by anyone online.

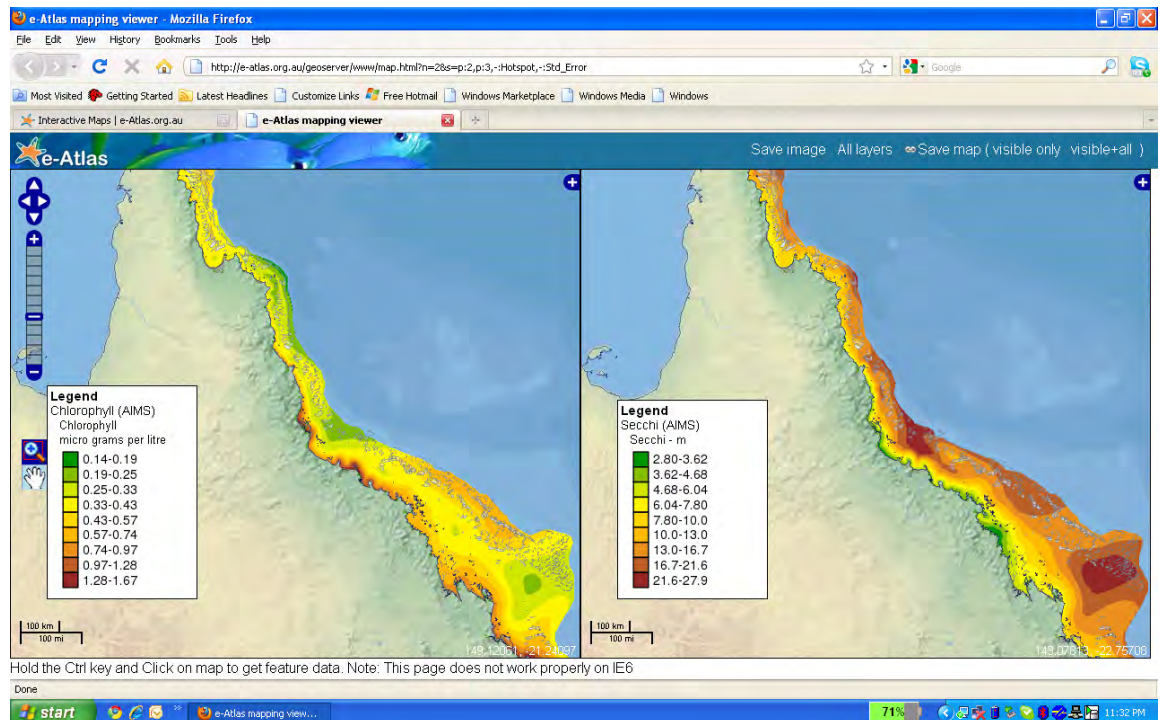
The e-Atlas uses a unique and sophisticated interactive mapping system that enables the simultaneous comparison of up to three maps and multiple variables side-by-side. This unique ability enables the e-Atlas to effectively illustrate the numerous characteristics of North Queensland's ecosystems, particularly patterns and hotspots of biodiversity and threats, facilitating the identification and improvement of understanding of the major risk and resilience factors influencing the MTSRF region, and their ecological, social and economic impacts; and enhances capacity to evaluate and implement effective policy and management responses to ensure the long-term sustainability of North Queensland's natural assets.

How does the e-Atlas share information?

The e-Atlas is based entirely on open-source software and integrates several technologies to fulfill the e-Atlas' central objective of sharing and communicating information. For example, the e-Atlas uses internationally recognized standards (WMS feeds) to deliver content to commonly used GIS systems, particularly within federal and state government departments and agencies. In addition, the e-Atlas is linked to a number of external databases enabling the latest information to be communicated from a distributed system of data stores. The e-Atlas also supports an online meta-data store that adheres to Australian best practices for spatial data management, 'wiki' capacity to facilitate external contributions of meta-data, data, reports, and images, and finally, downloadable KML versions of many of the maps so that they can be incorporated into your own Google Earth collection.

Demonstrable examples of adoption

Along with the MTSRF website, the e-Atlas is already the major knowledge and meta-data capture and delivery tool for the MTSRF program. Since March 2010, the e-Atlas has attracted 1700 unique visitors (based on IP), more than 7800 page views, and has received more than 410,000 map image requests. The e-Atlas has made a substantial contribution to the first GBRMPA Outlook Report and is currently being trialed internally within GBRMPA as a 'no-cost' GIS platform that provides all GBRMPA staff with the capacity to visualize and interrogate spatial information describing the GBR. Planning is also underway to incorporate the e-Atlas into the Australian Government's Caring for Our Country - Reef Rescue initiative as the major reporting tool for monitoring programs, enabling the evaluation of progress towards improvements in reef condition.



Screen capture of the e-Atlas interactive mapping system showing two maps side-by-side. The left hand panel illustrates the long-term average concentration of chlorophyll across the GBR. The right hand panel illustrates the long-term average water clarity across the GBR.

Conference report: the Annual MTSRF Conference, Cairns, 18-20 May 2010

The fourth and final annual MTSRF conference was the most successful and well-attended yet, with over 300 registered delegates listening to ~110 speakers over three days (18-20th May 2010, in Cairns). Themed Impacts and Achievements of the MTSRF, the objective of the conference was to showcase the Australian Government's investment in the MTSRF in terms of improved sustainability for the North Queensland region, and Australia. The conference was opened by Minister Peter Garrett, who spoke warmly about the MTSRF's many achievements and chose to particularly highlight the consortium's emphasis on producing practical information that can be applied by end-users. The conference included special sessions on Sustaining Rainforests, Sustaining the GBR, Sustaining the Torres Strait, and Managing reefs and rainforests despite climate change, as well as numerous satellite meetings and workshops and the launch of two major MTSRF-funded products. Most of the presentations, plus the 90-page conference program, are available on the conference page on the MTSRF website⁵.

⁵ http://www.rrrc.org.au/news/2010_conference.html



Minister Peter Garrett opening the fourth and final Annual MTSRF Conference in Cairns, 18 May 2010.

MTSRF Scholarship students

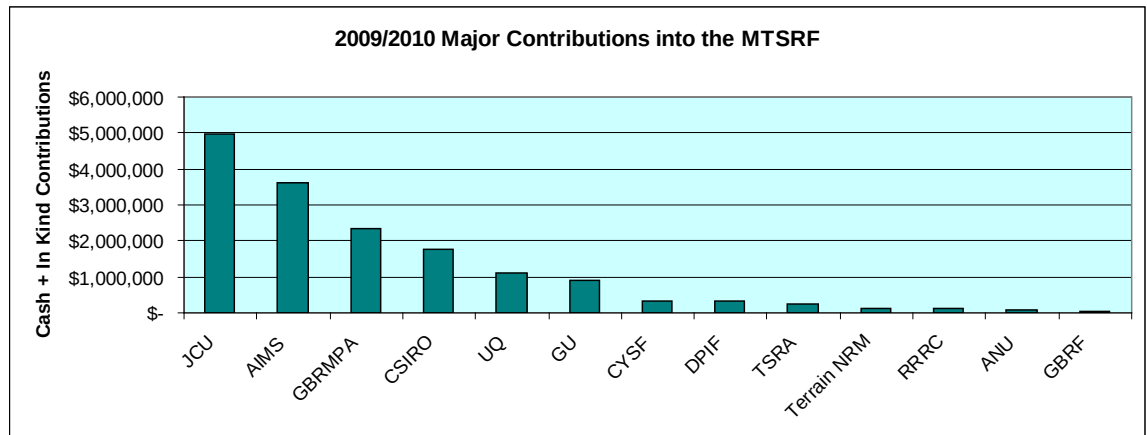
As part of its commitment to capacity-building in north Queensland, a large number of students have been supported by the MTSRF over its four-year term. Postgraduate research projects that have received funding are directly related to the multidisciplinary research addressed by the MTSRF and align with MTSRF Projects. Students are based at one or more of the contracted MTSRF research provider institutions. During 2009/2010, the following students were wholly or partially supported by MTSRF funding:

