National Environmental Research Program

TROPICAL ECOSYSTEMS hub

NERP Tropical Ecosystems Hub and Reef Rescue R&D Conference 2013

7th-10th May
Pullman Reef Hotel Casino, Cairns

Program Handbook & Abstracts

Reef Rescue Research & Development

CARING FOR OUR COUNTRY

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Welcoming remarks from the Conference Chair

Welcome to the joint conference of the NERP Tropical Ecosystems Hub and the Reef Rescue Research and Development Program.

The NERP Tropical Ecosystems Hub is a $62 million partnership between the Australian Government (DSEWPaC) and four core research institutions (AIMS, CSIRO, JCU, and UQ) for the delivery of applied environmental research in northern Queensland focussing on Torres Strait, tropical rainforests and the Great Barrier Reef.

The Reef Rescue Water Quality Research and Development (Reef Rescue R&D) is a $10 million component of the Reef Rescue program funded under the Australian Government's Caring for our Country initiative. It is designed to improve our understanding of the link between land management practices and environmental impacts, and to improve water quality in the Great Barrier Reef lagoon by supporting a reduction in the amount of nutrients, pesticides and sediments reaching coastal waters from agricultural lands.

The first Conference of the NERP TE Hub is being shared with the final Reef Rescue R&D Forum, since the current phase of the program is winding up in 2013. Both programs have invested in research supporting the goal of Reef Plan (2003-13) to "halt and reverse the decline in the quality of water entering the Great Barrier Reef Lagoon". This common area of interest will be explored on Day 3, while forums on the first two days will address other topical issues of biodiversity, natural resource management, and sustainability by the NERP. The last day will show how some of this research will be used by relevant industries and community stakeholders.

Both research programs place a high priority on working with research users to ensure that their needs, either for the development of government policy or delivery of on-ground action, are supported by the relevant research. Recently the Tropical Ecosystems Hub has worked with Indigenous community leaders to identify better mechanisms for working with their communities.

There are huge challenges facing northern Queensland. I feel certain that the four days of our joint conference will provide insights into those challenges and the means for addressing them. It should also be an excellent opportunity for research users and researchers to meet and discuss issues of common interest.

Di Tarte
Chair, Steering Committee
NERP Tropical Ecosystems Hub

Introducing the NERP Tropical Ecosystems Hub

The NERP TE Hub, administered locally by the Reef & Rainforest Research Centre (RRRC), is providing research results linked to better management, conservation, and sustainable use of Queensland's World Heritage properties (Great Barrier Reef, Wet Tropics rainforests) and the terrestrial and marine assets underpinning resilient communities in the Torres Strait.

The NERP TE Hub science program is being implemented by 240 researchers, who will deliver 39 projects between July 2011 and December 2014. When funding this Hub, the Commonwealth was clear that the success of the program will be judged by its relevance to research-users and demonstration of effective knowledge transfer.

In our first conference, a selection of projects will be highlighted in seven interactive forums during the first two days and our investments in water quality research will contribute to the RRRD program starting on Day 3.

On Day 1-2, our choice of topic-based forums over the standard oral presentations reflects the importance that we place on effective knowledge sharing and the practical uptake of our research results. The focus of the forums will be on defining the issues, identifying the knowledge gaps, and exploring possible solutions; not on describing details of the research. All stakeholders will have something to contribute to this general conversation and we encourage your active participation.

Since the discussion format, topic selection, and time available will not accommodate every project in the Hub and limits the content of those included to key messages, the associated poster displays form a critical part of the conference materials. All posters will remain on display throughout the week and we urge you to consult them during our frequent breaks to gain a fuller understanding of the breadth and depth of the Hub science. To reemphasise the importance of posters in this conference, you will hear nothing in the oral presentations from a quarter of the Hub projects simply because of topic choices. In addition to that certain loss of information, some questions arising from a forum discussion will be answered after viewing the poster from that project.

If the posters do not satisfy, questions should be directed to the Hub researchers. These specialists have made time to be accountable and they will be very receptive.

Along with others, we welcome all delegates to the NERP TE Hub / RRRD joint conference and wish that you have an enjoyable and productive experience. Please give us feedback during the week so that we can continue to make the TE Hub more useful and more relevant to you. That is our enduring goal.

Peter Doherty
Science Leader
Australian Institute of Marine Science

Sheriden Morris
Hub Administrator
RRRC

Introducing Reef Rescue Water Quality Research and Development Program

The $200 million Caring for our Country Reef Rescue program seeks to reduce the amount of nutrients, pesticides and sediments entering the Great Barrier Reef by assisting farmers and graziers in reef catchments to adopt land management practices that improve the quality of the water leaving their properties. This will increase the resilience of the reef to the impacts of other stressors such as climate change.

A key component of Reef Rescue is the $10 million Reef Rescue Water Quality Research and Development (Reef Rescue R&D) program, which aims to improve our understanding of the link between land management practices, water quality and environmental impacts.

The current Reef Rescue R&D portfolio of 18 projects runs from 2010 to 2013 and covers the following key Reef Rescue investment priorities:

- Land management practices that improve water quality outcomes in the sugarcane, grazing, horticulture and dairy sectors;
- The cost-effectiveness of implementing land management practices that have water quality benefits;
- The factors affecting practice adoption across industries and regions;
- The impact of pesticides on water quality in the Great Barrier Reef; and
- Improved techniques for monitoring and reporting the impacts of water quality investments in the Great Barrier Reef catchments.

Reef Rescue R&D is complemented by initiatives such as the National Environmental Research Program Tropical Ecosystems Hub and various programs under the Reef Water Quality Protection Plan, including the Paddock to Reef Integrated Monitoring, Modelling and Reporting (P2R) program and the Queensland Government's Reef Protection R&D program. The Reef and Rainforest Research Centre (RRRC) has been engaged to coordinate and integrate Reef Rescue R&D with other complementary research initiatives.

The outcomes of Reef Rescue R&D and related programs are crucial to the efficient design and implementation of government policies and programs, such as the $158 million Water Quality Grants and Partnerships component of Reef Rescue, which together have contributed significantly to the achievement of the Reef Plan goal of halting and reversing the decline in the quality of water entering the Great Barrier Reef. Governments acknowledge the continuing support of the Great Barrier Reef research community in helping to accomplish this very significant landmark.

Kevin Gale
Reef Policy and Programs Section, Biodiversity Conservation Division
Department of Sustainability, Environment, Water, Population and Communities

Introduction to Reef Rescue R&D; the RRRC perspective

The quality of the water that drains from coastal catchments to our marine environment is an omnipresent issue affecting the resilience of the Great Barrier Reef. However, amid the range of threats facing the World Heritage listed icon, we have the capacity to improve water quality and to mitigate the many, and compounding, ecological, social and economic impacts.

Reef Rescue R&D is a key component of the $200m Reef Rescue program. The $10m investment is designed to improve our understanding of the link between land management practices and environmental impacts. It aims to improve water quality across the Great Barrier Reef by supporting a reduction in the export of nutrients, pesticides and sediments from agricultural lands.

The 18 current projects across Reef Rescue R&D will increase knowledge about the cost effectiveness of implementing improved land management practices that have water quality benefits, and about the factors affecting practice adoption across industries and regions.

As administrator of the National Environment Research Program's Tropical Ecosystems Hub, the RRRC Ltd is well placed to coordinate and integrate Reef Rescue R&D with other complementary research. Connecting projects and activities between programs, including the Reef Water Quality Protection Plan, has been critical to the success of these programs.

Sheriden Morris
Managing Director, Reef & Rainforest Research Centre Ltd

Plenary: Tropical ecosystems on the other side of the Great Divide

Michael Douglas is Director of the NERP Northern Australia Hub and Professor of Environmental Science at Charles Darwin University. He is an aquatic ecologist with research interests in how weeds, fire, grazing and water extraction affect tropical rivers, floodplains and riparian zones. For the past 6 years he has been leading large collaborative research programs aimed at supporting land and water management across northern Australia including the NERP NA Hub. He is also the Director of the Tropical Rivers and Coastal Knowledge Research Hub (TRaCK).

Professor Michael Douglas
Director, NERP Northern Australia Hub

Tuesday 7 May Program Michaelmas Cay Room

0830-0900	**Guests arrive / Registration**
0900-0925	**Welcome to Country** (tbc) **Welcome to Delegates** (Di Tarte, Chair of NERP TE Hub Steering Committee)
0925-0955	**Opening of the NERP TE Hub and Reef Rescue R&D Conference** (Minister Burke, tbc)
0955-1015	**Introduction to the NERP Tropical Ecosystems Hub** (Peter Doherty, Science Leader)
1015-1040	**Plenary address** (Michael Douglas, NERP Northern Australia Hub)
1040-1100	**Morning Tea**
1100-1230	***Forum:*** **Implementing the NERP TE Hub Indigenous Engagement Strategy: building effective Indigenous-Science partnerships for bio-cultural diversity conservation** Conveners: Helene Marsh, JCU; Melissa George, Chair, Indigenous Advisory Committee *Presentations will be given by:* Melissa George (Wulgurukaba), Mark Hamann (JCU), Frank Loban (LSMU, TSRA), Helene Marsh (JCU), Helen Penrose (JCU), Petina Pert (CSIRO), Phil Rist (Nywaigi), Joann Schmider (RAPA), Leah Talbot (Eastern Kuku Yalanji) and Gerry Turpin (Australian Tropical Herbarium) *Facilitating interactive discussion between floor and an expert panel including the speakers*
1230-1330	**Lunch** (demonstration of eAtlas @ 1300)
1330-1500	***Forum:*** **How do we recognise progress in securing the conservation of the Wet Tropics?** Convener: Andrew Maclean, WTMA *Presentations on:* Rainforest animal communities (Steve Williams, JCU) Rainforest plant diversity and refuges (Darren Crayn, JCU) Surveys for missing and endangered frogs (Conrad Hoskin, JCU) Monitoring of cassowaries and flying foxes (David Westcott, CSIRO) *Facilitating interactive discussion between floor and an expert panel including the speakers*
1500-1530	**Afternoon Tea**
1530-1700	***Forum:*** **Managing for change** Convener: Carole Sweatman, Terrain NRM *Presentations on:* Fire and rainforests (Dan Metcalfe, CSIRO) Regeneration of rainforest (Carla Catterall, GU) Invasive species risks in the Wet Tropics (Helen Murphy, CSIRO) Impacts of extreme weather on biodiversity (Justin Welbergen, JCU) Climate change adaptation and landscape resilience (Allan Dale, JCU) *Facilitating interactive discussion between floor and an expert panel including the speakers*
1715-1915	**Social Event: NERP/RRRD Poster Session** **Michaelmas Cay Room**

Wednesday 8 May Program Michaelmas Cay Room

0800-0830	**Guests arrive / Registration**
0830-1000	***Forum:*** **Effectiveness of spatial zoning on biodiversity and fish populations** Convener: Laurence McCook, GBRMPA *Presentations on:* Monitoring the impacts of Green zones (David Williamson, JCU) Spill-over benefits from Green Zones (Geoff Jones, JCU) Movements of apex fish predators (Andrew Tobin, JCU) *Facilitating interactive discussion between floor and an expert panel including the speakers*
1000-1030	**Morning Tea**
1030-1230	***Forum:*** **What does the future hold for Torres Strait and its Indigenous People?** Convener: Damian Miley, TSRA *Presentations on:* Keeping an eye on the reefs of Torres Strait (Hugh Sweatman, AIMS) Developing Indigenous management outcomes from dugong research in Torres Strait (Helene Marsh, JCU) Hazard analysis for Torres Strait water quality (Jon Brodie, JCU) Mangrove and freshwater habitat status (Damien Burrows, JCU) Future scenarios for Torres Strait communities (Erin Bohensky, CSIRO) *Facilitating interactive discussion between floor and an expert panel including the speakers*
1230-1330	**Lunch** (demonstration of eAtlas @ 1300)
1330-1500	***Forum:*** **Drivers of Biodiversity on the GBR, COTS Outbreak Dynamics and Population Control** Convener: Doug Baird, Quicksilver Cruises *Presentations on:* The 27 year decline of GBR coral cover (Katharina Fabricius, AIMS) Status of COTS populations (Hugh Sweatman, AIMS) AMPTO starfish control program (Scott Firth, AMPTO) NERP Emerging Priorities response (Peter Doherty, AIMS) *Facilitating interactive discussion between floor and an expert panel including the speakers*
1500-1530	**Afternoon Tea**
1530-1700	***Forum:*** **Managing natural resources for future generations** Convener: Mark Read, GBRMPA *Presentations on:* Coastal shark populations (Andrew Tobin, JCU) Setting management objectives for inshore biodiversity (Cathy Dichmont, CSIRO) Seabird foraging patterns from offshore islands (Brad Congdon, JCU) *Facilitating interactive discussion between floor and an expert panel including the speakers*

Wednesday 8 May Concurrent Program – Reef Rescue R&D Special Sessions Reef Room

0800-0830	**Guests arrive / Registration**
0830-1230	**Water Quality in the Normanby Catchment, northern GBR** Led by Dr Andrew Brooks, Griffith University This session will outline a program of R&D on the Sediment budget for the Normanby Catchment, which is the dominant catchment delivering terrestrial runoff to Princess Charlotte Bay and the northern GBR. Results of this sediment budget work will be presented with additional findings about the alluvial gully management trials and the broader program of on-ground works focused on improving water quality delivery to the Northern GBR. The project was funded through the Australian Government Reef Rescue program.
0830-0910	Intro/project overview – Sediment budget modelling in the northern Great Barrier Reef, Australia; the importance of empirical data! (Andrew Brooks, GU)
0910-0920	The application of geochemical tracer techniques to identify sources of sediment to Princess Charlotte Bay (Jon Olley, GU)
0920-0940	Adapting the SedNet sediment budget framework to incorporate multiple empirical input data sets; an example from the Normanby catchment (John Spencer, GU)
0940-1000	The use of repeat LiDAR and historical airphotos for determining short & medium term gully and bank erosion rates (Graeme Curwen, GU)
1000-1030	**Morning Tea**
1030-1050	The role of in-channel benches as major stores of suspended sediment in the Normanby catchment & implications for catchment management (Tim Pietsch, GU)
1050-1110	A machine learning approach to estimate river bank erosion through multi-temporal LIDAR and spectral imagery (Fabio Iwashita, GU)
1110-1130	Water quality monitoring in the Normanby Catchment – 2006-2013 + a bonus video of sampling the 2013 flood (Ms Christina Howley)
1130-1150	Alluvial gully prevention and rehabilitation options for reducing sediment loads in the Normanby Catchment– initial results of passive and active management intervention approaches (Jeff Shellberg, GU)
1150-1210	On ground management activities aimed at improving water quality in the Normanby catchment (Isha Segboer, Cape York Sustainable Futures)
1210-1230	Summation and implications for Reef water quality management (Andrew Brooks, GU)
1230-1330	**Lunch** (demonstration of eAtlas @ 1300)

1330-1715	**BMP economics and adoption** Led by Dr Stuart Whitten, CSIRO Debate continues around the real costs of and the impediments to adopting best management practices (BMPs) with the aim of reducing pollutant exports to the GBR lagoon. Over the last two years the Reef Rescue R&D project "Integrated assessment of BMP cost-effectiveness and decision tool for regions and landholders" has sought to provide more detail around the nature of the costs (and benefits) of adoption as well as the non-monetary factors that are influencing adoption. This session will focus on the results to date with a summary of the emerging integration framework.
1330-1340	An overview of the project aims, objectives and structure (Stuart Whitten, CSIRO Water for a Healthy Country Flagship)
1340-1410	Economics of BMP adoption in grazing settings – implications of land-type, enterprise type and land class recovery (Megan Star, Qld DAFF)
1410-1440	Economics of BMP adoption in cane settings – implications of BMP type, enterprise type and region (Martijn van Grieken, CSIRO Water for a Healthy Country Flagship; Mark Poggio, Qld DAFF)
1440-1510	Risk – management tradeoffs in grazing and cane settings (Daniel Gregg, Central Queensland University)
1510-1530	**Afternoon Tea**
1530-1620	Barriers and opportunities to adoption at the individual BMP and delivery scales (John Rolfe Central Queensland University; Sallyann Harvey, Central Queensland University; Bruce Taylor, CSIRO Water for a Healthy Country Flagship)
1620-1650	Pulling it all together – implications for the costs of reducing nutrients and sediments across the GBR (led by Stuart Whitten, CSIRO)
1650-1715	*Panel session / questions and discussion* (led by Stuart Whitten, CSIRO)

Thursday 9 May Program Michaelmas Cay Room

	GBR water quality: What do we know and what more needs to be done? Chair: Sheriden Morris, Reef and Rainforest Research Centre
0800-0830	**Guests arrive / Registration**
0830-0840	**Welcome and Introduction to NERP / Reef Rescue R&D Water Quality Conference** Convenor: SEWPAC, TBC
0840-0900	**Reef Plan 3 and Reef Rescue II – the broad directions** (Claire Andersen, DPC; SEWPAC, TBC)
0900-0915	**Keynote presentation: Land use impacts on Reef water quality and ecosystems** (Jon Brodie, TropWater, JCU)
	Session 1: The Reef and its ecosystems – how are they shaping up? Convenor: John Bennett, DEHP
0920-0950	What is the current status of GBR water quality and associated impacts on ecosystems? (Britta Schaffelke, AIMS; Johanna Johnson, C_2O Consulting)
0950-1015	Historical changes on the GBR: Looking to the past to unravel the future (Tara Clarke, UQ)
1015-1030	Tracking coastal turbidity over time and demonstrating the effects of river discharge events on regional turbidity (Katharina Fabricius, AIMS)
1030-1100	**Morning Tea**
1100-1115	Chronic effects of pesticides and their persistence in tropical waters (Andrew Negri, AIMS)
1115-1130	Vulnerability of seagrass meadows of the GBR to water quality impacts (Catherine Collier, JCU)
1130-1145	Experimental and field investigations of combined water quality and climate effects on corals and other reef organisms (Sven Uthicke, AIMS)
1145-1200	On the relative 'value' of market and non-market goods and services provided by the GBRWHA (Natalie Stoeckl, JCU)
1200-1215	eReefs: Monitoring and modelling water quality in the Great Barrier Reef (Greg Stuart, Bureau of Meteorology)
1215-1245	*Panel discussion:* **Moving towards ecological targets for the GBR** Led by John Bennett, DEHP *Panel Members:* Hugh Yorkston, GBRMPA; Carol Honchin, GBRMPA; Jon Brodie, JCU *Key questions include:* What ecosystem benefits can we expect from reduced loads of nutrients, sediments and pesticides?
1245-1330	**Lunch** (demonstration of eAtlas @ 1300)

	Session 2: Prioritising future investment for GBR water quality improvement Convenor: Kevin Gale, SEWPAC
1330-1400	What are the main sources of pollutants to the GBR and how do transport mechanisms operate? (Frederieke Kroon, CSIRO; David Waters, DNRM)
1400-1430	Building confidence in the models and application of new findings into Source Catchments A model-data fusion approach for predicting TSS loads in Weany Creek and the Upper Burdekin Catchment (Petra Kuhnert, CSIRO) Runoff nitrogen generation rates from pasture legumes – an enhancement to reef catchment modelling (Craig Thornton, DNRM) Sediment budget modelling in the Normanby Basin: key findings and implications (Andrew Brooks, GU)
1430-1500	What is the relative risk between pollutants on GBR ecosystems, between NRM Regions? (Jon Brodie, JCU; Jane Waterhouse, JCU; Steve Lewis, JCU)
1500-1530	**Afternoon Tea**
1530-1550	Using multi-criteria analysis models for prioritisation of investment in the Great Barrier Reef (Michele Barson, DAFF)
1550- 1615	*Panel Discussion:* **What are the hot spots for management action– industries and localities?** Led by Kevin Gale *Panel Members:* Claire Andersen, DPC; Dan Galligan, QFF; Paul Birch, FBA; Nick Heath, WWF; SEWPAC, TBC *Key questions include:* Is it nutrients, pesticides or sediments? Where do we need to focus? How should we focus effort in the context of this knowledge?
1615-1700	**Improved techniques for monitoring and reporting** Using biomonitoring to detect impacts of pesticides in rivers draining on to the Reef (Ben Kefford, UTS) A proof of concept for an integrated framework for reporting of water quality in the Great Barrier Reef lagoon (Britta Schaffelke, AIMS) Getting ground cover right (Terry Beutel, DAFF)
1745-1930	**Social Event: Reef Rescue Awards Event, coordinated by QFF and RGC** **Venue: Shangri-La Hotel, The Marina**

