Multi-Year Research Plan

Tropical Ecosystems Hub

July 2011 – December 2014

National Environmental Research Program
(NERP)

Australian Government
Department of Sustainability, Environment, Water, Population and Communities

Contents

Acronyms

ABRS.................Australian Biological Resources Survey
AFMA.................Australian Fisheries Management Authority
AIMS..................Australian Institute of Marine Science
AMTPO..............Association of Marine Park Tourism Operators
ANU...................Australian National University
AQIS...................Australian Quarantine and Inspection Service
ARC...................Australian Research Council
AWP...................Annual Work Plan
BOM...................Bureau of Meteorology
CAFNEC............Cairns and Far North Environment Centre
CapReef............Capricorn Reef Monitoring Program
CERF.................Commonwealth Environment Research Facilities
CSIRO................Commonwealth Scientific and Industrial Research Organisation
CYPNRM............Cape York Peninsula Natural Resource Management
CYPSCAC..........Cape York Peninsula Scientific and Cultural Advisory Committee
DAFF..................Commonwealth Department of Agriculture, Fisheries and Forestry
DEEDI................Queensland Department of Employment, Economic Development, and Innovation
DERM................Queensland Department of Environment and Resource Management
DSEWPaC.........Commonwealth Department of Sustainability, Environment, Water, Population and Communities
DSS....................Decision Support System
EPBC Act..........Environment Protection and Biodiversity Conservation Act 1999
FNQROC............Far North Queensland Regional Organisation of Councils
GBR...................Great Barrier Reef
GBRMPA...........Great Barrier Reef Marine Park Authority
GBRMP.............Great Barrier Reef Marine Park
GBRWHA...........Great Barrier Reef World Heritage Area
GU.....................Griffith University
IMOS..................Integrated Marine Observing System
IPAs...................Indigenous Protected Areas
JCU....................James Cook University
LSMU..................Land and Sea Management Unit, Torres Strait Regional Authority
MLA...................Meat and Livestock Australia
MTSRF...............Marine and Tropical Sciences Research Facility
MYRP.................Multi-Year Research Plan
NCCARF............National Climate Change Adaptation Research Facility
NERP.................National Environmental Research Program
NGO...................Non Government Organisation
PNG...................Papua New Guinea
QA/QC...............Quality Assurance / Quality Control**QPWS**................Queensland Parks and Wildlife Service
RRRC.................Reef and Rainforest Research Centre

TE ....Tropical Ecosystems
TERN ....Terrestrial Ecosystems Research Network
TSRA ....Torres Strait Regional Authority
TUMRAs...........Traditional Use Marine Resource Agreements
UQ ....University of Queensland
WADEC............Western Australian Department of Environment and Conservation
WTMA................Wet Tropics Management Authority
WWF..................World Wildlife Fund

The National Environmental Research Program

The National Environmental Research Program (NERP) is an Australian Government program that provides funding for applied public good research. It builds on the Commonwealth Environment Research Facilities (CERF) program with a specific focus on biodiversity.

The program's objective is: *To improve our capacity to understand, manage and conserve Australia's unique biodiversity and ecosystems through the generation of world-class research and its delivery to Australian environmental decision makers and other stakeholders.*

NERP focuses on biodiversity research and delivering information that the Australian Government and other stakeholders need to better inform environmental management, policy and decision making, both in the short-term and into the future. This includes understanding how ecosystems function, monitoring their health, maintaining and building their resilience, using them sustainably and exploring how to better use markets to protect biodiversity.

The NERP seeks to achieve its objectives by supporting applied research that:

- Has a strong public-good focus and public-good outcome;
- Is end-user focused and addresses the needs of the Australian Government and other stakeholders in developing evidence-based policy to improve management of the Australian environment;
- Is highly innovative and aims to achieve world-class research;
- Enhances Australia's environmental research capacity;
- Is collaborative and builds critical mass by drawing on multiple disciplines from multiple research institutions to address challenging research questions;
- Provides results accessible to government, industry and the community; and
- Includes a focus on synthesis and analysis of existing knowledge.

Five large multi-institutional research hubs have been established to examine biodiversity issues in terrestrial, freshwater and marine ecosystems across Australia. For further details see www.environment.gov.au/nerp

This Multi Year Research Plan (MYRP)

This research plan has been developed for the Tropical Ecosystems Hub (NERP TE Hub). To check you have the most recent version of this document, please see the NERP website www.environment.gov.au/nerp.

The purpose of the NERP Tropical Ecosystems Hub MYRP is to:

- Provide contextual information and a breakdown of research activities in the Hub;
- Describe the research that the Hub will be undertaking under the NERP between 2011 and 2014;
- Identify research priorities and links to Australian Government Environment Portfolio policies and programs;
- Outline the relationship of the research to the Australian Government Environment Portfolio and other key end users; and

- Provide a framework for monitoring and evaluating the Hub activities, as part of the NERP.

The primary audience for the MYRP is the Minister for Sustainability, Environment, Water, Population and Communities, environment portfolio agencies, particularly the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC), Great Barrier Reef Marine Park Authority (GBRMPA), and the Hub with its researchers. Other interested stakeholders include non-hub researchers, government and non-government organisations and the general public.

This Multi-Year Research Plan broadly describes the scope of the Hub's research work program over the period 2011 to 2014. It will be accompanied by several Annual Work Plans (AWPs), which will define details of the scheduled activities on an annual basis.

1.0 The Tropical Ecosystems Hub

1.1 Introduction

The NERP Tropical Ecosystems Hub (TE Hub) is a $61.9m research program funded by the Australian Government in partnership with a number of Australian research institutions that will address issues of concern for the management, conservation and sustainable use of the World Heritage listed Great Barrier Reef (GBR) and its catchments, tropical rainforests including the Wet Tropics World Heritage Area (WTWHA), and the terrestrial and marine assets underpinning resilient communities in the Torres Strait, through the generation and transfer of world-class research and shared knowledge.

The mission of the Hub is to deliver research that supports evidenced-based policy, management, and decision-making by the Australian Government and other key end-users. The Hub is a partnership between research providers (core group: AIMS, CSIRO, JCU, UQ; others ANU, GU) and a diverse range of end-users including government agencies (Federal, State), management authorities (GBRMPA, TSRA, WTMA), NRM bodies, conservation NGOs, regional industries, Indigenous groups and the general public.

The Hub builds on five years of 'public good' environmental research supported through the Marine and Tropical Sciences Research Facility (MTSRF). The MTSRF was a large investment by the Commonwealth Environmental Research Program (CERF) funded by the Australian Government through the former Department of Environment, Water, Heritage and the Arts. The MTSRF program was built on the foundation of thirteen years of prior tropical research supported by the Cooperative Research Centre Program, which funded twin Cooperative Research Centres for the reef (GBR, Torres Strait) and Wet Tropics rainforest. As in these previous programs, the NERP TE Hub will benefit from significant co-investment from research providers and other agencies.

These successive research programs have sought to improve regional environmental decision making and inform national, state and regional stakeholders through better understanding of:

- The status and future trends of key species and ecosystems in northern Queensland;
- The social and economic interactions between northern Queensland communities and their regional environmental assets;
- The performance of existing management arrangements against their targets; and
- The options for adaptation and new management approaches to enhance ecological and social resilience in a changing environment.

The more complex of these issues requires combining new knowledge from multiple disciplines, particularly the fusion of socio-economic and biophysical sciences. They also require sharing knowledge among many different groups (e.g. researchers, managers, end-users, Indigenous). Since most of the problems require local solutions, these are best developed and delivered through regional networks that overcome the capacity constraints in individual institutions in northern Queensland. In addition to the challenging goal of developing and delivering useful information for the benefit of diverse end-users, the TE Hub as a co-ordinating mechanism also builds capability through providing opportunities for collaborative multi-disciplinary networks; and enhances capacity into research leading directly to improved environmental outcomes. The latter requires the end-users of this new knowledge to be engaged throughout the process from the early stages of problem definition to the implementation of new practices and/or the uptake into new policy. Consequently, the effectiveness of communications and knowledge brokering by the Hub will be just as important as its research portfolio.

1.2 Hub Mission

The NERP Tropical Ecosystems Hub will address issues of concern for the management, conservation and sustainable use of the World Heritage listed Great Barrier Reef (GBR) and its catchments, tropical rainforests including the Wet Tropics World Heritage Area (WTWHA), and the terrestrial and marine assets underpinning resilient communities in the Torres Strait, through the generation and transfer of world-class research and shared knowledge. This research will be highly relevant, influential in policy, planning and management, publicly available, and value for money.

1.3 Hub Strategic Goals

The strategic goals of the NERP Tropical Ecosystems Hub are to improve understanding and delivery of knowledge relating to:

1. **Monitoring condition and trend in natural resources**: Understanding the condition, trend and interdependencies of unique environmental assets of northern Queensland; building the capacity to predict the future for these resources.
2. **Understanding the impacts of cumulative pressures on ecosystem function:** Understanding how ecosystems and biodiversity respond to cumulative pressures; determining the ecological, social and economic implications for northern Queensland.
3. **Managing for resilient tropical systems:** Partnering with key environmental decision-makers in government, industry and community to develop information, systems and tools to support implementation of ecologically-sustainable management; preserving environmental values while strengthening social resilience to future change.
4. **Delivering an effective and efficient program**: Implementing a cost-effective program by ensuring a clear governance framework is supported by effective systems and efficient processes that deliver: world-class science; timely results; value for money; clear pathways for adoption of new information by all engaged end-users.

1.4 Expected Outcomes

Responding to the independent review of the CERF program[1], and the framing statements of the NERP, the TE Hub has a primary obligation to strengthen decision-making on environmental matters by the Australian Government and other stakeholders.

The Hub will develop and transfer new knowledge and tools (e.g. decision support systems) to managers and other users requiring environmental, social and/or economic information to support their respective future decisions.

The multiple community interests in managing the unique ecosystems of the Great Barrier Reef, Torres Strait, and the Wet Tropics rainforests (three tiers of government, industry, NRM bodies, conservation NGOs, public interest) means that the Hub will recognise the needs of the Australian Government along with the needs of a diverse range of interested stakeholders including Indigenous stakeholders.

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[1] Urbis Pty Ltd (2010) *Evaluation of the Commonwealth Environment Research Facilities Program –Final Report.* A report commissioned by the Commonwealth Department of Sustainability, Environment, Water, Population and Communities, www.environment.gov.au.

Desired outcomes of the research and knowledge transfer will include:

- Greater clarity about the condition and trend of the key environmental assets;
- New knowledge about historical changes in the GBR coastal zone;
- Better definition of threatening processes in tropical terrestrial and marine ecosystems;
- Management based on understanding multiple risks and cumulative pressures;
- Inclusion of the socio-economic values of ecological goods and services in environmental decisions in northern Queensland;
- Enhanced capacity and capability in north Queensland to support evidence-based decisions around competing resource uses, coastal development, invasive species, and climate change;
- Better informed management of species of high conservation concern (e.g. cassowaries, turtles, dugongs, vulnerable shark species);
- Greater participation by Indigenous stakeholders in co-management of biodiversity;
- Support for ecologically sustainable communities in the Torres Strait;
- Improved ability to predict ecosystem and societal responses to future change;
- Better tools to evaluate alternative ecosystem scenarios;
- Transfer of new knowledge and tools to other bioregions;
- Improved flow of clear and appropriately targeted information to Queensland's diverse northern communities, including Indigenous communities; and
- Evidence of real-world impacts of Hub research on policy and on-ground practice in addition to a list of scholarly publications.

Figure 1 provides a 'road map' of examples of pathways from research projects to adoption by environmental managers that are expected from investment in the TE Hub.

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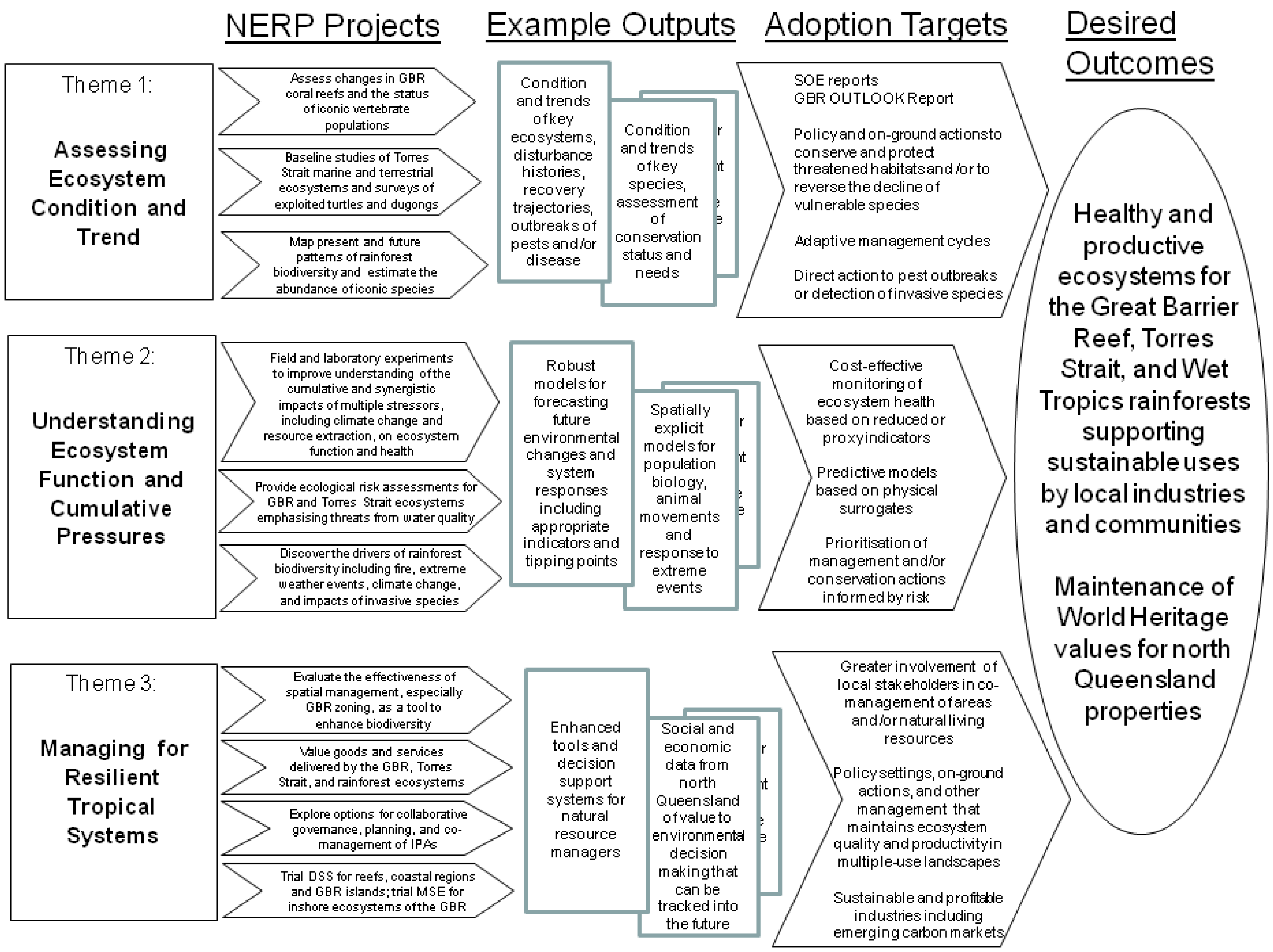
Figure 1: Pathways to adoption for NERP TE Hub research.



1.5 Expected Outputs

Table 1 provides a summary list of project outputs and end-users by geographic node (GBR, Torres Strait, Wet Tropics rainforests). For more detailed information refer to Section 3.2.

1.6 Hub and Research Activities

The Hub will build on a $25.8m investment from the Australian Government through the National Environmental Research Program to deliver $61.9m of research to address the priority issues identified by the Australian and Queensland Governments, their management agencies (in particular GBRMPA, TSRA, WTMA), and refined through a stakeholder consultation process.

As listed in Table 1, the TE Hub research program will support 38 research projects, and 2 communications and knowledge brokering projects, delivering to three geographic Nodes (Great Barrier Reef, Torres Strait, Wet Tropics rainforests) but with common themes recurring in each Node. Consequently the Hub will be organised around 12 research programs to reflect the thematic and geographic matrix, with 1 program dedicated to communications and knowledge brokering. While the Themes directly address the strategic goals of the Hub, the program structure enables effective aggregation at the specific ecosystem scale.

Figure 2 outlines the Themes and Programs of the Hub as well as showing the scale of investment of each of the Programs by tracking the allocation of NERP cash.

Table 1: Summary of expected NERP TE Hub outputs and end-users by geographic Node.

Project		Project Leader	Expected outputs	Key End-Users
THEME 1				
Program 1 – Historical and current condition of the Great Barrier Reef – Pandolfi				
1.1	Monitoring status and trends of coral reefs of the GBR	Dr Hugh Sweatman, AIMS	Broad-scale surveys of reef health and early warning of crown of thorns outbreaks on the GBR	GBRMPA –David Wachenfeld, Laurence McCook Fergus Molloy, Roger Beeden AMPTO - Col McKenzie DSEWPaC –Kate Sanford-Readhead, , Charles Brister, Leah McKenzie, David Calvert, Belinda Jago,
1.2	Marine wildlife management in the GBRWHA	Dr. Mark Hamann and Prof. Helene Marsh, JCU	Status of dolphin populations in the northern GBRWHA; Status of dugong populations within the GBRWHA; Ecological role and habitat use of dugongs and turtles	GBRMPA - Mark Read, Liz Wren DSEWPaC - Kate Sanford-Readhead, , Karen Arthur, Amy Crnic, Ilse Leissling, Belinda Jago,, Charles Brister, Leah McKenzie, David Calvert, Peter Wright, , DEHP - Col Limpus DAFF - Rob Coles, Julia Davies Girringun - Phil Rist
1.3	Characterising the cumulative impacts of global, regional and local stressors on the present and past biodiversity of the GBR	Dr Jian Zhao and Dr John Pandolfi UQ	Dating and chemical analysis of coral records to reveal the historical responses of coral communities to acute (e.g. cyclones) and chronic (e.g. water quality) disturbances	DSEWPaC - Kate Sanford-Readhead, Kevin Gale, David Calvert, Charles Brister, Leah McKenzieGBRMPA - Fergus Molloy, Roger Beeden, David Wachenfeld, Laurence McCook, Leigh Gray AMPTO - Col McKenzie DEHP - John Bennett Canegrowers - Matt Kealley DSEWPaC/DAFF Reef Rescue Team - Kevin Gale

Program 2 – Natural Resources of the Torres Strait land and sea – Marsh				
2.1	Marine Turtles and Dugongs of Torres Strait	Dr Mark Hamann and Prof Helene Marsh, JCU	Critical data on threatened species including habitat use, connectivity, and population size	TSRA - Damian Miley, Frank Loban DSEWPaC - Kate Sanford-Readhead, Nathan Hanna, Karen Arthur, Amy Crnic, John McDougall, Peter Komidar, Shaun Barclay, Kate Thomann, David Calvert, Charles Brister, Leah McKenzie GBRMPA - Mark Read AFMA - Annabel Jones DEHP - Col Limpus DAFF – TBC
2.2	Mangrove and Freshwater Habitat Status of Torres Strait Islands	Dr Norm Duke and Dr Damien Burrows, JCU	Baseline surveys of mangrove and freshwater habitats on populated islands of the Torres Strait	TSRA – Damian Miley, Simon Conaty, Vic McGrath Torres Strait Regional Council – Regional Engineer NAILSMA – Joe Morrison Qld Wetlands Programme – Mike Ronan DSEWPaC –Kate Sanford-Readhead, John McDougall, Shaun Barclay, Kate Thomann, DEEDI – Mal Pearce, Anne Clarke
2.3	Monitoring the health of Torres Strait coral reefs	Dr Ray Berkelmans, AIMS	Early warning system for coral bleaching based on real-time monitoring of sea temperature; Design and implementation of a long-term monitoring program to be delivered by Indigenous sea rangers	TSRA –Vic McGrath, John Rainbird, Damien Miley, Frank Loban Tagai College - Tim Hillier AFMA - Shane Fava DSEWPaC - Kate Sanford-Readhead, John McDougall, Shaun Barclay, Kate Thomann, Nathan Hanna GBRMPA – David Wachenfeld, Paul Marshall

Program 3 – Condition and trends of north Queensland rainforests – Williams				
3.1	Rainforest Biodiversity	Prof Steve Williams JCU	Maps of past, current and predicted future patterns in biodiversity and the environment; Conservation priorities for rainforest flora and fauna	WTMA - Andrew Maclean DNPRSR - Andrew Millerd FNQROC - Travis Sydes Terrain NRM - Rowena Grace, Carole Sweatman DSEWPaC – Margaret Considine, Kate Sanford-Readhead, David Calvert, Peter Latch, TBC, Karl Newport
3.2	Rainforest refugia and hotspots of plant genetic diversity in the Wet Tropics and Cape York Peninsula	Prof Darren Crayn, JCU	Assessment of genetic diversity of mountain-top floras and/or other postulated refugia to enable effective prioritisation of limited resources for species conservation	WTMA - Steve Goosem Terrain NRM - Rowena Grace DERM - Bruce Wannan DSEWPaC - Kate Sandford-Readhead, , Peter Latch, TBC, Margaret Considine, David Calvert, Karl Newport ABRS - Michael Preece TERN - Andy Lowe
3.3	Targeted surveys for missing and critically endangered rainforest frogs in ecotonal areas, and assessment of whether populations are recovering from disease	Dr Robert Puschendorf & Conrad Hoskin JCU	Baseline surveys of marginal habitats to learn whether they shelter populations of species considered extinct in their primary habitats	DNPRSR - Andrew Millerd; James Newman Terrain NRM - Rowena Grace WTMA - Steve Goosem DSEWPaC - Julian Barnard, Peter Latch, TBC, Karl Newport, Joanne Nathan, Margaret Considine, David Calvert, Kate Sanford-Readhead,

3.4	Monitoring of Key Vertebrate Species	Dr David Westcott, CSIRO	Estimates of distribution, abundance and population structure of Cassowaries and Spectacled Flying Fox populations across the Wet Tropics Region	DSEWPaC - Tim McGrath, Ben Maly, Peter Latch, TBC, Karl Newport, David Jackson, Kynan Gowland, Margaret Considine, Ben Phillips, Kate Sanford-Readhead, Joanne Nathan, Belinda Brown NPRSR - Andrew Millerd QPWS – Paula Peeters EHP – Michael Devery DERM - Michael Devery FNQROC - Travis Sydes Terrain NRM - Carole Sweatman Cairns Regional Council - Russell Wild

THEME 2				
Program 4 – Water quality of the Great Barrier Reef and Torres Strait – Schaffelke				
4.1	Tracking coastal turbidity over time and demonstrating the effects of river discharge events on regional turbidity	Dr Katharina Fabricius, AIMS	Region-specific quantitative relationships between river discharges, weather, and water clarity	DSEWPAC - David Calvert, Charles Brister, Leah McKenzie Reef Rescue - Kevin Gale GBRMPA - Katherine Martin, Carol Honchin DEHP - John Bennett Reef Plan Secretariat - Chris Chinn DAFF - Adam West. Phil Hales Terrain NRM - Fiona Barron Burdekin Dry Tropics NRM – Paul Duncanson Mackay Whitsundays NRM - Milena Gongora Fitzroy Basin Association - Tom Coughlin, Piers Harper Burnett Mary Regional Group - Fred Bennett MLA - Mick Quirk WWF - Nick Heath, Sean Hoobin

4.2	The chronic effects of pesticides and their persistence in tropical waters	Dr Andrew Negri, AIMS	Measuring the transport, fate and toxicity of herbicides in the receiving waters	GBRMPA - Katherine Martin, Leigh Gray DERM - Michael Warne Reef Rescue - Kevin Gale Reef Plan Secretariat – Chris Chinn Terrain NRM - Fiona Barron Burdekin Dry Tropics NRM - Ian Dight, Diana O'Donnell Mackay Whitsundays NRM – Milena Gongora Fitzroy Basin Association - Tom Coughlin, Piers Harper Burnett Mary Regional Group - Fred Bennett Canegrowers - Matt Kealley DSEWPAC - Jack Holland, David Calvert, Charles Brister, Leah McKenzie APVMA – Sharon Pike WWF - Nick Heath

4.3	Ecological risk assessment for water quality of the GBR	Dr Jon Brodie, JCU	A scoping of data and methods to be incorporated in an ecological risk assessment of the relative impacts of pesticides, nutrients, and sediments on GBR ecosystems (to be funded by other programs)	GBRMPA - Hugh Yorkston, Katherine Martin, Carol Honchin DSEWPaC – David Calvert, Charles Brister, Leah McKenzie, Phil Hambly, Kevin Gale, Meat & Livestock Australia Canegrowers - Matt Kealley DERM - John Bennett DEEDI –Adam West Reef Plan Secretariat - Chris Chinn, Claire Andersen Reef Rescue - Kevin Gale Terrain NRM - David Maclean NQ Dry Tropics - Ian Dight Reef Catchments NRM - Carl Mitchell Fitzroy Basin Association - Nathan Johnston
4.4	Hazard assessment for water quality threats to Torres Strait marine waters, ecosystems and public health	Dr Jon Brodie, JCU	Desktop hazard assessment of current sources of pollution to marine ecosystems and public health	TSRA – John Rainbird, Frank Loban, Damien Miley Tagai College - Tim Hillier Torres Strait Community - John Morris Torres Shire Council – Gus Yates AFMA – Shane Fava DSEWPaC - David Calvert, Charles Brister, Leah McKenzie, John McDougall, Kate Sanford-Readhead, Shaun Barclay, Kate Thomann AMSA – Adrian Davison Qld Transport – Frank Thomson

Program 5 – Cumulative impacts on benthic biodiversity – Fabricius				
5.1	Understanding GBR diversity: spatial and temporal dynamics and environmental drivers	Dr Glenn De'ath, AIMS	Knowledge of biodiversity drivers that can be incorporated in marine park management	GBRMPA - Roger Beeden, David Wachenfeld, Fergus Molloy, Laurence McCook DEHP - John Mullins DEEDI - Rob Coles DSEWPAC - Kate Sanford-Readhead, David Calvert, Charles Brister, Leah McKenzie, AMPTO - Colin McKenzie
5.2	Combined water quality-climate effects on coral and other reef organisms	Dr Sven Uthicke, AIMS	An experimental assessment of individual and synergistic effects of water quality and global change on key coral reef invertebrates to determine vulnerability	DSEWPaC – David Calvert, Leah McKenzie, Charles Brister GBRMPA - Katherine Martin, Paul Marshall, Hugh Yorkston, Reef Rescue - Kevin Gale DEHP - John Bennett Reef Plan Secretariat – Chris Chinn DAFF - Adam West Canegrowers - Matt Kealley MLA - Mick Quirk WWF - Nick Heath
5.3	Vulnerability of seagrass habitats in the GBR to changing coastal environments	Dr Catherine Collier, JCU	Exposure maps to flood plumes in coastal regions of the GBR; An experimental assessment of the impacts of light and nutrients on seagrass health leading to improved definition of thresholds of concern for water quality	DEEDI - Phil Hales, John Beumer GBRMPA - Katherine Martin, Carol Honchin DERM - Michael Warne Reef Rescue - Kevin Gale Reef Plan Secretariat - Chris Chinn DSEWPaC –Kate Sanford-Readhead, Lesley Gidding David Calvert, Charles Brister, Leah McKenzie, Karen Arthur, Amy Cmic,

Program 6 – Movements and habitat use by marine apex predators – Simpfendorfer				
6.1	Maximising the benefits of mobile predators to GBR ecosystems: the importance of movement, habitat and environment	Dr Michelle Heupel, AIMS	Acoustic tracking of sharks and other large predators to map habitat use and determine the protection from fishing offered by current spatial management	DSEWPaC - Nathan Hanna, Kate Sanford-Readhead, Bronwen Jones, Belinda Jago, Ilse Keissling, Charles Brister, Leah McKenzie, David Calvert, Peter Wright, Jeanette Muirhead GBRMPA - Randall Owens, Mark Read DEEDI - Bonnie Holmes QSIA – Scott Wiseman CapReef - Bill Sawynok
6.2	Drivers of juvenile shark biodiversity and abundance in inshore ecosystems of the GBR	Dr Colin Simpfendorfer, JCU	An assessment of the spatial heterogeneity and temporal changes in inshore shark biodiversity along the central GBR	GBRMPA - Randall Owens, Mark Read DAFF - Julia Davies DSEWPaC - Kate Sanford-Readhead, Nathan Hanna, Lesley Gidding, Bronwen Jones, David Calvert, Charles Brister, Leah McKenzie, Peter Wright, Jeanette Muirhead QSIA – Scott Wiseman
6.3	Critical seabird foraging locations and trophic relationships for the GBR	Dr Brad Congdon, JCU	Maps of shearwater and booby foraging locations from specified seabird colonies in relation to oceanographic conditions during breeding and non-breeding seasons	GBRMPA - Roger Beeden, Malcolm Turner, Paul Marshall BOM/CSIRO/NARP - Lynda Chambers AFMA - Steve Auld DEEDI - DSEWPaC –Kate Sanford-Readhead, David Calvert, Charles Brister, Leah McKenzie, Nathan Hanna, Fiona Bartlett, Ian Hay,

Program 7 – Threats to rainforest health – Metcalfe				
7.1	Fire & rainforests	Dr Dan Metcalfe, CSIRO	Mapping and assessment of fire impacts on threatened ecosystems	NPRSR - Andrew Millerd WTMA - Steve Goosem DSEWPaC - Kate Sanford-Readhead, Peter Latch, Anthony Hoffman, TBC, Karl NewportTerrain NRM - Rowena Grace Cassowary Coast Regional Council - Damon Sydes
7.2	Invasive species risks and responses in the Wet Tropics	Dr Helen Murphy, CSIRO	Maps of populations and communities that are sources of propagules for invasive weeds; Report and model of feral pig/management interaction	Biosecurity QLD – Shane Campbell NPRSR - Andrew Millerd DSEWPaC –Kate Sanford-Readhead, Joanne Nathan, David Calvert, TBC, Karl Newport WTMA - Steve Goosem Terrain NRM - Bart Dryden FNQROC – Travis Sydes
7.3	Climate change and the impacts of extreme events on Australia's Wet Tropics biodiversity	Dr Justin Welbergen, ANU	A generalised analytical toolkit for assessing vulnerability to extreme climatic events including generation of high resolution maps on exposure to extreme temperatures	WTMA - Steve Goosem, Andrew Maclean DNPRSR - James Newman, Andrew Millerd Terrain NRM - Rowena Grace, Carol Sweatman DSEWPaC – David Calvert, Peter Latch, Tim McGrath, TBC, Karl Newport, Kate Sanford-Readford

THEME 3				
Program 8 – Effectiveness of spatial management on the GBR – Sweatman				
8.1	Monitoring the ecological effects of GBR zoning plan on mid and outer shelf reefs	Dr Hugh Sweatman, AIMS	Measuring the impact of no-take areas created by the 2004 rezoning of the GBRMP upon fish, coral and Acanthaster	GBRMPA - David Wachenfeld, Laurence McCook AMPTO - Col McKenzie DSEWPaC - Kate Sanford-Readhead, Jeff Tranter, Charles Brister, Leah McKenzie, David Calvert, Belinda Jago, DAFF -
8.2	Assessing the long-term effects of management zoning on inshore reef of the GBR	Prof Garry Russ, JCU	Measuring the impact of no-take areas upon fish populations of importance to the recreational sector; Estimates of levels of non-compliance	GBRMPA - Fergus Molloy, Laurence McCook, David Wachenfeld CapReef - Bill Sawynock DAFF - Brigid Kerrigan WA DEC - Chris Simpson DSEWPaC – Charles Brister, Leah McKenzie, David Calvert, Belinda Jago,
8.3	Significance of no-take marine protected areas to regional recruitment and population persistence on the GBR	Prof Geoff Jones, JCU	Empirical estimates of recruitment subsidies to fished areas (Blue Zones) by coral trout spawning within no-take areas (Green Zones) in the southern GBR	GBRMPA - Laurence McCook, David Wachenfeld, Fergus Molloy CapReef - Bill Sawynock DAFF - DSEWPaC – Charles Brister, Leah McKenzie, David Calvert, Belinda Jago

Program 9 – Decision support systems for GBR managers – Pressey				
9.1	Dynamic Vulnerability Maps and Decision Support Tools for the Great Barrier Reef	Dr Ken Anthony, AIMS	Dynamic vulnerability maps for coral bleaching and a risk-based decision support system for the GBR	GBRMPA - Roger Beeden, Paul Marshall, David Wachenfeld DEEDI - TBC DSEWPaC - Kate Sanford-Readhead, Charles Brister, Leah McKenzie, David Calvert,
9.2	Design and implementation of management strategy evaluation for the GBR	Dr Cathy Dichmont, CSIRO	Identification of alternative strategies for the management of the inshore region aimed at biodiversity outcomes with a focus on multi-species fisheries management	GBRMPA - Mark Read, Randall Owens, Laurence McCook, Roger Beeden, Peter McGinnity DAFF – Ross Quinn DSITIA - Julia Playford, Michael Warne DEHP - John Bennett DSEWPaC - Kate Sanford-Readhead, Charles Brister, Leah McKenzie, David Calvert, Belinda Jago
9.3	Prioritising management actions for GBR islands	Prof Bob Pressey, JCU	A novel, cost-effective, and transparent approach to prioritising management actions for multiple objectives across islands in a selected sub-region of the GBR	DERM - John Hicks DSEWPaC – Charles Brister, Leah McKenzie, David Calvert, Belinda Brown, Kate Sanford-Readhead GBRMPA - Malcolm Turner AMPTO - Colin McKenzie

9.4	Spatial planning for coastal development in the GBR region	Prof Bob Pressey, JCU	Examination of governance and potential effectiveness of new instruments for management through the development of generalised and, for sub-regions, detailed models of alternative futures for the coastal zone	DEHP - John Bennett Reef Plan Secretariat – Chris Chinn GBRMPA - Hugh Yorkston, Peter McGinnity AMPTO - Colin McKenzie Reef Rescue - Kevin Gale DAFF - Adam West, Phil HalesTerrain NRM - Fiona Barron NQ Dry Tropics NRM - Ian Dight Reef Catchments NRM - Milena Gongora Fitzroy Basin Association - Tom Coughlin, Piers Harper Burnett Mary Regional Group - Fred Bennett WWF -Nick Heath QSIA -Winston Harris Canegrowers – Matt Kealley DSEWPaC - Kate Sanford-Readhead, , Kevin Gale, Charles Brister, Leah McKenzie, David Calvert,

Program 10 – Socio-economic value of GBR goods and services – Lane				
10.1	Social and economic long-term monitoring program (SELTMP)	Dr Nadine Marshall, CSIRO	Design and implementation of a long-term social and economic monitoring programme for the GBR region; Status and trends of socio economic data in the GBR	GBRMPA - Dave Wachenfeld, Margaret Gooch, Peter McGinnity QSIA – Scott Wiseman AMPTO - Col McKenzie FRDC - Crispian Ashby DEEDI - Kirrily McInnes, Kerrod Beattie QTIC – Daniel Gschwind QPWS/DERM - Andy Grodecki DSEWPaC – Charles Brister, Leah McKenzie, David Calvert, Shaun Barclay, Kate Thomann
10.2	Socio-economic system and reef resilience	Dr Natalie Stoeckl, JCU	Long term monitoring of visitor patterns in the GBR; Stakeholder views on the relative value of different market and non-market goods and services provided by the GBR	GBRMPA - Margaret Gooch, David Wachenfeld, Peter McGinnity DSITIA - Andrew Grodecki DAFF – Andrew Thwaites, Eddie Jebreen, Kirrily McInnes, James Webley,Tony Ham, Ross Quinn, Anthony Roelofs TTNQ - Rob Giason DEEDI - Adam West, Kirrily McInnes, Michelle Winning, Lew Williams QSIA – Scott Wiseman Sunfish - Barry Pollock, Judy Lynne CapReef – William Sawynok Charter Fishing Rep – Ewan Jones Alliance for Sustainable Tourism - John Courtenay AMPTO - Col McKenzie WWF – Nick Heath DSEWPaC – Charles Brister, Leah McKenzie, David Calvert, Shaun Barclay, Kate Thomann

Program 11 – Resilient Torres Strait communities – Butler				
11.1	Building resilient communities for Torres Strait futures	Dr James Butler, CSIRO	Typology of TS and PNG Treaty Village livelihoods; Valuation of ecosystem goods and services underpinning Torres Strait livelihoods and other beneficiaries	TSRA LSMU – Damian Miley, John Rainbird AFMA - Shane Fava QLD Govt - John O'Halloran DSEWPaC –John McDougall, Fiona Fraser, Shaun Barclay, Kate Thomann, Kate Sanford-Readhead DFAT - Simon Moore
11.2	Improved approaches for the detection and prevention of wildlife diseases in the Torres Strait.	Dr Susan Laurance, JCU	Improved approaches to biosecurity through detection and prevention of wildlife diseases in the Torres Strait.	DSEWPaC – Joanne Nathan, John McDougall, Shaun Barclay, Kate Thomann, Kate Sanford-Readhead Biosecurity Queensland – Hume Field AQIS – Lauren Schipke TSRA LSMU – Damian Miley, Simon Conaty, Vic McGrath

Program 12 – Managing for resilience in rainforests – Hill				
12.1	Indigenous co-management and biodiversity protection	Dr Ro Hill, CSIRO	Advice on the most effective approaches to collaborative governance, planning, and co-management of Indigenous Protected Areas	Girringun Aboriginal Corp - Phil Rist WTMA - Andrew Maclean JabalbinaYalanji Aboriginal Corporation - Michael Friday DNPRSR - Bruce Rampton DEHP – Lyn Wallace CWTICCAC - Joann Schmider DSEWPaC - Bruce Rose, Marcus Sandford, John Hunter, Fiona Fraser, Kate Thomann, Kirsty Attenburg, Kate Sanford-Readhead, MandingalbayYidinji - Dale Mundraby Terrain NRM - Carole Sweatman, Steve McDermott CYPSCAC - Nigel Stork
12.2	Harnessing natural regeneration for cost-effective rainforest restoration	Prof Carla Catterall Griffith/ Dr Luke Shoo UQ	A review and synthesis of approaches to managing and accelerating vegetation regrowth including a list of potential management interventions; DSS for passive versus active replanting strategies	WTMA - Steve Goosem, Deborah Pople, Bruce Jennison; Max Chappell Terrain NRM - Carole Sweatman, Steve McDermott, Rowena Grace, Penny Scott DERM - TBC FNQROC - Travis Sydes CVA - Dave Hudson DSEWPaC – David Calvert, Belinda Brown, Kate Sanford-Readhead

12.3	Relative social and economic values of residents and tourists in the WTWHA	Dr Natalie Stoeckl, JCU	A survey instrument for measuring the relative value of core attributes of the Wet Tropics region	WTMA - Andrew Maclean Terrain NRM - Rowena Grace Alliance for Sustainable Tourism - John Courtenay DNPRSR – Andrew Millerd, Scott Buchanen DEHP - Lyn Wallace TTNQ – Rob Giason FNQ Tour Operators Assoc. – Ross Maxted DSEWPaC – David Calvert, TBC, Tania Laity, Peter Latch
12.4	Governance, planning and the effective application of emerging ecosystem service markets: climate change adaptation and landscape resilience	Dr Allan Dale, JCU	Recommendations on the most appropriate regional governance systems and planning mechanisms to support adaptation to climate change in the Wet Tropics region	Terrain NRM - Carole Sweatman CYPNRM - Bob Frazer QRCC - Mike Berwick WTMA - Andrew Maclean DIP - Robyn Clark FNQROC - Darlene Irvine RDA FNQ&TS - Sonja Johnson DSEWPaC – Eleanor Sobey

Program 13 – Communications and Knowledge Brokering				
13.1	e-Atlas	Dr Eric Lawrey, AIMS	A linked website and mapping system containing a compilation of NERP GBR research outcomes, reference data.	GBRMPA – Fergus Molloy, Cherie Malone WTMA - Steve Goosem JCU – Alana Grech, Michelle Devlin AODN – Pauline Mak Reef Plan Secretariat - Chris Chinn Reef Rescue - Kevin Gale DEHP - John Bennett Terrain NRM - Fiona Barron NQ Dry Tropics - Ian Dight Reef Catchments NRM - Carl Mitchell Fitzroy Basin Association - Nathan Johnston DSEWPaC –Kate Sanford-Readhead, , Kevin Gale, Peter Wright, Jeanette Muirhead, John McDougall, AIMS Oceanography – Richard Brinkman AIMS Data Centre – Mark Rehbein CSIRO MAR – Mike Herzfeld TSRA –John Rainbird, Damien Miley, Melanie Smith AFMA – Annabelle Jones BOM – Jamie Treleaven, Frank Erjiang Fu Tagai College – Tim Hillier

Figure 2: Themes and Programs of the NERP Tropical Ecosystems Hub showing Program Leaders (institutional affiliation) and relative investment in each.

THEME 1	THEME 2	THEME 3
Assessing Ecosystem Condition and Trend	**Understanding Ecosystem Function and Cumulative Pressures**	**Managing for Resilient Tropical Systems**
Program 1 **Historical and current condition of the Great Barrier Reef** Professor John Pandolfi (UQ) 12%	**Program 4** **Water quality of the Great Barrier Reef and Torres Strait** Dr Britta Schaffelke (AIMS) 5%	**Program 8** **Effectiveness of spatial management on the GBR** Dr Hugh Sweatman (AIMS) 7%
Program 2 **Natural resources of the Torres Strait land and sea** Professor Helene Marsh (JCU) 10%	**Program 5** **Cumulative impacts on benthic biodiversity** Dr Katharina Fabricius (AIMS) 7%	**Program 9** **Decision support systems for GBR managers** Professor Bob Pressey (JCU) 10%
Program 3 **Condition and trends of north Queensland rainforests** Professor Steve Williams (JCU) 8%	**Program 6** **Movements and habitat use by marine apex predators** Dr Colin Simpfendorfer (JCU) 8%	**Program 10** **Socio-economic value of GBR goods and services** Dr Marcus Lane (CSIRO) 7%
	Program 7 **Threats to rainforest health** Dr Dan Metcalfe (CSIRO) 4%	**Program 11** **Resilient Torres Strait Communities** Dr James Butler (CSIRO) 3%
		Program 12 **Managing for resilience in rainforests** Dr Rosemary Hill (CSIRO) 5%
Total Investment 30%	**Total Investment** 24%	**Total Investment** 32%

Program 13
Knowledge Brokering and Communication
14%

1.7 Research relevance

This MYRP has been designed to address important research policy questions for the Great Barrier Reef, Torres Strait, and the Wet Tropics tropical rainforests of northern Queensland. The project selection has been guided by many sources of advice and a thorough process described below.

The formation of the science program was guided by eight Research Policy Questions specific to the Great Barrier Reef and Torres Strait that were selected by DSEWPaC (Box 1). The first five are consistent with the Great Barrier Reef Outlook Report (2009) and GBRMPA's Science Information Needs for the Management of the Great Barrier Reef Marine Park (2009-2014), which can be located on the GBRMPA website (www.gbrmpa.gov.au). As will be evident from the final project selection (Appendix A), the TE Hub has sought to address each of these questions.

Box 1: Research Policy Questions for the GBR and Torres Strait[2]

1. How can we best understand and manage the cumulative impacts of multiple pressures on the Great Barrier Reef ecosystem and the goods and services it provides?
2. What are the effects of existing management strategies on the Great Barrier Reef ecosystem?
3. What adaptation strategies, including improvements to current management and completely novel strategies, could be used to improve the Great Barrier Reef's resilience (particularly in the face of climate change)?
4. How can catchment and near shore management strategies (planning and decision making across all uses) in the Reef catchment be improved to better protect coastal ecosystems adjacent and connected to the Reef and to improve water quality, ecosystem health and ecosystem resilience of the Great Barrier Reef?
5. How can the fisheries of the Great Barrier Reef and adjacent areas be best managed to maximise ecosystem health, ecosystem resilience and ecosystem goods and services?
6. What are the current status and trends of the environmental assets of the Torres Strait?
7. How can the environmental, social, cultural and economic values of these Torres Strait assets be more efficiently and cost effectively monitored and reported to managers, industry and the public?
8. What information and tools are needed to build, maintain and monitor resilience to change – including climate change and development pressures - for the tropical environmental assets of the Torres Strait?

Some of the questions (e.g. 4 and 5) are of joint interest to both the Queensland and Australian Governments. For example, the Reef Plan is a decadal investment by the Australian and Queensland Governments to “halt and reverse the decline of water quality entering the Great Barrier Reef Lagoon”. The TE Hub was designed after extensive consultation with the Reef Plan Secretariat (Queensland Department of the Premier and Cabinet) to avoid duplication and to add value where appropriate (section 1.9). The water quality focus for NERP was on research at the marine component of the system, rather than the paddock or catchment component which is being addressed through other research funding initiatives including the Australian Government’s Reef Rescue R&D Program and the Queensland Government’s Reef Protection Program R&D component.

Fisheries issues were prioritised by strong input from DEEDI.

[2] http://www.environment.gov.au/about/programs/nerp/publications/pubs/gbrts-research-questions.pdf

The other geographic Nodes covered by the TE Hub also have regional management Authorities (Torres Strait Regional Authority, Wet Tropics Management Authority) responsible for environmental stewardship.

In addition to the guidance provided by NERP (Box 1), the research program for the Torres Strait Node was formed by direct input into the process by multiple staff from the Land and Sea Management Unit of the TSRA together with advice from an elected representative and a traditional elder. The program was also informed by a gap analysis of Torres Strait research needs undertaken as a MTSRF transition project. The LSMU staff referenced multiple planning documents including:

- *Torres Strait and Northern Peninsula Area Regional Plan 2009 to 2029*
- *Torres Strait Development Plan 2010 –2013 (TSRA)*
- *Land and Sea Management Strategy for Torres Strait (2005)*
- *Torres Strait Climate Change Strategy 2010-2013*
- *Sustainable Land Use Plans (all inhabited islands)*

Additional consultation was provided by a representative of AFMA and the Australian Government to ensure a good fit with research priorities identified by the AFMA Torres Strait Scientific Advisory Committee and the Protected Zone Joint Authority.

The selection of the most relevant projects for the Rainforest Node was guided by two sources of advice: a gap analysis of rainforest research needs done as a MTSRF transition project and the published research priorities of WTMA[3]. Both of these documents were based on extensive consultation with regional stakeholders (NRM, conservation, tourism) but the latter were also invited to contribute directly to the NERP process.

The detailed research programs for the NERP TE Hub were developed by parallel but independent processes for each Node in recognition of the separate stakeholder interests in each geographic region. The generic process was the formation of a working group representing researchers, managers, and other stakeholders approved by DSEWPaC. In the case of the GBR Node, more than 20 members were empanelled and up to 30 (including observers) attended meetings. Each working group met twice between April and June 2011 to evaluate, refine, and rank potential projects based on four criteria (quality, relevance, capability, and value for money). Final project selection to produce the Hub program was undertaken by the TE Hub Steering Committee, appointed by the DSEWPaC Minister, which includes the Chairs of the three Node working Groups.

[3] http://www.wettropics.gov.au/res/downloads/WTMAResearchStrategy2010-14.pdf

1.8 Partners/Collaborative Organisations

The core research providers in the NERP TE Hub are:

- Australian Institute of Marine Science (AIMS);
- Commonwealth Scientific and Industrial Research Organisation (CSIRO);
- James Cook University (JCU); and
- University of Queensland (UQ).

Other research providers will make significant contributions to selected projects, notably the Australian National University and Griffith University.

NERP TE funding and partner contributions are presented in Table 2. The research providers will contribute resources in excess of the NERP contribution and therefore must be considered as stakeholders with strong interest in the science program and its outcomes.

Table 2: Budget summary for the NERP TE Hub.

Hub Activity (ex GST)		2010-11	2011-12	2012-13	2013-14	2014-15	Total program budget
Research Projects	NERP	3,800,000	5,232,162	5,716,176	5,591,457	2,383,043	22,722,838
	CO-CONTRIBUTIONS	0	10,164,992	9,771,885	9,868,817	3,843,076	33,648,770
	TOTAL	**3,800,000**	**15,397,154**	**15,488,061**	**15,460,274**	**6,226,119**	**56,371,608**
Knowledge Brokering and Communication	NERP#	0	767,838	783,824	908,543	616,957	3,077,162
	CO-CONTRIBUTIONS	0	456,949	556,595	501,555	326,510	1,841,609
	TOTAL#	**0**	**1,224,787**	**1,340,419**	**1,410,098**	**943,467**	**4,918,771**
Administration*	Contracted*	661,819	649,091	636,364	661,182	70,000	2,678,456
	TOTAL	**661,819**	**649,091**	**636,364**	**661,182**	**70,000**	**2,678,456**
Total Funding (exc. GST)	*NERP Contracted Admin*	661,819	649,091	636,364	661,182	70,000	2,678,456
	NERP Hub	3,800,000	6,000,000	6,500,000	6,500,000	3,000,000	25,800,000
	NERP Total	**4,461,819**	**6,649,091**	**7,136,364**	**7,161,182**	**3,070,000**	**28,478,456**
	CO-CONTRIBUTIONS	0	10,621,941	10,328,480	10,370,372	4,169,586	35,490,379
	TOTAL	**4,461,819**	**17,271,032**	**17,464,844**	**17,531,554**	**7,239,586**	**63,968,835**

*Contracted Administration costs are additional to research costs and paid by separate contract to RRRC Ltd.
An additional $68,190 for communications (web site design) was paid from NERP in 2010-11.

Governments as knowledge brokers and end-users

The primary end-user for outputs and products from the Hub will be the Minister and DSEWPaC (multiple branches), management agencies such as GBRMPA and TSRA, and Commonwealth programs like Reef Rescue. The Queensland Government will be both research provider (DEEDI, DERM) and another key end-user through ReefPlan and WTMA. Sixteen Local Governments in northern Queensland also stand to benefit from incorporating Hub information into their planning processes. In other roles, Government agencies will contribute significantly to knowledge brokering and communications functions, potentially adding additional in kind resources to this component of the program (to be clarified in the Science Communication Plan).

Industry

Industries such as tourism, agriculture, fishing, ports and shipping, mining, and urban development are significant users of north Queensland's natural assets. Their individual approach to on-ground environmental management is a significant driver of ecosystem and biodiversity conservation in the region. To achieve the outcomes desired by the NERP TE Hub, it is essential that these industries are engaged and see value in the research program.

Indigenous partners

The NERP TE Hub, through historical antecedents, has history of formal and informal engagement with traditional owners in northern Queensland including the Torres Strait. The latter has solid structures for governance and external engagement. The Hub will plan, prosecute, and deliver its results for the Torres Strait in close consultation with the TSRA and traditional owners. In the context of the Wet Tropics and Great Barrier Reef, engagement with Traditional Owners will be guided by the *Guidelines for Ethical Research in Indigenous Studies* published by the Australian Institute for Aboriginal and Torres Strait Islander Studies. In the Wet Tropics, researchers and collaborators will be expected to adhere to the research protocol included in the *Wet Tropics Regional Agreement*[4] having regard to the nature of the research project. Further detail on engagement with Indigenous communities will be included in the Science Communication Plan. Specific proposed actions for engagement for each project will be included in the Indigenous Engagement Strategy and Implementation Plan 2013-2014 (IES&IP). The IES&IP will be endorsed in early 2013.

Regional NRM organisations

As a result of the MTSRF program, the NERP TE Hub has established working arrangements with Northern Gulf Catchments, Torres Strait Land and Sea Management Unit, Terrain NRM Ltd, Cape York Sustainable Futures, Cape York Peninsula NRM group, Dry Tropics NRM Ltd, Reef Catchments NRM Ltd, and Fitzroy Basin NRM Ltd.

NGOs

As with the other groups above, the NERP TE Hub will start with established working relationships with conservation NGOs, particularly WWF, PEW Trust and local groups (e.g. CAFNEC).

Regional Development Associations

Regional Development Associations and economic development organisations have an important role to play in framing future sustainable development for the region. The Hub will promote its research to these groups as appropriate.

The NERP TE researchers will undertake research with a large number of different communities in northern Queensland, including those in the Torres Strait, and the same high standards of ethics, attribution and acknowledgement will apply across the board.

1.9 Links to other research programs

The research programs for the three Nodes of the TE Hub (GBR, Torres Strait, and Wet Tropics rainforest) were developed through separate working group processes, each chaired

[4] http://www.wettropics.gov.au/rah/rah_pdf/regional_agreement.pdf

by a senior representative of an operational agency responsible for delivering community and environmental outcomes in Queensland (GBRMPA, TSRA, and WTMA). In addition, the working groups included representatives from the Queensland Government, NRM groups, conservation groups, and regional industries such as agriculture, grazing, fishing, and tourism. This presence of diverse stakeholders on the various working groups has provided knowledge about need, created awareness of other investments in the region, and identified the best ‘value adding activities’.

The Hub has been careful not to duplicate any part of the large investment ($375 million) by the Australian and Queensland Governments "to halt and reverse the decline of water quality entering the Great Barrier Reef" through the decadal program known as Reef Plan. This has involved multiple consultations with the DSEWPaC team responsible for Reef Rescue and the Reef Plan Secretariat in the Queensland Department of the Premier and Cabinet. This knowledge exchange has been facilitated by the separate appointments of Dr Peter Doherty to the Independent Science Panel advising Reef Plan and more recently to the position of TE Hub Science Leader. Co-ordination between the NERP TE Hub and the Australian Government’s Reef Rescue R&D investment ($9m) will also be facilitated by sharing the same Administrator (RRRC). For example the TE Hub will collect data from the coastal receiving environment of the GBR (chemical half-lives, impacts of chronic low-level exposure to pesticide breakdown products) that will complement the Australian Government's investment of $1.6m through Reef Rescue into pesticide management in the catchments.

The Hub will add value to the investment by the Australian and Queensland Governments of more than $13 million in infrastructure for ocean observations to link changes in the Coral Sea with the health of coastal marine ecosystems (part of the $102 million invested by the Australian Government in a national Integrated Marine Observing System (IMOS)). The latter will provide the context to Hub projects like understanding the impact of weather, including extreme events, upon the movement and foraging success of apex predators.

The Hub will complement recent investments in research infrastructure in Queensland made by the Australian Research Council (ARC). The best example is a $2m upgrade of a Quaternary Dating Laboratory at the University of Queensland that has increased the throughput of stable isotope analyses ten-fold. This technology improvement will allow a Hub project seeking to understand when inshore coral reefs in sections of the GBR were affected by deteriorating water quality based on accurate dating of old coral debris.

The Hub will support research predicting future states of northern Queensland ecosystems and exploited living resources that is of interest to the National Climate Change Adaptation Research Facility (NCCARF) based at Griffith University but will not duplicate any of its projects.

As appropriate, the TE Hub will build functional links with other NERP Hubs (Environmental Decisions; Landscapes and Policy; Marine Biodiversity; and Northern Australia). All five Hubs have agreed that this is a mutual obligation, although the geographic separation of the different Hubs' activities across the vast Australian terrestrial and marine jurisdictions means that the strongest shared interest is how to connect NERP research outputs with public policy and environmental decision-making by operational agencies. Not surprisingly, the greatest overlap is with the NERP Hub for Northern Australia, through the following projects:

- Catchment to coast planning;
- Carbon markets;
- Indigenous NRM and livelihoods;
- Freshwater habitats; and
- Partnerships to support biodiversity monitoring by Indigenous rangers

At least one of these (Carbon markets) is shared with a third Hub (Environmental Decisions) and clearly justifies careful cross-reference (possibly a small working group). In all other cases, however, the context is sufficiently different that the main need is to exchange learning among Hubs.

The main opportunity for NERP Hubs to learn from each other is about successful ways to communicate the results of their research to a diverse stakeholder base unified by desire for ecologically sustainable development and the maintenance of resilient ecosystems.

1.10 Communication, knowledge brokering, synthesis and analysis

The NERP TE Hub has reserved 14% of new funds for this critical purpose. Expenditure on specific activities will be resolved by wide consultation with diverse stakeholders, including the research providers and the regional management agencies (GBRMPA, TSRA, WTMA). The latter have well-established, statutory roles relevant to knowledge brokering and communication for their areas of responsibility and have developed relevant capacity in relation to these roles. The Hub Science Leader, Program Leaders, and Hub Administrator also have defined roles in these areas under the terms of the NERP TE contract. The roles, responsibilities, and resources for all are detailed in the Hub Science Communication Plan (available at www.nerptropical.edu.au).

1.11 Measuring Success

As above, the strategy and work plan to monitor and evaluate the return on investment in the NERP TE Hub has been developed with all stakeholders and is detailed in the Hub Monitoring and Evaluation Plan (available at www.nerptropical.edu.au).

2.0 Research Themes

Detailed information about each theme in the Hub over the life of the program is provided in each of the Hub's Annual Work Plans. The Annual Work Plans describe expected outcomes, outputs (including services and products), performance indicators, timelines and links to end-user requirements. Details on project outputs are contained in Section 3.2 and in the project schedules in each Annual Work Plan.

2.1 Theme 1 – Assessing Ecosystem Condition and Trend

A clear understanding of the ecological condition and trends of environmental assets of the Great Barrier Reef, the Torres Strait, and the Wet Tropics rainforest is fundamental to ecologically sustainable use of those assets by industry and communities, supported by appropriate management and policy settings. Theme 1 is comprised of three inter-related Programs, each of which concentrates on a specific component of north Queensland's natural and cultural heritage, and delivers reports on the condition and trend of key ecosystems and natural living resources.

2.1.1 Theme Activities

Program 1 (**Historical and current condition of the Great Barrier Reef**) has three projects assessing the condition and trend of Great Barrier Reef assets. Two of these concern temporal changes in coral communities: one over timescales of the last 100-200 years and one based on current monitoring of approximately 100 coral reefs representative of the whole system. The latter provides a synoptic view of coral cover and continues a time series that started in 1986. Over 20 years, these surveys have shown that the two main sources of coral mortality are predation by crown of thorns starfish and physical damage by severe tropical cyclones. The surveys have also captured the dynamics of recovery and shown the importance of connectivity to upstream spawning sources. The historical project will use modern radioactive dating methods to search for temporal shifts in abundance and/or community composition among coral death assemblages. Broad-scale directional change will be taken as evidence for changing environmental conditions and may be able to date the recent decline in water quality in some inshore sections of the GBR. The third project will continue to monitor the distribution, abundance, and ecology of iconic marine species of high conservation concern, notably dugongs, marine turtles, and coastal dolphins. This information directly supports the management of these vulnerable species and is critical to the issue of Indigenous use.

Program 2 (**Natural resources of the Torres Strait land and sea)** has three projects assessing the condition and trend of Torres Strait assets. One will provide information on marine turtles and dugongs that complements the study of these species on the GBR including data on movements and connectivity of populations. Aerial surveys will be conducted to estimate abundance as the importance of healthy stocks to Torres Strait communities cannot be overestimated. A second project will make baseline surveys of mangrove communities and freshwater habitats on Torres Strait islands. The former is important in shoreline stabilisation and as a littoral habitat. The latter provide potential stepping stones for invasive freshwater species from Australia's northern neighbours and represents a long term threat to the freshwater fauna of Cape York and elsewhere in northern Australia. The third project will design and implement a reef health monitoring program that will be delivered by Indigenous sea rangers and initiate monitoring of sea temperatures through a combination of remote sensing and real-time monitoring. The latter has been requested by the TSRA following the first account of widespread coral bleaching in the Torres Strait in 2010.

Program 3 (**Condition and trends of North Queensland rainforests**) has four projects focussed on biodiversity drivers of Queensland's Wet Tropics rainforests, particularly rainforest refugia and hot spots of genetic diversity in the World Heritage Area and adjacent Cape York regions. The Program will deliver species distribution models and composite biodiversity maps using long term data sets to describe patterns of environmental change. The Program will also search for remnant populations of critically endangered frogs and monitor the abundance of key vertebrate species such as the cassowary and the spectacled flying fox. Results from Program 3 will contribute to State of Environment and World Heritage reporting for the Wet Tropics World Heritage Area, and provide information to assist the development assessments under the *EPBC Act 1999*.

2.2 Theme 2 – Understanding Ecosystem Function and Cumulative Pressures

Theme 2 builds on research undertaken through the MTSRF and other programs that have identified many of the primary risks and threats to the environmental assets of Northern Queensland. These pressures do not occur in isolation to each other and it is clear that a greater understanding of the cumulative and synergistic impact of these pressures is required for improved management. These pressures are not static therefore predicting and preparing for change is a significant challenge for environmental decisions makers charged with stewardship of Queensland's natural environment. Changing climates, extreme natural events, changes in natural resource use and population growth are some of the pressures facing these ecosystems. Theme 2 is comprised of four Programs that will increase the understanding of ecosystem function and the impact of synergistic and cumulative pressures on the system. This understanding is essential in developing effective management responses that promote ecosystem resilience.

2.2.1 Theme Activities

Program 4 (**Water quality of the Great Barrier Reef and Torres Strait**) has three projects assessing risks to biodiversity from current water quality in the inshore Great Barrier Reef and a desktop hazard study for water quality outlook in the Torres Strait. The latter will concern flood plumes from the Fly River, one of Papua New Guinea's largest rivers, which regularly reach the eastern margins of the Torres Strait, Significant expansion of mining activity is forecast in PNG's western province which may result in new threats to the water quality of the region but the hazard assessment will also concern local declines in water quality near home islands affected by erosion and run-off. The GBR projects will focus on two components of terrestrial run-off discharged into coastal receiving waters. One project will measure the transport and settlement of fine sediments carried by river plumes and subsequently resuspended by winds. The new knowledge sought is the impact of these processes on light availability to benthic communities. A second project will establish the half-lives of common agricultural chemicals in the marine environment and study the impacts on biodiversity of chronic low-level exposure to these pollutants. This information will contribute to the Reef Water Quality Protection Plan (Reef Plan) and was designed in consultation with the Reef Rescue Program. The final project will be a methodological pilot study recommending how to conduct a formal risk analysis of the threats from multiple stressors in water quality that would be used to prioritise future investment decisions in the catchments (i.e. what is the relative risk from sediments, excess nutrients, and contaminants?).

Program 5 (**Cumulative impacts on benthic biodiversity**) has three projects designed to assess the impacts of cumulative pressures on coastal biodiversity in the GBR. One will be a synthesis and analysis of spatial and temporal patterns of inshore biodiversity seeking to partition the influence of different environmental drivers (water quality, crown of thorns starfish, cyclones, and connectivity) and identify synergistic interactions between stressors. The other two will be multi-factorial experiments exposing corals and seagrasses to different combinations of stressors in order to incorporate cumulative hazards into quantitative risk models.

Program 6 (**Movements and habitat use by marine apex predators**) has three projects designed to monitor the movements of apex predators in the GBRMP using widespread arrays of acoustic receivers installed and maintained by other funding programs (e.g. IMOS, ARC). One project will focus on the movement and habitat use of large predatory fishes (e.g. sharks and coral trout) in reef environments. New knowledge about the scale of daily and seasonal movements will establish a minimum viable size for no-take areas to offer effective protection to these mobile animals. A second project will focus on the movement and habitat use of coastal fish populations, with an emphasis on inshore shark populations. The latter are under considerable pressure from commercial netting and the study will seek to identify critical habitats (e.g. juvenile shark nurseries) that may require higher levels of protection to ensure sustainable populations. The third project will map the movements and habitat use of pelagic environments by foraging seabirds seeking an oceanographic explanation for the decline in seabird numbers observed in many breeding colonies.

Program 7 (**Threats to rainforest health**) has three projects addressing different threats to rainforest health. A generalised analytical toolkit for assessing vulnerability to extreme climatic events, particularly the sensitivity of Wet Tropics fauna to temperature extremes, will be developed. The role of fire as a driver of rainforest distribution (particularly on the threatened ecosystem of the Mabi forest) will be determined. The Program will also deliver maps of weed populations identifying sources of invasive propagules and rainforest areas that are particularly susceptible to invasion or re-invasion because of their connectivity to these source populations. This information is critical for invasive weed control programs, identifying high priority areas for control, and guiding surveillance. The Program will also provide a qualitative and operational assessment of alternative management strategies for feral pig management.

2.3 Theme 3 – Managing for Resilient Tropical Systems

Research undertaken within Theme 3 will provide knowledge and options to assist key decision makers in government, industry and the community in managing the complex ecosystems of the Great Barrier Reef, the Wet Tropics rainforest (including the World Heritage Area) and the Torres Strait. Theme 3 draws on the assessment of ecological condition and trends undertaken in Theme 1 and the improved understanding of ecosystem function and cumulative pressures from Theme 2. Theme 3 will provide tools and information for evidence-based decision making that address the pressures and sustains resilient ecological, social and economic systems.

2.3.1 Theme Activities

Program 8 (**Effectiveness of spatial management on the GBR**) has three inter-linked projects that will test the effectiveness of spatial management arrangements (differential use zones) for conserving exploited fish populations in the GBRMP. One project will compare the abundance of fish, corals, and the incidence of coral disease between fringing reefs in the coastal zone that have been closed to fishing at different times in the past with adjacent areas that remain in use by the recreational fishing sector. A second project in the southern GBR will apply genetic parentage analysis to estimate the recruitment subsidies to fished areas that are contributed by protected fish stocks spawning in no-take areas. The third project was started with the major rezoning of the GBR in 2004 and will track a suite a biodiversity indicators across 26 closely matched pairs of reefs offering fished/unfished contrasts. Since these 52 reefs are spread through the mid-shelf from Cairns to Gladstone, this new design covers the area with the highest incidence of crown-of-thorns starfish outbreaks. The strong experimental design will be the best chance yet to determine whether fishing has any impact on the frequency and/or severity of starfish outbreaks. If there is a positive association this will be further evidence that the starfish and its huge effect on coral cover may be unnatural and require further management intervention to restore the resilience of coral populations.

Program 9 (**Decision support systems for GBR managers**) has four projects designed to develop new tools for GBR managers. One project will develop methodology to allow managers to evaluate alternative management scenarios and choose between options. It will focus on tools to assist in the management of the inshore region for biodiversity outcomes, particularly inshore multi-species fisheries management, using a stakeholder driven approach. A second project will create vulnerability maps for coral reef communities and allow managers to prioritise the conservation of subregions with high natural resilience to coral bleaching from extreme sea temperatures. A third project will create a modelling framework suitable for exploring alternative futures for the coastal zone considering climate change, changes in land use and infrastructure, and the effects of land uses on water quality in the Great Barrier Reef lagoon. The fourth project will develop a framework and tools to allow managers to prioritise investment decisions for the day to day management of GBR islands. In addition, drivers of visitor (tourism) usage, particularly relating to reef health and economic and social impacts of reef-related tourism to northern Queensland will be assessed.