Miss Tara Clark	UQ
Mr George Roff	UQ
Mr Alberto Rodriguez	UQ
Rohan Wilson	JCU/ANU
Ms Mariana Fuentes	JCU
Ms Kristen Weis	JCU
Mr John Dawson	JCU
Aurelie Delisle	JCU
Alvaro Berg Soto	JCU
Mr Nikolaus Csaszar	UTS/AIMS
Ms Ana Redondo Rodriguez	UQ/AIMS
Vanessa Valdez Ramirez	JCU
Verena Witt	AIMS
Mr Aaron Ballagh	JCU
Mr Alistair Harry	JCU
Mr Jimmy White	JCU
Ms. Debora DeFreitas	JCU
Arnold Mangott and Matthew Curnock (PhD students)	JCU
Ms Charlotte Morgan	JCU
Lisa King (PhD student)	JCU
Ms Moni Carlisle	JCU
Ms Snowy Evans	JCU
Ms Renee Craft	JCU

Financial Report

The total funding into the MTSRF in 2009/2010, including co-investment and in-kind contributions for completed Themes 1 to 5 projects, was \$24 million.

The institutions which contributed via cash and/or in kind contributions into the MTSRF program for the 2009/10 financial year to a value greater than \$50,000 are highlighted in the chart below.







Appendix 1

This is the full list of projects managed and delivered by the RRRC in 2009/2010 (ARP4 of the MTSRF), including MTSRF Extension Projects and the Marine Monitoring Program.

Theme 1: Status of the Ecosystems

Program 1: Status and Trends of Species and Ecosystems of the Great Barrier Reef **Dr Peter Doherty, AIMS**

- Project 1.1.1: Identification of indicators and thresholds of concern for ecosystem health on a bioregional scale for the Great Barrier Reef.
A. Prof. Michelle Waycott, JCU & Dr Hugh Sweatman, AIMS
- Project 1.1.2: Condition and trend of the GBR ecosystem: Indicators, thresholds of potential concern and ecological influence of GBR Zoning Plan on mid and outer reefs
Dr Hugh Sweatman, AIMS & Dr Marie-Lise Schlappy, Reef Check
- Project 1.1.3: Condition, trend and risk in coastal habitats: Seagrass indicators, distribution and thresholds of potential concern
A. Prof. Michelle Waycott, JCU & Mr Len McKenzie, QDPI&F
- Project 1.1.3a*: Marine Monitoring Program - Inshore Seagrass Monitoring (3rd Party Task: GBRMPA)
A. Prof. Michelle Waycott, JCU & Mr Len McKenzie, QDPI&F
- Project 1.1.4: Dating and mapping historical changes in GBR coral communities
Dr Jian-Xin Zhao, UQ
- Project 1.1.5: The e-Atlas: Risk, Resilience and Response
Dr Katharina Fabricius, AIMS

Program 2: Status and Trends of Species and Ecosystems in the Wet Tropics Rainforests **Dr James Butler, CSIRO**

- Project 1.2.1a: Identification Skills Workshops – Australian Tropical Rain Forest Plants
Prof Darren Crayn, ATH
- Project 1.2.1b: Biodiversity Monitoring for Climate Change
Dr Stephen Williams, JCU
- Project 1.2.1c: Status and trends of biodiversity and ecosystem services: state of the environment reporting
Dr James Butler and Dr Petina Pert, CSIRO
- Project 1.2.1d: Status and trends of biodiversity and ecosystem services - Insect Biodiversity
Prof. Nigel Stork, UniMelb
- Project 1.2.1s: Mullumbarra Yidinji indicators and values of the Mulgrave Valley
Dr James Butler, CSIRO/JCU

Program 3: Torres Strait – Status, Use and Trends **Mr Vic McGrath, TSRA**

- Project 1.3.1: Oral histories of past and present climate change
A/Professor Kevin Parnell & Dr Karen McNamara, JCU
- Project 1.3.2: Ecological role and potential economic value of sponges to the Torres Strait
Dr Chris Battershill, JCU
- Project 1.3.2a*: Hawksbill turtle diet and distribution in the waters around Masig and Kodall Islands, Torres Strait (3rd Party Task: TSRA)
Dr Mark Hamann, JCU
- Project 1.3.2s: Impact and causes of sponge disease in Torres Strait and the Great Barrier Reef
Dr. Rocky De Nys, JCU



- Project 1.3.3: Livelihood benefits of co-management of hand collectable fisheries in the Torres Strait
Dr James Butler, CSIRO
- Project 1.3.3a: Sea Turtle and Dugong Education Program in Western Province PNQ
Dr David Roe, Sea Turtle Foundation
- Project 1.3.4: Communication, community engagement and enhanced delivery
Mr Vic McGrath, TSRA
- Project 1.3.5: Data integration and synthesis for development of reports on ecosystem health in the Torres Strait region
Dr James Butler, CSIRO

Program 4: Species and Communities of Conservation Concern Professor Helene Marsh, JCU

- Project 1.4.1: Condition trends and projected futures of marine species of conservation concern
Dr Mark Hamann, JCU
- Project 1.4.1s:* Ecological and trophic relationships within Wet Tropics freshwater turtle communities and their sensitivity to climate change and habitat alteration
Dr Mark Hamann, JCU
- Project 1.4.2: Sustainable use of marine species of conservation concern
Prof. Helene Marsh, JCU
- Project 1.4.3: Rainforest threatened species and communities and ecosystem processes
Dr Dan Metcalfe, CSIRO

Theme 2: Risks and Threats to the Ecosystems

Program 5: Climate Change: Understanding the Threat, Ecosystem Impacts and Mitigation

Program 5i: Climate Change: Great Barrier Reef Dr Julian Caley, AIMS

- Project 2.5i.1: Hydrodynamics at the whole of GBR scale
Dr Richard Brinkman, AIMS
- Project 2.5i.2: Early warning and assessment system for thermal stress on the Great Barrier Reef
Professor Ove Hoegh-Guldberg, UQ
- Project 2.5i.2b*: Early warning and assessment system for thermal stress on the Great Barrier Reef (3rd Part Task: GBRF)
Dr Scarla Weeks, UQ
- Project 2.5i.2c*: Early warning and assessment system for thermal stress on the Great Barrier Reef: development of a genetic method to assess bleaching tolerance in corals (3rd Part Task: RRRC)
Dr Madeleine Van Oppen, AIMS & Dr Petra Souter, AIMS
- Project 2.5i.2d*: Vulnerability of high trophic levels on the GBR (e.g. sea birds) to climate change (3rd Part task: RRRC)
Dr Brad Congdon, JCU
- Project 2.5i.2s:* Climate change and satellite oceanography of the Great Barrier Reef
Dr Scarla Weeks, UQ
- Project 2.5i.3: Resilience to climate change
Professor Terry Hughes, JCU & Dr Julian Caley, AIMS
- Project 2.5i.3s:* Assessment of ecological connectivity in corals: Implications for their recovery from major perturbations and their potential to adapt to climate change
Dr. Madeleine van Oppen, AIMS
- Project 2.5i.4: Tools to support resilience-based management in the face of climate change
Dr Scott Wooldridge, AIMS