Friday 10 May Program Michaelmas Cay Room

	Building Innovative Practices for Reef Outcomes Chair: Sheriden Morris, Reef and Rainforest Research Centre
0800-0830	**Guests arrive / Registration**
0830-0840	**Session 3: How are we tracking in management practice improvements for Reef outcomes?** Convenor: Kevin McCosker, DAFF
0840-0905	What do we know about the benefits of management practices in GBR catchments? (Peter Thorburn, CSIRO; John Rolfe, CQU)
0905-0910	Capturing paddock scale hydrology and water quality experiences relevant to the Great Barrier Reef (Justin Cutajar, RPS Australia East Pty Ltd)
0910-0920	**Session 4: Reef Rescue and beyond for the Cane Industry** Convenor: Matt Kealley, Canegrowers
0920-1045	*Series of presentations:* Water quality benefits associated with A-Class nutrient management practices in sugarcane (Peter Thorburn, CSIRO) Mineralisation of nitrogen within the sugarcane cropping system following legume fallows and the effect on water quality (Bernard Schroeder, BSES) Pesticides in the sugar industry: modelling and monitoring their behaviour and risk, assessing new products and examining water quality benefits of improved management practices (Stephen Lewis, JCU) Optimisation of drip irrigation for sugarcane and banana cropping to improve water quality outcomes consistent with industry and reef requirements in Queensland (David Midmore, CQU) Integrated assessment of BMP cost-effectiveness and decision tool for regions and landholders (Martijn van Grieken, CSIRO) Factors affecting adoption of land management practices that have water quality benefits in the GBR Catchments: Evaluation scenarios for sugarcane farming (John Rolfe, CQU)
1045-1115	Morning Tea
1115-1145	*Panel Discussion:* **What next for the cane industry?** Led by Rob Cocco, Reef Catchments *Panel members:* Matt Kealley, Canegrowers; Rob Cairns, WWF; Reef Rescue Award winners *Key questions include:* What improved practices can we now adopt and are there particular adoption pathways? What is next in practice improvement? Where could we invest in further R&D and to what benefit?
1145-1155	**Session 5: Reef Rescue and beyond for the Horticulture Industry** Convenor: Scott Wallace, GrowCom
1155-1230	*Series of presentations:* Investigations on minimising off-farm movement of nitrogen in the north Queensland banana industry (John Reghenzani, Terrain NRM) Pesticides management in bananas (Bronwyn Masters, DNRM) Simulating growth, development and nitrogen balance of banana crops in APSIM (Tony Webster, CSIRO)

1230-1315	Lunch
1315-1325	**Session 6: Reef Rescue and beyond for the Grazing Industry** Convenor: Marie Vitelli, Agforce
1325-1435	*Series of presentations:* Understanding the impacts of grazing land management on ground cover, pasture productivity and erosion (Scott Wilkinson, CSIRO) Quantifying the impacts of rehabilitating degraded lands on soil health, pastures, runoff, erosion, nutrient and sediment movement (Trevor Hall, DAFF) Rehabilitation Options for Alluvial Gullies in the Normanby Catchment (Andrew Brooks, GU) Tebuthiuron movement at the plot and small catchment scales within the Fitzroy Basin (Craig Thornton, DNRM) Reef Rescue investments in the grazing industry: Socio-economic outcomes (John Rolfe, CQU) The movement of Nitrogen and Phosphorus fertilisers applied to dairy pastures in the Great Barrier Reef Catchments (Jack Koci, JCU)
1435-1455	*Panel discussion:* **What next for the grazing industries?** Led by Colleen James, NQ Dry Tropics *Panel members:* Marie Vitelli, AgForce; Ian McConnell, WWF; Reef Rescue Award winners *Key questions include:* What improved practices can we now adopt and are there particular adoption pathways? What is next in practice improvement? Where could we invest in further R&D and to what benefit?
1455-1515	**Session 7: Reflections and Key Take Home Messages** Convenor: Col Creighton
	Perspectives: Knowledge – Col Creighton, Di Tarte Investors and co-investors – SEWPAC, TBC; Dan Galligan, QFF Beneficiary – Bruce Elliot, GBRMPA
1515	Conference Close
1515-1545	Afternoon Tea

NERP Tropical Ecosystems Hub

Forum Synopsis Tuesday 7 May 1100-1230

Forum: Implementing the NERP TE Hub Indigenous Engagement Strategy: building effective Indigenous-Science partnerships for bio-cultural diversity conservation

Convener: Prof Helene Marsh, Professor of Environmental Science, James Cook University
Helene.Marsh@jcu.edu.au www.jcu.edu.au

The Traditional Owners of the Wet Tropics World Heritage Area, the Great Barrier Reef region, and Torres Strait are custodians of lands and waters of globally significant biodiversity value. Traditional Owners see caring for their country as an integral to living on their homelands. They have expressed their customary responsibilities for their country via the establishment of dedicated natural and cultural resource management organisations including community ranger groups, and strategic and operational planning. The management of biodiversity is a key task for these Indigenous networks.

Australian governments and others are increasingly investing in environmental and cultural grants and related programs including Working on Country and Indigenous Protected Areas to provide better caring for country alongside meaningful lifestyle, education, training and employment opportunities for Indigenous communities. The capacity and influence of Traditional Owner networks to protect and conserve biodiversity, supported by such measures, far surpasses that of non-Indigenous organisations, especially in the remote regions of northern Australia.

Partnerships between Indigenous agencies and scientists /land and sea managers can improve, and enhance biodiversity outcomes by utilizing the expertise and knowledge of both groups. Merging the two knowledge systems and world views requires respectful, principled, collaborative and integrative approaches that appreciate Indigenous knowledges alongside scientific techniques, and support the capacity of Indigenous communities to again manage their traditional estates. In contemporary times, this means managing country as bio-cultural environments using the knowledge and logistical capacity of Indigenous communities in conjunction with scientific techniques, and other inputs, e.g. the local knowledges of other non-Indigenous networks.

The NERP TE Hub is focused on the sustainable management of environmental assets in northern Queensland including the Great Barrier Reef, the Wet Tropics Rainforests and the Torres Strait. These natural areas are strongly connected to the region's Aboriginal and Torres Strait Island peoples. There are an identified 20 Traditional Owner Groups, 120 clans and 6 language groups within the Wet Tropics region alone (Wet Tropics Management Authority, 2012). There are 40 Traditional Owner groups identified within the Great Barrier Reef region (Great Barrier Reef Marine Park Authority, 2012). The Torres Strait has 20 Traditional Owner groups (19 Torres Strait Islander Corporations, and one Aboriginal Native title Corporation). Indigenous ecological knowledge must be a fundamental pillar for the sustainable environmental management of the natural resources of north Queensland.

The NERP TE Hub seeks to better recognise the importance of Indigenous engagement in the understanding and management of north Queensland's natural assets. The overall goal of the Hub's incoming Indigenous Engagement Strategy and Implementation Plan is to ensure a meaningful two-

way engagement strategy that recognises and respects the interests, rights and Indigenous ecological knowledge of Traditional Owners in lands, waters and sea country and be developed through appropriate working partnerships between the Hub's networks and Traditional Owner groups.

This workshop seeks to illustrate how NERP scientists are recognising and respecting Traditional Owner relationships and knowledge and looking to further undertake co-research with Traditional Owners. The workshop will commence with an introduction to the context for Indigenous co-research in our region, followed by a presentation of the first principles of such co-research from Traditional Owner representatives, and the NERP TE Indigenous Engagement Strategy and Implementation Plan. The implementation of these principles will be illustrated using three case studies. Each case study will be viewed from the perspective of a Traditional Owner and NERP scientist and will focus on a different phase of the partnership process and a different geographic region: development (GBR), knowledge sharing (Torres Strait) and co-management (Wet Tropics).

The workshop will be introduced by the co-chairs Melissa George and Helene Marsh.

- A context for Indigenous co-research in our region. Helene Marsh
- Indigenous Bio-Cultural Engagement: Principles, Practice and Protocols. Joann Schmider, Phil Rist, Melissa George, Leah Talbot and Gerry Turpin
- NERP TE Hub Indigenous Engagement Strategy and Implementation Plan for 2013-2014, including the Research Guidelines in the Torres Strait: what does this document mean for future research under the NERP TE Hub? Melissa George, Leah Talbot and Frank Loban
- Case Study – Development (GBR)
  Phil Rist and Helen Penrose will describe the development of the burgeoning co-research partnership to monitor dolphins and dugongs in Girringun sea country.
- Case Study – Knowledge Sharing (Torres Strait)
  Frank Loban and Mark Hamann will illustrate how their teams are working together to inform Torres Strait communities of the outcomes of NERP research on turtles and dugongs.
- Case Study – Co-management (Wet Tropics)
  Petina Pert (CSIRO) and Joann Schmider (RAPA) will outline this multi-partner co-research project investigating the potential of collaborative models and tools including IPAs to engage Indigenous values and world views, and to identify the conditions under which these arrangements lead to effective joint management of country.
- Co-Chair Melissa George will draw together the insights from a Traditional Owner point of view and together with Co-Chair Helene Marsh introduce the Focus Question and Discussion Session.

The panel comprises:

- Ms Melissa George, a Wulgurukaba Traditional Owner from Magnetic Island and the greater Townsville region. Melissa uses her experience and knowledge to advise the Queensland and Australian Governments and is a member of a number of NRM committees including the Great Barrier Reef Marine Park Authority Board and the Wet Tropics Indigenous Working Group. Melissa is part of the core leadership group of the Rainforest Aboriginal Peoples' Alliance, and

has been Chair of the national Indigenous Advisory Committee that advises the federal Minister of Environment since 2006. Contact: pandanus_mg1@bigpond.com

- Dr Mark Hamann, a Senior Lecturer at JCU, works with Torres Strait Traditional Owners on community-based projects for monitoring and management of marine turtles and dugongs. Contact: mark.hamann@jcu.edu.au
- Dr Rosemary Hill is a human geographer specialising in collaborative environmental governance and planning research with communities at multiple scales to foster social-ecological sustainability, with a particular focus on Indigenous systems. Dr Hill is a member of the Board of the Wet Tropics Management Authority. Contact: ro.hill@csiro.au
- Dr Petina Pert is a spatial analyst specialising in visualisation, spatial analyses of landscape ecology, ecosystem services and other NRM issues. More recently she has begun working with Traditional Owners assisting with the display of indigenous estates and bio-cultural knowledge.
- Mr Frank Loban, a Torres Strait Islander Traditional Owner, is a Project Manager (Sea) with the Torres Strait Regional Authority's Land and Sea Management Unit.
  Contact: frank.loban@tsra.gov.au
- Professor Helene Marsh, Professor of Environmental Science at JCU, is a conservation biologist with many years' experience working with Traditional Owners to inform the sustainable use of marine wildlife, particularly dugongs. Helene is Chair of the national Threatened Species Scientific Committee. Contact: helene.marsh@jcu.edu.au
- Mr Phil Rist, Nywaigi Traditional Owner, is the Executive Officer Girringun Aboriginal Corporation, which represents the interests of traditional owners from nine tribal groups in the region from North Maria Creek to El Arish and south west to the Tully River, north to Ravenshoe and Herberton, south to include country to the east of Einsleigh, south west of Greenvale and east to Rollingstone and the offshore islands and surrounding waters. Phil is one of the core leadership group of the Rainforest Aboriginal Peoples' Alliance, and co-chair of the Queensland Traditional Owner Network (QTON). Contact: Executive Officer (Girringun) EO@girringun.com.au
- Dr Helen Penrose, a Research Officer at James Cook University, is working with several north Queensland Indigenous communities on the management of marine mammals particularly coastal dolphins in their sea country. Contact: helen.penrose@jcu.edu.au
- Ms Joann Schmider, is a Mamu Traditional Owner, and coordinates the NERP TE Hub Traditional Owner knowledge management project with the Cairns Institute. Joann is a Director of the Central Wet Tropics Institute for Country and Culture Aboriginal Corporation supporting 9 Traditional Owner groups, one of the core leadership group of the Rainforest Aboriginal Peoples' Alliance, and co-chair of the Queensland Traditional Owner Network (QTON).
  Contact: joann@comunityacets.com.au
- Ms Leah Talbot, is an Eastern Kuku Yalanji woman who holds a Masters Degree in Environmental Science. Ms Talbot is a member of the Board of the Wet Tropics Management Authority. She has recently commenced her PhD and is supported as a Research Project Officer with CSIRO. Leah is also a member of the leadership group of the Rainforest Aboriginal People's Alliance, and is

co-coordinating the Research and Knowledge Management Portfolio.

- Mr Gerry Turpin is an ethnobotanist at the Australian Tropical Herbarium in Cairns. He documents the traditional uses of native plants by Far North Queensland Indigenous communities and spends a large percentage of his time delivering plant collecting and plant identification training in remote communities. Gerry is also a member of the Rainforest Aboriginal People's Alliance, and is co-coordinating the Research and Knowledge Management Portfolio.

Some focus questions for the session to stimulate discussion. These questions may be replaced by questions from the floor:

- What agreements should be negotiated before commencing co-research with Traditional Owners and/or a local Indigenous community.
- How is it most effective to work with Traditional Owners and/or a local Indigenous community to translate their research priorities into scientifically robust co-research projects?
- What personal qualities, training and experience do research managers and researchers need to operate effectively with Indigenous co-researchers. How should they obtain the expertise required to implement the required way of working?
- How can research partnerships with Traditional Owners and/or Indigenous communities help provide a balanced suite of indicators for successful co-management given the inevitable difference in the values of Indigenous and non-Indigenous managers?
- How can the synthesised results from multiple research projects be successfully repatriated to Traditional Owners, Community and Managers?

Forum Synopsis Tuesday 7 May 1330-1500

Forum: How do we recognise progress in securing the conservation of the Wet Tropics?

Convener: Andrew Maclean, Executive Director , Wet Tropics Management Authority

The inscription of Australia's Wet Tropics rainforests 25 years ago as a World Heritage Area was a great achievement for conservation. Listing saw an immediate end to logging activity, limited the prospect of any future mining, prevented any significant vegetation clearing and led to the establishment of a robust, statutory management plan. In turn, listing as a World Heritage Area created a strong impetus for the growth of rainforest tourism, building understanding and support for conservation among residents and visitors alike.

We would be complacent if we were to conclude that our responsibility for protecting and conserving the outstanding universal value of the Wet Tropics was achieved simply through listing and formal reservation. Many threats to rainforest conservation operate without regard to our boundaries and rules.

Pests, such as tramp ants and feral deer; weeds, such as Miconia and Koster's Curse; and diseases,

such as Myrtle Rust and Chytrid Fungus have become established in the Wet Tropics despite World Heritage listing and our management efforts.

Climate change has accelerated over the last 25 years and we might be already seeing its manifestations in the Wet Tropics in increased cyclone intensity, more frequent hot spells and changing rainfall patterns.

Population growth in the region continues to drive land use change in the wider region and create pressure for establishing new, or improving existing, transport, water supply, energy and telecommunications infrastructure within the World Heritage Area.

The four papers presented in this session all contribute in various ways to our understanding of the conservation status of the Wet Tropics.

- Professor Steve Williams' research adds to and draws upon a very extensive rainforest fauna dataset established over many years. This data combined with sophisticated modelling techniques is helping us better understand processes, trends and management priorities relevant to rainforest conservation.
- Dr Darren Crayn is investigating the distribution of plant and fungal taxonomic richness, endemism, and genetic diversity across the Wet Tropics bioregion at the level of genus, species, and population. This information will provide a solid foundation for conservation prioritisation efforts in the region.
- Dr Conrad Hoskins's work focuses on the region's frog populations, several of which have been severely affected by chytrid fungus. Conrad's work is providing some cause for optimism that populations may persist in unexpected locations or may even have adapted to survive with chytrid fungus infections.
- Dr David Westcott's research focuses on population monitoring of the iconic southern cassowary, and flying foxes. Cassowaries and flying foxes are prominent features of Wet Tropics biodiversity, often evoking strong reactions in the human community. Aside from the information it provides on the species themselves, David's research highlights the challenge of monitoring trends in wildlife populations in ways that can allow confident conclusions about management strategy and results.

Representatives of the research user community will join the researchers in a Q and A panel session following the presentations.

Some focus questions for the discussion session:

- Having secured 900,000 ha of forest for conservation 25 years ago, all we ever seem to discuss is how things are getting worse. Is there any empirical evidence of positive trends in Wet Tropics forest conservation?
- Is the scientific/technical understanding of forest condition the same as the community/political understanding? If not, can we reconcile and align these?
- Is modelling monitoring? Is it acceptable to estimate and predict forest condition, or should we measure directly?
- Despite work done all over Australia and the world for many years, we do not seem to have

managed to identify informative, reliable, trusted and cost-effective indicators of trends in biodiversity. Is our search for indicators as likely to succeed as the quest for the Holy Grail?

- How influential has Wet Tropics research been in influencing policy, planning and management practice? What role do scientists themselves have in ensuring their work has influence?
- While we apparently like biodiversity and we trade on the biodiversity of the region, we like it to be in its place not our place. Snakes, flying-foxes, feral pigs, lorikeets, crocodiles, wallabies are all animals that are attracted to the habitats we make but are not welcome. Can we learn to live with these animals and what are the risks of not doing so?

Forum Synopsis Tuesday 7 May 1530-1700

Forum: Managing for Change

Convener: Carole Sweatman, Chief Executive Officer, Terrain - NRM in the Wet Tropics
caroles@terrain.org.au www.terrain.org.au

It goes without saying that we are part of a constantly changing global environment, influenced by the bio-physical and social dynamic of both the region and beyond.

Working within this dynamic, this forum may be more correctly titled "understanding and working with change". With so many variables in our landscape significantly influenced by human intervention, the challenge for research users will be the layering and adaptive use of the information needed to influence policy, programs, projects and community activity for long term and agreed outcomes.

The breadth of projects covered in this forum suggests that, at any one time, a land manager will be weighing up the impacts and use of potential tools for fire, weeds and pests, climate change and the planning and governance arrangements in place. The challenge from this forum is to understand both the research undertaken within the NERP, and the way it can account for community attitudes, interests and values before use in decision making.

The five papers presented will provide insight into the biophysical responses and outcomes from change, practical tools for improvement and improved governance frameworks for achieving better environmental outcomes in the face of some of these changes.

- Dr Dan Metcalfe will provide an understanding the biodiversity impacts of changing fire regimes on rainforest boundaries, and in particular the EPBC listed littoral forest habitat in the Wet Tropics.
- Prof Carla Catterall is focussing on the approaches to managing and accelerating vegetation regrowth particularly the potential for natural passive strategies for cost effective rainforest restoration.
- Dr Helen Murphy's work will help to clearly identify optimal strategies for weed management across the Wet Tropics particularly focussing on which invasive species cause or are likely to cause the greatest environmental harm.
- Dr Justin Welbergen's work will provide an analytical toolkit for assessing vulnerability to extreme climatic events including generation of high resolution maps on exposure to extreme temperatures.

- Dr Allan Dale's work is exploring and developing tools and governance frameworks for the emerging ecosystem service markets in the Wet Tropics. He will tell us about the mechanisms for NRM organisations and end users to guide carbon investments for priority biodiversity outcomes.

Joining the researchers in the Q & A panel at the end of the presentations will be three representatives who are working in the practical realm with the community and government who can potentially take these outcomes and tools to influence better landscape outcomes.

Some focus questions for the speakers and this forum are:

- How does the research help us to work through complex land management decisions and prioritisation of effort?
- Given that the changes happening are greatly influenced by human activity and intervention, how do we account for the social dimension to utilise the research outcomes?
- Given that land management is constantly evolving and adapting to change, how can the research help us with adaptive strategies?

Forum Synopsis Wednesday 8 May 0830-1000

Forum: Effectiveness of spatial zoning for biodiversity and fish populations

Convener: Dr Laurence McCook, Acting Director, Climate Change and Science, Great Barrier Reef Marine Park Authority

Spatial zoning, including networks of marine reserves, is a key tool in marine management and conservation, although it must be seen as only one of a portfolio of complementary approaches needed for effective management. The zoning of the Great Barrier Reef provides a globally significant scientific opportunity to test and understand the potential effects of spatial zoning, due to its unique combination of: regional scale replication; the use of a transparent and accountable set of design principles; relatively effective compliance and enforcement regimes; and the wealth of monitoring and background scientific information available, including some before-after comparisons.

Recent syntheses have covered a broad range of evidence on the outcomes of the zoning of the Great Barrier Reef, from effects on fish populations, through seabed biodiversity to social and economic perspectives. It is critical that we keep in mind that the primary objective of zoning is to enhance protection of the full-range of Reef biodiversity across the entire Marine Park. Thus, we are interested in the effects across the ecosystem, not just within the reserves, and we are interested in the effects on biodiversity generally, and not just the effects on fish populations within reserve zones. However, this presents some real challenges for the underlying logic of research and monitoring programs.

The three presentations in this session will provide key updates to the information available on the direct effects on zoning on target fish populations, and apex fish predators.

- Dr David Williamson will describe the work monitoring the effects of the GBR network of marine

reserves ("Green Zones") on fish populations. He will outline the latest data from the monitoring program on the effects of marine reserves, integrating work from a range of inshore and offshore reefs.

- Prof. Geoff Jones will outline spillover benefits from marine reserves and larval dispersal within and between zones. He will describe his team's ground-breaking research providing the first empirical evidence for larval spillover from marine reserves to other reserve areas, and to non-reserve reefs. This is critical research because it not only suggests benefits to fished populations, but also that the reserve network is functioning as a network, providing greater resilience to the entire ecosystem.
- Dr Andrew Tobin will discuss movements of apex fish predators, describing research on movement and behaviour of larger sharks and other predators, and how zoning and reserves contribute to the protection of these species. Unlike many of the target fish, which are relatively site-attached and hence effectively protected by reserves, more mobile species present different challenges, and illustrate the need for complementary spatial and other management approaches.

Joining the speakers in a Q and A panel session following the presentations will be representatives of the research user community and related experts.

Potential focus questions for the discussion include:

- How are the benefits within reserves transferred to the wider ecosystem, including groups other than fish…?
- How do the ecological effects translate into benefits for the wider community?
- How can we better share emerging knowledge of these effects with the wider population, including outside Queensland?