Program 10 (**Socio-economic value of GBR goods and services**) has two projects designed to capture social and economic information from GBR industries and coastal communities. One will be the start of a long-term compilation and tracking of essential socio-economic indicators to detect spatial and temporal trends in human uses of the region and to monitor variations in economic activity. Both will be useful in forecasting trends and providing the human dimension to scenario planning by coastal managers. The design of the database will be determined by close consultation with managers and other end-users including all levels of government. The second project will explore the social and economic valuation of environment assets in the GBRMP from the point of view of the ecosystems ability to supply sustainable ecological goods and services.

Program 11 (**Resilient Torres Strait Communities**) has a single large project designed to assist key decision makers in the Torres Strait community to build a resilient future based on sustainable environmental use. The program will deliver information on the value of ecosystem services underpinning Torres Strait livelihoods within the cultural frame of the region. The program will deliver information on resource sharing with Treaty Villages in the Western Province of PNG and improved methodologies to support emerging sustainable industries in the region. A mechanism to repatriate knowledge in culturally appropriate ways will continue to be developed and used to raise awareness of environmental issues and build community resilience in Torres Strait. The Program has a second smaller project that works with existing biosecurity arrangements to enhance the methodologies for detection and prevention of wildlife disease incursions.

Program 12 (Managing for resilience in rainforests) has four projects designed to assist environmental managers, industry, Indigenous, and community groups to manage the Wet Tropics bioregion. This is a complex and often highly contested landscape with many competing interests. The four projects will determine the most effective approaches to collaborative governance, planning and co-management of biodiversity within Indigenous Protected Areas; the most appropriate ways to develop a carbon market within the Wet Tropics region; the best approaches to managing and accelerating revegetation including potential management interventions particularly in the rainforest uplands; and the social and economic value of environmental icons of the Wet Tropics rainforest and their contribution to northern Queensland.

3.0 Research Projects

Table 3 lists the projects that were recommended by the Hub Steering Committee for funding within the constraints of the overall NERP TE Hub budget. These projects were selected for their relevance to various research policy questions and/or the research priorities of major end-users in each of the Nodes and for their capacity to deliver outcomes that contribute to better management and policy development for Australia's tropical ecosystems.

3.1 Project Activities

Table 3: Research projects recommended by the Steering Committee of the NERP TE Hub.

Project		Project Leader	NERP Funding	Co-contributions (In-kind)	Co-contributions (cash)	Total Co-contributions	Total Value (GST excl.)
NERP Tropical Ecosystems Hub			18,922,838	32,291,418	1,162,422	33,453,840	**52,376,678**
Theme 1			6,492,999	10,498,393	165,000	10,663,393	**17,156,392**
Program 1 - Historical and current condition of the Great Barrier Reef (Pandolfi)			2,624,999	4,188,521	0	4,188,521	**6,813,520**
1.1	Monitoring status and trends of coral reefs of the GBR	Dr Hugh Sweatman, AIMS	725,000	1,136,889	0	1,136,889	**1,861,889**
1.2	Marine wildlife management in the GBRWHA	Dr. Mark Hamann and Prof Helene Marsh , JCU	750,000	880,800	0	880,800	**1,630,800**
1.3	Characterising the cumulative impacts of global, regional and local stressors on the present and past biodiversity of the GBR	Dr Jian Zhao and Dr John Pandolfi, UQ	1,149,999	2,170,832	0	2,170,832	**3,320,831**
Program 2 - Natural Resources of the Torres Strait land and sea (Marsh)			2,113,000	2,832,888	0	2,832,888	**4,945,888**
2.1	Marine Turtles and Dugong of Torres Strait	Dr Mark Hamann and Prof Helene Marsh, JCU	750,000	1,002,697	0	1,002,697	**1,752,697**
2.2	Mangrove and Freshwater Habitat Status of Torres Strait Islands	Dr Norm Duke and Dr Damien Burrows, JCU	500,000	579,547	0	579,547	**1,079,547**
2.3	Monitoring the health of Torres Strait coral reefs	Dr Ray Berkelmans, AIMS	863,000	1,250,644	0	1,250,644	**2,113,644**

Project		Project Leader	NERP Funding	Co-contributions (In-kind)	Co-contributions (cash)	Total Co-contributions	Total Value (GST excl.)
Program 3 - Condition and trends of north Queensland rainforests (Williams)			1,755,000	3,476,984	165,000	3,641,984	**5,396,984**
3.1	Rainforest Biodiversity	Prof Steve Williams, JCU	1,035,000	2,094,170	150,000	2,244,170	**3,279,170**
3.2	Rainforest refugia and hotspots of plant genetic diversity in the Wet Tropics and Cape York Peninsular	Prof Darren Crayn, JCU	320,000	703,094	15,000	718,094	**1,038,094**
3.3	Targeted surveys for missing and critically endangered rainforest frogs in ecotonal areas, and assessment of whether populations are recovering from disease	Dr Robert Puschendorf and Dr Conrad Hoskin, JCU	90,000	384,720	0	384,720	**474,720**
3.4	Monitoring of Key Vertebrate Species	Dr David Westcott, CSIRO	310,000	295,000	0	295,000	**605,000**
Theme 2			5,333,626	8,626,873	436,682	9,063,555	**14,397,181**
Program 4 - Water quality of the Great Barrier Reef and Torres Strait (Schaffelke)			1,087,175	1,193,870	0	1,193,870	**2,281,045**
4.1	Tracking coastal turbidity over time and demonstrating the effects of river discharge events on regional turbidity	Dr Katharina Fabricius, AIMS	299,925	344,928	0	344,928	**644,853**
4.2	The chronic effects of pesticides and their persistence in tropical waters	Dr Andrew Negri, AIMS	647,250	741,842	0	741,842	**1,389,092**

Project		Project Leader	NERP Funding	Co-contributions (In-kind)	Co-contributions (cash)	Total Co-contributions	Total Value (GST excl.)
4.3	Ecological risk assessment for water quality of the GBR	John Brodie, JCU	60,000	60,000	0	60,000	**120,000**
4.4	Hazard assessment for water quality threats to Torres Strait marine waters, ecosystems and public health	Jon Brodie, JCU	80,000	47,100	0	47,100	**127,100**
Program 5 - Cumulative impacts on benthic biodiversity (Fabricius)			1,445,926	1,788,918	0	1,788,918	**3,234,844**
5.1	Understanding GBR diversity: spatial and temporal dynamics and environmental drivers	Dr Glen De'ath, AIMS	383,904	459,653	0	459,653	**843,557**
5.2	Combined water quality-climate effects on coral and other reef organisms	Dr Sven Uthicke, AIMS	762,022	765,695	0	765,695	**1,527,717**
5.3	Vulnerability of seagrass habitats in the GBR to changing coastal environments	Dr Catherine Collier, JCU	300,000	563,570	0	563,570	**863,570**
Program 6 – Movements and habitat use by marine apex predators (Simpfendorfer)			1,855,525	4,094,289	389,000	4,483,289	**6,338,814**
6.1	Maximising the benefits of mobile predators to GBR ecosystems: the importance of movement, habitat and environment	Dr Michelle Heupel, AIMS	875,000	1,447,355	25,000	1,472,355	**2,347,355**
6.2	Drivers of juvenile shark biodiversity and abundance in inshore ecosystems of the GBR	Dr Colin Simpfendorfer, JCU	735,000	1,788,596	364,000	2,152,596	**2,887,596**

Project		Project Leader	NERP Funding	Co-contributions (In-kind)	Co-contributions (cash)	Total Co-contributions	Total Value (GST excl.)
6.3	Critical seabird foraging locations and trophic relationships for the GBR	Dr Brad Congdon, JCU	245,525	858,338	0	858,338	**1,103,863**
Program 7 - Threats to rainforest health (Metcalfe)			945,000	1,549,796	47,682	1,597,478	**2,542,478**
7.1	Fire & rainforests	Dr Dan Metcalfe, CSIRO	350,000	393,675	47,682	441,357	**791,357**
7.2	Invasive species risks and responses in the Wet Tropics	Dr Helen Murphy, CSIRO	415,000	415,000	0	415,000	**830,000**
7.3	Climate change and the impacts of extreme events on Australia's Wet Tropics biodiversity	Dr Justin Welbergen, ANU	180,000	741,121	0	741,121	**921,121**
Theme 3			7,096,213	13,166,152	562,140	13,728,292	**20,824,505**
Program 8 – Effectiveness of spatial management on the GBR (Sweatman)			1,595,000	4,230,366	0	4,230,366	**5,825,366**
8.1	Monitoring the ecological effects of GBR zoning plan on mid and outer shelf reefs	Dr Hugh Sweatman, AIMS	725,000	1,481,254	0	1,481,254	**2,206,254**
8.2	Assessing the long-term effects of management zoning on inshore reef of the GBR	Prof Garry Russ, JCU	520,000	339,500	0	339,500	**859,500**
8.3	Significance of no-take marine protected areas to regional recruitment and population persistence on the GBR	Prof Geoff Jones, JCU	350,000	2,409,612	0	2,409,612	**2,759,612**

Project		Project Leader	NERP Funding	Co-contributions (In-kind)	Co-contributions (cash)	Total Co-contributions	Total Value (GST excl.)
Program 9 – Decision support systems for GBR managers (Pressey)			2,236,441	5,069,175	140,340	5,209,515	**7,445,956**
9.1	Dynamic Vulnerability Maps and Decision Support Tools for the Great Barrier Reef	Dr Ken Anthony, AIMS	580,000	820,056	0	820,056	**1,400,056**
9.2	Design and implementation of management strategy evaluation for the GBR	Dr Cathy Dichmont, CSIRO	925,000	1,404,626	0	1,404,626	**2,329,626**
9.3	Prioritising management actions for GBR islands	Prof Bob Pressey, JCU	200,000	1,432,633	119,840	1,552,473	**1,752,473**
9.4	Conservation planning for a changing coastal zone	Prof Bob Pressey, JCU	531,441	1,411,860	20,500	1,432,360	**1,963,801**
Program 10 - Socio-economic values and future options (Lane)			1,600,000	1,451,100	105,000	1,556,100	**3,156,100**
10.1	Social and economic long-term monitoring program (SELTMP)	Dr Nadine Marshall, CSIRO	800,000	873,500	105,000	978,500	**1,778,500**
10.2	Socio-economic system and reef resilience	Dr Natalie Stoeckl, JCU	800,000	577,600	0	577,600	**1,377,600**
Program 11 - Torres Strait communities (Butler)			672,772	898,338	196,000	1,094,338	**1,767,110**
11.1	Building resilient communities for Torres Strait futures	Dr James Butler, CSIRO	662,772	778,338	0	778,338	**1,441,110**
11.2	Improved approaches for the detection and prevention of wildlife diseases in the Torres Strait.	Dr Sue Laurance	10,000	120,000	196,000	316,000	**326,000**

Project		Project Leader	NERP Funding	Co-contributions (In-kind)	Co-contributions (cash)	Total Co-contributions	Total Value (GST excl.)
Program 12 - Managing for resilient rainforests (Hill)			992,000	1,517,173	120,800	1,637,973	**2,629,973**
12.1	Indigenous co-management and biodiversity protection	Dr Ro Hill, CSIRO	345,000	366,767	0	366,767	**711,767**
12.2	Harnessing natural regeneration for cost-effective rainforest restoration	Prof Carla Catterall, Griffith/ Dr Luke Shoo, UQ	342,000	891,106	120,800	1,011,906	**1,353,906**
12.3	Relative social and economic values of residents and tourists in the WTWHA	Dr Natalie Stoeckl, JCU	185,000	139,300	0	139,300	**324,300**
12.4	Governance, planning and the effective application of emerging ecosystem service markets: climate change adaptation and landscape resilience	Dr Allan Dale, JCU	120,000	120,000	0	120,000	**240,000**

3.2 Outputs from the NERP TE Hub

Theme 1: Assessing Ecosystem Condition and Trend

Outputs will include reports on the following topics.

Program 1: Historical and current condition of the Great Barrier Reef

- The status of coral reef communities of the GBR including damage assessments from three major cyclones (Larry, Hamish, Yasi) as a basis for estimating rates of recovery and resilience of reefs in different regions. Situational awareness for industry and managers on phenomena such as crown of thorn densities and coral disease.
- Status of inshore dolphins in the northern GBRWHA and dugong abundance within the GBRWHA. Report on current understanding of ecological and biological connectivity, understanding of food web interrelationships, ecological role and habitat use of dugongs and marine turtles in relation to protected areas and TUMRAs and areas impacted by severe weather events.
- Dating and chemical analysis of coral records to reveal the historical responses of coral communities to acute (e.g. cyclones) and chronic (e.g. water quality) disturbances. This information will be used to test the hypothesis that changes in the quality of terrestrial runoff from modified catchments were followed by major shifts in the condition of inshore coral communities.

Program 2: Natural resources of the Torres Strait land and sea

- The ecological and biological connectivity and habitat use of dugongs and marine turtles in relation to protected areas and community based management areas (tracking and genetics); and critical threatened species data on the abundance of turtles and dugongs within the Dugong Protected Area in western Torres Strait.
- An extensive baseline data list on mangrove condition, diversity and community structure, freshwater habitats, fish, (both native and exotic) and aquatic plants against which future changes can be assessed. This will include a renewable and expanding archive of geo-referenced maps and imagery, with assessments of past and current condition of coastal and estuarine habitats.
- An early warning system for coral bleaching based on the best-available knowledge of bleaching thresholds and a real-time environmental observing system for key parameters, including temperature and light. A long-term monitoring program for Torres Strait coral reefs delivered by Indigenous sea rangers.

Program 3: Condition and trends of north Queensland rainforests

- Maps of past, current and future status and trends in biodiversity and the environment, including downscaling of regional climate projections for a number of bioclimatic variables; projected changes and uncertainty estimates for species distribution models and composite biodiversity maps; and identification of key locations and species in long term data sets which may show patterns of environmental change.

- Spatial and temporal prioritisation of the conservation status of most rainforest vertebrates, significant invertebrate groups, vegetation classes and ecosystem processes.
- Assessment of genetic diversity of mountain-top floras and/or other postulated refugia to enable effective prioritisation of conservation efforts. This will include identification of populations that are potentially more resilient to climate change; and an updated assessment of conservation priorities for the Wet Tropics Bioregion as inferred from genetic data.
- Surveys of ecotonal habitats to see whether they provide refugia for frog species presumed to be extinct in their primary habitats due to fungal infection. Characterisation of the skin microbiota of lowland and upland frogs, emphasizing species that have re-invaded upland areas after local population declines to determine whether they are less vulnerable to chytridiomycosis.
- Estimates of cassowary population size, distribution and structure across the Wet Tropics Region based on faecal-DNA sampling. This will include estimates of cassowary population size for sub-regions and local areas and descriptions of patterns of relatedness between cassowary populations in sub-regions
- The size and distribution of spectacled flying-fox populations across the year and the long-term trends in these dynamics at local and regional scales (including an examination of the potential factors determining these dynamics and their likely consequences for biodiversity and flying-fox management).

Theme 2: Understanding Ecosystem Function and Cumulative Pressures

Outputs will include reports on the following topics.

Program 4: Water quality of the Great Barrier Reef and Torres Strait

- Region-specific quantitative relationships between terrestrial runoff, water clarity and environmental drivers including quantification of where and by how much the relationship between turbidity, waves and tidal currents changes throughout wetter and drier years as a function of location (in relation to river mouths), time (in relation to time since last flood plume, accounting for river flow rate and suspended solids loads), and hydrodynamics (tidal currents).
- The transport and fate of herbicides in the GBR including identification of the half lives of herbicides (including diuron, atrazine, hexazinone and tebuthiuron) at multiple temperatures relevant to those in flood plumes, understanding of pesticide transport (sediment bound or dissolved) and how this effects toxicity, and quantification of the contribution of herbicide breakdown products to potential toxicity.
- Advice on whether chronic herbicide exposures may influence critical coral reef processes such as coral recruitment and seagrasses, and evaluation of whether managing herbicide exposures will protect seagrasses and corals under conditions expected in changing climate (e.g. thermal stress).
- Development of a risk based framework for guiding future interventions to minimise the impact of particulate and dissolved contaminants on GBR coastal ecosystems.
- A hazard assessment of water quality as a potential threat to biodiversity and public health in the Torres Strait covering regional and local scales. The results could be used by management authorities to prioritise investment in local actions to minimise pollution and

should be a source of direct advice to Torres Strait communities. Recommendations for a water quality monitoring program may emerge if the threat level is high.

Program 5: Cumulative impacts on benthic biodiversity

- Knowledge of how diversity changes in response to disturbances and threats, and how diversity changes in space and time, the principal determinants and drivers of diversity on the GBR and quantification of their effects in terms of loss, gain and turnover of diversity. The major case studies will be GBR coral reefs and seafloor zones.
- An assessment of individual and synergistic effects of water quality and global change on reproduction, larval development and settlement of key coral reef invertebrates (e.g. corals, echinoderms). This information will inform the definition of the thresholds for global change stressors (temperature increase, ocean acidification) due to elevated local stressors, (increased nutrients, increased turbidity, decreased salinity) on key coral reef organisms.
- Predictions of the future performance of reef organisms by experimentally testing hypotheses about differences in the vulnerability of coral species to ocean acidification.
- Exposure maps to determine the impacts of flood plumes on seagrass habitats of the GBR. Experimental data to investigate the relative importance of light (turbidity) and nutrients upon seagrass health for the purpose of informing risk- and predictive models.

Program 6: Movements and habitat use by marine apex predators

- Estimating the minimum viable size of no-take zones required to provide effective protection from fishing to mobile fish predators with large home ranges, seasonal breeding migrations, and ontogenetic patterns of habitat occupancy. Case studies will cover reef, estuarine, and pelagic species.
- An assessment of the spatial and temporal patterns of shark biodiversity along the central GBR coast leading to identification of critical habitats (such as nurseries or breeding areas) that may require enhanced protection to sustain these vulnerable animals. Tagging of individual animals will yield new data on seasonal, ontogenetic, and climatic (extreme events) drivers of shark movements with implications for their vulnerability to fishing.
- Maps of shearwater and booby foraging locations during breeding and non-breeding seasons for populations at specific GBR sites, quantification of overlap in foraging areas used by adjacent colonies, weather and oceanographic correlates of foraging success. This information will link reproductive success in specific colonies to accessible food sources and may identify locations that carry higher or lower risks to replenishment.

Program 7: Threats to rainforest health

- Identification of key criteria to be used in assessing where and whether expansion of rainforest is desirable, together with mapping and assessment of the impacts of fire as a critical driver for rainforest biodiversity.
- Maps of weed populations and communities that are sources of propagules, areas particularly susceptible to weed invasion or re-invasion because of their connectivity to source populations or communities, and prioritisation outcomes for weed management e.g. high priority areas for control, containment and surveillance.

- Assessment of the spatial and temporal interaction between management and invasive animal populations. In particular report on a qualitative and an operationalised model of feral pig/management interaction applied to the assessment of alternative management strategies.

- A generalised analytical toolkit for assessing vulnerability to extreme climatic events in the Australian Wet Tropics and elsewhere including generation of high resolution maps on exposure and vulnerability to temperature extremes.

Theme 3: Managing for Resilient Tropical Systems

Outputs will include reports on the following topics.

Program 8: Effectiveness of spatial management on the GBR

- Response of biodiversity to Marine Park zoning, especially to no-take zones where all extraction is prohibited. Response variables will include the abundance and size structures of fish populations (exploited targets, by-catch species, prey species) to inform population (growth and recruitment overfishing) and community models (compensatory responses such as trophic cascades). In addition, the planned comparisons should reveal whether fishing has any impact upon the incidence of phenomena like outbreaks of *Acanthaster* and coral disease. Case studies will cover inshore and mid-shelf locations exploited mainly by the recreational and commercial line fisheries respectively.
- Direct estimates of the levels of non-compliance within no-take reef zones and assessment of the usage patterns of recreational fishers on high-use inshore reefs.
- Empirical estimates of recruitment subsidies to fished areas from protected brood stocks spawning in no-take areas. Following a successful pilot experiment in the MTSRF, the scale of the surveys will be enlarged to a large region of the southern GBR, and will for the first time quantify the longshore and cross-shelf components of larval fish dispersal. Data will inform the design of effective networks of marine protected areas.

Program 9: Decision support systems for GBR managers

- Dynamic coral bleaching vulnerability maps and a decision support system (DSS) for prioritising regions with high natural resistance/resilience as conservation targets.

- A novel, cost-effective, transparent, and accountable approach to prioritising management actions for multiple objectives across islands in the selected sub-region, shaped and understood by GBR managers, including an interactive, spatially explicit decision-support tool that will allow managers to prioritise management actions within and between islands.

- Identification of alternative strategies for the management of the inshore region aimed at maximising biodiversity outcomes with a focus on inshore multi-species fisheries and a stakeholder-driven approach. The analysis will be informed by social, ecological, economic and governance objectives of stakeholders for the inshore GBR region.

- Generalised and, for sub-regions, detailed models of alternative futures for the coastal zone, considering climate change, change in land use and infrastructure, and effects of land uses on water quality in the GBR lagoon. This will include an assessment of the strengths and limitations of governance in the coastal zone, with insights into how governance can be better coordinated and recommendations on the feasibility and potential effectiveness of new management instruments.

Program 10: Socio-economic value of GBR goods and services

- The design of a long-term social and economic monitoring programme covering all major social groupings and industries within the GBR region, and development of a management system for program implementation.
- Compilations of socio economic data for the GBR.
- The social and economic valuation of environment assets in the GBRMPA from the point of view of the ecosystems ability to supply sustainable ecological goods and services.
- An assessment of a range of stakeholder views on the relative value of different market and non-market goods and services provided by the GBR using innovative techniques. Key variables relating to stakeholder values (and associated indicators, and assessment/measuring techniques) that could be used in future socio economic long term monitoring programs will be identified.
- Long term monitoring of visitor patterns in the GBR will be connected with attributes of reef health to determine their importance to different classes of marine tourist. In addition, the impact of external socio-economic drivers (e.g. commodity prices, exchange rates, population growth) on water quality and thus indirectly on reef resilience will be explored.

Program 11: Resilient Torres Strait communities

- Regional stakeholder workshops (Australian, PNG stakeholders) and community scenario planning with selected Australian and PNG communities identified as having vulnerable livelihood systems. This information will be used in combination with data synthesis and modelling to:
  - Provide a synthesis and projections of human population and socio-economic trends in Torres Strait and Western Province, PNG.
  - Report on the identification and valuation of ecosystem services underpinning Torres Strait livelihoods and other beneficiaries.
  - Deliver a typology of Torres Strait and PNG Treaty Villages' livelihoods based on collation of existing data (e.g. ABS for Australia) and surveys (e.g. PNG Treaty Villages).
- Improved methodologies for detection of wildlife diseases in the Torres Strait. Assessment of corridors of movement people and wildlife between islands and the PNG Western Province to wildlife disease loads.

Program 12: Managing for resilience in rainforests

- Recommendations on the most appropriate regional governance systems and planning mechanisms needed to support regional scale adaptation to climate change in the Wet Tropics region. This will encompass the role of a new carbon market and other emerging ecosystem market investments on biodiversity outcomes within the Wet Tropics region.
- Advice on the most effective approaches to collaborative governance, planning and co-management of Indigenous Protected Areas and parks as a means of delivering biodiversity and Indigenous cultural conservation in the regional landscape.
- A survey instrument for measuring the relative value of core attributes of the Wet Tropics region assessing the degree to which stakeholders are willing to trade-off those 'values'

against other 'values'assessing the social acceptability of a range of different strategies for protecting core 'values' in the Wet Tropics region.

- A synthesis paper on approaches to managing and accelerating vegetation regrowth; including a list of potential management interventions to accelerate regrowth development relevant to the Wet Tropics uplands.
- A Decision Analysis tool to identify situations where passive rainforest restoration (natural regrowth) represents a more cost effective management option than active restoration (replanting) in meeting restoration objectives.

Program 13: Knowledge Brokering and Communication

Resource allocations for knowledge brokering and communication will be approved by the Steering Committee and detailed in the NERP TE Hub Science Communication Plan.

The success of the NERP TE Hub will, in part, be due to how information developed by the Hub is taken up by end users. Accordingly, the Hub research activities will be supported by a substantial commitment to knowledge brokering and communication (Section 1.10). The Hub research is likely to be communicated through diverse products including peer reviewed publications, technical reports, newsletters, and development of an appropriately branded website.

In addition, research results are likely to be captured through the further development of the e-Atlas that was developed for the same role in MTSRF. This could include:

a) Articles describing the research outcomes.

b) Metadata records suitable as reference information and searchable through the Australian National Data Service.

c) Maps as a visualisation of the research data. These maps will be provided in a range of formats to ensure they can be accessed on any computer. This will include access to map layer using a web browser, PDFs, and Google Earth KMLs. Maps developed for the e-Atlas will be available as a public Web Map Service (WMS) suitable for integration with external mapping systems and Desktop GIS software.

d) Images and videos associated with the datasets.

- A fast, flexible and state of the art mapping client (called the AtlasMapper) designed to run on any web browser and made available as an open source software project, developed to meet the needs of the e-Atlas end-users to maximise the utilisation and accessibility of the available map data.
- A set of tools for pre-processing a range of data formats into a form suitable for mapping. This includes statistical tools for interpolation of point data and conversion tools for point data to display in Google Earth. These tools will simplify the process of adding data to the e-Atlas system.
- Access to a wide range of data layers (not from the MTSRF or NERP programs) through the e-Atlas, based on those that complement the research data layers.
- A new Torres Strait e-Atlas which will provide a compilation of NERP and prioritised non-NERP research outcomes and reference data. This will include delivery of a customised and optimised Torres Strait front-end for the e-Atlas plus targeted capacity building and training, to ensure that the e-Atlas is both accessible and used by key end-users from the Torres Strait, especially by staff from the Torres Strait Land and Sea Management Unit.

4.0 Research Hub Administration

4.1 Leadership and Governance

Governance Framework

The Governance framework for the NERP TE Hub (Figure 3) is structured to accommodate the roles and responsibilities of the following parties:

The Minister

The role of the Minister is to approve the Multi-Year Research Plan (MYRP) and the Annual Work Plan (AWP) for the Hub.

DSEWPaC (the Department)

The role of the Department is to contract the Administrator, monitor progress of the research activities and approve payments to the Administrator and the research institutions. The Department will provide advice to the Minister on the MYRP and AWP. The Department approves the Hub Science Communication Plan and the Monitoring and Evaluation Plan.

NERP TE Hub Steering Committee

The Hub Steering Committee is appointed by the Minister and its members provide advice to the Hub Science Leader and the Hub Administrator on the development of the MYRP and the AWP from material selected by Working Groups for each geographic Node (Great Barrier Reef, Torres Strait, and Wet Tropics Rainforest). After Ministerial approval is granted, the Hub Steering Committee will oversee the implementation of the MYRP, including the development of each AWP. The Steering Committee will meet face-to-face at least twice in a full year to review progress, and approve documentation for transmission to DSEWPaC as required. In addition the Hub Steering Committee provides advice to the Department on the coordination of research, knowledge brokering and uptake of science relevant to the scope of the NERP TE Hub.

Research Providers

Research Providers also provide advice on the structure and form of the MYRP and the AWP and undertake the research described in the approved contracts. They also provide financial advice and contractual information to the Hub Administrator in accordance with the contracts. The Research Providers will play a significant role in communications and knowledge brokering in accordance with the Hub Science Communication Plan.

Hub Science Leader

The role of the Hub Science Leader is to lead the development of the MYRP and AWPs; oversee the scientific outputs for the Hub, lead and co-ordinate science communication, media, knowledge brokering and end-user engagement for the Hub; address disputes and issues arising from the research and collaboration arrangements; provide advice to the Hub Administrator and the Steering Committee on research performance and the quality of the scientific outputs. In addition, the Science Leader liaises with other Hub Directors and communicates directly with the Department. The Science Leader will be supported in these roles by the Research Providers, the Department and key government agencies involved in the NERP TE Hub. Leaders of the four institutions (JCU, CSIRO, AIMS and UQ) were invited to nominate a candidate for this role and Dr Peter Doherty (AIMS) was selected and fully supported by all four institutions.

Hub Administrator

The NERP TE Hub will be administered by the Reef and Rainforest Research Centre located in Cairns and Townsville, which will apply effective governance systems to ensure the strongest possible results are produced through coordinated project management, integration of effort and timely reporting.

The RRRC is responsible for:

- Consolidation of research projects into the Multi-Year Research Plan;
- Consolidation of Annual Work Plans;
- Development of the Hub Science Communication Plan;
- Development of the Hub Monitoring and Evaluation Plan;
- Contracting projects with the Research Providers;
- Receiving and reviewing milestone and financial reports from the Research Providers;
- Administering payments to contracted institutions (including GST obligations);
- Monitoring and evaluating performance against Project milestones on an ongoing basis including a mid-year review at the conclusion of each AWP;
- Organising the logistics of conferences and meetings as required;
- Providing secretariat support to the Hub committees; and
- Reporting to DSEWPaC.

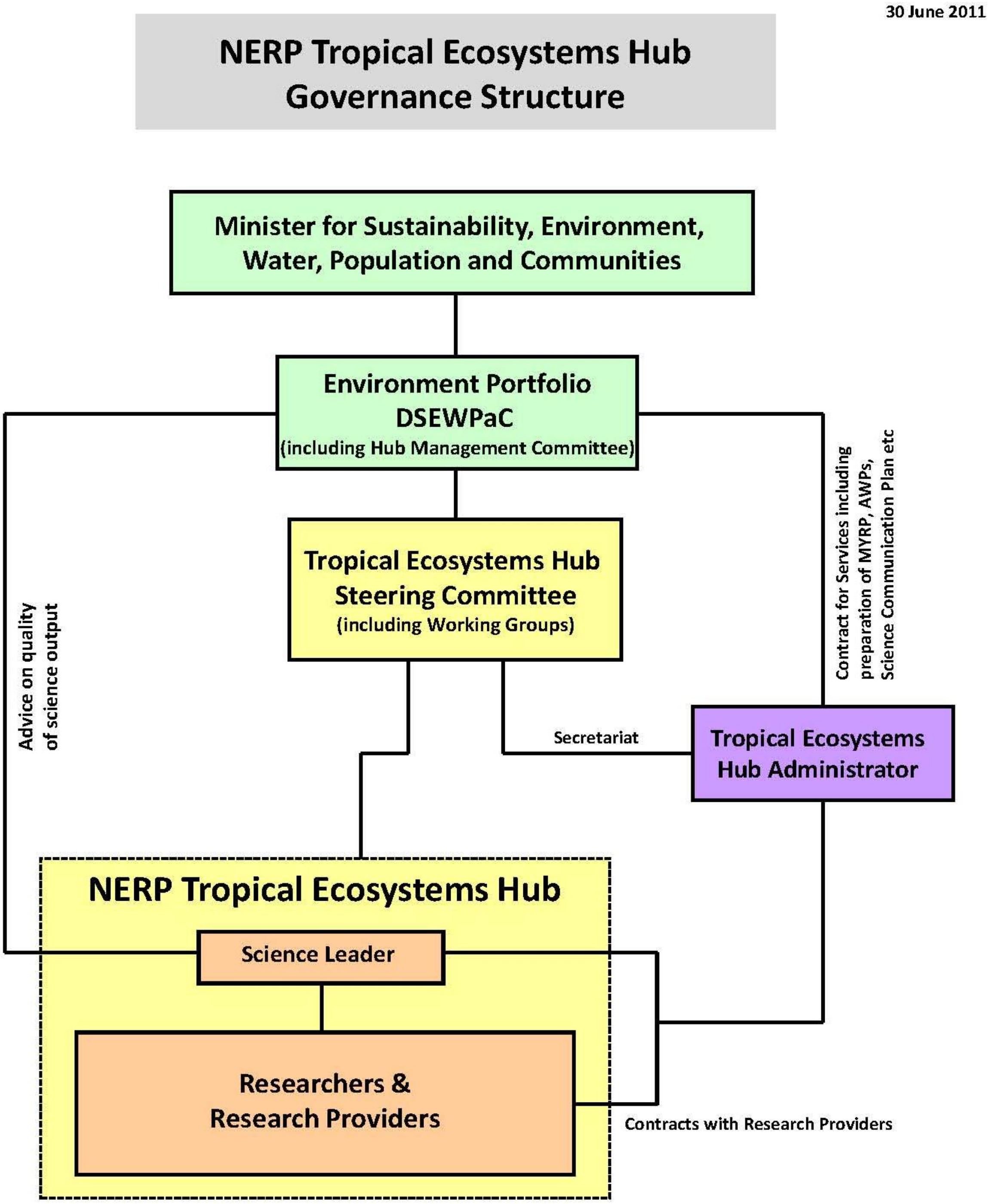


Figure 3. NERP Tropical Ecosystems Hub governance structure

Operational Systems

Project Management and Coordination

The RRRC has provided to the Science Leader its QA/QC framework to manage the science and procedures underpinning the delivery of research conducted within the NERP TE Hub (Figure 4). The mature QA/QC framework (including peer review) and alignment of project management systems with the project deliverables and formal engagement through Hub committees will protect, maintain, and sustain the integrity of research output and provide transparency and accountability for the application of quality control measures to ensure science delivery.

A critical component of the ongoing review of progress toward achieving the delivery of the Annual Research Plans and Multi-Year Research Plan will be the development of regular progress reports for scrutiny by the Department and the NERP TE Steering Committee in accordance with specifications in the DSEWPaC/Administrator contract. These progress reports will:

- Highlight and communicate the progress of the Hub;
- Enable tracking of individual projects ensuring that the research conducted remains focused on the outcomes intended at the outset;
- Provide an opportunity to revise the direction of projects to capture changing management priorities or emerging issues; and
- Identify projects that require assistance to overcome obstacles.

The QA/QC framework will ensure effective delivery of research outcomes through:

- Day to day management of project integration activities;
- Evaluation of project outputs against agreed deliverables; and
- Peer review of final reports from the projects.

The Administrator will give early notification to the research providers to remind the project team of their delivery commitments and will deliver six monthly progress reports and financial reports to DSEWPaC in accordance with the contract requirements.

By linking milestones to payment schedules through customised project and financial management databases, the Science Leader, working in consultation with the Administrator, will ensure that the research outputs meet the quality assurance standards and/or contract specifications prior to payment to research providers. Within this system, the Administrator will track all steps of a project, from development of a concept proposal, through contracting, delivery of milestones and payments to completion. Details of e-mail and telephone communications will be recorded against each project for transparency.

The Administrator will prepare reports describing project progress in accordance with specifications in the DSEWPaC/Administrator contract. The Science Leader will provide description of the science quality and delivery. These reports will be submitted to the Hub Management Committee and the NERP TE Steering Committee for consideration.

Where a dispute arises, the Science Leader will prepare a report for the Hub Management Committee and Hub Steering Committee on the matters of dispute and the impact on the delivery of the research milestones. If requested, the Science Leader will undertake a dispute resolution process that will be fair, equitable and non-discriminatory; will engage a senior manager from the institution involved; will be addressed in writing; and will be referred to an external body for decision if a resolution cannot be achieved in an appropriate timeframe. The Science Leader will ensure that a complaint or dispute does not unduly prejudice a research provider's future engagement in the NERP TE Hub.

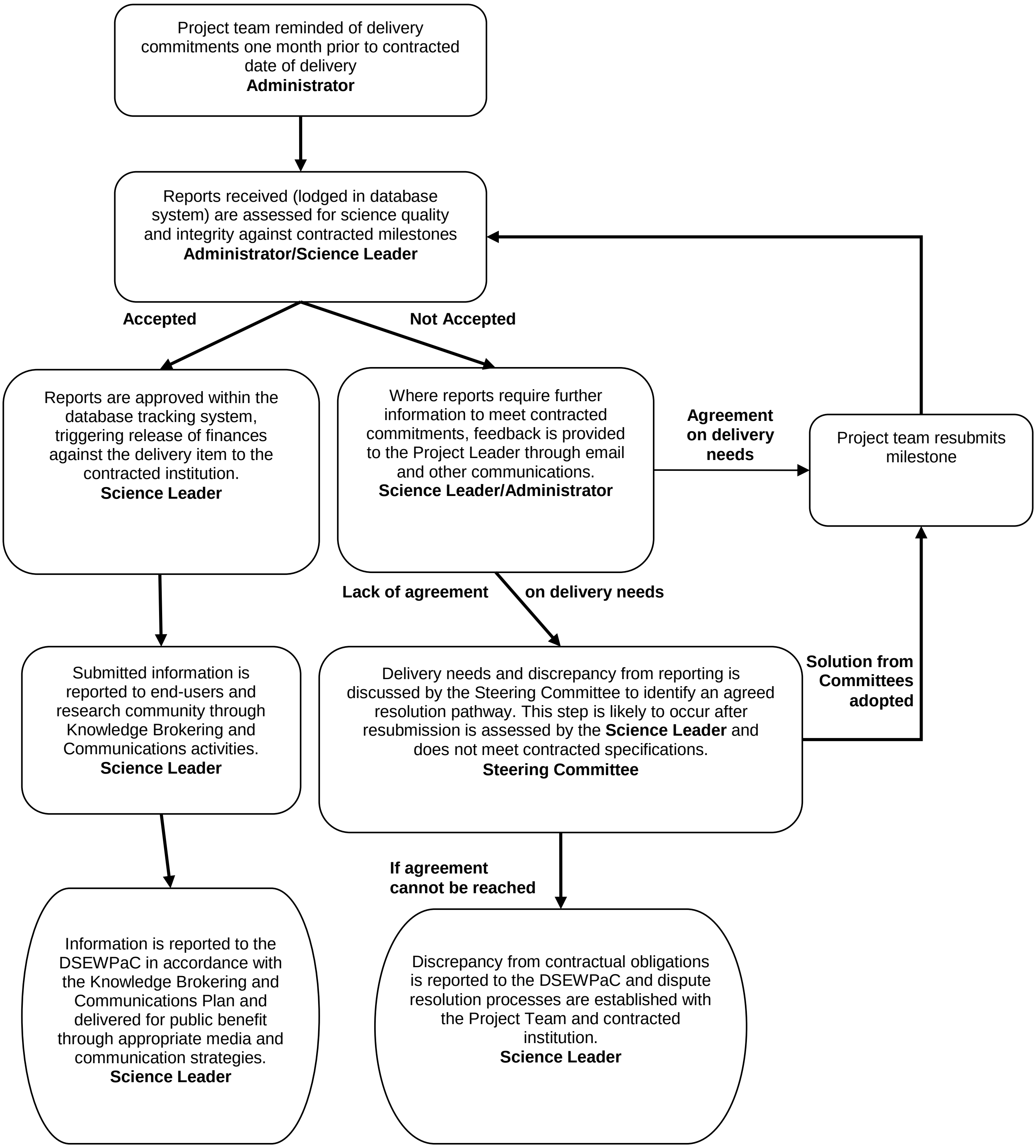


Figure 4: Diagram of the processes, and roles and responsibilities within the post-contracting QA/QC framework and project management system for the NERP TE Hub.

4.2 Reporting requirements

Reporting of the NERP TE Hub will be based on the financial year with milestone delivery, payments and auditing activities effectively co-ordinated to ensure clear linkages between research and financial obligations.

4.3 Risk Management

Risk Assessment for the delivery of the NERP TE Hub Program:

Key Risk Factors	Risk	Mitigating Action	Residual Risk
1. Delays in Hub program start up and delays in funding distribution	**Low/Medium** Protracted contracting	The four major providers have been part of the process and are well informed about project selection and financials	**Low**
2. Inability of the Hub to meet objectives due to researchers being unable to complete some projects	**Low/Medium** Unpredictable events including weather or the failure of critical infrastructure	Force majeure clause in DSEWPaC/Administrator agreement passed through to Administrator/Research provider agreements.	**Low**
3. Inability of the Hub to meet objectives due to loss of research, administrative and/or K/B and Comms skills in the region that are necessary to perform the functions identified in the MYRP	**Medium/High** Ongoing uncertainty of future employment may lead to loss of capacity before or early into the program, which is difficult to replace or results in costly delays	Timely implementation of the research phase; rapid agreement on projects and budgets.	**Medium**
4. Hub program not delivered on time and not of the expected quality	**Medium/High** Force majeure events may delay program delivery. Uncoupling project milestone delivery from the financial management may reduce the inducements to ensure timely and effective delivery.	Select researchers with demonstrated history of timely delivery in tropical conditions. Link project milestone delivery to institutional payments. Do not support ‘reach-through’ (subcontracting) research arrangements.	**Medium / Low**

Key Risk Factors	Risk	Mitigating Action	Residual Risk
5. Hub program not delivered due to erosion of trust between researchers and end-users.	**Medium** Inability of regional stakeholders to recognise their priorities in the Program; culturally inappropriate engagement with Indigenous communities	Active consultation and engagement of regional stakeholders in formation of the Hub program; retain the knowledge and mechanisms utilised	**Medium / Low**
6. Poor transfer of Hub outputs/outcomes to end-users of knowledge and/or tools	**Medium/low** Low quality of outputs and/or reliance on narrow range of products (e.g. over reliance on written reports). Hub relies on passive knowledge transfer mechanisms to distribute new understanding or capabilities	Employ a professional communications officer for delivery of multimedia (e.g. Web) Build multiple pathways for knowledge transfer; employ a skilled and dedicated knowledge broker to support the Science Leader and Key Researchers; develop user pull through willing “project associates” embedded in operational agencies	**Low**

Appendix B – Tropical Ecosystems Hub Multi-Year Research Plan – Project Descriptions (July 2011 – Dec 2014)

Contents

Project 9.2 Design and implementation of Management Strategy Evaluation for the Great Barrier Reef inshore (MSE-GBR)

Project 9.3 Prioritising management actions for Great Barrier Reef islands

Project 9.4 Conservation planning for a changing coastal zone

Program 10: Socio-economic value of GBR goods and services

Project 10.1 Social and Economic Long Term Monitoring Programme (SELTMP) (Marshall, JCU)

Project 10.2 Socio-economic systems and reef resilience

Program 11: Resilient Torres Strait Communities

Project 11.1 Building resilience communitie for Torres Strait futures (Butler, CSIRO)

Project 11.2 Improved approaches for detection of disease and prevention of spread in Torres Strait (Laurance, JCU)

Program 12: Managing for Resilience Rainforests

Project 12.1 Indigenous co-management and biodiversity protection

Project 12.2 Harnessing natural regeneration for cost-effective rainforest restoration

Project 12.3 Relative social and economic values of residents and tourists in the WTWHA (Stoeckl, JCU)

Project 12.4 Governance, planning and the effective application of emerging ecosystem service markets to secure climate change adaptation and landscape resilience in Far North Queensland (Dale, JCU)

Program 13: Knowledge Brokering and Communications

Project 13.1 e-Atlas (GBR) (Lawrey, AIMS)

Theme 1: Assessing Ecosystem Condition and Trends

A clear understanding of the ecological condition and trends of environmental assets of the Great Barrier Reef, the Torres Strait, and the Wet Tropics rainforest is fundamental to ecologically sustainable use of those assets by industry and communities, supported by appropriate management and policy settings. Theme 1 is comprised of three inter-related Programs, each of which concentrates on a specific component of north Queensland's natural and cultural heritage, and delivers reports on the condition and trend of key ecosystems and natural living resources.

Program 1: Historical and Current Condition of the Great Barrier Reef

Program 1 will have three projects assessing the condition and trend of Great Barrier Reef assets. Two of these concern temporal changes in coral communities: one over timescales of the last 100-200 years and one based on current monitoring of approximately 100 coral reefs representative of the whole system. The latter provides a synoptic view of coral cover and continues a time series that started in 1986. Over 20 years, these surveys have shown that the two main sources of coral mortality are predation by crown of thorns starfish and physical damage by severe tropical cyclones. The surveys have also captured the dynamics of recovery and shown the importance of connectivity to upstream spawning sources. The historical project will use modern radioactive dating methods to search for temporal shifts in abundance and/or community composition among coral death assemblages. Broad-scale directional change will be taken as evidence for changing environmental conditions and may be able to date the recent decline in water quality in some inshore sections of the GBR. The third project will continue to monitor the distribution, abundance, and ecology of iconic marine species of high conservation concern, notably dugong, marine turtles, and coastal dolphins. This information directly supports the management of these vulnerable species and is critical to the issue of indigenous use.

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

Project Leader and Host Organisation

Name	Dr Hugh Sweatman		
Organisation	Australian Institute of Marine Science		
Postal Address		**Delivery Address**	
	PMB 3		
	Townsville MC, QLD 4810		
Phone	07 4753 4470	**Fax**	07 4772 5852
Email	h.sweatman@aims.gov.au		

Project Team

Team	Organisation	Role
Hugh Sweatman	AIMS	Project management
Long-term Monitoring Field team (6)	AIMS	Data collection and analysis

Summary Table of End-users

Organisation	Organisational Contact	Email
GBRMPA	Dr Fergus Molloy Roger Beeden	fergus.molloy@gbrmpa.gov.au roger.beeden@gbrmpa.gov.au
AMPTO	Mr Col McKenzie	col@gempearl.com.au
DSEWPaC	Celeste Powell Kate Sanford-Readhead Jeff Tranter Andrew Read	Celeste.Powell@envionment.gov.au Kate.Sanford-Readhead@environment.gov.au Jeffrey.Tranter@environment.gov.au Andrew.Read@environment.gov.au

Project Duration

Start Date: 1 July 2011 End Date: 31 December 2014

Project Description / Task Objectives

In 2012-13 and 2014-15 the LTMP will resurvey the 'core' reefs that have been surveyed since 1992. This program provides the GBRMPA with situational awareness over large areas of the GBR and tracks the dynamics of shallow coral reef communities across much of the GBR province. The program will be a critical source of up to date information on the status and trends of GBR reefs for the Outlook Report 2014.

Key Objectives

(a) Legislation requires that The GBRMPA produce an Outlook Report for the GBR every five years. The next Outlook Report is to be tabled in Parliament in 2014, so the surveys in this program in 2012-13 will be included as the most up to date broad-scale information on status and trends on GBR reefs.

(b) The last five years have seen three unusually large cyclones *Larry*, *Hamish* and *Yasi*, hit parts of the GBR; in sum they have affected a large proportion of reefs in the central and southern GBR. How rapidly reef communities recover from the effects of these large cyclones is critical to the long-term persistence of the GBR. Monitoring data provides information on the coral and fish communities before and after the cyclones and surveys of juvenile corals will give an early indication of regenerative potential.

(c) Records of change in coral cover on LTMP survey sites since the early 1990s showed that the crown-of-thorns starfish was the major cause of coral loss up until the last two years when large cyclones became the leading cause. Extra reefs in the area north of Cairns where waves of outbreaks are thought to begin will be surveyed to provide early warning of developing outbreaks.

Project / Task Methodology

The AIMS LTMP has made intensive surveys of 47 'core' reefs since 1992. The survey reefs are stratified by latitude and position across the GBR lagoon so as to give broad geographic coverage. Divers make intensive surveys on marked transects in one habitat on the selected reefs and the perimeters of the reefs are also surveyed by manta tow to assess densities of crown-of-thorns starfish and estimate reef-wide coral cover. Additional reefs are surveyed by manta tow to give broad-scale information on coral cover, bleaching, coral disease, etc., as well as crown-of-thorns starfish outbreaks. Because of concern for their conservation status, reef sharks will also be counted during manta tow surveys.

Because standard survey methods are used, relevant data from NERP GBR Project 1.3 can also feed in to assessments of status and trends of GBR reefs

Based on recent history, another wave of starfish outbreaks is due and surveys in recent years have suggested that starfish numbers are increasing on reefs north of Cooktown where the first outbreaks of past waves have been seen. Under MTSRF, the LTMP surveyed extra reefs by manta tow in the area north of Cairns where the waves are thought to originate in order to provide early warning to the GBRMPA and to tourism operators whose businesses may be affected. These will be continued in 2012-13 and 2014-15.

Project Outputs / Outcomes

- This project continues a unique data set on the dynamics of coral reef communities of the GBR and provides both a spatial and a temporal context for the status of GBR reefs.
- The occurrence of three major cyclones that have affected reefs across large areas of the GBR Marine Park means that coral cover is low on a large proportion of reefs in the southern and central GBR. This gives an unusual opportunity to track recovery rates and compare resilience of reefs in different regions. Survey data will be used assess the extent of the damage as a basis for estimating rates of recovery.
- Monitoring data suggest that coral losses to crown-of-thorns starfish and cyclones dwarf losses to other causes over the past two decades. The LTMP provides the only broad-scale situational awareness of *Acanthaster* outbreaks on the GBR. The program will continue to monitor the remains of the third wave of outbreaks that can be found on a few reefs south of Mackay, while continuing intensive surveys north of Cairns where the first evidence of the next wave of outbreaks is expected to be seen

Expected Benefits

- Ongoing 'situational awareness' for the GBRMPA
- Provision of up-to-date information on the status of GBR reefs for the scheduled Outlook Report 2014 for the GBRMPA / DSEWPaC
- Early warning of developing waves of crown-of-thorns starfish for the GBRMPA and AMPTO

Description of Risk	Assessed Risk	Risk Control measures
Failure to complete surveys due to bad weather	Medium	Schedule includes days that can be used for broad-scale surveys to provide greater situational awareness or reallocated to priority reef surveys if absolutely necessary.
Departure of key project personnel	Low	The field team includes individuals that can fill multiple roles
Failure to achieve uptake of results by end-users	Low	Preliminary results of each survey circulated by email directly to stake holders and end-user representatives

Project Budget

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	-	-	-
AIMS	-	-	-
Total			**NO ACTIVITY**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	350,000	-	350,000
AIMS	-	740,239	740,239
Total	**350,000**	**740,239**	**1,090,239**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	-	-	-
AIMS	-	-	-
Total			**NO ACTIVITY**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	375,000	-	375,000
AIMS	-	396,650	396,650
Total	**375,000**	**396,650**	**771,650**

Project 1.2:	Marine wildlife management in the Great Barrier Reef World Heritage Area

Project Leaders and Host Organisation

Name	Dr Mark Hamann / Professor Helene Marsh		
Organisation	James Cook University		
Postal Address		**Delivery Address**	
	School of Earth and Environmental Sciences		
	James Cook University		
	Townsville, QLD 4810		
Phone	07 4781 4491 / 07 4781 5575	**Mobile**	(Hamann) 0415 298 238
Email	mark.hamann@jcu.edu.au / helene.marsh@jcu.edu.au		

Project Team

Title	Organisation	Role
Prof. Helene Marsh	JCU	Project co-leader
Dr. Mark Hamann	JCU	Project co- leader
Dr. Alana Grech	JCU	Spatial data analyst
Dr. Guido Parra	Flinders Univ.	Co-leader of objective 1
Prof. David Blair	JCU	Assistance with dugong genetics
Dr. Lyn Van Herwerden	JCU	Assistance with dugong genetics
Dr. Nancy FitzSimmons	Griffith Uni	Assistance with turtle genetics
Dr Isabel Beasley	JCU	Project manager – inshore dolphins
Dr. Karen Arthur	ANU	Advise the project on stable isotopes and ecosystem role
GBR TUMRA communities	Various communities	Assistance with field and logistic operations
Dr. Col Limpus	DEHP	Marine turtle advice
Technical officer	JCU	Objective 1 (2012 to 2014)
Research Officer	JCU	Objective 2 and 3 (2011 to 2013)

Summary Table of End-users

Organisation	Organisational Contact	Email
GBRMPA	Mark Read (ECSU) Liz Wren (IPG)	mark.Read@gbrmpa.gov.au liz.wren@gbrmpa.gov.au
DSEWPaC	Karen Arthur Amy Cmic Ilse Keissling Belinda Jago Charles Brister Leah McKenzie David Calvert Peter Wright Kate Sanford-Readhead Jillian Grayson Sylvana Maas Fiona Bartlett Karen Arthur	Karen.arthur@environment.gov.au Amy.cmic@environment.gov.au Ilse.keissling@environment.gov.au Belinda.jago@environment.gov.au Charles.brister@environment.gov.au Leah.mckenzie@environment.gov.au David.calvert@environment.gov.au Peter.wright@environment.gov.au Kate.sanford-readhead@environment.gov.au jillian.grayson@environment.gov.au Sylvana.Maas@environment.gov.au Fiona- Whales.Bartlett@environment.gov.au Karen.Arthur@environment.gov.au
QDEHP	Col Limpus	col.limpus@ehp.qld.gov.au

QDAFF	TBC	TBC
Girringun	Phil Rist	eo@girringun.com.au

Project Duration

Start Date: 1 July 2011 End Date: 31 December 2014

Project Description / Task Objectives

Marine wildlife are significant components of the Great Barrier Reef World Heritage Area's biodiversity and are threatened by a variety of anthropogenic pressures. In particular, populations of inshore dolphins are very small and at risk, there are serious concerns for dugong populations along the urban coast (south of Cooktown) and marine turtles are listed at threatened species and are at risk along the Queensland coast due to coastal change. The GBRMPA's Outlook Report highlights that there is (1) currently little information available on inshore dolphins of the GBRWHA, (2) a need to continue the time series of dugong abundance data to strengthen population estimates for the GBRWHA and (3) understand the ecosystem role and the impact of coastal change on marine turtle and dugong populations.

The proposed project has three focal areas; inshore dolphins, dugongs and green turtles and will use monitoring, genetics, satellite tracking and remote sensing to develop:

1) an understanding of the distribution and status of inshore dolphins in the northern GBRWHA
2) population estimates for dugongs along the GBRWHA coast (in relation to previous surveys)
3) an understanding of the role of green turtles and dugong in coastal ecosystems

The three research objectives have been determined in consultation with the key end-user groups[5] and the research will be conducted across jurisdictions at spatial scales relevant to ecology of the focal species and to the end-users of the research. Where links between this project and other NERP projects occur, we will ensure that collaboration with other research groups occurs to reduce duplication and maximise the research potential of both projects. Where applicable, information from this project/tasks will enable reporting and assessment of the ecosystem health of key environmental assets.

To achieve the projects goals we harness the expertise of researchers from several research institutions and Indigenous local experts to conduct world class multidisciplinary problem-focused research. The outputs will inform stakeholders of the condition and trends of inshore dolphins, dugongs and marine turtles in the Great Barrier Reef World Heritage Area and thus enhance the scientific information required to develop effective management strategies for the populations of marine species of conservation concern that occur in the Great Barrier Reef World Heritage Area. Further, we aim to build a better understanding of Traditional Owner issues relating to improving the sustainability of the traditional use of species of conservation concern.
Overall, the project will both improve stakeholder understanding, capacity and skills to better manage priority species and provide valuable data that is useable and understandable to those making decisions regarding marine wildlife.

Key Objectives

1. To inform an assessment of the conservation status of coastal dolphins in the northern Great Barrier Reef World Heritage Area
   a. What is the distribution and abundance of inshore dolphin species in the northern coast of the GBRWHA?

[5] Following advice of the working group about the turtle priorities and their suggested cash allocations for dolphins, dugongs and marine turtles we focused the turtle objective around green turtle connectivity and ecosystem role as this was the highest priority turtle project, and we left out projects on loggerhead and flatback turtles. Similarly we did not include Princess Charlotte Bay as a study site because of the very high costs associated with conducting field work in such a remote area.

   b. How does distribution relate to coastal habitat type?
   c. What are the threats to inshore dolphins in the northern GBRWHA?
2. To inform dugong management in the Great Barrier Reef World Heritage Area by continuing the time series of aerial surveys to monitor dugong distribution and abundance (data will be analysed in relation to previous surveys).
3. To understand the ecosystem role of green turtles and dugongs along the coastal zone between Edgecombe Bay (Bowen) and Hinchinbrook (Cardwell) area of the GBRWHA.
   a. What are the patterns of habitat use and home range size of green turtles and dugongs in Bowling Green Bay, Edgecombe Bay, Cleveland Bay and the Hinchinbrook coast?
   b. Can stable isotope data, tracking data, molecular data and habitat use data be combined examine dietary and habitat shifts?

Project / Task Methodology

Objective 1 – Inshore dolphins of the northern GBRWHA

2.5 years from July 2012 (i.e. not conducted in AWP1 - 2011/2012)

A post-doc researcher will be employed to:

- Identify likely important habitats for Australian snubfin and Indo-Pacific humpback dolphin in the northern Great Barrier Reef based on anecdotal and published information and the species-habitat relationships developed by previous researchers (Parra *et al.*).
- Investigate the distribution and relative abundance of these dolphins in key areas identified above in collaboration with Traditional Owners.
- Conduct line transect surveys of key areas in close collaboration with Traditional Owners while facilitating local capacity building by providing extensive training on: marine mammal research techniques; use of the Cybertracker unit; marine mammal identification and sample collection.
- Contribute samples collected by biopsy (if Traditional Owners agree) to investigations into population stock structure and phylogenetic patterns in Australia conducted by other researchers (Parra *et al.*).
- Will add value to the dolphin surveys by collecting data on other vertebrates of conservation concern – such as saw tooth sharks, dugongs and marine turtles.

Objective 2 – Dugong population surveys in the GBRWHA

The aerial survey design and methodology will reflect that used in previous surveys. The survey will be conducted over two years: the region from the southern boundary of the Great Barrier Reef World Heritage Area (GBRWHA) to Cooktown will be surveyed in year 1 (2011/2012); the region from Cooktown north in year 2 (2013) in association with a parallel survey of western Torres Strait. If co-funding is available from sources external to NERP the first survey will be extended from the southern boundary of the GBRWHA to the Queensland –NSW border. The objective will share a Research Officer with Objective 3.

The data collected will be used to:

- Estimate dugong numbers in the survey area.
- Make statistical comparisons of the estimates of dugong density with those obtained from past surveys for the regions surveyed on multiple occasions. These comparisons will provide insights regarding the impacts of the 2011 floods and cyclones.
- Estimate the sustainable anthropogenic mortality of dugongs from all causes in each survey regions using the PBR technique.
- Update the spatial model for dugong distribution and relative abundance
- Inform dugong management in the region.

Objective 3 – Green turtle and dugong – connectivity and ecosystem role

The GBRWHA has some of the largest populations of green turtles in the Pacific Ocean and they are presumed to play a vital role in coastal ecosystems, yet, this role has not been examined. At least two field trips per year between 2011 and 2014 will be conducted to collect samples of skin (turtle and dugong), feces (dugong) and marine flora (seagrass, algae and mangrove species) for analysis of Stable isotope (Carbon and Nitrogen) profiles to examine foraging dynamics and ecosystem role of green turtles and dugongs in algal and seagrass based ecosystems of the GBRWHA (coastal zone from Bowen to Cardwell). Connectivity of turtles and dugongs and their habitats will be examined using genetics, stable isotopes and telemetry (funded to be sought elsewhere). Results will aid the development of policy for managing coastal zones, water quality and seagrass habitats. We will also work with the JCU Vet school to revise and develop proxy indicators of turtle health. A PhD student on a JCU scholarship (2012 start) will undertake the research project on ecosystem role and the objective would share a Research Officer with Objective 2.

Project Outputs / Outcomes

<u>Outputs</u>

1. Defined status of inshore dolphins in the northern GBRWHA (links to Outlook Report information gap).
2. Revised estimates of dugong abundance within the GBRWHA (links to Outlook Report information gap).
3. Understanding of ecological and biological connectivity, ecological role and habitat use of dugongs and marine turtles in relation to protected areas and TUMRAs and areas impacted by severe weather events (stable isotopes, tracking, health and genetics) (links to Outlook Report information gap).
4. Understanding of food web interrelationships (through habitat use and stable isotopes) (links to Outlook Report information gap).
5. PhD thesis examining the ecosystem role of green turtles and dugongs in the coastal zone.

<u>Outcomes</u>

1. Improved population viability and stability of inshore dolphins, dugongs and marine turtles
2. Improved stakeholder understanding, capacity and skills to better monitor and manage priority species.
3. Improved understanding of Traditional Owner issues relating to the management of the Great Barrier Reef; such as the sustainability of the traditional use of species of conservation concern.
4. Improved non-indigenous participants knowledge of traditional ecological knowledge and cultural aspects of marine wildlife management

<u>Relevant end-users</u>

DSEWPAC, GBRMPA, TSRA, QDERM, QDEEDI, Coastal Indigenous communities.

Benefit to end-users

The objectives will deliver information on population viability, distribution abundance and threats for marine species of conservation concern (dugongs, marine turtles, inshore dolphins and saw tooth sharks). The implementation of the projects will involve several traditional owner groups from northern Queensland, and as such add value to indigenous coastal monitoring and management projects. The project's data will enable end-users to refine monitoring and improve the management of threatened marine species of conservation concern. In particular in-shore dolphins for which substantial knowledge and management gaps exist.

Links to other projects and hubs within the NERP

The project has links through objective 2 and 3 (dugong and turtle projects) to the Torres Strait node. With regard to objective 2, dugong aerial surveys have been conducted at intervals of approximately 5 years since the mid 1980s. They provide the most reliable dataset on dugong population status. Under the NERP, aerial surveys for dugong will be continued in both Torres Strait and the northern GBR. With regard to objective 3, green turtles from the northern GBR and Torres Strait are part of the same genetic stock. Understanding the importance of green turtles to coastal ecosystems (GBR objective 3) will assist Indigenous groups in the GBR as well as TS manage their turtle populations. Similarly, hawksbill turtles are shared between the GBR and TS region and to date research has focused on the GBR rookeries. Research in the TS node seeks to understand the status of the TS hawksbill rookeries. Information gained from the TS node will assist GBRMPA, QDERM and DSEWPAC manage hawksbill turtles in the GBR.

Project Risk Management

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	We have suitable and experienced staff in mind for employment.
Failure to obtain data	Medium	Field trips will be collaborations with the relevant Indigenous and community group(s). Many of the turtle objectives can be conducted at several sites, which makes organisation more flexible. Animal ethics and QPWS Permits currently exist for proposed marine turtle research and permits are pending for the dugong and dolphin surveys.
Failure to achieve outcomes due to dependence on outputs from other projects	Low	There is a very low reliance on data from other projects.
Failure to achieve uptake of results by end-users	Medium	Workshops/meetings will be convened with key end-users at various key project stages to ensure engagement and delivery of results in useful form. Representatives from end-users will also be invited to participate in field work. The dugong aerial surveys will follow techniques used in previous surveys meaning that new data will be easily compared to previous data. The dolphin surveys will follow closely with techniques used by Marsh *et al.* in the Gulf of Carpentaria.

Project 1.2 Budget

AWP 1 – 2011/2012 Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	188,000	-	188,000
JCU	-	225,500	225,500
Flinders University	-	-	-
University of Canberra	-	13,000	13,000
Total	**188,000**	**238,500**	**426,500**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	218,000	-	218,000
JCU	-	221,000	221,000
Uni of Canberra	-	13,000	13,000
Flinders University	-	22,000	22,000
QDERM	-	TBA	TBA
Total	**218,000**	**256,000**	**474,000**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	280,000	-	280,000
JCU	-	221,000	221,000
University of Canberra	-	13,000	13,000
Flinders University	-	22,000	22,000
QDEHP	-	TBC	TBC
Total	**280,000**	**256,000**	**536,000**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	64,000	-	64,000
JCU	-	95,300	95,300
Uni of Canberra	-	13,000	13,000
Flinders University	-	22,000	22,000
QDERM	-	TBA	TBA
Total	**64,000**	**130,300**	**194,300**

Project 1.3 Characterising the cumulative impacts of global, regional and local stressors on the present and past biodiversity of the GBR

Project Leader and Host Organisation

Project Team

Title	Organisation	Role
Prof Jian-xin Zhao	UQ	Project leader, geochemistry, geochronology and palaeoclimatology
Prof John Pandolfi	UQ	Project co-leader, palaeoecology
Prof Malcolm McCulloch	UWA	Boron isotopes and ocean acidification, geochemistry and palaeoclimatology
A/Prof Scott Smithers	JCU	Past sea-level and geomorphology
Dr Steve Lewis	JCU	Water quality and geochemistry
Tara Clark	UQ	Research Officer/Project coordinator, Geochemistry, geochronology, palaeoclimatology and ecological analysis.
Dr Terry Done	UQ	Reef ecology
Dr George Roff	UQ	Reef ecology and geochronology
Dr Yuexing Feng	UQ	Geochronological and geochemical methods
Dr Kevin Welsh	UQ	Palaeoclimate proxy reconstruction
Dr Laurence McCook	GBRMPA	Reef ecology and conservation
Dr Juan Pablo D'Olivo (Post-doc)	UWA	Calcification, boron isotope analysis & ocean acidification, and SST
Ms Emma Ryan	JCU	Study of sea-level and water quality
Mauro Lepore (PhD)	UQ	Reef palaeoecology and geochronology in the Keppel Islands region
Hannah Markham (PhD)	UQ	Reef palaeoecology and geochronology in the northern GBR
Nicole Leonard (PhD)	UQ	Reconstruction of past climate variability and sea-level
Martina De Freitas Prazeres (PhD)	UQ	Molecular biomarkers in forams and their response to heavy metal concentrations
Ian Butler (PhD)	UQ	Reef palaeoecology and geochronology in Hervey Bay, southern GBR
Mr Entao Liu (PhD)	UQ	Past cyclone history reconstruction

Summary Table of End-users

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DSEWPaC (Reef Rescue)	Kevin Gale	Kevin.Gale@environment.gov.au

Project Duration

Start Date: 1 July 2011 End Date: 31 December 2014

Project Description / Task Objectives

Coral reefs are showing evidence of decline on local, regional and global scales. Historical overfishing, nutrient loading, terrestrial discharge, combined with more recent threats of global warming, coral bleaching, ocean acidification and disease have resulted in long-term losses of abundance, diversity and habitat structure. Since European settlement of the Queensland coastline in the mid-19th century, extensive land use changes in the GBR catchment region have occurred resulting from grazing, agriculture and land clearance. However, it has been difficult to ascertain the link between terrestrial discharge, water quality, global warming, ocean acidification and coral decline on a regional scale, and the contribution of anthropogenic influence to the disturbance regimes of inshore reefs remains highly controversial. Up until now, there has been no direct evidence of changes in coral community structure following European settlement. This is largely due to (1) the lack of a reliable chronological tool that can be used to correlate episodes of ecological change and degradation with potential stressors and to reconstruct long-term (millennial timescale) same-site records of coral community change that can provide baselines against which to compare recent coral community changes, and (2) the lack of clear understanding of various stressors and their past variability and cyclicity, as well as their future trends, including sea-level; El Nino-Southern Oscillation (ENSO) variability and related flood/drought cycles; cyclones; sea-surface temperature (SST), salinity (SSS) and alkalinity (or acidity); sediment/nutrient discharge; and pollution from coastal development.