Program 5ii: Climate Change: Rainforests and Catchments Professor Steve Turton, JCU

- Project 2.5ii.1: Regional climate projections for tropical rainforests
Dr. Suppiah Ramasamy, CSIRO
- Project 2.5ii.2: Climate change: scaling from trees to ecosystems
Dr Michael Liddell, JCU
- Project 2.5ii.3: Understanding climate change threat to ecosystems and ecological processes
Dr David Hilbert, CSIRO
- Project 2.5ii.4: Impacts of climate change on biodiversity
Associate Professor Steve Williams, JCU
- Project 2.5ii.4s:* Conservation of the northern bettong B tropics, a rare and threatened endemic macropod species of the Wet Tropics: limits to current distribution and a mechanistic model for predicting effects of climate change
Dr Steven Williams, JCU
- Project 2.5ii.4s2:* Biodiversity of dung beetles in the Wet Tropics biogeographic region: assessing the impacts of climate change on an important functional group
Dr Steven Williams, JCU

Program 6: Understanding Threats and Impacts of Invasive Pests on Ecosystems Dr David Blair, JCU and Dr David Westcott, CSIRO

- Project 2.6.1: Understanding threats and impacts of invasive pests in the Great Barrier Reef
Dr David Blair, JCU
- Project 2.6.2: Identification and impact of invasive pests in the Wet Tropics rainforests
Dr David Westcott, CSIRO
- Project 2.6.2s:* Feral Pig Research in the Wet Tropics
Dr Michael Bird, JCU

Theme 3: Halting and Reversing the Decline of Water Quality

Program 7: Halting and Reversing the Decline of Water Quality Dr K. Fabricius, AIMS; Prof. R. Pearson, JCU; Prof. I. Gordon, CSIRO

- Project 3.7.1: Marine and estuarine indicators and thresholds of concern
Dr Katharina Fabricius, AIMS
- Project 3.7.1b*: Marine Monitoring Program – ‘Inshore Coral Reef Monitoring’ (3rd Party task: GBRMPA)
Dr Britta Schaffelke, AIMS & Prof Jochen Mueller, UQ
- Project 3.7.1s:* Understanding interactive effects between pesticides and climate change on symbiont bearing and calcifying marine species
Prof. Jochen Mueller, UQ
- Project 3.7.2: Connectivity and risk: tracing materials from the upper catchment to the reef
Mr Jon Brodie, JCU
- Project 3.7.2b*: Reef Rescue Marine Monitoring Program – Assessment of terrestrial runoff entering the GBR lagoon (3rd Part Task: GBRMPA)
Dr Michelle Devlin, JCU; Dr Arnold Dekker, CSIRO; Prof Jochen Mueller, UQ
- Project 3.7.3: Freshwater indicators and thresholds of concern
Professor Richard Pearson, JCU and Professor Angela Arthington, GU
- Project 3.7.3s2:* Validating freshwater fish indicators and thresholds of concern in the Wet Tropics streams
Professor Richard Pearson, JCU
- Project 3.7.4: Wetlands and floodplains: connectivity and hydro-ecological function
Professor Jim Wallace, CSIRO

- Project 3.7.5: & 3.7.6: Socio-economic constraints to and incentives for the adoption of land use and management options for water quality improvement
Dr Martijn van Grieken, CSIRO
- Project 3.7.7: Analysis and synthesis of information for reporting credible estimates of loads for compliance against targets and tracking trends in loads
Dr. Petra Kuhnert, CSIRO
- Project 3.7.8*: Marine Monitoring Program – Inshore Marine Water Quality Monitoringm (3rd Party Task: GBRMPA)
Dr Britta Schaffelke, AIMS; Prof Jochen Mueller, UQ; Dr Vittorio Brando, CSIRO
- Project 3.7.11: Sediment sources, sinks and drivers in the Normanby catchment, Cape York (3rd Party Task: Cape York Sustainable Futr.
Dr Andrew Brooks, GU

Theme 4: Sustainable Use and Management

Program 8: Sustainable Use and Management of Marine Resources of the Great Barrier Reef Dr Colin Simpfendorfer, JCU

- Project 4.8.1: Resilience and connectivity
Professor Terry Hughes, JCU
- Project 4.8.2: Influence of the Great Barrier Reef Zoning Plan on inshore habitats and biodiversity, of which fish and corals are indicators
Dr Peter Doherty, AIMS & Prof. Garry Russ, JCU
- Project 4.8.3: Evaluation of the resiliency of key inter-reefal fish species
Dr Colin Simpfendorfer, JCU
- Project 4.8.4: Evaluation of the impacts from industry and community uses on inshore biodiversity
Dr Andrew Tobin, JCU
- Project 4.8.4s:* Importance of blacktip reef sharks on inshore reefs of the Great Barrier Reef World Heritage Area
Dr Colin Simpfendorfer, JCU
- Project 4.8.5: Incorporating stakeholders and their values, knowledge and aspirations in the care and development of the Great Barrier Reef Marine Park
Dr Stephen Sutton, JCU
- Project 4.8.5c*: Exploring the response of the GBR Coral Reef Fin Fish Fishery to a major environmental event (Cyclone Hamish) (3rd party task: GBRM)
Dr Stephen Sutton, JCU
- Project 4.8.5s2: Recreational fishing of sharks in the GBRMP: Species composition and catch and release stress
Dr Stephen Sutton, JCU
- Project 4.8.6: Analysis of recreational and tourism use and impact on the Great Barrier Reef for managing sustainable tourism
Prof. Bruce Prideaux, JCU
- Project 4.8.7: Forecasting risk of exposure to irukandji
Professor Michael Kingsford, JCU
- Project 4.8.8: Investigation of the motivations of commercial and recreational fishers to comply with GBRMP zoning
Dr Renae Tobin, JCU

Program 9: Sustainable Use, Planning and Management of Tropical Rainforest Landscapes Professor Steve Turton, JCU

- Project 4.9.1: Indigenous landscapes of the Wet Tropics World Heritage Area
Professor Steve Turton, JCU

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- Project 4.9.2: Sustainable nature based tourism: planning and management
Professor Bruce Prideaux, JCU
- Project 4.9.2a*: Sustainable nature based tourism in the Port Douglas and Daintree Area: planning and management (3rd Party task: PDDT)
Professor Bruce Prideaux, JCU
- Project 4.9.3: Impacts of urbanisation on North Queensland environments: management and remediation
Professor Steve Turton, JCU
- Project 4.9.4: Integrating ecology, economics and people in forest and landscapes
Dr. Nick Emtage, UQ
- Project 4.9.5: Restoring tropical forest landscapes
Associate Professor Carla Catterall, GU
- Project 4.9.6: Strategic Natural Resource Management and land use planning
Dr Cathy Robinson, CSIRO
- Project 4.9.7a: Understanding social resilience and identification of social resilience indicators for management: *Great Barrier Reef*
Dr T. Lynam, CSIRO
- Project 4.9.7b: Understanding social resilience and identification of social resilience indicators for management: *Regional*
Prof. H. Ross, UQ
- Project 4.9.7c: Understanding social resilience and identification of social resilience indicators for management
Dr M. Gooch, JCU
- Project 4.9.7d: Tools for assessing consensus and adoption of management practices
Dr T. Lynam, CSIRO
- Project 4.9.7s:* Conservation Outreach and the GBR - A critical survey of perceptions, and a review and analysis of current communication initiative to minimize effects of climate changes on the GBR
Dr Margaret Gooch, JCU