Forum Synopsis Wednesday 8 May 1030-1230

Forum: What does the future hold for Torres Strait and its Indigenous People?

Convener: Damian Miley, Program Manager (Environmental Management), Land and Sea Management Unit, Torres Strait Regional Authority

The Torres Strait region covers an area of more than 35,000 square kilometres, of which 2.6 percent is terrestrial land, 6.2 percent is tidally inundated reef flats, and 91.2 percent open seas, most of which are relatively shallow. There are more than 247 islands and a multitude of cays, sandbanks and coral reefs scattered throughout the region, which stretches 200 kilometres from the tip of Cape York Peninsula (also referred to as the Northern Peninsula Area) to the south-west coast of Papua New Guinea (PNG).

Located on one of the world's most extensive continental shelves, the Torres Strait has long been recognised for its ecological complexity and biodiversity. The region has significant tropical

marine ecosystems, and populations of important and vulnerable marine species. The region also has a multitude of habitats including coral reefs, mangroves and extensive seagrass meadows. The clear waters and coral reefs to the east also provide rich fishing grounds within the most northerly section of the Great Barrier Reef. Marine turtles are found throughout the entire region, however predictions, particularly based on Raine Island data, are that the green turtle will suffer a catastrophic population decline in the next ten years unless dramatic actions are taken. Extensive seagrass beds in the west and north support the World 's largest dugong population, and represent a very significant proportion of Queensland's high density habitat for this animal, listed as 'vulnerable' under national environmental law.

The Torres Strait marine environment is of national and international significance. Located at the junction of the Arafura and Coral Seas, it is a major shipping route for transiting between the Indian and Pacific Oceans. The Torres Strait shares international borders with neighbouring PNG and Indonesia. The Torres Strait Treaty between PNG and Australia establishes the Torres Strait Protected Zone and other mechanisms for the shared governance of the region, including access to and management of its marine resources.

The region has one of the highest proportions of Indigenous people, many of whom still have strong affiliation with their land and sea. Native Title determinations have been made for most of the islands in the region, and a Regional Sea Claim process is being finalised.

The responsibility for managing environmental issues in the Torres Strait region is a complex arrangement which spans a number of key organisations to varying degrees. They are the:

- Various State and Federal Australian Government agencies
- Torres Shire Council (TSC)
- Torres Strait Islands Regional Council (TSIRC)
- Torres Strait Regional Authority (TSRA) and, to a lesser extent
- Northern Peninsula Area Regional Council (NPARC).

Of these, the TSRA is the only Commonwealth Statutory Authority and, as such, the bulk of the Australian Government's environmental program is delivered through this agency. Having said that, a lot of effort is put into ensuring all organisations work cooperatively towards a common goal in managing the region's assets including the unique environment.

Global pressures such as peak oil, shipping traffic and climate change will also have complex impacts on environmental assets, particularly when combined with human pressures. The extent of the potential effects of climate change, along with the geographic, social, cultural and spiritual characteristics of the Torres Strait region make Torres Strait communities amongst the most vulnerable in Australia. The effects of climate change threaten not only the islands themselves, but also marine ecosystems; and therefore the life, livelihoods and the unique culture of Torres Strait Islanders. This uncertain future will present challenges for achieving resilient Torres Strait communities, but may also provide opportunities for optional economic development opportunities.

The five papers presented in this session all contribute in various ways to our understanding of the

conservation status (mangroves and wetlands, turtle and dugong, fish, and coral reefs and addressing the question of resilience and threats (disease dynamics and building resilient communities).

- Professor Helene Marsh and Dr Mark Hamann continue to monitor dugong and turtles in the Torres Strait including movements, connectivity of populations and aerial surveys to estimate abundance. Prof Marsh recently reported that the Torres Strait has the healthiest and largest population of dugong.
- Dr Jon Brodie recently completed a study identifying the main water quality risks in the region and recommending a monitoring program to measure the threats from multiple water quality stressors, including toxic metals, oil, ship anti-foulants and litter.
- Dr Damien Burrows and Dr Norm Duke are assessing and monitoring the condition of mangroves and freshwater wetland habitats in the Torres Straits in collaboration with the traditional owners. Mangroves are important for shoreline stabilisation and as critical habitat for many species of fish, crustaceans and shorebirds.
- Dr Erin Bohensky's research explores potential future scenarios for the region, and will identify 'best bet' strategies to protect livelihoods and achieve sustainable economic development through participatory scenario planning with Torres Strait and PNG communities and stakeholders, informed by integrated ecosystem and climate modelling.
- Dr Hugh Sweatman and Dr Ray Berkelmans have designed and implemented a reef health monitoring program in the Torres Strait. Sea temperature monitoring, remote sensing and real-time monitoring of the health of the coral reef systems are delivered by Indigenous sea rangers in collaboration with the research team.

Please also note that other Torres Strait NERP research not covered in the Forum include work by Dr Susan Laurance (JCU) who is pioneering new surveillance techniques to detect emerging infectious diseases, with future outbreaks predicted to occur in frontier regions of tropical countries. Dr Eric Lawrey (AIMS) is also working closely with TSRA to establish the systems, tools, products and form of information (i.e. e-Atlas) that will maximise the benefit from Torres Strait-based NERP TE Hub research projects. The e-Atlas will be demonstrated by Dr Lawrey during the lunch after this Forum.

Joining the researchers in a Q&A panel session following the presentations will be staff from the TSRA Land and Sea Management Unit who are supporting these projects and delivering on a range of other activities; TSRA elected leaders Kenny Bedford, Member for Erub (Darnley Island) and Fisheries Portfolio Member, and Willie Lui, Member for Warraber and Portfolio Member for Environmental Management, will also be present to provide a political context to the discussion.

Some focus questions for the session:

- Turtles and dugongs are culturally and environmentally important to the Torres Strait, how do we protect populations with the threats of increased shipping, illegal fishing and water quality contaminants in the Torres Strait?
- What role should researchers play in addressing topics such as indigenous hunting in the ongoing media debate?

- As the Torres Strait has one of the most pristine coral reef ecosystems in Australian waters, and coral bleaching, COTS and coral diseases are being detected can and should the GBRMPA extend its research and monitoring activities into the Torres Strait, to cover the GBR reefs north of the Marine Park boundary?
- Are there any other issues you consider to be a threat to the region?

Forum Synopsis Wednesday 8 May 1330-1500

Forum: Drivers of Biodiversity on the GBR, COTS Outbreak Dynamics and Population Control

Convener: Doug Baird, Environment & Compliance Manager, Quicksilver Group
Dougie@quicksilver-cruises.com www.quicksilver-cruises.com

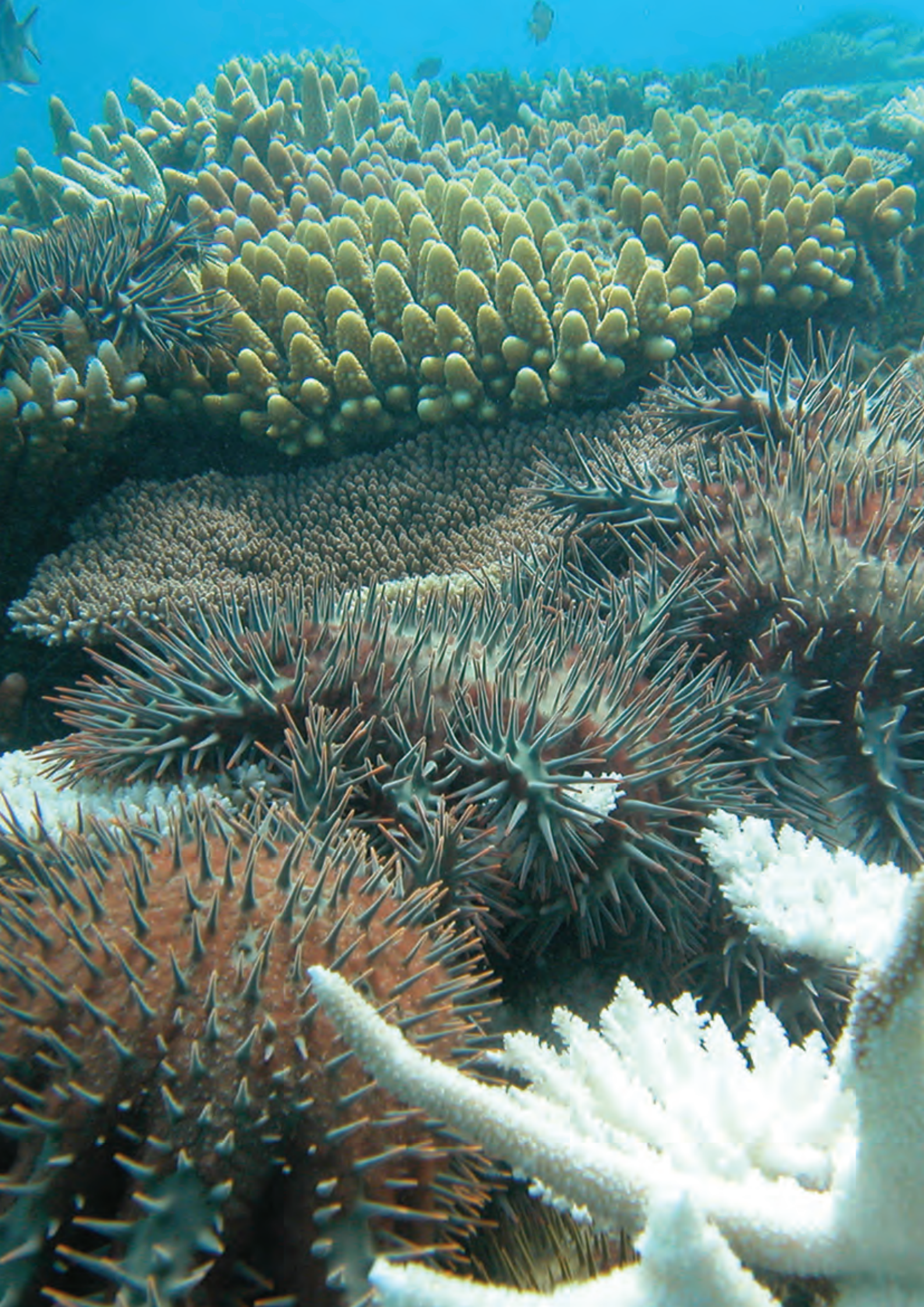
The crown of thorns starfish (COTS) is a multi-armed echinoderm coral predator, found on most tropical reef systems globally. When in "normal" population densities, deemed to be less than 30 mature animals per hectare, they are believed to contribute to maintaining the biodiversity of reefs due to their preference for consuming fast growing *Acropora* species. However, their populations occasionally boom to more than 30 mature animals per hectare, and at these "outbreak" densities they can overwhelm reefs, severely reducing coral cover and compromising the reef's ability to bounce back from other disturbances such as cyclones.

Temperature changes have little effect on COTS' survival yet have a major effect on the survival of coral, and, with climate change predicted to make the oceans more stressful for corals, outbreaks have the capacity to considerably reduce coral cover GBR-wide, and reduce the resilience of reefs.

Studies have been undertaken on these animals since the first recorded outbreak on the GBR at Green Island in 1962, and a variety of theories put forward regarding causes of outbreaks, most looking for some human-induced trigger. An alternative school of thought suggests that COTS' biology predisposes the animals to population outbreaks and that they are part of a natural cycle.

There have also been nearly as many ideas for controlling COTS as there have been theories for their outbreaks, from using giant triton shells, to injecting COTS with swimming pool chemicals. Control efforts require highly trained staff and an awareness of scale and reef topography to stand any chance of success.

In this session two AIMS researchers will lead off, with Dr Hugh Sweatman setting the scene, talking about the history and status of COTS on the GBR, including their role in the 27-year decline in coral cover. Dr Katharina Fabricius will then outline recent work on the link between COTS outbreaks and water quality. She will review the relationships between flood events and the timing and location of subsequent outbreaks, and summarise new eReefs results on the relative contributions of each of the main rivers to the high-risk area north of Cairns where outbreaks begin. Scott Firth of AMPTO will then describe current COTS mitigation programs, highlighting the technical aspects, limiting factors, costs and logistics. Dr Peter Doherty, again of AIMS, will describe the use of funds released by Minister Burke from the NERP Emerging Priorities program for tactical research into the current outbreaks and more efficient control agents.



Focus questions:

- With the Marine Tourism Industry generating somewhere in the region of $5 Billion into the Australian economy and employing around 60,000 people there is a great need for early warning of outbreaks, are we really any closer to establishing a trigger for these outbreaks and if so does it allow predictions of when and where the outbreak will occur?
- Are the current broad scale surveys sensitive enough to detect sub adult populations or should resources be put into fine scale surveys that will detect these much more cryptic animals?
- As AMPTO has successfully secured government funding to run an eradication program is the current strategy giving the best bang for the buck?
- How can we make a COTs eradication dive more efficient? A large proportion of each eradication dive is spent hunting for animals, and, when found, trying to ensure that the each is suitably injected. Can we make the COTS come out of hiding by developing attractants?
- What else can we do?

Forum Synopsis Wednesday 8 May 1530-1700

Forum: Managing natural resources for future generations

Convener: Mark Read PhD, Manager Species Conservation, Ecosystem Conservation and Sustainable Use Group, Great Barrier Reef Marine Park Authority

Managing natural resources for the benefit of future generations is often a delicate act to balance the need to address all threats to ensure long-term viability and resilience; to ensure that any use is ecologically and economically sustainable and that the social benefits of having these elements of biodiversity within the Great Barrier Reef World Heritage Area are recognised and respected.

Underpinning all of this is the need to make decisions based on the best available information. This can come from the well-respected and accepted disciplines of standard research and monitoring programs, but increasingly the information is coming from dependent industries, such as the tourism industry, and the multi-generational knowledge from Traditional Owners and fishers. It is also becoming increasingly obvious that the community wants (and expects) to take a more active role in decisions regarding the management of the Great Barrier Reef World Heritage Area and its biodiversity, which can lead to better environmental, social, economic and governance outcomes, particularly at the local level.

Contributing to the challenges of managing natural resources for future generations is that many species migrate or travel over large distances; that habitats or species can be cryptic or difficult to study; are managed by multiple jurisdictions and are exposed to multiple threats, particularly in inshore areas. Meeting some of these challenges can involve taking a more direct approach – intervening; and this management option comes with its own series of policy, operational and philosophical considerations.

The three speakers in this session all contribute in various ways to our understanding of the management of natural resources for future generations.

- Dr Andrew Tobin's research is making a significant contribution to improving our understanding of the life history parameters and distribution, abundance and movements of coastal shark populations.
- Dr Cathy Dichmont and her multi-disciplinary project team are developing by way of a bottom-up process with significant input from local people at a regional level (Mackay and Burdekin); a Management Strategy Evaluation (MSE) framework to build understanding of the key human uses and drivers of change in the inshore Great Barrier Reef (GBR), and to inform GBR stakeholders of the likely consequences, costs and benefits of particular management decisions that aim to minimise the impacts on biodiversity, particularly from inshore multi-species fisheries.
- Dr Brad Congdon's research is demonstrating the far-ranging foraging behaviour of seabirds that nest on offshore islands, and provides clear examples of connectivity between the Great Barrier Reef World Heritage Area, and the Coral Sea and waters off central New South Wales.

Joining the researchers in a Q and A panel session following the presentations will be representatives of the research user community.

- Mr Lyle Squire Jnr is the Director of Cairns Marine
- Mr Gavin Bassini is a Lama Lama Traditional Owner from Cape York Peninsula
- Mr Paul Aubin is the Director of CAREFISH, a recreational fishing representative group
- Ms Rebecca Williams is the Director of Wildlife Management for DEHP
- Mr Richard Quincey is the Director of the Field Management Group from GBRMPA

Some focus questions for the session are:

- Our best outcome for managing natural resources for future generations is for all users to work together and harness the collective resources available to continue and enhance current conservation and management and to ensure ecologically sustainable use. However, many of our processes do not facilitate this collaborative approach, such as the approval-by-approval consideration of biodiversity offsets, all operating at different spatial and temporal scales. Should we and can we do this better to improve the long-term outlook for the Reef?
- Despite our best efforts, there still seems to be a disconnect between our current understanding of the threats facing the Reef and its biodiversity and communicating this to some of our key stakeholders. How can we do this better and what other communication methods do we need to consider to improve information uptake and acceptance?
- Often the ideas for how we can reduce our impacts on habitats and species come from people who have spent their lives working on the Reef or Traditional Owners who have the multi-generation connection to country. However, we haven't been particularly good at recognising or respecting these ideas or incorporating these into the decision-making framework. How do we get better at including these ideas as a standard/mandatory component of decision making?
- For some populations that are really under pressure, just how far do we intervene to maximise their resilience into the future?

Poster Abstracts

Great Barrier Reef

Historical and Current Condition of the Great Barrier Reef

Project 1.1 Monitoring status and trends of coral reefs of the GBR

Hugh Sweatman, Alistair Cheal, Mike Emslie, Kerryn Johns, Michelle Jonker, Ian Miller, Kate Osborne

Australian Institute of Marine Science

The series of large cyclones that have passed through the GBR in recent years caused substantial loss of coral cover, notably from reefs in the southern GBR. Recent surveys show uneven rates of reef recovery among regions in terms of total coral cover and densities of coral recruits, with densities of coral recruits being high on Capricorn-Bunker reefs and on Pompey reefs and less so on the Swains and Whitsunday reefs.

Project 1.2 Linking Indigenous and scientific knowledge of inshore dolphins and dugongs within the northern Great Barrier Reef to evaluate their conservation status

Helen Penrose[1], Isabel Beasley[1], Mark Hamann[1], Helene Marsh[1], Phil Rist[2], Cheryl Grant[2], Chris Muriata[2], Arturo Izurieta Valery[2]

[1]School of Earth and Environmental Sciences, James Cook University, Townsville

[2]Girringun Aboriginal Corporation, Cardwell

This collaborative research project between James Cook University (JCU) and Traditional Owner groups from the northern Great Barrier Reef (GBR) addresses a fundamental gap in the scientific knowledge of the occurrence and distribution of inshore dolphins and dugongs in this region. Our research approach integrates Indigenous and western scientific knowledge of four focal species; Australian Snubfin dolphin (Orcaella heinsohni), Indo-Pacific humpback dolphin (Sousa chinensis), inshore bottlenose dolphin (Tursiops aduncus), and the dugong (Dugong dugon). Scientists consider that these dolphin species occur in small isolated populations across northern Australia but the locations of these populations is poorly known. While aerial surveys have been used for extensive regional assessments of dugong distribution and relative abundance, there are significant gaps in local-scale information. Within the northern GBR, coastal development and other human activities pose increasing pressure on the conservation and management of dolphins and dugongs. These species are Matters of National Environmental Significance that trigger development referrals to the Commonwealth Government.

JCU recognizes and respects the cultural significance of marine mammals to the Traditional Owners of the Great Barrier Reef, as well as their expert knowledge and connection to sea country. We

conducted Knowledge Sharing Mapping workshops with Traditional Owners and Indigenous Ranger groups from the Girringun Aboriginal Corporation (GAC) where dolphin and dugong sighting information (past and present) and habitat associations were recorded.

The six salt water Traditional Owner groups of GAC (Djiru, Gulnay, Girrimay, Bandjin, Warragamay and Nywaigi), who encompass the coastal region between Rollingstone and Mission Beach within the GBR Marine Park, were the first to develop an accredited TUMRA (Traditional Use of Marine Resources Agreement). The sea country knowledge shared by Indigenous participants during this mapping process is being used to identify locations for scientific surveys involving Traditional Owners and Indigenous ranger groups as active participants. Indigenous ranger groups within the northern GBR such as the Girringun Rangers, have a burgeoning capacity and increasing opportunities to collect data on their priority marine species. Information collected from this project contributes to sea country planning and management (including TUMRA and Indigenous Protected Areas), a national assessment of the status of the Australian snubfin and Indo-Pacific humpback dolphins and will inform the assessment of coastal developments.

Project 1.3: Historical changes on the GBR: Looking to the past to unravel the future

Zhao, Jian-xin[1], John M. Pandolfi[1], George Roff[1], Tara Clark[1], Malcolm McCulloch[2], Steve Lewis[3], Scott Smithers[3], Terry Done[4], Yue-xing Feng[1], Laurence McCook[5], Juan Pablo D'Olivo[2], Alberto Rodriguez[1], Mauro Lepore[1], Nicole Leonard[1], Hannah Markham[1], Martina Prazeres[1], Ian Butler[1], Emma Ryan[3]

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[2]The University of Western Australia
[3]Catchment to Reef Research Group, TropWater, James Cook University
[4]The Australian Institute of Marine Science
[5]Great Barrier Reef Marine Park Authority

While long-term monitoring has demonstrated that more than half (50.7%) of the Great Barrier Reef's (GBR) initial coral cover has been lost over the past 27 years, we have little understanding of how reefs existed and responded to disturbance prior to this time period. The aim of this large, multidisciplinary project is to better understand the dynamics of reef ecosystems over long time scales (i.e. before European settlement c. 1850) by reconstructing ecological and environmental changes from reef matrix cores and massive coral colonies, respectively. Here we demonstrate contrasting histories of reef development over the past several thousand years for two inshore regions. In the Palm Islands (central GBR), the onset of decline of the ecologically important coral genera Acropora can be traced back to the early 20th century. Yet Acropora has remained dominant in the Keppel Islands for the past 6 ka, despite being repeatedly impacted by flood events. These results provide important baseline information to reef managers so that the current status of inshore reefs can be appropriately assessed. Similar techniques are currently being applied to other regions, including the Wet Tropics and far-northern GBR, to provide a broad-scale understanding of the history of the reef.