This project builds upon the success of MTSRF Projects 1.1.4 (*Dating and mapping historical changes in GBR coral communities*) and 3.7.2c (*Tracing of materials from the upper catchment to the reef*), as well as the team members respective long-term endeavour in the development of novel analytical techniques, innovative methodology and approach to resolve previously untenable research questions, such as ecological reconstruction of coral reef communities from decadal to millennial time scales, high-precision U-series dating (to precisions of ±1-10 years) to establish a reliable chronological framework for processes and events to be reconstructed and correlated, high-precision boron isotope analysis for ocean acidification studies, reconstruction of past cyclone activity through dating a combination of cyclone proxies such as transported reef blocks, super-cyclone ridges and lagoon sediment profiles, reconstruction of high-resolution sea-level based on microatolls, high-resolution geochemical proxy analysis for reconstruction of ambient environmental conditions (e.g. SST, SSS, turbidity, etc). For instance, our recent MTSRF Project 1.1.4 established a 'proof-of-concept' for understanding changes in coral reef community structure and their timing over decadal to millennial time scales using a suite of techniques that rely heavily upon extensive high-precision U-series radiometric age dating. A total of ~500 TIMS U-series dates were generated for this project, resulting in a number of unprecedented discoveries and breakthroughs. Following a successful ARC LIEF bid led by CI Zhao (with Pandolfi and Yu as co-investigators), a new-generation multi-collector ICP-MS was installed at UQ in April 2010, and is now fully operational, resulting in an increase in sample throughput for U-series dating by average 5 times with typical sample sizes 5-10 times smaller than required by TIMS. Other facilities at the UQ lab are also capable of high-throughput trace element, elemental ratio (e.g. Sr/Ca, Mg/Ca, Ba/Ca) and stable isotope (e.g. 18O/16O) analyses for sea-surface temperature, salinity, ENSO, and flood history reconstruction as well as water quality studies. In addition, a brand-new radiogenic isotope geochemistry laboratory has been established at UWA since CI McCulloch took the WA Premier Fellowship. This is the only laboratory in Australia that has the capability for high-precision boron isotope analysis. Such new analytical capabilities are unique in Australia, and together with our holistic analytical approach, will ensure the smooth delivery of far broader and more significant research outcomes than it was possible to achieve in MTSRF Projects 1.1.4 and 3.7.2c.

The key research question that the Tropical Ecosystem Hub plans to answer is: ***How can we best understand and manage the cumulative impacts of multiple pressures on the Great Barrier Reef ecosystem and the goods and services it provides (GBRTS Q1)?*** We wish to point out that, in developing management plans, the following considerations must be made: (1) stressors have interactive and cumulative impacts, (2) management decisions require tradeoffs among all ecosystem services, (3) not all stressors are equal or have impacts that increase linearly, and (4) management must account for the different scales of activities and impacts. Our proposal presents a comprehensive and multidisciplinary approach that directly addresses these considerations. Our geochemical, geochronological and palaeoecological methods are highly innovative, and allow us to investigate a range of GBRMPA-listed key stressors: rising sea-level; rising sea-surface temperature; seawater acidification; increased sediment/nutrient discharge; increased pollution from urban development; and other climatic drivers such as ENSO and cyclones. We will develop a precisely dated chronological framework to correlate such stressors and assess their interactions and relative contributions toward reef degradation. Our sampling strategy covers high- and low- impact regions along a latitudinal gradient to isolate different stressors (e.g. water quality, climate change) and assess their relative roles in different regions.

We will also construct a long-term high-resolution environmental baseline which quantifies natural variability and cyclicity, and against which the impact of European settlement and anthropogenic global warming can be isolated and properly assessed. Studies over long time scales will provide information on how multiple stressors interacted, including ecosystem response. For instance, we will investigate relatively recent analogues of projected climate change: i.e. the Medieval Climatic Optimum (~800-1300 AD) and the Little Ice Age climatic reversal (~1400-1900 AD)? Through such initiatives, we can address how individual climatic factors interacted in the past, and how past acidity (or alkalinity) changes correlated with other climatic parameters, such as SST, ENSO and PDO (Pacific Decadal Oscillation),as well as their effects on coral calcification over centennial to millennial time scales?

Our research will provide valuable knowledge which we can use to assess ***the effects of existing management strategies on the Great Barrier Reef ecosystem (GBRTS Q2)***. The evaluation of existing and proposed management strategies must be built upon a better understanding of current and past status and trends in the ecosystem. Given that rates, extent and trend of climate change are predicted to vary significantly from place to place within the broad global bounds of IPCC projections, a better understanding of status and trends specific to the GBR is needed over multiple temporal scales. The approach of using 'natural ranges of variation' derived from palaeoecology in management is widespread in terrestrial ecosystems, but its implementation has lagged in marine ecosystems (but see our team's recent paper, Lybolt *et al.*, 2011). Our project will provide real estimates of natural ecological and environmental baselines on nearshore reefs of the Great Barrier Reef. Clear and objective baselines derived from knowing how different today's oceans are from their pristine condition, are instrumental in formulating effective management strategies for the recovery of inshore GBR coral reef communities at local and regional scales.

Our project is also particularly tailored to address the other two GBRTS Research Questions (**Q3, Q4**). For instance, the geochemical proxies for water quality to be delivered by this project, and their correlation with various coral community types and mortality events, will provide a hitherto unavailable long-term baseline by which the projected benefits for corals of improved water quality may be evaluated. By looking into the past, therefore, managers should be better able to define reasonable expectations for coral diversity, health and changes under climate change scenarios, and the water-quality management strategy that is expected to ameliorate temperature stress on corals. In particular, if we can reconstruct SST, salinity and turbidity at the time of the mid-1930s collapse in Acropora corals at our study site, it may help define environmental domains that should be avoided in future. In addition, our study focuses particularly on past coral bleaching and mortality rates and community structure change in the inshore reefs severely influenced by the runoff of Burdekin and Fitzroy Rivers, which have the largest catchment areas and highest sediment influx into the GBR lagoon. This study will deliver much needed knowledge to improve our understanding of the links between coastal ecosystems and their influences on the GBR ecosystems. Through high-precision (up to ±1-2 years) U-series dating of past coral bleaching and mortality events and correlate the timing of such events precisely with historic land-use and coastal development practices, it is now possible to pinpoint the causal relationship and identify the dominant factors responsible for reef decline or specific mortality events so that better targeted management strategies can be put into place. The emerging knowledge of these relationships could be used in education and extension programs in support of present and future catchment management initiatives.

In summary, our integrated project seeks to correlate the historical changes in the ecology of GBR inshore reefs with major anthropogenic stressors (e.g. water quality changes) and with natural and anthropogenically-derived climatic events over the past several millennia through European colonization of the Queensland coastline and up to the 21st century. The study has four mutually dependent sub-projects or **task objectives** (equivalent to independent projects derived from other EOIs) that rely on the same fieldwork, sampling, and geochronological framework, which is significantly more cost effective:

I) Palaeoecological reconstruction of coral mortality events, coral reef community structure changes, reef accretion, and coral calcification prior to and since European settlement based on high-precision U-series dating of sediment cores through the reef matrix.

II) Reconstruction of past climate variability prior to and since European settlement (***natural stressors***)

III) Reconstruction of past seawater characteristics prior to and since European settlement (***anthropogenic stressors***)

IV) Correlation of palaeoecological changes with major natural climatic (e.g. Medieval Climatic Optimum ~800-1300 AD, and Little Ice Age ~1400-1900 AD) and anthropogenic disturbance events (e.g. changes in water quality), for assessing the impacts on coral reef biodiversity and identifying drivers of ecological change.

Key Objectives

(a) Determine the decadal death rates of inshore reef corals over the last 150 years (since European settlement) based on high-precision U-series dating of surface death assemblages (Pandolfi, Roff, Zhao, Feng, McCook, Done, RA, Ph.Ds#3/4).

(b) Reconstruct reef accretion rates and coral mortality rates over the past 1-2 millennia based on high-precision U-series dating of sediment cores from the back reef environment (Roff, Pandolfi, Smithers, Zhao, McCook, Done, RA, Ph.Ds#3/4).

(c) Reconstruct the history of coral calcification using high-precision CT-scanning techniques for linear extension and density measurements of corals recovered from sediment cores and long-lived coral specimens (Pandolfi, Zhao, Roff, McCook, McCulloch, RA, Ph.Ds #1, 3/4).

(d) Determine the variation in coral reef community structure prior to and after European settlement based on palaeoecological analysis of sediment cores (Pandolfi, Roff, McCook, Done, RA, Ph.Ds#3/4).

(e) Quantify past SST, SSS and ENSO variability and cyclicity prior to and after European settlement based on geochemical proxy analyses (Sr/Ca, Mg/Ca, 18O/16O) of U-series-dated coral cores and long-lived coral specimens (Zhao, Yu, Lewis, McCulloch, Feng, RA, Ph.D#5).

(f) Reconstruct past sea-level variability based on high-precision dating and elevation survey of well-preserved fossil microatolls (Smithers, Lewis, Yu, Zhao, Ph.D#2).

(g) Reconstruct cyclone history and frequency over the past 1-2 millennia through precise dating of transported reef blocks, cyclone ridges and lagoon sediment cores (Yu, Zhao, RA).

(i) Assess water quality change since European settlement based on geochemical proxy analyses of coral cores in close spatial association with palaeoecological data retrieved in Objectives a and g (Lewis, McCulloch, Yu, Zhao, Feng, Ph.D#2).

(j) Reconstruct past seawater alkalinity variation and recent acidification based on high-precision boron isotope analyses of selected coral cores (including corals derived from sediment cores from Objective d) (McCulloch, Ph.D#1).

(k) Correlate palaeoecological changes with major natural climatic and anthropogenic disturbance events (the whole team).

(l) Assess the impacts on coral reef biodiversity and identify drivers of ecological change (the whole team).

Project / Task Methodology

This project aims to reconstruct both high-resolution, multi-proxy records of environmental parameters and ecological history of coral reef communities, and their accretion rates and patterns of coral calcification during the past 1-2 millennia, identified by IPCC AR4 as a crucial period with considerable uncertainty and paucity of high-resolution proxy data, especially in the Southern Hemisphere. A major goal is to disentangle the impact and trend of recent European settlement from natural and human-induced global climate change, principally by correlating in time major ecological changes with specific physical environmental drivers. We will use existing systematic field surveys of living (where data are available and our own surveys from photo quadrats/transects where they are not), dead (from rubble collections on the sea floor), and fossil coral assemblages (from sediment cores) to reconstruct a yearly, decadal, centennial to millennial history of coral reef communities in nearshore GBR coral reefs. This information will be integrated with palaeoecological, geochronological and geochemical tools to address and quantify the cumulative effects of multiple environmental factors (SST, seawater acidity and salinity, cyclones, major floods, runoff and water quality) that have been identified in the GBRMPA Outlook Report as likely to have a major impact on GBR reef health and biodiversity under global warming scenarios.

Table 1: U-series dates allow three episodes of mortality at three sites (PA, PB and PC) of a single reef to be clearly defined.

Sample Name	^{230}Th Age (AD)
PA6A1	1949±2
PA3A1	1950±1
PA6A2	1951±2
PB4B2	1984±1
PB7A1	1991±1
PB7B2	1997±1
PB1A1	2003±2
PC2A1	1935±2
PC4A1	1936±3
PC4B2	1937±3

Our approach is to investigate a number of geo-archives, including surface death assemblages, back-reef sediment cores, fringing reefs backed by historic photographs, massive coral cores, cyclone-transported reef/coral blocks, storm ridges, and lagoon sediment cores from a broad latitudinal stretch of the GBR. We will use pioneering geochemical techniques, such as boron-isotope-based ocean acidification studies, proxy-based paleoenvironmental and water quality analyses, and microatoll-based sea-level studies.

During MTSRF 1.1.4, we completed a pilot project on the history of coral reef communities from the Palm Islands. Our work established the efficacy of using high-precision U-series chronology of coral reef community changes to understand the present condition of coral reefs and environmental drivers of ecological change. Through U-series dating of surface death assemblages and systematically collected short sediment cores (2-5 m long), our study allowed us to pinpoint the collapse of *Acropora* corals on Pelorus reef, an inshore reef of the Great Barrier Reef, to around the late 1930's to early 1950's. At nearby sites, we demonstrated that there have been natural cycles of *Acropora* coral mortality and recovery prior to European settlement. Together these results raise the question of whether the 1930's to 1950's "no-return" collapse represents the crossing of some critical threshold and a shift to more sediment tolerant assemblages. This would imply there are now long-term chronic stressors, superimposed on natural climatic cycles, as a proximal cause of reef decline. In the case of our Palm Islands study area, the proximal driver is likely to be elevated sediment flux from the Burdekin River following European Settlement from 1870 onwards.

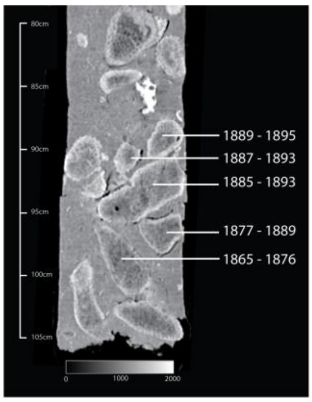

Figure 1: CT scan of a

In this project, we will now extend these studies to encompass inshore reefs adjacent to a range of catchments along the GBR, including a much-needed lower impacted site. We will focus on three key sites:

Far North GBR: in the vicinity of Princess Charlotte Bay (including the Ribbon Reefs), where coastal influences have been much reduced in comparison to the other regions. The combination of this lower impacted site with other high-impacted sites will enable us to separate local/regional stressors (e.g. water quality, cyclone) from global stressors (e.g. bleaching, ocean acidification). For this region, we will use AIMS RV James Kirby for field investigations and sampling.

Central GBR: To complement our heavily impacted Palm Islands site examined during MTRSF Project 1.4, we will target reefs adjacent to the Wet Tropics World Heritage Area near Cairns. These 'Wet Tropics' sites will include Dunk Island, Bedarra Island High Island, and Russell Island. So far no studies using our integrated approach have been undertaken in this area, but modern AIMS surveys exist. Apart from collecting surface death assemblages and back-reef sediment cores, many of the inshore and fringing reefs in this region also contain abundant massive *Porites* or microatolls, as well as cyclone ridges and uplifted reef blocks ideal for sea-level, cyclone and geochemical proxy-based palaeoclimate reconstructions. To sample in this region, we will use chartered boats for the easily accessible sites, and RV James Kirby for the more difficult sites, aiming at reducing the costs of fieldwork.

***Southern GBR*:** We will focus on the Keppel Islands near Rockhampton, which is strongly affected by the second largest river in terms of sediment discharge into the GBR lagoon – the Fitzroy River. Although reefs at this site appear to be strongly influenced by increased turbidity, our recent pilot sampling and dating of the surface death assemblage suggest that *Acropora* growth was still prolific until recently. One possible hypothesis that may explain this observation is that prolific *Acropora* growth at this relatively higher latitude site may have benefited from warmer SST as a result of recent global warming. This situation was observed on Lord Howe reef (31º30'S, see Woodroffe *et al.*, 2010), Moreton Bay (Lybolt *et al.*, 2011) and Leizhou Peninsula, northern South China Sea (Song *et al.*, 2007). Data from this site in comparison with those from the highly impacted central GBR will allow us to obtain a better understanding of the relative roles of global vs. local/regional stressors. So far only surface death assemblages and coral cores have been collected. Additional fieldwork is needed to systematically collect back-reef sediment cores. To sample in this region, we will continue to use the chartered boat to reduce the costs of fieldwork.

Objectives (a,b): Determine decadal to millennial coral mortality, reef accretion rate and calcification rates based on high-precision U-series dating of surface death assemblages and sediment cores from the back reef environment

As described earlier, in our recent MTSRF Project 1.1.4 we showed that U-series dating provides unprecedented high-precision chronologies (up to ±1-2 year) of coral death assemblages and sediment cores through the reef framework, previously untenable by any other methods (see Table 1, Fig. 4). Following a successful ARC LIEF bid led by CI Zhao (with Pandolfi and Yu as co-investigators), a new-generation multi-collector ICP-MS was installed at UQ in April 2010, and is now fully operational, resulting in a reduction in the instrument measurement time for U-series dating by 5 times, effectively removed the "bottleneck effect" experienced by the old TIMS. Typical sample sizes are also reduced by 5-10 times if compared with TIMS, speeding up sample preparation and vetting processes.

In this project, we will use the same approach to determine decadal to millennial coral mortality and reef accretion rates in the other three sites. Our goal is to collect grab samples of surface death assemblages and extract two long (5 m) and four short (2 m) reef sediment cores (using aluminium pipe, 100mm diameter, 1.6mm wall thickness) from three sites from each of four selected islands from each of the three regions, resulting in 72 cores per region. This is based on an extraction rate of about 4 cores per day, something that can only be achieved using a vibra-coring device. Cores are taken from the leeward back-reef habitats in about 5 m water depth. Upon return to the lab the cores are split lengthwise in half. One half is archived at 1ºC, and the other is divided into 10 cm segments for community ecological and coral calcification through time analysis. The coral surface death assemblages will be collected by excavating loose coral rubble to an approximate depth of 20cm, which will be sieved through a 2mm sieve before removal from the site. This sampling strategy will allow a total of 432 surface death assemblage grab samples and 216 sediment cores to be collected. These samples will be transported to UQ, treated, and coral separated for U-series dating to establish their chronologies of mortality and reef accretion rates.

Objective (c,d): Determine the variation in coral reef community structure and coral calcification rates over the last 1-2 millennia against which to assess recent anthropogenic impacts based on palaeoecological analysis of sediment cores.

Ecologists have coined the term 'Shifting Baselines' for the perception within each new human generation that what they are experiencing is the natural pristine environment as it always has been.

Yet, just a passing glance at the bounty of past natural ecosystems shows profound environmental change (e.g. Lybolt *et al.*, 2011; Pandolfi *et al.*, 2003). Ecologists differ in their opinions on the current status of the GBR ecology probably due to this syndrome. As described previously, to address this problem, during MTSRF 1.1.4, we completed a pilot project on the history of coral reef communities from the Palm Islands. Our work established the efficacy of using high-precision U-series chronology of coral reef community changes to understand the present condition of coral reefs and environmental drivers of ecological change. In the present study, we will apply the same approach and methodology to address past variability of coral reef community structure in the other three sites and assess if recent global warming and increased human activity in the region have significantly affected reef health. The research project involves the following main phases: (1) penetration and recovery of sediment cores using a vibra-coring device, (2) assessments of living coral communities using video transects, (3) collection of death assemblages (surface coral rubble) at each site, (4) analysis of coral community structure from living, death and fossil assemblages, (5) quantification of reef framework fabrics and sedimentary facies within cores, (6) analysis of coral composition to determine temporal variability in community structure, (7) CT analysis of coral skeletons to assess temporal variations in coral growth and calcification, and (8) determination of U-series dates to constrain the timing of reef accretion.

Objective (e): Quantify past SST, SSS, ENSO and tropical monsoon variability and cyclicity prior to and after European settlement based on geochemical proxy analyses (Sr/Ca, Mg/Ca, 18O/16O) of U-series-dated coral cores

Although IPCC model projections show a general increase in tropical monsoons, there is a general weakening trend of the ENSO-monsoon relationship and conflicting models on the projected trends in El Niño-Southern Oscillation (ENSO). This uncertainty poses a substantial dilemma to management decisions in Australia as far as climate/hazard mitigation and adaptation policies are concerned, because flood/drought cycles in Australia are controlled by both climate systems. Recent studies on past ENSO records have been controversial, too with high resolution coral Sr/Ca and $\delta^{18}O$ records showing substantial spatial variability (Gagan *et al.*, 2004, for review). This regional variability actually reflects the differential response of temperature and precipitation to ENSO at different locations, which may be related to the combined influence of ENSO and the mean location of the Intertropical Convergence Zone (ITCZ). This means high-resolution site-specific reconstructions of SST and precipitation response to ENSO in Australia is essential for a better understanding of the past and improved prediction of future climate change.

Despite many complicating factors, it has been well demonstrated that coral $\delta^{18}O$ is influenced by both SST and seawater $\delta^{18}O$ (a measure of sea-surface salinity or SSS), whereas coral Sr/Ca is primarily a function of SST. Hence, we can determine past SST using coral Sr/Ca and then use Sr/Ca-SST to extract the SST-related component in $\delta^{18}O$ and obtain a residual $\delta^{18}O$ ($\Delta\delta^{18}O$) representing an offset of seawater $\delta^{18}O$ relative to the modern seawater value. Using this approach, Gagan *et al.* (1998) were able to demonstrate that seawater in the GBR ~ 5350 years ago was 1.2 °C warmer and enriched in ^{18}O by 0.5‰ relative to modern seawater. The result was interpreted as reflecting a higher evaporation rate at the study site due to a warmer SST, resulting in moisture transportation to the higher latitude regions of eastern Australia to supply a higher rainfall there. In addition, the seasonal variation pattern in $\Delta\delta^{18}O$ can be used as an indicator for annual-resolution drought and flooding events. The inter-annual variability in $\delta^{18}O$, Sr/Ca and $\Delta\delta^{18}O$ can be used to assess the regional temperature and precipitation response to ENSO activity. $\delta^{18}O$ can also be used in conjunction with Ba/Ca ratios to constrain past flooding events (McCulloch *et al.*, 2003; McCulloch *et al.*, 1994), with major flood peaks corresponding to significantly more negative $\delta^{18}O$ values and significantly elevated Ba/Ca ratios.

We plan to collect massive *Porites* cores from all three regions. Among these samples, we will first use their U/Th dates to select samples representing the optimal age intervals and then use optical microscopy, XRD and SEM to vet for diagenesis-free pristine samples for high-resolution Sr/Ca, Mg/Ca, Ba/Ca and $\delta^{18}O$ analysis. Sr/Ca, Mg/Ca and Ba/Ca ratios at monthly resolution will be measured on the LIEF-funded Thermo X-series quadruple ICP-MS at UQ, using a newly developed high-throughput protocol that achieves a long-term reproducibility (over 8 months period) of <0.2% for Sr/Ca, corresponding to SST uncertainty of ±0.3 ºC. Mg/Ca and Ba/Ca will be measured together with Sr/Ca for cross-checking purpose, with Ba/Ca as a palaeo-flood indicator (McCulloch *et al.*, 2003). In addition, the $\delta^{18}O$ values of the same sub-samples will be analysed in the Stable Isotope Laboratory at UQ.

Objective (f): Reconstruct past sea-level variability and timing and rate of recent accelerated sea-level rise based on high-precision dating and elevation survey of well-preserved microatolls

IPCC (2007) acknowledged that projected sea-level rise is likely to be geographically variable, mainly because (1) the tide-gauge records for the last century are largely inadequate and concentrated heavily in northwestern Europe, introducing a spatial bias into global analyses of tide-gauge records, (2) global patterns of sea-level change are always controlled by regional sea-level variability through isostatic and tectonic processes steric effects, longer-term gravitational changes produced by changing ice–ocean mass flux and hemispheric-scale perturbations in the Earth's rotatio. The term "eustatic sea-level" (the one projected by IPCC) is therefore merely a concept, not a measurable quantity. In this regard, longer-term site-specific sea-level records are essential for mitigation and adaptation purpose.

On the other hand, although post-glacial (i.e. since 7 ka) sea-level fluctuation has been a hot research topic for many years, there are a number of unresolved issues regarding, for example, (1) the nature of sea-level variations on millennial scale – debates exist between models of a smoothly falling sea-level since mid-Holocene, and stepped or oscillating sea-level characterized by several episodes of sea-level highstands; (2) the exact timing, duration and magnitude of sea-level highstands; (3) sea-level variations on shorter time scales, e.g. at decadal to century resolution relevant to human society and usable for risk assessment; and (4) the timing and rate of accelerated sea-level rise in the 20th century, which is still poorly constrained due to insufficient and biased tidal gauge data. Such unresolved issues are related to: (1) mixed use of different sea-level indicators, which may have different sea-level implications and precisions, (2) uncertainty in the mixed use of different dating techniques in different laboratories at different times leading to poor chronological control, (3) proxy data lacking sufficient age or spatial resolution, and (4) spatial variability. Consequently, no sea-level curve is applicable on a global scale. The development of regional and local estimates of future sea-level rise incorporating past temporal and spatial variability - required for determining the causes of recent acceleration in sea-level rise for effective risk assessment - is one of the primary challenges in coming years.

In contrast to many other sea-level indicators, detailed sea-level movements on millennial to annual time scales can be determined using accurate elevation survey and high-precision U-series dating of individual rims of fossil microatolls. Previous studies show such microatolls are ideal sea-level indicators as the elevations of microatoll heads grow within a restricted range below the low spring tide level (e.g. Smithers and Woodroffe, 2000; Smithers and Woodroffe, 2001; Yu *et al.*, 2009a). Microatolls with ages covering the entire mid-Holocene to present interval of time are present on numerous reef sites along the length of the Great Barrier Reef (Chappell, 1983; Hopley *et al.*, 2007; Lewis *et al.*, 2008; Woodroffe and Gagan, 2000), but so far only one study on Magnetic Island is based on U-series chronology (Yu and Zhao, 2010) and no study based on U-series has ever been carried out in the Torres Strait.

In this study, we will carry out field investigations and sample collections in conjunction with other objectives. Detailed elevations will be measured for each sample and will then be dated by the high-precision U-series method with UQ's Nu Plasma MC-ICP-MS. This study will specifically answer the following questions:

(1) Millennial scale sea-level variations, especially the exact timing, duration and magnitude of sea-level highstands.

(2) Sea-level variations on decadal to century scales relevant to human society and highly-relevant for risk assessment.

(3) The timing and rate of accelerated sea-level rise in the 20th century.

Objective (g): Reconstruct cyclone history and frequency over the past 1-2 millennia through precise dating of transported reef blocks, cyclone ridges and lagoon sediment cores

Tropical cyclones are also likely to have large spatial and temporal variability. Holocene records of tropical cyclone frequency have been obtained for some areas of the GBR and Torres Strait (Nott, 1997; Nott and Hayne, 2001; Nott *et al.*, 2009), which show that the frequency of "super-cyclones" in this region is highly variable on century scales, and the frequency prior to the 20th century is much higher than previously assumed, posing a severe threat to coastal communities. However, the temporal resolution of these records is low, and the chronologies need to be verified and refined.

The frequency and magnitude of cyclones can be recorded in various archives, such as transported blocks, storm ridges/ramparts, lagoon and coastal sediments (sediment structure and grain-size distribution), near-shore lakes, sinkholes or swamps (fingerprints of sea-water surges), and even tree-rings and speleothems. Through dating and characterising such geological archives, cyclone histories can be reconstructed. In our previous studies, we discovered excellent correlation between the ages of transported coral blocks and coarse-grained lagoon sediment peaks on Yongshu Reef in the South China Sea (Yu *et al.*, 2009b), and thus interpreted the sediment peaks as recording cyclone/tsunami events (or clusters of cyclone/tsunami events) and the peak sizes as reflecting the intensity of the events (Yu *et al.*, 2004; Yu *et al.*, 2009b; Yu *et al.*, 2006). These studies demonstrate the combination of cyclone block dating and sediment grain size distribution analysis provides an adequate means of constructing a complete record of storm activity over the past few thousand years.

In this project, we plan to collect cyclone-uplifted reef/coral blocks, storm ridge coral rubble, and lagoon sediment cores from reefs in the Wet Tropics and Princess Charlotte Bay regions. The collected samples will be dated by U-series at UQ using the MC-ICP-MS and grainsize distribution of the lagoon sediment cores will be analysed using a laser particle size analyser at 1-cm core increments. The data will be used to construct a complete history of cyclone activity, especially its variability and cyclicity on multiple time scales, and the frequency of the largest cyclones in the two regions.

Objective (i): Assess water quality change since European settlement based on geochemical proxy analyses of coral cores in close spatial association with palaeoecological data retrieved in Objectives a and g.

Increased nutrient and pollutant loading and terrestrial discharge in the GBR lagoon as a result of land use and urban development have been considered as one of the main drivers of inshore reef degradation. A number of geochemical tools such as Ba/Ca, Mn/Ca, P/Ca, REE/Ca and other trace elements in coral skeletons have been developed by the team members (e.g. McCulloch, Lewis, Yu and Zhao in their separate research of corals in the GBR and the South China Sea) as excellent indicators for monitoring the change in water quality.

In this project, we plan to undertake a systematic annual to monthly resolution geochemical proxy-based study of coral cores across a water quality gradient from inshore reefs in the above three regions. Considering the budget constraint, we will use monthly-resolution Ba/Ca analyses of coral cores derived from Objective (e) to constrain terrestrial discharge events and rates and compare the data with ecological data from Objectives (a-d) at no extra cost to the project. In addition, we will undertake annual multiple trace element analyses of coral cores from the above three regions. A total of 1200 trace element analyses were budgeted, targeting the time periods identified to have experienced major ecological changes. The ultra-low trace elements typical of corals will be measured on the ARC LIEF-funded quadruple ICP-MS at UQ, following well-established ultra-clean analytical protocols. This analytical work will be performed by a new Ph.D enrolled at JCU.

Objective (j): Reconstruct past seawater alkalinity variation and recent acidification based on high-precision boron isotope analyses of selected coral cores in conjunction with back-reef sediment cores

Ocean acidification as a result of increasing anthropogenic CO2 in the atmosphere has been considered as one of the most serious global threat to coral reefs. To characterize past seawater alkalinity variation (i.e. pH change) and assess recent acidification rates, our team member Prof

McCulloch has pioneered the use of high-precision boron isotope analyses by thermal ionization mass spectrometry (Pelejero *et al.*, 2005; Wei *et al.*, 2009).

In this study, we will adopt the same approach developed by Wei *et al.* (2009) to undertake annual to 5-yearly resolution boron isotope analyses for coral cores from all three sites, covering key periods identified as having experienced major ecological changes. For most of the periods, 5-yearly resolution will be sufficient. For assessing the cause of identified major events, annual-resolution data will be obtained. A total of 300 boron isotope analyses are budgeted, which will cover a total of 1000-1500 years record. The work will be carried out at UWA by a Ph.D student under the supervision of Prof McCulloch. This work will complement objectives 1a,b,e in ascertaining how increasing ocean acidification, warmer sea surface temperatures and land-based pollution from river runoff has effected coral calcification.

Objectives (k-l): Correlate palaeoecological changes with major natural climatic and anthropogenic disturbance events, assess the impacts on coral reef biodiversity and identify drivers of ecological change.

Throughout the duration of this project, data from all above objectives will be continually synthesized by our entire interdisciplinary team to assess the relationship between ecological changes on nearshore reefs of the Great Barrier Reef and climatic and anthropogenic drivers. On the basis of these syntheses, we will make key recommendations reef management agencies and other key end-users regarding practical adaptation and mitigation measures to protect these reefs.

Project Outputs/Outcomes

<u>Outputs:</u>

During the course of this project, the team will undertake systematic field investigation and sampling across reef sites from three major regions of the GBR, with numerous back reef sediment cores, surface death assemblage grab samples, coral cores, storm ridges, lagoon sediment cores being collected. A total of 2100 high-precision U-series dates will be obtained to establish a unique geochronological framework, with ~70% of the dates to serve Objectives (a-d) and the remaining ~30% serving the other objectives (mainly for Objectives f and g). The sediment cores will also be processed for X-ray/CT scans for assessing calcification rates, identification of corals to genus/species levels for ecological analysis, and grainsize analysis for cyclone reconstruction, with a lot of data being generated. In addition, from Objectives (e-g), the following dataset will be generated: 300 boron isotope analyses at annual to 5-year resolution by TIMS @400/analyses (50% from NERP/50% from UWA) for ocean pH study; 6000 high-precision monthly resolution coral Sr/Ca, Mg/Ca, Ba/Ca analyses @14/sample (50% from NERP/50% from UQ); 3000 bi-monthly resolution 18O/16O analyses @20/sample (50% from NERP/50% from UQ); and 1200 multiple trace element analyses by high-precision solution ICP-MS @40/sample (50% from NERP/50% from UQ); targeting major climatic and anthropogenic drivers and processes that are responsible for major ecological changes/processes identified from Objectives (a-d).

<u>Outcomes:</u>

There will be numerous outcomes being derived from this multi-institutional and multi-disciplinary research. Key outcomes that will be derived from one or a combination of several objectives are outlined below:

(1) Long-term palaeoecological records of coral reef community structure along the length of the GBR, to evaluate the ecological effects of both terrestrial runoff from agricultural activities in the GBR lagoon post-European settlement and climate changes.

(2) High-resolution chronological records of various climatic stressors such as sea-level, sea-surface temperature, salinity, alkalinity (or acidity), cyclone frequency and ENSO variability on different time scales over the past 1-2 millennia, enabling prediction of future response to these stressors over regional scales.

(3) Comparative geochemical proxy records of site-specific seawater quality variation prior to and since European settlement along a latitudinal gradient.

(4) Long-term trends in coral calcification in response to multiple stressors including climate and water quality changes over the past hundreds to thousands of years.

(5) Chronological records of coral reef mortality events and rates on regional scales and their correlation with global, regional and local stressors such as global warming and coral bleaching, ocean acidification, ENSO variability and floods/droughts, cyclones, sediment/nutrient discharge and pollution.

(6) Past analog of coral reef community response to past globally warm climate conditions (e.g. during the Medieval Warm Period) to assess the effectiveness of management strategies for future global warming scenarios.

(7) A high-resolution chronostratigraphic and sedimentary framework for the palaeoecological history of each reef.

In addition, through this project, we will develop and fine-tune an integrated, multi-disciplinary ecological, geochemical and geochronological approaches and analytical techniques, which have already been established by our team of biologists, geologists and geochemists. The project will enhance collaborative insights arising from shared expertise, experience and skills across these disciplines and also across institutions (UQ, UWA, JCU, AIMS, GBRMPA). Our collaboration will allow the full potential of available outstanding research infrastructure to be realized. Such approaches and techniques will be directly available for other researchers in Australia. Through this research, the team will be placed in a more competitive position to attract more funding from other Australian or overseas sources to enhance further environmental research in Australia.

This project will provide a rare opportunity and unique platform backed by world-class research environment, infrastructure and facilities across four research institutes for early career researchers to grow and take off. The scope of the research conducted will provide opportunities for development of a variety of skills, including evaluation and problem solving, in a research area that is of worldwide significance, and has considerable economic value in Australia. It is also a particular goal of the project to re-invest in Australia's scientific community, recruiting and retaining Australian Intellect. A large number of early career researchers and Ph.D students will directly participate in this multidisciplinary research effort

Expected benefits to end-users

A) The historical range of both ecological and environmental variation will be defined so that a natural baseline can be used as a metric for how degraded inshore reef systems now are. Thus reef and catchment managers (DERM, GBRMPA), the Australian government (DSEWPaC, Reef Rescue), and industry (QLD Canegrowers) will be informed if there is a "shifting baseline" problem when making decisions on conservation, adaptation and mitigation measures.

B) A precise chronology of both long-term ecological patterns and trends occurring since European colonization, coupled with an understanding of the climatic and anthropogenic events, will enable understanding of the drivers of ecological change on the GBR. Once drivers are known, appropriate management actions can be applied (GBRMPA), and policies formulated (DERM; DSEWPaC). Importantly, industry (QLD Canegrowers) will be informed about how, and the extent to which, their activities are related to reef health. .

C) Management goals will be placed in an historical context, so that conservation measures can be evaluated against this historical record, enabling the success of management actions to be assessed (DERM, GBRMPA; DSEWPaC).

D) A history of coral calcification over the past millennium will enable an historical context for understanding more recent changes in calcification on the GBR (e.g. De'ath *et al.* 2009), and in understanding the climatic drivers of these changes. Managers will have a clearer idea of both the climatic as well as land-based (river-runoff) influences on coral calcification and reef resilience generally (DERM, GBRMPA; DSEWPaC).

E) An expanded history of climate change and anthropogenic influences set against a backdrop of the natural temporal history of nearshore reefs, including cyclone records, environmental change, and ecological response, will enable industry (AMPTO, QLD Canegrowers) to understand the extent to which, if any, their activities affect the ecology of the nearshore GBR reefs. This information will also be key in the Australian government's (DSEWPaC, DERM, Reef Rescue) efforts to formulate environmental policy from catchment to reef.

Structure and governance

Our project will have three research nodes distributed in UQ (or Brisbane), UWA (or Perth) and JCU (or Townsville), respectively. The UQ node will be led by Zhao and Pandolfi and consist primarily of existing team members on MTSRF Project 1.1.4 (Zhao, Pandolfi, Done, McCook, Yu, Roff, Rodriguez-Ramirez), as well as several new members (Feng, one new RA, and three new Ph.Ds) and be responsible for U-series dating, geochemical and ecological analysis of sediment and coral cores for a range of objectives. The UWA node will be led by McCulloch, responsible for TIMS boron isotope analysis and seawater acidity studies through supervision of a new Ph.D student. The JCU node will be led by Smithers and Lewis, who will be responsible for environmental baseline proxy (water quality) and microatoll-based sea-level study of inshore reefs. Each of the research objectives will be conducted by several expertise-based team members crossing institutional boundaries. The funding allocation will be split and managed by each node separately for the purpose of management convenience. Each university looks after its salary budget. The splitting of the operating budget, which is mainly for analytical work, is essentially laboratory-based, except that JCU will look after its budget for U-series dating of microatolls (for sea-level) and multiple trace element analyses that will be carried out at UQ RIF Lab. The bulk of the travel budget, mainly the fieldwork and shipment costs for sample collections, will be looked after by UQ. A small budg*et al.*location of travel goes to UWA and JCU mainly for the purchase of transportation of personnel to field sites and for attending meetings. Fieldwork will be carried out in a coordinated way, and collected samples, facilities and data will be shared among all members of the team. Cross-institutional joint supervision will also be arranged for future research students recruited to this project so that the students will receive maximum benefit in research training.

Identified and assessed hazards

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	RA is being appointed. Advertisement will be put up on several mail-lists shortly for Ph.D candidates
Failure to obtain samples from the field sites due to unpredictable weather conditions	Medium	We plan to use James Kirby for drilling at difficult sites and other means for easily accessible sites. A flexible cost-effective fieldwork plan will be developed to avoid carrying out fieldwork during bad weather.
Failure to obtain analytical data due to instrumental breakdown	Medium	We have both TIMS and MC-ICP-MS that can perform dating so the chance for both to breakdown at the same time is low. Also we can arrange access to other labs such as those at UWA, ANU or Melbourne should this occurs.
Departure of key project personnel	Low	All the investigators on the team have appointments for the duration of this project. Should departure of key personnel occur, we have many other suitable members with sufficient expertise in our institutions to take up the role.

Description of Risk	Assessed Risk	Risk Control measures
Failure to achieve outcomes due to dependence on outputs from other projects	Low	Our project has very little dependence on the outputs from other projects.
Failure to achieve uptake of results by end-users	Medium	Workshops/meetings will be convened with key end-users at various key project stages to ensure engagement and delivery of results in a useful form.

Links and dependencies to other hubs and projects

This project was the only one derived from the UQ-led EOI selected by DSEWPaC to form the Tropical Ecosystem Hub – the Great Barrier Reef Node. It contains a number of inter-dependent sub-projects which are equivalent in essence to individual projects derived from several other EOIs led by JCU, AIMS and CSIRO. All these sub-projects rely on the same set of fieldwork and geochronological framework, aimed at delivering the most cost-effective outcomes.

The delivery of this project has no dependencies on any other hubs or projects. However, in terms of research questions, it is linked to several other NERP projects such as 3.3, 4.1, 4.3 and the e-Atlas (GBR). We continue to view our work as linking to a large number of projects within the hub by providing a long-term temporal perspective of ecological dynamics and environmental change. Without this temporal perspective, interpreting drivers of short-term variability can be misguided. We also view our work as highly relevant to the goals and approaches developed within the Torres Strait Island Node. We would welcome any opportunity to apply similar techniques and approaches to questions of immediate interest to the Torres Strait Islands.

Project Budget

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	328,571	-	328,571
The University of Queensland	-	510,715	510,715
University of Western Australia	-	62,143	62,143
James Cook University	-	47,380	47,380
Total	**328,571**	**620,238**	**948,809**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	328,571	-	328,571
The University of Queensland	-	510,715	510,715
University of Western Australia	-	62,143	62,143
James Cook University	-	47,380	47,380
Total	**328,571**	**620,238**	**948,809**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	328,571	-	328,571
The University of Queensland	-	510,715	510,715
University of Western Australia	-	62,143	62,143
James Cook University	-	47,380	47,380
Total	**328,571**	**620,238**	**948,809**

AWP 4 (July 2014 to Decemberember 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	164,286	-	164,286
The University of Queensland	-	255,357	255,357
University of Western Australia	-	31,071	31,071
James Cook University	-	23,690	23,690
Total	**164,286**	**310,118**	**474,404**

Program 2: Natural Resources of the Torres Strait Land and Sea

Program 2 will have three projects assessing the condition and trend of Torres Strait assets. One will provide information on marine turtles and dugongs that complements the study of these species on the GBR including data on movements and connectivity of populations. Aerial surveys will be conducted to estimate abundance as the importance of healthy stocks to Torres Strait communities cannot be overestimated. A second project will make baseline surveys of mangrove communities and freshwater habitats on Torres Strait islands. The former is important in shoreline stabilisation and as a littoral habitat. The latter provide potential stepping stones for invasive freshwater species from Australia's northern neighbours and represents a long term threat to the freshwater faunas of Cape York and elsewhere in northern Australia. The third project will design and implement a reef health monitoring program that will be delivered by indigenous sea rangers and initiate monitoring of sea temperatures through a combination of remote sensing and real-time monitoring. The latter has been requested by the TSRA following the first account of widespread coral bleaching in the Torres Strait in 2010.

Project 2.1: Marine turtles and dugongs of Torres Strait

Project Leader and Host Organisation

Name	Dr Mark Hamann / Professor Helene Marsh		
Position			
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Unit	School of Earth and Environmental Sciences		
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	Townsville		
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Email:	mark.hamann@jcu.edu.au / helene.marsh@jcu.edu.au		

Project Team

Title	Organisation	Role
Dr Mark Hamann	JCU	Project leader and co-supervise PhD student/post doc
Prof. Helene Marsh	JCU	Oversee dugong tracking and co-supervise PhD student/post doc
Dr Lynne Van Herwerden	JCU	Supervise dugong genetics
Prof. David Blair	JCU	Supervise dugong genetics
Dr Alana Grech	JCU	Oversee analysis of spatial data
Dr Mariana Fuentes	JCU	Supervise dugong tracking
Research Officer	JCU	Field and logistic operations
Dr Nancy FitzSimmons	Uni of Can	Supervise green turtle genetics
Dr Col Limpus	QEHP	Marine turtle advise, provision of hawksbill turtle data from GBR
TS Community rangers/TSRA staff	TSRA/Various communities	Field and logistic operations
Frank Loban	TSRA	Oversee TSRA LSMU staff and ranger involvement as well as field and logistic operations
Technical officer	JCU	Objectives 1,2 & 3
Research Officer	JCU	Objectives 1,2 & 3

Summary Table of End-users

Organisation	Organisational Contact	Email
TSRA	Damian Miley Frank Loban	damian.miley@tsra.gov.au frank.loban@tsra.gov.au
DSEWPaC	Karen Arthur Amy Cmic Nathan Hanna John McDougall Peter Komidar Shaun Barclay Kate Thomann David Calvert Charles Brister Leah McKenzie Kate Sanford-Readhead	karen.arthur@environment.gov.au amy.cmic@environment.gov.au Nathan.hanna@environment.gov.au John.mcdougall@environment.gov.au Peter.komidar@environment.gov.au Shaun.barclay@environment.gov.au Kate.thomann@environment.gov.au David.calvert@environment.gov.au Charles.brister@environment.gov.au Leah.mckenzie@environment.gov.au Kathryn.sanford-readhead@environment.gov.au
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AFMA	Shane Fava	shane.fava@afma.gov.au
QEHP	Col Limpus	col.limpus@ehp.qld.gov.au
QDAFF	TBC	

Project Duration

Start Date: 1 July 2011 End Date: 31 December 2014

Project Description / Task Objectives

The project will use monitoring, genetics, state of the art tracking and remote sensing to develop (a) an understanding of the status of marine turtles (b) a detailed understanding of turtle and dugong spatial ecology, plus the threats to these populations and (d) dugong population assessments. The project will both improve stakeholder understanding, capacity and skills to better manage priority species and provide valuable data that is useable and understandable to those making decisions regarding turtle and dugongs. We will enhance the ability of Government and community to manage these threatened species, and also add value to the evolving Turtle and Dugong Management Plans and the Land and Sea Ranger Program.

Key Objectives (2011 to 2014)

1. Determine the status of green turtles in Torres Strait – sex ratios, patterns of juvenile recruitment, nesting success and hatchling production (2011 to 2014).
2. Determine the status of hawksbill and flatback turtles in Torres Strait (2011 to 2014).
3. Use genetic markers and satellite tracking to understand population connectivity of dugong and green turtles in Torres Strait in relation to protected areas and community based management areas (2011 to 2013).
4. To determine if there are seasonal differences in the relative abundance of dugongs in western Torres Strait, especially the Dugong Sanctuary (2013/2014).
5. To determine the importance of western Torres Strait as habitat for green turtles (2014).

Project / Task Methodology

Region of activities – Torres Strait – various communities
Relevant end-users – DSEWPAC, TSRA, AFMA, GBRMPA, QDERM, QDEEDI, Torres Strait communities.

Objective 1 (status of green turtle**)** – In conjunction with the Torres Strait Regional Authorities (TSRA) Land and Sea Unit and the TSRA Community Ranger program seasonal surveys will be conducted in green turtle foraging and nesting sites of Torres Strait. Foraging sites will vary to cover as many different habitats as possible (e.g. one per year). Nesting sites will include Maizub Kaur (Bramble Cay) and Dowar Island (Mer Group). A workshop will be held in year one to compile existing data on marine turtles of Torres Strait and further develop methods for community based monitoring for marine turtles.

Objective 2 (status of hawksbill and flatback turtles**)** – In conjunction with the Torres Strait Regional Authorities (TSRA) Land and Sea Unit, the TSRA Community Ranger program, Iama community and Mabuiag Community seasonal surveys will be conducted and remote cameras deployed at Sassie Island and Malu Kiai (Deliverance Island) to quantify nesting events, which are suspected to be declining, and predation levels, which are speculated to be high. Data will then be used in combination with survey data collected by QDERM (Col Limpus) since 1992, and other life history and mortality data to determine a robust account of population status.

Objective 3 (population connectivity of dugong and green turtles**)** – In conjunction with the Torres Strait Regional Authorities (TSRA) Land and Sea Unit and the TSRA Community Ranger program we will track two dugong and three green turtles from western Torres Strait with GPS satellite transmitters to determine patterns of habitat use and behaviour. The tags applied to the three green turtles will be fitted with dive sensors to allow the first data to be collected on vertical habitat by Torres Strait green turtles. The dive information will be used to inform the aerial survey population estimates. The tracking project will build on existing (dugong) and previous (green turtle) projects therefore allowing more robust sample sizes. Genetic samples will be collected from dugongs and marine turtles to inform molecular connectivity.

Objective 4 (aerial survey) - An aerial survey will be conducted in western Torres Strait, including the Dugong Sanctuary and the area west of Orman Reef in November 2013 in association with a parallel survey of the northern GBR. The survey will repeat transects flown in March 2011 and provide: (1) a valuable second dataset for the previously unsurveyed areas in the context of the key dugong and turtle area west of Orman Reef; (2) insights into seasonal differences in the use of the region by dugongs and green turtles.

Objective 5 (analysis of historical turtle data) –Turtle sightings data have been collected during seven dugong aerial surveys of Torre Strait since the mid 1980s, however these data have not been analysed. This project will analyse this historical data to examine patterns of turtle abundance in key areas such as western Torres Strait and the Dugong Sanctuary. Correction factors will be improved through the deployment of timed depth recorders on tracked animals in Torres Strait (objective 3) and through an associated externally funded project.

Links – TSRA Land and Sea Management Unit, Torres Strait Community based management plans, DSEWPAC Marine turtle recovery plan, QDERM marine turtle monitoring project, The National Partnership approach for sustainable use of marine turtles and dugongs in northern Australia. GBRWHA marine turtle NERP projects, TS NERP Themes 2 and 3.

Project Outputs/Outcomes

Outputs

1. Defined status of the green turtle in Torres Strait
2. Defined status of the hawksbill and flatback turtles in Torres Strait
3. Improved understanding of ecological and biological connectivity and habitat use of dugongs and marine turtles in relation to protected areas and community based management areas (tracking and genetics)
4. Improved understanding of the abundance of turtles and dugongs within the Dugong Protected Area in western Torres Strait
5. Improved understanding of the abundance of dugongs in western Torres Strait and the dugong sanctuary using aerial surveys

Outcomes

1. Improved population viability and stability of marine turtles and dugong
2. Improved stakeholder understanding, capacity and skills to better monitor and manage priority species
3. Improved non-indigenous participants knowledge of traditional ecological knowledge and cultural aspects of turtle and dugong management

Project Risk Management

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	We have suitable and experienced staff in mind for employment in all positions.
Failure to obtain data	Medium	All field trips will be collaborations with the TSRA Land and Sea management unit and the relevant community group(s). Many of the turtle objectives can be conducted at several sites, which makes organization more flexible. Animal ethics and QPWS Permits currently exist for proposed marine turtle research and

Description of Risk	Assessed Risk	Risk Control measures
		dugong tracking.
Failure to achieve outcomes due to dependence on outputs from other projects	Low	There is a very low reliance on data from other projects.
Failure to achieve uptake of results by end-users	Medium	Workshops/meetings will be convened with key end-users at various key project stages to ensure engagement and delivery of results in useful form. Representatives from end-users will also participate in field work – such as TSRA L&SMU staff, rangers and community members.

Project 2.1 – Turtle and Dugong – Budget

Life of project – Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	750,000	-	750,000
JCU	-	758,300	758,300
Uni of Canberra	-	13,000	13,000
QDERM	-	TBA	TBA
TSRA L&SMU	-	TBA	TBA
Total	**750,000**	**771,300**	**1,521,300**

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	217,000	-	217,000
JCU	-	221,000	221,000
Uni of Canberra	-	13,000	13,000
QDERM	-	TBA	TBA
TSRA LSMU	-	TBA	TBA
Total	**217,000**	**234,000**	**451,000**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	191,000	-	191,000
JCU	-	221,000	221,000
Uni of Canberra	-	13,000	13,000
QDERM	-	TBA	TBA
TSRA LSMU	-	TBA	TBA
Total	**191,000**	**234,000**	**425,000**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	316,000	-	316,000
JCU	-	221,000	221,000
University of Canberra	-	13,000	13,000
QEHP	-	TBC	TBC
TSRA (LSMU)	-	205,397	205,397
Total	**316,000**	**439,397**	**755,397**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	26,000	-	26,000
JCU	-	95,300	95,300
Total	**26,000**	**95,300**	**121,300**

Project 2.2: Mangrove and Freshwater Habitat Status of Torres Strait Islands

Project Leader and Host Organisation

Name	Dr. Norm Duke and Dr. Damien Burrows		
Position			
Organisation	James Cook University		
Unit	Australian Centre for Tropical Freshwater Research		
Postal Address		Delivery Address	
	James Cook University		
	Townsville		
	Qld 4810		
Phone	07 4781 4262 (Burrows)	Mobile	0419 673 366 (Duke)
Email:	norman.duke@jcu.edu.au / damien.burrows@jcu.edu.au		

Project Team

Title	Organisation	Role
Dr. Norm Duke	JCU	Joint Project leader (mangroves)
Dr. Damien Burrows	JCU	Joint Project leader (freshwater)
Research assistants	JCU	Field and office research assistance

Summary Table of End-users

Organisation	Organisational Contact	Email
TSRA	Damian Miley Simon Conaty	damian.miley@tsra.gov.au simon.conaty@tsra.gov.au
Torres Strait Regional Council	Shire Engineer	info@tsirc.qld.gov.au
NAILSMA	Joe Morrison	joe.morrison@nailsma.cdu.edu.au
Qld Wetlands Programme	Mike Ronan	mike.ronan@derm.qld.gov.au
DSEWPaC	John McDougall Shaun Barclay Kate Thomann Kate Sanford-Readhead	John.mcdougall@environment.gov.au Shaun.barclay@environment.gov.au Kate.thomann@environment.gov.au Kathryn.sanford-readhead@environment.gov.au

Project Duration

Start Date: 1 July 2011 End Date: 30 June 2014

Project Description / Task Objectives

This proposal covers both mangrove and freshwater habitats of Torres Strait islands.

Mangrove and Tidal Wetland Habitats

Torres Strait islands have extensive mangrove margins and several islands (e.g. Saibai, Boigu) are predominantly made up of intertidal swamps (including mangroves, tidal saltpans and salt marsh). Despite this, there has been no thorough assessment of the diversity, extent and health of mangrove ecosystems there. Establishing the baseline of mangrove 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 are among the most threatened ecological communities in Torres

Strait. They are also a shoreline community that plays a vital role in mitigating the effects of oceanic intrusion, depending on its resilience and capacity to adapt. Mangroves buffer coastlines against waves and provide erosion protection. It is thus important that these ecosystems remain intact and to understand the role these habitats play in providing such protective and beneficial services.
Implicit in this project, is that Torres Strait islanders have a long and intimate knowledge of mangrove 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. A recent rapid survey of Boigu Island mangroves by Dr Duke discovered that while the number of mangrove species known to scientists and managers was significantly increased from 18 to 30, these were already well-known locally and named. The current proposal builds on this understanding, where scientists are better off working in partnership with traditional owners to fully describe and document new and existing knowledge of mangrove habitats throughout Torres Strait.

Freshwater Wetland Habitats

Whilst the marine (seagrass and coral reef) ecosystems of Torres Strait are fairly well known, the freshwater ecosystems are almost unknown (or at least unrecorded). For most islands, it is not known (or at least recorded) what freshwater ecosystems are present, whether they are permanent and what their biota, condition and status are. There is thus a serious lack of baseline data on this important ecosystem type in Torres Strait.

Whilst there is not expected to be an extensive array of freshwater habitats on most islands, the few that are present are likely to be of high ecological and/or social value. The ephemeral nature of most freshwaters on the islands makes them vulnerable to disturbance (eg, humans or feral animals such as pigs or toads) and climate change. Thus, establishing a baseline of current condition is important to detect any future trends in the condition of the resource.

The co-project leader (Burrows) has recently confirmed the existence of the exotic fish climbing perch on Saibai and Boigu Islands and has alerted relevant stakeholders to the very real threat posed by a variety of other, even more serious exotic fish that have recently invaded the southern coastline of PNG, and pose a serious threat to Torres Strait freshwater environments and even Cape York. Surveys for these pests will form part of the project activity.

We propose a project to examine the status, diversity and condition of mangroves and freshwater habitats in the Torres Strait. This will provide a snapshot of the status of the resource, recommendations for better management of the resource, and provide a baseline against which future changes can be assessed and will also enable planning for adaptation to potential sea level rise/increased storm surge.

Key Objectives

To gain an appropriate understanding of these vital wetland habitats, we must firstly fully describe what is there, where it is, and what condition it is in. We propose to do this in full collaboration with traditional owners, with the added objective of not only gaining local custom knowledge but also to learn more about the vulnerability and resilience of these highly threatened natural ecosystems.

Overall project goals are:

1. Undertake a baseline survey of the status and condition of mangroves and freshwater wetland habitats in Torres Strait.
2. Document knowledge of selected communities about their uses of mangrove and freshwater habitats
3. Provide management advice for these habitats where required
4. Survey freshwater fishes across the islands, especially for the presence of exotic fishes and aquatic plants
5. Assess mitigation options for mangroves, protection/management/rehabilitation needs, and climate change-related adaptive strategies

Project / Task Methodology

Tidal wetland habitat (mangrove, tidal saltmarsh and saltpan) classification and mapping

The assessment of status and condition of mangroves will be based on a combination of aerial imagery and on-ground surveys. Aerial imagery will include comparisons (where possible) between historical and contemporary aerial imagery. On-ground surveys will include determination of any areas of dieback, inventories of diversity and assessment of structure and biomass. The project leaders have recently done similar wok on mangrove biodiversity on Boigu Island for TSRA, discovering one mangrove species new to Queensland and another new to Australia.

The proposed baseline survey goal above has four possible integrated elements, depending on available funding:

A. Shoreline aerial ecological surveys using oblique geo-videography for all land-sea margins throughout the study region providing a comprehensive account of key habitats present, noting condition and processes (including known and reported instances) taking place along the shoreline.
B. On-ground survey data, gathered with the assistance of land and sea rangers, to systematically record, describe and quantify the status and condition of fringing shoreline habitats throughout the study region – noting more specific vegetative condition like dieback, presence of plant mutations, notable erosion, presence of seedlings, along with verified lists of species present in each habitat assemblage.
C. Mapping and quantification of the full extent of coastal vegetation units (like tidal and freshwater wetlands), how these units have changed in area and condition since earlier times – using aerial imagery where available to record notable occurrences of vegetation dieback and expansion, and overall changes to habitat health reflected in vegetative condition.
D. Field based verification for each of notable vegetation unit observed in the other elements to, characterize and quantify floral and faunal biodiversity, biomass (as possible blue carbon stores) and abundance of each - as well as, an assessment of condition and health for each shoreline habitat.

Freshwater wetland habitat classification and mapping

The assessment of status and condition of freshwaters will include delineation of the extent of freshwater habitats and assessment of their condition and management needs. The project leaders have recently done similar work on Boigu Island for TSRA, finding new populations of exotic climbing perch and uncovering historical information about the loss of freshwater springs on the island. Fish surveys will be conducted on each island as will inventories of other flora and fauna in the freshwater habitats. The presence of exotic species will be of particular interest, especially exotic fishes and cane toads. Patterns of biota occurrence between the islands and adjacent continental areas will be examined. Artificial waterbodies on each island, such as dams, will be included in this work.

All work will include thorough literature and professional contact reviews of any existing work relevant to the topics here. Islands and locations that should be prioritised for assessment will be discussed with TSRA and TSRIC before fieldwork commences.

Project Outputs/Outcomes

The outcomes of this project will provide material to report back to communities and also provide a starting point for discussions about community usage and management of mangroves and freshwater habitats. The status assessment will also indicate any locations that require management and/or further monitoring and the adaptive potential of mangroves forests in relation to potentially rising sea levels.

Products and outcomes of the project offering tangible and lasting benefits include:

1. Reports on assessment of status and condition of mangroves and freshwater habitats in Torres Strait

2. Extensive baseline data on mangrove condition, diversity and community structure against which future changes can be assessed.
3. Extensive baseline data on freshwater habitats, fish and exotic fish and aquatic plants.
4. A renewable and expanding archive of geo-referenced maps and imagery, available online with assessments of past and current condition of coastal and estuarine habitats, aided by a new web access platform called ShoreView, complimented by a community science partnership program called MangroveWatch (www.mangrovewatch.org.au) coordinated by Dr Duke;
5. Community dialogue on values and management of mangroves and freshwaters and increased awareness, especially among land and sea rangers

Linkages

As indicated above, this project will provide strong linkages with the community-based Mangrove Watch program (see http://www.mangrovewatch.org.au/) which the co-project leader (Dr. Norm Duke) operates. Currently, Dr. Duke is negotiating the expansion of the Mangrove Watch program into Torres Strait, for adoption by land and sea rangers. Mangrove Watch is a community-based mangrove monitoring tool and is only being discussed for islands with functioning land and sea rangers groups, whereas this current project provides a comprehensive scientific baseline assessment of mangroves across many islands. Nonetheless, the two projects provide significant value-adding linkages.

This project has linkages with public awareness programs currently being implemented over stopping the spread of exotic fishes into and through the Torres Straits. These were initiated by the co-project leader (Burrows) and are now run by DEEDI and AQIS.

Project 2.2 Budget

AWP 1 – (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	160,000	-	160,000
JCU	-	169,000	169,000
Total	**160,000**	**169,000**	**329,000**

AWP 2 – (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	160,000	-	160,000
JCU	-	160,000	160,000
Total	**160,000**	**160,000**	**320,000**

AWP 3 – (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	180,000	-	180,000
JCU	-	180,000	180,000
TSRA (LSMU)	-	70,547	70,547
Total	**180,000**	**250,547**	**430,547**

Identified and assessed hazards

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	Personnel are already employed.
Failure to obtain data	Low	The project is based around field sampling, not experimental. There are many suitable options for field sites if some become unavailable
Departure of key project personnel	Medium	Centre-based staff arrangement means there is some skill redundancy.
Failure to achieve outcomes due to dependence on outputs from other projects	Low	There is limited such dependence
Failure to achieve uptake of results by end-users	Medium	Workshops/meetings will be convened with key end-users at various key project stages, including before project start and at planning stage of each field season to ensure engagement and delivery of results in useful form.

Project 2.3: Monitoring the health of Torres Strait coral reefs

Project Leader and Host Organisation

Dr Ray Berkelmans, Australian Institute of Marine Science

Project Team

Title	Organisation	Role
Ray Berkelmans	AIMS	Project leader, coral bleaching
Scarla Weeks	UQ	Current conditions reports
Scott Bainbridge	AIMS	Real-time observing stations
ADC technician	AIMS	Temperature loggers
Technicians	AIMS	Real-time observing stations
Hugh Sweatman	AIMS	Project leader, coral reef ecology
AIMS GBR Long-term Monitoring Team	AIMS	Monitoring and assessment
LSMU staff	TSRA	Participation in monitoring

Summary Table of End-users

Organisation	Organisational Contact	Email
TSRA	Vic McGrath John Rainbird Damien Miley Frank Loban	Vic.mcgrath@tsra.gov.au John.Rainbird@tsra.gov.au Damian.Miley@tsra.gov.au Frank.Lobanr@tsra.gov.au
GBRMPA	Paul Marshall David Wachenfeld	paul.marshall@gbrmpa.gov.au roger.beeden@gbrmpa.gov.au
AFMA	Shane Fava	Shane.Fave@afma.gov.au
DSEWPAC	John McDougall Shaun Barclay Kate Thomann Nathan Hanna Kate Sanford-Readhead	john.mcdougall@environment.gov.au Shaun.barclay@environment.gov.au Kate.thomann@environment.gov.au Nathan.hanna@environment.gov.au Kathryn.sanford-readhead@environment.gov.au

Project Duration (Entire Project)

Start Date: 1 July 2011 End Date: 31 December 2014

Project Description / Task Objectives

The reefs of Torres Strait are threatened by a variety of local and global agents: notably climate change (widespread coral bleaching was recorded for the first time in 2010) but also by the coral-feeding crown-of-thorns starfish and increasing levels of coral diseases.

This project involves a detailed biodiversity assessment of coral communities on selected reefs to bridge a critical gap in knowledge of “What’s out there?”, “What’s unique?” and “What’s their relationship to fisheries and other resources?”. This and other information will be used to select sites for monitoring to look for changes in the condition of coral reefs in the Torres Strait, with the intention that LSMU employees will gain experience to be able to be able to continue the monitoring and reporting and adapt the program in response to changing needs and threats.

As part of this project, an early warning system will be established for coral bleaching in the Torres Strait. This will give the TSRA, communities, industry and other government agencies the ability to predict, prepare for and respond to coral bleaching. Resources can be prioritised and mobilised to adequately quantify bleaching impacts. Communities and industry in high risk areas can prepare and implement contingency plans. Early warning will also enable the TSRA to be in charge of timely information to feed back into the community and key stakeholders (incl government) about the extent and severity of bleaching and address concerns.

The priority objectives for the first year are:

1. Conduct a detailed biodiversity assessment of coral reefs in the Torres Strait involving LSMU rangers and synthesise with local knowledge and existing data on TS reefs. This will form the basis for planning the on-going monitoring program.
2. Review and establish interim bleaching thresholds for the TS.
3. Select sites for temperature loggers and real-time observing stations. Deploy loggers with LSMU rangers and develop logger exchange protocols. Build and install one real-time observing station.
4. Acquire and process satellite data for the TS region, generating long-term climatologies for the region. Prepare “current conditions and forecast” summaries and for the TS region and update monthly.

Key Objectives

1. Build on extensive previous surveys of reef resources by the CSIRO [CMAR] by adding information on biodiversity and conservation value for a range of sites representing the various different types of reefs and regions of the Torres Strait seascape. Biodiversity surveys to involve LSMU staff and draw on local knowledge.
2. Consult with TSRA and community to design a monitoring program for reefs of Torres Strait that addresses community needs.
3. Train a field monitoring team of up to 6 LSMU rangers (so that more than one individual can fulfil each role) and implement an effective reef monitoring program, to be run by the LSMU.
4. Establish a data management system for data capture and delivery of appropriate and useful data products using the e-Atlas.
5. Establish an early warning system for coral bleaching based on the best-available knowledge of bleaching thresholds and a real-time environmental observing system for key parameters, including temperature and light. One real-time observing stations will be included in the western Torres Strait.
6. Establish a network of non real-time temperature loggers at 15 sites to adequately capture the range of thermal regimes in the Torres Strait.
7. Provide regular updates on current coral reef conditions and summer forecasts for bleaching risk. These updates are a compilation of all available satellite and in-situ data together with forecasts from POAMA and NOAA bleaching risk models and will be provided to key stakeholders.
8. Assist the TSRA in developing a bleaching response plan to effectively deal with the next coral bleaching event.
9. Transfer knowledge and technology to LMSU Rangers to exchange temperature loggers, perform diagnostics and maintenance of real-time monitoring stations and provide field verification of bleaching.
10. Identify ways in which the reef monitoring program might expand into additional sites and/or adopt alternative tools as capacity increases and should additional funds become available
11. Facilitate uptake of project outputs and outcomes to key end-users and stakeholders (TSRA, TS rangers, DSEWPAC, researchers, TS community), through production of outcomes in forms suitable for upload to e-Atlas (data layers for mapping, plain English article(s), metadata); and establishment of a network of data kiosks in strategic locations throughout Torres Strait.