Theme 5: Enhancing Delivery

Program 10: Enhancing Delivery Dr Suzanne Long, RRRC

- Project 5.10: Enhancing delivery of the MTSRF
Dr Suzanne Long, RRRC
- Project 5.10.1: Visual Documentation of MTSRF Projects
Dr Suzanne Long, RRRC
- Project 5.10.2: Communication, engagement and enhanced delivery for tourism operators in the Wet Tropics rainforests
Ms Annie Riddet, TTNQ
- Project 5.10.3: Communication, community engagement and enhanced delivery for Indigenous knowledge of the MTSRF Region
Jean Fenton and Melissa George, George Fenton
- Project 5.10.5*: Program management and information synthesis: RWQPP Marine Monitoring Program (Third Party Task: GBRMPA)
Jo Johnson, C2O



Appendix 2

Peer-reviewed scholarly articles

Since July 2006, MTSRF funded researchers have authored or contributed to over two hundred scientific journal articles, books and book chapters. Peer-reviewed scholarly journal articles stemming from MTSRF-generated research outputs are listed alphabetically by lead author surname. Where possible, links to the articles online are provided (may require password access via your research institute).

The most recent and up-to-date version of this list can be found on the [RRRC website](http://www.rrrc.org.au/publications/journal_articles.html)¹.

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- ANTHONY**, K. R., Hoogenboom, M. O., Maynard, J. A., Grottoli, A. and Middlebrook, R. (2009) Energetics approach to predicting mortality risk from environmental stress: A case study of coral bleaching. [*Functional Ecology* 23\(3\): 539-550](#) [doi:10.1111/j.1365-2435.2008.01531.x]
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- ARTHINGTON**, A. H., Naiman, M. E., McClain, E. and Nilsson, C. (2009) Preserving the biodiversity and ecological services of rivers: New challenges and research opportunities. [*Freshwater Biology* 55: 1-16](#).
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Details of books or book chapters stemming from MTSRF-generated research outputs are listed alphabetically by lead author. Where possible, links to the online version or supplier websites are provided. The most up-to-date version of this list can be viewed online on the [RRRC website](http://www.rrrc.org.au/publications/research_reports.html)².

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35	Project 4.9.2 Dr K. McNamara, JCU Prof B. Prideaux, JCU	Tourist Exit Survey Second Annual Report: January – December 2008. Annual and quarterly patterns of reef and rainforest tourism in North Queensland from exit surveys conducted at Cairns Domestic Airport ISBN 9781921359347 Published September 2009 http://www.rrrc.org.au/publications/tourist_exitsurvey2.html
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31	Project 4.9.4 Dr N. Emtage, UQ	Market segmentation study of rural landholders in relation to the promotion of natural resource management on private land in the Wet Tropics region of Queensland ISBN 9781921359309 Published June 2009 http://www.rrrc.org.au/publications/marketsegmentation_nrm.html
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27	Project 4.9.6 Dr A. Coggan, CSIRO Dr S. Whitten, CSIRO	Market Based Instruments, Ecosystem Services and Development in Mission Beach, Far North Queensland <i>Background Report 1: Impacts of Urbanisation on Ecosystem Services</i> ISBN 9781921359262 Published March 2009 http://www.rrrc.org.au/publications/missionbeach_backgroundreport1.html



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22	Project 4.9.4 Dr N. Emtage, UQ Dr J. Herbohn, UQ	Profiles of Rural Landholders in Relation to Natural Resource Management in the Wet Tropics Region of North Queensland ISBN 9781921359217 Published February 2009 http://www.rrrc.org.au/publications/landholders_profiles.html
21	Project 4.9.3 Dr M. Goosem, JCU <i>et al.</i>	Nocturnal Noise Levels and Edge Impacts on Amphibian Habitats Adjacent to Kuranda Range Road ISBN 9781921359194 Published November 2008 http://www.rrrc.org.au/publications/amphibian_habitats.html
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15	Project 2.6.1 Dr L. Sparrow, JCU Dr K. Heimann, JCU	The Influence of Nutrients and Temperature on the Global Distribution of Algal Blooms ISBN 9781921359149 Published September 2008 http://www.rrrc.org.au/publications/algal_blooms.html
14	CRC⇒MTSRF Transition Report Mr G. Dawe, JCU Dr M. Goosem, JCU	Noise Disturbance Along Highways: Kuranda Range Road Upgrade Project ISBN 9781921359132 Published October 2008 http://www.rrrc.org.au/publications/noise_disturbance.html
13	Project 4.9.3 Dr C. Pohlman, JCU Dr M. Goosem, JCU	The effects of Severe Tropical Cyclone Larry on rainforest vegetation and understorey microclimate adjacent to powerlines, highways and streams in the Wet Tropics World Heritage Area ISBN 9781921359125 Published August 2008 http://www.rrrc.org.au/publications/cyclonelarry_vegetationandmicroclimate.html
12	Project 3.7.1 Dr K. Nobes, AIMS Dr S. Uthicke, AIMS	Benthic Foraminifera of the Great Barrier Reef <i>A guide to species potentially useful as Water Quality Indicators</i> ISBN 9781921359118 Published August 2008 http://www.rrrc.org.au/publications/benthic_foraminifera.html



Report No.	MTSRF Project and Key Author/s	Report Title and Details
11	Project 4.9.4 Dr N. Emtage, UQ <i>et al.</i>	The management of forests, plantations and remnant vegetation patches for biodiversity conservation <i>Principles and recommended tree species for revegetation plantings on the Atherton Tablelands, North Queensland</i> ISBN 9781921359101 Published August 2008 http://www.rrrc.org.au/publications/vegetation_management.html
10	Project 4.9.4 Dr N. Emtage, UQ Dr J. Reghenzani, Terrain NRM	Wet Tropics Sustainable Agriculture Survey Interim Report <i>A survey of rural landholders in the Wet Tropics Natural Resource Management region</i> ISBN 9781921359095 Published May 2008 http://www.rrrc.org.au/publications/agriculture_survey.html
9	Project 4.9.3 Dr M. Goosem, JCU <i>et al.</i>	Highway Overpass Evaluation of Effectiveness: Kuranda Range Road Upgrade Project ISBN 9781921359088 Published July 2008 http://www.rrrc.org.au/publications/highway_overpasses.html
8	Project 4.8.6 Dr A. Coghlan, JCU Prof B. Prideaux, JCU	Reef Tourism First Yearly Report: November 2006 – October 2007 Quarterly Patterns of Reef Tourism on the Great Barrier Reef – Northern, Central and Whitsunday Areas ISBN 9781921359071 Published July 2008 http://www.rrrc.org.au/publications/reef_tourism.html
7	Project 4.8.5 Dr S. Sutton, JCU	Recreational fishers' perceptions about the costs and benefits of the 2004 Great Barrier Reef Marine Park Zoning Plan ISBN 9781921359064 Published May 2008 http://www.rrrc.org.au/publications/recreational_fishers.html
6	Project 4.8.2 Dr P. Speare, AIMS Dr M. Stowar, AIMS	A comparative study between fished and protected inter-reefal shoal habitats and their fish communities on the Great Barrier Reef <i>Report on ongoing monitoring off Townsville and initial surveys near Cardwell and Cairns, North Queensland</i> ISBN 9781921359057 Published May 2008 http://www.rrrc.org.au/publications/shoal_habitats.html
5	Project 1.4.1 Prof H. Marsh, JCU <i>et al.</i>	Condition, status and trends and projected futures of the dugong in the Northern Great Barrier Reef and Torres Strait <i>Including identification and evaluation of the key threats and evaluation of available management options to improve its status</i> ISBN 9781921359057 Published April 2008 http://www.rrrc.org.au/publications/dugong_statusandtrends.html