Cumulative Impacts on Benthic Biodiversity

Project 5.1 Coral Cover and Diversity of the Great Barrier Reef

Glenn De'ath, Katharina Fabricius

Australian Institute of Marine Science

The reefs of the GBR have experienced a major decline in coral cover from 28.0% to 13.8% (0.53% yr-1) from 1985-2012. This is shown to be due to tropical cyclones, coral predation by crown-of-thorns starfish (COTS), and coral bleaching that accounted for 48%, 42% and 10% of the losses and amount to 3.38% yr-1 mortality. The relatively pristine northern region showed no overall decline. The estimated rate of increase in coral cover in the absence of cyclones, COTS and bleaching was 2.85% yr-1, demonstrating substantial capacity for recovery of reefs.

Although total coral cover is a useful measure of reef health, it does not reflect the complexity of reef communities. Diversity is a key concept for understanding such communities and how they are changing in response to these pressures. The theory of ecological diversity has for many years been problematic and bedevilled by a multitude of definitions and the inability to relate spatial and temporal change of diversity to complex environmental drivers. The Multinomial Diversity Model (MDM; De'ath 2012) is a solution to this problem. It is based on a parametric formulation of entropy and diversity and a novel link between entropy and the log-likelihood of the multinomial model. In initial analyses, we apply the MDM to coral cover data of 73 taxa (AIMS LTMP) and show how diversity varies over time in six zones of the GBR.

In the final year of this project the MDM toolbox will be applied to several GBR biotic data sets and a comprehensive report on the current state of diversity on the GBR. It will show how the GBR has evolved in space and time due to the effects of tropical cyclones, coral predation by crown-of-thorns starfish, and coral bleaching.

Project: 5.2 Experimental and field investigations of combined water quality and climate effects on corals and other reef organisms

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Increasing temperatures, ocean acidification (OA) and decreasing water quality from terrestrial runoff are likely to significantly alter ocean and coastal ecosystems over the next few decades. These issues are commonly considered as individual pressures on tropical systems, but their interactions are as yet poorly understood and likely to be more damaging than each pressure in isolation. Increased ocean temperatures negatively affect symbiotic relationships (e.g. causing coral bleaching) and atmospheric CO_2 pollution is reducing the ability of tropical marine organisms to calcify. The research in project 5.2 uses integrated laboratory and field experimental studies to assess causal relationships between the interactions of water quality, ocean warming and ocean acidification and the responses of key coral reef organisms. In the first 18 months of this project, a number of medium-term (2-8 weeks) experiments have been conducted to investigate the interactive effects of two combined factors, for example: i) OA and temperature, ii) OA and salinity, iii) OA and turbidity/light, iv) Temperature and elevated nutrients/increased suspended sediment.

Organisms investigated included several coral species, calcifying algae, seagrasses, foraminifera and echinoderms. In most cases, the combination of local and global stressors showed additive effects. A new model of the relationship between nutrient availability and thermal tolerance in corals was formulated and published. In the second half of the project, further experiments will allow to formulate conceptual frameworks for most of the other organisms of their responses to combined environmental pressures. However, it is already apparent that improving marine water quality would convey increased resilience to climate change for most of the organisms investigated.

Project 5.3: Vulnerability of seagrass meadows of the GBR to water quality impacts

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Seagrass meadows have an important ecological role in the GBR. Many estuarine, coastal and reef animals, including species of fisheries importance, use seagrass meadows as habitat. Dugongs and turtles feed directly on seagrasses and changes to seagrass health have direct consequences for these fauna. Seagrass meadows also form a buffer between the catchment and the reef as they trap sediments and absorb nutrients. Seagrasses in the GBR have been in decline over the past few years. This occurred because water quality had deteriorated due to above average runoff from modified catchments. We developed a novel approach to model exposure of seagrasses to flood plumes using remote sensing imagery. This approach has identified that the impact of flood plumes on seagrass is strongly linked to the type of plume waters and the duration of exposure. Seagrass meadows with the highest exposure to flood plumes have reached the lowest abundance in recent years. Water quality is complex and there are a number of ways in which it can impact upon seagrass health. We are systematically testing these possibilities. We found that coastal seagrasses have broad salinity tolerance, with seagrass death occurring only at salinities <9ppt after 10 weeks exposure. These results indicate that low salinity was probably not the cause of recent seagrass loss. However, we analysed in-situ monitoring data, which showed strong correlation between low light (turbid water) and seagrass loss, so we are testing the impacts of low light even further. Using experimental approaches, we tested the effects of low light conditions and elevated nutrients on seagrass health to simulate flood plumes. Analysis of this is still in progress but is showing that seagrasses exhibit early-warning signs of water quality stress. Outcomes from this project feed directly into the Reef Rescue Marine Monitoring Program, assisting with the interpretation of monitoring data and in the development of indicators.

Movements and Habitat Use by Marine Apex Predators

Project 6.1 Worlds apart? Connectivity between marine predator communities

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Many coastal, and especially reef based species are considered to be highly site attached with limited movement from home locations. This is also true for predatory marine fish, including sharks, despite research to indicate the potentially broad movements of some species. A limited understanding of the broad-scale movements of predators and the overall implications for habitat connectivity and management of marine resources are evident. This project examines the long-term movement patterns of marine predators to define their use of space in relation to habitat type, location and marine park zonation. Preliminary results indicate that although some portions of populations are more resident than others, movement between reefs is not uncommon. Further, movement between inshore and offshore regions is also apparent in both teleost and elasmobranch species. Finally, broad-scale alongshore movements are also occurring. These movement patterns indicate potential problems for mobile species that are moving in and out of protective zones, encountering a number of commercial fishing fleets, and also crossing jurisdictional boundaries. Future management of mobile populations will require consideration of these previously unconsidered aspects of movement.

Project 6.2 The role of nursery areas in the management and conservation of inshore sharks

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Shark nursery areas, where the young are born and live, are widely used by shark species. Within the GBRWHA coastal embayments are the most commonly used nursery areas, being inhabited by more than a dozen species. This research project investigates how the use of bays in the central GBR varies both spatially and temporally, and what factors drive this variation. To date, surveys using gillnets and longlines in five embayments have identified 19 species of shark. Of these at least seven use these areas as nurseries, with others occurring more regularly as adults or later stage juveniles. There are significant differences in shark communities between bays, and differences in the species using bays as nurseries. Zoning differences, levels of freshwater input, geomorphology and environmental parameters are being investigated as potential drivers of this observed variation. Theoretical work, and data from other locations, suggests that shark species may derive benefits from using multiple nursery areas through a "portfolio" effect, where changes in individual nurseries result in dampened variation over time. Ultimately this project will help improve the management and conservation of inshore sharks of the GBRWHA through understanding the benefits of nursery areas and portfolio effects.

Project 6.3 Critical foraging areas for seabirds of the Great Barrier Reef

Fiona McDuie, Bradley Congdon

School of Marine & Tropical Biology, James Cook University

Previously, we have shown that both El Niño activity and sea-surface temperature variation significantly influence seabird breeding success on the GBR. These findings highlight the potential

vulnerability of seabirds to predicted climate change impacts under all future climate scenarios. As a first step in assessing magnitude of these potential impacts we are identifying and mapping the principal foraging locations of seabirds breeding at significant GBR colonies.

Current data are preliminary but confirm that many important foraging sites are outside of the management zone of the GBRMP and that foraging activity overlaps significantly with known commercial fishing activity. For wedge-tailed shearwaters adults are restricted to using near-colony foraging grounds for chick provisioning. Foraging success at these sites is primarily linked to local ocean dynamics. Adults on longer self-provisioning trips routinely travel to distant foraging grounds in the Coral Sea and Tasmantid Seamount Region. These 'at-distance' locations are characterized by specific meso-scale oceanographic features such as frontal systems and eddies, or by steep bathymetric change. Both near-colony and at-distance foraging locations can vary among-seasons, but within-seasons specific locations are often consistently reused by multiple individuals.

In addition tracks encompassing the 7-8 month winter migration period (May to October) have been obtained for wedge-tailed shearwaters. These tracks identify wedge-tailed shearwaters of the GBR as trans-equatorial migrants that overwinter in Micronesia, in a region known globally for its commercial tuna catch rates. This finding raises significant further conservation concerns for this GBR breeding species.

Effectiveness of Spatial Management on the Great Barrier Reef

Project 8.1 Monitoring the ecological effects of the Great Barrier Reef Zoning Plan on mid- and outer shelf reefs

Hugh Sweatman, Alistair Cheal, Mike Emslie, Kerryn Johns, Michelle Jonker, Ian Miller, Kate Osborne

Australian Institute of Marine Science

The zoning plan for the GBR Marine Park that was implemented in 2004 aims to conserve biodiversity, but the most direct effects were to regulate fishing. AIMS has surveyed a series of mid-shelf and offshore reefs that are matched by size and distance from shore, but differ in access for fishing. The most recent surveys in 2012 showed that exclusion of fishers correlated with a small increase in numbers of coral trout and a larger increase in biomass (as protected reefs support bigger fish). There are also strong regional effects because coral trout densities are much higher in the southern GBR.

Project 8.2 Do green zones work? Assessing the ecological effects of management zoning on inshore reefs of the Great Barrier Reef Marine Park

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Networks of no-take marine reserves (green zones) are increasingly being established with the goals of restoring and conserving biodiversity, boosting populations of exploited fishes and increasing the sustainability of fishery catches. Numerous studies have documented significant increases in the abundance, body size and reproductive potential of exploited species within adequately protected reserves. There is also increasing evidence that networks of reserves can provide fishery benefits via spillover and recruitment subsidies to surrounding areas. There is little evidence however, that reserves provide protection against broad-scale acute disturbances such as coral bleaching events, cyclones or flood plumes. The Great Barrier Reef Marine Park (GBRMP) encompasses the World's largest coral reef ecosystem and multiple-use management zoning, including an extensive network of no-take reserves, is the cornerstone of marine park management. Here we provide an overview of recent findings from a long-term monitoring program that is assessing the ecological effects of management zoning on inshore reefs of the GBRMP. We demonstrate significant and persistent increases in populations of key fishery target species such as coral trout (Plectropomus spp.) within well-protected reserves. However, there are clear regional differences in the magnitude of reserve effects on target fish species, and these differences can be directly linked to non-compliance (poaching) and/or habitat degradation from climatic disturbances. This project provides significant insight into the long-term effects of reserves on the persistence of exploited fish populations, fish and benthic community structure, and ecosystem health and resilience.

Project 8.3 Closing the generation gap: secrets of larval fish dispersal on coral reefs

Geoffrey P Jones

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One of the enduring mysteries in marine biology is the fate of individuals during their brief pelagic larval stage. The link between parents and their offspring has remained a secret because of the seemingly impossible task of tagging tiny eggs or larvae. The lack of concrete data on dispersal has fuelled controversies over how marine populations are regulated, and how marine populations should be managed, both for conserving species and sustaining fisheries. With a large team effort we have measured where larvae go by using DNA to detect parent-offspring relationships. We began with some of the smallest of reef fishes (clownfish), but have since expanded our work to include some of the largest (coral trout, groupers). The unfolding story for all species is a tale of two extremes - from offspring that find their way home, to others that cross >100km of open water to find a home away from home. We hypothesize that this 2-tailed dispersal strategy promotes population resilience, as natal homing contributes to local persistence, while long-distance dispersal contributes to population recovery. Networks of marine reserves can achieve both conservation and sustainable fishing objectives, as reserve populations will retain some of their progeny, while others will be spread to areas open to fishing and to other reserves. We argue for pluralism in the management of coral reef fishes, because although they are confronted with many problems, their innate dispersal abilities offer a range of solutions.

Decision Support Systems for GBR Managers

Project 9.1 Dynamic Vulnerability and Resilience Maps for the Great Barrier Reef

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We present the first predictive coral vulnerability and resilience maps for the Great Barrier Reef (GBR). The maps are based on functional integration of a set of environmental information layers for ocean warming and acidification, water quality, cyclones and Crown-of-Thorns starfish predation. At the core of the framework is a dynamic community model for corals, macroalgae and other benthic groups, using the suite of environmental layers as input parameters. The model is calibrated using coral growth and recovery data from the AIMS Long-Term Monitoring Program, and is modelled for 1200 reef sites across the entire GBR. Vulnerability is calculated as the net loss of coral cover over the management time frame (e.g. 5, 10 or 20 years), and resilience is calculated as the capacity of the system to return to pre-disturbance states within that timeframe. In essence, the spatial vulnerability and resilience model framework consists of a set of animations of environmental behaviour feeding dynamically into the spatial ecosystem model, which produces a map of vulnerability and a map of resilience as outputs. Because environmental layers are probabilistic (i.e. they consist of probabilities of for example a warming event occurring and a probability of the event's severity), animations are generated a thousand times (as Monte Carlo analyses). The end-product of these analyses are four maps: predicted vulnerability and resilience, and their associated uncertainties. The key strength of the model is the forecasting of reef vulnerability and resilience under complex climate change and local/regional scale stress scenarios. Here, the team is collaborating with several world-leading groups to produce state-of the-art environmental layers to inform the model: Hadley Centre UK (ocean warming), CSIRO (Brando, water quality), Stanford University (ocean acidification, Long and Caldeira) and MIT (cyclone risk maps, Emanuel). Further, the team is developing a spatial decision interface to enable managers to identify areas of high versus low reef resilience, and to assist effective reef planning and spatial prioritization under climate change, and under cumulative stressors resulting from coastal development and land-use practises.

Project 9.2 Design and implementation of management strategy evaluation for the Great Barrier Reef Inshore (MSE-GBR)

Project leader: Dr Cathy Dichmont (CSIRO)

Project Team: CSIRO, Great Barrier Reef Marine Mark Authority, Department of Agriculture, Fisheries and Forestry, Department of Environment and Heritage Protection, Department of Science, Information Technology, Innovation and the Arts, James Cook University

This project is developing a Management Strategy Evaluation (MSE) framework to build a real understanding of the key human uses and drivers of change in the inshore Great Barrier Reef (GBR).

It will also inform GBR stakeholders of the likely consequences, costs and benefits of particular management decisions that aim to minimise the impacts on biodiversity, particularly from inshore multi-species fisheries.

Local stakeholders are helping drive the project to qualitatively integrate our understanding of the key drivers of change in the GBR inshore ecosystem and human uses.

Following a period of extensive consultation with the two chosen case studies – Mackay and the Burdekin – the project aims to:

- Develop qualitative models to understand key interactions in the region, and underlying processes and drivers
- Identify social, ecological, economic and governance objectives of stakeholders for the inshore Great Barrier Reef region
- Identify alternative strategies for the management of the inshore region, using a stakeholder driven approach
- Assess the impacts of the management strategies against objectives using a semi-quantitative approach
- Develop management options (with end users) aimed at biodiversity outcomes, focusing on inshore multi-species fisheries management.

Project 9.3 A decision-making tool for prioritising management actions on islands in the southern Great Barrier Reef

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Managers of the Great Barrier Reef's (GBR's) 1100 islands and cays face difficult decisions when it comes to investing in conservation management. The islands contain a wide variety of natural, cultural and presentation values, that face multiple and dynamic threats, that have to be managed within a fixed budget, using actions with varying levels of effectiveness and with different costs. To assist in prioritising management of the islands, a transparent yet flexible decision-support tool is being developed. Using spatial data, programming using quantitative objectives, and a user-friendly software interface, managers will be able to update information on values, threats, budgets or completed management actions to identify and revise management priorities.

To develop and test the decision-support tool, the method is being applied to several hundred islands and cays in the southern Great Barrier Reef. Existing data on features, threats, objectives and management actions are being collated from published and unpublished sources. As with most (environmental) datasets, there are gaps in knowledge in space, time and accuracy. Sensitivity analysis will be applied to the selected islands, for which a near-complete dataset will be available, to identify the influence of data gaps on apparent priorities for management. The results of this analysis will guide which data gaps to fill for other islands through expert elicitation. The decision-

support tool will be able to create a list of the top management priorities within a given budget, or estimate the budget needed to achieve a set of management objectives.

On this poster, we will describe the results of the data collation, method development, difficulties encountered, plans for sensitivity analysis, and the design of expert elicitation.

Project 9.4 Coastal development in the Great Barrier Reef coastal zone: Using scenarios for conservation planning

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The Great Barrier Reef (GBR) and its lagoon are classified as a World Heritage Area (GBRWHA) and are protected by the Great Barrier Reef Marine Park (GBRMP). Hence, most of the marine part of the coastal zone is consistently managed, but most of this legislation does not cover the extensive terrestrial regions that influence the GBR. The terrestrial, freshwater and estuarine fringe of the GBR hosts nurseries and feeding grounds for animal species of the GBR and has been subject to intensive development. Coastal development has led to degradation or loss of coastal ecosystems, increased run-off, and reduced water quality. The key development activities in the GBR coastal zone are ports, intensive agriculture, urban development, and tourism. All these activities are set to expand and intensify. Conservation planning determines the best spatial use of limited conservation resources to minimise the loss of valued aspects of the natural world. Conservation planning is faced with a significant challenge with coastal development because the future extent and intensity of development is difficult to predict. Hence, future threats to ecosystems and species are uncertain. Our research project uses spatially explicit scenario planning to identify plausible futures to 2035 for the GBR coastal zone. The project is using ArcGIS and IDRISI software to model land changes corresponding to each of eight scenarios, using spatial data on land use, infrastructure, tourism, land suitability, ecosystems, models of sea level rise, and available coastal and port development plans for the next 20 years. The resulting spatially explicit scenarios allow for comprehensive conservation planning with better understanding of where threats to ecosystems and species will most likely occur, what conservation goals should be developed, and how conservation resources would be best distributed.

Socio-economic value of GBR goods and services

Project 10.1 How are the people of the Great Barrier Reef doing?

Nadine Marshall[1], Erin Bohensky[1], Matt Curnock[1], Jeremy Goldberg[1], Margaret Gooch[1], Ally Lankester[1], Petina Pert[1], Lea Scherl[2], Samantha Stone-Jovicich[1], Renae Tobin[1]

[1]CSIRO Ecosystem Sciences, Townsville
[2]Environmental Sciences & Geography, James Cook University, Townsville

Knowing how people of the Great Barrier Reef (GBR) are interacting with the Reef is an essential component of effective Marine Park management. The "SELTMP" is the first Social and Economic Long term Monitoring Program set up in the GBR region to provide annual snapshots of the human

dimension. It aims to include up-to-date descriptions of Traditional Owners, the marine tourism industry, the commercial fishing industry, recreational users and coastal communities as well as ports and shipping, catchment and mining industries. The aim of the SELTMP is to assist policy makers and leaders to make decisions that not only enhance conservation goals, but also maximize the wellbeing of the region. For example, social and economic data presented in the SELTMP may assist managers to understand the capacity that Reef-dependent people have to undergo change as well as adapt. This may be as important for effective Reef management as are the efforts to build resilience of GBR ecosystems. Our approach has been to engage with industry, government and community to identify and prioritise data needs, synthesize existing datasets and identify data gaps. We have also structured our data collection needs based around the Millennium Ecosystem Assessment and ecosystem services frameworks, which were then modified for our purposes. Here, we introduce the SELTMP for 2011 ("SELTMP 2011") as a "proof of concept" that will be further refined for 2012 and again in 2013. We welcome all comments and suggestions.

Project 10.1 Development of a long term social and economic monitoring programme (SELTMP)

Petina L Pert, Erin Bohensky, Matt Curnock, Jeremy Goldberg, Margaret Gooch, Nadine Marshall, Renae Tobin

CSIRO Ecosystem Sciences, Townsville

The Great Barrier Reef Marine Park was the world's first declared large-scale marine protected area. The park is a multiple-use resource and supports key activities such as commercial fishing, tourism, recreational fishing, shipping and traditional use. It is estimated that the Great Barrier Reef contributes $5.8 billion annually to the Australian economy. Since the establishment of the Great Barrier Reef Marine Park in 1975, a variety of social and economic research has been conducted to support planning and management. Nevertheless, much of this research is yet to be linked to broader frameworks for understanding human dimensions of resource-use and marine park management problems and decision making. Through the multi-year National Environmental Research Program (NERP), CSIRO and James Cook University are addressing this gap by examining a number of indicators and developing a long term social and economic monitoring programme for coastal communities, catchment industries, marine tourism, commercial fishing, aquaculture, recreation, traditional owners and shipping sectors in the Great Barrier Reef. Using a spatial approach we are able to characterise the spatial and temporal heterogeneity of human uses and analyse how these uses relate to the complex human and natural systems in which they are embedded. This study can positively contribute to marine spatial planning, management and long term monitoring designed to achieve ecological, economic, and social objectives.

Project 10.2 On the relative 'value' of market and non-market goods and services provided by the GBRWHA – preliminary findings from NERP project 10.2

Natalie Stoeckl

School of Business, James Cook University, Townsville

Many of the GBR's ecosystem services are not bought or sold in the marketplace, so do not have a price. But absence of price does not mean absence of value, so this project investigates people's perceptions of the importance of and state of various ecosystem services, asking: How important are various ecosystem services to different people? How satisfied are people with the current state of various ecosystem services and how would they feel if some were degraded? Are people willing to pay money to help improve the state of some services?