Project / Task Methodology

1. In Year 1:
   a. Using sites selected on the basis of past surveys of reefs and in consultation and collaboration with the LSMU, AIMS staff will make rapid assessments of reef biodiversity and condition. LSMU rangers will first need to be trained as divers (budgeted) and in survey methods. The surveys will involve use of a charter vessel and LSMU staff. Biodiversity information will be summarised in a final report and also fed into the e-Atlas.
   b. Consult with TSRA, LSMU staff and relevant TS researchers and select the optimal placement of loggers and real-time monitoring stations. Deploy loggers at 15 sites (2 loggers/site at different depths) and train LSMU rangers to exchange loggers on a 6-12 monthly basis (depending on site accessibility). Logger data will provide a more comprehensive picture of temperature than can be provided by the real-time observing stations, especially during thermal stress events. These will also enable characterization of spatial and temporal patterns in temperature in the Torres Strait and help develop/refine locally specific bleaching thresholds.
   c. Conduct site inspection, undertake detailed design and install one real-time observing station in the western TS before the 2011/12 summer, at or near Thursday Island, where the intensity of bleaching was greatest in 2010. The real-time station will provide real-time data on water temperature, tide, salinity, surface light and a range of standard weather variables (wind speed and direction, humidity, air temperature, rain). Six data kiosks (computer displays) will provide an instant view of current and recent conditions on the water to local communities. Kiosks could be located at local schools, shops or points of community gathering. These kiosks will combine data from local observing stations with weather forecasts from BOM and relevant local information from e-Atlas. In addition to the data kiosks all data will also be available generally over the internet via the e-Atlas.
   d. Prepare regular outlook reports. These will compile existing and relevant satellite and in-situ data with interpretation to assess current conditions and seasonal outlook. Satellite data will be acquired and processed for the past 10 yrs and long-term means generated to allow forecast of anomalous conditions. Data will include regional and local temperature, winds, currents, sea-surface height, ENSO Indices and NOAA and POAMA seasonal forecasts. Outlook reports will be delivered monthly.

2. In Years 2 to 4:
   a. Establish a training/ capacity building package for TSRA LSMU staff including sea rangers for reef monitoring and data management. Consult potential users to design the most useful presentation of data outputs for the e-Atlas. Based on past surveys and in consultation with TSRA, establish monitoring sites and survey them with LSMU Rangers.
   b. Conduct 6-monthly maintenance trips and train LSMU rangers to undertake diagnostic tests and perform basic maintenance of the real-time observing station.
   c. Train and build capacity in TSRA LSMU staff including LSMU rangers to report bleaching.
   d. Continue regular outlook reports.
   e. Conduct a spatial and temporal analysis of temperature data in the Torres Strait and review bleaching thresholds.
   f. Establish a data management system for data capture and delivery of appropriate and useful data products using the e-Atlas. Provide recommendations for expansion of the monitoring program and adoption of other tools should further resources become available.

Risks

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	Most FTE involvement will be by re-assigning staff already employed by AIMS
Failure to obtain data	Medium	• There is a high risk that no data will be retrieved from some loggers. This is mitigated against by deployment of 2 loggers per site and having loggers at multiple sites. • There is a high risk of sensor failure or station failure with the real-time observing system for some period of time. This is mitigated against by early feedback of failure (i.e. real-time data not arriving) and modular construction of station allowing components to be swapped out. LSMU rangers will be trained to undertake basic diagnosis and component swapping. • For the Current Conditions and Seasonal Outlook reports there is a dependency on two projects in the GBR NERP being approved (WQ, Fabricius; and sea birds, Congdon). The cost of basic and ongoing satellite data processing is shared among these three projects. If one or both of the two GBR NERP projects are scrapped, extra funding will be required to do the monthly current conditions reports • There is a high risk of bad weather preventing access to some planned biodiversity assessment and on-going monitoring sites. This is mitigated against by planning field surveys for summer when trade winds abate. Where sites are accessible by small boats, missed sites may be re-surveyed at a later date. Where access is only possible by large boats, missed sites may be more difficult to re-survey.
Departure of key project personnel	Low	Tasks and responsibilities of key staff can most likely be assigned to another staff member. If not, key staff will be replaced.
Capacity building of LSMU rangers for coral reef monitoring will not reach the required standard for future independent monitoring (post NERP)	Medium	A realistic assessment and appraisal of LSMU capacity will be included in the final report along with recommendations for future successful on-going community-based monitoring.
Failure to achieve uptake of results by end-users	Medium	Workshops/meetings will be convened with key end-users at various key project stages to ensure engagement and delivery of results in useful form.

Delivery and Adoption of Results

Coral reef biodiversity survey results will be delivered as a report. The report and spatial data layers on diversity, coral cover and size class frequencies will be made available through the e-Atlas. Biodiversity survey results will be used to select and implement the on-going monitoring program. The report and data layers will also provide the basis for future marine park planning initiatives. Results from on-going monitoring will be delivered through the e-Atlas.

Data and information from real-time observing station will be delivered via the e-Atlas as well as through a number of local “data kiosks”. These are essentially a customised computer display with several tabs which scroll through recent trends and observations from the real-time stations, marine wind and weather forecasts from BOM and relevant information from other projects to the local area from the e-Atlas. The content of the displays will be developed in consultation with the TSRA. A total of 6 data kiosks are budgeted for.

Synoptic overviews of ocean and atmospheric conditions and seasonal forecasts reports will be delivered via the e-Atlas and as a slide show emailed directly to key stakeholders. These will focus strongly on thermal anomalies as they develop in summer and will include bleaching early warnings from the real-time observing station.

Links and Collaborations

a. TSRA LSMU ranger activities, especially the sea-ranger program. Diver training (through Cairns TAFE) and training in all aspects of the logger and reef monitoring program will be provided to rangers to support full engagement in six-monthly exchange of temperature loggers at most of the proposed 15 sites, maintenance of real-time observing stations, undertaking coral reef biodiversity surveys and on-going monitoring.
b. AIMS long term monitoring program for coral reefs and water quality on the GBR
c. TS NERP projects: Water quality hazard assessment (3.x); e-Atlas (3.x)
d. GBRMPA BleachWatch and bleaching workshops
e. Ranger sea country surveillance and monitoring activities.
f. Community-based seagrass monitoring through Seagrass-Watch, including sites where temperature loggers have been used on seagrass beds.

Benefit to End-users and Community

1. Improved knowledge of Torres Strait coral reefs, their value to fisheries and other major resources.
2. Essential data layers will be available to enable future MPA planning and resource use allocation to be undertaken.
3. Improved knowledge and responses of Torres Strait reefs to thermal stress.
4. Ability to predict, prepare and respond to challenges that arise from major changes to coral reef ecosystem, especially bleaching.
5. Ability for TSRA to be the source of timely and accurate information which will build trust and credibility with communities who crave to know what is going on during and after bleaching disturbances.
6. Ranger capacity in diving, monitoring coral reefs and in interpreting changes. Ability to continue the program in subsequent years and adapt it in response to any new threats or conditions.
7. Safer boating with accurate real-time observations of marine weather and tide conditions (a spinoff from the real-time observing station, but one that communities may value greatly).

Project Budget

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	**280,070**	-	**280,070**
AIMS	-	250,589	250,589
UQ	-	24,000	24,000
TSRA		60,000	60,000
Total	**280,070**	**334,589**	**614,659**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	**274,682**	-	**274,682**
AIMS	-	274,665	274,665
UQ	-	24,000	24,000
Total	**274,682**	**298,665**	**573,347**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	178,814	-	178,814
AIMS	-	177,690	177,690
UQ	-	24,000	24,000
TSRA (LSMU)	-	300,000	300,000
Total	**178,814**	**501,690**	**680,504**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	129,434	-	129,434
AIMS	-	74,700	74,700
UQ	-	11,000	11,000
Total	**129,434**	**85,700**	**215,134**

Program 3: Condition and Trends of North Queensland Rainforests

Program 3 will have four projects focussed on biodiversity drivers of Queensland's Wet Tropics rainforests, particularly rainforest refugia and hot spots of genetic diversity in the World Heritage Area and adjacent Cape York regions. The Program will deliver species distribution models and composite biodiversity maps using long term data sets to describe patterns of environmental change. The Program will also search for remnant populations of critically endangered frogs and monitor the abundance of key vertebrate species such as the Cassowary and the Spectacled Flying Fox. Results from Program 2 will contribute to State of Environment and World Heritage reporting for the Wet Tropics World Heritage Area, and provide information to assist the development assessments under the *EPBC Act 1994*.

Project 3.1: Rainforest Biodiversity
a. Monitoring
b. Climate change vulnerability and adaptation
c. Determinants of biodiversity – synthesis and integration
d. Status, trends and future predictions

Project Leader and Host Organisation

Name	Prof Stephen E. Williams		
Position	Senior Principal Research Fellow		
Organisation	James Cook University		
Unit	Centre for Tropical Biodiversity & Climate Change School of Marine & Tropical Biology		
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	James Cook University		
	Townsville Qld 4811		
Phone	07 4781 5580	Mobile	
Email:	stephen.williams@jcu.edu.au		

Project Team

Title	Organisation	Role	FTE
Prof S.E. Williams	JCU	Principal Investigator	0.5*
A/Prof J. Van Der Wal	JCU	Spatial Ecologist	0.3
Dr Brett Scheffers	JCU	Post-doctoral Fellow	1.0
Dr Cassandra James	JCU	GIS Technician	0.4
Nadiah Roslan	JCU	Research Assistant	1.0

* Williams is also Rainforest Node leader and this 0.5 EFT includes time commitment to integrating and strategic planning across the rainforest node in addition to the specific contributions to the research in this project

Summary Table of Key End-user contacts

Organisation	Organisational Contact	Email
WTMA	Andrew Maclean	Andrew.Maclean@wtma.qld.gov.au
NPRSR	Andrew Millerd	Andrew.Millerd@nprsr.qld.gov.au
FNQROC	Travis Sydes	T.Sydes@cairns.qld.gov.au
Terrain NRM	Rowena Grace Carole Sweatman	rowenag@terrain.org.au caroles@terrain.org.au
DSEWPaC	Margaret Considine Kate Sanford-Readhead David Calvert Peter Latch TBC Karl Newport	Margaret.considine@environment.gov.au Kate.sanford-readhead@environment.gov.au David.calvert@environment.gov.au Peter.latch@environment.gov.au Anthony.whalen@environment.gov.au Karl.newport@environment.gov.au

Project Duration

Start Date: 1 July 2011 End Date: 31 December 2014

Project Description / Task Objectives

This project will provide detailed mapping of present and future biodiversity patterns and drivers, environmental and evolutionary refugia and a comprehensive assessment of the vulnerability and resilience of rainforest biodiversity in Australian tropical forests. We will use a combination of available knowledge, existing datasets and strategic research to inform adaptive strategies for promoting persistence of biodiversity. This knowledge will enable efficient spatial and temporal prioritisation of vulnerable species and threats to maximise the efficiency of management investment.

Utilising the significant potential of the Wet Tropics as a “learning landscape”, we will capitalise on previous investment in biodiversity research in the region to maximise the national benefits of this research via the development of biodiversity science, analytical approaches/tools, resources, capacity and expertise that will be disseminated both nationally and internationally. The ambitious aims set out below are only possible due to the strategic, collaborative, end-user driven research program proposed within the Rainforest node of the TE NERP hub and the existing capacity and data within the Centre for Tropical Biodiversity and Climate Change (CTBCC) at James Cook University (directed by Williams).

A broad objective of this project is to build and maintain strong collaborative links to most other projects within the rainforest node and extensive external links to the other NERP hubs, and other national and international collaborations. Outcomes of the whole rainforest node will be greatly enhanced via this role as a focal point of synthesis, integration and interpretation of much of the biodiversity research across other projects. We will also, as much as possible, value-add to many of the other proposed projects by i) providing co-access to sites, all available biodiversity and environmental datasets and analytical tools developed under MTSRF, ii) by providing biodiversity and spatial analysis expertise and resources, and iii) by developing an easy pathway for uptake and dissemination of knowledge in useable formats into regional/national/international data infrastructure initiatives such as the Atlas of Living Australia (ALA), Terrestrial Ecosystem Research Network (TERN), National Climate Change Adaptation Research Facility (NCCARF) and Global Biodiversity Infrastructure Facility (GBIF).

Key Objectives

This project will act as an integrating focus within the rainforest theme to strategically target research gaps and thereby increase our understanding of the drivers of rainforest biodiversity. We will achieve this goal using a combination of existing data and research capacity within the CTBCC, ongoing long-term monitoring that builds on previous MTSRF investment, strategic gap filling and collaboration across the other projects within the Tropical Ecosystems hub, the Northern Biodiversity and AEDA hubs and links to research funded under other initiatives (e.g. ARC, NCCARF, CSIRO) (see Table above). The project will promote integration and synthesis of biodiversity data across the NERP Rainforest projects in order to inform management about spatial and temporal trends in biodiversity status, trends, threats and vulnerabilities.

Key objectives include:

1. Mapping of biodiversity values and trends in time;
2. Increased understanding of the environmental biodiversity pattern and process in Australian rainforests;
3. Increased understanding of the relationships between rainforest ecosystems and biodiversity such that this knowledge can be utilised in conservation planning and prioritisation, policy and management;
4. An understanding of the threats, vulnerability and adaptive capacity of rainforest biodiversity to global climate change to inform prioritisation and adaptation management that result in positive biodiversity outcomes;
5. An understanding of the relative importance of landscape structural features that promote ecosystem resilience such as refugia, habitat connectivity and heterogeneity, seasonal and long term environmental stability, and management of key ecosystem processes.

Project / Task Methodology

A. Monitoring

A comprehensive review of regional literature followed by extensive stakeholder consultation identified long-term monitoring data as the most important knowledge gap in the region (Welbergen et al. 2011). This sub-project is aimed at maintaining and significantly improving a regional-scale, long-term environmental monitoring program that provides biodiversity and environmental data that has a demonstrated value to a wide range of users including the research community, regional/state/national management agencies and conservation policy development, and national / international bioinformatic infrastructure initiatives (e.g. ALA, TERN). Data collected and maintained here will provide the primary input for the other sub-projects described below with flow-on inputs to many of the other proposed projects across the rainforest node. These data will include but not be limited to:

1. Regional microclimate sensor network at more than 30 sites established under MTSRF that are strategically placed across elevational and latitudinal gradients in the region.
    - Replace microclimate stations with hygrobuttons to continue standardised established microclimate site monitoring (now defunct/worn out)
    - Establish standardised hygrobuttons in new sites in gaps in environmental coverage, identified climatic refugia, and increased coverage of the rainforest edge habitats (e.g. wet sclerophyll). Data: temperature (air, soil, microhabitats) and humidity.
2. Standardised vertebrate surveys across all long-term sites (>30) including:
    - 2-3 complete surveys per year for three years with 6 replicated sampling points within each site and including standardised surveys of: birds, reptiles, spotlighting (mammals and other nocturnal fauna) and microhylid frogs, with potential to add specific other groups dependent on student projects.
    - These surveys follow well-established and extensively published methodologies within the CTBCC (e.g. Williams et al. *Ecology* 2010).
3. Additional monitoring data will be harvested across the node for increased regional and taxonomic coverage and baseline data improvements via links and data exchange with NERP projects which are collecting empirical data.

B. Climate change vulnerability and adaptation

Climate change is arguably the single largest threat to biodiversity in Australia and the unique biodiversity of the Wet Tropics rainforests is recognised as one of the most threatened ecosystems globally (IPCC 4th AR). This subproject will build on previous and existing research to provide cutting-edge predictions on climate change impacts, vulnerability assessment and adaptation options for rainforest biodiversity. We will link closely with the National Climate Change Adaptation Research Network to ensure that outputs, tools and approaches are distributed across this network for maximum national and regional benefit and outcomes. Specific objectives and collaborative links include:

1. Produce and make available downscaled regional climate projections using eight Global Climate Models across multiple (at least 3) emission scenarios at 10 year time steps from 1970-2080 from more than 50 bioclimatic variables;
2. Projected changes, including uncertainty estimates, in species distribution models and composite biodiversity maps for the majority of rainforest vertebrates and many species of invertebrates, (baseline data for these analyses were collected under MTSRF and ongoing projects within the CTBCC);
3. Identify and map climatic refugia (extension of previous MTSRF work that mapped landscape-scale temperature refugia by Shoo et al. 2010a, 2010b). This analysis will expand previous work to include finer scale microhabitat refugia and also increase the generality of the analyses by examining moisture refugia and dry season drought events that have been shown to have significant impacts on biodiversity (Williams & Middleton 2008, Middleton & Williams in review).
4. Produce predictive impact models on biodiversity that explicitely include a consideration of extreme events rather than just environmental means/averages. Project will link closely with the extreme climate events project (Project 7.3 – Welbergen) to incorporate the impacts of changes in the frequency, intensity, duration and extent of extreme events, such as heat waves and droughts, as a major component of assessing relative vulnerability and adaptation actions;
5. Other external links:
    - NCCARF Refugia project (National) - proposed
    - NCCARF Terrestrial Biodiversity Research Network
    - Northern Biodiversity NERP Hub

- AEDA Hub – Restoration project and Future Fellowship (Wintle) examining demographic modelling and climate change.

6. Incorporate IPCC 5th Assessment Report climate models and scenarios into all above analyses, once they become available.

C. Synthesis, analysis and integration: determinants of biodiversity

An understanding of the drivers of biodiversity in the region is crucial to predicting impacts from a variety of threats and ensuring effective conservation planning and management that aims to maintain a resilient landscape. We will use data collected in subproject A in combination with our existing extensive vertebrate and invertebrate database to examine the drivers of biodiversity in the region and to provide the resources and knowledge to make this useful to stakeholders. Specific objectives will include, but not be limited to:

1. Mapping of almost all rainforest vertebrates and 200+ species of invertebrates (distribution and abundance) with emphasis on threatened species;
2. Identify key locations and taxa where we have long-term count data and/or high frequency of repeat count surveys over time periods that have encompassed important environmental change. We will undertake statistical power analyses to evaluate condition and trends of species (e.g., range shifts, change in population size);
3. Analyses will also inform the design of our ongoing monitoring program (subproject A) to maximise the detection of change in a cost-effective manner.

D. Status, trends and future projections

No practical measure currently exists to evaluate trends in biodiversity values at the ‘whole-of-region’ scale in near real-time on a regular, repeatable and affordable basis (WTMA Research Strategy 2010-2014). We will generate high resolution maps and landscape scale estimates of temporal trends in the condition of biodiversity and environmental changes. This will be the major vehicle for synthesizing, integrating and communicating data from all projects. This project will make use of extensive computing power represented by the collaboration between the CTBCC and the James Cook University eResearch group and High Performance Computing Facility. Specific objectives:

1. Produce and make publicly available a spatial and temporal resources tool that allows web-based query of all the above datasets based on a user-defined spatial area that will return all predicted and observed data within the query area for climate (past, current and future projections), habitat, species (predicted and observed), biodiversity values, terrain, ecosystem processes and, where available data is site-based, the tool could query the temporal patterns in the data (e.g. changes in abundance of a species) with “approaching real-time” updates (expected bi-annual upload of all new biodiversity and environmental data with temporal resolution dependent on the specific data stream, example quarterly for the standardised vertebrate surveys).
2. Automatic upload, synthesis and visualisation in JCU eResearch group (Tropical Data Hub) including time series examination of trends;
3. Automated upload via Tropical Data Hub onto National (ALA, TERN, NPEI) and international (GBIF) data infrastructure. This means that as data is entered into our system from the monitoring program and other projects, it will be uploaded and available via national and international data portals;
4. Future forecasting of trends and forecasts via combination of modelling and workshopping to conduct future horizon scanning.

Once established, these bioinformatic tools could form the basis for UNESCO, and Queensland and Australian government reporting on the state of the Wet Tropics World Heritage Area, and could easily be utilized more generally across other ecosystems in Australia.

Project Outputs/Outcomes

Specific outputs and outcomes are listed within each sub-project (above). General project outcomes include:

- Detailed, and publicly available, mapping of past, current and future status and trends in biodiversity and the environment.
- Increased understanding of the drivers of biodiversity that will inform evidence-based policy and management
- Comprehensive assessment of the relative vulnerability of the regions biodiversity to global climate change.
- Spatial and temporal prioritisation of the conservation status of most rainforest vertebrates, significant invertebrate groups, vegetation classes and ecosystem processes.
- Provision of the necessary biodiversity data for systematic conservation planning in the region that accounts for global climate change (link Pressey project).
- Significant regional capacity building and early career training
- Production of globally leading research tools and expertise that will be exported nationally and internationally.

Expected Benefit to End-Users

The project consists of four subprojects that will each deliver into appropriate program and NERP themes and address high priority research needs of NERP program, stakeholder research gap analysis (GAP), Wet Tropics Management Authority (WTMA) and Terrain NRM. Links to other TE NERP projects, other NERP Hubs and external links are identified in the table below.

Program Theme		**Project**	**Research Priorities**			
			NERP	**GAP**	**WTMA**	**Terrain**
Monitoring, Status and Trends	3.1a	Monitoring	1, 2	1, 3, 4	A,E	3, 5
Risks and Threats	3.1b	Climate Change vulnerability and adaptation	3	2,4,6, 8	A, B	3,5
Integration, Analysis and Synthesis	3.1c	Drivers of biodiversity pattern and process	1, 2, 3	2, 4, 6, 7, 8, 10	A,B, C	3,5
Communication, Interpretation and Knowledge Brokering	3.1d	Status of the environment reporting and future predictions	1,3, 4	2,3,4, 7, 10	A,B,C	3,4,5

Risk Assessment

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	There may be minor delays to employment of key staff but the CTBCC already has established staff that can gap fill until personnel have been employed.
Failure to obtain data	Low to Medium	The refurbishment of monitoring sites will mean slight delays to data collection but previous experience in establishment will mean this is minimal.
Departure of key project personnel	Medium	This is unlikely however we have sufficient capacity within the CTBCC to cover any unforeseen departs and we will actively train staff to duplicate essential skills.
Failure to achieve outcomes due to dependence on outputs from other projects	Low	Although other projects will value add to this project, this project is not dependent on other projects to achieve its outcomes.
Failure to achieve uptake of results by end users	Low to Medium	Workshops/meetings will be held with key end users at various key project stages to ensure engagement and delivery of results in useful form. Key parts of this project are aimed at knowledge brokering and communication so this potential risk will be minimal.

Project 3.1 A,B,C,D Budget

AWP 1 – 2011/2012 Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
James Cook University –July 2011 to June 2012	100,000	403,521 SEW 64,000 RA 67,200 JVW 40,000 GIS 72,000 PD	746,721
Total	**100,000**	**646,721**	**746,721**

AWP 2 (July 2012 – June 2013) Project Funding and Partnerships

Contributing Organisation	NERP	JCU Cash	In-kind	Total
JCU	295,714	50,000	SW 403,521 RA 64,000 JVW 67,200 GIS 40,000 PD 72,000	992,435
Total	**295,714**	**50,000**	**646,721**	**992,435**

AWP 3 (July 2013 – June 2014) Project Funding and Partnerships

Contributing Organisation	NERP	JCU Cash	In-kind	Total
JCU	295,714	50,000	SW 403,521 JVW 64,000 BS 67,200 CJ 40,000 NR 72,000	992,435
Total	**295,714**	**50,000**	**646,721**	**992,435**

AWP 4 (July 2014 – December 2014) Project funding and Partnerships

Contributing Organisation	NERP	In-kind	Total
JCU	147,858	38,500 31,118 17,995 16,988 49,406	301,865
Total	**147,858**	**154,007**	**301,865**

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

Project Leader and Host Organisation

Name	Professor Darren Crayn		
Position	Director		
Organisation	James Cook University		
Unit	Australian Tropical Herbarium, JCU/CSIRO/Qld Govt. joint venture		
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	Cairns QLD 4870		
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Email:	darren.crayn@jcu.edu.au		

Project Team

Title	Organisation	Role
Prof Darren Crayn	ATH/JCU	Project Leader, contribute to all aspects, student supervision.
Dr Craig Costion	ATH/JCU	Postdoc. Project design, management, data collection/analysis/interpretation, communications (publications, reporting, stakeholder engagement)
Ms Kaylene Bransgrove	ATH/JCU	PhD student, fungal biodiversity component: Project design, management, data collection/analysis/interpretation, communications (publications, reporting, stakeholder engagement)
Ms Lalita Simpson	ATH/JCU	PhD student, mountain-top phylogeography component: Project design, management, data collection/analysis/interpretation, communications (publications, reporting, stakeholder engagement)
Dr Katharina Schulte	ATH/JCU	Project design, data analysis and interpretation (phylogeography), student supervision
Dr Sandra Abell-Davis	ATH/JCU	Project design, data analysis and interpretation (fungi), student supervision
Dr Dan Metcalfe	CSIRO	Project design, data collection/analysis/interpretation
Dr Maurizio Rossetto	Royal Botanic Gardens Sydney	Project design, data analysis and interpretation, articulation with separately funded SE QLD / NE NSW rainforest plant multi-species phylogeography project.
Prof Andy Lowe	U. Adelaide and State Herbarium of South Australia	Project design, data analysis and interpretation, articulation with TERN-LTERN.
Prof Stephen Williams	JCU	Data analysis and interpretation, integration with faunal and environmental datasets.

Summary Table of End-users

Organisation	Organisational Contact	Email
Wet Tropics Management Authority (WTMA)	Steve Goosem	steve.goosem@wtma.qld.gov.au
Terrain NRM	Rowena Grace	rowenag@terrain.org.au
Qld Dept. Environment and Heritage Protection (formerly Environment and Resource	Bruce Wannan	bruce.wannan@ehp.qld.gov.au

Management - DERM)		
Australian Natural Heritage Assessment Tool (ANHAT), Heritage Division, DSEWPaC	Karl Newport	Karl.newport@environment.gov.au
Australian Biological Resources Study (ABRS), DSEWPaC	Michael Preece	michael.preece@environment.gov.au
TERN-LTERN	Andy Lowe	andy.lowe@adelaide.edu.au
DSEWPaC	Peter Latch TBC Margaret Considine David Calvert Kate Sanford-Readhead	Peter.latch@environment.gov.au Anthony.whalen@environment.gov.au Margaret.considine@environment.gov.au David.calvert@environment.gov.au Kathryn.sanford-readhead@environment.gov.au

In this project we will work closely with the end-users listed above and deliver to them the following:

- Maps of taxonomic richness and phylogenetic diversity (PD) for flora across the NE Qld rainforests to inform conservation priority-setting
- Phylogenetic datasets for analysis by DSEWPaC's Australian Natural Heritage Assessment Tool (ANHAT), enabling downstream PD and other analyses of Wet Tropics and Cape York ecosystems, a research goal of ANHAT
- Community phylogenies to enable cutting-edge evolutionary ecology research in TERN-LTERN tropical rainforest plots
- Critical analysis of whether tractable proxies/correlates exist for PD that would enable more efficient biodiversity assessments in the study area
- Updated and enhanced assessments of the World Heritage values of the Wet Tropics, and critical data to inform development of the World Heritage nomination for Cape York Peninsula.
- Enhanced knowledge of the distribution and diversity of fungi and plants on mountain-tops
- Taxonomic opinions (and likely new species descriptions) on mountain-top fungi and plants found to exhibit variation not accounted for in current taxonomies

Project Duration

Start Date: 1 July 2011 End Date: 31 December 2014

Project Description / Task Objectives

This project will better characterise biodiversity refugia in NE Queensland rainforests by assessing genetic diversity at landscape scale in rainforest plants and fungi.

Australia's tropical rainforest in far north Queensland is internationally renowned for preserving one of the most complete and continuous records of earth's evolutionary history, and harbours much of the remaining Gondwanan flora that was once widespread across the continent. Little is known however, about the distribution of this evolutionary history within the region, particularly for plants and fungi. Where are the hotspots of evolutionary history and what correlations exist between these and hotspots of taxonomic richness and endemism? This study will investigate the distribution of plant and fungal taxonomic richness, endemism, and genetic diversity (as a measure of evolutionary history) across the wet tropics bioregion at the level of genus, species, and population. This information will provide a solid foundation for conservation prioritization efforts in the region.

The project consists of two nested subprojects. Project 'a' (PD analysis) will provide a broad scale analysis of patterns of genetic diversity (as phylogenetic diversity which measures evolutionary history/distinctiveness) across the NE Qld rainforests. Project 'b' (mountain-top diversity) takes a finer scale look at population-level genetic diversity in one highly restricted rainforest ecosystem – mountain-top rainforest – projected to be most threatened by climate change.

a) Rainforest biodiversity hotspots – phylogenetic diversity analysis

Measures of biological diversity underpin priority-setting of areas for conservation by government agencies (including DSEWPaC) in Australia. The most commonly used measure is taxonomic richness (the number of species per unit area). Phylogenetic diversity is an inherently superior measure because it accounts for evolutionary 'distinctiveness' but its intractability, due to the paucity of available phylogenetic information for most taxa, means taxonomic richness is frequently used as its proxy. However there is considerable debate over whether taxonomic richness is a good proxy. Recent work on the hyperdiverse heath flora of the Cape Region of South Africa suggests it is not. This study will investigate the relative performance of taxonomic richness and phylogenetic diversity measures for conservation priority setting in the Wet Tropics and Cape York rainforest contexts. We will use the results to identify and map areas of high biodiversity significance and investigate correlations with environmental and ecological variables. This research builds on a CERF Emerging Priorities investment (through the TRIN hub) in DNA-barcoding of tropical tree species undertaken in Crayn's lab (2010). This project could also assist DSEWPaC's Heritage division to interpret phylogenetic analyses and their meaning for conservation priority setting and national assessments.

b) Mountain-top biodiversity hotspots – genetic and floristic analysis

The mountains of the Wet Tropics and Cape York Peninsula represent cool islands in a sea of warmer (lowland) climates and harbour a very rich biota with high levels of endemism. The plants and fungi of these mountains are especially vulnerable to global warming as upward species' range shifts leave them nowhere to go. Studies on genetic diversity in mountain fauna have provided the underpinnings of informed management strategies for these groups. But almost nothing is known about genetic diversity of the co-occurring plants and fungi and findings from faunal studies cannot be extrapolated because long-lived and immobile plants will likely respond to environmental change very differently. Furthermore, for fungi we lack the most basic knowledge of which species occur in these threatened landscapes. We will address these major knowledge gaps by combining emerging genetic technologies with environmental, ecological and morphological information to: 1) elucidate the location and relative importance of high altitude refugia for plants in the Wet Tropics and Cape York Peninsula Bioregions and the mechanisms that influence the survival of populations and species; and 2) document the fungal biodiversity of the mountain tops. This will provide baseline data and predictive tools to help determine exactly what is at risk, predict likely responses of the flora to future climate change, and support evidence-based conservation and management decision making for whole tropical mountain ecosystems.

Key Objectives

Over the **life of the project** we will:

Subproject 'a' (PD)

1. Identify hotspots of evolutionary history (PD) in NE Queensland rainforest floras and explore correlations between these and taxonomic richness and endemism.

2. Test the performance of PD relative to taxonomic richness and endemism measures for estimating biodiversity and make recommendations as to the most efficient method to use for conservation priority-setting

3. Relate patterns of PD to environmental variables to infer evolutionary and ecological drivers

Subproject 'b' (mountain tops)

1. Identify the location of high altitude refugia and their relative importance by assessing population genetic diversity of selected mountain endemic plant species across their known range

2. Systematically survey the mountain-top fungal flora and catalogue their taxonomic richness
3. Explore possible correlations between patterns of fungal taxonomic richness and plant population genetic diversity in this biome
4. Discover and describe new taxa of mountain-top fungi and plants

Project / Task Methodology

For subproject 'a' (PD) we will:

1. compile a species distribution dataset based on ID-verified herbarium specimens (in collaboration with ANHAT and the major Australian herbaria through the Council of Heads of Australasian Herbaria);
2. generate a DNA-barcode dataset of 600+ species of rainforest plants using standard methodologies currently used in Crayn's lab
3. analyse the DNA data using 'Biodiverse' and other relevant software

This subproject builds on a CERF Emerging Priorities investment in DNA-barcoding of tropical tree species in Crayn's lab (2010). We will significantly expand this dataset with 100 more taxa to create a comprehensive and representative dataset containing the majority of the genera of higher plants occurring in the Wet Tropics Bioregion. This will provide a sound basis for assessing PD patterns across the rainforests of NE Queensland.

These datasets will be analysed against available environmental datasets to infer evolutionary and ecological processes influencing the observed biodiversity patterns.

For subproject 'b' (mountain tops) we will:

1. generate population genetic datasets for up to 15 populations of each at least 5 species of mountain-top endemic plants. Species selection will maximise representation of phylogenetic and functional groups, and biogeographical origins (Gondwanan versus Indo-Malayan). For species with distributions that extend to SE QLD / N NSW, samples will be obtained and analysis funded by Rossetto as an inkind contribution.
2. Standard Amplified Fragment Length Polymorphism (AFLP) methods will be used for most species since the wide taxonomic range of the organisms included in this study renders development of (co-dominant) microsatellite markers for all taxa cost- and time-prohibitive.
3. systematically survey and describe fungal taxonomic richness in mountain-top habitats.

Knowledge of Australian tropical mountain-top fungal species diversity is so poor that it is not yet feasible to undertake population genetic analysis on these organisms - the essential first step is to discover and document the species that occur there. Therefore we will undertake systematic forays for mountain-top fungi using standard systematic survey methodologies to determine what species are present (we will limit our study to macrofungi for reasons of feasibility) and their distribution and ecology. It is expected that numerous new species will be discovered (as has been the case for recent systematic macrofungal forays in nearby rainforest and woodland habitats by Abell-Davis) and described in collaboration with authorities on the relevant taxonomic groups.

We have conducted a preliminary risk assessment and identified risk control measures for this project as per the matrix below:

Identified and assessed hazards

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	Postdoc and PhD candidates (Costion, Bransgrove) who are committed to this project (should it be funded) have been identified.
Failure to obtain sufficient samples	Medium	Research and collecting permits already in hand. Plant species that are identifiable when sterile will be selected for analysis. Fungal forays will be timed to coincide with appearance of fruiting bodies, monitored by regular trips to local, easily accessible sites.
Departure of key project personnel	Medium	Ensure key team members are supported and engaged. Ensure PhD student progress is monitored closely through at least fortnightly meetings with supervisory team.
Failure to achieve outcomes due to dependence on outputs from other projects	Low	While project will potentially be enhanced by linkages with TERN-LTERN and Rossetto's SE QLD/N NSW phylogeography project, we are not dependent on these linkages to achieve proposed outcomes. Environmental and faunal datasets relevant to our project are already available and involvement of Williams will ensure access to these.
Failure to achieve uptake of results by end-users	Medium	Workshops/meetings will be convened with key end-users at various key project stages (including year 1) to ensure engagement and delivery of results in useful form.

Project Outputs/Outcomes

1. Maps of taxonomic richness and phylogenetic diversity across the study region will enable the identification of conservation priorities at a bioregional scale.
2. Assessment of genetic diversity of mountain-top floras and/or other postulated refugia to enable effective prioritization of conservation efforts. Identification of populations that are potentially more resilient to climate change.
3. Report on an updated assessment of conservation priorities for the Wet Tropics Bioregion as inferred from genetic data.
4. Taxonomic publications describing new and/or revised species of plants and fungi

We will maximize the likelihood of adoption and uptake of our findings by end-users through seminars/workshops/meetings. The content and structure of these will be tailored to the end-user's requirements.

This project addresses Gap Analysis priorities 4, 6, 10; NERP priorities 1, 2, 3; Terrain Priority 3; WTMA priorities A, B. Links to several other TE Hub projects (Williams, Atkinson, Phillips, Pressey) and to the Northern Hub through work on Cape York Peninsula. Also links strongly to TERN-LTERN investment in CSIRO's tropical rainforest plot network through provision of community phylogeny data for plots.

Project Budget

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	87,042	-	87,042
Australian Tropical Herbarium/JCU	5,000	140,050	145,050
CSIRO	-	7,550	7,550
Royal Botanic Gardens Sydney	-	7,550	7,550
University of Adelaide	-	9,600	9,600
Total	**92,042**	**164,750**	**256,792**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	143,876	-	143,876
Australian Tropical Herbarium/JCU	5,000	140,050	145,050
CSIRO	-	7,550	7,550
Royal Botanic Gardens Sydney	-	7,550	7,550
University of Adelaide	-	9,600	9,600
Total	**148,876**	**164,750**	**313,626**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	78,046	-	78,046
Australian Tropical Herbarium/JCU	5,000	193,594	198,594
CSIRO	-	7,550	7,550
Royal Botanic Gardens Sydney	-	7,550	7,550
U. Adelaide	-	9,600	9,600
Total	**83,046**	**218,294**	**301,340**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	11,036	-	11,036
Australian Tropical Herbarium/JCU	-	142,800	142,800
CSIRO	-	3,800	3,800
Royal Botanic Gardens Sydney	-	3,800	3,800
U. Adelaide	-	4,900	4,900
Total	**11,036**	**155,300**	**166,336**

Project 3.3:	Targeted surveys for missing and critically endangered rainforest frogs in ecotonal areas, and assessment of whether populations are recovering from disease

Project Leader and Host Organisation

Name	Dr Conrad Hoskin & Dr Robert Puschendorf		
Position	Research Scientists		
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Unit	Discipline of Zoology and Tropical Ecology		
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Project Team

Title	Organisation	Role
Dr. Conrad J. Hoskin	JCU	Principal Investigator
Dr. Robert Puschendorf	JCU	Principal Investigator

Summary Table of End-users

Organisation	Organisational Contact	Email
DNPRSR	Andrew Millerd James Newman	Andrew.Millerd@nprsr.qld.gov.au; James.newman@nprsr.qld.gov.au
TERRAIN	Rowena Grace	rowenag@terrain.org.au
WTMA	Steve Goosem	Steve.Goosem@epa.qld.gov.au
DSEWPaC	Julian Barnard Peter Latch TBC Karl Newport Joanne Nathan Kate Sanford-Readhead Margaret Considine David Calvert	julian.barnard@environment.gov.au peter.latch@environment.gov.au Anthony.whalen@environment.gov.au Karl.newport@environment.gov.au Joanne.nathan@environment.gov.au kathryn.sanford-readhead@environment.gov.au Margaret.considine@environment.gov.au David.calvert@environment.gov.au

Project Duration

Start Date: 1 July 2011 End Date: 30 June 2014

Project Description / Task Objectives

Ten frog species disappeared from the upland rainforests of the Wet Tropics and Eungella during outbreaks of amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) in the late 1980s and early 1990s, representing 25% of the frogs endemic to the Wet Tropics and all of the Eungella endemics. Five of these species occurred only in the uplands and have been presumed extinct because no individuals have been found despite intensive searches. This represents a significant loss of endemic species diversity, particularly in the Wet Tropics World Heritage area. The exciting recent development is that we recently rediscovered one of these 'extinct' species, the Armoured Mistfrog (*Litoria lorica*) in high elevation dry sclerophyll forest 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*) but have been overlooked because searches have focussed on rainforest and not the adjacent dry forest. We can now target very particular sites – ecotonal dry forests bordering rainforest – that have rarely been surveyed for these species and offer the maximum chance of success. These sites are also key to understanding how frogs can survive through disease outbreaks. Coincidentally, these ecotonal areas are also poorly surveyed for vertebrates in general and represent a gap in Wet Tropics and Eungella diversity knowledge. A number of frogs declined dramatically during disease outbreaks but persisted in the lowlands (e.g. *Litoria nannotis, Litoria rheocola* and *Nyctimystes dayi*). Recent surveys suggest that some 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. We will conduct rigorous, targeted surveys for the missing, critically endangered and endangered rainforest frog species of the Wet Tropics and Eungella. We will also survey all vertebrates more broadly at these sites.

Key Objectives

1. Survey dry forest ecotonal sites and adjacent rainforest sites for missing and endangered frogs of the Wet Tropics and Eungella, and also survey vertebrates more broadly at these sites. Swab frogs at these sites to determine the distribution and prevalence of chytrid fungus across populations and different environments.
2. Determine whether threatened frogs are recolonising upland rainforest sites from which they disappeared in the past, and the mechanisms of this recovery.
3. Determine whether the few minute populations of *Taudactylus rheophilus* recorded after disease outbreaks have persisted.
4. Provide management recommendations and a list of critical ecotonal areas, which act as disease refugia for critically endangered rainforest frogs, or areas of importance for other vertebrate species.

Project / Task Methodology

Based on what we have learnt from *L. lorica* (Puschendorf *et al.*, in press), we will target dry forest sites adjacent to rainforest on the western side of the Wet Tropics and Eungella. We have already identified key sites in one region that fit the criteria as high potential for ‘extinct’ and endangered frogs, and other parts of the western Wet Tropics and Eungella will be assessed in detail to locate further sites. We will conduct the sampling as paired dry forest and adjacent rainforest sites. We will target the missing and endangered frogs at each site but will also broadly survey all vertebrates (mammals, birds, reptiles, frogs, fish) at all sites. Field trips will be conducted during spring and summer over all three years. It is important that we are funded over three years to enable us to revisit sites through time and under different conditions. Also it will take time to organise access to some of the trickier sites. Most sites will be accessed by car and on foot. About one third of the planned sites are very remote and these will be accessed by helicopter. For these, the drop off/pick up point will be near the dry forest site and we will access the paired rainforest site on foot during the survey. At all sites we will record all vertebrate species and will take genetic samples wherever possible. This survey data will fill big gaps in knowledge and may potentially even discover new species as one of us (CJH) has done elsewhere in the Wet Tropics. Genetic samples from these ecotonal areas are extremely important as they will contribute greatly to understanding the adaptation of rainforest vertebrates to past and future climate change and therefore the resilience of the Wet Tropics and Eungella regions. We will swab frogs for chytrid at all sites. At least 60 swab samples will be collected per population, so as to accurately determine prevalence of the pathogen (Skerratt *et al.* 2008). Our project overlaps extensively with other proposed NERP projects and we will collaborate with Williams and collaborators (Project # 3), Metcalfe & Kutt (# 4), Pressey (#6), Schwartzkopf (#11), VanDerWal (#14), Phillips & Llevellyn (#15), Burrows (# 17), and others where opportunities arise.

Project Outputs/Outcomes

This project is absolutely essential if we are to determine: (1) whether the ‘extinct’ frogs of the Wet Tropics and Eungella are really extinct, (2) whether the dry forest/rainforest ecotones of the western

Wet Tropics and Eungella harbour overlooked populations of these and other critically endangered species, and (3) whether threatened frogs are recovering from chytrid disease. Our surveys and associated data will thoroughly address these questions. This is urgent as some species are teetering on the verge of extinction and little is being done about it. Our results will also determine how widespread chytrid is across these regions and environments and how frogs are currently dealing with this threat. This project will also provide important survey data and genetic samples for vertebrates more broadly in these poorly surveyed areas, providing key material for understanding the evolution of rainforest communities and their resilience to future change. Our outcomes will include survey lists for frogs and other vertebrates across all sites; detailed assessments of current status, distribution and population size for missing and critically endangered frog species of the Wet Tropics and Eungella; maps of chytrid distribution and intensity across ecotonal areas; recommendations for the management of endangered frogs and other threatened vertebrates; liasing with managers regarding management actions; and publications on the survey results, chytrid results, and conservation value of ecotonal regions. Our project will compliment many others in the NERP hub and will facilitate conservation and management by DERM, EPBC, WTMA, TERRAIN, AWC, and others.

References

Puschendorf, R., Hoskin, C., Cashins, S.D., McDonald, K. Skerratt, L.F., VanDerWal, J., Alford, R.A. 2011. Environmental refuge from disease-driven amphibian extinction. *Conservation Biology*. In press.

Skerratt, L. F., Berger, L., Hines, H., McDonald, K. R., Mendez, D. & Speare, R. 2008 Survey protocol for detecting chytridiomycosis in all Australian frog populations. *Diseases of Aquatic Organisms* 80, 85-94.

Project Budget

Project Funding and Partnerships life of project

Contributing Organisation	Cash	In-kind	Total
JCU Puschendorf & Hoskin	-	384,720	384,720
TE NERP	90,000	-	90,000
Total	**90,000**	**384,720**	**474,720**

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
JCU Puschendorf & Hoskin	-	128,240	128,240
TE NERP	30,000	-	30,000
Total	**30,000**	**128,240**	**158,240**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
JCU Puschendorf & Hoskin	-	128,240	128,240
TE NERP	30,000	-	30,000
Total	**30,000**	**128,240**	**158,240**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	30,000	-	30,000
JCU	-	128,240	128,240
Total	**30,000**	**128,240**	**158,240**

Identified and assessed hazards

Description of Risk	Assessed Risk	Risk Control measures
No road access to the general survey areas due to poor weather conditions	Medium	Have flexible field plans, so field trip dates and sites can moved according to conditions. Plan the most intense fieldwork for the dry season; however this will not always be possible, since some groups, such as amphibians and reptiles can be more common in the wet.
Issues with helicopter transportation in remote regions due to poor weather conditions.	Medium	Have an alternative plan, were we could walk out of sites if it would become necessary. Always carry a satellite phone so we can communicate with the helicopter crew and other personnel involved in the project. Have enough supplies to be able to stay extra days in the field if it would be necessary.
Failure to achieve uptake of results by end-users	Medium	Workshops/meetings will be convened with key end-users at various key project stages to ensure engagement and delivery of results in useful form. Papers and reports will be published at the end of the project.

Project Linkages

Project	Research Leader	Research Priorities				Links to others projects, NERP hubs or external collaborative projects	
		NERP	GAP	WTMA	TERRAIN	TE NERP Hub proj #	Other
Declining frogs – ecotone refugia	Puschendorf, Hoskin	1,3	1,3,4	B	3,5	3,4,6,11, 14,15,17	Northern Biodiv. Hub

Project 3.4: Monitoring of Key Vertebrate Species

Project Leader and Host Organisation

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Project Team

Title	Organisation	Role
David Westcott	CSIRO	Project Leader
Suzanne Metcalfe	CSIRO	Genetics
Adam McKeown	CSIRO	Field technician

Summary Table of End-users

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FNQROC	Travis Sydes	T.Sydes@cairns.qld.gov.au
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Cairns Regional Council	Russell Wild	R.Wild@cairns.qld.gov.au

Project Duration

Start Date: 1 July 2011 End Date: 31 December 2014

Project Description / Task Objectives

Monitoring is a fundamental component of the management of threatened species and is of particular importance when those species come into direct conflict with humans and their interests. In such circumstances up-to-date information on population status, trends and distribution become key inputs into decision making. In these circumstances, systematic, objective and transparent data is critical to the acceptance of the decision making process. In the Wet Tropics two species are the focus of repeated demands for management, made to all levels of government, and are frequently the focus of bitter debates, often with financial and legal implications. These are the endangered southern cassowary, *Casuarisus casuarius*, and the vulnerable spectacled flying-fox, *Pteropus conspicillatus.* For both species questions relating to population sizes, trends and distribution are central to decision making and conflict resolution processes. For both species there are issues around the adequacy of the monitoring data available and being used for management decision making.

For the cassowary, current population estimates are based on data that is more than two decades old (Crome and Moore 1990) and extrapolations and *ad hoc* modifications of this (Moore 2007). Currently decisions are made based on assumed numbers and continuing declines in abundance are both assumed and asserted (e.g. WTMA 2002, 2007, 2009) in the absence of data. Elsewhere, very different claims based on the same data are made (Garnett 2011). If justifiable decisions about issues that impact on cassowaries and cassowary management are to be made, reliable and up-to-date population estimates are obviously required. To achieve this, this project proposes to implement a reliable monitoring methodology using DNA fingerprinting of cassowary dung, developed and successfully trialed as part of previous MTSRF and agency funded projects (Westcott *et al.* 2011). This systematic, objective and transparent monitoring program will significantly improve upon the approach that has underpinned cassowary management over the last decade.

For the spectacled flying-fox, an appropriate monitoring method has been developed and assessed (Westcott *et al.* 2008; Westcott *et al.* submitted) and has been implemented at a species range level for a period of six years. This is the only long-term, distribution-wide, flying-fox monitoring program in the world, and has been providing monthly data on population abundance and distribution across the species' Wet Tropics range. While this monitoring program has provided a good estimate of spectacled flying-fox population sizes, our modeling indicates that longer-term data is required to determine population trends (Westcott *et al.* 2008; Westcott *et al.* submitted). This data on current and past dynamics of particular camps and the population as a whole continues to be called upon for decision making at all levels of government and is currently informing the design and development of SEWPC's program for flying-fox monitoring. Furthermore, having conducted this monitoring program over six years also allows us to provide answers about the spatial ecology of flying-foxes by documenting population distribution across the species' range on monthly basis. This information is necessary for addressing management issues related to predicting crop impacts, urban nuisance, public safety and emerging infectious diseases. For example, the monitoring program enabled the development of the Cairns International Airport's Flying-Fox Collision Risk Management Strategy. This project proposes to i) continue to provide up to date data for flying-fox management, ii) contribute to the development of an effective national approach to monitoring of flying-foxes, iii) and allow us to collect the long-term data that is required to understand the spatial dynamics of flying foxes for the management of their agricultural, nuisance and emerging infectious disease impacts.

Key Objectives

- Conduct cassowary monitoring at the scale of the Wet Tropics Region:
- Provide data on cassowary abundance and distribution, and, the influence of habitat on this
- Provide data on the structure and phylogeography of cassowary populations across the region.
- Conduct monthly surveys of the spectacled flying-fox population in the Wet Tropics Region:
- Determine the size and spatial distribution of the population
- Determine trends in abundance with an estimate of confidence

- Use this long-term monitoring database to identify drivers of the spatial dynamics of the population in order to inform decision making with respect to agricultural and urban nuisance and future disease risk.

Project / Task Methodology

Cassowary Monitoring:

In MTSRF a method for identifying individual cassowaries from their dung was developed. This method is based on the extraction of cassowary DNA from cassowary faecal material and the use of DNA fingerprinting to determine the identity of the bird producing the dung. Application of this method across dungs collected during surveys allows for identification of i) the number of individuals producing the dungs, and, ii) an estimate of recapture rates of individual birds. These two pieces of information allow for the application of a variety of survey methodologies which allow for greater confidence and accuracy in population estimation.

Transects will be established across the region. The distribution and extent of these transects will be stratified according to i) habitat type, ii) landscape context, and, 3) altitude. Transects will be walked at least once with dungs being collected and other sign recorded. Where possible more intensive surveys of local cassowary populations will be coordinated with community groups and indigenous ranger groups.

The surveys will be conducted in 3 rounds over the duration of the project. In each year, one round of surveys will be conducted during the peak fruiting (and therefore dung) period. Spreading the surveys over multiple years will minimize the impact of year-to-year variation in dung production on the final estimates.

Collected dungs will be processed in the laboratory and individual identities assigned to those dungs.

The resulting data will be used to estimate population sizes. The exact estimation method will vary depending on the scale at which the analysis is being conducted. For example, a Maximum Likelihood Estimation estimator will be used at the scale of individual transects, while a form of distance sampling modified for mark-recapture data will be used for population estimation and occupancy modeling will be used for comparison with previous data.

Working with community, Indigenous Ranger and management agencies, e.g. QPWS Staff, to provide detailed surveys of areas of key interest.

Flying-fox monitoring:

Monthly surveys of all known spectacled flying-fox camps in the Wet Tropics Region will be conducted. Prior to each survey, informants around the region will be contacted for current anecdotal information on flying-fox distribution and any new camps or foci of activity.

Each camp will be visited and camp size estimated using a modification of the method outlined in Shilton *et al.* (2008).

Resulting data will be used to describe population distribution, population size and trends, the latter following methods outlined in Westcott *et al.* (submitted).

Each month's data will be added to the long-term database on flying-fox population dynamics begun under the Rainforest CRC and maintained as part of the MTSRF program.

Project Outputs/Outcomes

Cassowary Monitoring:

Output: Estimates of cassowary population size, distribution and structure across the Wet Tropics Region based on faecal-DNA sampling.

Outcome: Assessment of cassowary conservation status and trends based on field monitoring data made possible with a baseline derived from this project (WTMA, DSEWPaC, QPWS, QDERM)

Output: Estimates of cassowary population size for sub-regions and local areas

Outcome: Identification of the key sub-regions and local areas for cassowary conservation and for conservation planning (WTMA, Terrain, QPWS).

Outcome: Assessments of cassowary population trends and status for impact, management assessments and offsets can be measured against local area base-lines (DSEWPaC, DERM, Terrain).

Output: Descriptions of patterns of relatedness between cassowary populations in sub-regions

Outcome: conservation planning in these areas and for linkages across the WTR based on an understanding of the spatial connectedness of cassowary populations. (DSEWPAC, Terrain, WTMA)

Outcome: Long-term monitoring of cassowary populations in particular regions performed with a baseline data set. (WTMA, DSEWPAC, QPWS, QDERM)

Output: Estimates of the relative abundance of cassowaries in different vegetation types and therefore the relative value of different habitats to cassowary populations.

Outcome: Will enable assessment of the relative value of habitats for assessment of the likely impact of proposed projects, natural disturbances and for predicted future climate change (DSEWPAC, TERRAIN, QPWS, QDERM).

Output: A standardised method for long-term cassowary monitoring and estimation of cassowary population sizes at regional, local, and tenure scales

Outcome: allow for improved impact and offset assessment (DSEWPaC, Terrain, WTMA, QPWS)

Outcome: allow for the assessment of the efficacy of management actions (DSEWPaC, Terrain, WTMA, QPWS)

Outputs will include scientific papers (population size and distribution, patterns of relatedness, monitoring methodologies) and reports as well as provision of data to agencies that request it. Outputs will also include communication and extension activities such as public lectures, community workshops and community surveys.

Flying-fox Monitoring:

Output: Reports on the size and distribution of spectacled flying-fox populations across the year and the long-term trends in these dynamics at local and regional scales (WTMA, DSEWPaC, QDERM, QPWS, FNQROC, Terrain)

Outcome: this will enable assessment of potential impact of alternative management options of camps and flying-fox impacts

Outcome: enable assessment of the potential threat of flying-fox vectored and emerging zoonoses

Output: Report examining the potential factors determining these dynamics and their likely consequences for biodiversity and flying-fox management (WTMA, DSEWPaC, QDERM, QPWS, FNQROC, Terrain).

Outcome: informed decision making for camps in urban areas through identification of the factors influencing both the spatial distribution of flying-foxes and their impacts and the drivers of apparent trends towards greater urbanization of flying-fox camps

Output: Maintenance and management of long-term database on spectacled flying-fox population trends at local and regional scales .

Outcome: a permanent record of flying-fox dynamics is maintained to allow continued provision of data for decision making with respect to individual camps (WTMA, DSEWPaC, QDERM, QPWS, FNQROC, Terrain).

Provision of data on particular camps for decision making at all levels of government as requested. These requests, for long-term and current camp sizes, are made on a regular basis. (DSEWPaC, QDERM, QPWS, FNQROC, Terrain)

Presentation of results from this and other work on flying-foxes as part of public meetings and forums designed to facilitate decision making around flying-fox management. These forums are organized by management agencies, local government and community groups seeking to understand perceived amenity and health threats of flying-foxes and the options for effective management response. (WTMA, FNQROC, Terrain, QPWS)

Expected Benefits

This project will implement methodologies for monitoring populations of key vertebrates in the Wet Tropics Region. Both species are the focus of management activities and conflict within the community. This project will provide data for assessing the current status of these species in the WTR, and, for the spectacled flying-fox, their population trends. This data will allow managers to assess the need for management action and to assess the efficacy of their management.

This work will also have the benefit of making public the status and trends of these species and as such will facilitate public discussion on appropriate management of these species.

Listed against major stakeholders priorities:

Gap Analysis

1. Provides long-term monitoring methods and programs for two iconic and threatened species.
2. Provide data and maps on the spatial distribution and vegetation associations of two iconic and threatened species
3. Provides monitoring methods for two species
4. Provides data on the distribution and habitat associations of two iconic species that will enable conservation and global change mitigation planning.

NERP Priorities

1. Will provide data on the habitat requirements and tolerances of two iconic species
2. Will provide data on two species that play key roles in ecosystem processes
3. Will provide data crucial for conservation planning for two threatened species

WTMA Research Strategy

- Will provide monitoring methods and data for two key species.
- The two focal species are key indicators for threat to the Wet Tropics values, both through threat to their habitat by change and one because of its potential to alter the perception of the public of the benefits of biodiversity. By understanding their populations and trends this project will contribute to understanding the management needs of the region.
- By working with community and managers, and through the provision of data for management decisions this project will strengthen the science management partnership in the region.

Terrain NRM

Priority 2: As was the case in MTSRF, this project will link with Hill *et al.*'s by contributing data and community and indigenous ranger surveys and consequently will contribute to the development of conservation planning approaches

Priority 3: By indentifying the relationship between cassowary and flying-fox abundance and vegetation types and areas this project will contribute to the identification of priority areas for the conservation and management of two iconic species.

Priority 4: Public perception of species such as flying-foxes and their impacts are often based on local areas and personal impact. This project will provide a local and regional context for this type of knowledge, allowing for more sober assessments of particular situations and a more balanced approach to decision making.

Priority 5: This project will implement a long-term monitoring and reporting programs for two iconic species in the Wet Tropics Region allowing assessment of their status and allowing tracking of their population and spatial trends in the face of anthropogenic and natural global change drivers.

Description of Risk	Assessed Risk	Risk Control measures
Cassowary: Failure of extraction methods to work consistently	Medium	• Continue to refine extraction method • Maintain expertise in alternative extraction methods • Use multi-samples to ensure spare samples
Poor fruiting results in few dungs	Medium	• Sample across three years to spread risk
Departure of key project personnel	Low	• Maintain expertise across staff • Identify internal and external alternatives and maintain protocols to ensure they can pick up work if required
Failure to achieve uptake of results by end-users	Medium	• Regular formal and informal reporting will be maintained with all stakeholders

Project 3.4 Budget

Whole of Life Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
CSIRO (see note below)	-	295,000	295,000
NERP	310,000	-	310,000
Total	**310,000**	**295,000**	**605,000**

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Item	NERP	In-kind	Total Cost
NERP	89,945		89,945
CSIRO		86,195-	86,195
Total	**89,945**	**86,195**	**176,140**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	92,015	-	92,015
CSIRO	-	88,265	86,865
Total	**92,015**	**88,265**	**180,281**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	97,855	-	97,855
CSIRO	-	94,105	94,105
Total	**97,855**	**94,105**	**191,961**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	30,185	-	30,185
CSIRO	-	26,435	26,435
Total	**30,185**	**26,435**	**56,620**

Budget Justification:

Cassowary Monitoring (65% of total):

Costs associated with this project include salary time for surveys (30 days per year), laboratory processing of samples and write up. Laboratory labour and costs are based on an estimate of 400 dungs per year.

Flying-fox Monitoring (35% of total):

Costs associated with this project include mileage and labour (3 days per month) for surveys and write up costs.

Communication and Extension:

This project requires significant direct communication and extension activities on the part of the project leader. These activities include, but are not restricted to, conducting community research participation, public seminars, participation in community forums, collaborator meetings and presentations of results and data to government agencies. These activities require significant time and travel costs. As a result half the funds are budgeted to be retained for the project for these activities (under Extension) while the remainder are budgeted for NERP related activities (under Communication).

CSIRO contribution:

Because Communication funds do not come to the project but rather are retained by NERP the CSIRO contribution is calculated on the NERP contribution to the project of 310K minus the 15K it retains, i.e. 295K. Thus the CSIRO contribution represents 50% of the funds to be received by the project itself and is a 49% contribution to the total costs allocated to the project.

Project	Research Leader	Research Priorities				Links to others projects, NERP hubs or external collaborative projects	
		NERP	GAP	WTMA	TERRAIN	TE NERP Hub proj #	Other
Cassowaries and flying foxes	Westcott	1,2,3	1,3,4,10	A,B,E	2,3,4,5	2, TS Biosecurity Project	Northern Biodiv Hub

Theme 2: Understanding Ecosystem Function and Cumulative Pressures

Theme 2 builds on research undertaken through the MTSRF and other programs that have identified many of the primary risks and threats to the environmental assets of Northern Queensland. These pressures do not occur in isolation to each other and it is clear that a greater understanding of the cumulative and synergistic impact of these pressures is required for improved management. These pressures are not static therefore predicting and preparing for change is a significant challenge for environmental decisions makers charged with stewardship of Queensland's natural environment. Changing climates, extreme natural events, changes in natural resource use and population growth are some of the pressures facing these ecosystems. Theme 2 is comprised of four Programs that are increasing the understanding of ecosystem function and the impact of synergistic and cumulative pressures on the system. This understanding is essential in developing effective management responses that promote ecosystem resilience.

Program 4: Water quality of the Great Barrier Reef and Torres Strait

Program 4 will have three projects assessing risks to biodiversity from current water quality in the inshore Great Barrier Reef and a desktop hazard study for water quality outlook in the Torres Strait. The latter will concern flood plumes from the Fly River, one of Papua New Guinea's largest rivers, which regularly reach the eastern margins of the Torres Strait, Significant expansion of mining activity is forecast in PNG's western province which may result in new threats to the water quality of the region but the hazard assessment will also concern local declines in water quality near home islands affected by erosion and run-off. The GBR projects will focus on two components of terrestrial run-off discharged into coastal receiving waters. One project will measure the transport and settlement of fine sediments carried by river plumes and subsequently resuspended by winds. The new knowledge sought is the impact of these processes on light availability to benthic communities. A second project will establish the half-lives of common agricultural chemicals in the marine environment and study the impacts on biodiversity of chronic low-level exposure to these pollutants. This information will contribute to the Reef Water Quality Protection Plan (Reef Plan) and was designed in consultation with the Reef Rescue Program. The final project will be a methodological pilot study recommending how to conduct a formal risk analysis of the threats from multiple stressors in water quality that would be used to prioritise future investment decisions in the catchments (i.e. what is the relative risk from sediments, excess nutrients, and contaminants?).

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

Project Leader and Host Organisation

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Project Team

Title	Organisation	Role
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Murray Logan	AIMS	Biostatistician, experimental design, data analysis
Sam Noonan	AIMS	Data organisation
Jon Brodie	JCU	Experimental design, write-up
Eric Wolanski	JCU	Experimental design, hydrodynamics analysis, write-up
Scarla Weeks	UQ	RS data analysis, write-up
Marites Canto	UQ	RS data analysis, write-up

Summary Table of End-users

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Burnett Mary Regional Group	Fred Bennett	Fred.Bennett@bmrg.org.au
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Organisation	Organisational Contact	Email
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Project Duration

Start Date: 1 July 2012 End Date: 31 December 2014

Project Description / Task Objectives

Summary:

We will, for each of the four NRM regions between Gladstone and Port Douglas, deliver an improved understanding of the quantitative relationships between changing deliveries of suspended solids from their main river ways to the GBR, and changes in the coastal water clarity within their region.

Background:

Turbidity is a fundamental environmental property of coastal marine ecosystems, because suspended particles reduce irradiance for primary producers, alter trophic structures, and can be vectors for nutrients, pollutants and diseases. On the Great Barrier Reef, increasing turbidity has been related to a five-fold increase in macroalgal cover and a 30% reduction in coral biodiversity [De'ath and Fabricius, 2010]. Due to its relevance, both levels of turbidity and changes in turbidity are used as indicators for environmental reporting of the condition of estuarine and coastal waters [ANZECC, 2000].

A recent study investigated the spatial and temporal variation in turbidity at 14 inshore reefs in four regions of the Australian Great Barrier Reef (GBR) over ~3 years. Generalized additive mixed models were used to relate spatial and temporal changes in turbidity to environmental drivers. The study documented that inshore turbidity in four regions of the GBR is strongly related to river runoff and rainfall, and that it improves in the dry season, if wave height and tidal currents are being accounted for (Fabricius *et al.*, 2011; Fabricius *et al.*, submitted). The study showed that distance of a reef to the nearest major river mouth was a strong predictor of turbidity, and so was wave height, wave period and tidal ranges (leading to sediment resuspension). Averaged across all reefs, turbidity declined by 69% between weeks with highest and lowest waves, and by 13% between weeks with highest and lowest tidal ranges. Differences between weeks with highest and lowest river flow and rainfall accounted for a further 13% decline in weekly averaged turbidity. Turbidity also declined by 28% from the beginning to the end of the dry season at any given wave and tidal condition, suggesting gradual export or compaction of unconsolidated sediments. The data show that significant intra-annual changes in turbidity on the inshore GBR are related to variation in terrestrial runoff. The study suggested that a reduction in the river loads of fine sediments and nutrients through improved land management should lead to measurably improved inshore water clarity.

This study provides the strongest indication yet that inshore water quality is affected by terrestrial runoff, and hence amenable to improvement through improved land management. The study was however too short to investigate inter-annual variation in turbidity (e.g. differences between relatively wet and dry years), and the 14 points spatially too limited for providing specific information in relation to differences between the different NRM Regions.

Task Objectives:

The objective of this study will be to determine for each NRM region specific quantitative relationships between changed terrestrial runoff to the GBR and intra- and inter-annual variation in coastal water clarity. We propose to investigate variation in coastal turbidity for the whole inshore GBR over 10 years, using daily Modis Aqua remote sensing data at 1 km resolution. We will use a newly developed index of euphotic depth, based on the relationship between the 10% light level ($Zeu_{10\%}$, as derived from the inherent optical properties of the water column; Lee *et al.* 2007) and the GBR Secchi Depth data time series to investigate inter- and intra-annual changes in euphotic depth. Specifically, we will quantify where and by how much the relationship between turbidity, waves and tidal currents changes throughout wetter and drier years as a function of location (in relation to river mouths), time (in relation to time since last flood plume, accounting for river flow rate and suspended solids loads), and hydrodynamics (tidal currents).

The outputs of this project will feed important information into a later stage of the Receiving Waters Model / eReefs project, which will work towards the development and application of a whole of GBR wave and sediment transport model. Our satellite euphotic depth time series data, together with the previously collected turbidity logger data will provide valuable process information, and will be valuable to calibrate and validate such sediment transport model.