Report No.	MTSRF Project and Key Author/s	Report Title and Details
4	Project 2.6.1 S. Garrard, JCU <i>et al.</i>	Assessment of the Threat of Toxic Microalgal Species to the Great Barrier Reef World Heritage Area ISBN 9781921359033 Published March 2008 http://www.rrrc.org.au/publications/toxic_microalgae.html
3	Catchment to Reef Joint Research Program Dr K. Fabricius, AIMS <i>et al.</i>	Candidate Bioindicator Measures to Monitor Exposure to Changing Water Quality on the Great Barrier Reef ISBN 9781921359026 Published August 2007 http://www.rrrc.org.au/publications/waterquality_bioindicators.html
2	CRC Reef Research Centre Dr H. Sweatman, AIMS <i>et al.</i>	Status of Near-Shore Reefs of the Great Barrier Reef 2004 ISBN 9781921359019 Published June 2007 http://www.rrrc.org.au/publications/nearshore_reefs.html
1	Project 4.9.5 Dr J. Kanowski, GU A/Prof C. Catterall, GU	Monitoring Revegetation Projects for Biodiversity in Rainforest Landscapes: Toolkit Version 1, Revision 1 ISBN 9781921359002 Published May 2007 Superseded by Versions 2 and 3 of the toolkit. See Version 3, released July 2010: http://www.rrrc.org.au/publications/biodiversity_monitoring3.html



Unpublished Scientific and Technical Reports

This section outlines unpublished MTSRF research and technical reports available for download from the RRRRC website. Items are listed according to MTSRF Project number, with most recent items noted first. The latest and most up-to-date version of this list is available [online](http://www.rrrc.org.au/publications/unpub_reports.html)⁴. There are an additional ~130 unpublished MTSRF project milestone reports available for download from the [publications page](http://www.rrrc.org.au/publications/search_program.html)⁵ of the RRRRC website.

MTSRF Project	Project Leader OR Lead Author, Institute	Title of Website Link
Project 1.1.1	Dr R. Pitcher, CSIRO	Project 1.1.1 CSIRO/AIMS Pitcher, R. et al. (2007) Indicators of protection levels for seabed habitats, species and assemblages on the continental shelf of the Great Barrier Reef World Heritage Area
Project 1.1.2	Dr H. Sweatman, AIMS	Project 1.1.2 AIMS Sweatman, H (2007) Coral reef health indicators and thresholds of concern
Project 1.1.3	Ms A. Grech, JCU	Project 1.1.3 JCU Grech, A. et al. (2008) Spatial risk assessment for coastal seagrass habitats in the Great Barrier Reef World Heritage Area: Case Study
Project 1.1.3	Dr R. Coles, DPI	Project 1.1.3 QDPI&F Coles, R. et al. (2007) Status and trends of seagrass habitats in the Great Barrier Reef World Heritage Area.
Project 1.1.3	Dr M. Rasheed, DPI	Project 1.1.3 QDPI&F Rasheed, M. et al. (2008) Coastal seagrass habitats at risk from human activity in the Great Barrier Reef World Heritage Area: Review of areas to be targeted for monitoring
Project 1.1.3	Dr G. De'ath, AIMS	Project 1.1.3 AIMS De'ath, G. (2008) Spatial distributions and temporal change in distributions of deep water seagrasses in the Great Barrier Reef region
Project 1.1.4	J. Quaintance, UQ	Project 1.1.4 UQ Quaintance, J. (2007) Coral community structure in life and death assemblages from the Swain Reefs, Great Barrier Reef, Australia
Project 1.1.5	Dr G. De'ath, AIMS	Project 1.1.5 AIMS De'ath, G. (2007) The spatial, temporal and structural composition of water quality of the Great Barrier Reef, and indicators of water quality and mapping risk.
Project 1.3.1	Dr M. Haywood, CSIRO	Project 1.3.1 CSIRO Haywood, M. et al. (2007) Improved knowledge of Torres Strait seabed biota and reef habitats
Project 1.3.2	Dr E. Evans-Illidge, AIMS Dr C. Battershill, AIMS (eds)	Project 1.3.2 AIMS Evans-Illidge, E. et al. (2010) 'Ecological Role and Potential Values of Sponges to Torres Strait' Final Report on Project Activities
Project 1.3.2	Dr S. Whalan, AIMS	Project 1.3.2 AIMS Whalan, S. (2009) Ecological role and potential value of sponges to Torres Strait – Annual Report 2009

4 http://www.rrrc.org.au/publications/unpub_reports.html

5 http://www.rrrc.org.au/publications/search_program.html



MTSRF Project	Project Leader OR Lead Author, Institute	Title of Website Link
Project 1.3.2	Dr A. Duckworth, AIMS	Project 1.3.2 AIMS Duckworth, A. (2008) Ecological Role and Potential Value of Sponges to Torres Strait – Annual Report 2008
Project 1.3.2	Dr A. Duckworth, AIMS	Project 1.3.2 AIMS Duckworth, A. (2007) Ecological Role and Potential Value of Sponges to Torres Strait – Annual Report 2007
Project 1.3.2	Dr A. Duckworth, AIMS	Project 1.3.2 AIMS Duckworth, A. (2006) Distribution and abundance of the bath sponge Coscinoderma in Central and Eastern Torres Strait
Project 1.3.3	Mr D. Roe, Sea Turtle Foundation	Project 1.3.3 STF Roe, D. (2010) Marine Turtle and Dugong Awareness Program for Western Province, Papua New Guinea. Outcomes of Development Workshop, 10 June 2010, Daru
Project 1.3.3	Mr A. Tawake, JCU	Project 1.3.3 JCU Tawake, A. (2008) Livelihood benefits of adaptive co-management of hand collectable fisheries in the Torres Strait
Project 1.3.3	Prof. H. Marsh, JCU	Project 1.3.3 JCU Marsh, H. (2008) Spatial closures as possible management tools for community-based management of dugongs and turtles in Torres Strait
Project 1.3.3	Dr S. Pascoe, CSIRO	Project 1.3.3 CSIRO Pascoe, S. (2007) Preliminary review of key resource economics in the Torres Strait
Project 1.4.1(e)	Dr G. Parra, UQ	Project 1.4.1(e) UQ Parra, G. et al. (2009) Feeding habits of Australian Snubfin (Orcaella heinsohni) and Indo-Pacific humpback dolphins (Sousa chinensis)
Project 1.4.1	Prof. H. Marsh, JCU	Project 1.4.1 JCU Marsh, H. (2007) Northern Great Barrier Reef and Torres Strait Final Report
Project 1.4.2	Ms A. Grech, JCU	Project 1.4.2 JCU Grech, A. et al. (2008) Torres Strait Community GIS: Building the capacity of Torres Strait Islander communities in Natural Resource Management through integration of Traditional Ecological Knowledge and Western Scientific Knowledge
Project 1.4.3	Dr D. Metcalfe, CSIRO	Project 1.4.3 CSIRO (2009) The spatial distribution and characteristics of the Queensland Forest Service rainforest map units in the Wet Tropics of North Queensland
Project 2.5i.2	Prof. O. Hoegh-Guldberg, UQ	“Other Resources” article added to Project 2.5i.2 webpage with external link to GBRMPA's BleachWatch program with current condition reports available for download: http://www.rsrc.org.au/mtsrp/theme_2/project_2_5i_2.html
Project 2.5i.3	Prof. T. Hughes, JCU	Project 2.5i.3 JCU Hughes, T. (2007) Herbivory by fishes on the Great Barrier Reef: A review of knowledge and understanding