Using data collected from a survey of more than 1700 tourists to and 1000 residents of the GBR Catchment area, this poster presents some preliminary (largely descriptive) analyses of responses to questions like those. Both residents and tourists rate many non-market ecosystem services (e.g. healthy reef fish, healthy coral reefs) as being more 'important' than other market-based services (e.g. the incomes and jobs associated with industry or high-quality accommodation). Residents believe that more frequent oil spills, more pollution, or increased turbidity could have a more significant (negative) impact on their overall quality of life than higher local prices; Tourists had similar reactions. The (stated) mean amount which respondents were willing to donate to a fund designed to improve water quality was higher than the amount they were willing to pay to help protect top predators or reduce the risk of fishing accidents, but many respondents are not willing to contribute anything at all.

Torres Strait

Natural Resources of the Torres Strait Land and Sea

Project 2.1 Communicating knowledge across cultural boundaries

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Over the past 10 years there has been an increased investment, both in time and capacity, towards applied research of turtles and dugong in Torres Strait. The research projects have largely been managed and coordinated through various combinations of Indigenous communities, Torres Strait Regional Authority, the Queensland Government and University groups. With multiple "players" involved effective communication of the research process (from conception to completion) is paramount, but challenging to achieve. In our presentations we use our turtle and dugong conservation project in north Queensland as (1) an example of cooperative arrangements and process that can easily be incorporated into project or project plans to improve communication success and (2) the value of adaptive field-based research. Through the development of our research project it has become clear that communication models for researchers and stakeholders need to be "two-way" and incorporate many communication tools. Equally important, the communication tools should be co-developed and sufficient time needs to be allocated to these aspects of the project. Overall we show that incorporating communication pathways as well as monitoring and evaluation strategies are effective tools for researchers to use to demonstrate research impact and can aid research groups participants to maximise the value of research in terms of managing natural resources in sea country.

Project 2.2 Wetland Habitats of the Torres Strait Islands

Damien Burrows, Norm Duke, Jock Mackenzie

TropWATER – Centre for Tropical Water and Aquatic Ecosystem Research, James Cook University, Townsville

Whilst the marine (seagrass and coral reef) ecosystems of Torres Strait are fairly well known, the wetland ecosystems on the islands (mangroves, salt marsh and freshwaters) are almost unknown (or at least unrecorded). For most islands, there is no documentation of what wetland types are present, and what their biota, condition and status are. Whilst freshwater wetlands are rarer, most Torres Strait islands have extensive mangrove margins and several islands (eg, Saibai, Boigu) are predominantly made up of intertidal swamps. Establishing the baseline of wetland status and condition is important, especially as many islands are low lying and the predictions of sea level rise and increased storm surge frequency mean that mangroves and coastal wetlands may be among the most threatened ecological communities in Torres Strait. Shoreline communities also buffer coastlines against waves and provide erosion protection. It is thus important that these habitats remain intact and to understand the role they play in providing such protective services.

Torres Strait islanders have a long and intimate knowledge of their wetland habitats, reflected in their traditions, culture and long-standing reliance on the basic benefits and resources provided, like food fishes, wood construction products and medicinal aids. This project builds on this understanding, where scientists benefit from working in partnership with traditional owners to fully describe and document new and existing knowledge of wetland habitats.

Our project aims to visit approximately 20 of the major islands, conducting on-ground, helicopter and boat-based surveys of the wetlands and their biota. Already many new species records have been documented on all islands visited to date. Much data is being collected via digital video following standardised protocols that we are also using in other regions. This is an effective medium for demonstrating habitat condition, especially for traditional communities. It also provides a permanent and reviewable archive of habitat status. Our fieldwork is conducted with land and sea rangers who accompany us during this work, thus increasing their capacity in wetland management.

Beyond providing a snapshot of the wetlands and a baseline against which future changes can be assessed, we aim to provide recommendations for better wetland management and planning, and to promote community dialogue on their values and management.

Project 2.3 Monitoring status and trends of coral reefs of the GBR

Ray Berkelmans, Hugh Sweatman, Scott Bainbridge, Scarla Weeks

Australian Institute of Marine Science, Townsville

Coral reefs of the Torres Strait (TS) are at the northern tip and part of the GBR province. Despite its ecological connection to the GBR and its clear importance to TS communities, comparatively little work has been done on these reefs. As elsewhere, climate change, crown of thorns starfish, disease, storms, and pollution from river runoff and shipping are threatening the ecological integrity

of TS reefs. This project seeks to establish a monitoring program to enable resource managers to keep abreast of key indicators of coral health and to train local rangers to undertake ongoing monitoring.

The project has so far delivered on:

- Establishing a network of in-situ temperature loggers to monitor anomalously warm temperatures
- Developing locally specific bleaching thresholds for the TS
- Installing a real-time weather station which will be used to provide early warning of coral bleaching
- Providing a monthly synopsis of ocean and atmosphere conditions to key stakeholders
- Conducting a review of past coral reef surveys
- Undertaking biodiversity surveys of key reefs
- Undertaking baseline monitoring of selected coral communities and large reef fishes
- Training local rangers in monitoring techniques and maintaining the temperature monitoring program.

The results of biodiversity and first monitoring surveys are currently being analysed.

Resilient Torres Strait Communities

Project 11.1 Building resilient communities for Torres Strait futures

James Butler

CSIRO Ecosystem Sciences, Brisbane

Globally, change is happening at a faster and more unpredictable rate. Climate change, economic growth and human populations are all likely to result in significant and unexpected impacts on local communities, both positive and negative. This requires pro-active planning so that communities and their livelihoods can be ready for such change. Torres Strait communities are particularly vulnerable to future change, being remote, low islands bordering two rapidly growing economies, Papua New Guinea and Indonesia. This project aims to explore potential future development pathways for the Torres Strait, and develop adaptation strategies for local communities and their natural resources which will prepare them for future uncertainties. Working with the TSRA, government and community stakeholders, the project uses participatory processes to analyse future scenarios for the Torres Strait, their potential impacts on ecosystem services and livelihoods, and strategies which can build communities' resilience to potential shocks and undesirable change. The process encourages social learning amongst stakeholders, therefore aiming to build their adaptive capacity. Issues explored include population growth and resource extraction in Western Province, PNG, climate change impacts on ecosystems and cultural change. The project forms the basis of the TSRA's community adaptation planning process, which is beginning in 2013.

Project 11.2 Determining disease dynamics across the Torres Strait and improved approaches for disease detection and management

Susan Laurance[1], Dagmar Meyer Steiger[1], Scott Ritchie[2]

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The Torres Strait has long been recognised as a biological bridge to mainland Australia. Currently, there is real concern over its vulnerability to emerging infectious diseases and its potential to facilitate disease movement to the mainland. One of the difficulties with the detection of infectious disease in remote areas is that traditional sampling methods are either too expensive or not appropriate. Across four islands in the Torres Strait (Saibai, Boigu, Badu & Moa), we are exploring a novel method of sampling mosquitoes with a passive trap baited with yeast generating CO_2.

Fieldwork to capture mosquitoes near and far from human communities has been completed during the wet season on Saibai, Boigu, Badu and Moa (Kubin). Preliminary results show that mosquito captures are higher in the natural habitats far from humans on Saibai and Boigu, but more mosquitoes were captured near humans on Badu. Once the mosquito identification work is complete we will have a greater idea of disease risk.

Rainforests

Condition and Trends of North Queensland Rainforests

Project 3.1 Rainforest Biodiversity

Stephen E Williams, Jeremy VanDerWal, Yvette Williams, Barbara Anderson, Brett Scheffers, Nadiah Roslan

Centre for Tropical Biodiversity & Climate Change
James Cook University, Townsville

This project consists of four subprojects examining rainforest biodiversity in the Wet Tropics:

- Monitoring
- Climate change vulnerability and adaptation
- Drivers of biodiversity pattern and process
- Status of the environment and future projections.

We present our latest results showing that there have been observable shifts and declines of a number of upland vertebrate mammals and birds that are worryingly in accord with the impacts predicted under the more severe projections of future climate driven impacts. Species are showing a slight, but detectable, shift upwards in elevation with declines at the bottom edge of their range and either increases or decline at the upper edge depending on their elevational distribution. Power analyses of the data suggest that to monitor and detect a 10% change in abundance of common species over a 10 year period we need to monitor the sites at least twice per year. We will present ongoing work examining the importance of buffered microhabitats and microclimate

gradients in ameliorating impacts on biodiversity. Future predictions of climate change impacts on vertebrates have been refined following our vulnerability framework (Williams & Shoo et al. 2008) and utilizing the latest modeling approaches, climate projections and the IPCC 5th Assessment Report scenarios. Predictions refine our previous projections but have not significantly changed the previous qualitative results. |That is, latest projections indicate that approximately one third of the vertebrate species will be severely threatened, one third will be vulnerable and one third will not change or increase. Preliminary systematic conservation planning for the region using Zonation and a combination of both vertebrate and freshwater biodiversity data has been completed and the results will be presented. We provide an update on analyses examining the efficient spatial and temporal selection of corridors and landscape design for maximizing resilience under climate change. We will synthesise these results in the context of pathways to adaptation for the region using our recently published decision framework (Shoo et al. 2013).

Project 3.2 What is at risk? Identifying rainforest refugia and hotspots of plant genetic diversity in the Wet Tropics and Cape York Peninsula

Darren Crayn[1,2],Craig Costion[1], Kaylene Bransgrove[1,3], Sandra Abell-Davis[1,3], Lalita Simpson[1,2,3], Katharina Schulte[1,2], Dan Metcalfe[4], Maurizio Rossetto[5], Andy Lowe[6], Steve Williams[2,3]

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[5]National Herbarium of New South Wales, Botanic Gardens and Domain Trust
[6]State Herbarium of South Australia, Department of Environment and Natural Resources

Australia's tropical rainforests of far north Queensland are globally renowned for preserving one of the most complete and continuous records of the evolutionary history of Earth's biota, and harbour much of the remaining Gondwanan flora that was once widespread across the continent. Much remains to be discovered however, about the distribution of this evolutionary history within the region, particularly for plants and fungi. Where are the refugia and hotspots of phylogenetic diversity (concentrations of evolutionarily distinct species)? How is genetic diversity within species, a strong predictor of resilience to environmental threats, distributed across the landscape?

In this multifaceted project we are mapping diversity across a range of scales - species, populations and genes - of selected plants and fungi of the Wet Tropics and Cape York. A current focus is on species potentially at most risk: mountaintop specialists whose cool, wet habitat is projected to be severely impacted under a warming climate. This research is enhancing the scientific basis for conservation priority-setting and planning for future environmental change.

Project 3.3 Targeted surveys for endangered rainforest frogs and other herpetofauna in peripheral areas of the Wet Tropics and Eungella, and assessment of frog population recovery from disease

Conrad Hoskin[1], Robert Puschendorf[2]

[1]School of Marine & Tropical Biology, James Cook University
[2]University of Plymouth, UK

Ten frog species disappeared from the upland rainforests of the Wet Tropics and Eungella during outbreaks of an amphibian chytrid fungus (Batrachochytrium dendrobatidis) in the late 1980s and early 1990s. Five of these species occurred only in the uplands and were presumed extinct because no individuals were subsequently found despite intensive searches. The exciting recent development is that we rediscovered one of these 'extinct' species, the Armoured Mistfrog (Litoria lorica) in high elevation dry sclerophyll forest very close to rainforest sites it vanished from. Equally exciting is that this population coexists with chytrid fungus, suggesting that at some sites these species can persist with the pathogen. This rediscovery strongly suggests that other missing frogs may well still be out there (including Litoria nyakalensis, Taudactylus acutirostris, Taudactylus rheophilus and even the Northern Gastric Brooding Frog Rheobatrachus vitellinus). Further, it has allowed us to target very particular sites – dry forests bordering rainforest – that have rarely been surveyed for these species. Coincidentally, these ecotonal and peripheral habitat areas are poorly surveyed for vertebrates more generally, because most of the work in these regions has focused on rainforests. A number of frog species declined from the uplands of these areas but persisted in the lowlands. Our surveys suggest that some of these species are starting to reappear at historic upland rainforest sites. It is very important to know the degree to which this is occurring and whether it represents population recovery for species such as Litoria nannotis, Litoria rheocola and Nyctimiste dayi. We have now completed many surveys in the Wet Tropics and Eungella regions as part of our NERP project and I will present a summary of the results of these, management implications, and future plans.

Project 3.4 Monitoring of Key Vertebrate species

David Westcott

CSIRO Sustainable Systems

Effective biodiversity management assumes an ability to monitor trends in the status of key assets, including the ecological processes that support biodiversity, ecological communities, species and populations. Not only is monitoring information fundamental to on-ground management but it is recognised under our own legislation and planning and under international agreements to which we are a party. Despite this there is surprisingly little direct information available on the status and trends of biodiversity in Australia and instead we are often reliant on indirect measures such as extent of vegetation cover or area of protected habitat to provide us as indicators. The reason for this is that direct monitoring of biodiversity can be expensive and time consuming and these costs demand that the investment is justified both in terms of the value of the asset and the lack of alternative management approaches. In the Wet Tropics Region two of our most iconic vertebrate species, the southern cassowary and the spectacled flying-fox, fall into this category. Both species are listed under the EPBC Act and both are the focus of significant community concern. However, neither species is amenable to standard monitoring approaches necessitating the development of species specific methods. Drivers and problems are outlined for monitoring of these two species, and methods that have been developed are discussed followed by overview of results to date.

Threats to Rainforest Health

Project 7.1 Fire and rainforests

Dan Metcalfe

CSIRO Ecosystem Sciences, Brisbane

Fire is a significant environmental driver of change across most of Australia, yet we know little of the effects of fire on tropical rainforest communities. Tropical rainforests used to cover almost all of Australia, but today only account for about 2% of the land mass, so how does that tiny remnant respond to the fire at its margins? Current approaches to managing fires which threaten rainforest are driven by concerns over infrastructure protection, public perception, research into fire impacts in other countries, and by the availability of trained staff to deal with such threats. We are compiling research data to support development of management strategies; these data will illustrate both the positive and negative effects of fire in rainforests, and will provide a distinct Australian contextual understanding of the problems faced by managers and decision makers.

Project 7.2 Identifying and managing emerging weed threats in the Wet Tropics

Helen Murphy

CSIRO Ecosystem Sciences, Tropical Forest Research Centre, Atherton

Climate change will enhance the capacity of non-native species to establish, spread and transform ecosystems, and tropical regions may be especially at risk. Therefore, current approaches to identifying and managing weed risks need to be revised in line with projected climate change across northern Australia. Management strategies will need to consider the potential future distributions of the suite of invasive species already present in the region as well as the potential distributions of species which may establish in the region as climatic conditions become more suitable. Part of the challenge of adapting to climate change will be incorporating proactive management of the threat of newly emerging weeds into existing invasive species management frameworks within the region.

We have used bioclimatic modelling and climate matching methodologies to identify:

- High-risk source areas for future invasive species based on matched climates with Wet Tropics predicted future climate scenarios
- Species that are currently not widespread in the region but which pose an increased risk of establishment and spread under future climate scenarios
- Strategic, proactive management approaches which have the potential to greatly reduce future weed impacts and the future cost of weed management.

Project 7.3 Climate change and the impacts of extreme climatic events on Australia's Wet Tropics biodiversity

Justin Welbergen

Centre for Tropical Biodiversity & Climate Change, School of Marine & Tropical Biology
James Cook University, Townsville

While anticipated changes in the means of the world's climate will have numerous effects on a range of environmental, social, and economic sectors, many significant impacts of climate change will emerge through shifts in the intensity and the frequency of extreme weather and climate events, including heat waves, flooding rains, and cyclones. Such extreme events represent the way in which our communities, animals and plants will strongly experience climate change. Extreme temperature events are of special concern to biodiversity conservation, not only because of their direct impacts on organismal health but also because of their effects on the frequency and intensity of droughts and wildfires. However, despite the clear importance of temperature extremes for our understanding of climate change impacts, little is known about their effects on biodiversity. Our project investigates the exposure and the sensitivity of the Wet Tropics vertebrates to extreme temperature events. Integration of our information on exposure and sensitivity will then enable us to quantify the vulnerability of Wet Tropics biota to extreme climatic events, and to map the historical and future impacts of these events on biodiversity in the Wet Tropics Bioregion. Although our focus is on temperature extremes, we will use the analytical and conceptual advances gained from this project to form the basis of a generalised framework for assessing the impacts of extreme weather and climate events on natural systems across Australia and elsewhere.

Managing for Resilient Rainforests

Project 12.1 Indigenous co-management of rainforest diversity

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[6]Jabalbina Yalanji Aboriginal Corporation
[7]Mandingalbay Yidinji Aboriginal Corporation
[8]Australian Conservation Foundation
[9]Eastern Kuku-Yalanji Traditional Owner
[10]Central Wet Tropics Institute for Country and Culture
[11]Mamu Traditional Owner
[12]Rainforest Aboriginal Peoples' Alliance

Australia's wet tropics region encompasses 20 traditional estates of Rainforest Aboriginal peoples. They have been actively working for 20+ years at various levels in asserting Traditional Owner (TO) relationships and rights to manage their country. Land management arrangements are multi-tiered, involving lease and freehold owners and several State, local and Federal government authorities. More recently, the outstanding significance of Rainforest Aboriginal peoples' cultural values associated with the wet tropics was recognized through national heritage listing in 2012.

Our project, which includes a co-research team between Rainforest Aboriginal peoples, scientists and managers, has identified different pathways connecting cultures and knowledge through co-management. For equitable engagement to occur five components have been described:

- Principles (e.g. self-determined level of involvement)
- Relationships (e.g. good ones enable Indigenous roles)
- Mechanisms (e.g. plans)
- Power (e.g right to exercise native title)
- Regimes for joint governance (e.g. legislation, policy).

Our institutional analysis identified that significant barriers exist to equitable engagement. Queensland human rights institutions do not include the protection for cultural, social and economic rights that currently exist internationally. Raising human rights standards appears important to generate equitable engagement of culture and knowledge through co-management.

Project 12.2 Active vs passive options for re-establishing rainforest on post-agricultural land

Carla P Catterall[1], Luke P Shoo[2], Kylie Freebody[1]

[1]School of Environment & Environmental Futures Centre, Griffith University

[2]School of Biological Sciences, The University of Queensland

Progress towards rainforest restoration can be achieved through different pathways which vary in their intensity of intervention, timescale, and cost. High-diversity tree planting has been widely used in the Wet Tropics, where research has demonstrated promising short-term results of "best practice" restoration plantings for recovering biodiversity and biomass. However, the costs of tree planting over large areas can be prohibitively high, and the longer-term biodiversity development within these plantings remains uncertain. Accordingly, there is a need to explore alternative restoration techniques that require lower input of labour and resources, and to understand why these succeed or fail in relation to various goals. We are investigating how fast unassisted (ie, low-cost) natural regrowth can produce ecological outcomes, how these compare with the outcomes of tree-planting, what factors limit or accelerate the development of regrowth, and whether there is potential for low-intensity intervention to kickstart regrowth in retired pasture. The longer-term aim is to identify a menu of approaches that differ in type and cost of intervention, speed and quality of outcome, and environmental situations or goals to which each approach is either well- or poorly-suited. This will help landowners and planners to make effective decisions based on risks, costs and benefits, about how to restore rainforest wherever needed across the landscape.

Project 12.3 Relative social and economic values of residents and tourists in the Wet Tropics World Heritage Area (WTWHA)

Michelle Esparon, Natalie Stoeckl

School of Business, James Cook University, Townsville

The Wet Tropics World Heritage Area (WTWHA) is famous for its wildlife, biodiversity and natural beauty. However, very little is known about the 'value' of these attributes, partly because it is quite challenging to quantify them. Recognizing that the absence of price does not mean absence of value, this project – which started in July 2012 – seeks to improve our understanding of the

importance of these non-market values to residents and tourists. It complements NERP Project 10.2 which is investigating non-market values in the Great Barrier Reef World Heritage Area (a separate poster provides preliminary findings from that work).

Given the many attributes of the WTWHA and the fact that it is impossible to measure all, a workshop was organized with some key stakeholders of the region to identify and prioritise a) key attributes for assessment and b) development 'changes' that may erode on those values. Of the attributes identified for assessment thus far, forest health, landscape, iconic species, culture, accessibility, quality of access, water quality, and employment opportunities were deemed most important. The most significant management issues identified for consideration related to the: protection of native animals and plants (while allowing access); maintenance of undeveloped scenic beauty; and improvement in water quality/clarity. Further engagement with Indigenous stakeholders is underway. This information is helping to inform the design of two questionnaires that will be distributed to residents of and tourists to the WTWHA during 2013/14. When complete, the project will provide insights into the priorities and attitudes of residents and tourists (as they relate to the WTWHA), thus generating information that will be useful to the tourism industry, the WTMA and other key policy makers.

Project 12.4 A Governance Analysis of Australia's System of Greenhouse Gas Abatement Through Landscape-Scale NRM

Allan Dale[1], James McKee[2], Karen Vella[3]

[1]Tropical Regional Development, The Cairns Institute
[2]CSIRO Land and Water
[3]School of Environment, Griffith University

Healthy governance systems are key to delivering effective outcomes in any broad domain of natural resource management (NRM). One of Australia's newest (and still emerging) NRM domains in is our national framework for greenhouse gas abatement (GGA) as delivered through a wide range of management practices in the Australian land and sea scape. This domain resides within the nation's broader NRM policy framework and it is primarily progressed through the Australian government's Clean Energy Package (CEP), and more particularly, its Carbon Farming Initiative (CFI). This paper explores key areas of governance risk within the governance system underpinning this new and emerging domain. We then map some of the potential reform or continuous improvement pathways required (from national to paddock scale) with the view to securing improved landscape outcomes over time through GGA activities.