Project Methodology and Key Objectives

The question of region-specific relationships between terrestrial runoff and inshore water clarity will be addressed by relating ten years of Modis Aqua euphotic depth time series data to wave height and frequency, wind speed, tides, river discharge and rainfall data. Specifically:

- We will process and build time series of daily data (cloud cover permitting) for the whole GBR since the beginning of Modis/Aqua (July 2002) at 1 km resolution, following NASA's recently completed (2010) mission long ocean colour reprocessing of MODIS data. Coastline pixels will be masked out where land is included, and optically shallow waters will be treated separately. In 2010/2011, NASA completed the mission long ocean colour reprocessings of SeaWiFS, MODIS/Aqua, and MODIS/Terra, to incorporate latest calibration and validations, including improved atmospheric corrections. We plan to use these reprocessed data for our project, but it requires rebuilding the time series to ensure we incorporate the latest refinements.
- Apply Lee's QAA algorithm regressed against AIMS Secchi data (Weeks *et al.*, submitted) to the full time series of Modis Aqua data.
- Obtain, clean up, aggregate and merge BOM and DERM daily data from nearest stations in each of the NRM regions of predicted and observed tides, observed waves, wind, rain, river flow data (2002-2011).
- Estimate suspended solids discharge from rivers.
- Using the Slim model, calculate tidal currents for each grid point. The Slim model will be used to assess tidal forcing because of its variable cell sizes (<300 m near islands, reefs and coastlines) and our requirement of a very fine-scale resolution due to the complex bathymetry and geometry of currents near inshore islands, reefs and the coastline.
- Relate euphotic depth data to river discharges, wind speed and currents: To assess the relative effects of the environmental drivers on turbidity, data aggregation solutions will be compared. Generalized additive mixed models (GAMM, Woods 2006) will then be used to predict turbidity in several points or target areas or along transects from rivers within each NRM region. Generalized additive mixed models (GAMMs; Wood, 2006) have the capacity to model the complex relationships between the response (turbidity) and its environmental predictors, and to deal with auto-correlations between successive turbidity observations over time. The effects of the environmental drivers on turbidity are likely to vary within and across NRM regions, and hence analyses will be conducted for each NRM region separately. The results will be presented as partial effects plots, maps and tables that document the significance of effects of each of the environmental drivers.
- Relate the remote sensing data to the on-ground turbidity logger data of Craig Humphrey and Reef Plan Marine Monitoring Program, using appropriate statistical analyses and visualisations.
- Write publications.
- Create layers of water clarity for the e-Atlas.
- **NOTE: If the initially requested budget of 408,000 was granted, we would use the additional 12 months of project time to also include Modis Terra and/or SeaWiFS remote sensing data that will allow us increased data coverage and to go back in time to October 1997. We would also investigate the use of other algorithms that are presently under development (S. Weeks, in prep).**

Project Outputs and Outcomes, and Expected Benefit to end-users

The end-users of the results of this project include Reef Rescue and DSEWPaC, GBRMPA, for Reef Plan the Queensland Department of the Premier and Australian Governments, the four NRM bodies between Port Douglas and Gladstone (Terrain, North Qld Dry Tropics, Reef Catchments, Fitzroy Basin Association), local governments, industry including mining and agriculture, and NGO groups, among others.

- Based on empirical data, we will provide an explicit link between terrestrial runoff and the intra- and inter-annual variation in water clarity on the inshore GBR for each NRM Region.
- A better scientific information basis for Reef Rescue and Reef Plan and refinement of targets.
- Region-specific quantitative relationships between terrestrial runoff, water clarity and environmental drivers will allow validation and calibration of the Receiving Waters Model (Parslow and Brinkman), and the WQ Risk Analysis (Kookana *et al.*).

Links and dependencies to other hubs and projects

This project provides critical data to many of the activities listed in the NERP Coastal Program proposed by Sheaves *et. al.,* Pressey, Brodie, Kookana, and others, NERP projects that also use remote sensing data, the Water Quality – Climate change interactions Project (Uthicke *et al.*) and the Seagrass Project (Collier *et al.*). The project will build upon and integrate existing knowledge and data sets (eg Fabricius *et al.*, 2010, submitted; De'ath and Fabricius, 2008, 2010; Lewis *et al.* 2009, Kroon *et al.* in 2010, water quality data from GBR rivers). It also provides essential information to Reef Rescue, and to the Receiving Waters model.

Identified and assessed hazards

Description of Risk	Assessed Risk	Risk Control measures
Failure to obtain data	Low	All data exist but have to be processed and retrieved from various organizations.
Departure of key project personnel	Medium	All participants have a strong interest in the project, and are committed to doing this. If necessary, subtasks may be transferred to other skilled persons.
Failure to achieve outcomes due to dependence on outputs from other projects	Low	The Remote Sensing data are being processed on a regular basis, SLIM model has been tried and tested, and no other dependencies exist.
Failure to find adequate statistical solution for a very complex data set	Medium	Although this data set is very complex, we have already completed a smaller-scale study based on turbidity loggers rather than remote sensing data helped us developing the model solutions.

Total Year 1-3: Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	299,925	-	299,925
AIMS	-	138,261	138,261
UQ	-	106,667	106,667
JCU	-	100,000	100,000
Total	**299,925**	**344,928**	**644,853**

AWP 1 – July 2012 to June 2013 Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	116,678	-	116,678
AIMS	-	49,907	49,907
UQ	-	42,667	42,667
JCU	-	40,000	40,000
Total	**116,678**	**132,574**	**249,252**

AWP 2 – July 2013 to June 2014 Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	124,843	-	124,843
AIMS	-	61,374	61,374
UQ	-	42,667	42,667
JCU	-	40,000	40,000
Total	**124,843**	**144,041**	**268,884**

AWP 3 – July 2014 to December 2014 Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	124,843	-	124,843
AIMS	-	61,374	61,374
UQ	-	42,667	42,667
JCU	-	40,000	40,000
Total	**124,843**	**144,041**	**268,884**

The key objectives constitute steps towards the main Task Objective of the investigation of GBR turbidity and its main drivers. The project cannot be split into smaller sub-units hence it has been costed as one single unit.

References

Fabricius, KE, Humphrey, C, De'ath, G and Schaffelke, B (2011) *Environmental drivers of changes in water clarity in the inshore Great Barrier Reef: Final Report*. Australian Institute of Marine Science and Marine and Tropical Sciences Research Facility, Cairns (32 pp.).

Fabricius, KE, De'ath, G, Humphrey, C and Schaffelke, B (Submitted) Intra-annual variation in turbidity in response to terrestrial runoff at near-shore coral reefs of the Great Barrier Reef. *Journal of Geophysical Research – Oceans*.

Weeks, SJ, Werdell, PJ, Lee, ZP, Canto, M, Schaffelke, B and Feldman, GC (2011) Satellite Derived Euphotic Depth on the Great Barrier Reef: Understanding Physical Drivers of Spatio-Temporal Patterns of Water Clarity. *Proceedings of 34th International Symposium for Remote Sensing of the Environment* (ISRSE), April 2011 (full paper in prep.).

Lee, ZP, Weidemann, A, Kindle, J, Arnone, R, Carder, KL and Davis, C (2007) Euphotic zone depth: Its derivation and implication to ocean-color remote sensing. *Journal of Geophysical Research* 112: C03009.

Project 4.2: The chronic effects of pesticides and their persistence in tropical waters

Project Leader and Host Organisation

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Project Team

Title	Organisation	Role
Andrew Negri	AIMS	Project leader, researcher, ecotoxicology
Catherine Collier	JCU	Researcher seagrass
Jochen Mueller	UQ	Analytical, bioanalytical techniques (0.1)
Peter Ralph	UTS	Photophysiology (0.1)
Florita Flores	AIMS	Technical assistant
Victor Beltran	AIMS	Zooxanthellae culturing
Adam Wilkinson	AIMS@JCU	Seagrass component
Phil Mercurio	UQ/AIMS	Pesticide persistence component

*Victor Beltran 0.1 in 2011/12, increasing to 0.2 in 2012/13

Summary Table of End-users

Organisation	Organisational Contact	Email
GBRMPA	Katherine Martin Leigh Gray	katherine.martin@gbrmpa.gov.au leigh.gray@gbrmpa.gov.au
DERM	Michael Warne	Michael.Warne@derm.qld.gov.au
Reef Rescue Team (DAFF)	Kevin Gale	Kevin.Gale@nrm.gov.au
Reef Plan Secretariat (Dept. Premier and Cabinet)	Chris Chinn	reefplan@premiers.qld.gov.au
Regional NRM Groups	Multiple	
APVMA	Sharon Pike	sharon.pike@apvma.gov.au
Canegrowers	Matt Kealley	matt_kealley@canegrowers.com.au
DSEWPaC	Jack Holland	jack.holland@environment.gov.au
WWF	Nick Heath	nheath@wwf.org.au

Delivery and adoption, and benefits for stakeholder

Data from the two Key Objectives will contribute to cumulative risk models and thus to policy development to protect the GBR from the effects of pollution and climate change. Key end-users will be kept up to date as the project progresses. Data and findings will be published in reports and scientific publications and disseminated at NERP and international conferences.

Project Duration

Start Date: 1 July 2011 End Date: 31 December 2014

Project Description / Task Objectives

<u>Project Description</u>

A key policy to minimise the effects of climate change on tropical marine organisms (e.g. coral bleaching and loss of seagrass cover) is to improve water quality, thereby reducing the potential for pollution to exacerbate the effects of thermal stress (Reef Plan, 2009). While pesticides 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.

Pesticides, and particularly herbicides from agricultural sources (Lewis *et al.*, 2009), have been detected in nearshore sites of the Great Barrier Reef (GBR) all year round (Shaw *et al.*, 2010). The most commonly detected herbicides inhibit photosynthesis, thereby reducing primary productivity and calcification in key marine species. When plants and corals are stressed from increased sea surface temperatures (SST), additional stresses from reduced salinity and at high irradiance the impact of secondary chronic pollution such as herbicides exposure can become additive or synergistic (Negri *et al.*, 2011). There is little data to explain to what extent chronic exposure to herbicides might interact with climate change to negatively affect sensitive tropical organisms such as corals and especially seagrass (Haynes *et al.*, 2000; Ralph, 2000; Jones and Kerswell, 2003). Furthermore, little is known of the fate and persistence of agricultural herbicides that have been detected in the lagoon of the GBR. Understanding the half lives of these compounds 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 organisms and communities of the GBR.

<u>Relevance</u>

The identified herbicide concentrations that cause chronic stress in marine biota can be used to refine pollution targets for the GBR. When combined with the herbicide persistence data (determined here), water quality and climate data this will contribute to cumulative risk models and thus to policy development to protect the GBR from the effects of pollution and climate change.

Key Objectives

This project will experimentally:

1. Quantify the chronic effects and toxic thresholds of herbicides detected in the GBR on seagrass and corals under current and future climate scenarios.
2. Determine the persistence of herbicides under conditions relevant to tropical coastal and inshore waters and test the toxicity of their breakdown products.

Project / Task Methodology

The key objectives of this project will be conducted in parallel.

<u>1. Chronic pesticide effects</u>

A series of unique laboratory studies will quantify effects of herbicides and increased sea surface temperature, light stress/limitation and reduced salinity on seagrasses and corals. The experiments will be undertaken in existing climate-dosing aquarium facilities at AIMS, and later in advanced aquarium facilities (ATOS at AIMS, currently being designed). Acute toxic thresholds will be determined initially to inform later longer-term experiments to assess chronic stress thresholds. Species will include those relevant to inshore areas such as the seagrasses *Halodule uninervis* and *Zostera muelleri* and corals of the genus *Acropora*.

Indicators of sub-lethal stress in seagrass, corals and crustose coralline algae will include:

- Effects on growth (seagrass and juvenile corals)
- Effects on photosynthesis (pulse amplitude modulation fluorometry and respiration for all species)
- Effects on pigment concentrations (bleaching and photo-protection by high performance liquid chromatography)
- Effects on species tolerance (combined analysis of above indicators)

2. Herbicide persistence

A series of both flask and outdoor pond experiments will be performed to quantify the persistence and fate of commonly detected herbicides under conditions relevant to GBR flood plumes. The experiments will be conducted at a range of salinities to mimic upstream, estuarine and marine conditions and will be performed over a range of temperatures to match those in the southern GBR under mild conditions to peak summer temperatures of the northern GBR. Since pesticide concentrations and turbidity are highest during flood plumes, the partitioning and fate of herbicides will be examined at different total suspended solid and organic carbon levels. High performance liquid chromatography- mass spectrometry will be used to quantify the herbicides and their breakdown products. The toxicity of breakdown products and the influence of turbidity and organic carbon levels to the effects of herbicides on GBR microalgae will be examined using existing pulse amplitude modulation fluorometry assays (Schreiber *et al.*, 2007).

Project Outputs/Outcomes

Objective 1: *Quantify the chronic effects and toxic thresholds of herbicides detected in the GBR on seagrass and corals under current and future climate scenarios.*

1. Identification of herbicide threshold concentrations for seagrass for use in risk assessment models
2. Assess whether managing low-level, chronic herbicide exposures can protect seagrasses and corals from climate change pressures (e.g. thermal stress)
3. Determine whether chronic herbicide exposures may influence critical coral reef processes such as coral recruitment - can managing herbicide exposures improve the ability of corals to recruit under conditions expected in changing climate

Objective 2: *Determine the persistence of herbicides under conditions relevant to tropical waters and test the toxicity of their breakdown products.*

1. Half lives of herbicides (including diuron, atrazine, hexazinone and tebuthiuron) will be identified at multiple temperatures relevant to those in flood plumes for use in environmental risk models from catchment to coast
2. The contribution of herbicide breakdown products to potential toxicity will be quantified
3. A better understanding of how pesticides move through the water column (sediment bound or dissolved) and how this affects toxicity - critical for environmental risk models

Research Linkages

- NERP “Ecological risk assessment of pesticides, nutrients and sediments on water quality and ecosystem health” (Kookana, Brodie *et al.*)
- NERP “Coastal and ecosystem risk assessment” (Pressey *et al.*)
- NERP “Combined water quality-climate effects on corals and other reef organisms” (Uthicke *et al.*)
- NERP “Vulnerability of seagrass habitats in the GBR to changing environments” (Collier *et al.*)

- Reef Rescue (RRRD038) Pesticide dynamics in the Great Barrier Reef catchment and lagoon: management practices (grazing, bananas and grain crops) and risk assessments (Brodie, Lewis, Negri)

Risk assessment: identified and assessed hazards

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	Most personnel are already committed to the project and the only new positions will be students.
Failure to obtain data	Low	Most of the experiments will be performed in laboratories under controlled conditions to minimize the risk of failure due to environmental factors.
Departure of key project personnel	Low	Full documentation of the research plan, methods and results to date will ensure continuation of the project following appointment of replacement personnel.
Failure to achieve outcomes due to dependence on outputs from other projects	Low	This project feeds into (rather than relies on) other projects and communication via meetings and workshops will ensure high levels of integration.
Failure to achieve uptake of results by end-users	Low	Workshops/meetings will be convened with key end-users at various key project stages to ensure engagement and delivery of results in useful form.

Project Budget

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	158,443	-	158,443
AIMS	-	92,584	92,584
JCU	-	34,170	34,170
Total	**158,443**	**126,754**	**285,197**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	168,898		168,898
AIMS		134,124	134,124
JCU		34,170	34,170
UQ		48,149	48,149
Total	**168,898**	**216,443**	**385,341**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	215,946	-	215,946
AIMS	-	171,643	171,643
JCU	-	34,170	34,170
UQ	-	48,149	48,149
Total	**215,946**	**253,962**	**469,908**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	103,963	-	103,963
AIMS	-	103,523	103,523
JCU	-	17,085	17,085
UQ		24,075	24,075
Total	**103,963**	**144,683**	**248,646**

Project 4.3:	Ecological risk assessment of pesticides, nutrients and sediments on water quality and ecosystem health – Phase 1

Project Leaders and/or Organisation:			
Name	Rai Kookana & Jon Brodie		
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Project Team

Title	Organisation	Role
Rai Kookana	CSIRO	Project Leader, overall approach, data analysis, reporting
Jon Brodie	JCU	Project Leader, End-user liaison, reporting
Danni Oliver	CSIRO	Input into methodology review and database
Katharina Fabricius	AIMS	Input into methodology review and database
Andrew Negri	AIMS	Marine pesticides risks–, marine data
Michael Warne	DERM	Input into methodology review and database
Keith Hayes (Brent Henderson)	CSIRO	Risk methodology review
Steve Lewis	JCU	Meta database preparation
Frederieke Kroon	CSIRO	Input into methodology review and database

To guide monitoring, management and mitigation decisions, we propose to conduct a Phase 1 study to develop a robust approach that will allow us in Phase 2 to carry out an ecological risk assessment (ERA) of nutrients, fine suspended sediments, and pesticides used in agriculture in the GBR region including ranking the relative risk of individual contaminants originating from priority catchments to the GBR ecosystems using a systematic, objective and transparent approach.

Project Duration

Start Date: 1 July 2011 End Date: 30 June 2012

Project Objectives

- To develop a systematic, objective and transparent risk-based approach to quantify the relative risk of pesticides, nutrients and sediment to the ecosystems of the GBR which can be used in a Phase 2 project (yet to be funded) to actually assess risk.
- Review the methodology available for such a risk assessment and make recommendations as to the most suitable method given our objectives and the data sources available to drive the assessment. The methodological recommendations will consist of a suite of complimentary methods chosen to reflect the level of understanding, data availability and previous studies.
- Prepare a 'meta database' of the existing data and information needed to run the analysis. Determine where in the chosen methodology the data will be used.
- To use the results of the Phase 1 study to secure support to carry out the full risk assessment.

Project Activities/Method

The project will entail three components carried out concurrently:

1. Reviewing the methodology
2. Preparing the meta database
3. Formally liaise with the end-users (DSEWPaC, DERM, DPC, Reef Partnership, GBRMPA, industry) to develop the scope of the study, the actual end-user needs and ensure fit with timelines for Reef Rescue 2013 and Reef Plan 2013. A final step, towards the end, will be to check back with the end-users to review progress and endorse what is being proposed before final write up of the proposed method and development of the proposal for the actual risk assessment (Phase 2). Liaison will use existing structures such as the Reef Partnership Committee, the Independent Science Panel, the P2R Coordination and Advisory Group.

A flexible, ecological risk assessment (ERA) methodology will be recommended, based on well recognized international approaches, for assessing the relative risk of contaminants and associated land uses in the GBR region. The strategy will be finalized during the scoping study of the project based on the (i) a review of risk assessment approaches currently being conducted by CSIRO (Keith Hayes) (ii) the data availability as determined during the information gathering and synthesis component (Steve Lewis and Danni Oliver) and (iii) the suitability to achieve the objectives of this project (all participants). This will ensure that best possible tiered methodology (as allowed by available data) is employed in the ERA. The selected approach will consider land-uses, catchment characteristics and toxicants. The end-point ecosystems likely to be considered will be estuarine wetlands, seagrass, coral reefs and the pelagic zone ecosystems (e.g. plankton communities) of the GBR lagoon. The proposed ERA methodology is expected to employ a combination of semi-quantitative and quantitative assessments for the relative risk of water quality constituents from major agricultural land-uses in the GBR catchments, as permitted by the data availability. We will specifically look at a method able to evaluate relative risk to different ecosystems and their keynote species from the different contaminants e.g. suspended sediments versus nitrogen (and different forms of nitrogen) versus phosphorus (different forms) versus pesticides (different types).

Key outcomes

1. The selection of a systematic, objective and transparent approach to assess the relative ecological risks posed by nutrients, pesticides and suspended sediments to GBR ecosystems.
2. A guaranteed approach which will give more usable and much more robust results than the previous MCA approaches.
3. Direct engagement with strategic stakeholders, including industry groups, Australian Government, Queensland Government and regional NRM bodies.

Key outputs:

Technical reports, communication products and publications including:

1. A review paper on currently used risk assessment methods including methods for cumulative risk assessment suitable for the GBR and our data holdings.
2. A report of the meta database of data and information (including spatial data) available to use in the risk assessment.
3. A report with recommendations as to the most suitable methodologies and the known data inputs for each step of the process. This report would also outline how the risk assessment can be used, how it could guide investment in new programs such as Reef Rescue 2013 and Reef Plan 2013 and the likely robustness of the findings from the risk assessment.

End-users and Impact

The end-users of findings from this project include the Department of Sustainability, Environment, Water, Population and Communities - DSEWPaC (particularly the Reef Rescue initiative), GBRMPA, Queensland Government (particularly the Department of Environment and Resource Management), Reef Plan (Australian and Queensland Governments together), NRM bodies (Terrain, NQDT, Reef Catchments, FBA, BMRG) local government, industry including fishing, mining and agriculture, and NGO groups, among others. Moreover, the project is a partnership between CSIRO JCU, AIMS and DERM, providing direct linkages to State and Federal Government, and GBR NRM bodies. The project is specifically directed to providing advice for the development of Reef Rescue 2013 and Reef Plan 2013.

Summary table of end-users

Organisation	Organisational Contact	Email
GBRMPA	David Wachenfeld	David.wachenfeld@gbrmpa.gov.au
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Reef Plan Secretariat, QLD Dept Premiers & Cabinet	Claire Andersen	Claire.Andersen@premiers.qld.gov.au,
Reef Rescue Team DAFF	Kevin Gale	Kevin.Gale@nrm.gov.au
GBR coast NRM groups (Terrain)	David Maclean	
GBR coast NRM groups (NQ Dry Tropics)	Ian Dight	Ian.dight@nqdrytropics.com.au
GBR coast NRM groups (Reef Catchments)	Carl Mitchell	carl.mitchell@reefcatchments.com.au
GBR coast NRM groups (Fitzroy Basin Association)	Nathan Johnston	Nathan.Johnston@fba.org.au

Delivery and Adoption

The proposed project will engage end-users early during the Phase I of the project, and seek continuous stakeholder input and therefore while the outputs have been clearly defined (see other sections of the proposal) they may evolve. The key outputs include reports on the proposed ERA methodologies, the data needed to drive the risk assessment and a final end-user agreed proposal to carry out the risk assessment. The format of the outputs will be tailored for the target audiences to ensure their suitability and easy adoptability. The review will consider the suitability of a particular risk assessment framework and the potential role of stakeholders in the risk assessment process.

Linkages with other projects under NERP and the Reef Protection Program have been identified. Two-way flow of information with these projects, together with early engagement of end-users will ensure timely delivery and adoption. The project team belongs to the agencies that are both sources of relevant input data as well as end-users of the project findings. Thus the project team would become an effective conduit of two-way information flow.

To most effectively communicate the findings of the project to, and seek input from, a wide group of stakeholders, a communication strategy will be developed. This will build on existing communication strategies of Reef Rescue, Paddock to Reef and CSIRO's Water for a Healthy Country Flagship. Advice will be sought from key stakeholders on best communication strategies for broader adoption. Knowledge transfer to the research community will be by presentations at conferences, seminars etc

Collaboration and links to other research projects

The project draws staff from several other institutions acknowledged to have well developed and relevant expertise and linkages with end-users, all of which will play a role in delivery of the project. These include joint leadership from JCU (Jon Brodie) and CSIRO (Rai Kookana); collaboration with AIMS (Katharina Fabricius and Andrew Negri); DERM (Michael Warne and Glen Moller) and cross divisional input from CSIRO (Land and Water - Kookana and Oliver, Ecosystems Sciences- Kroon and Abbott, and Mathematics, Information and Statistics - Hayes and Henderson).

The project will build upon and integrate existing knowledge and data sets (eg Fabricius *et al.*, 2010, De'ath and Fabricius, 2008, 2010; Lewis *et al.* 2009, Kroon *et al.* in 2010, in review; water quality data from GBR rivers from Turner, Joo, Vardy, Smith *et al.*), together with the NERP projects proposed by Pressey & Brodie and Stoeckl and others.

Specifically, this study will:

- Develop an analysis framework to integrate the information from both the other components of the NERP program and pre-existing data such that a robust ecological risk assessment can be conducted. Previous forms of this type of analysis, e.g. the MCA of 2004 (Greiner *et al.* 2005), the MCA of for the Reef Rescue program (Cotsell *et al.* 2009), and the MCA for the GBR Amendment Act (Brodie *et al.* 2009; Brodie and Waterhouse 2009) used naive and relatively crude modelling frameworks and these can be improved upon substantially. Quite different methodologies than MCAs will be examined.
- Use inputs from a recent review of risk assessment approaches conducted by CSIRO (Keith Hayes, CMIS)
- Use inputs from recent DERM projects, especially on Assessment for prioritising integrated waterway monitoring in Queensland (DERM 2011Technical Report on Assessment for integrated waterway monitoring in Queensland – Technical Report, January 2011, State of Queensland (Department of Environment and Resource Management), Brisbane.

Data sharing across projects

The project data and results will be shared with the following NERP projects:

- Several projects funded through the Reef Rescue program involving in some case project team are relevant. These include: Brodie and team (Pesticide dynamics in the GBR catchment and lagoon: management practices in the sugarcane, grazing, grains cropping and horticulture industries with sub-projects: Lewis (half lives in soil) *RR37 - 1A*; Lewis (alternative pesticides) *RR37 – 1B*; Lewis (WQ benefits improved practices) *RR37 – 1C*; Kookana (management options for runoff of dissolved and colloidal pesticides) *RR37 – 1D*; Thornton (tebuthiuron persistence in grazing lands) *RR38 – 2B*; Packett (dissolved & particulate partitioning in grazing lands) *RR38 – 2C*; Armour (management in bananas) *RR38 – 2D;* Negri (marine half lives) *RR38 – 2A;*

- Reef Rescue Devlin and Brando remote sensing and exposure project.

NERP projects that have some opportunity to two-way sharing of data include:); Negri and team (The chronic effects of pesticides in combination with climate pressures on the health and performance of primary producers); Negri and team (Persistence of pesticides in tropical marine & estuarine waters);

Risks

Following potential risk areas have been identified and the strategies to deal with these have been developed.

- Project management and skill mix - The two project leaders have well developed project management skills. All team members are highly experienced in working with multidisciplinary teams of varying sizes and have successfully delivered in a timely manner, on numerous large and/or important projects.
- Staff movement and loss of critical skill – the project team has been drawn from multiple agencies and in each case there more than one person involved. Besides the agencies have skill pool that can be called upon in the case of staff movement. Here it is notable that the project is jointly led by CSIRO and JCU.
- Science quality – The project would employ best available risk assessment tools e.g. from recent review of risk assessment methodology.
- Input data availability – The team is well informed on history of relevant projects, custodians of relevant data and the project has allocated resources to collate and synthesize the relevant data in phase 1, rather than assuming the availability of necessary data and information. Existing resources have been identified as useful platforms to build on. Methodology employed would be matched with data availability.
- Linkages with other projects – while there is no critical dependence on any other project has been identified for ensuring the success of this project, the involvement of staff members such as Jon Brodie, Frederieke Kroon, Michael Warne and Rai Kookana in relevant projects would ensure active relationships with relevant projects for data sharing.
- Resources issues – The original project had to be modified to suit the available budget and therefore the scope of the project has been revisited to match the resources. The project is supported by both cash and in-kind contribution of the partner organizations and this provides a broader base to the project. The project leaders would ensure the resources are optimal used and the project directions are carefully monitored.
- End-users engagement – in the light of potential risk to project delivery and adoption due to lack of end-user engagement, engagement with end-user is planned to at the start of the project. This provides an opportunity have a two-way flow of information with end-users, ensuring timely delivery and adoption. Besides the project team belong to the agencies that are both sources of relevant input data as well as end-users of the project findings.

References:

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Project Budget

AWP 1 – July 2011 – June 2012 Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	60,000	-	60,000
AIMS	-	2,000	2,000
DERM	-	2,000	2,000
JCU	-	27,000	27,000
CSIRO	-	29,000	29,000
Total	**60,000**	**60,000**	**120,000**

Project 4.4: Hazard assessment for water quality threats to Torres Strait marine waters, ecosystems and public health

Project Leader and Host Organisation

Jon Brodie, James Cook University

Project Team

Title	Organisation	Role
Jon Brodie	Catchment to Reef Research Group, ACTFR, JCU	Project leadership, pollutant source survey, RS image retrieval and analysis, data analysis, basic monitoring program design, reporting
Jane Waterhouse	Catchment to Reef Research Group, ACTFR, JCU	Pollutant source survey, PNG/ West Papua/TS development survey, RS image retrieval and analysis, reporting
Eric Wolanski	Catchment to Reef Research Group, ACTFR, JCU	SLIM modeling, RS image retrieval and analysis, reporting

Summary Table of End-users

Organisation	Organisational Contact	Email
TSRA	John Rainbird (Project buddy) Frank Loban (Project buddy) Damien Miley	John.Rainbird@tsra.gov.au Frank.Loban@tsra.gov.au Damian.Miley@tsra.gov.au
Torres Strait Community	John Morris	Jmorris.kel@bigpond.com
TSIRC	Patrick McGuire (Director, Engineering Services)	Pat.McGuire@TSIRC.qld.gov.au
Torres Shire Council	Gus Yates (Director, Engineering Services)	des@torres.gov.au
AMSA	Adrian Davison	Phone contact
Queensland Transport	Frank Thomson	Frank.j.thomson@msq.qld.gov.au
AFMA	Annabel Jones	Annabel.Jones@afma.gov.au
Tagai College	Andrew Denzin	adenz2@eq.edu.au
DSEWPaC	Celeste Powell	Celeste.powell@environment.gov.au

Project Duration

Start Date: 1 July 2011 End Date: 30 June 2013

Project Description / Task Objectives

An understanding of the status of water quality in Torres Strait and its influence on marine foods, human health, marine ecosystems and ecological processes in the Straits is important. Potential water quality issues include both regional such as discharge of metal (and other pollutants in future) pollution from the Fly River associated with mining and future projects involving oil palm plantation development, the port at Daru, other mines in PNG or West Papua and other land clearing, and local such as sewage and stormwater discharge and shipping issues (dredging, oil spills, ship groundings, shipyards). No detailed water quality issues hazard analysis has been done. Previous studies include the Torres Strait Baseline Study(TSBS) of the early 1990s (Dight, Gladstone, Brodie, Evans-Illidge and others), further studies on metal pollution by Haynes and Kwan (mid 1990s), studies on the Fly River plume (Wolanski and others, 1980-1990s) and basic science studies (Continental Shelf Research special issue 2008) with limited recent work.

For confident predictions of pollutant transport from source to effect area a model able to be used in the specific Torres Strait physical and ecological environment is essential. Several previous studies have characterised specific aspects of water flow in Torres Strait, but these studies have limitations that compromise their application in the current project, as outlined below:

- Griffin (2008) has performed a series of numerical experiments in an attempt to track drifters through the Strait using the Bluelink ocean model (Schiller *et al.*, 2008). This particular model however allows too much flow through due mainly to it being too coarse for this particular application and tides were not included in the forcing.
- Recent numerical modelling studies (Saint-Caste, 2008) have been done and the results indicate that wind setup of sea level is a significant driver of inflow. However these studies using the data from very limited field studies are hampered by inadequate boundary conditions and observations. Further, the coarse grid on which this model's 3 dimensional predictions are based, provides inadequate resolution for understanding the detail of 2 dimensional current flow on the scale needed for the present study (eg flow in between reefs, through passages and around islands).
- The Oil Spill Trajectory Model (OSTM) is used by AMSA as a decision support tool to predict the behaviour of various oils in the water column based on wind and tidal data. The components of OSTM were upgraded in June 2004. A new hydrodynamic model, HYDROMAP, was implemented which expands the modelling capability. A new version of the oil spill mapping component of the model, OILMAP, was also installed. However while OSTM is very suitable for oil spill response modelling it is clearly stated by AMSA that it not designed nor suitable to be used for other uses. It is not a suitable model for use in river plume trajectory predictive modelling or diffuse coastal discharge modelling.

Overall, due to the numerous islands, their complex shapes, complex bathymetry and strong current regimes, a fine scale 2-dimensional model based on an extensive observational network is needed for the Torres Strait so as to be confidently be able to assess pollutant transport and dispersion. SLIM is able to do this due to its variable grid size feature and our ability to draw upon the extensive past data sets gathered by Eric Wolanski and colleagues over the past several decades. Without such a model our ability to predict and explain contaminant transport pathways and thus potential ecological and public health effects would devolve back to, for example, crude visual assessment of river flood plume movement from satellite imagery when available.

Key Objectives

1. Assess and describe all existing and potential sources of pollution to the Torres Strait marine environment.
2. Assess the hazard (and to some degree risk) of these pollutant sources to marine ecosystems and public health.
3. Facilitate uptake of project outputs and outcomes to key end-users and stakeholders (TSRA, TS rangers, DSEWPAC, researchers, TS community), through provision of reports and production of outcomes in forms suitable for upload to e-Atlas (data layers for mapping, plain English article(s), metadata).
4. Design a basic monitoring program which would allow reporting on the status of water quality in the Torres Strait and assessments to be made as to the success of pollution management interventions.

(A Stage 2 project for the period after June 2012 conjunction with the Project 2.2a and drawing of the results of 2.2b to implement a water quality program will be proposed).

Project / Task Methodology

The analysis will review all water quality information available for the region, use land use and pollutant generation analysis to predict pollutant loadings and analyse risk to marine ecosystems in the region. No new water quality sampling will be required but acquisition of land use data, development project information, remote sensed imagery and socio-economic data will be involved particularly for assessment of regional scale issues. Currently available information on the effects of different types of contaminants on coral reef and seagrass ecosystems, marine food species and human populations will be used to assess risk.

To identify water quality issues of concern at the local scale, we plan to visit as many of the island communities as possible to examine land use issues, sewage systems and other waste disposal systems. This program would be guided by an initial workshop with TS rangers and TSRA LSMU staff, to collate issues of concern and plan a site visit program. We anticipate that the TS rangers will be able to assist with this work in both a community liaison role as well as practically getting us to the sites of the waste systems and also to the marine waters which may be affected by such wastes. Many of these areas may form the basis of future monitoring sites. TS rangers could also help in the communication of the results of project to local communities through written material and end-of-project meetings. Rangers would also gain knowledge during the process on, for example, sewage treatment systems and shipping pollutants, and be well prepared for further input (stage 2) to the development and implementation of a water quality monitoring program.

The pollution risks will be evaluated by providing maps of potential pollution plumes. Pollution plumes will be calculated from oceanography models. The pollutants may be wastewater at the local scale of individual islands, in the northern Torres Strait fine sediment and heavy metals from the Fly River, throughout the Torres Strait oil spills from accidents at sea, and in the northern Torres Strait industrial pollutants from spills from the proposed Daru deep water port presently at the design stage. The Daru port is planned to handle mining ore, gas and petroleum, and ultimately forestry and palm oil products.

The present oceanographic models are too coarse in resolution to realistically represent the complex bathymetry. Thus, outputs from this project will rely on a combination of fine-scale resolution models including HYDRO and SLIM (as outlined above). Oceanographic field data for driving this model are available for the western side from Wolanski (1993), for the southern Torres Strait from Wolanski *et al.* (1984 and 1988), for the eastern Torres Strait from Wolanski and Thomson (1984), and for the northern Torres Strait from Wolanski *et al.* (1984 and 1999).

Data sets on the spatial location of current and proposed pollutant sources relevant to the Torres Strait will be provided to e-Atlas along with text descriptions and statistics of the sources.

In summary, the steps in the project (Stage 1) will be:

1. Collate existing water quality and hydrological data in Torres Strait to identify key issues at a range of scales.
2. Develop SLIM model for use in the Torres Strait to assess hazard.
3. Survey existing and proposed large scale development proposals, particularly in PNG and West Papua, from which discharge of contaminants to the TS region may occur.
4. Undertake a hazard assessment to key marine ecosystems and public health in TS, due to water quality issues identified.
5. Provide recommendations for a potential water quality monitoring program to track the status of water quality and the response of water quality to management interventions in the future.

References

E. Wolanski, G.L. Pickard and D.L.B. Jupp (1984). River plumes, coral reefs and mixing in the Gulf of Papua and the northern Great Barrier Reef. Estuarine Coast. Shelf Science18, 291-314.

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E. Wolanski, P. Ridd and M. Inoue. (1988). Currents through Torres Strait. J. Physical Oceanography, 18, 1535-1545.

E. Wolanski (1993). Water circulation in the Gulf of Carpentaria. J. Marine Systems 4, 401-420.

E. Wolanski, S. Spagnol and Brian King (1999). Patchiness in the Fly River plume, Papua New Guinea. J. Marine Systems, 18, 369-381.

Project Outputs/Outcomes

- Collated information regarding Torres Strait water quality contaminant sources at a range of scales (regional to local)
- Hazard (and to some degree risk) assessment of the pollutant sources to marine ecosystems and public health, as the basis for management authorities to prioritise investment and political action to minimize pollution and public health/marine ecosystem damage.
- Recommendations for a water quality monitoring program, designed to allow assessment of the status of water quality and measurements of effectiveness of pollution management interventions.
- Georeferenced data sets on the spatial location of current and proposed pollutant sources relevant to the Torres Strait will be provided to e-Atlas along with text descriptions and statistics of the sources.
- TS ranger capacity building in understanding of TS water quality issues at a range of scales, and proposed monitoring.

Results will be delivered to end-users as a report identifying the hazards and their priority, and provision of results to the e-Atlas (as outlined above). As a Stage 2 activity in 2013 a set of management response scenarios could be developed. These could be very complicated given the transnational nature of the likely issues. The SLIM model will also be available for other and future project use.

Benefits to end-users

The benefits to end-users, primarily community and government organizations responsible for water quality in the Torres Strait, will be an overall assessment of water quality issues and a basis on which to plan water quality management and prioritization of such management. The Torres Strait community will get an independent assessment of the status of water quality in the Torres Strait and the issues threatening good water quality.

This project is linked to the rest of TS NERP Project 2.2.

Overall Project Budget for life of project:

	NERP AWP 1	AWP 2	AWP 3	Total
Salary	36,000	36,000		72,000
Travel	3,000	3,000		6,000
Operating	1,000	1,000		2,000
Capital				
Total NERP	**40,000**	**40,000**		**80,000**
In-kind:				
AIMS				
CSIRO				
JCU	23,550	23,550		47,100
TSRA (rangers)	Personnel and boats	Personnel and boats		
Total In-kind	**23,550**	**23,550**		**47,100**

Project 4.4 Budget for AWP 1

Year 1 – 1 July 2011 – 30 June 2012 Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	40,000	-	40,000
JCU	-	23,550	23,550
TSRA	-	*	-
Total	**40,000**	**23,550**	**63,550**

*Note that the above and below in-kind from TSRA does not include a costing for anticipated in-kind from the TS ranger program.

Year 2 – 1 July 2012 – 30 June 2013 Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	40,000	-	40,000
JCU	-	23,550	23,550
TSRA	-	*	-
Total	**40,000**	**23,550**	**63,550**

*Note that the above and below in-kind from TSRA does not include a costing for anticipated in-kind from the TS ranger program.

Program 5: Cumulative Impacts on Benthic Biodiversity

Program 5 will have three projects designed to assess the impacts of cumulative pressures on coastal biodiversity in the GBR. One will be a synthesis and analysis of spatial and temporal patterns of inshore biodiversity seeking to partition the influence of different environmental drivers (water quality, crown of thorns starfish, cyclones, and connectivity) and identify synergistic interactions between stressors. The other two will be multi-factorial experiments exposing corals and seagrasses to different combinations of stressors in order to incorporate cumulative hazards into quantitative risk models.

Project 5.1: Understanding Diversity of the GBR: Spatial and Temporal Dynamics and Environmental Drivers

Project Leader and Host Organisation:

Name	Dr Glenn De’ath		
Position	Principal Research Scientist		
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Project Team

Title	Organisation	Role
Dr Glenn De’ath	AIMS	Biostatistician, Ecological Modeller
Dr Katharina Fabricius	AIMS	Coral Reef Ecologist
Alistair Cheal	AIMS	Fish Ecologist, LTMP
Dr Mike Cappo	AIMS	Fish Ecologist

Summary Table of End-users

Organisation	Organisational Contact	Email
GBRMPA	David Wachenfeld Fergus Malloy Laurence McCook Roger Beeden	david.wachenfeld@gbrmpa.gov.au fergus.malloy@gbrmpa.gov.au Laurence.mccook@gbrmpa.gov.au Roger.beeden@gbrmpa.gov.au
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AMPTO	Colin McKenzie	col@gempearl.com.au

Project Duration

Start Date: 1 July 2011 End Date: 30 June 2014

Project Description

Our current knowledge of diversity of the GBR and the mechanisms that determine it are minimal. Based on a new statistical model of diversity, we will map the diversities of biota and environments of the GBR, and will relate biotic diversity to spatial, environmental and temporal drivers. These relationships will be interpreted in the context of risk, zoning and management. The project will be based on existing long-term and large-scale data from the GBR (including LTMP on coral cover and density of crown-of-thorns starfish, seafloor diversity data, large-scale diversity surveys of octocorals and corals, water quality data, bleaching history data, satellite derived SST and ocean colour history data, BOM path and intensity of tropical cyclones).

The results and outputs of this research will be published in high impact peer reviewed journals, and may substantially inform the Outlook Report. Maps and other summaries will be available through the e-Atlas, an interactive open-source online mapping and visualisation platform.

Key Objectives

- Map the diversities of fishes, corals, other biota and environments of the GBR at optimal spatial and temporal scales.
- Determine the main drivers of diversity on the GBR, and quantify their effects in terms of loss, gain and turnover of diversity.
- Quantify changes in space and time of reef and seafloor diversities, and provide diversity-based indicators of reef health.
- Enhance our knowledge and understanding of biodiversity the GBR.
- Assess the effects of the zoning on diversity on the GBR reefs and seafloor.

Background

Diversity is a key concept for both the scientific understanding and effective management of the GBR. Despite its importance to both theorists and users, both the definition of diversity and associated empirical methods have been contentious and confused. Diversity is typically referred to in terms of hierarchies (α, β and γ) or as turnover between sites or over time. This over-simplified view of diversity has greatly limited studies and hence our understanding of diversity. In particular it has precluded the capacity to relate diversity to complex environmental drivers, and to address questions such as 'Does diversity decline linearly with latitude, and 'Does the rate of decline vary with distance from coast'. A novel comprehensive framework for diversity analyses has been developed (De'ath, 2011) that offers better conceptual and analytical tools than previously available. It includes a more general definition of diversity and it can be incorporated into a statistical model. This model, called the multinomial diversity model, can relate change in diversity to multiple predictors. Such predictors could, for example, represent groupings such as regions or experimental treatments, and/or continuous diversity gradients due to factors such as temperature and latitude. Non-linear effects and interactions between predictors can also be included to address questions such as 'How does diversity change over time, do rates of change vary between regions, and what are the projected levels of diversity for future years'.

Using these new diversity concepts, methods and associated software, we will relate existing diversity data sets (e.g. LTMP, Seafloor Diversity, hard coral and soft coral surveys) to environmental data, including water quality, satellite derived SST, bleaching, salinity and ocean colour history data, fishing, COTS, currents, and tropical cyclones.

Project Methodology

The study will identify, quantify and map the main forms of chronic and acute environmental pressures, and the diversity of biotic responses to them, for the coral reefs and seafloor communities of the GBR. We will identify regions of high diversity with low disturbance histories (potential sanctuaries), and regions with high frequencies of episodic and chronic disturbance. We will determine the attributes of regions that are associated with recovery of coral and fish diversities after disturbance. The study will identify properties that may mediate or exacerbate risk for reefs including zoning, depth, location (latitude, distance from coast, human populations, rivers, etc), connectivity and size of reefs. The study will examine the dynamics of diversity in relation to threats and stress, and will determine conditions most and least suitable for recovery after disturbance along depth, latitudinal and cross-shelf gradients.

Diversity and risk maps, developed from these analyses, could be the foundation for developing more regionally specific management and monitoring programs. All analyses will directly feed into the e-Atlas, and may substantially inform the 'Outlook Report' and 'State of Environment Report'.

Specific sub-projects under this theme will include:

- Construction of a spatial-temporal data-base comprising all biotic and environmental datasets used in the study. This will include spatial-temporal links between data sets to facilitate merging and manipulation. The data base will be made available to all interested parties.
- Mapping of the diversities of fishes, corals and other biota of the GBR, and their interactions, at appropriate spatial and temporal scales. These maps will be added to the e-Atlas map repositories and will be available in a browsable linked document.
- Determine the main drivers of diversity on the GBR and quantify their effects in terms of loss, gain and turnover of diversity.
- Quantify changes in space and time of reef and seafloor diversities and provide diversity-based indicators of reef health. Exploration of spatial zonation based on regions of low diversity turnover; such regions will represent a classification of the GBR with each region bounded by high turnover. Use these indicators to produce maps of the dynamics and current levels of GBR diversity.

Project Outputs and Outcomes

- An improved understanding of the distribution and dynamics of diversity on the GBR. This will include knowledge of how diversity changes in response to disturbances and threats, and how diversity changes in space and time.
- Extensive maps of diversities of fishes, corals, other biota and environments that will be available online through the e-Atlas. These maps will be fully interactive, and also available as publication quality vector graphics for use in publication, reports and presentations.
- Knowledge of the principal determinants and drivers of diversity on the GBR and quantification of their effects in terms of loss, gain and turnover of diversity.
- Diversity-based indicators of reef and seafloor condition and how it varies under various environmental scenarios.
- Assessment of the effects of the zoning on diversity of the GBR reefs and seafloor zones.
- Diversity maps for ‘State of the Environment’ and ‘Outlook Report’ reporting.

Links and dependencies to other hubs and projects

This project will provide critical information to many of the activities listed in the NERP Program, including those from Sweatman (the Long-Term Monitoring Program), Russ, Zhao, Pressey, Lawrey, and Anthony/Wooldridge projects. It will provide key data layers to the e-Atlas, and also substantially inform the Reef Rescue Program.

Identified and assessed hazards

Description of Risk	Assessed Risk	Risk Control measures
Failure to obtain data	Low	All data exist but have to be processed and retrieved from various sources.
Departure of key project personnel	Medium	All participants have a strong interest in the project, and are committed to doing this.
Failure to achieve outcomes due to dependence on outputs from other projects	Low	The project is largely self-contained

References

De’ath G. 2011. The multinomial diversity model: a new approach to relating diversity to multiple environmental drivers (submitted).

Budget

Year 1 – 2011/2012 Project Funding and Partnerships

Contributing Organisation	Cash	AIMS In-kind	Total
NERP	136,687	-	**136,687**
AIMS	-	159,529	**159,529**
Total	**136,687**	**159,529**	**296,216**

Year 2 – 2012/2013 Project Funding and Partnerships

Contributing Organisation	Cash	AIMS In-kind	Total
NERP	117,217		117,217
AIMS		148,084	148,084
Total	**117,217**	**148,084**	**265,301**

Year 3 – 2013/2014 Project Funding and Partnerships

Contributing Organisation	Cash	AIMS In-kind	Total
NERP	130,000	-	130,000
AIMS	-	152,040	152,040
Total	**130,000**	**152,040**	**282,040**

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

Project Leader and Host Organisation

Name	Dr Sven Uthicke		
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Project Team

Title	Organisation	Role
Sven Uthicke	AIMS	Project leader, researcher ecology and physiology
Sam Noonan	AIMS	Experimental scientist
Florita Flores	AIMS	Experimental scientist
Katharina Fabricius	AIMS	Researcher ecology
Andrew Negri	AIMS	Researcher ecotoxicology
Frances Patel	AIMS	Experimental scientist
Nikolas Vogel	AIMS	PhD student
Yan Xiang Ow	AIMS/JCU	PhD student
Melissa Rocker	AIMS/JCU	PhD student

Summary Table of End-users

Organisation	Organisational Contact	Email
GBRMPA	Katherine Martin Paul Marshall Hugh Yorkston	Katherine.Martin@gbrmpa.gov.au Paul.marshall@gbrmpa.gov.au Hugh.yorkston@gbrmpa.gov.au
DSEWPaC/ Reef Rescue	Kevin Gale	Kevin.Gale@environment.gov.au
DSEWPaC	David Calvert Charles Brister Leah McKenzie	David.calvert@environment.gov.au Charles.brister@environment.gov.au Leah.mckenzie@environment
DEHP	John Bennett	John.Bennett@dehp.qld.gov.au
Department of the Premier and Cabinet	Chris Chinn	chris.chinn@premiers.qld.gov.au
DAFF	Adam West Phil Hales	adam.west@daff.qld.gov.au phil.hales@daff.qld.gov.au
Canegrowers	Matt Kealley	matt_kealley@canegrowers.com.au
Meat and Livestock Australia	Mick Quirk	Mick.Quirk@mla.com.au
WWF	Nick Heath	Nheath@wwf.org.au

Delivery and adoption, and benefits for stakeholder

Key end-users will be informed and kept up to date throughout the project. Data and findings will be published in reports and scientific publications and disseminated at conferences and workshops with end-users. Data produced are vital for future management decisions and prioritization of management effort, e.g. whether to focus on management of local (runoff) issues or global change.

Project Duration

Start Date: 1 July 2011 End Date: 31 December 2014

Project Description / Task Objectives

Summary

The objective of this project is to assess how management of local stressors such as land runoff can help improve the resilience of coral reefs to global stressors (climate change) which are more difficult to manage.

Background

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 have normally been considered as individual threats to tropical systems, but their interactions are as yet poorly understood and likely to be more damaging than the threats in isolation.

Increased ocean temperatures negatively affect symbiotic relationships (e.g. coral bleaching) and atmospheric carbon pollution is reducing the ability of tropical marine organisms to calcify. Inshore coral reefs are an important model system to predict whether and how the calcification of reef organisms in general may respond to lower carbonate saturation states and increased temperatures. Freshwater and organic matter from terrestrial runoff may also affect benthic calcification on inshore reefs, by influencing pH, oxygen saturation and carbonate saturation, particularly in the boundary layers of terrigenous siliciclastic and carbonate sediments on coastal reefs. Particular attention needs to be directed toward water quality - OA interactions affecting coral reef organisms that grow within the sediment boundary layers. Physiological studies are needed to understand the impact of changes in the finely tuned balance between symbiontic relationships and on calcification and metabolism resulting from enhanced carbon (through OA) and enhanced nitrogen (from land runoff). The proposed research project will conduct a series of integrated and complementary laboratory and field experimental studies to assess causal association between the interactions of water quality, ocean warming and ocean acidification.

Task Objective

The task objective of this project is to investigate the following assumptions through laboratory experiments and field studies: Organisms and ecosystems on nearshore reefs of the GBR are particularly vulnerable to increased water temperatures and OA because i) they are already stressed by water quality impacts, ii) the symbiotic relationships of their corals are under threat because of release from C and N limitation, iii) alkalinity and dissolved inorganic carbon on inshore reefs are more variable because of lower buffering capacity of low carbonate sediments and sporadic freshwater influx in flood plumes, iv) reduced light conditions reduce the capacity of photosynthetic organisms to 'capture' CO_2 and transform it to organic material.

Key Objectives

1) To experimentally quantify changes in the thresholds for global change stressors (temperature increase, ocean acidification) due to elevated local stressors, (increased nutrients, increased turbidity, decreased salinity) on key coral reef organisms.
2) Caring for the next generation by investigating individual and synergistic effects of water quality and global change on reproduction, larval development and settlement of key coral reef invertebrates (e.g. corals, echinoderms).

3) Predicting the future performance of reef organisms, by experimentally testing hypotheses about differences in the vulnerability of coral species to ocean acidification, as derived from our studies of natural CO_2 seeps.
4) Using inshore reefs as a model system to investigate the performance of calcifying organisms at low or variable carbonate saturation state.

Project / Task Methodology

In collaboration with other projects of the NERP, this project will focus on multi-factorial laboratory studies and field research, quantifying effects of different water quality parameters (specifically nutrients, reduced light, increased sediment load and reduced salinity) in combination with increased temperature or ocean acidification on keystone species groups and ecosystem processes on nearshore areas of the GBR. AIMS is in a unique position to address this problem, due to the advanced experimental aquarium system (ATOS), access by research vessels to the whole GBR, and controlled flow-through seawater facilities that allow manipulation of nutrients, carbonate saturation, light and temperature.

Specific sub-projects will include:

1. Increased carbon supply through OA, enhanced nutrients and increased temperatures all disturb the balance between host and symbiont in organisms such as corals and foraminifera. We will study the interactive effects of these factors in laboratory experiments using existing AIMS facilities and ATOS, to establish if management of local factors (ie land runoff) can ‘buy time’ for reef communities until these adapt or climate change is managed on a global scale. Findings will be underpinned by field data investigating host-symbiont relationships under different field conditions, including natural carbon dioxide vents (see below). This study will be supported through a PhD student.
2. Water quality, altered temperatures and changes in ocean pH alone or in combination can affect the recruitment of corals and other coral reef invertebrates, thus reducing recovery potential for the next generation. Subtle changes in these environmental parameters can alter the biofilm community on bare substrates and on crustose coralline algae which are important for larval settlement. Invertebrate larvae are sensitive to environmental changes during the planktonic phase. We will experimentally investigate how gonad and larval development, and larval settlement in keystone reef invertebrates (e.g. corals, crown-of-thorns, rock boring sea urchins) are affected by single and multiple environmental variables. This will inform whether, and to what extent, improvements in water quality will ameliorate climate change impacts on reef recovery.
3. Using a natural field setting around volcanic but cool carbon dioxide (CO_2) seeps, we have quantified relative differences in tolerances between coral species to long-term exposure to high levels of carbon dioxide (CO_2). We will now experimentally investigate the differential responses of the more sensitive and more robust corals to high CO_2, to understand the mechanisms that lead to CO_2 tolerance, and to predict the ways in which coral reef communities may be structured in a high CO_2 world. We will investigate molecular, physiological and microbial measures of coral health/performance under different OA scenarios, using both medium - and long-term exposures. We will then investigate contributing environmental factors (especially turbidity and the organic enrichment of sediments) that might alter the sensitivity of corals to high CO_2.
4. Estuarine waters are known to have relatively low pH and carbonate saturation state, yet some of them do host coral reefs, where some coral recruits are able to grow and calcify. Such coral reefs may be particularly vulnerable to ocean acidification, and represent an important model system to predict whether and how reef calcification may be altered at low carbonate saturation states. A laboratory experiment will be used to test the hypothesis that pH and the physiological health and calcification of coral recruits and crustose coralline algae differ when in the boundary layer of calcareous vs organically enriched sediments. Based on field measurements we will also investigate pH and biotic calcification rates in the boundary layer of inshore reef sediments near and away from rivers, and within and away from macroalgal stands. Finally, in collaboration with the MMP program we will characterize the alkalinity and pH conditions around the 14 MMP inshore reefs and off river mouths in the wet and dry season.

Collaboration and data sharing, links and dependencies

This project has links to several other projects in the NERP. Close ties exist to the "Seagrass and acidification" project (Collier *et al.*), "Ecological risk assessment of pesticides, nutrients and sediments on water quality and ecosystem health" (Kookana, Brodie *et al.*), "Coastal and ecosystem risk assessment" (Pressey *et al.*),"The chronic effects of pesticides and their persistence in tropical waters" (Negri *et al.*), and "Tracking coastal Turbidity" (Fabricius *et al.*). Furthermore, this project has strong linkages and collaboration with the Reef MMP.

Risks

Given that experimental and field research is involved there are intrinsic risks of project delays due to weather or equipment failure. However, the 3.5 yr time frame of the project provides flexibility and scope to cope with these risks. Project staff has been involved in previous MTSRF research and an excellent track record of delivery.

Risk assessment: identified and assessed hazards

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	Most personnel are already committed to the project and the only new position will be a student.
Failure to obtain data	Low	Most of the experiments will be performed in laboratories under controlled conditions to minimize the risk of failure. Research and technical personnel highly experienced in experimental studies.
Departure of key project personnel	Low	Full documentation of the research plan, methods and results to date will ensure continuation of the project following appointment of replacement personnel.
Failure to achieve outcomes due to dependence on outputs from other projects	Low	This project is linked to other projects but does not rely on the outcomes. Communication via meetings and workshops will ensure high levels of integration.
Failure to achieve uptake of results by end-users	Low	Workshops/meetings will be convened with key end-users at various key project stages to ensure engagement and delivery of results in useful form.

Project Outputs/Outcomes

Objective 1:

- The work will result in improved understanding on climate and WQ interactions and will allow to model changes in thresholds and consequences of improved land management.
- The results will assist to better define the threshold of concern for several stressors in combination

Objective 2:

- The study will inform how small changes in single stressors or combinations of stressors can affect the next generation of invertebrates thus potentially eroding reef resilience and diversity.

Objective 3:

- Improved understanding of mechanisms leading to contrasting tolerances of corals to ocean acidification, and the flow-on effects on coral reef communities.

Objective 4:

- A better understanding of the carbonate saturation conditions on coral reefs exposed to terrestrial runoff, and the consequences for photosynthesis and calcification of coral recruits and coralline algae,

Project Budget

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	176,650	-	176,650
AIMS	-	218,486	218,486
Total	**176,650**	**218,486**	**395,136**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	231,323	-	231,323
AIMS	-	216,388	216,388
Total	**231,323**	**216,388**	**447,711**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	234,309	-	234,309
AIMS	-	222,818	222,818
Total	**234,309**	**222,818**	**457,127**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	119,740	-	119,740
AIMS	-	108,003	108,003
Total	**119,740**	**108,003**	**227,774**

Project 5.3: Vulnerability of seagrass habitats in the GBR to flood plume impacts: light, nutrients, salinity

Project Leader and Host Organisation

<table>
<tr><td>Name</td><td colspan="3">Dr Catherine Collier</td></tr>
<tr><td>Position</td><td colspan="3">Postdoctoral Fellow</td></tr>
<tr><td>Organisation</td><td colspan="3">James Cook University</td></tr>
<tr><td>Unit</td><td colspan="3"></td></tr>
<tr><td colspan="2">Postal Address</td><td colspan="2">Delivery Address</td></tr>
<tr><td></td><td>James Cook University</td><td></td><td></td></tr>
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</table>

Project Team

Title	Organisation	Role
Dr Catherine Collier	JCU	Project leader, experimental researcher, seagrass eco-physiology
Assoc Prof Michelle Waycott	JCU	General input, data provider, seagrass population dynamics
Dr Michelle Devlin	JCU	Lead researcher of water quality
Len McKenzie	DEEDI	Monitoring provider, data provider, assist with interpretation and general input in relation to seagrass ecology
Dr Rob Coles	DEEDI	Monitoring provider, data provider, assist with interpretation and general input in relation to seagrass ecology
Research worker	JCU	Assist with general activities associated with experimental research

Summary Table of End-users

Organisation	Organisational Contact	Email
DAFF	Phil Hales John Beumer	phil.hales@deedi.qld.gov.au john.beumer@deedi.qld.gov.au
GBRMPA	Katherine Martin Carol Honchin	katherine.martin@gbrmpa.gov.au carol.honchin@environment.gov.au
DERM	Michael Warne	Michael.Warne@derm.qld.gov.au
DSEWPaC (Reef Rescue)	Kevin Gale	Kevin.Gale@environment.gov.au
Reef Plan Secretariat (Dept. Premier and Cabinet)	Chris Chinn	chris.chinn@premiers.qld.gov.au
DSEWPaC	David Calvert Charles Brister Leah McKenzie Lesley Gidding Karen Arthur Amy Cmic Kate Sanford-Readhead	David.calvert@environment.gov.au Charles.brister@environment.gov.au Leah.mckenzie@environment.gov.au Lesley.gidding@environment.gov.au Karen.arthur@environment.gov.au Amy.cmic@environment.gov.au Kathryn.sanford-readhead@environment.gov.au

Project Duration

Start Date: 1 July 2011 End Date: 31 December 2013

Project Description / Task Objectives

Seagrass meadows are a vital habitat in tropical coastal ecosystems: they support biodiversity of estuarine, coastal and reef communities, including fisheries species, and they are a direct food source for obligate seagrass feeders such as dugongs. Seagrass meadows in the coastal zone also form a buffer between the catchment and the reef, trapping sediments and absorbing nutrients, with their high productivity rates facilitating rapid nutrient cycling. The Reef Rescue Marine Monitoring Program has identified that seagrass meadows along the GBR are in a state of decline (McKenzie *et al.* 2010). Based on monitoring trends to June 2010, the indicators of this decline are: seagrass abundance reduced below subregional guidelines at 67% of sites, shrinking meadow area at 50% of sites, many sites having limited or are no production of seeds that would enable rapid recovery, indications of light limitation at 63% of sites, nutrient enrichment at 33% sites and high or elevated nitrogen at 90% of sites. There is also evidence of long-term increases of seagrass-tissue nutrients in coastal and reef seagrasses, particularly in the Wet Tropics and Burdekin regions. In addition, widespread impacts from flooding and cyclones occurred throughout the GBR in the summer 2010-2011, causing further declines in an already fragile system. The trends in seagrass decline, apart from the direct impact of tropical cyclones, are the result of changing water quality, particularly caused by the direct and indirect effects of flood plumes.

One of the biggest threats to seagrass meadow health is low light levels, particularly chronic low light levels, and pulsed acute low light that occurs as a result of flood plumes (Collier & Waycott 2009, Waycott *et al.* 2009). As such, light has, and is continuing to be, the focus of considerable research and monitoring over the last few years. We are now in a good position to explore interactive effects of low light with other water quality impacts, particularly features of water quality under flood plume conditions including high nutrients and low salinity. This two-year project will explore exposure of seagrass meadows to light, nutrients and salinity, seagrass responses to the interactive effects of these water quality impacts and contribute to the development of thresholds, the establishment of fundamental biological traits for input into modelling exercises and to biodiversity assessments.

Key Objectives

1. Develop an understanding of the spatial and temporal extent of changing water quality associated with intense weather events and its impacts on the status of seagrass meadows in the GBR
2. Use flood plume exposure data to develop environmental thresholds for experimental parameter setting.
3. Synthesise existing data on light, nutrients and salinity impacts to seagrass meadows and evaluate knowledge gaps on seagrass responses to these water quality impacts.
4. Develop baseline salinity thresholds for coastal seagrass species for input into interactive experiments.
5. Identify fundamental biological traits of seagrasses by measuring the interactive effects of light, nutrients and salinity on seagrass productivity.
6. Refine thresholds of concern of water quality impacts, with a particular focus on flood plumes, and input into the development of guidelines for the protection of seagrass meadows.
7. Contribute to risk assessment reports for the GBR (e.g. GBR outlook report) by highlighting risks to seagrass loss.
8. Contribute to the development of priorities for water quality management.

Project / Task Methodology

This project will undertake desktop analyses of existing data including: exposure of seagrass to flood plumes (light, nutrients, salinity); and, seagrass responses to these water quality impacts. This project will also generate new data that explores seagrass responses (e.g. productivity, nutrient content) to light, nutrients and salinity in aquaria experiments.

June 2011-June 2012

- Incorporate temporal remote sensing data and water type information into flood plume exposure analysis with an emphasis on 2010-2011 major event data associated with TC Yasi and major flooding in southern GBR, and previous events such as TC Larry. Multiple images over a wet season will be overlaid onto annual exposure maps. These annual maps will then form part of a long-term exposure analysis (~12 years).
- Use flood plume exposure mapping to assess the time and level of exposure of seagrass meadows to water quality impacts for input into experimental parameter setting.
- Synthesise existing data on light, nutrients and salinity responses (data from MTSRF 1.1.3, Reef Rescue MMP and other unpublished data sources) and publish in peer-reviewed journals.
- Evaluate data needs and potential analytical approaches for analysis of seagrass health responses to water quality (light, nutrient and salinity).
- In experimental aquaria, test seagrass responses to reduced salinity, and identify critical salinity thresholds for parameter setting in interactive experiments.
- Begin interactive experiments on seagrass responses (productivity, nutrient content) to light, nutrients and salinity.

July 2012-June2013

- Undertake aquaria experiments on seagrass responses (productivity, nutrient content) to the interactive effects of nutrients, light and salinity
- Synthesise findings, contribute to the refinement of thresholds and publish findings in peer-reviewed journals.

Ongoing

- Feed results into MMP reporting, spatial water quality and seagrass risk models and monitoring thresholds
- Liaise with end-users to update on project findings
- Conduct integration workshops for this and related projects, as appropriate

Linkages

This project will link with researchers from a number of institutions with well-established expertise. This project will link with *Design and Implementation of Management Strategy Evaluation for the Great Barrier Reef inshore (MSE-GBR)* Dichmont *et al.* Personnel from this project will contribute expertise to the management strategy evaluation project throughout its duration.

This project will also link with *The chronic effects of pesticides in combination with climate pressures on the health and performance of primary producers Negri et al.* The linkage with the pesticides project will provide a comprehensive analysis of seagrass responses to water quality impacts. These projects are linked through shared personnel (Collier) and focus species (inshore coastal seagrass species).

This project also has strong linkages with Reef Rescue Marine Monitoring Program activities (McKenzie/Waycott and Devlin). Data from the Reef Rescue MMP will contribute to desktop analyses.

This project is not dependent on data outputs from other projects. This project will use pre-existing data held by the project participants (published or unpublished) and will generate new data through new original research. However, it will benefit from findings from *The chronic effects of pesticides in combination with climate pressures on the health and performance of primary producers Negri et al.* as that project will provide data on the impacts to seagrass health associated with toxicant inputs – a factor that will contribute to our understanding of seagrass health responses to water quality. The data itself will not be required; however, the general findings, transferred through overlapping personnel (Collier), will help to fine-tune conceptual models as the projects progress.

Project Outputs/Outcomes and benefits to end-users

- Quantified level of exposure of seagrass meadows to broadscale (i.e. regional and landscape scale) and long-term (weeks-months) changes in water quality associated with flood plumes in coastal regions of the GBR.

- Seagrass responses to the interactive effects of light, nutrients and salinity
- Refinement of fundamental biological traits in relation to changes in water quality for input into future modelling
- Refinement of thresholds of concern for seagrass health contributing to the development of water quality guidelines in relation to light, nutrients and salinity
- Experimentally tested indicators of seagrass status adopted in MMP (e.g. nutrient ratios) in response to changes in water quality
- A refined understanding of future trajectories for GBR ecosystems, which will contribute to risk assessment reports for the GBR (e.g. GBR outlook report)
- Experimental verification of water quality response models and values (e.g. models developed through the MMP)
- Input into biodiversity assessments (Management Strategy Evaluation)
- Journal publications – peer-reviewed work that can be used for evidence-based policy

Delivery and reporting

In addition to routine Milestone reporting, outcomes of this work will be delivered through routine reporting and integration activities currently undertaken by project participants (Waycott, McKenzie, Devlin, Collier), including regular Reef Rescue MMP meetings, the annual MMP integration and synthesis workshop and Paddock to Reef reporting. Key stakeholders not involved in this process will also receive annual reports and regular meetings will be arranged by the project leader to update on progress-to-date and to get feedback on research direction (i.e. every 6 months or as appropriate).

Risk assessment

The overall risks associated with this project are low. Existing data will provide critical insight into exposure to light, nutrients and salinity and to seagrass responses to these water quality impacts. There remain many gaps in our understanding of light, nutrient and salinity responses and the interactive effects of these impacts. We are limited by the degree with which we can address these gaps within a two-year project timeframe. It should be noted that water quality toxicant impacts will be addressed in this NERP TE round (Negri *et al.*) and any remaining data gaps will not de-value the results we can generate through this project.

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	Key staff are awaiting start of project.
Failure to obtain data	Low	Short time frames with this project (total duration of 2 years) do mean that there is some risk that complications during experimental work will delay results; however, prior experience by key personnel in running similar experiments should ensure that any potential problems are identified quickly and measures put in place remediate the issues.
Failure to achieve outcomes due to dependence on outputs from other projects	Low	Some data already available, new data to be generated carries low risk.
Failure to achieve uptake of results by end-users	Low	Workshops/meetings will be convened with key end-users at various key project stages to ensure engagement and delivery of results in useful form.