MTSRF Project	Project Leader OR Lead Author, Institute	Title of Website Link
Project 2.5i.4	Dr S. Wooldridge, AIMS	Project 2.5i.4 AIMS Wooldridge, S. (2009) Modelling the improved resilience of inshore coral reefs to climate change due to terrestrial water quality improvements: A case study from the Tully-Murray River catchment, North Queensland
Project 2.5i.4	Dr S. Wooldridge, AIMS	Project 2.5i.4 AIMS Wooldridge, S. (2009) Managing local water quality to help combat climate change impacts on the Great Barrier Reef, Australia
Project 2.5i.4	Prof. B. Miles, CQU	Project 2.5i.4 CQU Miles, R. et al. (2009) Assessing the Socio-Economic Implications of Climate Change (Coral Bleaching) in the Great Barrier Reef Catchment
Project 2.5i.4	Dr S. Wooldridge, AIMS	Project 2.5i.4 AIMS Wooldridge, S. (2009) Modelling the improved resilience of inshore coral reefs to climate change due to terrestrial water quality improvements: A case study of the Burdekin River catchment
Project 2.5i.4	Dr S. Wooldridge, AIMS	Project 2.5i.4 AIMS Wooldridge, S. (2007) Linking land-use change scenarios with predicted water quality improvements within the GBR lagoon
Project 2.5i.4	Dr S. Wooldridge, AIMS	Project 2.5i.4 AIMS Wooldridge, S. (2008) Regional Scale Coral Bleaching Predictions for the Great Barrier Reef
Project 2.5i.4	Dr S. Wooldridge, AIMS	Project 2.5i.4 AIMS Wooldridge, S. (2007) Metadata Inshore GBR Datasets
Project 2.5ii.1	Dr M. Thatcher, CSIRO	Project 2.5ii.1 CSIRO Thatcher, M. et al.(2007) Regional climate downscaling for the Marine and Tropical Sciences Research Facility (MTSRF) between 1971 and 2000
Project 2.5ii.1	Dr S. Ramasamy, CSIRO	Project 2.5ii.1 CSIRO Ramasamy, S. (2007) Climate Change Projections for the Tropical Rainforest Region of North Queensland
Project 2.5ii.2	Dr M. Liddell, JCU	Project 2.5ii.2 JCU Liddell, M. (2010) MTSRF Project 2.5ii.2 'Climate Change: Scaling from trees to ecosystems' Final Report on Project Activities, June 2010
Project 2.5ii.3	Dr D. Hilbert, CSIRO	Project 2.5ii.3 CSIRO Hilbert, D. (2010) 'Threats to ecosystems in the Wet Tropics due to climate change and implications for management'
Project 2.6.1	Dr K. Heimann, JCU	Project 2.6.1 JCU Heimann, K. et al. (2009) June Interim Report – Part 1 – The continuing development of the toxic dinoflagellates atlas
Project 2.6.1	P. Momigliano, JCU	Project 2.6.1 JCU Momigliano, P. et al. (2009) June Interim Report – Part 2 – Development of genetic probes for the identification of marine microalgae



MTSRF Project	Project Leader OR Lead Author, Institute	Title of Website Link
Project 2.6.1	Dr K. Heimann, JCU	Project 2.6.1 JCU Heimann, K. et al. (2009) March Interim Report – Part 1 – Laboratory culture of marine microalgae of the Great Barrier Reef toxic dinoflagellate cultures established by the North Queensland Algal Identification/Culturing Facility (NQAIF)
Project 2.6.1	Dr D. Blair, JCU	Project 2.6.1 JCU Blair, D. et al. (2009) March Interim Report – Part 2 – Review of genetic probe development for invasive marine species, with a focus on choice of target gene and on DNA amplification technology
Project 2.6.2	Ms T. Lawson, CSIRO	Project 2.6.2 CSIRO Lawson, T. et al. (2010) 'Audit and prioritisation of physical barriers to fish passage in the Wet Tropics region'
Project 2.6.2	Dr E. Poon, CSIRO	Project 2.6.2 CSIRO Poon, E. et al. (2007) Assessment of Research Needs for the Management of Invasive Species in the Terrestrial and Aquatic Ecosystems of the Wet Tropics
Project 3.7.1(c)	S. Hedge, QPIF	Project 3.7.1(c) QPIF Temporal and spatial morphological variability of the seagrasses <i>Halophila ovalis</i> and <i>Halodule uninervis</i> throughout the Great Barrier Reef region: Preliminary analysis
Project 3.7.1	Dr L. McKenzie, DPI	Project 3.7.1 DPI McKenzie, L. (2007) Relationships between seagrass communities and sediment properties along the Queensland coast
Project 3.7.1	Dr K. Fabricius, AIMS	Project 3.7.1 AIMS Cooper, T. (2007) Coral-based Indicators of Changes in Water Quality on Nearshore Coral Reefs of the Great Barrier Reef
Project 3.7.1	Dr K. Fabricius, AIMS	Project 3.7.1 AIMS Fabricius, K. (2007) The Use of Biomarkers in Barramundi (<i>Lates calcarifer</i>) to Monitor Contaminants in Estuaries of Tropical North Queensland
Project 3.7.1	Dr K. Fabricius, AIMS	Project 3.7.1 JCU Sheaves, M. (2007) Assessment of Techniques for Determining the Health of Tropical Estuarine Ecosystems
Project 3.7.1	Dr K. Fabricius, AIMS	Project 3.7.1 AIMS Fabricius, K. (2007) Conceptual Model of the effects of runoff on the ecology of corals and coral reefs of the Great Barrier Reef
Project 3.7.2	Dr E. Wolanski, AIMS	Project 3.7.2 AIMS Wolanski, E. (2007) Wet season fine sediment dynamics on the inner shelf of the Great Barrier Reef
Project 3.7.3	Prof. R. Pearson, JCU Prof. A. Arthington, GU	Projects 3.7.3/3.7.4 CSIRO Wallace, J. (2007) Hydro-ecological modeling in coastal catchments: Connectivity and hydro-ecological function
Project 3.7.4	Dr J. Wallace, CSIRO	Project 3.7.4 CSIRO Hawdon, A. et al. (2007) Design and application of automated flood water quality monitoring systems in the Wet Tropics