Knowledge Brokering and Communications

Project 13.1 e-Atlas – Discover, learn, investigate and download environmental research data

Eric Lawrey

Australian Institute of Marine Science

With the e-Atlas you can discover, learn, investigate and download environmental research and reference data for the Great Barrier Reef, its catchments, the Wet Tropics and the Torres Strait regions.

The e-Atlas is a website and mapping system for presenting environmental research data in an accessible form that promotes greater use of this information. It is also a data management system for preserving and encouraging reuse of this data.

Decades of research have generated a large amount of data and information on the Great Barrier Reef and the terrestrial tropical ecosystems. Until now this information has generally been under-used. The e-Atlas aims to promote collaboration and support the work of management agencies, researchers, reef-based industries and community groups.

From the site, users can discover what research is being done in a given region or on a given topic, then learn more about this research and its outcomes. The data behind the research can be investigated through an interactive mapping system and, where possible, the data itself can be downloaded. The e-Atlas also contains a wide range of reference datasets that complement its research content.

The e-Atlas is the primary data and knowledge repository for 38 NERP Tropical Ecosystems Hub projects, 6 Reef Rescue Marine Monitoring Program projects and historically, the Marine and Tropical Science Research Facility. This research covers a wide range of topics some of which include: seagrass, coral reefs, turtles, dugongs, seabirds, bathymetry, fish abundance, Crown Of Thorns Starfish (COTS), rainforest revegetation, wet tropics species distributions, etc.

The e-Atlas was initially developed in 2008, funded by the Marine and Tropical Science Research Facility and the Australian Institute of Marine Science. The e-Atlas is now supported through funding from the Australian Government's National Environmental Research Program and the Australian Institute of Marine Science.

Water Quality of the Great Barrier Reef and Torres Strait

Project 4.1 Tracking coastal turbidity over time and demonstrating the effects of river discharge events on regional turbidity

Katharina Fabricius[1], Murray Logan[1], Scarla Weeks[2], Sam Noonan[2], Jon Brodie[3], Eric Wolanski[4]

[1]The Australian Institute of Marine Science
[2]University of Queensland
[3]Catchment to Reef Research Group, TropWater, James Cook University
[4]James Cook University

The objective of this recently commenced study is to quantify the relationships between daily variation in coastal water clarity and daily Burdekin River discharge volumes into the GBR, using daily Modis Aqua remote sensing data at 1 km resolution. We used a newly developed index of euphotic depth, and quantified where and by how much the relationship between water clarity, waves and tidal currents has changed throughout the recent wetter and drier years as a function of location (inshore, midshelf and offshore, and with increasing distance to the Burdekin river mouth), bathymetry, river flow rates, and hydrodynamics (waves and tidal currents). Preliminary analyses show a strong relationship between Burdekin discharge volumes and annual and daily values in water clarity in the GBR within the Burdekin sector. Across the ten years, mean annual water clarity was 24% greater in the driest compared to the wettest years (11.7 vs 8.9 m mean euphotic depth).

Within years, water clarity was lowest in February and progressively improved throughout the dry season, reaching highest values around October, and rapidly declining soon after the onset of the river flow. The study suggests that the Burdekin River is a significant factor determining water clarity throughout the Burdekin sector of the GBR.

Project 4.2 Chronic effects of pesticides and their persistence in tropical waters

Andrew Negri[1], Florita Flores[1], Phil Mercurio[1,2], Catherine Collier[2], Jochen Mueller[3]

[1]Australian Institute of Marine Science

[2]James Cook University

[3]ENTOX, University of Queensland

Pesticides, and particularly herbicides from agricultural sources have been detected in nearshore sites of the Great Barrier Reef (GBR) all year round. The most commonly detected herbicides inhibit photosynthesis, potentially reducing primary productivity in key marine species. While herbicides are thought to contribute to the stress on nearshore habitats, little is known of their chronic effects on tropical species or their persistence in tropical waters. In this project, two species of seagrass were shown to be sensitive to four PSII herbicides in three-day laboratory exposures. The order of toxicity was Diuron > Hexazinone > Atrazine > Tebuthiuron for both species. The order of toxicity and the sensitivity of seagrass to these herbicides were generally consistent with corals and microalgae. Identifying the concentrations of herbicides that inhibit photosynthesis in seagrass by 10% and 50% has contributed to risk assessment process for the Reef Plan Scientific Consensus Statement on water quality. Understanding the half-lives of these herbicides and the toxicity of their breakdown products in the tropical marine environment is also a critical data-gap required to develop realistic ecological risk models for sensitive coastal communities of the GBR. Two flask experiments have been conducted for 12 months each to measure degradation in up to nine herbicides in seawater at 25°C, 31°C and in the dark and light. Analyses are still underway; however, preliminary data indicates very slow degradation of the herbicides Diuron, Atrazine, Ametryn, Simazine, Hexazinone, Tebuthiuron, 2, 4-D, Metolachlor and Glyphosate in seawater. This long persistence is likely to contribute to the common detection of herbicides in GBR waters.

Project 4.4 Hazard Assessment for water quality threats to Torres Strait marine waters and ecosystems

Jane Waterhouse[1], Jon Brodie[1], Eric Wolanski[1], Caroline Petus[1], Will Higham[2]

[1]Catchment to Reef Group, TropWater, James Cook University

[2]Reef Catchments NRM, Mackay

The project's aim was to provide an assessment of current and potential water quality issues in the Torres Strait Region. This involved a review of available water quality information for the region, documentation of the status of island sewage treatment and other discharges such as desalination waste on the islands, documentation of the status and scope large scale developments in the region, and review of current and projected shipping activity in the region. While the study has identified a number of relatively minor local pollutant sources that may pose a risk to the ecological

values of the Region, the largest threats are most likely to be associated with the potential risks from the transit of large ships through the Region.

Shipping appears to pose significant potential threats. The shipping route through Torres Strait is already an bottleneck for Australian east coast shipping traffic. With the expansion of ports, especially coal and coal seam gas loading ports, on the Australian east coast in response to proposed large increases in export large increases in shipping traffic up the Queensland coast are predicted. Additional increased shipping through the Torres Strait will also result from the construction of the major port at Daru. Increased shipping will result in greatly increased risk of accidents in the Torres Strait. Currently there is very limited capacity to respond in any meaningful way to a large oil spill in the Strait. The area is remote in Australia with strong winds and currents and a matrix of reefs and islands on which oil could impinge. Any large oil spill would have devastating consequences for the populated islands on which it landed as well as severe environmental consequences.

Large developments in PNG including gas platforms, oil palm expansion and Daru port development may also be significant. Preliminary analysis of proposed developments in western PNG suggest that although large scale development is likely to occur, adverse effects in the Australian part of the Torres Strait are likely to be restricted to the northern islands – Boigu, Saibai, Erub and Stephens. Hydrodynamic modeling and remote sensing analysis show that excursions of water from the Fly River drainage basin predominantly move to the east into the northern Coral Sea and along the PNG coast towards Port Moresby and are uncommon to the west of the river mouth. In addition the currents in this western region are generally from east to west both in the central TS and along the PNG coast. However, construction and operation of a major port at Daru has the potential to lead to excursions of contaminated water along the PNG SW coast and thus to Saibai and Boigu. It is now almost certain the Ok Tedi mine will continue production for at least another 10 years instead of shutting down in 2014. Continuing introduction of toxic metals such as copper into the northern TS via Fly River discharge can only be viewed with concern given the absence of transparent monitoring programs as to the effects of the discharge in the lower Fly River and Torres Strait. While the TSBS showed little influence of Fly River discharge on metal levels in TS, the data are now 20 years old and it would be valuable to repeat the study in a more limited way to assess the changes since the early 1990s.

Reef Rescue R&D

Presentation Abstracts

Wednesday 8 May

Concurrent Program: Reef Rescue R&D Special Sessions

Water Quality in the Normanby Catchment, northern GBR

Led by Dr Andrew Brooks, Griffith University

This session will outline a program of R&D on the Sediment budget for the Normanby Catchment, which is the dominant catchment delivering terrestrial runoff to Princess Charlotte Bay and the northern GBR. Coupled with some of the surprising results from this work will be presentations about the alluvial gully management trials as well as the broader program of on-ground works focused on improving the quality of water delivered to the Northern GBR. The project is funded by the Australian Government Reef Rescue program. A series of manuscripts and reports are currently in preparation.

Further information is available by contacting Dr Andrew Brooks, Senior Research Fellow, Australian Rivers Institute. Contact: Griffith University, Nathan Qld 4111 Australia

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BMP economics and adoption

Led by Dr Stuart Whitten, CSIRO

Debate continues around the real costs of and the impediments to adopting best management practices (BMPs) with the aim of reducing pollutant exports to the GBR lagoon. Over the last two years the Reef Rescue R&D project "Integrated assessment of BMP cost-effectiveness and decision tool for regions and landholders" has sought to provide more detail around the nature of the costs (and benefits) of adoption as well as the non-monetary factors that are influencing adoption. This session will focus on the results to date with a summary of the emerging integration framework.

Further information is available by contacting Dr Stuart Whitten, Team Leader – Markets, Incentives and Institutions, CSIRO Ecosystem Sciences. Contact: GPO Box 1700, Canberra ACT 2601

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Thursday 9 May

GBR water quality: What do we know and what more needs to be done?

Keynote presentation: Land use impacts on Reef water quality and ecosystems

Jon Brodie[1]

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As part of a number of projects including the Risk Assessment, Scientific Consensus Statement, Outlook Reporting and the GBR Strategic Assessments teams of scientists have been examining scientific evidence as to the state of the Great Barrier Reef, its response to the numerous pressures it now faces and the effectiveness of management. In particular projects I am involved in are focussing on water quality. Analysis of this evidence leads me (with some support from the rest of the team!) to conclude that:

- GBR ecosystems are showing declining trends in condition due to the cumulative pressures of climate change impacts, increasing intensity of episodic events, continuing poor water quality and the associated effects of crown of thorns starfish outbreaks.
- The decline of marine water quality associated with terrestrial runoff of pollutants is a major cause for the currently poor state of many of the key marine ecosystems of the GBR.
- Extreme weather events in the GBR since 2008 have had catastrophic impacts on coral reefs, seagrass meadows, and dugong and turtle populations. As per climate change predictions, the likelihood that weather events will become more extreme in the future has severe implications for GBR water quality.
- The highest risks of pollution to the GBR are from nutrient discharge, associated with crown-of-thorns starfish outbreaks and their destructive effects on coral reefs, and sediment discharge with associated nutrients, which drives light reduction for seagrass ecosystems.
- Marine water quality continues to be negatively affected by the discharge of nutrients, fine sediments and pesticides from the adjacent catchments at levels far above those experienced in previous times.
- The main source of poor water quality comprising the discharge of nutrients, fine sediments and pesticides from GBR catchments is from diffuse source pollution from agriculture.
- The use of improved land and agricultural management practices is proven to work at the paddock scale to reduce the runoff of suspended sediment, nutrients and pesticides.
- Micropollutants including microplastics, heavy metals, pharmaceuticals, industrial chemicals and anti-foulants are an under-researched area of water quality concern for the GBR although known to be present in potentially damaging amounts.
- Science coordination has improved over the last decade, however there is a need for further review of governance arrangements to ensure science is available and effectively utilised in environmental policy and management.

Session 1: The Reef and its ecosystems – how are they shaping up?

Convenor: John Bennett, DEHP

What is the current status of GBR water quality and associated impacts on ecosystems?

Britta Schaffelke[1], Johanna Johnson[2]

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Great Barrier Reef (GBR) marine ecosystems and their associated catchments are part of a dynamic, interconnected system. Activities within the catchments affect ecosystems along this catchment-to-reef continuum. The condition of coral reefs and seagrass meadows in the GBR has declined severely over the last five years, predominantly due to the effects of extreme weather events. Recent scientific evidence confirms that marine water quality continues to be negatively affected by the discharge of excess nutrients, fine sediments and pesticides from adjacent catchments and that poor marine water quality is a major cause of the currently deteriorating state of GBR marine ecosystems. Marine water quality will continue to be affected by extreme weather events – heavy rainfall and floods, tropical cyclones – and the severity and frequency of these events is increasing due to climate change. Recent extreme weather events are consistent with the type of events scientists expect to see more often in a warming climate (Climate Commission 2013). A reduction in pollutant loads from catchments is essential to enhance the resilience of freshwater, estuarine, mangrove, coral reef and seagrass ecosystems to other disturbances. Reducing losses of nutrients, sediments and pesticides from the land will 'buy' ecosystems time by partially offsetting increasing stress and damage from climate drivers such as increasing sea temperatures, ocean acidification, intensifying cyclones and storms, greater rainfall variability and flooding, and improving recovery potential. The status of GBR ecosystems and impacts of current and future extreme events on water quality and ecosystems is discussed in the Reef Plan Scientific Consensus Statement update, currently being drafted.

Historical changes on the GBR: Looking to the past to unravel the future

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While long-term monitoring has demonstrated that more than half (50.7%) of the Great Barrier

Reef's (GBR) initial coral cover has been lost over the past 27 years, we have little understanding of how reefs existed and responded to disturbance prior to this time period. The aim of this large, multidisciplinary project is to better understand the dynamics of reef ecosystems over long time scales (i.e. before European settlement c. 1850) by reconstructing ecological and environmental changes from reef matrix cores and massive coral colonies, respectively. Here we demonstrate contrasting histories of reef development over the past several thousand years for two inshore regions. In the Palm Islands (central GBR), the onset of decline of the ecologically important coral genera Acropora can be traced back to the early 20th century. Yet Acropora has remained dominant in the Keppel Islands for the past 6 ka, despite being repeatedly impacted by flood events. These results provide important baseline information to reef managers so that the current status of inshore reefs can be appropriately assessed. Similar techniques are currently being applied to other regions, including the Wet Tropics and far-northern GBR, to provide a broad-scale understanding of the history of the reef.

Tracking coastal turbidity over time and demonstrating the effects of river discharge events on regional turbidity

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The objective of this recently commenced study is to quantify the relationships between daily variation in coastal water clarity and daily Burdekin River discharge volumes into the GBR, using daily MODIS Aqua remote sensing data at 1 km resolution. We used a newly developed index of euphotic depth, and quantified where and by how much the relationship between water clarity, waves and tidal currents has changed throughout the recent wetter and drier years as a function of location (inshore, midshelf and offshore, and with increasing distance to the Burdekin river mouth), bathymetry, river flow rates, and hydrodynamics (waves and tidal currents). Preliminary analyses show a strong relationship between Burdekin discharge volumes and annual and daily values in water clarity in the GBR within the Burdekin sector. Across the ten years, mean annual water clarity was 24% greater in the driest compared to the wettest years (11.7 vs 8.9 m mean euphotic depth). Within years, water clarity was lowest in February and progressively improved throughout the dry season, reaching highest values around October, and rapidly declining soon after the onset of the river flow. The study suggests that the Burdekin River is a significant factor determining water clarity throughout the Burdekin sector of the GBR.

Chronic effects of pesticides and their persistence in tropical waters

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Pesticides, and particularly herbicides from agricultural sources have been detected in nearshore

sites of the Great Barrier Reef (GBR) all year round. The most commonly detected herbicides inhibit photosynthesis, potentially reducing primary productivity in key marine species. While herbicides are thought to contribute to the stress on nearshore habitats, little is known of their chronic effects on tropical species or their persistence in tropical waters. In this project, two species of seagrass were shown to be sensitive to four PSII herbicides in three-day laboratory exposures. The order of toxicity was Diuron > Hexazinone > Atrazine > Tebuthiuron for both species. The order of toxicity and the sensitivity of seagrass to these herbicides were generally consistent with corals and microalgae. Identifying the concentrations of herbicides that inhibit photosynthesis in seagrass by 10% and 50% has contributed to risk assessment process for the Reef Plan Scientific Consensus Statement on water quality. Understanding the half-lives of these herbicides and the toxicity of their breakdown products in the tropical marine environment is also a critical data-gap required to develop realistic ecological risk models for sensitive coastal communities of the GBR. Two flask experiments have been conducted for 12 months each to measure degradation in up to nine herbicides in seawater at 25°C, 31°C and in the dark and light. Analyses are still underway; however, preliminary data indicates very slow degradation of the herbicides Diuron, Atrazine, Ametryn, Simazine, Hexazinone, Tebuthiuron, 2, 4-D, Metolachlor and Glyphosate in seawater. This long persistence is likely to contribute to the common detection of herbicides in GBR waters.

Vulnerability of seagrass meadows of the GBR to water quality impacts

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Seagrass meadows have an important ecological role in the GBR. Many estuarine, coastal and reef animals, including species of fisheries importance, use seagrass meadows as habitat. Dugongs and turtles feed directly on seagrasses and changes to seagrass health have direct consequences for these fauna. Seagrass meadows also form a buffer between the catchment and the reef as they trap sediments and absorb nutrients. Seagrasses in the GBR have been in decline over the past few years. This occurred because water quality had deteriorated due to above average runoff from modified catchments. We developed a novel approach to model exposure of seagrasses to flood plumes using remote sensing imagery. This approach has identified that the impact of flood plumes on seagrass is strongly linked to the type of plume waters and the duration of exposure. Seagrass meadows with the highest exposure to flood plumes have reached the lowest abundance in recent years. Water quality is complex and there are a number of ways in which it can impact upon seagrass health. We are systematically testing these possibilities. We found that coastal seagrasses have broad salinity tolerance, with seagrass death occurring only at salinities <9ppt after 10 weeks exposure. These results indicate that low salinity was probably not the cause of recent seagrass loss. However, we analysed in-situ monitoring data, which showed strong correlation between low light (turbid water) and seagrass loss, so we are testing the impacts of low light even further. Using experimental approaches, we tested the effects of low light conditions and elevated nutrients on seagrass health to simulate

flood plumes. Analysis of this is still in progress but is showing that seagrasses exhibit early-warning signs of water quality stress. Outcomes from this project feed directly into the Reef Rescue Marine Monitoring Program, assisting with the interpretation of monitoring data and in the development of indicators.

Experimental and field investigations of combined water quality and climate effects on corals and other reef organisms

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Increasing temperatures, ocean acidification (OA) and decreasing water quality from terrestrial runoff are likely to significantly alter ocean and coastal ecosystems over the next few decades. These issues are commonly considered as individual pressures on tropical systems, but their interactions are as yet poorly understood and likely to be more damaging than each pressure in isolation. Increased ocean temperatures negatively affect symbiotic relationships (e.g. causing coral bleaching) and atmospheric CO_2 pollution is reducing the ability of tropical marine organisms to calcify. The research in project 5.2 uses integrated laboratory and field experimental studies to assess causal relationships between the interactions of water quality, ocean warming and ocean acidification and the responses of key coral reef organisms. In the first 18 months of this project, a number of medium-term (2-8 weeks) experiments have been conducted to investigate the interactive effects of two combined factors, for example: i) OA and temperature, ii) OA and salinity, iii) OA and turbidity/light, iv) Temperature and elevated nutrients/increased suspended sediment. Organisms investigated included several coral species, calcifying algae, seagrasses, foraminifera and echinoderms. In most cases, the combination of local and global stressors showed additive effects. A new model of the relationship between nutrient availability and thermal tolerance in corals was formulated and published. In the second half of the project, further experiments will allow to formulate conceptual frameworks for most of the other organisms of their responses to combined environmental pressures. However, it is already apparent that improving marine water quality would convey increased resilience to climate change for most of the organisms investigated.

On the relative 'value' of market and non-market goods and services provided by the GBRWHA

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Many of the Great Barrier Ree's (GBR) ecosystem services are not bought or sold in the marketplace, so do not have a price. But absence of price does not mean absence of value, so this project investigates people's perceptions of the importance of and state of various ecosystem services, asking: How important are various ecosystem services to different people? How satisfied are people with the current state of various ecosystem services and how would they feel if some were degraded? Are people willing to pay money to help improve the state of some services? Using data

collected from a survey of more than 1700 tourists to and 800 residents of the GBR Catchment area, this talk presents preliminary (largely descriptive) analyses of responses to questions like those. Both residents and tourists rate many non-market ecosystem services (e.g. healthy reef fish, healthy coral reefs) as being more 'important' than other market-based services (e.g. the incomes and jobs associated with industry or high-quality accommodation). Residents believe that more frequent oil spills, more pollution, or increased turbidity could have a more significant (negative) impact on their overall quality of life than higher local prices; Tourists had similar reactions. The (stated) mean amount which respondents were willing to donate to a fund designed to improve water quality was higher than the amount they were willing to pay to help protect top predators or reduce the risk of fishing accidents, but many respondents are not willing to contribute anything at all.

eReefs: Monitoring and modelling water quality in the Great Barrier Reef

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eReefs is a response by Australian and Queensland Government agencies plus private investors to mitigate the risks associated with the multiple use of the Great Barrier Reef. The project uses the latest measurement technologies to monitor and deliver observations together with a suite of integrated and data assimilating models across paddock, catchment, estuary, reef lagoon and ocean scales. By 2015, the project partners of eReefs (Bureau of Meteorology, CSIRO, AIMS, the Queensland Government and the Great Barrier Reef Foundation) will deliver a framework to explore and predict the impact of factors such as temperature, chlorophyll, nutrients, turbidity and pH, and provide an interactive visual picture of the reef and its component parts. Further enhancements through citizen science initiatives within eReefs will allow the broader community to engage on the health of the reef – contributing monitoring information and learning about the reef. This paper outlines the progress made in delivering the foundations of eReefs. These are a) a dashboard to access and analyse remotely sensed water quality data across the reef; b) numerical models to simulate hydrodynamics, sediment transport and nutrient concentrations; and c) an information system that allows increased discovery, access and re-use of the eReefs data sets. This unprecedented level of access to information will allow coastal land and marine managers, industry, and the community to make informed decisions about the changes to the environment and their impact on it. Systems such as eReefs provide an integral component of the adaptive management framework required to live within a changing climate.