Project 5.3 Budget

Budget summary

Item	NERP	Applicant		Other sources		Total
		Cash	In-kind	Cash	In-kind	
2011/12	161,500		236,500		32,560	430,560
2012/13	138,500		163,780		32,560	334,840
Total	**300,060**		**405,010**		**65,120**	**770,120**

AWP 1 – 2011/2012 Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	161,500		161,500
James Cook University		236,500	236,500
DEEDI		32,560	32,560
Total	**161,500**	**269,060**	**430,560**

AWP 2 – 2012/2013 Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	138,500		138,500
James Cook University		163,780	163,780
DEEDI		32,560	32,560
Total	**138,500**	**196,340**	**334,840**

AWP 3 (July 2013 – June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	-	-	-
James Cook University	-	98,170	98,170
Total	**-**	**98,170**	**98,170**

References

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Palacios SL, Zimmerman RC (2007) Response of eelgrass Zostera marina to CO2 enrichment: possible impacts of climate change and potential for remediation of coastal habitats. Mar Ecol Prog Ser 344:1-13

Waycott M, Duarte CM, Carruthers TJB, Orth RJ, Dennison WC, Olyarnik S, Calladine A, Fourqurean JW, Heck KL, Hughes AR, Kendrick GA, Kenworthy WJ, Short FT, Williams SL (2009)

Accelerating loss of seagrasses across the globe threatens coastal ecosystems. Proceedings of the National Academy of Sciences 106:12377-12381

Zimmerman RC, Kohrs DG, Steller DL, Alberte RS (1997) Impacts of CO_2 enrichment on productivity and light requirements of eelgrass. Plant Physiology 115:599-607

Program 6: Movements and habitat use by marine apex predators

Program 6 will have three projects designed to monitor the movements of apex predators in the GBRMP using widespread arrays of acoustic receivers installed and maintained by other funding programs (e.g. IMOS, ARC). One project will focus on the movement and habitat use of large predatory fishes (e.g. sharks and coral trout) in reef environments. New knowledge about the scale of daily and seasonal movements will establish a minimum viable size for no-take areas to offer effective protection to these mobile animals. A second project will focus on the movement and habitat use of coastal fish populations, with an emphasis on inshore shark populations. The latter are under considerable pressure from commercial netting and the study will seek to identify critical habitats (e.g. juvenile shark nurseries) that may require higher levels of protection to ensure sustainable populations. The third project will map the movements and habitat use of pelagic environments by foraging seabirds seeking an oceanographic explanation for the decline in seabird numbers observed in many breeding colonies.

Project 6.1:	Maximising the benefits of mobile predators to GBR ecosystems: the importance of movement, habitat and environment

Project Leader and Host Organisation:

Name	Michelle Heupel		
Position	Research Scientist, ARC Future Fellow		
Organisation	Australian Institute of Marine Science/James Cook University		
Unit			
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	Townsville 4811		
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Project Team

Title	Organisation	Role
Michelle Heupel	AIMS	Project leader. Responsible for project coordination and managing all aspects of the project.
Colin Simpfendorfer	JCU	Responsible for coordination of the JCU aspects of the research
Mike Cappo	AIMS	Collaborator in inshore to reef connectivity research
Andrew Tobin	JCU	Collaborator in central GBR research
Marcus Stowar	AIMS	Assists on the inshore to reef connectivity research
Field technician, TBA	JCU	Assists in maintaining all telemetry networks and databases
Leanne Currey	JCU/AIMS	PhD student on southern GBR research

Summary Table of End-users

Organisation	Organisational Contact	Email
DSEWPaC	Sustainable Fisheries Group – Nathan Hanna	Nathan.hanna@environment.gov.au
GBRMPA	Mark Read Randall Owens	Mark.Read@gbrmpa.gov.au randall.Owens@gbrmpa.gov.au
DEEDI	Bonnie Holmes	bonnie.holmes@deedi.qld.gov.au
QSIA	Scott Wiseman	eo@qsia.com.au
CapReef	Bill Sawynock	bill@info-fish.net

Project Duration

Start Date: 1 July 2011 End Date: 31 December 2014

Project Description / Task Objectives

Large predatory fish are essential to a balanced marine ecosystem and also form the basis of important commercial and recreational fisheries. Sustainable fisheries and sustainable ecosystems require that management is able to achieve a balance between these divergent needs. The large size of many of these predators means that they often are highly mobile. This mobility complicates the management of these species, especially in regions such as the GBR where there is a complex mosaic of open and closed areas. Understanding the residency and movements of large predators is thus important to ensuring the long-term sustainability of this functional group. Similarly, understanding the conditions that cause them to migrate outside their normal home ranges will enable marine park managers to better design spatio-temporal protection now and under future climate scenarios.

Task Objectives

1. Define space use and extent of movement of mobile predator species in coastal and reef ecosystems.*
2. Determine the factors (e.g. habitat, ontogeny, environmental conditions, level of protection) that lead to changes in the residency and movement of mobile predators.*
3. Examine the role that active mobility plays in connecting populations within coral reef systems, and between inshore areas and reef systems.
4. Identify and assess the appropriate tools for managing mobile predators, including determining the efficacy of spatial management for this functional group.

* Indicates Objectives that will be prioritised in Year One. These Objectives will continue throughout the project as further data are collected. Data from Objectives 1 and 2 will help inform Objectives 3 and 4.

Key Objectives

A. Define the activity space, extent of movement and residency patterns of target species within reef and inshore ecosystems.*

B. Quantify the amount and direction of movements between and within reef platforms and between inshore and reef habitats.*

C. Compare and contrast telemetry data with conventional tagging data to define long-term movement patterns of target species.

D. Correlate observed movements with habitat type, ontogeny, environmental or seasonal conditions.

* Indicates Key Objectives that will be prioritised in Year One.

Project / Task Methodology

This project will employ acoustic monitoring technology in a series of inshore and offshore environments including coastal bays, inshore reefs and offshore reefs to monitor the presence and movements of predator species (elasmobranchs and teleosts). Mobile predators will be fitted with acoustic transmitters to define their presence and distribution, extent of movement and amount of connectivity between study locations (i.e., movement from bay to inshore reef, movement among reef platforms, etc). In addition, predator presence and movement will be integrated with habitat mapping and environmental monitoring data to identify factors that lead to changes in movement patterns, and to define any preferred locations or conditions that can be targeted for conservation or management. Examination of use of habitats will provide information about the amount of time spent in various GBRMP zones and amount of movement among zones to assess the amount of protection provided under current management arrangements.

The results of extensive long-term tagging data from the CapReef program will be integrated with acoustic monitoring data to provide a comparison of information on small- and large-scale movements of target species over broader spatial and temporal scales than possible with the acoustic monitoring component. These combined data will be utilised to define the applicability of spatial management for species in this functional group and form the basis for recommendations regarding future management approaches including potential recommendations for changes to fishery management.

Inshore offshore connectivity
This project will focus on inshore habitats (Cleveland Bay and parts of Bowling Green Bay) and reefs offshore of Townsville (from the Palm Islands to Davies Reef and stretching offshore to Cotton Shoal) to examine inshore to reef connectivity of large predators. Species will also be fitted with transmitters in inshore regions to examine linkages between inshore waters to reef systems. This will be facilitated by utilizing acoustic monitoring equipment in the AIMS Scientific Research zone and Cleveland Bay. Due to funding limitations expansion to other inshore regions (ie Repulse Bay) is not feasible. The focal species for this study will initially be mangrove jack (*Lutjanus argentimaculatus*) that migrate from estuarine and nearshore habitats to offshore areas at sizes around 450 mm. Additional species will be incorporated in later years of the project. Other inshore target species will include fingermark (*Lutjanus johnii*), golden trevally (*Gnathanodon speciosus*) and barramundi (*Lates calcarifer*). This research will complement previous and current telemetry of scalloped hammerhead (*Sphyrna lewini*), spottail (*C. sorrah*), pigeye (*C. amboinensis*) and blacktip reef (*C. melanopterus*) sharks.

Between reef connectivity
Two regions of the GBR will be examined to understand the residency on, and movements between, reef platforms by large predators: reefs in the Townsville region used in the inshore to reef connectivity portion of the study (see above), and reefs in the Capricorn Bunker group. The Townsville reef acoustic array will be composed of approximately 50 acoustic receivers located at >15 mid-shelf reefs. This will include receivers provided by JCU (Dr Andrew Tobin) and AIMS (Dr Michelle Heupel). The Capricorn Bunker group array will consist of approximately 50 acoustic receivers at three reef platforms (Heron, Sykes and One Tree). Changes in residency and movement in each of the arrays will be correlated with environmental parameters via IMOS and AIMS environmental monitoring equipment located in the two regions. Target species in the Townsville reefs array will include coral trout (*Plectropomus maculatus, P. leopardus, P. laevis*), red emperor (*Lutjanus sebae*), and reef sharks (*Carcharhinus amblyrhynchos* and *Triaenodon obesus*). In addition, Spanish mackerel (*Scomberomorus commerson*) will be tagged as part of an FRDC-funded study in the same region. In the Capricorn Bunk group study species will be red throat emperor (*Lethrinus miniatus*) and red emperor. These species will be monitored in addition to coral trout (*Plectropomus leopardus*) and reef sharks (*C. amblyrhynchos, C. melanopterus, T. obesus*) currently monitored via ARC funding. Focal species will be surgically fitted with depth sensing acoustic tags (Vemco V13P or V16P) that have lives between one and two years.

Project Outputs/Outcomes
1. Compile report on spatial utilisation of target species to define the presence of individuals within specific habitat regions (ie, inshore, reef, etc) and the amount of time spent within marine park zones. This data will inform how much protection target species receive from zones closed to fishing.
2. Report on the extent of movement between inshore and reef habitat and among reef platforms to define broad scale movements of target species and how these movements may play a role in reproduction or other behaviours. In addition, these data will indicate if these movements are undertaken by specific size or age classes which may be crucial to fishery and spatial management plans.
3. Report on integration of movement data with environmental conditions and habitat to identify whether individuals are linked to specific habitats or environmental conditions. This data will help define if there are specific habitat regions that require additional protection and/or if individuals move beyond protection zone borders during specific environmental conditions. If movement is related to predictable seasonal environmental conditions seasonal or time closures to fisheries may be recommended to improve stock management.
4. Combine the available data sources in this research to provide an assessment of current management approaches for target species and make recommendations on how effective current measures are and whether additional measures can or should be employed to better protect these mobile predator species. Advice to managers will be compiled based on this assessment.

Expected Benefits to End-users
As indicated above, end-users of this research will include DSEWPaC, GBRMPA, DEEDI and QSIA. Results of this research will help inform managers about fish residency within various habitat types and marine park zones. Additionally data will be gathered on how environmental conditions and

ontogeny influence fish presence and movements, and whether environmental or biological conditions cause fish to move between habitats, thus becoming more or less exposed to fishing pressure or other anthropogenic impacts. Results will be relayed to end-users via reporting, presentations to resource managers, regular briefings and scientific publications. It is anticipated these results will be utilised in future marine park zoning and fisheries management while providing additional data on the ecology of target species.

There should be no risk in data being taken up by stakeholders as this project includes species of management concern and important habitat regions. The data provided by this project will be highly relevant to assessing current and future management of key commercial and recreational species and as such will be of importance to end-users. Results will be disseminated as clearly and widely as possible to ensure end-users have the ability to access and utilise the collected information and recommendations.

Links to other projects and infrastructure

This project will utilise IMOS infrastructure available in the Capricorn Bunker Group, Orpheus Island and the AIMS scientific research zone, use ARC-Linkage funded infrastructure in Cleveland Bay, and partner with an AIMS/JCU Future Fellowship project, to reduce project costs. This infrastructure includes >100 acoustic receivers in the water in the southern and central GBR, as well as environmental monitoring equipment at three reefs (One Tree, Heron and Orpheus). This project will leverage off and extend current ARC funded research in the Capricorn-Bunker group focusing on coral trout and reef sharks. Monitoring additional reef species (red throat emperor, red emperor) within this system will enhance NERP opportunities. ARC research funding for Cleveland Bay will have expired at the time of this project initiation, but the infrastructure used in that project will be utilized for the purposes of this NERP project to examine inshore-reef connectivity.

This project links with NERP research Project 14 (PI Colin Simpfendorfer, JCU), FRDC research by Andrew Tobin (JCU), AIMS funded research by Mike Cappo (AIMS), IMOS funded infrastructure managed by AIMS, ARC Future Fellowship research by Michelle Heupel (AIMS) and PhD research by Leanne Currey (JCU and AIMS). Each of these linked projects (except proposed NERP project) are currently funded and will supplement and support results provided in this proposed NERP research. Data will be shared across these projects via integrated and shared databases managed by the AIMS Data Centre in addition to integration into IMOS databases where appropriate. Shared databases will allow all collaborators to define movements of their target species within the broader acoustic telemetry network thus increasing the power of the entire network.

Risk assessment

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	Skills sets of applicants for technical staff position will be reviewed carefully to ensure someone with appropriate skills and expertise is appointed
Departure of key project personnel	Low	All partners in the project will be aware of all aspects of the project to ensure a succession of skills and tasks should one of the project personnel leave during the study period
Complications in completing field work due to inclement weather	Medium	All field based research programs are reliant on favourable weather for project completion. In this project field work is spread throughout the year and is not reliant on biological processes (i.e. sampling does not need to occur during a specific reproductive phase or period). Therefore it is possible to delay and reschedule field work to avoid periods of bad weather. Thus, even if work is delayed due to weather, it can still be completed without compromising the results of the project and will continue to achieve defined milestones.

Non-residency of study animals within the study site.	Medium	Non-residency of individuals fitted with transmitters is always a risk involved in long-term acoustic monitoring research. However, the large tracts of area covered in this project and multiple reef platforms will work to ensure individuals are detected. One of the aims of this research is to consider movement among reef platforms and marine park zones. Therefore, lack of residence at a single reef would still be useful in answering the questions presented in this project.
Loss of acoustic receivers from the study site.	Low	Loss of acoustic receivers will be avoided by construction of effective mooring systems. Dr. Heupel has used acoustic receivers for over 12 years and has designed a unique mooring system that has been highly successful. Highest risk will come from high energy storm events such as tropical cyclones. If extensive reef damage occurs, mooring systems may be damaged or dislodged, but aside from these events the moorings should be secure.
Failure to achieve uptake of results by end-users	Low	A strong working relationship with end-users will be maintained throughout this research. Continued reporting, workshops and updates will ensure end-users are aware of and engaged in the outputs of this research.

Project Budget

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	250,000		250,000
AIMS		268,861	268,861
JCU	10,000	235,954	245,954
IMOS (infrastructure)		70,000	70,000
Total	**260,000**	**574,815**	**834,815**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	250,000		250,000
AIMS		132,658	132,658
JCU	10,000	207,204	217,204
Total	**260,000**	**339,862**	**599,862**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	NERP	In-kind	Total
NERP	250,000	-	250,000
AIMS	-	136,569	136,569
JCU	-	217,204	217,204
Total	**250,000**	**353,773**	**603,773**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	125,000		125,000
AIMS		70,303	70,303
JCU	5,000	103,602	108,602
Total	**130,000**	**173,905**	**303,905**

Project 6.2: Drivers of juvenile shark biodiversity and abundance in inshore ecosystems of the Great Barrier Reef

Project Leader and Host Organisation

Name	Dr Colin Simpfendorfer		
Position	Senior Principal Research Fellow		
Organisation	James Cook University		
Unit	School of Earth and Environmental Sciences		
Postal Address		Delivery Address	
	School of Earth and Environmental Sciences		School of Earth and Environmental Sciences
	James Cook University		James Cook University
	Townsville, Qld 4811		Townsville, Qld 4811
Phone	07 4781 5287	Fax	
Email	colin.simpfendorfer@jcu.edu.au		

Project Team

Title	Organisation	Role	FTE
Dr Colin Simpfendorfer	JCU	Project leader. Leader environmental effects. Responsible for all aspects of the project	0.5
Dr Andrew Tobin	JCU	Co-project leader. Leader of nursery surveys	0.6
Dr Michelle Heupel	AIMS	Provide expertise on shark nursery areas and acoustic telemetry	0.1
Mr Steve Moore	JCU	Research worker – lead field trips for nursery surveys, assists with acoustic monitoring	1.0
Dr Richard Saunders	QDAFF	Analysis of QDAFF data, assist with field work, data analysis and reporting	0.2
Mr Peter Yates	JCU	PhD student	1.0
Ms Samantha Munroe	JCU	PhD student	0.5
Ms Audrey Schlaff	JCU	PhD student	0.5
Mr Vinay Udyawer	JCU	PhD student	0.5
Mr Andrew Simmonds	JCU	MPhil student	0.3

Summary Table of End-users[1]

Organisation	Organisational Contact	Email
GBRMPA	Randall Owens Mark Read	randallo@gbrmpa.gov.au mark.read@gbrmpa.gov.au
QDAFF	TBC	TBC
QSIA	TBC	TBC
DSEWPaC	Lesley Gidding Bronwen Jones Nathan Hanna David Calvert Charles Brister Leah McKenzie Peter Wright Jeanette Muirhead Kate Sanford-Readhead	Lesley.gidding@environment.gov.au Bronwen.jones@environment.gov.au Nathan.hanna@environment.gov.au David.calvert@environment.gov.au Charles.brister@environment.gov.au Leah.mckenzie@environment.gov.au Peter.wright@environment.gov.au Jeanette.muirhead@environment.gov.au Kathryn.sanford-readhead@environment.gov.au

[1] *End-users are those organisations either directly related to the project or could benefit from the outputs of this project. All final reports will be circulated to nominated contacts prior to upload to web.*

Project Duration

Start Date: 1st July 2011 End Date: 31st December 2014

Project Description / Task Objectives

Sharks play an important role in marine ecosystems but are facing increasing pressure from fishing and other anthropogenic factors. Along the Queensland coast inshore waters play an important role as nursery areas for sharks. However, the same inshore waters are also most prone to fisheries exploitation and effects of freshwater discharge from coastal streams and rivers. This project will examine the importance of different types of inshore habitat (protected bay vs open coastline) and marine park zoning (open and closed to fishing), and how environmental factors such as freshwater discharge from rivers effect how these nursery areas function. The project has two broad objectives:

A. Investigate the spatial and temporal changes in the biodiversity and abundance of sharks in inshore nursery areas along the central GBR coast.
B. Determine the effect of environmental drivers on inshore shark biodiversity along the central GBR coast.

Results from the project will be used to improve the information available to fisheries and marine park managers on the relative importance of inshore habitats, the role of areas closed to fishing, and the sustainability of inshore shark populations.

Key Objectives

1. To investigate on the abundance and biodiversity of sharks in nursery areas at broad spatial scales along the central GBR coast.
2. To identify the role of season, zoning, aspect and productivity on the abundance and biodiversity of sharks in nursery areas along the central GBR coast.
3. Determine what role changes in environmental conditions play in how juvenile sharks use nursery areas in inshore habitats (bay and inshore reef)

Project / Task Methodology

This project will have two main tasks to address the key objectives– broad-scale nursery area surveys and focused acoustic monitoring studies to investigate the effects of environmental drivers on shark nursery area use.

A. Nursery area surveys (Key Objectives 1 and 2)

This project will use a two stage approach to investigate spatial patterns in nursery areas. In the first year of the project a broad-scale survey of bays along the GBR coast from Edgecombe Bay to Hinchinbrook Island will be undertaken to provide a baseline understanding of the species composition and abundance of juvenile sharks in these areas. These differences will be related to the zoning, habitat and anthropogenic influence on each of the bays examined. The selection of the bays for this broad-scale survey will be informed by an analysis of DEEDI commercial net fishing logbook data from this region. These data will be obtained from DEEDI through a data sharing arrangement and analysed by the DEEDI staff member working on this project. Logbook data will also be used to inform about the level of anthropogenic influence in each of the nursery areas.

In years two and three detailed seasonal surveys of a subset of the bays used in the broad-scale survey will be undertaken. These surveys will provide data on seasonal changes in nursery area use, species diversity and abundance. The focal bays will be selected to have a mix of open and closed to fishing, high and low freshwater input and protected and exposed aspect.

Surveys will be conducted using research longlines and gillnets to ensure the full size range of sharks present in the bays are sampled. Sharks caught in surveys will be identified, measured, sexed and tagged with an external identification tag. A small amount of fin tissue may also be taken for future genetic analyses. Sharks will then be released near the point of capture. Catch rate data will be compiled and used to compare abundances between bays. Species composition data will be used to compare biodiversity between different inshore areas and habitats.

B. Environmental drivers in shark nursery areas (Key Objective 3)

The importance of environmental drivers on shark nursery area use will be examined using an acoustic monitoring array at two locations in inshore waters: Cleveland Bay and Orpheus Island. Both arrays are already established (Cleveland Bay by JCU and Orpheus by IMOS) enabling this component to be implemented soon after the project begins. The utilisation of significant infrastructure (>80 acoustic receivers) from other organisations (JCU, IMOS, AIMS) adds significant value (see Budget table) to this project.

Focal shark species for the work in Cleveland Bay will be important species in the commercial gillnet catch: Australian/common blacktip sharks (*Carcharhinus tilstoni* and *C. limbatus*), Australian sharpnose sharks (*Rhizoprionodon taylori*), milk sharks (*Rhizoprionodon acutus*), creek whalers (*Carcharhinus fitzroyensis*), whitecheek sharks (*Carcharhinus dussumieri*) and nervous sharks (*Carcharhinus cautus*). In addition, data from species previously investigated for other purposes in this array (spottail *Carcharhinus sorrah*, pigeye *Carcharhinus amboinensis* and scalloped hammerhead *Sphyrna lewini* sharks) will be included in the analysis of environmental drivers. Environmental data for the Cleveland Bay work will be obtained from directed sampling, AIMS monitoring stations, Bureau of Meteorology, Townsville City Council, and other sources as appropriate.

The Orpheus Island array will focus on shark species common at inshore GBR islands, mostly blacktip reef sharks (*Carcharhinus melanopterus*). Environmental data will be obtained from the FAIMMS sensor array deployed as part of the IMOS infrastructure at Orpheus Island, as well as monitoring data from JCU's Orpheus Island Research Station.

Sharks in both locations will be captured by short research longlines or rod and reel, measured, sexed and tagged. Focal species will have acoustic transmitters (Vemco V16) surgically implanted into the body cavity to enable long-term monitoring. Tags will have a life of 18-24 months. Acoustic receivers in Cleveland Bay will be downloaded every 3-4 months, and at Orpheus Island every 6 months. Data will be stored in a database and queries used to extract data for analysis. Analytical tools will be developed to provide information on the extent of movements, changes in movements and distribution in response to changes in environmental parameters (especially temperature and salinity).

This project will also interact with several other NERP projects, including Project 12 (Maximising the benefits of mobile predators to GBR ecosystems: the importance of movement, habitat and environment, PI: Michelle Heupel) and Project 19 (Setting Estuarine and Wetland Species in their Functional Habitat Mosaics, PI Marcus Sheaves). Interaction with the first of these will be maintained by overlapping PIs on the projects. This will be important as species from each of the studies may eventually be detected on acoustic arrays maintained by the complimentary project. Contact with the second of these projects will be maintained through regular contact between PIs who will discuss and facilitate the sharing of data where appropriate to achieve project outcomes.

Project Outputs/Outcomes

1. Report on the spatial heterogeneity of inshore shark biodiversity along the central GBR coast (results of the broad-scale survey in year one). This will include the results of the broad-scale surveys in year one of the project as well as the analysis of DEEDI commercial net fishing logbook data.
2. Report on the temporal changes in inshore shark biodiversity along the central GBR coast (results of the surveys in years 2 and 3). This report will examine seasonal and inter-annual trends in shark biodiversity between different nursery areas and examine the drivers that lead to differences.
3. Report on the effects of environmental drivers on the movement, distribution and habitat use of juvenile sharks in coastal and inshore island nursery areas. This report will examine how changes in factors such as salinity (driven by freshwater flows), temperature, and other factors affect juvenile sharks and what implications these have for the management and conservation of shark populations and inshore habitats in the GBR.

In addition to these direct outputs from the project, at least three PhD theses will also be generated. These will overlap with the above output, but will also extend the activities. These PhD projects will add value to the overall project.

The information generated by this project will be of significant value to at least two management agencies: GBRMPA (who currently have a focus on inshore biodiversity and sharks) and DEEDI (who have regulatory responsibility for managing fishing for sharks). The PIs will maintain regular contact with key people in these agencies throughout the project, providing regular updates on progress and outcomes (outside of regular project reporting). Interactions with DEEDI will also be facilitated by the involvement of a DEEDI employee on the project team. Where appropriate, briefings will be provided to management committees (e.g. DEEDI Shark Panel, GBRMPA LMACs) and agencies. Regular contact with agencies will minimize the risk that key outcomes will not be utilised by end-users.

Expected Benefits to End-users

As indicated above, end-users of this research will include DSEWPaC, GBRMPA, DEEDI and QSIA. Results of this research will help inform resource managers about the role of sharks in inshore areas of the GBRMP, and how environmental conditions affect their use of these areas. These information can be used to help in the development of sustainable fishing practices for shark populations as well as inshore areas and fisheries. Results will be relayed to end-users via reporting, presentations to resource managers, regular briefings and scientific publications. It is anticipated these results will be utilised in future marine park zoning and fisheries management while providing additional data on the ecology of target species.

There should be no risk in data being taken up by stakeholders as this project includes species of management concern and important habitat regions. The data provided by this project will be highly relevant to assessing current and future management of key commercial and recreational species and as such will be of importance to end-users. Results will be disseminated as clearly and widely as possible to ensure end-users have the ability to access and utilise the collected information and recommendations.

Links and dependencies to other projects and hubs

This project will directly utilise infrastructure available in Cleveland Bay (provided by JCU) and Orpheus Island (provided by IMOS). This infrastructure includes >80 acoustic receivers in the water, as well as environmental monitoring equipment at Orpheus Island. ARC research funding for Cleveland Bay will have expired at the time of this project initiation, but the infrastructure used in that project will be utilized for the purposes of this NERP project.

This project links with NERP research Project 5.1 (PI Michelle Heupel, AIMS), IMOS funded infrastructure managed by AIMS, ARC Future Fellowship research by Michelle Heupel (AIMS) and PhD research by Samantha Munroe and Peter Yates (JCU and AIMS). Data will be shared across these projects via integrated and shared databases managed by the AIMS Data Centre in addition to integration into IMOS databases where appropriate. Shared databases will allow all collaborators to define movements of their target species within the broader acoustic telemetry network thus increasing the power of the entire network.

The project will also have some connection to FRDC-funded research (PI Andrew Tobin, JCU) that is using conventional tagging of inshore sharks to estimate exploitation rates of key commercial species. This NERP project will release tagged sharks during nursery area surveys that may provide data to the FRDC funded project. The connection of PI Tobin with both projects will facilitate the linkage of data between these projects.

Identified and assessed hazards

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	Skills sets of applicants for technical staff position will be reviewed carefully to ensure someone with appropriate skills and expertise is appointed
Departure of key project personnel	Low	All partners in the project will be aware of all aspects of the project to ensure a succession of skills and tasks should one of the project personnel leave during the study period
GBRMPA do not provide permit for desired sampling strategy	Medium	The PIs have already discussed the sampling strategy with GBRMPA staff, and will continue to liaise with them until the permit has been approved. The sampling design will be refined in consultation with GBMRPA to ensure sampling can proceed as required.
Complications in completing field work due to inclement weather	Medium	All field based research programs are reliant on favourable weather for project completion. The timetable for fieldwork includes a significant number of days for weather interruption. If interruptions are severe, then we will use multiple field crews to sample during favourable weather periods.
Sampling does not collect sufficient animals to produce results.	Low	The PIs on this project have significant experience sampling sharks in nursery habitats. This experience will allow them to design effective sampling programs that will produce results. Should initial sampling prove problematic in terms of results, the PIs will use their connections with the commercial recreational fishing communities to assist in locating appropriate sampling locations and methods.
Loss of acoustic receivers from the study site.	Low	Loss of acoustic receivers will be avoided by construction of effective mooring systems. The PIs have used acoustic receivers for over 12 years and have designed mooring system that have been highly successful, even during severe weather events such as tropical cyclones. Highest risk will come from high energy storm events such as tropical cyclones. If extensive habitat damage occurs, mooring systems may be damaged or dislodged, but aside from these events the moorings should be secure.
Failure to achieve uptake of results by end-users	Low	A strong working relationship with end-users will be maintained throughout this research. Continued reporting, workshops and updates will ensure end-users are aware of and engaged in the outputs of this research.

Project Budget

AWP 1 – (July 2011 to June 2012)Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	220,825		220,825
JCU	104,000[A]	440,340	544,340
AIMS		35,100	35,100
DEEDI		10,000	10,000
IMOS (infrastructure)		40,000	40,000
Total	**324,825**	**525,440**	**850,265**

[A] JCU cash contribution to cover salaries and on-costs of staff in contract positions (50% of Colin Simpfendorfer and 30% of Andrew Tobin)

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	224,673		224,673
JCU	104,000[A]	440,340	544,340
AIMS		35,100	35,100
DEEDI		10,000	10,000
IMOS (infrastructure)		40,000	40,000
Total	**328,673**	**525,440**	**854,113**

[A] JCU cash contribution to cover salaries and on-costs of staff in contract positions (50% of Colin Simpfendorfer and 30% of Andrew Tobin)

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	215,150	-	215,150
JCU	104,000[A]	470,683	574,683
AIMS	-	37,964	37,964
QDAFF	-	10,000	10,000
IMOS	-	40,000	40,000
Total	**319,150**	**558,647**	**877,797**

[A] JCU cash contribution to cover salaries and on-costs of staff in contract positions (50% of Colin Simpfendorfer and 30% of Andrew Tobin)

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	74,352		74,352
JCU	52,000[A]	156,519	208,519
AIMS		17,550	17,550
DEEDI		5,000	5,000
Total	**126,352**	**179,069**	**305,421**

[A] JCU cash contribution to cover salaries and on-costs of staff in contract positions (50% of Colin Simpfendorfer and 30% of Andrew Tobin)

Project 6.3: Critical seabird foraging locations and trophic relationships for the Great Barrier Reef

Project Leader and/or Organisation			
Name	Dr Brad Congdon		
Position	Reader & Deputy Head of School - Cairns		
Organisation	Jams Cook University		
Unit	School of Marine & Tropical Biology		
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Project Team

Title	Organisation	Role
Dr Brad Congdon	JCU	Chief investigator
Fiona McDuie	JCU	PhD candidate
Carol Devney	AIMS@JCU	Research Associate/PhD candidate
William Goulding	JCU	Seabird field research officer
Dr Scarla Weeks	UQ	Satellite image oceanographer
Craig Steinberg	AIMS	Physiochemical oceanographer

Summary Table of End-users[1]

Organisation	Organisational Contact	Email
GBRMPA	Malcolm Turner Roger Beeden Paul Marshall	malcolm.turner@gbrmpa.gov.au roger.beeden@gbrmpa.gov.au paul.marshall@environment.gov.au
BOM/CSIRO/NARP	Lynda Chambers	L.Chambers@bom.gov.au
AFMA	Steve Auld	steve.auld@afma.gov.au
QDAFF	TBC	
DSEWPaC	Kate Sanford-Readhead Lesley Gidding David Calvert Charles Brister Leah McKenzie Nathan Hanna Fiona Bartlett Ian Hay	Kate.Sanford-Readhead@environment.gov.au Lesley.Gidding@environment.gov.au David.calvert@environment.gov.au Charles.brister@environment.gov.au Leah.mckenzie@environment.gov.au Nathan.hanna@environment.gov.au Fiona.bartlett@environment.gov.au Ian.hay@environment.gov.au

[1]*End-users are those organisations either directly related to the project or could benefit from the outputs of this project. All final reports will be circulated to nominated contacts prior to upload to web.*

Project Duration
Start Date: 1st July 2011 End Date: 31st December 2014

Project Description / Task Objectives
Effective management of seabird populations on the GBR requires identifying the population-specific causes of current declines and their associated threatening processes. Without detailed information on

foraging areas, resource use and links to oceanographic variation it is not possible to isolate or manage anthropogenic threats that occur outside of nesting colonies.

To date, we have trialled and successfully deployed a range of logging systems on foraging shearwaters in the southern GBR. This work has characterised shearwater foraging habitat at near-colony scales and linked specific oceanographic parameters to levels of provisioning and reproductive success. At the broader meso-scale, studies in both the northern and southern GBR have provided preliminary data on links between seabird foraging success and specific ocean frontal systems, currents, bathymetry and upwelling phenomena. This research has also identified potential overlap between seabird foraging areas and blue-water billfish and tuna fishing activity outside of the GBR.

The current program will complement and considerably expand this previous work using already proven methodology. It will; 1) enlarge the shearwater program at the meso-scale to comprehensively sample 'at-distance' foraging habitat used by GBR breeding shearwaters in both the GBR and Coral Sea regions; 2) for the first time identify and sample foraging habitats used by GBR shearwaters between breeding seasons, 3) add additional seabird species and colonies, specifically masked and brown boobies in the northern and southeastern GBR, so as to further identify overlap in critical foraging habitat within and among GBR taxa/populations 4) identify and map possible overlap between these foraging areas/resources and blue-water billfish and other commercial fishing activity

Key Objectives

Overall key objectives of this program are to: 1) identify and map the principal foraging locations for shearwaters and boobies breeding at the most important colonies of the GBR, both within and between breeding seasons; 2) Obtain detailed information on the biophysical oceanographic characteristics of these foraging habitats in both the GBR and Coral Sea regions by exploring a range of biophysical parameters derived from satellite and *in situ* data collection, such as sea-surface temperature, chlorophyll concentration, sea-surface height, and bathymetry; 3) Quantify how prey availability at these sites varies with climate driven changes in biophysical oceanography, both within and among breeding seasons; 4) quantifying the level of prey availability and associated oceanographic conditions required to maintain viable reproduction at significant breeding colonies and 5) establish potential linkages and interactions between these areas/processes and other anthropogenic activities.

Project / Task Methodology

The project methodology will combine state-of-the-art data logging technology with medium-resolution satellite and other biophysical oceanographic information to link patterns of forage-fish availability to oceanography using seabirds as spatial sampling units.

Seabird foraging tracks will be obtained at a range of spatial and temporal scales using a combination of different Geolocation, GPS and Satellite PTT data loggers. These data will provide the first information on at-sea foraging locations used by seabirds in different regions of the GBR and identify overlap in foraging area use among colonies and species for specific GBR sites. (*key objective 1*)

As well as providing foraging locations, data loggers attached to foraging adults will also record foraging dive depth and temperature profiles, thus characterising the foraging habitat associated with trips to specific locations (*key objective 2*). Data on foraging success associated with each trip/dive-profile will be obtained via relative comparison of chick and adult weights obtained during logger deployment and retrieval (*key objective 3*).

Combining the logger and foraging success data with biophysical information from *in situ* loggers and satellite imagery will then allow us to remotely identify larger-scale oceanographic characteristics associated with species-specific preferred and/or high quality foraging habitat (*Key objective 2*). These data will also be used to quantify how the quality of foraging habitat changes in response to changes in specific climate driven biophysical oceanographic parameters throughout and between breeding seasons (*Key objective 3*), thus providing putative links between specific oceanographic features that influence/characterise foraging grounds and seabird reproductive success at associated colonies (*Key objective 4*).

In addition, a sub-set of Geolocation loggers will be deployed on individuals at each colony at the end of the 2012 season to be retrieved in following seasons. Data from these loggers will establish for the first time where any population of tropical shearwaters or boobies overwinters between breeding seasons. Thus, identifying the level of potential overlap between breeding and non-breeding resources and the oceanographic conditions associated with attaining breeding condition and successful egg production (*Key objective 1 & 2*).

Together these data sets can then be synthesized to quantifying the level of prey availability and associated oceanographic conditions required to maintain viable reproduction at significant breeding colonies (key objective 4).

Foraging location, foraging success and associated biophysical oceanographic data will also be overlaid on available indices and charts of commercial fishing activity, particularly for the blue-water billfish and other pelagic fisheries. Such analyses will provide data on location and resource use overlap among foraging pelagic seabirds and predatory fish species, as well as providing estimates of bait-fish availability associated with specific commercial catch rates under specific oceanographic conditions (key objective 5)

Project Outputs/Outcomes

Short-term (2011-2012) & continuing

1. Maps of shearwater and booby foraging locations during breeding for populations at specific GBR sites.
2. Quantification of overlap in foraging area use among colonies and/or species for specific GBR sites
3. Characterization of the species-specific biophysical-oceanographic foraging environment at each foraging location
4. Overlays of seabird foraging locations and correlations of foraging success on indexes/charts of commercial fishing activity.
5. Acquisition and processing of MODIS mission-long data (2000-) to ensure incorporation of latest algorithm refinements[6]. Rebuild time series of biophysical parameters (SST, chlorophyll concentration) to characterise the oceanographic environment of breeding and foraging seabirds,
6. Specifically, generate and map long-term climatologies, monthly and short-term means and anomalies for the GBR and Coral Sea region (10^{o}S – 26^{o}S; 142^{o}E – 155^{o}E).
7. Extraction of along-seabird foraging track environmental data for Year 1 breeding season quantification of the foraging habitat.
8. Generate bathymetry dataset for the GBR / Coral Sea region – initially from the Etopo-2 dataset (2nm resolution).

Longer-term seabird outputs to be generated using between season comparative data and/or pooled sample sizes:

9. Maps of shearwater/booby foraging locations and oceanographic correlates during the non breeding season.
10. Quantification of biophysical-oceanographic correlates of foraging success at foraging locations associated with specific colonies
11. Colony-specific estimates of foraging success and oceanographic parameters within which reproductive success remains viable.

Longer-term satellite remote sensing outputs:

12. Assessment of recently refined algorithms to potentially generate chlorophyll time series from MODIS Terra - to increase daily coverage, especially in summer months when cloud cover may be severe.
13. Investigate the potential of generating chlorophyll from SeaWiFS to produce the full time series (Oct 1997-Dec 2010) at 1km resolution – this will entail generation of a unique MLAC (merged local area coverage) data time series to include all SeaWiFS data that exists for the GBR (AIMS HRPT downloaded, LAC recorded onboard for GBR specifically + GAC data). The retrospective data coverage to Oct 1997 will allow inclusion of environmental data for seabird foraging during earlier ENSO events.
14. Improved bathymetry dataset for the GBR/Coral Sea region - to include the best available data for this region (e.g. Rob Beaman's dataset).

[6] In 2010/2011, NASA completed the mission long reprocessing of MODIS/Aqua, MODIS/Terra and SeaWiFS, to incorporate latest calibration and validations, including improved atmospheric corrections. Further refinements that may occur during the lifetime of this project will likewise be included to ensure incorporation of latest algorithm refinements, even though that will incur a further mission long reprocessing.

15. Explore altimeter data from *Topex/Poseidon* satellites for generation of sea-surface height and geostrophic currents to allow determination of sea surface fronts, and the potential of thermocline depth.

    Notes: *Logistic constraints on both the time that can be spent at breeding colonies each season (particularly from boat platforms) and the number of data loggers that can be deployed within a single season means that data from multiple seasons will be required to provide robust sample sizes for addressing each seabird objective. However, a single season's data will provide substantial preliminary results for Project Outputs/Outcomes 1-4 listed. Outputs 5 to 8 in the first year are not subject to these constraints.*

    Satellite image data acquisition and processing as described above will also be used to underpin analyses and outputs in other NERP programs involving Dr S. Weeks

Project Budget

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	86,939		
JCU		176,467	176,467
UQ		58,000	58,000
AIMS		7,901	7,901
GBRMPA		30,000	30,000
Total	**86,939**	**272,368**	**359,307**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	74,293		74,293
JCU		176,467	176,467
UQ		37,000	37,000
AIMS		7,901	7,901
GBRMPA		30,000	30,000
Total	**74,293**	**251,368**	**325,661**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	74,293	-	74,293
JCU	-	176,467	176,467
UQ	-	37,000	37,000
AIMS	**-**	7,901	7,901
GBRMPA	**-**	30,000	30,000
Total	**74,293**	**251,368**	**325,661**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	10,000		10,000
JCU		83,234	83,234
UQ			
AIMS		3,951	3,951
GBRMPA		15,000	15,000
Total	**10,000**	**102,185**	**112,185**

Project Risk Assessment

Description of Risk	Assessed Risk	Risk Control measures
Failure to obtain seabird foraging data due to adverse weather	Medium	Adverse weather can make either the use of boat platforms impossible, or alter seabird breeding patterns such that they do not overlap with boat schedules. This is only a problem for the Raine Island and Swains Reef field trips, not for the bulk of the work which will be undertaken on Heron Island. QPWS are experienced at scheduling boat trips to avoid possible adverse weather conditions. As we are reliant on QPWS boats for transport we must also rely on their ability schedule appropriately.
Failure to obtain seabird foraging data due to equipment failure/loss	Low	Logger types and deployment methods have been tested over the past 4 years. Protocols have been developed that substantially minimize the risk of logger loss over short term deployments. Some level of logger loss/failure is expected particularly over longer deployment periods and has been allowed for in estimates of the numbers of loggers needed. Multiple logger types are being deployed to minimize the risks associated with failure of any one logger type.
Failure to obtain winter seabird foraging data due to poor between season recovery of loggers	Medium	This is the principal risk associated with the longer term outputs of the project as described. Return rates of adults between seasons has not been quantified previously. However, random recapture rates of banded individuals within the study area each year over a 9 year period range from 7-27%, giving an estimated minimum return expectation of ~10% for birds carrying loggers between years. This figure has been used to estimate logger deployment needs for this component of the project.
unavailability of key project personnel	Low	Will Goulding is a contract research officer and so his involvement is subject to availability. Training of alternative personal began last field season to be able to replace him if necessary. He should be able to complete this training before any potential issues with his availability arise. Having funding available to confirm his appointment early also negates this problem. Other personnel will be available for the tenure of the project subject to normal employment provisions.

Failure to achieve outcomes due to dependence on outputs from other projects	Low	No inputs are required from other NERP projects to meet the outcomes specified. However, further synthesis of the data obtained from this project with other project outcomes may substantially enhance our understanding of trophic linkages and dynamics with the GBR system
Failure to achieve uptake of results by end-users	Medium	Meetings will be organised with key end-users to ensure engagement and delivery of results in useful form.

Expected Benefit of the project to end-users

The main benefit of this project will be in guiding informed seabird and fisheries management decisions. It is anticipated that the project outputs will directly influence and be incorporated into the future design of seabird management and monitoring strategies aimed at maintaining ecosystem integrity in the face of changing oceanographic/climatic conditions.

Results will highlight specific areas and resources critical to pelagic foraging seabirds breeding within the GBR and identify linkages within and between components of the GBR and Coral Sea systems, thus establishing the spatial scales and main biological drivers that seabird management options need to consider. The data obtained will also provide a biological evaluation of the current/future locations of Marine Protected Areas within the Coral Sea region and highlight potential overlap in the resources used by foraging seabirds and predatory fish species taken in commercial and sport fisheries outside of GBR waters. In addition our data will also facilitate the development of management strategies for specific seabird populations. Previously, costs associated with obtaining data on forage-fish and predator associations at comparable spatial scales, using conventional at-sea survey techniques from ocean-going boat platforms, have been extremely prohibitive. In Australia this has severely restricted the acquisition and use of these data. Our detailed information on these associations will be obtained at a fraction of the costs associated with generating similar data sets using only at-sea surveys, thereby establishing the foundation of a biological monitoring system for climate change impacts within the GBR and elsewhere that is cost effective and sustainable over the longer-term.

In general, by increasing our understanding of how changing ocean conditions will impact prey availability to seabirds and other marine predators this project clearly and directly addressing a number of high priority, independently identified international, national and state research priorities. For example, the emphasis of our work on understanding and predicting the long-term effects of climate change at upper trophic levels directly addresses ***National Research Priority (NRP) 7 - Responding to climate change and variability*** by substantially *'increasing our understanding of the impact of climate change and variability at the regional level and addressing the consequences of these factors.'* Our work also addresses ***NRP 5 - Sustainable use of Australia's biodiversity*** by providing critical information necessary to facilitate '*management that protects Australia's marine biodiversity and allows long–term use of ecosystem goods and services ranging from fisheries to ecotourism.'* Our research addresses ***Queensland Research Development Priorities (QRDP) – 201. Enhance the understanding of climate change trends,*** and ***202 Management strategies towards impacts of climate change.*** It does this by developing models that increase our *'Understanding of the nature of possible climate change, its impact on the environment'* and by assisting in *'identifying and developing appropriate adaptive management and mitigation strategies to help protect the state's natural assets.'*

Program 7: Threats to Rainforest Health

Program 7 will have three projects addressing different threats to rainforest health. A generalised analytical toolkit for assessing vulnerability to extreme climatic events, particularly the sensitivity of Wet Tropics fauna to temperature extremes, will be developed. The role of fire as a driver of rainforest distribution (particularly on the threatened ecosystem of the Mabi forest) will be determined. The Program will also deliver maps of weed populations identifying sources of invasive propagules and rainforest areas that are particularly susceptible to invasion or re-invasion because of their connectivity to these source populations. This information is critical for invasive weed control programs, identifying high priority areas for control, and guiding surveillance. The Program will also provide a qualitative and operational assessment of alternative management strategies for feral pig management.

Project 7.1: Fire and rainforests

Project Leader and Host Organisation

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Project Team

Title	Organisation	Role
Dan Metcalfe	CSIRO	Project leader; rainforest fire ecology
David Hilbert	CSIRO	Fire & veg modeling
Matt Bradford	CSIRO	Tech support, fire ecology
Andrew Ford	CSIRO	Tech support, plant ecology, GIS

Summary Table of End-users[1]

Organisation	Organisational Contact	Email
NPRSR	Andrew Millerd Dave Fuller	Andrew.Millerd@nprsr.qld.gov.au David.Fuller@nprsr.qld.gov.au
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Terrain	Tony O'Malley	tonyo@terrain.org.au
Cassowary Coast Regional Council	Damon Sydes	Damon.Sydes@ccrc.qld.gov.au
DSEWPaC	Peter Latch Anthony Hoffman TBC Karl Newport Kate Sanford-Readhead	Peter.latch@environment.gov.au Anthony.hoffman@environment.gov.au Anthony.whalen@environment.gov.au Karl.newport@environment.gov.au Kathryn.sanford-Readhead@environment.gov.au

Project Duration

Start Date: 1st July 2011 End Date: 31st December 2014

Project Description / Task Objectives

Rainforests are generally thought of as being highly susceptible to damage by fire, and for many South-east Asian and Amazonian rainforests this is indeed the case. However, Australian rainforests have persisted for millennia in an environment where fire is common, and repeated contractions into refugia and subsequent expansions during glacial cycles (Hilbert *et al.* 2007) means that extant rainforest taxa have survived frequent exposure to fire. Indeed, 91% of 281 species for which records exist (Metcalfe, unpublished data) survive fire by resprouting, root-suckering or coppicing, and it may be inferred that fire-susceptible species have either already gone extinct after thousands of cyclones, dry seasons and lightning strikes, or are limited to the few parts of the landscape which are predictably wet within and between years.

Six to eight thousand years of aboriginal habitation in rainforests, and many tens of thousands of years of aboriginal utilisation of rainforests and associated fire pressures, are also likely to have had significant impacts on rainforest species and their distribution, but beyond work by Hill (2003) we have limited understanding of aboriginal fire regimes and their impacts.

Consequently, fire management protocols in the Wet Tropics rainforests are based on inference and personal experience but limited experimental data; as some fire-affected habitats become increasingly threatened by other processes this lack of hard data becomes critical. Thus, this project seeks to address some key questions in relation to fire and habitat management in a Wet Tropics context, namely the importance of fire in controlling vegetation succession following cyclone impacts, the role that fire has in controlling the margins of rainforest/open woodland, and identification of the criteria that should be used to highlight areas where fire management is of greatest importance both for vegetation and associated faunal communities. In collaboration with other NERP funded projects, and with regionally relevant research conducted by other individuals and agencies, we seek to provide appropriate spatially and temporally relevant data to underpin future management and policy decisions.

In the first year our efforts will be particularly focused on understanding the conflicting roles of fire in mediating the recovery of mahogany glider habitat, where the impacts of Severe Tropical Cyclone Yasi have been felt across the entire species range, and fire poses both a threat to animals sheltering in fallen timber near ground level, but also a potential saviour in restricting rainforest invasion and enhancing regeneration of eucalypt species.

Key Objectives

(i) Are rainforest boundaries expanding into surrounding forests and woodlands in the wet tropics? If so, does this constitute a departure from historical variability and is it a threat to biodiversity? This question is of particular relevance at a time when the entire species range of the endangered mahogany glider has been severely impacted by Tropical Cyclone Yasi, and rainforest invasion of its woodland habitat is considered one of the key threats to its long-term population viability
(ii) What are the dynamics at rainforest/open forest edges and how might these be affected by prescribed fire management? Focal habitats EPBC-listed littoral rainforest communities, and Mabi rainforest.
(iii) What are the criteria that need to be developed to identify key areas for fire management and other areas where expansion of rainforest is a desirable or not as a natural phenomenon? What are the drivers of these dynamics? Should management focus on containing rainforest boundaries and preserving, for example, wet sclerophyll forests using high intensity fires?

Project / Task Methodology

(i) In collaboration with QPWS rangers, and where possible with local NGOs and Indigenous Rangers, we propose to establish vegetation and faunal monitoring sites across the rainforest/woodland boundaries and associated vegetation types in key areas of the Cardwell Range and Kennedy Valley areas to assess faunal and floral status and trends. These measurements will enable us to assess pre-cyclone vegetation condition, extent of rainforest invasion, evidence of past burn history and degree of cyclone impact. At sites scheduled for routine management burning, or where controlled burns are necessary to protect infrastructure or reduce wildfire hazard, we will be ale to assess post-burn recovery both of woodland and rainforest taxa over a three year period, and monitor aspects of faunal response to such management activities. Pre- and post-cyclone aerial photography, vegetation mapping and remote sensing should enable site-specific data to be extrapolated with some confidence over a much more significant area, informing and supporting species conservation and habitat management approaches. This work should ideally be carried out in association with NERP projects led by Williams, Laurance and VanderWal, and with the Bushfire CRC-funded PhD (Daniel Collins, working with Jerry VanClay, Southern Cross Uni)
(ii) Fire is probably an important if rare event in the maintenance of forest/woodland boundaries, particularly along the western margins of the Wet Tropics Bioregion, but also in rain-shadow area in the lowlands and uplands. Recent concern about endangered ecological communities on the Atherton Tablelands (Mabi forest) and in coastal areas (Littoral Rainforest & Coastal Vine Tickets of Eastern Australia (LR&CVToEA)) have highlighted problems of isolation, fragmentation and

weed invasion. We will use historical documents, maps and aerial photographs, and surveys of current extent, to identify natural forest/woodland boundaries, and then seek evidence of past fire in these areas. Field surveys in collaboration with agency staff in fuel reduction burns in cyclone-damaged littoral rainforest sites (e.g. Meunga Creek) and in habitat adjacent to littoral rainforest (e.g. Clump Point) will be used to build a picture of the impact and threat posed to littoral rainforest by fire. A similar approach will be used for Mabi forest, but with the addition of small controlled fire experiments to assess the value of fire in reducing marginal weed infestations (with QPWS), and off-site fire modelling to determine the capacity and likelihood of fire impacting on Mabi forest. This work should ideally be carried out in association with the NERP projects led by Murphy and VanderWal.

(iii) The boundaries of rainforest with woodland and other open communities are variably dynamic, and in some instances is likely to be mediated by fire. Spatial analyses of current boundary distributions in relation to key environmental variables will assess the factors likely to be having most influence on their current positions. Historical research into former boundaries and documented fires, together with long term data on succession at boundaries, will further inform these analyses. Mapping of current features which interrupt, modify or contribute to boundaries, together with climate change scenarios, will enable areas most vulnerable to change to be identified. This work should draw on the extensive work by Harrington *et al.* (Rainforest CRC) and ideally be carried out in association with the WTMA-supported PhD research of David Tng (with David Bowman, U Tasmania).

Project Outputs/Outcomes

The project will bring together existing and new data on the effects of fire on rainforest communities in the Wet Tropics, and on the maintenance of rainforest boundaries in different contexts, both where rainforest is aggressively spreading out into more open habitat types and where fire poses a significant threat to the continued viability of rainforest communities. This compilation will allow us to generate new insights into the problems posed and solutions offered by fire, and provide critically-needed data to underpin future policy advice and the generation of appropriate management approaches which consider environmental impacts of fire, as well as impacts on infrastructure, agriculture and aesthetics. Specific outputs will include:

(i) Mapping, initial assessment and potential long-term monitoring of impacts of TC Yasi on mahogany glider habitat, levels of rainforest invasion, and impacts of fire on succession. Report and publications
(ii) Review of mapping approaches taken to identify LR&CVToEA, revision and proposal of enhanced approaches through fieldwork, expert opinion and participatory workshops with community groups, leading to advice on revised mapping approaches and consequent advice on management. Report and possible publication.
(iii) Assessment of potential for and impacts of fire on Mabi forest. Report and publication
(iv) Identification of key criteria to be used in assessing where and whether expansion of rainforest is desirable, together with mapping and assessment of where critical impacts of fire may be. Scenarios showing where such critical areas may be in the future. Report and publications

Expected benefits of the project to end-users, community, DSEWPaC etc

a. Understanding impacts of cyclone Yasi, and subsequent effects of fire on mahogany glider habitat, will inform implementation of the Species Recovery Plan for Mahogany Gliders, QPW management of fire in those key habitats, and the activities of volunteer groups with concern for mahogany gliders in actively working with agencies to support appropriate fire management.
b. Work on littoral rainforest and Mabi forest will again support QPW and DSEWPaC management of these EPBC-listed habitats, and the work of relevant agencies and councils who manage land adjacent to these communities. Community groups such as the Tableland Tree Kangaroo Group and the Mission Beach-based Community for Coastal and Cassowary Conservation (C4) will also benefit from insights into appropriate management, with information shared at field days and working bees. Revised mapping of LR&CVToEA will support Terrain NRM and Cassowary Coast Regional Council management planning and protection of critical habitat.
c. QPW will benefit from all aspects of the work through the provision of data which may be used to support fire management planning; Cassowary Coast Regional Council has also expressed

an interest in obtaining data to support their fire management planning for coastal ecosystems.

Links and dependencies to other hubs and projects

1. The work on lowland sclerophyll invaded by rainforest species should ideally be carried out in association with NERP projects led by Williams, Laurance and VanderWal, and with the Bushfire CRC-funded PhD (Daniel Collins, working with Jerry VanClay, Southern Cross Uni).
2. The work on impacts of fire and weeds on rainforest margins should ideally be carried out in association with the NERP projects led by Murphy and VanderWal.
3. The work on upland boundaries should draw on the extensive work by Harrington *et al.* (Rainforest CRC) and ideally be carried out in association with the WTMA-supported PhD research of David Tng (with David Bowman, U Tasmania).

Project Budget

AWP 1 – (July 2011 to June 2012)Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	100,000		100,000
CSIRO	19,073	80,927	100,000
QPWS		20,000	20,000
Terrain			
WTMA			
Total	**119,073**	**100,927**	**220,000**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	100,000		100,000
CSIRO	19,073	92,284	111,357
QPWS		20,000	20,000
Total	**119,073**	**112,284**	**231,357**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	100,000	-	100,000
CSIRO	-	100,000	100,000
QPWS	-	20,000	20,000
Total	**100,000**	**120,000**	**220,000**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	50,000		50,000
CSIRO	9,536	40,463	50,000
QPWS		20,000	20,000
Total	**59,536**	**60,463**	**120,000**

Identified and assessed hazards

Description of Risk	Assessed Risk	Risk Control measures
Failure to build appropriate collaborative relationships	Low	Project developed at the request of and in collaboration with local, state and federal agencies and groups with concern for the impacts of fire on rainforests and associated habitat
Failure to obtain data	Medium	Collaborative development of project timelines with key agency staff to ensure coordination of activities
Departure of key project personnel	Medium	CSIRO has sufficient breadth of experience to be able to substitute in staff to meet any capacity gaps
Failure to achieve outcomes due to dependence on outputs from other projects	Low	Key outcomes are dependent on this project alone – links to other projects mostly provide opportunities for enhanced delivery or supplementary outputs
Failure to achieve uptake of results by end-users	Medium	Workshops/meetings will be convened with key end-users at various key project stages to ensure engagement and delivery of results in useful form.

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Project 7.2: Invasive species risks and responses in the Wet Tropics

Project Leader and Host Organisation

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Project Team

Title	Organisation	Role
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Dr Dan Metcalfe	CSIRO (Atherton)	Research Scientist
Matt Bradford	CSIRO (Atherton)	Research Technician, rainforest ecology
Dr David Westcott	CSIRO (Atherton)	Research Scientist
Nat Raisbeck-Brown	CSIRO (Atherton)	Research Technician, spatial analyst
Dr Cameron Fletcher	CSIRO (Atherton)	Research Scientist, modeller
Dr Darren Kriticos	CSIRO (Canberra)	Research Scientist, climate change modeller

Summary Table of End-users[1]

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WTMA	Steve Goosem	steve.goosem@derm.qld.gov.au
FNQROC	Travis Sydes	T.Sydes@cairns.qld.gov.au
Terrain NRM	Bart Dryden	bartd@terrain.org.au
DSEWPaC	Joanne Nathan David Calvert TBC Karl Newport Kate Sanford-Readhead	Joanne.nathan@environment.gov.au david.calvert@environment.gov.au Anthony.whalen@environment.gov.au Karl.newport@environment.gov.au Kate.sanford-Readhead@environment.gov.au

[1]*End-users are those organisations either directly related to the project or could benefit from the outputs of this project. All final reports will be circulated to nominated contacts prior to upload to web.'*

Project Duration

Start Date: 1st July 2011 End Date: 31st December 2014

Project Description / Task Objectives

Invasive species management in the Wet Tropics is currently driven by a species-led prioritisation approach, as are weed and pest animal management activities globally. However, land managers in the region are increasingly recognising the necessity for regional-scale population prioritisation tools that incorporate the complexity of ecological processes of invasive species spread and establishment and take account of the values and assets in the landscape. In addition, climate change and intense cyclones will enhance the capacity of non-native species to establish, spread and transform the Wet Tropics ecosystems, and for maximum effectiveness over the long-term, strategic management and prioritization approaches should consider emerging risks under future climate scenarios. Current approaches to identifying and managing weed risk in particular need to be revised in line with projected climate change across northern Australia.

This project builds on and integrates outputs from several other invasive species and biodiversity research and management activities carried out over the previous two to four years including under the previous MTSRF. This project will support the management of invasive plants and animals by providing process-based decision support tools that enable the design and assessment of strategic approaches to on-ground management.

Key Objectives

The project will assess current and future invasive species risks and responses in the Wet Tropics and provide managers with tools for prioritising management activities at a regional scale, and allocating resources and effort on the ground. The overall objective of our project is to fill gaps in existing invasive species management frameworks within the region, building on existing knowledge and aligning with existing regional management products and services, rather than re-inventing new systems and tools. The focus of our research will be on weed species and feral pigs, however, the models will be developed with the capacity to integrate management for suites of invasive species to form the basis of a whole-of-system approach to invasive management in the Wet Tropics.

We will be working closely with state, regional and local government invasive species managers to ensure rapid adoption of our outputs, including running several workshops (including representatives from WTMA, Biosecurity Qld, QPWS, local councils, NRM and FNQROC) for input and feedback. We will also work closely with other Rainforest NERP researchers at JCU and CSIRO (Sue Laurance, Jeremy VanDerWal and Dan Metcalfe) to value-add to the project through collaborative data collection and synthesis and through engaging students to undertake components of work supporting the project (we have included funding for support of student projects and collaboration with JCU in the budget). Other funded projects that team members are currently engaged in provide integration opportunities with this project including the RIRDC funded "Containment of invasive plants: a basis for decision-making and best practice" (team members: Helen Murphy, Cameron Fletcher, David Westcott) which involves several case studies on Wet Tropics weeds.

Specifically our project will:

1. Improve knowledge about the pathways of spread of invasive species in the Wet Tropics
2. Identify
    a. important source populations of invasives in the Wet Tropics with the potential to disproportionately contribute to spread and impact
    b. important connecting elements in the landscape for spread
    c. high-value natural assets at risk from invasion and impact
    d. emerging weed threats in the Wet Tropics as a result of climate change
3. Develop a population-level prioritisation approach for strategic invasive species management in the Wet Tropics
4. Explore the efficacy of alternative approaches to the on-ground management of suites of invasive species and to protect assets once regional and landscape level priorities have been identified.
5. Build an accessible platform of data for future and ongoing scenario-based planning and bio-economic modelling
6. Incorporate project outputs into regional invasive species and landscape management planning and delivery

Project / Task Methodology

There are three linked components to this project:

(1) Networks of weed spread and landscape scale prioritization

The project will assess patterns and pathways of spread of weed species through vegetation and hydrology networks in the Wet Tropics region, and provide managers with a landscape-scale strategic basis for prioritising control, surveillance, containment and natural asset protection activities. We will utilize and build on existing data on the distribution of nationally and regionally important suites of weed species and use network analyses to understand landscape connectivity for weed spread. We will overlay this analysis with data on the distribution of natural assets in the region including the location of regional ecosystems which potentially contain EPBC listed plant and animal species, and the location of EPBC listed communities, remnant vegetation, cool-climate refugia and connecting corridors, conservation estate, etc. The network analyses will then be used to identify which weed populations/sites have the greatest potential to impact these natural assets and which natural assets are most vulnerable from weed invasion.

Outputs include:

1. Spatial outputs and mapping products. We will provide all stakeholder groups with spatial layers (and hard copy mapping products where relevant) of the results of the project identifying, for example:
    a. weed populations and communities which serve as important potential sources of propagules to the region via their connectivity to un-infested areas and natural assets
    b. areas particularly susceptible to invasion or re-invasion because of their connectivity to source populations or communities
    c. components in the landscape that form important connections between sources and natural assets
    d. natural assets vulnerable to weed invasion and priority areas for asset protection activities
    e. prioritisation outcomes for weed management; e.g. high priority areas for control, containment and surveillance
2. Synthesis mapping products/spatial layers which integrate results of weed management prioritisation with strategic land management objectives such as restoration and revegetation.
3. Publication of a clear methodology for our prioritisation framework such that it is accessible for use in other regions, with examples of the outputs for the Wet Tropics
4. Scientific publications in international journals

(2) Modelling the Invasion-Management Spatial Dynamic

The next step of this analysis is to translate the regional-scale prioritisation process into on-ground allocation of resources over the relevant spatial and temporal scales of management. We will build on dispersal models developed in the invasives project over the previous MTSRF funding cycle to determine optimal allocation of resources and effort to on-ground activities for control, containment, surveillance and protection of natural assets.

We will also use the modelling framework developed under the MTSRF program to develop tools and frameworks to assess the spatial and temporal interaction between management and invasive animal populations. Unlike plants, animals can potentially disperse throughout their lives and move on a daily basis resulting in daily redistribution of the population as well as continued dispersal. These movements occur in response to a variety of social, ecological and management drivers and defining and quantifying these drivers is therefore critical to predicting the spatial dynamics of the invasion process. In this part of the work we will:

use a detailed understanding of the factors driving vertebrate patterns of movement and re-distribution to develop a generalisable, spatially explicit model that can be applied to any vertebrate species with appropriate parameterisation,

Working with stakeholders (Terrain NRM and FNQROC) operationalise and parameterize the model for assessment of alternative strategies for pig management in the WTR.

Outputs include:

1. Assessment of the eradication and economic efficacy of different strategies for the management of *Miconia calvescens* in the WTWHA
2. A qualitative and an operationalised model of feral pig/management interaction applied to the assessment of alternative management strategies.

3. Scientific publications describing these results.

(3) Climate change and emerging weed risks

The project will also assess future weed risks and responses by identifying emerging weed threats and their capacity for establishment and spread in the Wet Tropics under changing climatic conditions and following severe cyclones. We will use bioclimatic modeling and climate matching methodologies to address this issue and incorporate our results into the prioritisation and strategic management process.

Outputs include:

1. Identification of species:
   a. that are invasive in areas that have matched climates to the Wet Tropics but are not yet present in Australia or are present but not yet invasive;
   b. Identification of high-risk source areas (which can be used in risk assessments) for future invasive species based on matched climates with Wet Tropics predicted future climate scenarios.
2. Identification of weed species that:
   a. pose potential medium- to high-risk for increased abundance/spread/impact under future climate scenarios and determination of appropriate eradication, control, containment or monitoring strategies for these species.
   b. may pose lesser risk under future climatic conditions because of a reduction in suitable habitat
3. Identification of geographic areas within the bioregion that are potential high risk for weed invasion in future climate scenarios (the results of this work will then be fed back into Task 1).
4. Scientific publications in International journals

Project Outputs/Outcomes *(Provide a description of the major outcomes of each objective within this project)*

The project's outcomes will include knowledge, products, tools and methods that support decision making across all scales of invasive species management (from populations/sites, to catchments, to landscapes) including temporal scales (immediate short-term control and impact mitigation, and longer term adaptation and policy), and which are widely accessible within the region. The outcomes of this project have the potential to reduce the future cost of invasive species management in the Wet Tropics region through identifying strategic and pro-active management for mitigation of the impacts of invasive species and adaptation to climate change.

We envisage an end-user adoption strategy to include:

(1) A user's manual on the development and implementation of a spatial population prioritisation framework for weed management which would be transferable to other regions
(2) Regular workshops with end-users to facilitate ownership and uptake of the prioritisation process and results
(3) Regular presentations of the results and outputs of the work at regional stakeholder meetings (e.g. FNQ Pest Advisory Forum, BQ Four Tropical Weeds Operational and Management Committee meetings, QPWS Annual Pest and Fire Workshop).
(4) Training workshops targeted at all levels of weed management from ground control crews, to managers, to policy makers on the use of prioritisation tools developed during the project with the goal of establishing a basis for ongoing adaptation
(5) Explicit incorporation of data and results of the prioritisation process into the existing regional Local Government Natural Assets registers and regional invasive species and landscape management planning and delivery
(6) A communications platform via an interactive Web Portal, integrated with the existing regional Pest and Weeds Web Portal and the Weeds Web Portal being developed by DSEWPaC to facilitate information exchange regarding emerging and future weed threats, to provide results of the current project and facilitate use of data for future and ongoing scenario-based planning and bio-economic modelling

Project 7.2 Budget

Whole of Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	415,000		415,000
CSIRO		415,000	415,000
Total (GST ex)	**415,000**	**415,000**	**830,000**

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	133,425		133,425
CSIRO		133,425	133,425
Total	**133,425**	**133,425**	**266,850**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	125,645		125,645
CSIRO		125,645	125,645
Total	**125,645**	**125,645**	**251,290**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	108,874		108,874
CSIRO		108,874	108,874
Total	**108,874**	**108,874**	**217,748**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	47,056		47,056
CSIRO		47,056	47,056
Total	**47,056**	**47,056**	**94,112**

Risk Assessment

Description of Risk	Assessed Risk	Risk Control measures
Failure to obtain data	Low	The project has a low dependence on data from other sources. Where data from other sources is desirable, the availability of these has been verified during proposal formation.
Departure of key project personnel	Medium	The modellers on the project are key members of the research team. In the early stages of the project the format of the model will be modified to a form that is more readily accessible and useable by other team members. In the event that either the PI (CSIRO Atherton) or other team members are unable to continue on the project, CSIRO is large enough that they can nominate a substitute who is capable of taking over the role. Any such substitutions will be discussed early with RRRC.
Failure to achieve outcomes due to dependence on outputs from other projects	Low	While the project will benefit from integration with outputs from other projects (e.g. RIRDC funded projects) this project's success is not dependent on these outputs.
Failure to achieve uptake of results by end-users	Medium	Workshops/meetings will be convened with key end-users at various key project stages to ensure engagement and delivery of results in useful form.