MTSRF Project	Project Leader OR Lead Author, Institute	Title of Website Link
Project 3.7.4	Dr J. Wallace, CSIRO	Projects 3.7.3/3.7.4 CSIRO Wallace, J. (2007) Hydro-ecological modeling in coastal catchments: Connectivity and hydro-ecological function
Project 3.7.5	Dr M. van Grieken, CSIRO	Project 3.7.5 CSIRO van Grieken, M. (2009) Review of socio-economic constraints to and incentives for the adoption of land use and management options for water quality improvement in the Tully-Murray catchment (Wet Tropics)
Project 3.7.5	Dr P. Roebeling, CSIRO	Project 3.7.5 CSIRO Roebeling, P. et al. (2007) Financial-economic analysis of current best management practices for sugarcane, horticulture, grazing and forestry industries in the Tully-Murray catchment.
Project 3.7.7	Dr P. Kuhnert, CSIRO	Project 3.7.7 CSIRO Kuhnert, P. et al. (2010) Analysis and synthesis of information for reporting credible estimates of loads for compliance against targets and tracking trends in loads
Project 3.7.7	Dr P. Kuhnert, CSIRO	Project 3.7.7 CSIRO Kuhnert, P. et al. (2009) Statistical methods for the estimation of pollutant loads from monitoring data: Final project report
Project 3.7.7	Dr R. Bartley, CSIRO	Project 3.7.7 CSIRO Kuhnert, P. et al.(2007) Conceptual and statistical framework for a water quality component of an integrated report card for the Great Barrier Reef catchments.
Project 3.7.7	Dr A. Steven, CSIRO	Project 3.7.7 CSIRO Browne, M. et al.(2007) Review of existing approaches used to develop integrated report card frameworks (IRCF) and their relevance to catchments draining to the Great Barrier Reef
Project 4.8.2	Dr M. Stowar, AIMS	Project 4.8.2 AIMS Stowar, M. (2008) Influence of zoning on midshelf shoals of the southern Great Barrier Reef
Project 4.8.2	Dr P. Speare, AIMS	Project 4.8.2 AIMS Speare, P. (2008) Temporal monitoring of northern shoals off Cardwell and Townsville
Project 4.8.2	Dr C. Johansson, AIMS	Project 4.8.2 AIMS Johansson, C. et al. (2008) The use of stereo BRUVS for measuring fish size
Project 4.8.2	Dr P. Doherty, AIMS	Project 4.8.2 AIMS Speare, P. (2007) Preliminary findings from the first baseline survey of the Magnetic Shoals
Project 4.8.3	Dr L. Currey, JCU	Project 4.8.3 JCU Currey, L. et al. (2010) Resilience of reef fish species on the Great Barrier Reef and in Torres Strait
Project 4.8.3	Dr L. Currey, JCU	Project 4.8.3 JCU Currey, L. et al. (2008) Comparative biology of key inter-reefal lethrinid species on the Great Barrier Reef
Project 4.8.3	Dr L. Currey, JCU	Project 4.8.3 JCU Currey, L. et al. (2010) Comparative biology of key inter-reefal labrid species on the Great Barrier Reef
Project 4.8.3	Mr A. Mapleston, JCU	Project 4.8.3 JCU Mapleston, A. (2009) Comparative biology of key inter-reefal serranid species on the Great Barrier Reef



MTSRF Project	Project Leader OR Lead Author, Institute	Title of Website Link
Project 4.8.3	Dr M. Heupel, JCU	Project 4.8.3 JCU Heupel, M. et al. (2009) The Comparative Biology of Lutjanid Species on the Great Barrier Reef
Project 4.8.3	Dr C. Simpfendorfer, JCU	Project 4.8.3 JCU Simpfendorfer, C. (2007) Harvest patterns of the 'Other Species' quota group in the Coral Reef Fin Fish Fishery
Project 4.8.5	Dr S. Sutton, JCU	Project 4.8.5 JCU Sutton, S. (2007) Assessment of the Influence of the 2003 Great Barrier Reef Zoning Plan on use of the Great Barrier Reef
Project 4.8.6	Prof. B. Prideaux, JCU	Project 4.8.6 JCU Prideaux, B. (2007) Reef Tourism: Establishment of Visitor Monitoring Structure
Project 4.9.1	Dr R. Hill, CSIRO	Project 4.9.1 CSIRO Hill, R. (2008) Indigenous Cultural Actions Workshop Report.
Project 4.9.2	Prof. B. Prideaux, JCU	Project 4.9.2 JCU Prideaux, B. (2007) Rainforest Tourism: Establishment of a visitor monitoring structure
Project 4.9.3	Prof. S. Turton, JCU	Project 4.9.3 Turton, S and Dale, A. (JCU/CSIRO/Terrain) An assessment of the environmental impacts of Cyclone Larry on the forest landscapes of northeast Queensland, with reference to responses to natural resource management issues in the aftermath
Project 4.9.5	Dr C. Catterall, GU	Project 4.9.5 GU Catterall, C. (2010) Rainforest restoration: approaches, costs and biodiversity outcomes
Project 4.9.6	Dr A. Coggan, CSIRO	Program 9 CSIRO Coggan, A. and Jess, M. (2008) Thinking Offsets in FNQ – Workshop Outcomes
Project 4.9.7	Dr S. Stone-Jovicich, CSIRO	Project 4.9.7 CSIRO Stone-Jovicich, S. <i>et al.</i> (2010) Tools for assessing consensus and adoption of management practices (cigarette butt litter disposal)
Project 4.9.7	Associate Prof. M. Cuthill, UQ	Project 4.9.7 UQ Cuthill, M. (2008) Reporting social outcomes of development: An analysis of diverse approaches
Project 4.9.7	Dr K. Maclean, UQ	Project 4.9.7 UQ Maclean, K. et al. (2008) Regional Level Indicators of Social Resilience
Project 4.9.7	K. Alexandridis, CSIRO	Project 4.9.7 CSIRO Alexandridis, K. (2007) Monte Carlo Extreme Event Simulations for Understanding Water Quality Change Classifications in the Great Barrier Reef Region.
Project 4.9.7	Dr M. Gooch, JCU	Project 4.9.7 JCU Gooch, M. (2007) Literature and lay reviews of community resilience to changes in water quality - Phase one of Townsville/Thuringowa Case Study



Conference Abstracts and Proceedings

Presentation and communication of MTSRF-generated results at professional conferences is another important means of delivering scientific information. Programs and presentation abstracts from MTSRF Annual Conferences can be accessed via the relevant conference pages on the RRRC website ([2007](#), [2008](#), [2009](#), [2010](#)). The following list includes conferences and major workshops **other than** the annual MTSRF conferences. Abstracts and proceedings are listed alphabetically by lead author surname. The latest and most up-to-date version of this list can be viewed online on the [RRRC website](#)⁶.