Session 2: Prioritising future investment for GBR water quality improvement

Convenor: Kevin Gale, DSEWPaC

Terrestrial sources and pathways of sediment, nutrients and PSII herbicides to the GBR lagoon

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Water discharged from the Great Barrier Reef (GBR) catchment into the GBR lagoon continues to be of poor quality in many locations. The latest modelling and monitoring support previous research that the largest loads of sediments, nutrients and PSII herbicides are derived from diffuse agriculture sources, in particular dryland grazing and sugarcane. Estimates of pollutant loads to the GBR lagoon have greatly improved due to implementation of the GBR Catchments Loads Monitoring Program, development of load estimation tools, development of the new Source Catchment model, and synthesis of all previous load estimates based on monitoring and modelling. Moreover, our understanding of major sources and processes contributing to these increased pollutant loads has greatly improved due to provenance tracing of sediments. We recommend the application of provenance tracing to confirm catchment sources and pathways of bio-available nutrient constituents in the GBR lagoon.

Building confidence in the models and application of new findings into Source Catchments

A model-data fusion approach for predicting TSS loads in Weany Creek and the Upper Burdekin Catchment

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The export of pollutants from coastal catchments within Australia has important implications for the health of the Great Barrier Reef (GBR). To quantify end of catchment constituent loads, and assess progress towards defined constituent load targets, requires robust statistical methods (with some measure of certainty). We have developed a model-data fusion approach that integrates

measurements with model outputs to better estimate catchment loads. The framework utilises a Bayesian Hierarchical model that accounts for the uncertainty in measurements as well as the physical processes underpinning the model outputs. We are currently applying the approach to a well sampled CSIRO site in the Burdekin catchment, Weany Creek, where over 10 years of data (TSS and flow) have been collected. We will then apply the methodology to the Upper Burdekin where data on TSS and flow have been measured at 10 sites. These results will be integrated with modelled outputs from the Queensland State Government's Source Catchment model which has been run for the period between 1986 and 2009 and provides outputs at 411 spatial locations. We will present the models developed for each case study and show how the models can be used to develop a load estimate over any temporal and/or spatial period. We will also present results from scenario analyses where the aim is to investigate changes in loads with respect to changes in cover and rainfall.

Runoff nitrogen generation rates from pasture legumes – an enhancement to reef catchment modelling

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The Fitzroy and Burdekin Basins are Queensland's largest coastal catchments, draining directly into the Great Barrier Reef (GBR) lagoon. Greater than 80% of each basin is impacted by grazing, on both native and improved pastures. Despite substantial historical and ongoing plantings of legume pastures, no evidence exists on the potential for increased exports of nitrogen in runoff from these systems. This work examined if the pasture legumes leucaena and butterfly pea pose a risk to GBR lagoon water quality by increasing loads of nitrogen in runoff waters compared to both grass only pastures and native brigalow scrub. At the small catchment scale (12 to 24 ha) during hydrological years 2010 and 2011, loads of total suspended solids and nitrogen (total and species) from grass only and grass-leucaena pastures were typically lower than or equal to loads from native brigalow scrub. Phosphorus loads (total and species) from the grass only and grass-leucaena pastures showed the opposite trend. Loads of all parameters from butterfly pea ley pasture were equal to or higher than loads from native brigalow scrub. During 2012, no runoff occurred from native brigalow scrub, so loads from all catchments were an absolute increase compared to their pre-European condition. Modelling of observed flow and water quality from cropping and grazed buffel grass pasture from 1984 to 2012 showed similar trends. These findings have been distilled into values suitable for direct input into simulation modelling to further refine estimations of the impact of changed land management on GBR water quality.

Sediment budget modelling in the Normanby Basin: key findings and implications

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In this study we test the previous SedNet modelling for the Normanby catchment, which

indicated 89% of the ~ 1.1Mt annual average suspended sediment output was sourced from hillslope erosion, with the remainder from bank erosion (1%) and gully erosion (10%). Following an extensive data collection program we established that the upper catchment contributes on average ~1.4Mt/yr of fine sediment to the reef - a similar quantum to previous modelling, but from entirely different sources. The budget is instead dominated by bank erosion in minor alluvial channels (54%); alluvial gully erosion (24%); colluvial gully erosion (13%), primary channel bank erosion (8%) and hillslope erosion (~1%). Sediment storage accounts for ~55% of sediment input (1.69Mt/yr) , of which 424Kt/yr is stored within benches in channels. Geochemical tracing to the Princess Charlotte Bay indicates 46% of benthic sedimentation has a terrestrial source, in contrast to previous empirical estimates of 4%. Of the terrestrial sources, we found that only ~18% of the fine sediment is sourced from the upper catchment (i.e. the ~1.4Mt), with the bulk coming from erosion of the coastal plain/delta (representing an additional ≥ 4Mt/yr not previously considered). The study highlights that without the underpinning of extensive empirical data any attempt to model the system is at best, futile, and at worst likely to give completely misleading results and hence management actions. The data also highlights some inherent shortcomings of the previous modelling; notably the K & C factors used in the RUSLE; the representation of gully erosion and small alluvial channels, as well as the lack of representation of in-channel storage of fine sediment. All of these things need to be critically reviewed in the models for the rest of the GBR catchments.

What is the relative risk between pollutants on GBR ecosystems, between NRM Regions?

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Declining water quality is recognized as one of the greatest threats to the long term health of the Great Barrier Reef (GBR) and it is now agreed that management of this issue can aid in building ecosystem resilience to other pressures such as those associated with a changing climate. A recent assessment of the risk of water quality pollutants on key GBR habitats indicates that the highest risk of pollution to the health of the GBR is from nutrient discharge, particularly dissolved inorganic and particulate forms of nitrogen, as higher nutrient availability is linked to COTS population outbreaks, enhanced macroalgal growth, and enhanced susceptibility to coral bleaching. Nutrients also interact with sediment discharge, enhancing the effects of sediment on seagrass and coral reefs. Of equal importance, terrestrial sediment discharge reduces light for seagrass and inshore coral ecosystems, alters microbial assemblages, and compromises many life processes (colonisation, survival, growth) of small benthos. At smaller scales, particularly in freshwater, and estuarine and seagrass habitats, pesticides can be of high risk. Concentrations of a range of pesticides are continuously above water quality guidelines in many freshwater and estuarine reaches of streams downstream of cropping lands. The cumulative risk of these pollutants to GBR ecosystems is not quantified to but is believed to have increased the vulnerability of GBR marine ecosystems to natural disturbances and reduced the resilience of these ecosystems to recover to undisturbed states.

From a combined assessment of water quality variables in the GBR and end of catchment anthropogenic loads, the greatest risk to coral reefs on a regional basis is in the Wet Tropics, followed

by the Fitzroy region. The rankings of the remaining regions are: Mackay Whitsunday, Burdekin, Cape York and Burnett Mary. The greatest risk to seagrass from the combined assessment is in the Burdekin region, followed by the Wet Tropics. The rankings of the remaining regions are: Fitzroy, Mackay Whitsunday, Burnett Mary and Cape York. The results of this recent assessment will be presented.

Using multi-criteria analysis models for prioritisation of investment in the Great Barrier Reef

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In preparing for Reef Rescue 2, it is acknowledged that substantial progress has been made in understanding the sources of pollutants through the Reef Plan Paddock to Reef Integrated Monitoring, Modelling and Reporting Program, and in reducing pollutant generation by changing land management practices through the Reef Rescue Water Quality Grants and Partnerships program. Investments in reef science have improved understanding of the link between agricultural land management practices and Reef health. As part of the process to prioritise new investment, a Working Group was established to advise on:

- the relative investment priority for each of the 35 GBR sub catchments, based on potential for further improvement in on-farm management for each priority industry, for sediment, nutrient and pesticide management
- the highest priority sites across the reef catchment, based on potential for cost effective water quality, biodiversity and carbon sequestration outcomes, for wetland, riparian buffer and mangrove rehabilitation and reinstatement.

We chose the Multi-Criteria Analysis Shell for Spatial Decision Support (MCAS-S) tool to draw together the evidence from water quality monitoring and modelling, research and practice change to enable input from Reef stakeholders and exploration of the data inputs and potential solutions. These assessments will provide robust, targeted scientific evidence of where in the catchment and from which industries high risk pollutants affecting corals and seagrasses are generated. The results will contribute to improved prioritisation of Reef Rescue and Reef Plan investments.

Improved techniques for monitoring and reporting Using biomonitoring to detect impacts of pesticides in rivers draining on to the Reef

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The chemical analysis of pesticides in water samples from rivers is costly and their remains uncertainty as to whether any sampling strategy captured the maximum concentration that

occurred in the river and ecological relevance of the concentration of pesticides measured. As freshwater organisms are continuously in rivers, they will experience peak concentrations of pesticides and any ecological change detected by biomonitoring is by definition ecologically relevant. In Victoria and Europe a new trait base biomonitoring index, known as SPEcies At Risk from pesticides (or SPEARpesticides), has been shown to be able detect changes in stream macroinvertebrates as a result of pesticide toxicity but to be largely invariant of other environmental changes. Our project has been determining if SPEAR pesticides can be used to detect pesticide toxicity on stream macroinvertebrates in the rivers draining on to the Reef. As herbicides are generally of more concern for the Reef than insecticides and fungicides, we have also been developing a similar biomonitoring index based on a group of photosynthetic organisms: attached diatoms. To do this we have also been conducting a series of toxicity tests on various diatoms taxa collected from rivers draining on to the Reef. This presentation will briefly report the preliminary findings of the project.

A proof of concept for an integrated framework for reporting of water quality in the Great Barrier Reef lagoon

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Long-term monitoring of spatial and temporal trends of water quality within the Great Barrier Reef (GBR) Marine Park is central to the assessment of the Reef Water Quality Protection Plan and the Reef Rescue policy objectives. The current water quality monitoring under the Reef Rescue Marine Monitoring Program (MMP) assesses a number of water quality indicators and uses a combination of three complementary approaches at various spatial and temporal scales.

We will present the development of a proof of concept for a reporting framework that integrates water quality data at various spatial and temporal scales into an aggregated score. The framework is intended to be implemented in future Paddock-to-Reef Report Cards.

The proof of concept required the selection of defined marine reporting regions, development of seasonally-explicit compliance assessments against water quality guidelines and had to overcome significant computational challenges. We present the outcomes for 2010-11 for a small reporting region around the Tully mouth/Rockingham Bay. By selecting the most data-rich region and the most extreme year we aimed to maximise the ability of the proposed reporting framework to show seasonal and spatial differences. The key parameter selected for the reporting framework proof of concept was total suspended solids (TSS; measured by remote sensing, direct water sampling both during floods and ambient conditions). The reporting also includes (i) reporting of TSS values as measured by water quality instruments directly on coral reefs and (ii) DIN and PN values measured by direct water sampling both during floods and ambient conditions.

Getting ground cover right

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This project has focussed on improving the value of remotely sensed ground cover data to land managers and RD&E agencies. This has been achieved through four major activities:

- Producing an improved time series of Landsat derived fractional ground cover data for grazing land in the Fitzroy and Burdekin regions that better separates ground and over storey cover.
- Using ground cover as a surrogate for condition to produce grazing land condition imagery. Validated across ~1700 sites, this imagery explicitly describes probability of grazing condition class.
- Trialling two approaches to quantify sustainable ground cover thresholds, one based on the relationship between catchment runoff and catchment ground cover, and a second relating minimum ground cover levels from one drought to the next.
- Distributing and supporting the above products through a variety channels including professional networks, map products and the FORAGE website. Most notably the project has trained ~25 RD&E agency staff to use project products through the VegMachine software, which has subsequently been used to assess grazing country on more than 300 grazing properties.

At least two key recommendations arise from this work. Firstly, the ground cover product is now an effective and critical component of the reef/grazing RD&E space. It needs ongoing support to ensure ongoing supply to end users. Secondly, land managers need better access to these and similar products. We think this can achieved through moving the VegMachine software online to allow public access to data and suitable support products.

Reef Rescue Awards

The Reef Rescue partnership will host the Reef Rescue Awards evening on Thursday 9 May from 5.45pm to 7.30pm at the Shangri-La Hotel at the Cairns Marina.

Since 2008, the Australian Government, agricultural industry groups, regional natural resource management bodies and rural land managers have been delivering Reef Rescue, an innovative program which integrates training, incentives, agricultural extension, Research and Development and Monitoring and Evaluation to improve the adoption of agricultural practices that deliver water quality benefits in the Great Barrier Reef catchments. The current program finishes in July 2013 and has already exceeded ambitious land manager engagement targets. The Reef Rescue Awards are an opportunity to publicly celebrate the outcomes of the Reef Rescue program and to acknowledge land managers who have contributed to Reef Rescue outcomes.

The Reef Rescue Awards are an initiative of the Reef Rescue partnership including the Queensland Farmers' Federation, Queensland Regional NRM Groups Collective, peak agricultural industry bodies and regional natural resource management groups.

Friday 10 May

Building Innovative Practices for Reef Outcomes

Session 3: How are we tracking in management practice improvements for Reef outcomes?

Convenor: Kevin McCosker (DAFF)

Capturing paddock scale hydrology and water quality experiences relevant to the Great Barrier Reef

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A Reef Rescue R&D project has captured and synthesised over 100 studies dealing with hydrology-water quality related to land use and management, predominately at the paddock scale. These studies are all relevant to estimating changes in hydrology and water quality associated with various management practices in the Great Barrier Reef catchments.

A hierarchical data structure was used to summarise experimental sites with sufficient detail that audiences such as the Great Barrier Reef catchment modellers can pursue and add value to current and future modelling exercises.

Time-series of hydrology and water quality data are used to produce 'best bet' vegetation and soil parameters across a variety of land uses and regions. A protocol for pragmatic water quality modelling is established that estimates hydrology and water quality for a range of environments with reasonable accuracy. Synthesised studies, datasets and best bet vegetation and soil parameter files are published on a publicly available database, www.Howleaky.net/index.php/library. These data summaries will be updated periodically.

This study has demonstrated that a range of data or reporting detail can be applied to inform hydrology and water quality simulation. While daily time series of hydrology, sediment and water quality are ideal, annual summaries are valuable. We have successfully captured several datasets that would have almost inevitably have been lost. Yet such studies represent significant past effort and can provide useful physical evidence to support future management and modelling activities.

What do we know about the benefits of management practices in GBR catchments?

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Sediments, nutrients and pesticides exported from agricultural lands are significant contributors to the deterioration of Great Barrier Reef (GBR) marine ecosystems. Managing agricultural lands

to reduce the export of these pollutants is an important part of strategies to increase resilience of GBR ecosystems. Knowledge has increased about the water quality and economic outcomes of improved agricultural management practices on farms, and more information is becoming available about the benefits and tradeoffs of these reductions. Sediment loads are reduced by maintaining ground cover and enhancing infiltration, and redistributing the pressure of agricultural activities away from areas vulnerable to erosion. The actions needed to implement these principles in grazing and cropping are well understood. Reducing sediment exports will also reduce the export of nutrients and pesticides in the sediments. Pesticide exports will be further reduced by increasing the time between pesticide application and runoff and reducing the total amount of pesticide applied. Losses of nitrogen are related to nitrogen fertiliser applications at both the field and whole-GBR scales. Aligning nutrient inputs to the actual crop yields achieved by farmers rather than potential yields that might be obtained under ideal conditions will reduce nutrient exports. Improving farm management to meet Best Management Practices and improve water quality often gives positive economic benefits in the long-term, although the benefits may not be large enough to drive uptake by farmers. Further changes to management to improve water quality are likely to come at a cost to farmers. The costs may also have regional impacts if they threaten the viability of regional infrastructure, such as sugar mills.

Session 4: Reef Rescue and beyond for the Cane Industry

Convenor: Matt Kealley, Canegrowers

Water quality benefits associated with A-Class nutrient management practices in sugarcane

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Nitrogen exported from agricultural lands, notably sugarcane, is contributing to the degradation and reduced resilience of Great Barrier Reef (GBR) marine ecosystems. The widespread adoption of industry-supported 'best management practices' is unlikely to achieve an adequate reduction in nitrogen loads, so there needs to be a focus on 'even better' practices, termed 'A-Class' practices. There are sound philosophies underlying A-Class practices, such as improving soil health (e.g. by reducing soil compaction) and matching nutrient inputs to the requirements of an individual field (rather than a whole farm or region). However, the effects of these practices are largely untested. Then there are other practices that affect nutrient exports that need to be considered for example, the input of nutrients from organic sources, and the role of irrigation management in managing nutrient losses. This project examines the water quality benefits of A-Class and other practices through a combination of field and simulation studies. We have found that A-Class management of nutrients results in lower exports of nitrogen than conventional management, and improving irrigation efficiency can lead to improved water quality. Also, nitrogen lost through runoff comes from interactions between soil management (that reduces runoff) and the inputs of nitrogen. But nitrogen lost through leaching is more directly affected by inputs. This result is relevant as leaching and groundwater flow may be significant pathways for nitrogen reaching the Great Barrier Reef, in

which case, managing nitrogen inputs will be relatively more important. Finally, large inputs of organic nitrogen into sugarcane crops are likely to increase nitrogen losses. It will be hard to 'offset' these inputs through reducing nitrogen fertiliser, so organic inputs themselves should be better managed.

Mineralisation of nitrogen within the sugarcane cropping system following legume fallows and the effect on water quality

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Growing legumes as a break crop is a common practice for sugarcane growers. However, questions remain about the amount of nitrogen (N) available for sugarcane ratoon crops following legume fallows and whether N applications to these ratoon crops can be reduced. This project aims to investigate aspects of N release from legume break crops in sugarcane rotations and implications for water quality. The three project field trial sites in Bundaberg, Herbert and Mackay are each at different stages within the sugarcane crop cycle. Although leaf data from the Bundaberg trial indicated no significant treatment (rates of N) effects, yields ultimately showed responses to applied N. Mineralisation of the legume fallow crop probably contributed some N to the first ratoon. In contrast, data from the Herbert trial showed little carry-over of N (from the legume fallow) to the first ratoon. Rainfall, soil type and position in the landscape probably all contribute to the different crop reactions to legume-derived N. The fallow legume established at the Mackay site produced biomass containing about 170 kg N/ha that was potentially available to the ensuing sugarcane crop cycle. The plant crop will be harvested during the 2013 season. A series of pot experiments have also been conducted under semi-controlled conditions. Leguminous/N treatments were applied to two different soil types – Trial 1: yellow clay loam (Dermosol) with some restricted drainage, and Trial 2: a Red Volcanic soil (Ferrosol) which is well-drained. Trial 1 was expanded to include nitrous oxide (N2O) measurements and soybean plant material that had been grown with 15N labelled fertiliser. This, in combination with leachate sampling, will enable components of the N cycle to be determined within a 'closed' system. Visual treatment differences were visible during the inspections conducted two months after establishment of the trials and at harvest.

Pesticides in the sugar industry: modelling and monitoring their behaviour and risk, assessing new products and examining water quality benefits of improved management practices

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This Reef Rescue project focuses on the behaviour and risk of pesticides used by the sugar cane,

grazing and horticulture industries in the Great Barrier Reef (GBR) catchment, and the results of components relevant to the sugar cane industry will be presented here. Our data show variable soil half lives to those previously reported in the literature and also some variation with soil type. Some of the new/alternative herbicides show promise with respect to agronomic benefits, although additional data are required to examine the presence and risk of these products. Field trials have revealed the benefits of improved management practices with reductions of up to 90% of the residual herbicides (e.g. diuron, atrazine) with banded spraying and spot spraying techniques. The monitoring of the Barratta Creek complex has revealed interesting trends of pesticide use over the past two years including an apparent increase in the use of some new/alternative herbicides and the influence of the regulation of diuron in December 2011. Most of the herbicides detected in monitoring programs are transported in the dissolved phase (generally > 80% dissolved, < 20% particulate bound). The outcomes of this program clearly show the benefits of using 'knockdown' herbicides over 'residual' herbicides; the improved management practices implemented under the Reef Rescue program; and have greatly improved our understanding of herbicide risk in the Great Barrier Reef. It is recommended that further monitoring be conducted in the Barratta Creek complex to continue the examination of pesticide use and management effectivness in the Burdekin district, and that further research is carried out on new/alternative herbicide products before they are more widely endorsed by the sugar industry.