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

Project Leader and Host Organisation

Name	Dr Justin A. Welbergen		
Position	Senior Research Fellow		
Organisation	James Cook University		
Unit	Discipline of Zoology & Tropical Ecology		
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Project Team

Title	Organisation	Role
Dr J A. Welbergen	James Cook University	Project leader
A/Prof A K Krockenberger	James Cook University	Ecophysiologist
Research Assistant (RA)	James Cook University	Research Assistant

Summary Table of End-users[1]

Organisation	Organisational Contact	Email
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DNPRSR	James Newman Andrew Millerd	james.newman@nprsr.qld.gov.au Andrew.Millerd@nprsr.qld.gov.au
TERRAIN	Rowena Grace Carol Sweatman	rowenag@terrain.org.au caroles@terrain.org.au
DSEWPaC	David Calvert Peter Latch Tim McGrath TBC Karl Newport Kate Sanford-Readhead	David.calvert@environment.gov.au Peter/latch@environment.gov.au Tim.mcgrath@environment.gov.au Anthony.whalen@environment.gov.au Karl.newport@environment.gov.au Kathryn.sanford-readhead@environment.gov.au
FNQROC	Travis Sydes	t.sydes@cairns.qld.gov.au
DSEWPaC, CSRIO, JCU, Australian Wildlife Conservancy, and the FNQ Regional Organisation of Councils also have strong interests in research pertaining to 'extreme events vulnerability', as identified in our '*Gap Analysis of Environmental Research Needs in the Australian Wet Tropics*' (Welbergen et al 2011 [1]).		

[1]*End-users are those organizations either directly related to the project or could benefit from the outputs of this project. All final reports will be circulated to nominated contacts prior to upload to web.*

Project Duration

Start Date: 1st July 2011 End Date: 31st December 2014

- **The proposed research will provide information and tools to enable scientists and management agencies to predict and limit the impacts of extreme climatic events on Australia's biodiversity.**
- **The funds requested from the National Environmental Research Program ($179,838) represent less than 20 percent of the total funds allocated to the research.**

Project Description / Task Objectives

While changes in the long-term mean state of 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 events, including heat waves, fires, flooding rain, and cyclones [2]. Such extreme events represent the way in which our communities, animals and plants will strongly experience climate change [3].

Extreme temperature events are of special concern to biodiversity conservation [4, 5], both because of their direct impacts on organismal health, but also because of their effects on water demand and evaporative losses and the frequency and intensity of droughts and wildfires [e.g. 6]. They can directly result in mass die-offs [7] and already contribute significantly to determining which species occur in which ecosystems [8, 9]. Since the frequency, duration and severity of extreme temperature events are rising faster than the means [10-13], they will continue to gain significance as mechanistic drivers of ecological responses to climatic change [4, 5]. However, despite their clear importance for our understanding of climate change impacts (and hence adaptation action), very little is known about their effects on biodiversity.

Tropical rainforests are the hotbed of the world's biodiversity; yet, the vulnerability of tropical rainforest biota to extreme temperature events is largely unknown [14]. This is of concern because although the increase in temperature variability is expected to be most pronounced at high latitudes, tropical species may already be living closer to their maximum thermal tolerances so that even small temperature changes could have disproportionally large impacts [15-17]. Australia's Wet Tropics bioregion is the world's best understood tropical system [18]. At our Centre for Tropical Biodiversity and Climate Change (CTBCC) we have access to detailed distribution and environmental data collected systematically in the bioregion over the last 19 years [19, 20]. The dataset is recognised as one of the world's most comprehensive ecological and environmental information sources available, and is unique for any tropical region. Thus, the Wet Tropics provide a singular opportunity for assessing the vulnerability of tropical biodiversity to contemporary and future impacts of extreme events.

This project will investigate the *exposure* and *sensitivity* of Wet Tropics biota to extreme climatic events. Integration of the information on exposure and sensitivity will then enable us to assess quantitatively the *vulnerability* of Wet Tropics biota to extreme climatic events, and map the contemporary and future impacts of these events on biodiversity in the Wet Tropics Bioregion. Although the focus will initially be on impacts of temperature extremes, we will use the analytical and conceptual advances gained from this project to form the basis of a generalized framework for assessing the impacts of extreme climatic events, including droughts and wildfires, on natural systems across Australia and elsewhere.

Key links to NERP projects and hubs

Analyses of the Wet Tropics bioregion's spatial and temporal exposure to extreme events, combined with analyses of rainforest biota with respect to their sensitivity to changes in the regimes of climatic extremes will enable, for the first time, the modelling of extinction risk and potential impacts of temperature extremes on the distribution and abundance of species. Therefore, this project will -

- play a vital part in understanding the risks and threats to rainforest biodiversity under climate change and thus be a major component of assessing relative vulnerability and adaptation actions (NERP TE Hub project 6.1b).

- deliver critical input for predictions of future trends (NERP TE Hub project 6.1d)
- provide essential contribution to our understanding of the drivers of rainforest biodiversity patterns and change (NERP TE Hub projects 6.1a and 6.1c)
- inform adaptation management and restoration practice so cost-efficient allocation of resources can be achieved (NERP TE Hub project 8.3).

In addition to the firm links to proposed projects within the NERP TE Hub, this project also clearly falls within the general capacities and intents of NERP Terrestrial Hubs 1 and 2, and the Northern Australia Hub. Once the final structure of these research hubs is in place we will ensure that appropriate links are made to help maximise collaboration across hubs.

Expected benefits to end-users

It is widely recognised that knowledge of the relative vulnerability of biodiversity to extreme events is crucial for sound conservation action in the face of climate change [4, 6]. This is further evidenced by the high ranking of this issue among the stated research priorities of the main end-user organisations at both the national [e.g. [21] and bioregional level [1, 22, 23]. In addition, a host of other stakeholders in the Wet Tropics bioregion, including DSEWPaC, CSRIO, JCU, the Australian Wildlife Conservancy, and the FNQ Regional Organisation of Councils expressed strong interests in research pertaining to 'extreme events vulnerability', as revealed by our '*Gap analysis of environmental research needs in the Wet Tropics*' [1], that was conducted under the Commonwealth Environmental Research Facilities (CERF) Transition Program.

We also anticipate that our new information and tools will be of particular benefit to both research providers and end-users with a stake in climate change adaptation research. In order to disseminate our work effectively among these stakeholders we will use the NCCARF Terrestrial Biodiversity Adaptation Research Network, which is hosted by our research centre.

Summary of key research links and end-user research priorities

Links to NERP projects, NERP hubs, and external networks			Links to top end user research priorities		
TE NERP Hub Project #	**Other NERP Hubs**	**External**	**Gap analysis** [1]	**WTMA** [20]	**TERRAIN** [21]
6.1a, b, c, d; 8.3	NERP Terrestrial Hub 1 NERP Terrestrial Hub 2 NERP Northern Australia Hub	NCCARF Terrestrial Biodiversity Network	4, 6, 8	A, B, D	3, 5

Key Objectives

The research program has the following key objectives:

1) Determine the *exposure* of Wet Tropics biodiversity to climatic extremes
2) Determine the *sensitivity* of Wet Tropics biodiversity to climatic extremes
3) Determine the *vulnerability* of Wet Tropics biodiversity to climatic extremes, and assess contemporary and future impacts

Project / Task Methodology

Objective 1 – Exposure: (a) *Landscape-scale exposure* will be mapped by determining relationships between broad-scale macro climate and direct measurements of organism exposure in different environments. (b) *Microhabitat-scale exposure* will be determined by combining the microhabitat preferences of Wet Tropics biota with the thermal characteristics of their known preferred habitat [19]. (c) Landscape-scale and microhabitat-scale exposure will be combined to map accurately temperatures experienced by organisms in-situ.

Objective 2 - Sensitivity: Sensitivity of Wet Tropics biota to temperature extremes will be determined by integrating information on their thermal tolerance limits, their resilience, and their capacity to adapt.

(a) *The thermal tolerance limits* have already been quantified by the CTBCC for a range of representative taxa. Using validated methodology, data on thermal physiology of an additional 25 key taxa will be collected in-situ. (b) *Resilience* will be quantified from known traits that affect a species' ability to survive and recover from an environmental insult [19, 24]. (c) The *capacity to adapt* will be estimated by comparing the thermal characteristics of a species' most favourable microhabitat with that of its other viable habitats. The three types of information will then be combined to obtain highly accurate estimates for the sensitivities of a range of representative Wet Tropics species.

Objective 3 – Vulnerability: The project will explicitly incorporate the correlative and, where possible, mechanistic links between exposure and sensitivity to model spatiotemporal variation in current and future vulnerability to extreme temperature events. This will enable the mapping of impacts of anthropogenic changes in the regimes of temperature extremes on the distribution, abundance and extinction risk of species, something that has not been attempted before in any region.

Ultimate aim - The project will initially concentrate on the regimes of temperature extremes; however, our analytical approaches will then also be applied to the regimes of other extreme climatic events, particularly droughts and wildfires as they are strongly linked to extreme heat events. Our ultimate aim is to develop a generalized framework for assessing the vulnerability of any natural system to any extreme climatic event. This will be critical for informing proactive conservation strategies that minimise biotic vulnerability to such events in the face of climate change.

Project Outputs/Outcomes

Objective	Outputs / outcomes
1	Accurate high resolution maps of the exposure to temperature extremes as experienced by organisms in-situ
2	Accurate estimates of the sensitivities of organisms to temperature extremes
3a	Identification of the areas where biodiversity is currently most vulnerable to temperature extremes ('thermal hotspots')
3b	Identification of the areas where biodiversity is least vulnerable to temperature extremes in the future ('thermal refugia')
3c	A list of biodiversity values particularly at risk from extreme events
Ultimate aim	A generalised analytical toolkit for assessing vulnerability to extreme climatic events in Australia and elsewhere

Key risks to the project's success

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	Welbergen (JAW) and Krockenberger (AKK) are already appointed though JCU for the duration of the project, and both are already aware of many possible RA candidates with suitable qualifications.
Failure to retain key project personnel	Low-Medium	The NERP funding will ensure that JAW and AKK will remain with the project because it will enable them to pursue their primary research objectives.
Failure to obtain data	Low	The data collection methods are based on proven methodology employed extensively by our Centre for Tropical Biodiversity & Climate Change.

Failure to achieve outcomes due to dependence on outputs from other projects	Low-Medium	The project has limited dependence for outcomes from other projects to which it is linked.
Failure to achieve uptake of results by end-users	Low-Medium	Workshops/meetings will be convened with the key end-users identified here, and our tools and findings will be disseminated through the NCCARF Terrestrial Biodiversity Adaptation Research Network. These will ensure end-user engagement and delivery of results in useful form.

Project Budget

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP TE HUB	61,025		61,025
James Cook University		210,911	210,911
Total	**61,025**	**210,911**	**271,936**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP TE HUB	52,125		52,125
James Cook University		210,911	210,911
Total	**52,125**	**210,911**	**263,036**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP TE HUB	44,625		44,625
James Cook University		213,844	210,911
Total	**44,625**	**213,844**	**255,536**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP TE HUB	22,225		22,225
James Cook University		105,455	105,455
Total	**22,225**	**105,455**	**127,680**

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Theme 3 – Managing for Resilient Tropical Systems

Research undertaken within Theme 3 will provide knowledge and options to assist key decision makers in government, industry and the community in managing the complex ecosystems of the Great Barrier Reef, the Wet Tropics rainforest (including the World Heritage Area) and the Torres Strait. Theme 3 draws on the assessment of ecological condition and trends undertaken in Theme 1 and the improved understanding of ecosystem function and cumulative pressures from Theme 2. Theme 3 will provide tools and information for evidence-based decision making that address the pressures and sustains resilient ecological, social and economic systems.

Program 8: Effectiveness of spatial management on the GBR

Program 8 will have three inter-linked projects that will test the effectiveness of spatial management arrangements (differential use zones) for conserving exploited fish populations in the GBRMP. One project will compare the abundance of fish, corals, and the incidence of coral disease between fringing reefs in the coastal zone that have been closed to fishing at different times in the past with adjacent areas that remain in use by the recreational fishing sector. A second project in the southern GBR will apply genetic parentage analysis to estimate the recruitment subsidies to fished areas that are contributed by protected fish stocks spawning in no-take areas. The third project was started with the major rezoning of the GBR in 2004 and will track a suite a biodiversity indicators across 26 closely matched pairs of reefs offering fished/unfished contrasts. Since these 52 reefs are spread through the mid-shelf from Cairns to Gladstone, this new design covers the area with the highest incidence of crown-of-thorns starfish outbreaks. The strong experimental design will be the best chance yet to determine whether fishing has any impact on the frequency and/or severity of starfish outbreaks. If there is a positive association this will be further evidence that the starfish and its huge effect on coral cover may be unnatural and require further management intervention to restore the resilience of coral populations.

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

Project Leader and Host Organisation

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Project Team

Title	Organisation	Role
Hugh Sweatman	AIMS	Project management
Long-term Monitoring Field team (6)	AIMS	Data collection and analysis

Summary Table of End-users[1]

Organisation	Organisational Contact	Email
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[1] End-users are those organisations either directly related to the project or could benefit from the outputs of this project. All final reports will be circulated to nominated contacts prior to upload to web.

Project Duration

Start Date: 1 July 2011 End Date: 31 December 2014

Project Description / Task Objectives

Implementation of networks of protected areas is the single most widely advocated action to protect marine biodiversity; the GBR Marine Park was one of the first and is one of the largest examples of such a network in the world. While some effects of marine protected areas can be seen rapidly, there are also long term changes that may develop over 1-2 decades. Surveys of the matched pairs of reefs during the term of the NERP Program will enable the longer-term effects of zoning to be assessed eight and ten years after the new zoning plan came into force.

The Task objective is to examine the effects of time since closure to fishing on communities of coral reef fishes and benthic organisms on mid- and outer shelf reefs in five regions of the GBR Marine Park

Key Objectives

a. Track dynamics of populations of target fish species fished reefs compared with similar reefs that are closed to fishing in five regions of the GBR Marine Park. This will also include by-catch species, such as reef sharks.
b. Track indirect effects of protection from fishing in terms of populations of non-target fish species. Since many exploited species are carnivorous, differences in their numbers may in turn affect the abundance of their prey (and potentially cause more extensive "trophic cascades") as well as other community components that are related to resilience such as numbers of herbivorous fishes.
c. Track potential ecosystem effects of protection from fishing, such as increased coral recruitment and coral cover due to increased herbivorous fish numbers, and reduced incidence of coral disease (due to lower numbers of coral-feeding butterflyfishes inside no-take areas)

Project / Task Methodology

To monitor the ecological effects from rezoning the GBRMP in 2004, 5 regional sets of pairs of similar reefs (matched by latitude, size, position on the continental shelf and geomorphology) have been surveyed repeatedly in alternate years since 2006. Reefs in each pair were both open to fishing prior to 2004; one of the pair was closed to fishing in the new zoning plan, the other reef remained open to fishing. AIMS LTMP has used standard monitoring methods to survey reef communities for almost 20 years. These use marked sites in one reef habitat (the reef slope on NE face of each survey reef) and involve visual counts of fishes and assessment of benthic communities from digital images, combined with intensive surveys for juvenile corals and for coral diseases and other causes of coral mortality, plus broad-scale manta tow surveys for crown-of-thorns starfish and reef-wide coral cover. In response to suggestions from the GBR Working Group, divers surveying the 750 m of transects at each reef will record the presence and age of any fishing line as evidence of non-compliance. Manta tow surveys of the reef perimeters will record any sharks that are seen, since there is concern for the conservation status of reef sharks.

The five regional sets of reef pairs will be resurveyed in 2011-12 and 2013-14, each annual survey involving approximately 100 days at sea.

Project Outputs/Outcomes

- The most direct effect of regulating fishing is likely to be on the target fish species. Early surveys found that numbers and biomass of coral trout were higher on no-take reefs less than two years after the new zoning plan was implemented. Comparisons of the numbers of target species of fishes on matched pairs of reefs, one fished and one no-take, will provide an estimate of the effects of difference in fishing pressure and whether the early differences have been maintained. The densities of target species, notably coral trout, vary greatly along the GBR and among the different sets of paired reefs. Fishing pressure is expected to have a direct effect on by-catch species such as reef sharks, which will be counted in the manta tow surveys.
- Differences in the numbers of predatory fishes on fished and no-take reefs can be expected to lead to an inverse relationship with density of prey species. Some studies have suggested a greater "Cascade" effect leading to compensatory changes in abundances of animals in lower trophic levels as well. No consistent differences in abundance of likely prey of coral trout have been detected in past surveys; these surveys will tell if a difference emerges in the longer term.
- Changes in the fish communities due to fishing can have ecosystem effects. For instance, the abundance of herbivorous fish is widely thought to affect the success of coral recruitment and in one case the incidence of coral disease was lower inside an MPA, presumably because there were fewer butterflyfishes to act as vectors. Evidence for such indirect processes will be investigated.
- While the most immediate effects of zoning a reef as a no-take zone is likely to be on the target fishes, the intention of the new zoning plan was to protect reef biodiversity. The surveys will allow some degree of assessment of the comparative diversity of fishes and benthic organisms on fished and no-take reefs

In addition, because standard methods are used in the two components of AIMS' monitoring (Projects 1.1 and 1.3) the data from the rezoning monitoring surveys (1.3) feed into and extend assessment of status and trends of reefs of the GBR (1.1).

Expected Benefits

- Provision of information to the GBRMPA and the Australian Community about the developing effects of rezoning the GBRMP in 2004
- Contribution of information on the effects of zoning for inclusion in the Outlook Report 2014
- Scientific publications on the effects of a large network of marine protected areas

Description of Risk	Assessed Risk	Risk Control measures
Failure to complete surveys due to bad weather	Medium	Schedule includes days that can be used for broadscale surveys to provide greater situational awareness or reallocated to priority reef surveys if absolutely necessary.
Departure of key project personnel	Low	The field team includes individuals that can fill multiple roles
Failure to achieve uptake of results by end-users	Low	Preliminary results of each survey circulated by email directly to stake holders and end-user representatives. Dissemination of findings via peer-reviewed publications and conference presentations

Project Budget

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	350,000		350,000
AIMS		714,909	714,909
Total	**350,000**	**714,909**	**1,064,909**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	0		
AIMS			
Total			***NO ACTIVITY***

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	375,000		375,000
AIMS		766,345	766,345
Total	**375,000**	**766,345**	**1,141,345**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	0		
AIMS			
Total			***NO ACTIVITY***

Project 8.2:	**Do no-take marine reserves contribute to biodiversity and fishery sustainability? Assessing the effects of management zoning on inshore reefs of the Great Barrier Reef Marine Park**

Project Leader and Host Organisation

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Project Team

Investigators	Organisation	Role
Professor Garry Russ	JCU	Project Leader
Dr. David Williamson	JCU	Project Leader
Dr. Daniela Ceccarelli	JCU	Project Researcher
Dr. Richard Evans	DEC	Collaborator
Prof. Bette Willis	JCU	Project Coordinator

Summary Table of End-users[1]

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[1] End-users are those organisations either directly related to the project or could benefit from the outputs of this project. All final reports will be circulated to nominated contacts prior to upload to web.

Project Duration

Start Date: 1 July 2011 End Date: 31 December 2014

Project Description / Task Objectives

Spatial zoning for multiple-use is the cornerstone of management for the Great Barrier Reef Marine Park (GBRMP). Multiple-use zoning was first implemented widely in the GBRMP in the late 1980's and this original zoning plan was in place until 2004, when the marine park was completely rezoned under the Representative Areas Program (RAP). An increased appreciation of current and future threats to the GBR ecosystem, strong national support for increased protection and sufficient political will, led to the establishment of a large number of new no-take marine reserves ('NTRs' - Marine National Park 'green' zones and Preservation 'pink' zones). The overall proportion of the marine park area assigned into NTRs was increased from around 5% (~ 25% of the coral reefs) to 33.4%, with the greatest proportional increases assigned to non-reef habitats that were under-represented for protection in the original zoning plan. The need to objectively assess the ecological and sociological implications of zoning management is widely acknowledged, and it has attracted an increasing amount of research effort in recent years. Critical knowledge gaps still remain however, and research is required to determine how and to what extent NTR networks may help to protect biodiversity, sustain stocks of fished species and increase ecosystem resilience.

This project was established in 1999 and expanded in 2004, with the primary objective of providing a robust assessment of the ecological effects of multiple-use zoning on inshore coral reefs of the GBRMP. The project uses underwater visual census (UVC) to provide a spatially and temporally replicated assessment of fish and benthic communities and will include concurrent surveys of coral health within no-take (Green) and fished (Blue) zones on high-use inshore reefs. It is one of the few long-term monitoring projects specifically assessing the effects of zoning management within the GBRMP and the only one with a solid baseline data set that was established prior to the implementation of the 2004 zoning management plan.

The project has provided the most convincing evidence to date that no-take protection in the GBRMP has led to significant enhancement of exploited fish populations within no-take zones. It has also established the basis for effectively assessing the role of NTR networks in protecting biodiversity, sustaining ecosystem goods and services, and mitigating against disturbance events and the cumulative impacts of climate change.

This project has been supported by MTSRF (Project 4.8.2), and complements the AIMS assessments of inter-reefal zoning (MTSRF Project 4.8.2), the JCU assessment of environmental drivers of coral disease (MTSRF Project 2.5i.3), and the AIMS LTMP assessments of zoning effects on offshore GBR reefs (NERP TE GBR Q2 Theme 1.2). The project also links closely to MTSRF Project 4.8.1 (connectivity of no-take and fished zones in the Keppel Islands – NERP TE GBR Q2 Theme 1.5) and to the GBR larval connectivity project which is currently funded through an ARC Linkage grant with the Great Barrier Reef Marine Park Authority (GBRMPA) as the industry partner.

Key Objectives

The key objective of the proposed project is to provide a robust assessment of the effects of multiple-use management zoning on:

- Abundance and population structure of fishery target species
- Reef fish assemblage structure and dynamics
- Benthic community composition and dynamics
- Coral health based on occurrence and severity of coral diseases
- Usage patterns of recreational fishers and compliance with zoning regulations

Project / Task Methodology

We propose to continue UVC monitoring of fish and benthic communities at 50 no-take marine reserve (green zone) sites and at 50 sites that have remained open to fishing within the Palm, Magnetic, Whitsunday and Keppel Island groups. Sixty (60) of these sites assess the effects of the 'original' (1987/88) zoning (Long-term 'LT' monitoring sites), and forty (40) assess the 'recent' (2004) zoning ('RAP' monitoring sites). During the 3.5 year NERP funding period, UVC surveys will be conducted in the Palm Islands (30 sites) and Keppel Islands (20 sites) in years 1 and 3; and in the Whitsunday Islands (42 sites) and Magnetic Island (8 sites) in years 2 and 4. The proposed work regime will require approximately 40 days of field time and 120 person-days of office time (project management, data processing, analyses and reporting) per annum.

Survey methods

Fish, benthos and habitat complexity:

Underwater visual census (UVC) will be used to survey reef fish and benthic communities on fringing coral reefs of the Palm, Magnetic, Whitsunday and Keppel Island groups. Within each island group, sites are evenly distributed between zones that have remained open to fishing (General Use and Conservation Park zones), NTRs that were closed to fishing in 1987, and NTRs that were established in 2004 (Marine National Park zones) (Figure 1).

Within each site UVC surveys will be conducted using 5 replicate transects (50m x 6m, 300m^2 survey area). Transects are deployed on the reef slope between approximately 4 and 12 metres depth. Using SCUBA, two observers survey approximately 190 species of fish from 15 Families (Acanthuridae, Balistidae, Chaetodontidae, Haemulidae, Labridae, Lethrinidae, Lutjanidae, Mullidae, Nemipteridae, Pomacanthidae, Pomacentridae, Scaridae, Serranidae, Siganidae and Zanclidae). A third diver (observer 3) swims directly behind observers one and two, deploying the transect tapes. This UVC technique reduces diver avoidance or attraction behaviour of the surveyed fish species. To increase accuracy of the fish counts, the species list is divided between the two fish observers. Observer one surveys the fish families Haemulidae, Lethrinidae, Lutjanidae, Mullidae, Nemipteridae, Serranidae and the larger species of Labridae targeted by fishers. Observer one also records all derelict (discarded or lost) fishing tackle (predominantly monofilament fishing line) present on each transect. Observer two surveys the families Acanthuridae, Balistidae, Chaetodontidae, Pomacanthidae, Pomacentridae, Scaridae, Siganidae, Zanclidae and small 'non-targeted' species of Labridae. Pomacentrids and small labrids are recorded by observer two during return transect swims within a 2m band (1m either side of the tape, 100m^2 survey area).

Broad-scale structural complexity of the reef habitat will be estimated by observer one using a simple method that applies a rank (1-5) to both the angle of the reef slope and the rugosity for each ten-metre section of each transect. Observer three will utilise a line intercept survey method to record a benthic point sample every metre along each transect tape (50 samples per transect). Benthos sampled in the benthic survey will be live and dead hard coral within morphological categories (branching, plate, solitary, tabular, massive, foliose, encrusting) live soft coral, sponges, clams (*Tridacna* spp.), other invertebrates (such as ascidians and anemones), macro-algae, coral reef pavement, rock, rubble and sand.

Coral health:

A second survey team will conduct UVC surveys at each monitoring site to record signs of compromised coral health, such as disease, bleaching, predation and physical damage. Coral condition surveys will be conducted along the first 20m of each of the first three transects placed by divers conducting the UVC fish surveys. Along each 20 m transect, each scleractinian (hard) coral colony located within one metre of either side of the transect tape (40 sq. m total survey area per transect) will be identified and recorded to the genus level. All non-scleractinian corals will also be recorded. Based on macroscopic visual examinations, each colony recorded will be further classified as either healthy or placed into one or more disease categories recognised on the GBR. Disease categories include black band disease (BBD)/other cyanobacterial mats, skeletal eroding band (SEB), brown band disease (BrB), white syndromes (WS), atramentous necrosis (AtN), ulcerative white spots (UWS), and growth anomalies (GA). Other factors that compromise coral health will also be recorded, including breakage and physical damage, pigmentation response, thermal or unusual bleaching patterns, algal overgrowth, and crown-of-thorns, *Drupella* and unknown predation scars.

An assessment will be conducted to determine if coral health varies between protected NTR and fished sites. Other potential ecological effects will also be explored, such as specific interactions between coral health (overall pooled disease prevalence, individual disease prevalence, and prevalence of bleaching and signs of other factors that compromise coral health) and measures of NTR effectiveness (percent cover of hard corals, coral density and family richness, as well as species richness, abundance, size and overall biomass of pooled fish families).

Compliance with zoning regulations:

Derelict (lost and abandoned) fishing lines that are entangled in the coral reef will be recorded during the UVC surveys of each site. Monofilament nylon fishing line is persistent in the marine environment and once entangled in the reef, it can remain in place for many years. Temporal monitoring of the relative number of fishing lines recorded at each site can be used as a proxy for fishing effort. During the last few years we have established a collaboration with ReefCheck Australia to enhance this aspect of the project. In 2007, volunteer divers were tasked with removing all derelict fishing lines from a subset of the monitoring sites in the Palm Islands. In the last few years, the rate of line re-accumulation has been monitored to gauge relative levels of fishing effort and zoning compliance. This pilot project has already yielded valuable data that has direct relevance to effective management of the GBRMP. We propose to expand this aspect of the project during the NERP funding period.

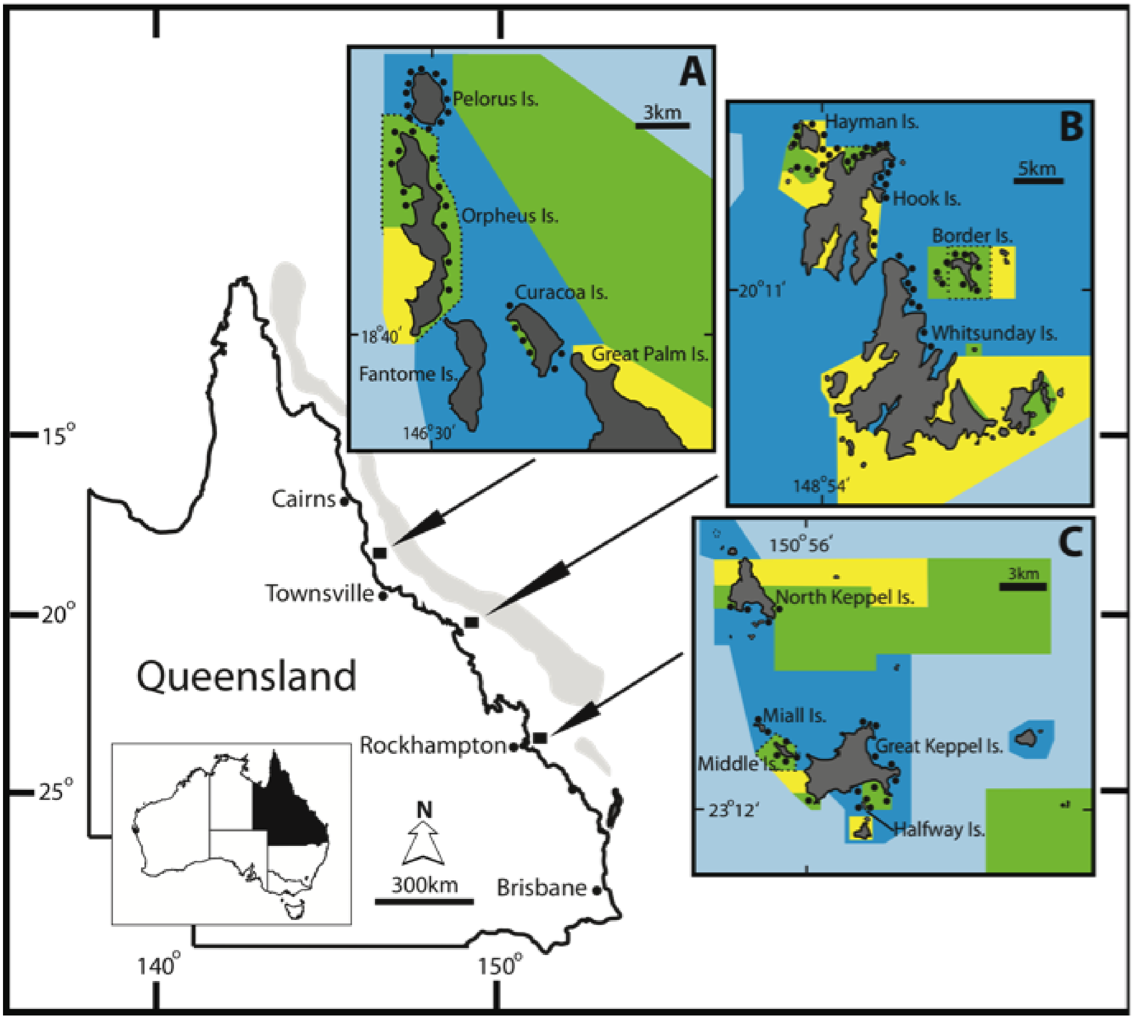

Figure 1: Study locations in the A. Palm, B. Whitsunday and C. Keppel Island groups showing the approximate position of long-term and RAP monitoring sites (black markers). Green shaded areas are no-take reserves (NTRs). NTRs delineated with black dotted lines were established in 1987/88, the remainder were established in July 2004. Yellow shaded areas are conservation park zones that are open to recreational hook and line fishing. Dark blue shaded areas are open to all extractive uses other than demersal trawling. Light blue shaded areas are open to all uses.

Field schedule July 2011 – Dec 2014

- UVC surveys at 50 monitoring sites per year (coral disease surveys during 2011/AWP1 & 2012/AWP2 only)
- Palm and Keppel Island groups in 2011 (AWP1) and 2013 (AWP3)
- Whitsunday and Magnetic Island groups in 2012 (AWP2) and 2013/2014 (AWP3/4)

Project Outputs & benefits to end-users

The Great Barrier Reef is Australia's iconic marine habitat, and the GBRMP is a globally significant marine reserve network. Understanding how effectively the GBRMP protects reef biodiversity and how the existing reserve network may assist in sustaining reef fisheries is vital to Australia, to neighbouring countries in the coral triangle and to all tropical nations. Our results will be of direct relevance to all end-users, including the GBRMPA and several other government departments, to recreational and commercial fishers, to the tourist industry, to conservation groups and NGOs, and to the general public.

The GBRMPA has the responsibility of protecting the Great Barrier Reef ecosystem and it has identified an improved understanding of how the 2004 zoning plan is working to protect reef biodiversity and reef fisheries as a high priority research goal (see www.gbrmpa.gov.au "Research priorities"). The first "Outlook Report-2009" identifies climate change, declining water quality from catchment runoff, loss of coastal habitats and impacts from fishing and poaching as the priority issues reducing the resilience of the Great Barrier Reef ecosystem. It also highlights gaps in information required for a better understanding of ecosystem resilience, and overall rates the prognosis for the reef as "Poor". Despite the heavy reliance on the GBRMP marine reserve network as a key strategy for achieving long-term ecosystem resilience, the degree to which reserves contribute to biodiversity conservation or the sustainability of fishery resources remains largely unknown.

This project will generate outputs that will provide a direct assessment of the ecological effects of multiple-use management zoning on inshore reefs of the GBRMP. Temporal sampling of fish assemblages and benthic communities within NTRs and in areas that have remained open to fishing will provide information on:

- effects of no-take zoning on targeted and non-targeted reef fish species
- variations in fish assemblage structure due to NTR protection and natural disturbance events
- natural and fishing induced mortality of exploited species
- benthic community structure and dynamics
- coral health, bleaching, incidence and severity of disease and coral predators

The project will also build on previously acquired data on derelict fishing lines on the reef to provide an assessment of the usage patterns of recreational fishers on these high-use inshore reefs. Specific information will be gained on the distribution of fishing effort and the relative levels of effort imposed on open and NTR zones, based on abundance and distribution of derelict fishing lines. This aspect of the project will provide direct estimates of the levels of non-compliance within NTR zones.

Links to other research projects

This proposed project is a continuation of the inshore reefs monitoring project which was previously funded under MTSRF Project 4.8.2. The project has an established link with the AIMS long-term monitoring project and will also link closely with NERP project 1.5 (*Significance of no-take marine protected areas to regional recruitment and population persistence on the GBR*). Information generated from this project will be used to inform and enhance outputs from NERP project 1.5. Despite this close research link, neither NERP projects 1.4 or 1.5 would be reliant on the outputs from the other project to achieve the stated objectives.

Project 8.2 Budget

AWP1 - (1 July 2011 – 31 June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	131,000	-	131,000
James Cook University (JCU)	-	93,000	93,000
Department of Environment & Conservation (DEC)	-	4,000	4,000
Total	**131,000**	**97,000**	**228,000**

AWP 2 - (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	149,000	-	149,000
JCU	-	93,000	93,000
DEC	-	4,000	4,000
Total	**149,000**	**97,000**	**246,000**

AWP 3 - (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	190,000	-	190,000
JCU	-	93,000	93,000
DEC	-	4,000	4,000
Total	**190,000**	**97,000**	**287,000**

AWP 4 - (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	50,000	-	50,000
JCU	-	46,500	46,500
DEC	-	2,000	2,000
Total	**50,000**	**48,500**	**98,500**

Identified and assessed hazards

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	The proposed team of personnel for this project has a strong track record of delivering on stated research outputs, to schedule and within budget. Field assistants for each survey trip will be selected from a pool of experienced personnel that have previously been involved in this project.
Failure to obtain data	Low	This project has a strong record of obtaining robust data and presenting tangible results. We assess the risk of not obtaining data as extremely low.
Departure of key project personnel	Low	The collaborators on this project hold a shared vision for seeing this work through to completion. In the unlikely event that key personnel depart the project, we are confident that there is adequate capacity within the group to ensure that the stated outputs from this project will be achieved.
Failure to achieve outcomes due to dependence on outputs from other projects	Low	Although this proposed project has strong research links with NERP project 1.5 and the AIMS long-term monitoring project, the generation of outputs from this project would not depend on the outputs from either of these projects.
Failure to achieve uptake of results by end-users	Low	Workshops and meetings will be convened with key end-users at various key project stages to ensure engagement and delivery of results in a useful form. Key end-users of information generated from this project will include the GBRMPA, DEEDI, QPWS, AFMA, QSIA and community groups such as Sunfish & CapReef. Uptake and utilization of project outputs will ultimately depend on the socio-political landscape in which these organisations operate. We will ensure that project findings are scientifically robust and delivered in a form that can be used in development of policies and plans.

Project 8.3:	Significance of no-take marine protected areas to regional recruitment and population persistence on the GBR

Project Leader and Host Organisation

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Project Team

Title	Organisation	Role
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Dr DH Williamson	JCU	Research Associate, Reef fish ecologist, project manager
Dr GR Almany	JCU	Future Fellow, Reef fish ecologist; GIS analysis
Dr M Berumen	King Abdullah University of Science and Technology	Microsatellite development, Gene sequencing
Dr L van Herwerden	JCU	Geneticist
Dr S Choukroun	JCU	Research Associate, Hydrodynamic modeller, Instrumentation
Dr L Mason	JCU	Biophysical modeller

Summary Table of End-users[1]

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[1] End-users are those organisations either directly related to the project or could benefit from the outputs of this project. All final reports will be circulated to nominated contacts prior to upload to web.

Project Duration

Start Date: 1 July 2011 End Date: 31 December 2014

Project Description / Task Objectives

Our recent four-year MTSRF project demonstrated significant export of larvae of the inshore coral trout species (*Plectropomus maculatus*) from existing no-take marine reserves (green zones) in the Keppel Island group on the Great Barrier Reef (GBR). In addition, no-take reserves were shown to make a disproportionately large contribution to recruitment in fished areas (blue zones) at this location. These significant findings were revealed by a unique combination of genetic analysis of parent-offspring relationships and biophysical dispersal modeling. While these previous results provided crucial support for green zones as an effective conservation and fisheries management tool, the scale over which reserves benefit fisheries through recruitment subsidies and the degree to which reserves contribute to long-term population persistence have yet to be evaluated. To understand how marine reserve networks function in a larger conservation and fisheries framework, it is vital to extend the study beyond the Keppel Island group and to include the more important commercially exploited coral trout species (*P. leopardus*). The expansion of the project will permit us to describe patterns of dispersal on larger regional scales and to assess how marine reserves contribute to population persistence over future generations.

The overall goal of this project will be to apply genetic parentage analysis and biophysical modeling, to assess larval dispersal patterns, demographic connectivity and levels of recruitment subsidies from green zones at a regional scale. The project will employ meta-population modeling to extend predictions over multiple generations. Specifically, our *target objectives* are to:

(1) Provide empirical estimates of recruitment subsidies for both *P. maculatus* and *P. leopardus*) over a >200km scale on the southern GBR, quantifying larval retention within and connectivity among inshore (Keppel Islands, Percy and Duke Islands) and offshore reefs (Capricorn-Bunker Group) (Figure 1).

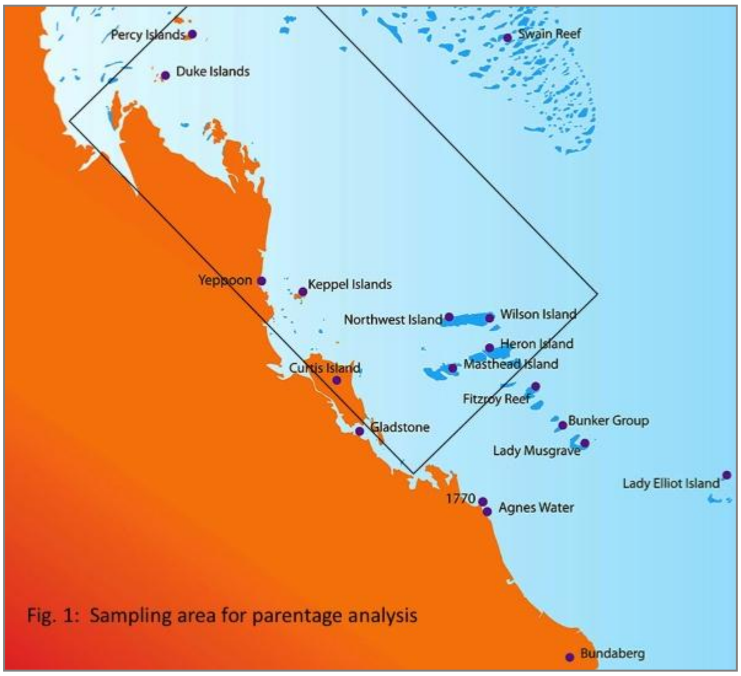

Fig. 1: Sampling area for parentage analysis

(2) Refine the existing biophysical model for this region to take account of new information on coral trout larval behaviour, larval sensory abilities and availability of critical recruitment habitat to better predict regional recruitment patterns.

(3) Compare observed patterns of larval dispersal from parentage studies and predicted patterns of larval dispersal from the biophysical model, and use both approaches to evaluate strengths and weakness of the existing marine reserve network for the target species.

(4) Develop spatially explicit meta-population models that incorporate real data on larval dispersal to evaluate the effects of reserve network design, differential production in reserves and fishing pressure outside reserves on long-term population persistence.

Key Objectives

A . Period 1 – AWP1 (1 July 2011-31 June 2012):

1. Develop a new set of hyper-variable microsatellites for *P. maculatus* and *P. leopardus* for examining parent-offspring relationships. If possible, test parentage assignments from hatchery-reared *P. leopardus*.
2. Carry out field studies on hatchery–reared *P. leopardus* larvae of different ages to quantify depth preferences, swimming speed and orientation, and habitat selection.

3. Refine the existing biophysical model to apply new information on coral trout larval behaviour, fix discrepancies in reef locations, modify reef detection distance and incorporate knowledge of suitable recruitment habitat.
4. Conduct sampling of tissues of adult and juvenile *P. maculatus* and *P. leopardus* from green zones in the Keppel Islands, selected Percy and Duke Islands and a sub-set of the Capricorn-Bunker reefs (including Masthead, North Reef and One Tree). If possible, supplement sampling from recreational and commercial catches from blue zones.

B. Period 2 – AWP2 (1 July 2012 - 31 June 2013):

5. Complete micro-satelite DNA sequencing for the adult tissues to establish a data-base of potential parents.
6. Undertake model simulations targeting the 2011 spawning season to predict dispersal patterns and trajectories for both coral trout species from target green zones in the Keppel Islands, selected Percy and Duke Islands, and selected Capricorn-Bunker reefs.
7. Complete sampling of juvenile tissues of *P. maculatus* and *P. leopardus* from selected green and blue zone reefs at the Keppel islands, Percy and Duke Islands, and Capricorn Bunker Reefs.
8. Complete micro-satelite DNA sequencing of juvenile tissues and genetic parentage analyses to empirically derive dispersal pathways in the study region.
9. Assemble information on growth, mortality and reproduction in the two coral trout species for incorporation into a meta-population model.

C. Period 3 – AWP3 (1 July 2013 – 31 June 2014):

10. Undertake post-processing analyses using refined biophysical model to assess likely origins of larvae at key recruitment hot spots in the region.
11. Compare biophysical modeling results with empirical estimates of larval dispersal to validate the model.
12. Use empirical and model descriptions of dispersal to assess strengths and weaknesses of the current reserve network.
13. Undertake demographic metapopulation analyses using dispersal distances and trajectories derived from this study and available demographic data (growth, natural mortality, fishing mortality) to evaluate long-term persistence of green zone and blue zone populations under different levels of fishing pressure.

D. Period 4 – AWP4 (1 July 2012 – 31 Dec 2014):

14. Consolidate empirical, larval dispersal modelling and metapopulation modelling outputs, preparation of final reports and publications.

Project / Task Methodology

1. Micro-satellite genetic markers will be developed in the new genetics laboratory at the King Abdullah University of Science and Technology. If adult tissues can be obtained from captive brood-stock, parentage assignments will be tested using hatchery reared *P. leopardus* larvae from the Northern Fisheries Centre (NFC) in Cairns.
2. Hatchery-reared coral trout larvae will be supplied by the NFC. These larvae will be released in the field and observed by divers to determine depth preferences, swimming speed and orientation and habitat selection in their natural habitat. This new information will be used to refine the existing biophysical larval dispersal model.
3. High-resolution multi-spectral satellite imagery (WorldView 2, 50cm resolution) will be used to classify known recruitment sites in the Keppel region based on their multispectral profile. This will then be used to identify and map specific areas with a high probability of being important recruitment sites in the larger region, where on-the-ground surveys are lacking. This will facilitate

targeted recruit sampling of large areas while also allowing for the verification of our methods using satellite imagery to quickly and cost-effectively identify important recruitment sites.

4. The existing biophysical model will be refined to apply new information on larval coral trout behaviour, to fix discrepancies in reef locations, to modify reef detection distance and incorporate suitable recruitment habitat.
5. Adult tissues of *P. maculatus* and *P. leopardus* will be sampled from green zones in the Keppel islands, selected Percy and Duke Islands, and a sub-set of the Capricorn-Bunker reefs (including Masthead and Northwest reefs). Teams of divers using tissue biopsy probes that are mounted on spear guns will carry out the sampling. Offshore sampling will be carried out from an AIMS research vessel and from island stations .
6. Complete micro-satellite DNA sequencing for the adult tissues to establish a data-base of potential parents. These analyses will be carried out in a state-of-the-art DNA sequencing laboratory at KAUST.
7. Select sites and times to run model simulations targeting the 2011/12 spawning season to predict dispersal patterns and trajectories for both coral trout species from target green zones in the Keppel Islands, Percy and Duke islands, and selected Capricorn-Bunker reefs.
8. Sampling of juvenile tissues of *P. maculatus* and *P. leopardus* from selected green and blue zone reefs at the Keppel islands, Percy and Duke Islands, and selected Capricorn Bunker Reefs will be carried out over a 1-year time period. Both spearing and clove oil collections will be made.
9. The refined biophysical model will be used to assess likely origins of larvae at key recruitment hot spots in the region. This is a post processing analysis of computer simulations.
10. Micro-satelite DNA sequencing of juvenile tissues and genetic parentage analyses will be carried out using established methods to empirically derive dispersal pathways in the study region.
11. We will assemble information on growth, mortality and reproduction in the two coral trout species for incorporation into a metapopulation model. Age, growth and natural mortality data will be derived from existing literature, while fishing mortality estimates will be derived from available catch data.
12. Dispersal kernels and trajectories derived from biophysical modeling results will be compared with empirical estimates of larval dispersal to validate the model on a large scale.
13. Use empirical and modeled dispersal distances and trajectories to assess the strengths and weaknesses of the current reserve network, with particular emphasis on (a) Important larval sources that are not represented in green zones, and (b) Locations in blue zones that do not receive recruitment subsidies from green zones.
14. Demographic metapopulation analyses will be carried out using MATLAB. The model will be based on dispersal matrices derived from this study of a real geographic setting and available demographic data (growth, natural mortality, fishing mortality). It will model the long-term persistence of green zone and blue zone populations under different levels of reproductive potential in green zones and different fishing pressure regimes in blue zones.

Benefits to end-users

The Great Barrier Reef is Australia's iconic marine habitat, and the GBRMP is a globally significant marine reserve network. Understanding how effectively the GBRMP protects reef biodiversity and how the existing reserve network may assist in sustaining reef fisheries is vital to Australia, to neighbouring countries in the coral triangle and to all tropical nations. Our results will be of direct relevance to all end-users, including the GBRMPA and several other government departments, to recreational and commercial fishers, to the tourist industry, to conservation groups and NGOs, and to the general public.

The GBRMPA is charged with the responsibility of protecting the Great Barrier Reef ecosystem, both because it is a national treasure and because of its World Heritage Status. Success in long-term protection will bring economic, cultural and social benefits to Australia and failure will erode these benefits. The GBRMPA has identified an improved understanding of how the 2004 zoning plan is working to protect reef biodiversity and reef fisheries as a high priority research goal (see www.gbrmpa.gov.au "Research priorities"). The 2009 Great Barrier Reef 'Outlook Report' identifies climate change, declining water quality from catchment runoff, loss of coastal habitats, coastal development and impacts from fishing and poaching as the key drivers that are reducing the resilience of the Great Barrier Reef. Furthermore, it was stated that the long-term prognosis for the reef was "Poor". The report also highlighted gaps in the information required for a better understanding of ecosystem function and resilience, and improved adaptive management of the marine park. Despite a huge investment into the NTR network as a key management strategy, the degree to which it contributes to ecosystem resilience remains uncertain. This project will address GBRMPAs key concerns by establishing whether or not the current NTR network encompasses and protects the natural processes of population replenishment for ecologically, economically and socially important reef fish species on the GBR. In doing so, it will support GBRMPAs adaptive management strategy. We expect the results to provide robust evidence that the GBRMP reserve network is enhancing the natural resilience of reef fish populations and therefore provides a more optimistic outlook for the near future.

Australia has led the world in the implementation and evaluation of marine reserves for biodiversity conservation and sustainable fishery exploitation. The GBRMP is the largest system of no-take marine protected areas in the world and the most intensively studied coral reef environment in the world. This project will continue to strengthen that position, by combining state-of-the-art marine ecological research and adaptive management of marine resources. Australia's approach to marine conservation will demonstrate the way forward for effective management of marine biodiversity and reef fishery resources in our region. This project will contribute to enhancing socio-economic stability of human populations in Australia's neighbouring countries by demonstrating that food security can be achieved through the implementation of resilient marine reserve networks. The project has obvious benefits for Australia, providing expertise and leadership in the Coral Triangle Initiative (CTI) on Coral Reefs, Fisheries and Food Security (APEC Summit, Sydney, September 2007). Overall, it provides the foundation for further productive collaborations between scientists, management agencies and communities to address critical global environmental issues.

Links to other research projects

This proposed project links directly with the ARC linkage project which is currently underway within this research group. Additional NERP funding will facilitate expansion of the project and the addition of the common coral trout (*Plectropomus leopardus*) to the experiment. Operational costs within this proposed project have been kept to a minimum due to the close ties with the ARC linkage project.

This project will also link closely with NERP project 1.4 (monitoring of zoning effects on inshore GBR reefs). Information generated from project 1.4 will be used to inform and enhance outputs from this proposed project (1.5). Despite this close research link, neither project 1.5 nor 1.4 would be reliant on the outputs from the other project to achieve the stated objectives.

Project Outputs/Outcomes 2011/2012

1. Progress up-date on Key objectives 1-4 (1 Sept 2011). Work on objectives 1-4 should be in progress.
2. Progress report on key objectives 1-4 (1 June 2012). Objectives 1-2 should be complete. Objectives 3-4 should be in progress.
3. Meetings with end-users and key stakeholders to communicate preliminary results (1 Sept 2012).

Project 8.3 Budget

AWP 1 – 2011/2012 Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	150,000	-	150,000
1. James Cook University	-	338,706	338,706
2. Australian Museum	-	51,469	51,469
3. AIMS	-	180,000	180,000
4. King Abdulla University of Technology, Saudi Arabia	-	168,000	168,000
Total	**150,000**	**738,175**	**888,175**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	100,000	-	100,000
JCU	-	338,706	338,706
AIMS	-	180,000	180,000
AUSMUS	-	51,469	51,469
KAUST	-	168,000	168,000
Total	**100,000**	**738,175**	**838,175**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	75,000	-	75,000
JCU	-	338,706	338,706
AUSMUS	-	51,469	51,469
King Abdullah		168,000	168,000
Total	**75,000**	**558,175**	**633,175**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	25,000	-	25,000
JCU	-	169,353	169,353
AUSMUS	-	25,734	25,734
Total	**25,000**	**195,087**	**220,087**

Identified and assessed hazards

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	The proposed team of personnel for this project has a strong track record of delivering on stated research outputs, on schedule and within budget. We have total confidence in the appointed personnel.
Failure to obtain data	Low	The pilot project for this expanded research project demonstrated that the proposed methodological approach is fully capable of meeting the stated objectives. Although we cannot pre-empt the ultimate findings from this project, we are certain that valuable data and outputs will be generated through this work.
Departure of key project personnel	Low	The collaborators on this project hold a shared vision for seeing this project through to completion. In the unlikely event that key personnel depart the project, we are confident that there is adequate capacity within the listed project personnel and through our network of external collaborators, to ensure that the stated objectives and outputs will be achieved.
Failure to achieve outcomes due to dependence on outputs from other projects	Low	Although this proposed project has strong links with NERP project 1.4, the generation of outputs from this project would not be hinged on the outputs from project 1.4. This project will function independently and outcomes will be achieved as proposed, regardless of what happens with any other project.
Failure to achieve uptake of results by end-users	Low	Workshops and meetings will be convened with key end-users throughout the project to ensure engagement and delivery of results in a useful form. Key end-users of information generated from this project will include the GBRMPA, DEEDI, QPWS, AFMA, QSIA and community groups such as Sunfish & CapReef. The outputs from this project will attract interest from a broad range of government departments and NGOs in Australia and Internationally. Uptake and utilization of project outputs will ultimately depend on the socio-political landscape in which these organisations operate. We will ensure that project findings are scientifically robust and delivered in a form that can be used in development of policies and plans.

Program 9: Decision support systems for GBR managers

Program 9 will have four projects designed to develop new tools for GBR managers. One project will develop methodology to allow managers to evaluate alternative management scenarios and choose between options. It will focus on tools to assist in the management of the inshore region for biodiversity outcomes, particularly inshore multi-species fisheries management, using a stakeholder driven approach. A second project will create vulnerability maps for coral reef communities and allow managers to prioritise the conservation of subregions with high natural resilience to coral bleaching from extreme sea temperatures. A third project will create a modelling framework suitable for exploring alternative futures for the coastal zone considering climate change, changes in land use and infrastructure, and the effects of land uses on water quality in the Great Barrier Reef lagoon. The fourth project will develop a framework and tools to allow managers to prioritise investment decisions for the day to day management of GBR islands. In addition, drivers of visitor (tourism) usage, particularly relating to reef health and economic and social impacts of reef-related tourism to northern Queensland will be assessed.

Project 9.1: Dynamic Vulnerability Maps and Decision Support Tools for the Great Barrier Reef

Project Leader and/or Organisation

Name	Dr Ken Anthony		
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Project Team

Title	Organisation	Role	FTE
Ken Anthony	AIMS	Project leader, Framework and model development, experimental design	0.12
Scott Wooldridge	AIMS	Researcher, model development, data analysis	0.12
Richard Brinkman	AIMS	Researcher, spatial information layers: hydrodynamics, water quality	0.04
Hemerson Tonin	AIMS	Researcher, spatial information layers	0.06
Peter Mumby	UQ	Researcher, model development, experimental design and analysis	0.07
Hugh Possingham	UQ	Researcher, spatial decision support tool	0.03
Nick Wolff	UQ	Spatial modeller	0.1
Eve MacDonald-Madden	UQ	Structured decision scientist	0.1
Karlo Hock	UQ	Network/connectivity modeller	0.1
Paul Marshall Roger Beeden	GBRMPA	Facilitating input by GBRMPA managers into project planning and collaborating on development of decision support system	0.23

Summary Table of End-users[1]

Organisation	Organisational Contact	Email
GBRMPA	Roger Beeden Paul Marshall David Wachenfeld	Roger.Beeden@gbrmpa.gov.au Paul.marshall@gbrmpa.gov.au David.wachenfeld@environment.gov.au
QDAFF	TBC	
DSEWPaC	Charles Brister Leah McKenzie David Calvert Kate Sanford-Readhead	Charles.brister@environment.gov.au Leah.mckenzie@environment.gov.au David.calvert@environment.gov.au Kathryn.Sanford-Readhead@environment.gov.au

[1]*End-users are those organisations either directly related to the project or could benefit from the outputs of this project. All final reports will be circulated to nominated contacts prior to upload to web.*

Project Significance and Value for End-users

This project directly targets a key science need identified by reef management worldwide, and is specifically relevant to management questions and challenges for the Great Barrier Reef Marine Park. We expect project deliverables to have a high degree of uptake by GBRMPA, which will be facilitated via engagement, consultation and collaboration.

Project Duration

Start Date: 1st July 2011 End Date: 31st December 2014

Project Description / Task Objectives

Summary: This project will deliver a novel framework for linking impacts of environmental change to spatial patterns of coral reef resilience and vulnerability. We will use an innovative, multidisciplinary approach that mechanistically integrates information layers on environmental drivers (warming, hydrodynamics, ocean chemistry) with biological and ecological responses and consequences at multiple temporal and spatial scales. Our approach builds on recent advances in quantitative resilience assessments by the group to produce a reef vulnerability tool that can guide management decisions and marine park planning

Background: Understanding temporal and spatial patterns of vulnerability under environmental impacts and change is central to the management of marine parks. Quantitative assessments of vulnerability, however, are one of the greatest challenges for management planning of coral reef ecosystems, including the Great Barrier Reef (GBR). One reason is the lack of a functional operational framework that can link environmental factors to vulnerability via physical, biological and ecological processes and their interactions. Here we bring together key players in the fields of coral reef biology, ecology, physical oceanography, spatial modeling, decision theory and marine park management under a multidisciplinary project to develop a framework for the first dynamic vulnerability maps for the GBR.

The project will build on recent advances by the group in the area of resilience analyses for coral reef systems under combined scenarios of climate change, ocean acidification, nutrification and grazing (overfishing) and disease (Mumby *et al.* 2007, Anthony *et al.* 2011, Maynard *et al.* 2011). Specifically, in a recent study we developed a quantitative framework for benthic reef resilience using a probabilistic community model informed by the nature of disturbances (pulse versus press), the species groups affected by each factor, and how the vital rates of the interacting populations are affected (mortality, growth, recruitment, Anthony *et al.* 2011). This study demonstrated for the first time analytically that climate change, ocean acidification, nutrients and overfishing of grazers can all erode reef resilience (promote phase shifts from corals to algae or barrens) in isolation, but that interactions between stressors can significantly lower the thresholds for coral-algal phase shifts. The strength and tractability of this approach is that it can account for the impacts and interactions of a suite of stress and mortality factors on the GBR. For example, differential nutrients/sediment impact on macroalgal growth rates and coral mortalities under varying levels of herbivore grazing (algal mortality) can change the likelihood of phase shifts from coral to macroalgal dominance. Also, compounding threats such as thermal anomalies and ocean acidification can be accounted for via their impacts on coral mortality risk and coral growth rates, respectively. The approach is therefore a tractable avenue for operationalizing the frameworks for reef resilience and vulnerability in a format that can be directly applied by reef managers to guide planning decisions.

Task Objectives: The objectives of this study are three-fold. Firstly, and overall, we aim to develop a framework for a dynamic spatial vulnerability model for the GBR. The model will build on a resilience framework informed by a mechanistic understanding of the linkages between key environmental stressors and ecological responses. The project will have a full GBR scope but will initially target smaller areas to test and validate the model against long-term data sets for disturbance factors (e.g. sea surface temperatures, water quality, cyclones and crown of thorns starfish) and data on benthic compositions and reef states (AIMS Long Term Monitoring Project, Osborne *et al.* 2011). Secondly, we will experimentally calibrate interactions between key environmental stressors that vary along inshore-offshore or latitudinal gradients (e.g. thermal anomalies and nutrient/turbidity loading) in their effect on sub-lethal coral stress (bleaching) and mortality risk (e.g. Wooldridge and Done 2009). The purpose here is to strengthen components of the model that are associated with varying degrees of uncertainty. Thirdly, we will develop an interface that uses the output of the vulnerability model as input into a dynamic decision support tool for marine park planning. In essence, while the resilience/vulnerability model is built mostly on vertical integration between environmental and biological/ecological data layers, the decision support tool will have a greater spatial focus and will be driven by combinations of social, financial as well as ecological criteria (Roberts *et al.* 2003, Fernandes *et al.* 2005). Collectively, these three components will substantively increase the ability of managers to consider cumulative pressures (including climate change) and interactions between stressors in spatial planning and management decisions in the GBRMP.

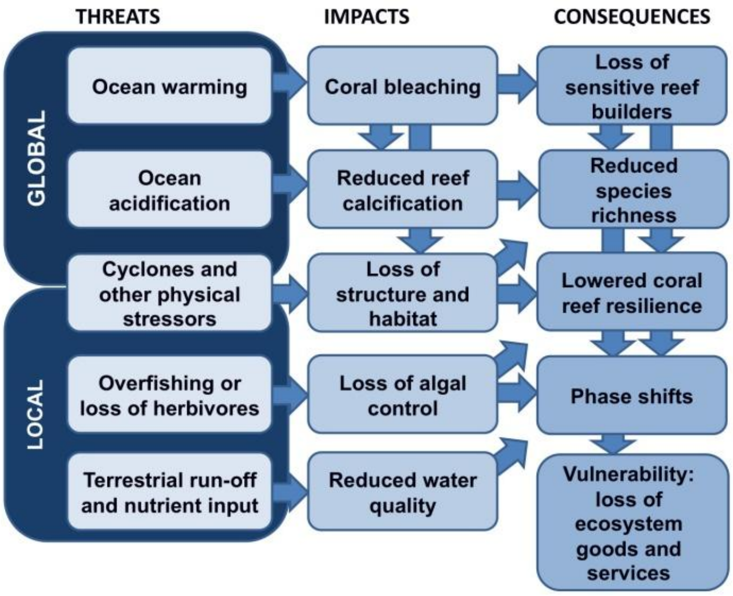

Figure 1. Simplified conceptual layout of the proposed operational resilience and vulnerability framework. Arrows indicate processes that link environmental threats/pressures to biological/ecological impacts and their flow-on effects to resilience and vulnerability. Information layers on the environmental drivers or projected threat scenarios will be generated using a combination of LTMP data, the Receiving Waters Model (Brinkman), and SST/CO_2 projections (Chollett *et al.* 2010, Anthony *et al.* 2011).

Project Methodology and Key Objectives

The project research plan will be conducted in four stages, of which 1 and 2 will run in parallel.

1. Development of vulnerability metrics based on resilience framework. Here, we will construct the mathematical and operational framework based on the integration of several approaches, including spatial simulations of benthic interactions and environmental impacts (Mumby *et al.* 2007), environmental parameterization of differential equations for community dynamics (Anthony *et al.* 2011) and the use of a Bayesian Belief Network to describe environment-biology response functions. A key indicator of vulnerability here is the loss of ecological function (e.g. loss of reef structure, spatial complexity, fish habitats) and goods and services (Fig. 1).
2. Compilation of and integration of data layers and scenario-building. Data layers on ecological variables including benthic cover and composition, reef structure and fish communities (particularly herbivores) will be based largely on data archived under AIMS' Long Term Monitoring Program (LTMP) and the Reef Rescue MMP database. Together with historical data on water quality, thermal anomalies, crown-of-thorns starfish and disease outbreaks the LTMP ecological data and MMP data will be used to generate a baseline resilience/vulnerability dataset. The vulnerability layer (based partly on the probability of reduced reef function and goods and services) will then be analyzed as a function of the pressures from the underlying physical (SST, cyclone impacts), chemical (ocean acidification, water quality), and biological (COTS, coral-algal interactions, grazing) data layers.

3. Experimental calibration of biological/ecological responses to multiple environmental variables. These studies will have strong links with NERP project 25 and other external activities. Here we will use an orthogonal design for two or more variable using the new aquarium facilities at AIMS (ATOS). Preliminary analyses indicate that factor interactions that may lead to particularly high sensitivity of vulnerability estimates or uncertainty are those between thermal stress and nutrient loading in their effect on coral bleaching (Wooldridge and Done 2009) and between nutrients, ocean acidification and coral-algal interactions in their effect on coral mortality (Diaz-Pulido *et al.* 2011). Experiments will be run for 8-12 weeks in a flow through set-up under natural lighting using 3-4 levels for each factor, and replicated by 4-5 tanks per level. Dosing and control of CO_2 and nutrient/sediment turbidity loading will be conducted using methods developed by the group (Anthony *et al.* 2007, Anthony *et al.* 2008). The output data will be made available in the e-Atlas, but will also be generated in a stand-alone version to be directly integrated with the decision support tool (see below).
4. Development of a decision support system (DSS) to guide spatial planning of the GBRMP under projected scenarios of climate change, ocean acidification and water quality. The purpose of the DSS is to place the vulnerability projections in the context of specific management criteria and to help GBRMPA managers inform zoning and targeted planning efforts. Here, we will build on advances and tested management decision frameworks developed by the Ecology Centre (Possingham Group). Within the DSS, reef managers will formally integrate reef vulnerability with a set of decision criteria set by values, costs, priorities and constraints on the protection and management of reef areas (e.g. Roberts *et al.* 2003). This system will provide GBRMPA with the ability to build climate change into marine park management at all levels of activity, from day-to-day management, to policy development and strategic planning.

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End-users and Impact

This project proposal is targeting a key challenge for the management of the GBRMP: spatial and dynamic vulnerability assessments under environmental change. The outcomes of this project will have relevance for a series of management applications, including future park rezoning, identification of refugia under climate change, and identification of areas where local-scale stressors (e.g. fishing and water quality) will have consequences for maintaining reef resilience (Anthony *et al.* 2011). The value of this project to end-users such as GBRMPA will be maximized through close collaboration with marine park managers. The project team welcome substantial investment of FTE from the Great Barrier Reef Marine Park Authority in the planning and implementation of this project

Project Outputs and Outcomes

- A novel, innovate framework for reef vulnerability assessments will advance this research area and strengthen the interface between research delivery and management application
- The development of dynamic vulnerability maps for the GBR will be made available in e-Atlas, and will contribute a key information tools set for the spatial planning of the GBR under both current and future environmental disturbance scenarios.
- Delivery of the first decision support system (DSS) for the GBR that builds formally on spatial and operational indicators of vulnerability under environmental change scenarios.