- ANDERSON**, A., Shoo, L. and Williams, S. E. (2009) Latitudinal shifts in optimum elevation of rainforest birds in eastern Queensland and their relevance to predicting the impacts of climate change. Australasian Ornithological Conference, 29 November - 4 December, Armidale, NSW.
- ARTINGTON**, A. H. (2008) Water scarcity, environmental flows and floodplain ecology. Commonwealth Environment Research Facilities (CERF) Conference, Canberra, 16 September 2008.
- AZAM**, M. M., Akbar, D. and Greer, L. (2009) Climate change and resilience of the Great Barrier Reef: Laws and institutions. *Regional sustainability: Local solutions to global issues*, Central Region Engineering Conference, 14-15 August, Rockhampton, Queensland.
- BAINBRIDGE**, Z., T., Brodie, J. E., Lewis, S. E., Waterhouse, J. and Wilkinson, S. N. (2009) Utilising catchment modelling as a tool for monitoring Reef Rescue outcomes in the Great Barrier Reef catchment area. In: Anderssen, R. S., Braddock, R. D. and Newham, L. T. H. (eds.) 18th World IMACS Congress and MODSIM09 International Congress on Modelling and Simulation, Cairns, 13-17 July [[Access extended abstract online](#)]
- BAINBRIDGE**, Z. T., Lewis, S. E. and Brodie, J. E. (2007) Sediment and nutrient exports for the Burdekin River catchment, North Queensland: A comparison of monitoring and modelling data. In: Oxley, L. and Kulasiri, D. (eds.) MODSIM 2007 International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand, December 2007 [[Access extended abstract online](#)]
- BATEMAN**, B., VanDerWal, J. and Johnson, C. (2009) Modelling biotic interactions under climate change scenarios: Predicting Northern Bettong (*Bettongia tropica*) distribution. INTECOL 10th International Congress of Ecology, Brisbane, 16-21 August [[Access abstract online](#)]
- BERG SOTO**, A., Marsh, H., Parra, G. and Noad, M. (2008) The acoustic and surface behaviour of coastal dolphins in Queensland: Implications for management. In: Taylor, R. and Long, S. (eds.) Proceedings of the 2008 Marine and Tropical Sciences Research Facility Annual Conference, 28 April to 1 May, 2008 [[Access extended abstract online](#)]
- BERKELMANS**, R. (2008) Shifting bleaching thresholds: Acclimatisation or a flawed model? Proceedings of the 11th International Coral Reef Symposium, 7-11 July, Fort Lauderdale, Florida.
- BRUNO**, J., Vu, I., Weil, E. and Sweatman, H. (2008) Effects of fishing and macroalgae on coral disease dynamics. Proceedings of the 11th International Coral Reef Symposium, 7-11 July, Fort Lauderdale, Florida.
- BYRNES**, P. and Goosem, M. (2009) Road avoidance and barrier effects of roads on medium-sized, ground-dwelling rainforest mammals. INTECOL 10th International Congress of Ecology, Brisbane, 16-21 August [[Access abstract online](#)]
- CARMODY**, J. (2008) The Wet Tropics World Heritage Area. Inaugural Conference on Green Travel, Climate Change and Ecotourism, 17-20 November, Adelaide, South Australia.

⁶ http://www.rrrc.org.au/publications/abstracts_proceedings.html



- CARMODY, J. and Prideaux, B. (2009)** The Wet Tropics of Queensland World Heritage Area: Community use of information sources. See Change: Tourism and hospitality in a dynamic world. CAUTHE 2009 Conference, 10-13 February, Fremantle, Western Australia.
- CARMODY, J. and Prideaux, B. (2008)** Visitation and recreation in the Wet Tropics World Heritage Area: A comparison of urban and regional residents. In: Taylor, R. and Long, S. (eds.) Proceedings of the 2008 Marine and Tropical Sciences Research Facility Annual Conference, 28 April to 1 May, 2008 [[Access extended abstract online](#)]
- CARMODY, J. and Prideaux, B. (2008)** World Heritage rainforests in the life of a community. In: Richardson, S., Fredline, L., Patiar, A. and Ternel, M. (eds.) Proceedings of the 18th Annual CAUTHE Conference, Griffith University, Gold Coast, Australia, 11-14 February 2008 [[Access extended abstract online](#)]
- CARMODY, J., King, L. and Prideaux, B. (2010)** The Savannah Guides: A tour guiding model for regional Australia. Council for Australian University Tourism and Hospitality Education (CAUTHE) Conference, 8-11 February 2010, Hobart, Tasmania.
- CARRUTHERS, T. J. B., Williams, S. L., Waycott, M., Dennison, W. C., Duarte, C. M., Fourqurean, J. W., Heck, K. L., Hughes, A. R., Kendrick, G. A. and Kenworthy, W. J. (2007)** Could climate change and eutrophication promote *Ruppia* as the seagrass of the future? Estuarine Research Federation 2007 Conference, *Science and Management: Observations / Syntheses / Solutions*. 4-8 November, Providence [[Access abstract online](#)]
- CATTERALL, C. (2009)** Ecological offsets: An Australian case study - vegetation offsets for land clearing. INTECOL 10th International Congress of Ecology, Brisbane, 16-21 August.
- CATTERALL, C. P., Freeman, A., Kanowski, J. and Reis, T. (2010)** Are rainforest restoration plantings useful to birds? Birds Australia Southern Queensland 2nd Annual Conference, Brisbane, March 2010.
- CATTERALL, C., Kanowski, J. and Freebody, K. (2010)** Ecological outcomes of rainforest restoration projects: Dreams and realities. INTECOL 10th International Congress of Ecology, Brisbane, 16-21 August [[Access abstract online](#)]
- CATTERALL, C. P., Kanowski, J., Freebody, K., Harrison, D. and Freeman, A. (2010)** Restoring rainforest biodiversity while sequestering carbon. Commonwealth Environment Research Facilities (CERF) Conference, Canberra.
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Reef Rescue Marine Monitoring Program

In addition to the MTSRF, the RRRC also manages the Reef Rescue Marine Monitoring Program. The most up-to-date list of reports and publications generated by this program is available on the [RRRC website](http://www.rrrc.org.au/mmp/mmp_pubs.html)⁷.

Project	Project Leader OR Lead Author, Institute	Title of Website Link
Quality Assurance / Quality Control Methods and Procedures Manual	RRRC	Reef & Rainforest Research Centre Ltd (2010) Reef Rescue Marine Monitoring Program: Quality Assurance/Quality Control Methods and Procedures Manual . Reef & Rainforest Research Centre Ltd (2010) Reef Rescue Marine Monitoring Program: Quality Assurance/Quality Control Methods and Procedures Manual – Appendices .

⁷ http://www.rrrc.org.au/mmp/mmp_pubs.html



Project	Project Leader OR Lead Author, Institute	Title of Website Link
2008/2009 Synthesis Report	MMP Writing Team	Johnson, J.E., Waterhouse, J., Maynard, J.A. and Morris, S. (Writing Team) (2010) Reef Rescue Marine Monitoring Program: 2008/2009 Synthesis Report.
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Project	Project Leader OR Lead Author, Institute	Title of Website Link
2007/2008 Summary Report With supporting background research reports	MMP Writing Team	Prange, J., Johnson, J. and Morris, S. (Writing team) (2009) Reef Water Quality Protection Plan Marine Monitoring Program: 2007/2008 Summary Report.
	Bartkow, M. (EnTox)	Bartkow, M., Dunn, A., Komarova, T., Paxman, C. and Mueller, J. (2008) <i>Monitoring of organic chemicals in the Great Barrier Reef Marine Park and selected tributaries using time integrated monitoring tools</i> (National Research Centre for Environmental Toxicology, The University of Queensland)
	Brando, V. (CSIRO)	Brando, V. E., Schroeder, T., Dekker, A. G. and Blondeau-Patissier, D. (2008) <i>Remote sensing of GBR-wide water quality</i> (CSIRO)
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	McKenzie, L. (DPI&F)	McKenzie, L., Mellors, J. and Waycott, M. (2008) <i>Intertidal seagrass report for sampling period 1 September 2007 to 31 May 2008</i> (Queensland Department of Primary Industries and Fisheries and James Cook University)
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2008 Mid-year Progress Report	Dr J. Prange, RRRC	Reef Water Quality Marine Monitoring Program Mid-year Progress Report June 2008

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