Optimisation of drip irrigation for sugarcane and banana cropping to improve water quality outcomes consistent with industry and reef requirements in Queensland

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Field trials being conducted on sugarcane in the Burdekin region are comparing furrow and drip irrigation, and on banana crops in Bundaberg are comparing micro-sprinkler and drip irrigation. The trials will assess the effects of irrigation management on crop water and nutrient use efficiencies and evaluate off-farm movements of water, nutrients and pesticides. Run-off from the drip irrigated cane plots was significantly lower (36 mm versus 273 mm) compared to furrow. None of the run-off events in drip were associated with irrigation, unlike in the furrow. Of the total 78 rainfall events contributing a total of 954 mm, rainfall-induced run-off occurred only in three major events that recorded >100 mm. In events of <100 mm, rainfall was captured in the soil showing potential of drip irrigation to minimise rainfall-induced run-off during moderate rain events. Deep drainage was as high as, or greater than, the run-off in both crops. Amounts were notably linked to timing and amount of irrigation and rainfall. As much as 15% of the total water input into the drip (222 mm deep drainage out of 1447 mm), and 16% the total water input into the furrow irrigation (294 mm deep drainage out of 1850 mm) was recorded in sugarcane. Hence, drip irrigation minimised run-off and deep drainage in sugarcane and banana cropping. Detailed predictions will generate scenarios for run-off and deep drainage in APSIM.

Cane irrigaion water use efficiency was greater by 42% (22.04 versus 14.17 t/ML of applied irrigation), and nitrogen use efficiency by 83% (1.32 versus 0.72 t/kg applied N) in drip compared to the furrow. There is a significant opportunity to optimise the drip irrigation for sugarcane production leading to further improvements. Data on pesticide losses for both species are being analysed.

Integrated assessment of BMP cost-effectiveness and decision tool for regions and landholders

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In the Great Barrier Reef (GBR) catchment area, estimates of the relative cost and effectiveness of best management practices (BMP) to reduce water pollution are becoming available for some practices and in some locations. In the sugarcane growing industry recent analysis suggests that many practices would increase the returns of landholders if adopted. However adoption of these practices has been patchy. We hypothesise that this may be because existing approaches do not adequately represent the diversity of farm enterprises and therefore the generalised results may not apply universally. Some landholders may experience greater than expected gains from adoption, while adoption may impose costs on others. This landholder diversity may be driven by a combination of biophysical and enterprise structural variables. In this research we identify landholder costs of changing BMPs and quantify impact on pollutants for the three major sugarcane growing regions in the GBR catchment area. We incorporate identified enterprise variability and explore the economic implications across a large number of model farms, rather than using single representative farms. Preliminary results support our hypothesis and indicate that bio-physical and enterprise structural heterogeneity causes variability in the costs and benefits of adopting BMP. Furthermore, rather than aggregating results to generic farming systems incorporating multiple BMP, our results show the variation in costs and benefits of a wide range of specific BMP. Our results support that bio-physical and enterprise structural targeting could facilitate an increased rate of adoption; a one size fits all approach may not be effective and quite costly.

Factors affecting adoption of land management practices that have water quality benefits in the GBR Catchments: Evaluation scenarios for sugarcane farming

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The aim of this study was to identify the factors affecting adoption of land management practices (LMPs) in cane farming that have water quality benefits in Great Barrier Reef catchments. The study used a case study approach to explore the key factors in two case study areas – Mackay and Bundaberg – and a literature review to identify the factors that impact adoption of LMPs in cane farming. Issues around adoption of these factors were examined through interviews with 17

stakeholders and 116 sugarcane farmers. Their responses were analysed using descriptive statistics, fuzzy logic (involving triangular fuzzy numbers) and a measure of consensus / dissention (i.e. collective opinion of stakeholders or farmers). The study identified 20 key variables under four major factors (socio-demographic, cultural, economic and support services) that influence the complexity of farmers' attitudes to and behaviours in adoption decisions. Six variables (farmer's desire to protect natural resources, self-awareness and openness to current and scientific knowledge, controlling own practices, maintaining budget and risk management plan, profit maximising and long term motive of financial gain) were the most highly influential variables with more than 80% consensus with soil and erosion management practices. Twelve variables were moderately to highly influential with 60% to 80% consensus with soil and erosion management practices. Two variables (partner's involvement in farming and intention to expand the farm size) were poor to moderately influential with less than 60% consensus with soil and erosion management practices. Although there were some differences in the consensus level between water and irrigation management practices compared with nutrient and herbicide management practices, the six key variables identified were the most influential factors affecting all LMPs. The research findings identify that some socio-cultural factors may be as important as existing financial incentives in policy design for adoption of LMPs.

Session 5: Reef Rescue and beyond for the Horticulture Industry

Convenor: Scott Wallace (GrowCom)

Investigations on minimising off-farm movement of nitrogen in the north Queensland banana industry

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Ninety per cent of Australia's banana industry is located on Queensland's wet tropical coast, bordering the Great Barrier Reef (GBR). Loss of fertiliser nitrogen (N) off-farm is considered a serious threat to GBR water quality. Leaching of N through the soil profile as well as erosive losses from the soil surface are the important loss pathways. Lower cost controlled release fertilizers have become available and have the potential to reduce leaching of N if the rate of release is better aligned to plant demand. A study started in 2011 at the Centre for Wet Tropics Agriculture, South Johnstone aims to compare eight methods of delivering N fertiliser: urea, porous bags, Novatech (nitrification inhibitor, BASF), multicote (polymer coated urea, Haifa) and CoRon (Polymethylene Urea, BARMAC). Crop performance, loss of N and potassium in deep drainage, and soil fertility have been monitored in a plant crop and first ratoon. Agronomic data from date of bunch emergence to marketable yield for the plant crop cycle did not show any significant differences between treatments. Concentrations of nitrate-N in the soil at planting were as high as 33 mg/kg. This resulted in a high nitrate-N load of 127 kg N/ha in the soil profile to a depth of 0.6 m, which was likely to have masked any differences between the form of N fertiliser delivery. Nitrate-N concentrations were as high as 27 mg/L for the first six weeks after planting and then declined sharply to low concentrations until harvest of the plant crop.

Pesticide management in bananas

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Pesticide runoff from agricultural lands has been recognised as a serious threat to the health and productivity of the Great Barrier Reef. In contrast to PSII herbicides, little is known about the rate and extent of movement of the herbicides commonly used in banana production (~11,000 ha).

Two herbicides, glufosinate-ammonium (Basta) and glyphosate (inter-row only), were monitored in runoff and deep drainage from a banana plot at South Johnstone from 2011-2013. Runoff was collected following rainfall with a refrigerated automated sampler at an existing Paddock to Reef monitoring site. In addition, deep drainage was collected regularly with a lysimeter system from a depth of 1 m beneath the banana row.

Event mean concentrations of glufosinate (acid) in runoff in January 2012, one week after application, were 6.3 µg/L and then generally declined with time and rainfall to <0.5 µg/L by early March. They remained at <0.5 µg/L until the end of monitoring in late March. In next wet season, EMC values of glufosinate (acid) were 0.5 to 1 µg/L during a large runoff event that occurred 5 days after application. Glyphosate (EMC 0.3-2.5 µg/L) and its breakdown product, AMPA (EMC 1.3-6.3 µg/L) were detected in all runoff samples analysed. This was despite runoff occurring as long as 6 months after application.

In deep drainage, glyphosate was detected in only 2 samples (0.8-1.1 µg/L) in January 2013, 6 months after application, following 700 mm of rain over 4 days.

Simulating growth, development and nitrogen balance of banana crops in APSIM

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Banana plantations can have a detrimental impact on reef water quality, particularly through the export of nitrate from the farming system. Cropping system models are used to quantify nitrate exports caused by different management actions and farming system designs in crops such as sugarcane. Models are also used to design and test alternative cropping systems and management actions to evaluate biomass production, yield and nitrate exports through 'virtual experimentation'. To date there has been no usable cropping system model to quantify and evaluate yield and nitrate exports from banana cropping systems in Queensland. This presentation describes the physiological basis and validation of such a model, using the APSIM framework. Key physiological parameters were derived from literature and experimentation at South Johnstone Research Station. The model has been tested on an independent set of experiments, focusing on phenological development, biomass accumulation, nitrogen balance and yield. The model can be used to more accurately describe nitrate export from banana plantations for a range of management actions under the ABCD management practice framework, and consequently improve reporting of Reef Rescue

outcomes. The model is also able to test alternative management actions, and extrapolate results of experimentation (such as RRRD049) both spatially (to other soil types or climates) and temporally (to other climate years, to evaluate experimental results under a range of climates). Because the model has been developed in APSIM it complements existing Reef Rescue reporting structures.

Session 6: Reef Rescue and beyond for the Grazing Industry

Convenor: Marie Vitelli (Agforce)

Understanding the impacts of grazing land management on ground cover, pasture productivity and erosion

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The 25+ year archive of remotely-sensed dry-season ground cover data potentially represents a 'real-life experiment' in which a range of grazing management practices has been applied across the hundreds of properties in Great Barrier Reef (GBR) regions, to result in a range of vegetation ground cover scenarios. This project tested whether the ground cover does indicate property differences in grazing practices, and quantified the outcomes of those practices for pasture productivity and sediment loss. The project used the ground cover data to select three focus properties with historically high, medium or low ground cover levels. We replicated this across three soil types common in the Fitzroy & Burdekin catchments. At the focus properties we assessed land condition including (i) pasture composition and productivity, (ii) soil infiltration capacity as a measure of the ability to retain rainfall to support pasture production and reduce offsite runoff, and (iii) soil stability. To scale up this knowledge we developed a technique for isolating the management signal in property ground cover time-series from spatial variations in rainfall across large regions, to potentially provide a regional assessment of grazing practices. We also assessed the potential to improve regional pasture productivity and reduce soil loss.

The results to date demonstrate that ground cover data is strongly indicative of historical stocking rates, pasture productivity, runoff, and soil and nutrient run-down at paddock to property scales. Based on the interdependency between these factors, a cycle of recovery is described whereby reductions in stocking rates should lead to long-term increases in pasture productivity, ground cover, reduced erosion and consequent improvement in sustainability and profitability.

Quantifying the impacts of rehabilitating degraded lands on soil health, pastures, runoff, erosion, nutrient and sediment movement

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The extensive grazing lands of north Queensland provide a significant proportion of the water flowing into the Great Barrier Reef (GBR) lagoon through the Burdekin and Fitzroy river catchments.

The bare, eroded D-condition areas provide a disproportionate amount of water, sediment and nutrients in runoff. These areas require mechanical intervention to rehabilitate back to a pasture cover, which will make the patches usable for grazing and will improve water quality flowing into the GBR. This project has three approaches to rehabilitating degraded bare areas: field trials, landholder experience surveys, and a literature review. Four mechanical rehabilitation methods were evaluated in the Burdekin catchment (chisel ploughing, deep ripping, crocodile seeding, hay mulch after levelling) and two methods in the Fitzroy catchment (ripping and blade-ploughing). These surface disturbance methods were compared with an undisturbed control. All treatments were sown with a tropical grass and legume pasture mix and grazing was controlled in the first year. Pasture composition, production, cover, time lag to improved condition, sediment and nutrient loss, and costs and benefits of rehabilitation methods are being measured. The landholder surveys assess social and economic drivers and barriers to rehabilitation. Initial results suggest the main criteria of rehabilitation success of D-condition bare patches in grazing land requires:

- Select suitable soil types, such as vertosol
- Sow adapted pasture grass and legume species
- Use mechanical soil surface disturbance methods with a sufficient disturbance level
- Control grazing in the initial years
- Conduct rehabilitation in above average rainfall years.

Rehabilitation Options for Alluvial Gullies in the Normanby Catchment

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Alluvial gully erosion into floodplains and terraces is widespread across northern Australia and the Normanby catchment and is fundamentally different in form and process than hillslope or colluvial gully erosion. It is a major sediment source at the catchment scale and has been accelerated by European land-use and cattle grazing. Contrary to the perception of the Normanby catchment being "near-pristine", large land tracts are in desperate need of active or passive rehabilitation to reduce alluvial gully erosion.

To prevent or reduce alluvial gully erosion, a three-pronged approach is needed to:

- Reduce water runoff/concentration from river frontage into gullies
- Increase erosion resistance in gullies
- Control the grade of gullies to reduce further incision.

Ideally, to ensure success at any given gully, all three approaches are needed. This can be accomplished by both passive and active land management measures.

Passive measures to reduce water runoff and soil disturbance are the most applicable to addressing the 'cumulative effects' of thousands of gullies at the landscape scale. For grazing land in native woodlands, this entails fencing or spelling cattle out of alluvial high banks and adjacent floodplain catchment flats, or from larger areas of sodic soils prone to alluvial gully erosion; limiting road access

and applying appropriate burning regimes to increase 4P grass cover (the 4th P being protective).

Active measures to reduce existing alluvial gullies are costly and appropriate only for areas of strategic concern. They include:

- Installing water diversion/retention banks above gully heads (difficult in native woodlands)
- Re-grading gully slopes with machinery
- Amending sodic soils with gypsum (CaSO4), compost, mulch, and fertilizer
- Sowing slopes with perennial grass seed
- Installing grade control structures embedded into channel beds and banks.

Several trial examples of gully rehabilitation efforts in the Normanby using both passive and active approaches will be reviewed.

Tebuthiuron movement at the plot and small catchment scales within the Fitzroy Basin

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Tebuthiuron is a herbicide used to control woody vegetation in grazing systems, and under Objective 1 of Reef Plan (2009), is one of the five priority herbicides identified as main pollutants to water entering the Great Barrier Reef Lagoon. A literature review of tebuthiuron research in Australia found 12 published papers all focusing on basins 10,000 km^2 and greater. Thus, this work sought to examine the movement of tebuthiuron at both the plot (1.7 m^2) and small catchment (12.7 ha) scales.

At the plot scale, maximum load of tebuthiuron in the soil from 0 to 5 cm deep occurred 28 days after application. This is likely due to the movement of tebuthiuron from trash into the soil following rainfall. Maximum loads in the soil from 5 to 20 cm deep occurred between 56 and 98 days after application. After 98 days tebuthiuron concentrations at all depths tended to decrease over time.

At the small catchment scale, runoff 100 days after application showed high concentrations of tebuthiuron averaging 103 µg/L; however, the total lost in runoff was only 0.05% of the amount applied to the catchment. Runoff 224 and 361 days after application lost 0.22% and 0.25% of applied tebuthiuron, respectively. However, the flow volume from these two events was an order of magnitude greater than the event 100 days after application. Concentrations of tebuthiuron throughout individual hydrographs were consistent indicating high solubility rather than transport adsorbed to suspended sediments. Concentrations between the hydrographs declined exponentially with time.

Reef Rescue investments in the grazing industry: Socio-economic outcomes

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Technical information is accumulating about the types of management changes that are desirable

in the grazing sector to reduce pollutants, particularly sediments, into Great Barrier Reef (GBR) catchments. However the costs of making management changes and the incentives facing landholders to adopt new practices are poorly understood. Landholders do not simply follow short term profit signals, but make land management decisions according to a complex mix of drivers, including expected returns, historical patterns, their ability to adapt to changed conditions, and their personal characteristics and circumstances. Determining the cost effectiveness of management changes is complex because of interrelations between production, profitability and environmental changes, and variability across time and space. Results of economic analysis show that the costs of changing management to improve water quality vary greatly (e.g. two orders of magnitude) between different practices and enterprises, indicating that more cost-effective targeting of actions to reduce pollutants is possible. The treatment of uncertainty and attitudes towards risk, particularly in highly variable environments, as well as the transaction costs associated with changing management may be important reasons why landholders have different preferences for improving environmental management. Although some practice changes should give positive economic benefits in the long-term, the economic benefits may not be large enough to drive widespread adoption without external support.

The movement of Nitrogen and Phosphorus fertilisers applied to dairy pastures in the Great Barrier Reef Catchments

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Research into the various loss pathways of nitrogen and phosphorus from fertiliser is limited for the dairy industry in the Great Barrier Reef Catchment (GBR). The aim of the Reef Rescue funded research project was to understand the different loss pathways through the establishment of two research sites across the GBR catchment. By quantifying losses and measuring pasture biomass yields we aimed to validate the cost/benefits of improved fertiliser practices.

Investigations were conducted on irrigated ryegrass plots treated with different rates of standard Urea, and Entec-coated urea. The application rates were 50 kg ha^{-1} and 98 kg ha^{-1} (23 kg ha^{-1} and 45 kg ha^{-1} of Nitrogen). Urea applications occurred approximately every 3 weeks post grazing.

Measurements from each plot included runoff, drainage and gas emissions. To understand the soil profile, deep soil nutrient analysis was undertaken. 15N labelled urea was added to trace the N movement through the profile. Pasture yields were also measured to coincide with grazings.

Results and findings from the research are currently being analysed and will be available in August-September 2013.

Queensland Dairyfarmers' Organisation manages the Research project on behalf of the Queensland dairy industry. The research is supported by Incitec Pivot and is being conducted by James Cook University and the Queensland University of Technology.

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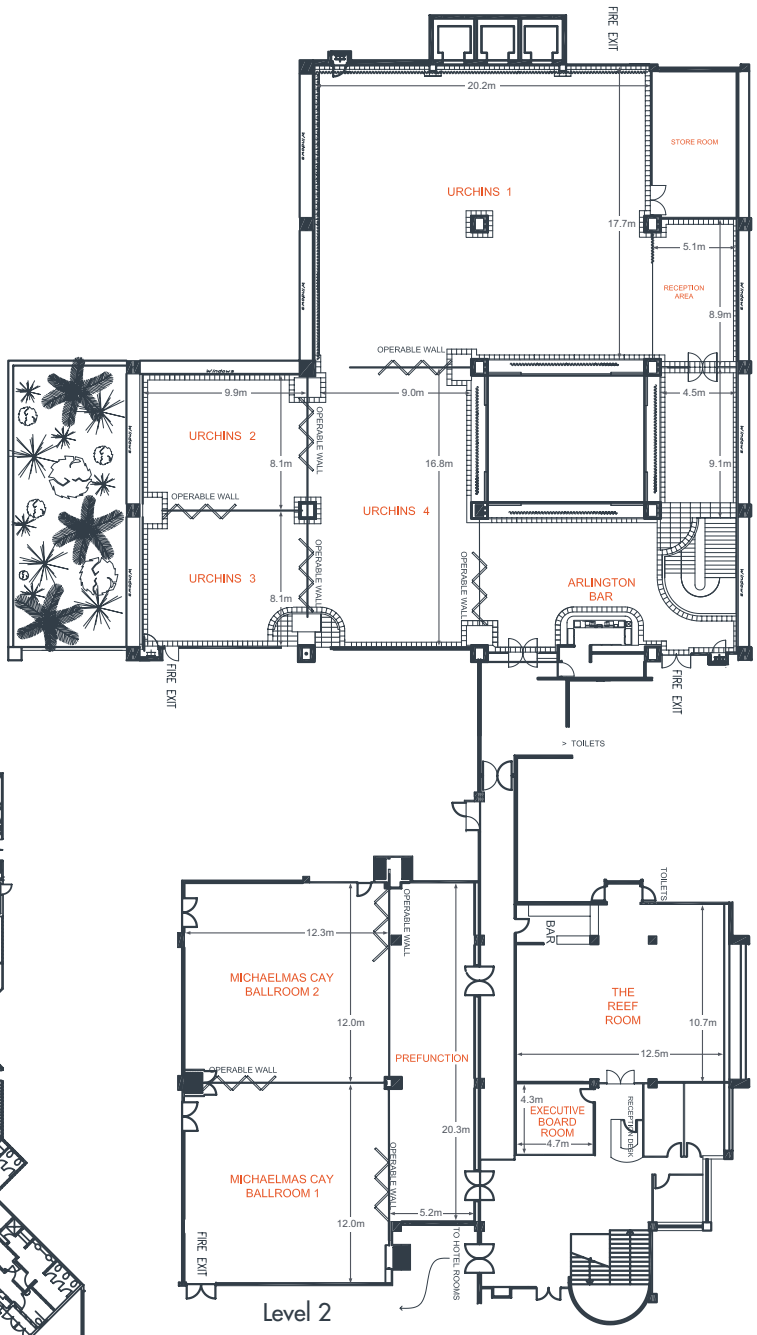

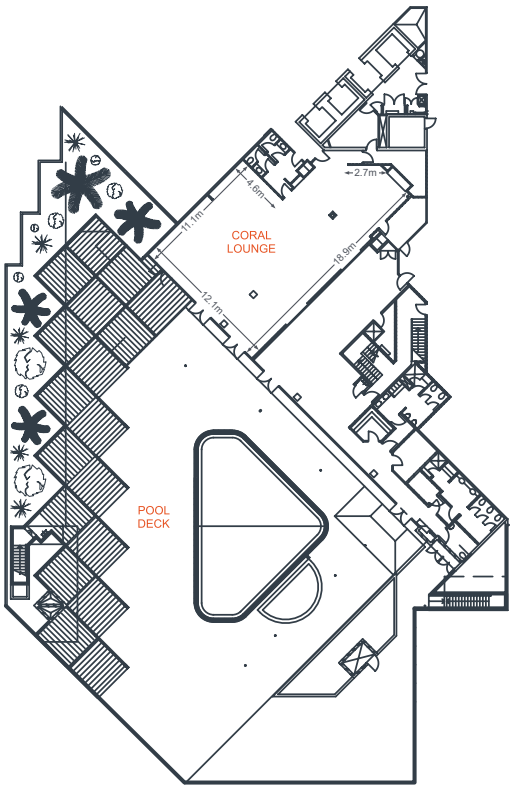

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