Risk assessment

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	All personnel except Dr Cholett from the Mumby lab are already committed to the project. However, her appointment under this project is more than 90% likely.
Failure to obtain data	Low	A large part of the work is data synthesis rather than the collection of new data. Experimental studies and data analyses will be conducted by personnel with very strong track records.
Departure of key project personnel	Low	A detailed research plan with a number of contingencies has been constructed to enable new suitable personnel to replace departing team members
Failure to achieve outcomes due to dependence on outputs from other projects	Low	This project is able to stand alone, but can benefit as well as benefit from the outcome of other projects. The project will collaborate via data integration and synthesis to the extend possible but its success is not dependent on other projects.
Failure to achieve uptake of results by end-users	Low	The end-users are formal collaborators on the project. A plan is already in place for how the engagement and exchange will occur to ensure that research products are taken up and used effectively.

Project Milestones: July 2011 – June 2012

Objective	Targeted Activity	Completion Date
Tool development and vulnerability formulation with end-users	AIMS/UQ/: Workshops/think tanks and technical exchanges with managers to develop/formalize resilience/vulnerability frameworks.	1st December 2011
Data / model compilation	AIMS: Compile environmental and ecological (LTMP) data for selected sites for model calibration. UQ: Comparison of model against data for model validation and test of robustness	1st Feb 2012
Analyses of sensitivity and uncertainty	AIMS/UQ: Sensitivity analyses of resilience/vulnerability framework to identify areas/elements of uncertainty for detailed experimental testing	1st June 2012

Project Milestones Jul 2012 – June 2013

Objective	Targeted Activity	Completion Date
Experimental calibration	AIMS: Set up of targeted experiments to test and calibrate interactions between environmental/ecological factors in their impact on resilience and vulnerability elements.	1st Sep 2012
Scenario building and projections	UQ: development of spatial layers for SST AIMS: development of spatial layers for hydrodynamics, water quality and carbon chemistry	1st Feb 2013
Data analysis and synthesis	AIMS/UQ: parameterise interactions between environmental and biological/ecological variables based on LTMP, experimental and synthesis of environmental data layers	1st Jun 2013

Project Milestones Jul 2013 – Jun 2014

Objective	Targeted Activity	Completion Date
Integration with decision support system	AIMS/UQ: complete and test interface between vulnerability maps and management decisions framework: spatial management priorities and mitigation options against multiple objectives.	1 Dec 2013
International workshop	The partners will host a reef vulnerability management workshop with key stakeholder for the purpose of enhancing the model framework and relevance to reefs globally	1 Jun 2014

Project Milestones Jul 2014 – Dec 2014

Objective	Targeted Activity	Completion Date
Vulnerability mapping	AIMS/UQ: delivery of initial GBR vulnerability maps for testing/review by end-users: (1) vulnerability projections under example scenarios, (2) skills maps to discern areas of uncertainty, (3) sensitivity maps to indicate the role of different physical, biological, or ecological factors in driving vulnerability and its uncertainty	1st Sep 2014
Product delivery	All: Deliver final vulnerability and decision support tools. Complete final reports and manuscripts for publications.	1st Dec 2014

Project Budget

AWP 1 – July 2011 – June 2012 Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	100,834		100,834
AIMS		71,700	71,700
UQ		69,300	69,300
GBRMPA		80,000	80,000
Total	**100,834**	**221,000**	**321,834**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	188,971		188,971
AIMS		103,135	103,135
UQ		118,095	118,095
GBRMPA		80,000	80,000
Total	**188,971**	**301,230**	**490,201**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	201,819		201,819
AIMS		104,511	104,511
UQ		58,000	58,000
GBRMPA		80,000	80,000
Total	**201,819**	**242,511**	**444,330**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	88,376		88,376
AIMS		31,615	31,615
UQ		23,700	23,700
GBRMPA			
Total	**88,376**	**55,315**	**143,691**

Project 9.2: Design and implementation of Management Strategy Evaluation for the Great Barrier Reef inshore (MSE-GBR)

Project Leader and Host Organisation

Name	Dr Cathy Dichmont		
Organisation	CSIRO		
Unit	Marine and Atmospheric Research		
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Project Team

Title	Organisation	Role	FTE
Cathy Dichmont	CSIRO	Project Leader / MSE development	0.25
Olivier Thébaud	CSIRO	MSE development	0.15
Wendy Proctor	CSIRO	Multi-criteria decision approaches	0.15
Roy Deng	CSIRO	GIS/ Data management	0.30
Roland Pitcher	CSIRO	Biodiversity	0.10
Leo Dutra	CSIRO	Stakeholder engagement	0.15
Jeffrey Dambacher	CSIRO	Qualitative modelling	0.05
Rachel Harm	CSIRO	Project Support	0.06
Neil Gribble	JCU	Inshore fisheries and biodiversity	0.20 (in kind)
Catherine Collier	JCU	Seagrass expertise	0.05
Michele Waycott	JCU	Seagrass expertise	0.05
Staff co-ordinated by Laurence McCook	GBRMPA	GBR Management, biodiversity, fisheries	0.30 (in kind)
Ross Quinn	DAFF	Facilitation of access to Fisheries Queensland information and high level interpretation, assistance with stakeholder workshop strategic planning	0.10
Eddie Jebreen	DAFF	Fisheries manager	0.10 (in kind)
Julia Playford	DSITIA	Water quality, DSITIA co-ordinator	0.05 (in-kind)
Michael Warne	DSITIA	Water quality, DSITIA science co-ordinator	0.05 (in-kind)
DSITIA, DEHP staff	DEHP, DSITIA	Water quality data and high level interpretation	0.20

Summary Table of End-users[1]

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DSEWPaC	Charles Brister Leah McKenzie David Calvert Belinda Jago Kate Sandford-Readhead	Charles.brister@environment.gov.au Leah.mckenzie@environment.gov.au David.calvert@environment.gov.au Belinda.jago@environment.gov.au Kathryn.sanford-readhead@environment.gov.au

[1]End-users are those organisations either directly related to the project or could benefit from the outputs of this project. All final reports will be circulated to nominated contacts prior to upload to web.

Project Duration

Start Date: 1st July 2011 End Date: 31st December 2014

Project Description / Task Objectives

Develop a Management Strategy Evaluation (MSE) framework using a stakeholder driven approach to qualitatively integrate our understanding of the key drivers of change in the GBR inshore ecosystem and human uses, with an emphasis on biodiversity and inshore multi-species fisheries management.

Key Objectives

1. Identify social, ecological, economic and governance objectives of stakeholders for the inshore Great Barrier Reef region, including the fisheries therein.
2. Develop a qualitative system model of the region to understand the interactions between the various components of the region.
3. Identify alternative strategies for the management of the inshore region, using a stakeholder driven approach.
4. Assess the impacts of the management strategies against each objective using a semi-quantitative approach.
5. Develop management options (with end-users) aimed at biodiversity outcomes, focusing on inshore multi-species fisheries management.

Project / Task Methodology

Management Strategy Evaluation (MSE) is an approach to informing stakeholders of the likely consequences, costs and benefits of choosing particular management decisions (across all uses) on ecosystems such as the Great Barrier Reef. It uses an iterative procedure to assist stakeholders in formulating objectives and assessing trade-offs between social, economic and ecological outcomes. MSE serves as a filter to identify which policies and methods have the potential to meet stated objectives, and to answer critical questions, such as how fast we have to adapt, how much we need to understand and what do we need to learn.

The MSE approach involves developing models (whether expert driven or process based) using the best available knowledge, that capture the key attributes of each significant component of the management problem, including processes underlying the evolution of biophysical systems, human uses of ecosystems and their socio-economic drivers, and the three major components of an adaptive management strategy – monitoring, assessment and management decision processes. The approach is therefore based on a framework that integrates all these components into a single, interacting simulation environment.

CSIRO has pioneered coastal MSE, which has now been applied in four contexts including tropical systems like the Ningaloo reef and the North-West shelf in Western Australia (where cumulative impacts were considered), but also within the subtropical waters of South East Queensland (where there was a focus on catchment management) and within the GBR itself (where previous work has taken a fisheries-oriented focus). The range of coastal MSE applications work has called on a range of approaches including qualitative models of system function and statistical emulators, which can be used in an interactive setting with stakeholders to elicit the broad strategic insights that can be derived from the integration of knowledge in an MSE framework. At the other extreme, whole-of-system models (i.e. detailed process models) have also been used; these provide the ability to explore specific strategies at varying levels of detail under a wide range of scenarios, but with longer development and run time.

Based on this breadth of experience, a staged approach to the MSE is proposed. It will involve an initial scoping phase that will consist of a) scoping of the project, b) data and information gathering, c) stakeholder elicitation of objectives and d) understanding key processes. The second phase will be centred on the elicitation and assessment of management strategies using a *qualitative* MSE in the GBR region (e.g. Dichmont *et al.*, in prep). This will consist of a) developing management strategies, b) assessing the relative impact of the management strategies against the objectives and c) steps required for implementation. The form of the MSE in Phase 2 will be dictated by what is uncovered during Phase 1, but the MSE will **not** be quantitative (given the resources available and end-user priorities), but will rather focus on a qualitative modelling approach.

It is essential that the management strategy evaluation framework and identification of management strategies be developed in a collaborative and interactive environment with managers and others stakeholders. A tiered approach of establishing a joint stakeholder-researcher group, which will iteratively develop strategies and examine results is proposed. Key stakeholders (e.g. GBRMPA – e.g. Peter McGinnity, David Wachenfeld (or delegates), DEEDI – Ian Yarroll's replacement (or delegates), DERM – John Bennett, Julia Playford (or delegates) could also be invited to join the research project as members of a project steering committee. Both these processes will ensure that the MSE framework and management strategies developed are relevant and embedded within the management system.

This project will primarily be aimed at biodiversity outcomes, focusing on inshore multi-species fisheries management. It will draw as much as possible from other projects and experts in the area – see "Related projects" list below – that contribute knowledge on water quality impact from e.g. catchments and nursery grounds especially seagrass.

PHASE 1:

a) **Scoping the project:** This will set the stage for the whole project through engaging with the key end-users such as GBRMPA, DEEDI and DERM. It will establish the process of engagement and set up the various (scientific and/or stakeholder) committees as required and agreed. This stage will also link with relevant scientists from projects already underway or funded as part of the NERP process. Scoping will also define the extent of the region to be considered and the emphasis of the project in terms of, for example, fisheries, biodiversity, water quality issues.

b) **Data and information gathering:** This component would be a fact finding process of connecting with key agencies, scientists and managers to gain a thorough understanding of information already gathered, collated or being collected that are of relevance to the project. It will undertake this process through workshops as well as directly visiting key agencies. This stage will also search for models relevant to the system that could be of relevance to the region and the development of management strategies. Key data will be collated and, if possible, linked to e-Atlas.

c) **Elicitation of objectives:** Using participatory multi-criteria decision-making methods, this phase will aim to elicit the objectives and key trade-offs associated with alternative management strategies of the Great Barrier Reef using input from the relevant stakeholders in the community.

The objectives will cover a broad range of areas, including ecological, economic, social, governance objectives. This process has been successfully undertaken by CSIRO in several studies especially in the fisheries context, including by the project leader. This requires a small task force to develop a draft objective hierarchy, which is then modified and tested by a larger stakeholder group. An input to this process is an analysis of all available legislation from the relevant management agencies, especially GBRMPA and DEEDI. Once this objective hierarchy is developed, the key stakeholders are asked to weight the different objectives against each other and the resultant process is analysed using decision analysis methods (see Pascoe *et al.* 2009 for an example of the method).

d) **Understanding key processes using qualitative tools:** MSEs are divided into two key components – a model that describes the underlying system (often called the operating model) and a model that describes the monitoring and management system (called the management model). In order to move towards a quantitative operating model (*not undertaken in this project*) and develop stakeholder understanding of the system, a stakeholder driven qualitative model will be undertaken (see Dambacher 2007). This process is highly interactive and draws on the expertise of scientists, managers and key stakeholders. The feedback properties of ecological and socioeconomic systems provide a means to characterise and understand the ability of systems to recover from disturbance and persist in alternative stable states - this phase will develop qualitative approaches to describe system and provide understanding of the key system processes. It will integrate, in a qualitative framework, biophysical and socio-economic knowledge to examine the environmental, social and economic impacts of current and potential management options under various scenarios. It will investigate key processes such as the influence on catchments to the inshore region and in particular nursery grounds such as seagrass beds, the influence of uses on the biodiversity of the area and the impact of the multiple fisheries in the region. As a result, the interaction within the system and between users will be emphasised. For example, coastal habitats of the GBR seagrass meadows are important reservoirs of biodiversity and fisheries habitat. The RRMMP has documented on-going declines to seagrass habitats in coastal ecosystems through a large proportion of the GBR and declining water quality is the dominant cause of these declines. The loss of seagrass ecosystems forewarns declines in dugong and turtle populations and is expected to impact fisheries productivity.

PHASE 2:

e) **Developing management strategies:** The second component of a MSE is the management model of which management strategies are a key component. Management strategies consist of monitoring, evaluation or assessment and management decisions. This component will focus primarily at biodiversity outcomes with particular emphasis on inshore multi-species management. It will attempt, where possible, to address at multiple scales rather than GBR-wide so as to link with regional management processes already underway. This phase will be an iterative process with developing management strategies and the development of a semi-quantitative MSE. Management strategies here will focus mainly on the decisions that can be made to advance biodiversity and fisheries measures. A further stakeholder engagement process will be used to develop these management strategies, first through the use of a strawmen and then by refining it to a management strategy that can actually be modelled.

f) Assess relative impact of the management strategies against objectives: The stakeholder and/or scientific committees will assess the relative impact of management strategies against *status quo* for each objective using a qualitative approach (e.g. Pascoe *et al.*, 2009). These scores will be assessed, either broken down by stakeholders or the different high-level objectives, or an overall figure using, for example, multi-criteria decision analysis approached (Dichmont *et al.*, in prep).

g) Implementation: The output from the above research activities will allow the project team to identify the components, which would need to be included as part of a more quantitative, process-model based approach to the evaluation of management strategies for inshore fisheries of the GBR, with a specific emphasis on the biodiversity outcomes of these strategies. At this stage, the end-users and the project team will have gained a more detailed understanding of the key processes, categories of objectives and types of management issues, which need to be considered, as well as the degree of confidence that exists in the knowledge of key system components. This will allow the project team to recommend future steps and direction for the development of an integrated approach to management strategy evaluation in the GBR.

Related projects: socio-economic, e-Atlas, risk assessment, resilience,

1. Collier: Vulnerability of seagrass habitats in the GBR to flood plume impacts: light, nutrients, salinity
2. Simpfendorfer: Drivers of juvenile shark biodiversity and abundance in inshore ecosystems of the GBR.
3. Heupel: inshore species of Maximising the benefits of mobile predators to GBR ecosystems: the importance of movement, habitat and environment
4. Fabricius: Tracking coastal turbidity over time and demonstrating the effects of river discharge evens on regional turbidity.
5. Marshall: Design of a Long-Term Monitoring Programme of the Social and Economic Dimensions of the GBR
6. Pressey:
7. De'ath: Understanding GBR diversity: spatial and temporal dynamics and environmental drivers.
8. Marshall: Design of long-term monitoring program of the social and economic dimensions of the GBR.
9. Lawrey: e-Atlas.

Project Outputs/Outcomes

1. The outcome of objective 1 is an understanding of the relative importance of different objectives for each stakeholder group and for all stakeholders combined. The output is a objective hierarchical tree and relative weightings.
2. The qualitative model of the system will allow stakeholder input to develop a joint understanding of the inshore system.
3. Different management strategies (objective 4) and an assessment of their relative impacts compared to present management systems (objective 5) will provide clear direction as to the pros and cons (and trade-offs) of different management strategies for the inshore region. The process also joins stakeholders together in a discourse that is often lacking. It provides an objective difference between stakeholders and their requirements.
4. Management options aimed at biodiversity outcomes, focusing on inshore multi-species fisheries management.

	AWP 1 July 2011 – June 12	AWP 2 July 2012 – June 13	AWP 3 July 2013 – June 14
NERP to CSIRO			
Salary	64,659	104,533	166,521
Travel	15,984	26,871	46,533
Operating	9,590	10,749	18,613
Collaborator Funds	84,500	84,500	84,500
Total NERP to CSIRO	**174,733**	**226,653**	**316,168**
NERP to JCU - Salary			
Salary	25,000	25,000	
Total NERP to JCU	**25,000**	**25,000**	**0**
Overall NERP Budget	**199,733**	**251,653**	**316,168**
In-kind			
CSIRO	366,053	285,333	166,167
JCU	35,000	35,000	35,000
DEEDI	29,300	29,300	29,300
DERM	22,080	22,080	22,080
GBRMPA	64,941	64,941	64,941
Total In-kind	**517,374**	**436,654**	**317,489**
TOTAL	**717,107**	**688,307**	**633,657**

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	199,733		199,733
Other Organisations		517,374	517,374
Total	**199,733**	**517,374**	**717,107**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	NERP	In-kind	Total
CSIRO	226,653	285,333	511,986
JCU	25,000	35,000	60,000
DEEDI		29,300	29,300
DERM		22,080	22,080
GBRMPA		64,942	64,942
Total	**251,653**	**436,655**	**688,308**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	NERP	In-kind	Total
CSIRO	316,168	166,168	482,335
JCU		35,000	35,000
QDAFF		29,300	29,300
QDSITIA		22,080	22,080
GBRMPA		64,942	64,942
Total	**316,168**	**317,490**	**633,656**

AWP4 (July 2014 to June 2014) Project Funding and Partnerships

Contributing Organisation	NERP	In-kind	Total
CSIRO	157,446	57,446	214,892
JCU		17,500	17,500
QDAFF		14,650	14,650
QDSITIA		11,040	11,040
GBRMPA		32,471	32,471
Total	**157,446**	**133,307**	**290,553**

Identified and assessed hazards

Description of Risk	Assessed Risk	Risk Control measures
Failure to obtain data	Low	This project will be gathering data, but is essentially an expert driven process and therefore relies on the input from different stakeholders and scientists.
Departure of key project personnel	Medium	This project is reliant on the connections created to certain key personnel within the project which makes this a risk when these key staff are no longer available to the project. However, the different agencies on the project have great depth in their staff and are most likely able to replace these staff.
Failure to achieve outcomes due to dependence on outputs from other projects	Low	This project does have dependencies, but is essentially an expert driven process and therefore relies on the input from different stakeholders and scientists.
Failure to achieve uptake of results by end-users	Medium	This project has a very large component of its budget allocated to stakeholder engagement through the use of, particularly, workshops. It also intends to develop a series of advisory committees that will provide input to the project and also help connect the work to their constituents.

Project 9.3: Prioritising management actions for Great Barrier Reef islands

Project Leader and Host Organisation

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Position	Leader, Program 6: Conservation planning for a sustainable future		
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Project Team

Title	Organisation	Role
Bob Pressey	JCU	Project leader
John Hicks	DNPRSR (QPW)	Project co-leader
Malcolm Turner	GBRMPA	Project co-leader
John Olds	DNPRSR (QPW)	Project co-leader
Mirjam Maughan	JCU	Analysis and liaison

Summary Table of End-users[1]

Organisation	Organisational Contact	Email
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DSEWPaC	Charles Brister Leah McKenzie David Calvert Belinda Brown Kate Sanford-Readhead	Charles.brister@environment.gov.au Leah.mckenzie@environment.gov.au David.calvert@environment.gov.au Belinda.brown@environment.gov.au Kathryn.sanford-readhead@environment.gov.au

[1]*End-users are those organisations either directly related to the project or could benefit from the outputs of this project. All final reports will be circulated to nominated contacts prior to upload to web.*

Project Duration

Reduction of budget from NERP means that this project has been re-designed to extend initially over two years, pending co-investment from the Queensland Government or others sources.

Start Date: 1st July 2011 End Date: 30th June 2013

Project Description / Task Objectives

The broad goal is to work collaboratively with DERM and GBRMPA to develop an explicit decision-making framework for investing cost-effectively in management actions across the islands of the Great Barrier Reef. More specifically, the goal is to maximize a conservation outcome, defined by specific objectives for diverse natural features (e.g. native plant and animal species, vegetation assemblages, breeding aggregations), in the face of spatially heterogeneous and dynamic threats, within a budget constraint, by applying a suite of actions that cost different amounts, and that contribute differently to objectives, under considerable uncertainty and the prospects of climate change. This problem – complex, dynamic and multifaceted – describes the reality of much conservation decision-making, and defines the problem faced by managers of the GBR's 900 islands.

Key Objectives

1. Review literature, search databases, and liaise closely with GBR island managers and other experts to set parameters for key variables to be used in the management prioritization, considering uncertainty;
2. Work with GBR island managers to develop a cost-effective, transparent, accountable approach to prioritizing management actions for multiple objectives across GBR islands;
3. Produce a decision-support tool with GIS interface for day-to-day use that will allow managers to identify spatially explicit and action-specific management priorities within and between islands.

Project / Task Methodology

The project will cover both Queensland- and Commonwealth-owned islands. The reduction of the NERP budget means that only a subset of GBR islands can be addressed, at least until (and if) co-funding can be arranged. Reducing the number of islands to be covered can be approached in two ways: taking a representative sample from throughout the GBR region, or focusing on a coherent sub-region. In discussions with DERM and GBRMPA, it was agreed that a coherent sub-region would have the dual advantages of proving the project's concept as well as allowing the method to be applied for prioritization within an actual management unit. The rationale for choosing a management unit in the southern GBR as the case study is outlined in detail below.

Research method

The approach, with 11 parts (Figure), is adapted from the stages of systematic conservation planning. The project will be implemented in close collaboration with GBR managers and experts on the biodiversity of GBR islands. Parameters for quantitative steps (e.g. costs) will be based on the literature and expert estimates. Actions will be diverse and include: pest control, adjustment of fire regimes, biosecurity measures, and monitoring. Guiding principles (Figure) will shape decisions about features (species, ecosystems) to be managed. Feature weightings will guide solutions when (typically) not all objectives can be achieved. Threat models will help to define objectives for each feature and estimate potential losses of features in the absence of management. Areas will be the candidate spatial units assessed for actions. Actions will be assigned costs and relative contributions to each objective. The formulation will maximize the achievement of objectives within cost constraints. Application will involve new coding, linked interactively to a graphical user interface, and identifying multiple cost-effective solutions. Application will also explore alternative funding scenarios and implications of funding cuts and commitments of funds to particular island groups or iconic species. The project's time-frame will allow some monitoring of success to redefine the problem and revise parameters. Uncertainty will be estimated for key parameters as a basis for sensitivity analysis and guiding risk-averse and risk-seeking decisions.

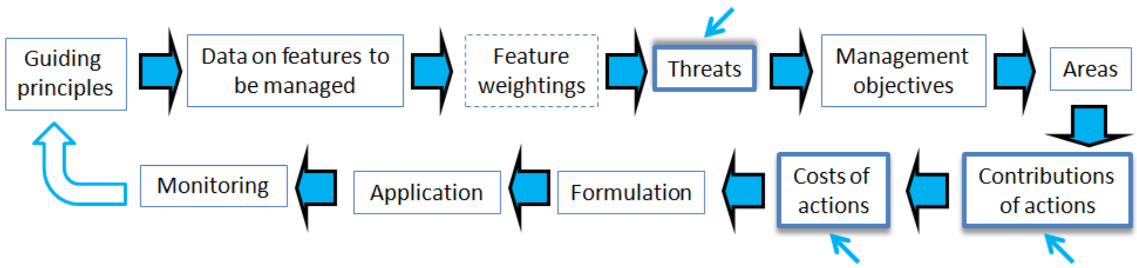

Figure. Technical framework for prioritizing management actions on GBR islands. Dashed box indicates that feature weightings are not required for all applications of the method. Shadowed boxes with diagonal arrows will be informed by sub-models.

Development of the decision-making model will proceed in parallel with collation of data from the literature and from managers and other experts.

Choice of case study area

The selected sub-region extends from Broad Sound / Shoalwater Bay to the southern boundary of the GBRWHA and to the eastern boundary of the GBRWHA. At least 150 islands are included. Broadly, the sub-region can be described as GBRWHA from south of Mackay to Bundaberg. This choice has several advantages for the project:

- The sub-region's diversity provides a sound basis for the decision-support model. The area contains a good range of geomorphic types, including high continental islands with varied vegetation communities (grasslands, eucalypt woodlands, fringing mangrove forests) and fauna to vegetated coral cays, rubble banks, and unvegetated sand cays (e.g. the Swains Reefs). The locations of islands are also very variable, ranging from close inshore (e.g. mangrove islands in estuaries and Curtis Island) to mid-shelf continental islands such as Prudhoe Island, to distant cays (vegetated and unvegetated in the Swains Reefs). There is a corresponding diversity of conservation values, threats and trends in condition. Some islands have high densities of animal and/or plant pests and others are relatively free of pests.
- The sub-region contains islands of considerable significance. For example, the Capricorn/Bunker Group of vegetated coral cays supports 80% of the *Pisonia* forest in the GBRWHA.
- The selected islands are used in many ways, presenting varied challenges for management. Uses range from National Park (Scientific) islands (e.g. Wreck, Peak) with total access restrictions, to National Park day-use or camping islands (e.g. Humpy, North West), heavily used islands with internationally renowned resorts (Great Keppel, Heron and Lady Elliot), and scientific research stations (Heron, One Tree).
- The sub-region is subject to important emerging management problems, making cost-effective and explicit management actions all the more urgent. The Keppel Bay islands will be subject to increasing pressure for tourism and recreation use with the expanding population along the Capricorn Coast and a major resort redevelopment proposed for Great Keppel. The Curtis Coast is about to undergo a huge expansion in ports and shipping, driven by the boom in LNG and coal exports. Curtis Island will be the location of four major LNG processing plants, with associated shipping facilities. The population of Gladstone will expand rapidly to meet the demands of the construction and operational phases of these industries. There will be a flow-on consequences of increased shipping and recreational use of the adjacent GBR waters and islands, with implications for pest introductions and pressures on biosecurity, especially for the Capricorn/Bunker Group, and elevated risk of shipping incidents (as per the *Shen Neng 1* in 2010).

Project Outputs/Outcomes *(Provide a description of the major outcomes of each objective within this project)*

1. Compilation of all available data, including expert judgements, on islands in the sub-region to set parameters for key variables to be used in the management prioritization, considering uncertainty;
2. A novel, cost-effective, transparent, and accountable approach to prioritizing management actions for multiple objectives across islands in the selected sub-region, shaped and understood by GBR managers;
3. An interactive, spatially explicit decision-support tool for day-to-day use that will allow managers to identify action-specific management priorities within and between islands.

Generally, the project will produce a method that is explicit and world's best-practice for identifying management priorities across areas and will improve conservation outcomes for Great Barrier Reef islands.

Expected benefit to end-users

The project has been designed in close collaboration with DERM and GBRMPA. These agencies will be closely involved in the implementation of the project and are poised to adopt the results in day-to-day management of GBR islands. Benefits to DSEWPaC include the potential to extend the approach to prioritizing management actions in other islands in Australia waters and across terrestrial and freshwater ecosystems on the mainland. Delivery and adoption will be rapid and direct because of the involvement of the implementing agencies in the design and implementation of the project.

Risk assessment

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	Position of postdoctoral researcher will be advertised widely, including on email lists and key web sites. Position description, salary, working environment and project will all be attractive to suitably skilled applicants.
Departure of key project personnel	Low	For reasons above, there is a low risk of the postdoctoral researcher departing before the project is finalized.
Failure to obtain data	Low	Both DERM and GRMPA field officers and other experts have agreed to provide published and unpublished data.
Failure to achieve outcomes due to dependence on outputs from other projects	Low	Project is self-contained if necessary, but synergies with other funded projects with similar objectives (to be encapsulated in decision support tools) will provide a net benefit.
Failure to achieve uptake of results by end-users	Low	There is close to zero risk of the project's results not being adopted by end-users. Both DERM and GBRMPA have prioritized this project, will be involved in its development, and are ready to apply the results.

Links and dependencies to other Hubs and research projects

The project links to another multi-objective prioritization project in the coastal zone of tropical Queensland, funded through the NERP Tropical Ecosystems Hub. The project will also link to the integrated catchment-to-coast project (in the Gilbert, Daly and Fitzroy catchments) with confirmed funding from the NERP Northern Australia Hub, and will help to inform another project under this Hub on prioritization of weed control in northern Australia.

Project Budget

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	100,000		100,000
JCU		273,280	273,280
DERM		179,235	179,235
GBRMPA		28,070	28,070
Total	**100,000**	**480,585**	**580,585**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	100,000		100,000
JCU	9,920	284,220	294,140
DERM		186,620	186,620
GBRMPA		29,300	29,300
Total	**109,920**	**500,140**	**610,060**

AWP 3 (July 2013 – June 2014) project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	-	-	
JCU	109,920	284,220	394,140
DERM	-	144,038	144,038
GBRMPA	-	23,650	23,650
Total	**109,920**	**451,908**	**561,828**

Project 9.4: Conservation planning for a changing coastal zone

Project Leader and Host Organisation

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Project Team

Title	Organisation	Role
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Hugh Yorkston	GBRMPA	Project co-leader
Allan Dale	JCU	Project co-leader
Jon Brodie	JCU	Project co-leader
Amélie Augé (postdoctoral researcher)	JCU	Analysis, modeling, liaison
Mirjam Maughan (GIS technician)	JCU	Analysis, modeling, liaison

Summary Table of End-users[1]

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Canegrowers	Matt Kealley	matt_kealley@canegrowers.com.au

DSEWPaC	Charles Brister Leah McKenzie David Calvert Kate Sanford-Readhead	Charles.brister@environment.gov.au Leah.mckenzie@environment.gov.au David.calvert@environment.gov.au Kate.Sanford-Readhead@environment.gov.au

[1]*End-users are those organisations either directly related to the project or could benefit from the outputs of this project. All final reports will be circulated to nominated contacts prior to upload to web.*

Project Duration

Start Date: 1st July 2011 End Date: 31st December 2014

Project Description / Task Objectives

The broad goal of this project is to identify strategic priorities for protection and restoration of coastal ecosystems that support the health and resilience of the GBRWHA, in the context of changing land use, expanding infrastructure, and climate change. More specifically, the project will address three limitations of previous research and application in conservation planning. First, conservation planning has focused principally on snapshots of biodiversity and land uses, as if planning regions were static. Approaches to conservation planning are being developed to address natural and anthropogenic dynamics[1], and these approaches will be adapted and extended by this project. Second, few exercises in conservation planning have attempted to address the physical and biological interactions between land and sea and the cross-realm impacts of human activities[2]. This project will advance land-sea planning and guide planners and managers in resolving tradeoffs between conservation objectives for terrestrial, freshwater and marine environments. Third, the implementation of effective actions in priority areas identified by conservation planning has been hampered by complex, conflicting governance (especially in coastal zones), poor understanding of real-world opportunities for and constraints on management, and lack of engagement with stakeholders. This project will link cutting-edge methods for explicit conservation planning to analysis of governance, new spatial data on management constraints and opportunities, and close collaboration with stakeholders in multiple sectors.

[1] Pressey, R.L., Cabeza, M. Watts, M.E. Watts, Cowling, R.M. and Wilson, K.A. 2007. Conservation planning in a changing world. Trends in Ecology and Evolution 22:583-592.
[2] Álvarez-Romero, J.G., Pressey, R.L., Ban, N.C., Vance-Borland, K., Willer, C., Klein, C.J. and Gaines, S.D. 2012. Integrated land-sea conservation planning: the missing links. Annual Reviews of Ecology, Evolution and Systematics (in press).

Key Objectives

1. Compile spatial data on biodiversity pattern in Great Barrier Reef coastal ecosystems (e.g. regional ecosystems, localities of threatened species), key biodiversity and connectivity processes (e.g. biological linkages between ecosystems via movements of barramundi, Torresian imperial pigeons), and socio-economic characteristics, for direct input to conservation planning analyses and as a basis for modelling dynamics (below);
2. Apply scenario-based modelling to develop spatially explicit representations of alternative futures for the coastal zone, using models of climate change, trends in land use, potential changes based on social and economic drivers (e.g. expansion in population or mining activity), expansion of infrastructure based on these drivers, and likely impacts on coastal ecosystem functions, biodiversity and water quality;
3. With advice from stakeholders, identify explicit conservation goals for biodiversity pattern and process and goals for coastal development, especially urbanisation, tourism, recreation and commercial uses;
4. Analyse the structural and functional aspects of governance of the coastal zone, review existing decision-making arrangements, and trial strategic improvements in governance arrangements;
5. Using participatory decision-support tools with stakeholders, identify spatial options for allocating protection and restoration actions to achieve conservation goals and goals for use and development, identify spatial conflicts between achievement of goals, and resolve choices

and conflicts between these options to identify priorities for investment in conservation management.

Project / Task Methodology

The following methods will be refined with a scoping study, including a consultative workshop, that will be completed within the first six months of the project.

Study region

The study region will extend from Cape York to Gladstone, including inshore waters of the Great Barrier Reef lagoon, and extend inland to take in coastal areas subject to expansion of urban and tourist developments, mining and port infrastructure. Although, changes in land use and infrastructure are expected to be concentrated around major population centres, some development pressures extend along the coastal zone, including north of Cooktown.

Mapping biodiversity pattern and process and socio-economic characteristics

Building on existing data sets held by GBRMPA and other organizations (particularly DERM), compile spatial data on biodiversity and socio-economic characteristics of the coastal zone, including:

- Regional ecosystems and other maps of coastal habitats;
- Threatened species;
- Functionality and connections between coastal ecosystems, mediated by movements of animals, plant propagules, and organic and inorganic material;
- Land tenure and uses;
- Recreational and commercial uses of coastal, estuarine and inshore marine ecosystems;
- Opportunities for and constraints on conservation management, indicated by tenure, traditional ownership, and commercial, industrial and recreational uses.

Modeling change

Modeling change will cover the whole study region at coarse resolution and selected sub-regions more comprehensively at fine resolution. The time-frame for modeling changes in land use and infrastructure will be 50 years. A longer time-frame will be used for the effects of climate change so that planning decisions can begin to anticipate the longer-term effects of altered climate. Models of change to land use and infrastructure will consider the urban and tourist developments in relation to zonings, structure plans, subdivisions, proximity to roads and utilities, and plans for ports and mining-related developments.

Goals

The project will refine state-of-the-art approaches to formulating conservation goals for biodiversity pattern and process. The project will also work with stakeholders in multiple sectors to identify explicit goals for access to and use of terrestrial, freshwater and marine parts of the study region.

Governance

Structurally, the project will focus on the interplay between and within Australian, State, and local government institutions *and* institutions representing research, community, industry and traditional owners. Functionally, the project will emphasize the interactions between institutional capacity, knowledge management, and the level of connectivity between decision-making systems. From these theoretical foundations, and in collaboration with other projects in the Tropical Ecosystems Hub, this project will road-test the emerging concepts by reviewing existing decision-making arrangements and trialing strategic improvements, identifying barriers to integration (e.g. limited funding and transfer of knowledge, historic development patterns, administrative and thematic fragmentation, antagonism and competition, and divergent objectives (particularly between different levels of planning), and ways of overcoming these barriers. The governance assessment will investigate the potential for ad hoc decisions to override planning and assess the effectiveness of emerging instruments for improved management, including offset schemes.

Identifying priorities for conservation management

The project will modify existing decision-support tools to promote extended involvement of stakeholders in identifying spatial options and priorities to achieve conservation goals, considering constraints, opportunities, and goals for access and use. This planning process will identify conflicts between achievement of conservation goals and goals for access and use, apply tools for prioritizing risks (linked to Jon Brodie's project on risk assessment), and use explicit methods to resolve conflicts and maximize the achievement of goals.

Project Outputs/Outcomes *(Provide a description of the major outcomes of each objective within this project)*

1. Compilation of all available data on coastal ecosystems and their biodiversity patterns and processes and key socio-economic variables, as input to conservation planning and as a foundation for modelling change;
2. Generalized and, for sub-regions, detailed models of alternative futures for the coastal zone, considering climate change, change in land use and infrastructure, and effects of land uses on water quality in the Great Barrier Reef lagoon;
3. A comprehensive set of quantitative and, where necessary, qualitative goals for coastal ecosystems and their biodiversity patterns and processes and for development, access and use of the coastal zone;
4. An assessment of the strengths and limitations of governance in the coastal zone, with insights into how governance can be better coordinated and recommendations on the feasibility and potential effectiveness of new instruments for management.
5. Application of spatially explicit decision-support tools to involve stakeholders in resolving spatial options to achieve goals and resolving conflicts between goals.

Generally, the project will advance world's best-practice in systematic conservation planning, both scientifically and in terms of collaboration with managers and other stakeholders. The project's science and application are specifically designed to allow managers to make more informed decisions about the conservation of Queensland's tropical coastal zone and the GBRWHA.

The project will provide a strong focus for supplementary research funding and PhD projects based at JCU.

Expected benefit to end-users

Members of the project team either directly represent key end-users (Yorkston) or are closely linked to diverse end-users in the study region (Dale, Brodie). In the first six months of the project, a large scoping study and workshop will draw on expertise from the full range of the region's stakeholders and from DSEWPaC. Thereafter, the project team will involve end-users at Commonwealth, state, NRM and LGA levels in key decisions about goals, analyses, and identification of spatial priorities for management of coastal ecosystems. The project is relevant to many other regions in Australia, including other of DSEWPaC's priorities. The project is directed specifically at maximizing relevance and uptake by involvement of managers and other key stakeholders in project design (the scoping workshop), establishing goals for conservation, access and use of the coastal zone, and spatial decision making.

Risk assessment

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	Position of postdoctoral researcher will be advertised widely, including on email lists and key web sites. Position description, salary, length of appointment, working environment and project will all be attractive to suitably skilled applicants. The GIS position will be filled without difficulty from the extensive national and international contacts of the project team.

Departure of key project personnel	Low	For reasons above, there is a low risk of the postdoctoral researcher departing before the project is finalized. The GIS position can be replaced, if necessary, without harming the project's schedule.
Failure to obtain data	Low	GRMPA will provide extensive data, compiled over many years, to the project. Licences will be negotiated for additional data. Subject to licence agreements, raw data and new modeled data from this project will be available to other TE Hub projects.
Failure to achieve outcomes due to dependence on outputs from other projects	Low	Project is self-contained if necessary, but synergies with other funded projects with similar objectives (to be encapsulated in decision support tools) will provide a net benefit.
Failure to achieve uptake of results by end-users	Low	There is close to zero risk of the project's results not being adopted by end-users. Consultation with and involvement of key stakeholders is a hallmark of this project and will minimize the risk of results not being adopted. Both DERM and GBRMPA have prioritized this project, will be involved in its development, and are ready to apply the results. The collective experience of the project team and stakeholders will ensure that the detailed project design that emerges from the scoping study is feasible and effective.

Links and dependencies to other Hubs and research projects

The project links to other projects proposed under the GBR theme of the Tropical Ecosystems Hub (e.g. Jon Brodie's work on risk assessment and modeling water quality, Natalie Stoeckl's project on the economic dimensions of environmental management), and Allan Dale's proposed work on governance under the rainforest theme. These other projects have different geographical scopes and objectives, but will provide data and/or analytical tools to inform the project proposed here. The reverse is also true: this project will contribute data, models and analytical approaches to related projects in the TE Hub. In the same way, this project also links to a multi-objective prioritization project confirmed for the NERP Northern Australia Hub, covering three study regions across northern Australia (outside the Queensland coastal zone).

Project Budget

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	210,360		210,360
JCU	7,500[A]	441,680	449,180
GBRMPA		50,590	50,590
Total	**217,860**	**492,270**	**710,130**

[A] Cash contribution by JCU to support travel

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	125,860	-	125,860
JCU	5,000	321,570	326,570
GBRMPA	-	34,400	34,400
Total	**130,860**	**355,970**	**486,830**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	125,860		125,860
JCU	5,000	347,300	352,300
GBRMPA		37,160	37,160
Total	**130,860**	**384,460**	**515,320**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	69,361		69,361
JCU	3,000	187,550	190,550
GBRMPA		20,100	20,100
Total	**72,361**	**207,650**	**280,011**

Program 10: Socio-economic value of GBR goods and services

Program 10 will have two projects designed to capture social and economic information from GBR industries and coastal communities. One will be the start of a long-term compilation and tracking of essential socio-economic indicators to detect spatial and temporal trends in human uses of the region and to monitor variations in economic activity. Both will be useful in forecasting trends and providing the human dimension to scenario planning by coastal managers. The design of the database will be determined by close consultation with managers and other end-users including all levels of government. The second project will explore the social and economic valuation of environment assets in the GBRMPA from the point of view of the ecosystems ability to supply sustainable ecological goods and services.

Project 10.1: Social and Economic Long Term Monitoring Programme (SELTMP)

Project Leader and Host Organisation

Name	Dr Nadine Marshall		
Position	Senior Social Scientist, Townsville		
Organisation	CSIRO		
Unit	Ecosystem Sciences, Climate Adaptation Flagship		
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	ATSIP Building 145, James Cook University		
	Townsville QLD 4811		
Phone	07 4753 8537	**Fax**	07 4753 8600
Email	nadine.marshall@csiro.au		

Project Team

Title	Organisation	Role
Dr. Erin Bohensky, social scientist	CSIRO	Work area leader: coastal communities
Dr. Matt Curnock research scientist	CSIRO	Work area leader: marine tourism and traditional owners
Dr. Nadine Marshall, senior social scientist	CSIRO	Work area leader; catchment communities, technical scientist
Dr. Renae Tobin	JCU	Work area leader; fisheries
Dr. Petina Pert	CSIRO	Database manager and GIS
Dr. Samantha Stone-Jovicich	CSIRO	Anthropologist across all working groups
Steering committee members	Industry, research, govt (including coastal NRM bodies) and GBRMPA	Steering committee members
Science technical group	Experts across tourism, fishing, communities, and economics	Science committee members
Communications specialist	CSIRO	Assistance with delivery of products
Team of Casual staff	CSIRO	In Data collection activities

Summary Table of End-users[1]

Organisation	Organisational Contact	Email
GBRMPA	Margaret Gooch David Wachenfeld Peter McGinnity	Margaret.Gooch@gbrmpa.gov.au David.wachenfeld@gbrmpa.gov.au Peter.mcginnity@gbrmpa.gov.au
QSIA	Scott Wiseman	eo@qsia.com.au
AMPTO	Col McKenzie	col@gempearl.com.au
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QTIC	Daniel Gschwind	Daniel.gshcwind@qtic.com.au
WWF	Nick Heath	nheath@wwf.org.au
NQDryTropics	Scott Crawford	scott.crawford@nqdrytropics.com.au
DSEWPaC	Charles Brister Leah McKenzie David Calvert Shaun Barclay Kate Thomann	Charles.brister@environment.gov.au Leah.mckenzie@environment.gov.au David.calvert@environment.gov.au Shaun.barclay@environment.gov.au Kate.thomann@environment.gov.au

[1]*End-users are those organisations either directly related to the project or could benefit from the outputs of this project. All final reports will be circulated to nominated contacts prior to upload to web.*

Project Duration

Start Date: 1st July 2011 End Date: 31st December 2014

Project Description / Task Objectives

Managers of the world heritage Great Barrier Reef have repeatedly made stronger calls for social science data to assist them in their day-to-day duties. Our objectives are to work directly with the GBRMPA, DEEDI, GBRF, DERM, industry and community to develop world-class social and economic research that will directly facilitate the management of the Great Barrier Reef.

We propose to design a long-term social and economic monitoring programme of coastal communities, catchment communities, marine tourism, commercial fishing, recreational fishing, indigenous communities and shipping. Long-term monitoring offers reef managers, industries and communities the opportunity to understand the current status of marine park users, industries and communities, including those potentially impacting on the ecological components of the system. Long-term monitoring offers the opportunity to assess the future of each industry and community in the face of climate change impacts and other drivers of change such as environmental degradation, regulatory change, cultural change and short-term impacts. It provides the potential to evaluate the effectiveness of management interventions and to assess equity dimensions within the region. However, the success of such a programme can only occur with well-translated cutting-edge social and economic sciences that directly feeds into current management processes. The science must be excellent, collaborative and must itself adapt as learnings from the monitoring datasets are developed. Most importantly, long-term monitoring offers the best research approach available for refining theory and methods for conceptualizing and assessing how people are prepared for change and adapt. Hence, the specific objectives of this project are to:

1. develop a long-term social and economic monitoring program using the advice of a user-based steering committee and science advisory committee that provides sufficient social and economic data to assist the GBRMPA and industry bodies to understand changes that are occurring within the region and to make plans for the future
2. to collect three longitudinal data points a year apart for each of the seven stakeholder groups

Key Objectives

1. Establish a management steering committee of international standing to guide the design and development of the long-term monitoring programme
2. Establish a scientific steering committee of international standing to guide the design and development of the long-term monitoring programme
3. Design a collaborative world-class long-term social and economic monitoring programme of the seven main social groups within the GBR region using established scientific approaches where possible and designing novel approaches where necessary
4. Establish a system within which the collection of primary and secondary datasets can be managed and incorporated in the reporting schedule
5. Establish a protocol for a regular reporting schedule to the GBRMPA and beyond
6. Identify and gain access to existing social and economic datasets that may be useful to incorporate into the programme
7. Establish a first data-point for each of the seven social groups within a year of commencing the project
8. Establish a second data-point a year later
9. Assist with the development of GBRMPA's Outlook Report
10. Use the social and economic data to directly test explicit hypotheses about how people change, are resilient and whether they are adapting.
11. Establish a third data point a year later
12. Developing learnings across time about the social and economic dimensions of the GBR region beyond what can be reported in the monitoring schedule.
13. Work with GBRMPA, community and industry so that if any management interventions are identified and implemented, that they can be monitored and evaluated, with the intention that the interventions could be adaptively refined for equity or effectiveness.

Project / Task Methodology

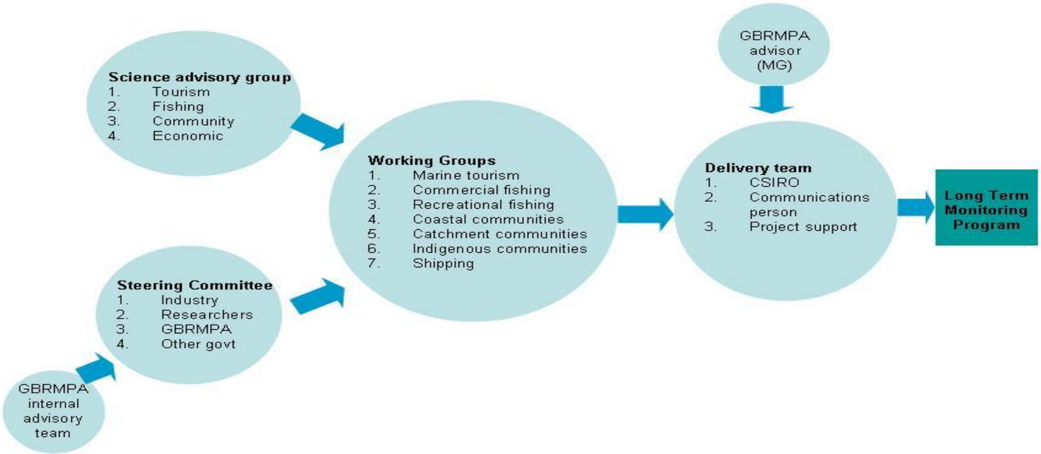
These will reflect each of the key objectives listed above. Please note that on the advice of the working group we will be including Dr. Natalie Stoeckl, Dr. Steve Sutton and Dr. Stuart Whitten on the science advisory panel. Nadine Marshall is already involved in another Reef Rescue project with Dr. Delwar Akbar. Dr. Renae Tobin will be a key working group member.

Time frames for each task are listed here;

1. Establish a management steering committee; July 2011
2. Establish a scientific steering committee; July 2011
3. Design a collaborative world-class long-term social and economic monitoring programme of the seven main social groups; Dec 2011
4. Establish a system within which the collection of primary and secondary datasets can be managed; Dec 2011
5. Establish a protocol for a regular reporting schedule to the GBRMPA and beyond; Dec 2011
6. Identify and gain access to existing social and economic datasets that may be useful to incorporate into the programme; Dec 2011
7. Establish a first data-point for each of the seven social groups within a year of commencing the project; March 2012
8. Establish a second data-point a year later; March 2013
9. Assist with the development of GBRMPA's Outlook Report; as required during 2013 and 2014

10. Use the social and economic data to directly test explicit hypotheses about how people change, are resilient and whether they are adapting. Dec 2013
11. Establish a third data point a year later: March 2014
12. Developing learnings across time about the social and economic dimensions of the GBR region beyond what can be reported in the monitoring schedule: After each milestone report is produced
13. Work with GBRMPA, community and industry so that if any management interventions are identified and implemented that they can be monitored and evaluated, with the intention that the interventions could be adaptively refined for equity or effectiveness; as required

A likely governance framework is provided here:



Potential individuals and groups to be formally invited to join the steering committee include: Peter McGinnity, Dave Wachenfeld, Margaret Gooch, Paul Marshall, GBRF, FRDC, Brigid Kerrigan, DERM, Marcus Lane, Andy Stevens, Helene Marsh, Col McKenzie, Winston Harris, Sunfish, local council members

Potential individuals to be formally invited to join the science advisory panel include: Natalie Stoeckl, Gianna Moscardo, Bruce Prideaux, Steve Sutton, Josh Cinner, Sturt Whitten, Russell Wise, Sean Pascoe, Cathy Robinson, Ro Hill, Allan Dale, Karen Vella, James Butler

Project Outputs/Outcomes

Developing a reporting schedule that works for the GBRMPA, industry groups and other interested stakeholders will be developed as part of objective 5. *At the very least*, the following outputs will be developed:

1. Three annual reports representing the current status of each of the seven stakeholder groups
2. Three presentations to stakeholder groups
3. Direct assistance with delivering to the Outlook report in 2013 and 2014
4. Shorter reports as required

Outcomes of the project include:

1. Strong liaison with GBR stakeholders of the social and economic status of the region
2. GBR management and industries with better access to social and economic information necessary for planning purposes

Additional Information
This section attempts to clarify points that have been raised during the assessment process and relate directly to David Souter's email dated 22 June 2011:

1. *Expected benefit of the project to end-users*: This project provides social and economic information necessary for the GBRMPA, QSIA, QFS and FRDC as well as interested stakeholders to make decisions about the future. It provides a check for monitoring the status of each stakeholder group and should serve as an alert if predictions about the future are not realised.
2. *Links and dependencies to other hubs and projects*: The project directly links to those of Natalie Stoeckl and Cathy Dichmont within the NERP structure.
3. *Changes:* Some of the changes that have occurred from the original proposal relate to a significant decrease in budget. This is reflected in the FTE decrease. Renae Tobin was omitted from the previous version in error (apologies!) but is again included and still at 60%. Leanne Fernandez will not be included in the project.
4. *Stipend:* No stipend will be paid to the steering committee
5. *Reporting schedule:* Milestone reports will be delivered every six months in January and June.
6. JCU's component (through Renae Tobin) will be paid directly to JCU
7. A risk assessment is provided:

Identified and assessed hazards

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	We will advertise widely for a suitable staff member
Failure to obtain data	Medium	We have a steering committee which will ensure that we are well linked with secondary data houses
Departure of key project personnel	Medium	CSIRO has the capacity to replace personnel
Primary data collection is too expensive to collect for all stakeholder groups	Medium	The steering committee will help guide priority tasks
Failure to achieve uptake of results by end-users	Low	The steering committee - who represents end-users - and workshops/meetings will be convened at various key project stages to ensure engagement and delivery of results in useful form.

AWP 1 – 2011/2012 Project Funding and Partnerships

Contributing Organisation	Cash	In-kind*	Total
NERP	175,719		175,719
CSIRO	-	273,421	273,421
James Cook University	30,000	51,000	81,000
Total	**205,719**	**324,421**	**530,140**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	248,751		248,751
CSIRO		214,120	214,120
JCU	30,000	51,000	81,000
Total	**278,751**	**265,120**	**543,871**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	256,038		256,038
CSIRO		123,356	123,356
JCU	30,000	51,000	81,000
Total	**286,038**	**174,356**	**460,394**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	119,492		119,492
CSIRO		84,103	84,103
JCU	15,000	25,500	40,500
Total	**134,492**	**109,603**	**244,095**

Project 10.2:	Socio-economic systems and reef resilience

Project Leader and Host Organisation

Name	Prof Natalie Stoeckl		
Position	Professor of Economics		
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Unit	School of Business		
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	Townsville QLD 4810		
Phone	07 4781 4868	**Fax**	07 4781 4019
Email	natalie.stoeckl@jcu.edu.au		

Project Team

Title	Organisation	Role
Natalie Stoeckl	Economics, JCU	Overall project leader and coordinator
Jon Brodie	ACTFR, JCU	Project co-leader (water quality activity), advisor on attributes of reef health for tourism activity, conduit to other biophysical researchers and research
Margaret Gooch	GBRMPA	Liaison with GBRMPA and with Project 10.2; contributing insights and perspectives for development of questionnaires, development of sampling approaches, analysis, and presentation of data
Silva Larson	Economics, JCU (Adjunct)	Project co-leader (resident activity)
Bruce Prideaux	Tourism, JCU	Project co-leader (tourism activity)
Steven Lewis	ACTFR, JCU	Analysis and preparation of water quality data
Renae Tobin	EES, JCU	Providing specialist fisheries advice, liaison, and perspectives.
Taha Chaiechi	Economics, JCU	Co-ordination of analysis, development of measures of rainfall variability, and development of survey instruments across activities (to ensure cohesive and comparable approaches)
Professor Bob Costanza & Ida Kubiszewski	Australian National University	International liaison & perspectives
Research officers (Michelle Thomson, Michelle Esparon, Zula Altai and Diane Jarvis)	JCU	Assistance with preparation and administration of surveys, data entry, data collation, analysis of data; assistance with writing of reports and papers

Summary Table of End-users[1]

Organisation	Organisational Contact	Email Address
GBRMPA -	Margaret Gooch, David Wachenfeld, Peter McGinnity	Margaret.Gooch@gbrmpa.gov.au David.Wachenfeld@gbrmpa.gov.au Peter.McGinnity@gbrmpa.gov.au
Department of Science, Information Technology, Innovation and the Arts (DSITIA)	Andrew Grodecki	Andrew.Grodecki@dsitia.qld.gov.au
QDAFF	Andrew Thwaites, Eddie Jebreen, Kirrily McInnes James Webley Tony Ham Ross Quinn Anthony Roelofs	Andrew.Thwaites@daff.qld.gov.au eddie.jebreen@daff.qld.gov.au Kirrily.McInnes@daff.qld.gov.au James.Webley@daff.qld.gov.au Tony.Ham@daff.qld.gov.au Ross.Quinn@daff.qld.gov.au Anthony.Roelofs@daff.qld.gov.au
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Sunfish	Barry Pollock Judy Lynne	judylynne@sunfishqld.com.au BarryPollock@sunfishqld.com.au
CapReef	William Sawynok	Bill@info-fish.net
Charter Fishing Rep	Ewan Jones	EJONES@bigpond.com
Alliance for Sustainable Tourism	John Courtenay	exec@probe.net.au
AMPTO	Col McKenzie	colmckenzie@ampto.com.au
WWF	Nick Heath	NHeath@wwf.org.au
DSEWPaC	Charles Brister Leah McKenzie David Calvert Shaun Barclay Kate Thomann	Charles.brister@environment.gov.au Leah.mckenzie@environment.gov.au David.calvert@environment.gov.au Shaun.barclay@environment.gov.au Kate.thomann@environment.gov.au

[1]*End-users are those organisations either directly related to the project or could benefit from the outputs of this project. All final reports will be circulated to nominated contacts prior to upload to web.*

Project Duration

Start Date: 1st July 2011 End Date: 31st December 2014

Project Description / Task Objectives

The GBRMPA is keen to develop a socio-economic monitoring program, but there are a vast number of variables (or 'indicators') that could, potentially, be monitored[7] and monitoring is not a costless exercise. So, it is important to ensure that the variables selected for 'monitoring', are ones which (a) provide reliable, relevant information[8], which (b) measure interactions between sub-systems (e.g.

[7] Since the 1987 Brundtland report which called for 'monitoring' there has been an *indicator explosion* (Riley, 2001a). As such, "there is little problem with finding an indicator; the problem is to find an appropriate one" Custance and Hillier, 1998 (reported in Riley, 2001b). See Smajgl for an example of methodological approaches for integrated monitoring in the GBR refer to Smajgl *et al.* 2010.

[8] "*Without appropriate economic indicators, some communities may be allowing for development that is incompatible with other community goals or with the local natural environment",* Parkin (2001).

socio-economic and biophysical)[9] and which (c) are clearly associated with the Authority's primary goal of protecting the GBR – i.e. of promoting reef resilience[10].
This project will, therefore, test the relationship between several socio-economic variables and other variables that are likely to be associated with reef resilience. It will generate information that is useful by, and of itself, whilst also contributing to the development of the GBRMPA's socio-economic monitoring program.

Research will build on work of
(i) Stoeckl *et al.* (2010a, b) who used both satisfaction and 'willingness to pay' measures to investigate the relative 'value' of iconic marine species to tourists in the Northern Section of the GBR;
(ii) Larson (2009, 2010a, 2010b) who developed a novel approach to gauge the relative 'value' of a range of different social, economic and ecological contributors to 'well-being' using non-monetary approaches that combine measures of satisfaction and 'importance';
(iii) Prideaux who started a long-term monitoring program during MTSFR, and who has used that data to investigate a range of issues including, but not limited to tourism seasonality (Coghlan and Prideaux 2010) and visitor segmentation (Thompson and Prideaux 2011); and
(iv) Lewis, Brodie and others who did an exploratory investigation of the link between various indicators of water quality in the Burdekin (hindcast from coral core samples) and other observable indicators of socio-economic activity and land-management (e.g. stocking rates).
The project comprises three related activities.

<u>ACTIVITY A: The relative value of different goods and services produced by the GBR</u>
The hypotheses underlying this investigation are that (1) different people hold different 'values'; that (2) those 'values' underpin community priorities and thus influence policy; (3) it is not just the number but also the 'mix' of people that changes with population growth. Those interested in exploring the impact of socio-economic factors on reef resilience, thus need to consider community 'values'. However, 'valuation' techniques are often both complex and costly, so it is important to explore new techniques – ideally identifying ones that are robust, cost-effective, easily understandable and equitable, and thus suited to monitoring programs that require frequent, repeat measures (the appendix contains a more detailed discussion of this important issue).
Using primary data collected from a survey of residents of and visitors to the GBRCA, this activity will compare and contrast different techniques for assessing the relative value (or importance) of different goods and services (e.g. consumptive services such as those associated with commercial fishing and non-consumptive services such as those associated with culture, 'identity', aesthetics, tourism and recreation). It will also explore the extent to which the relative value (or 'importance') of different goods and services that are produced by the GBR vary across different stakeholder groups (e.g. visitors to the region, or residents who work in the tourism, shipping, mining or fishing industry; those who do, or do not use the GBR for recreation; those who have recently moved to the region and those whose ancestors were born here).

<u>ACTIVITY B: The relative importance of different attributes of reef 'health' to visitor satisfaction.</u>
The hypotheses underlying this activity are that (1) different types of tourists 'value' different aspects of their recreational experience; and that (2) the quality of the existing tourist experience affects the reputation of the reef as a quality destination. As such indicators of visitor 'values' and visitor satisfaction with recreational experiences, provide information about both the long-term viability of the tourism industry and about visitor perceptions of the health of the reef.

Using primary data collected from a survey of visitors to the GBRCA this activity will compare and contrast different techniques for assessing the relative value (or importance) of different attributes of reef health. It will also (i) collect data similar to that collected in activity A about the relative value of a

[9] Gallopin (1997)
[10] In some situations, it is relatively easy to discern the link between socio-economic indicators and reef resilience, but the relationship between the 'health' of a socio-economic system and that of a biophysical one can be ambiguous. For example, wealthy people are often more willing (and certainly more able) to pay for environmental goods and services than poor people and are also likely to have more adaptive capacity. So 'healthy' socio-economic systems (characterized by wealth) might be resilient, adaptive and able to generate, or protect 'healthy' biophysical systems. But 'values' differ significantly across different individuals and some wealthy people may not want to contribute to or participate in programs that protect the reef. Moreover, if increases in income have been generated by increases in mining, manufacturing or agricultural activity, then there may be coincident changes in water quality or in environmental risks (e.g. those associated with shipping) that inhibit rather that promote reef resilience. Whether the net effect of increases in income (and/or of changes in many other socio-economic indicators) is 'good', 'bad' or indifferent' news for reef resilience is thus an empirical question.

range of different goods and services associated with the reef (so that the 'values' of tourists and residents can be compared), and (ii) explore the extent to which the relative value (or 'importance') of different recreational 'experiences' that are associated with reef health and water quality (e.g. snorkeling in regions with varying degrees of water visibility &/or coral cover) and visitor satisfaction with key aspects of those experiences, vary across visitor types and regions of the GBR. Importantly, it will also continue, enhance, and thus build upon, the long-term tourism monitoring work begun by Prideaux during MTSRF.

ACTIVITY C: Economic pressures and water quality

The three hypotheses underlying this investigation are that: (1) reef resilience is at least partially dependent on water quality in the GBR Lagoon; (2) water quality in the GBR Lagoon is at least partially a function of water quality in the rivers; and that (3) water quality in the rivers is affected by a range of biophysical and socio-economic factors. Those interested in exploring the impact of socio-economic factors on reef resilience, thus need to include both biophysical and socioeconomic factors in their analysis (or risk omitting confounding factors).

Using the Burdekin catchment as a case-study area, this activity will seek to assess the degree to which external socio-economic factors influence reef resilience. It will focus on just one measure of water quality (sediment load), exploring the extent to which it is associated with rainfall patterns (hereafter simply referred to as Rain), land use/management patterns (referred to as Land-use), and external socio-economic influences (socioeconomics).

Key Objectives (over the entire 3.5 years)

This project has several key objectives, namely to:

1) improve our understanding of a diverse range of stakeholder views on the relative 'value' of the different goods and services provided by the reef;
2) improve our understanding of the relative importance of different attributes of reef health to a range of different types of tourists;
3) improve our understanding of the way in which external socio-economic pressures (such as rising commodity prices) have, historically, affected water quality and thus (indirectly) reef resilience;
4) continue the long term tourism monitoring work started by Prideaux in MTSRF;
5) improve our ability to assess the relative importance (or 'value') of different market and non-market goods and services using both monetary and non-monetary approaches;
6) use insights from all of the above to identify potentially useful indicators and methods for measuring those indicators for long term monitoring.

This project will thus fill critical information gaps about the relative importance (or 'value') of different goods and services produced by the reef (particularly non-market services such as cultural, existence and bequest values) to a variety of different stakeholders (tourists, residents, miners, fishers, etc) and about the way in which those 'values' might be effected by a range of external influences (e.g. increases in population, changes in the mix of visitors). Moreover, researchers will be able to use this information to make predictions about the way in which the relative importance of different goods and services or of reef-attributes, and thus management conservation and marketing priorities may alter in the future as both population and tourist numbers change. It will also fill a critical methodological gap – testing and refining both 'traditional' and state-of-the art techniques for generating estimates of the relative importance of those 'values' (the appendix provides background information about why this is so important).

LINKS TO OTHER PROJECTS

- This project will generate information that is useful by, and of itself, whilst also contributing to the development of the GBRMPA's socio-economic monitoring program. It will concentrate on 'economics' issues, which will complement the work being led by Nadine Marshall (who will concentrate on 'social' issues).
- This project has strong links with previous MTSRF projects (led by Bruce Prideaux) which established a monitoring program for tourists in FNQ. Bruce Prideaux is also involved in this GBR project – and we can thus ensure that substantial sections of the tourism questionnaire 'match' those used in the earlier MTSRF projects. This will ensure that our research serves the dual purpose of (a) providing NEW information; and (b) continuing to collect data which the

tourism industry has found to be particularly useful (i.e. long-term data series that allow one to monitor trends).

- The project will also link to a previous MTSRF project led by Stephen Sutton which developed a list of socio-economic indicators for GBR users (particularly recreational and commercial fishers), and FRDC research by Renae Tobin developing socio-economic indicators for Queensland inshore fishers and seafood consumers. It may also link to FRDC research (Renae Tobin is co-investigator on the project) exploring regional management options, by providing relative estimates of values of goods and services for various stakeholder groups
- This project has links to another Tropical Ecosystems NERP project in the rainforest Node (Relative social and economic values of residents and tourists in the WTWHA – led by Natalie Stoeckl and Silva Larson). Both activities (a) and (b) in this project and the rainforest project, seek to learn more about the relative importance of market and non-market goods and services associated with world heritage regions; both plan to survey tourists and residents; both plan to use traditional and state-of-the art economic valuation techniques as part of the analysis; and both have similar research teams. We will ensure that both projects use similar questionnaires, sampling, surveying and analytical techniques (although there will need to be contextualisation). This has two, significant benefits: (1) it means we have been able to prune costs considerably, assuming for example that many of the significant costs associated with the development of good quality questionnaires, can be shared across both projects (indeed the costs of either one of these projects would increase if one of the two did not get approved); (2) it means that we will be able to make some extremely useful comparisons about the 'values' which residents and tourists attribute to both the reef and rainforest – looking, for example, at the way in which those 'values' change across stakeholder groups and also across space (do residents of Cairns have similar 'values' with respect to the reef and the rainforest as residents of Atherton or of Rockhampton?).
- The outputs of activity C will also be able to be used in correlation with NERP project "Tracking coastal turbidity …" by Fabricius, Brodie and others so as to be able to hindcast turbidity levels near coral reefs in Cleveland Bay and around Magnetic Island over the last 100 years.

Project / Task Methodology

ACTIVITY A: The relative value of different goods and services produced by the GBR

Researchers working on this activity will develop the list of goods and services to be assessed or 'valued' (hereafter termed 'attributes') by consulting previous studies, and by working in collaboration with key regional stakeholders (e.g. representatives from GBRMPA, from recreational and commercial fishing associations, from tourism associations and other scientists). This will help ensure relevance of the information generated. Specifically,

i) During the first year, researchers will
   a. survey the literature and work closely with key stakeholders to
      i. Identify and characterize core attributes for assessment. These will include proxies for the goods and services produced by the GBR – e.g. recreation, fish. At least one of the attributes will be associated with water quality, to facilitate connections with Activity C, and another attribute will be associated with 'identity' since the GBRMPA is interested is assessing the degree to which the GBR is part of the Queensland and Australian 'identity'.
      ii. Identify and characterize other 'values' (e.g. employment, or income) to be compared with those core attributes, so that managers are able to assess trade-offs between these and other 'values'.
   b. construct a survey instrument that will allow one to assess the relative importance of those attributes using both traditional money-based valuation techniques (contingent valuation and expenditure attributable), and Larson's non-monetary based technique;
   c. devise a sampling approach that will ensure inclusion of a broad range of stakeholders from across the GBRCA.

ii) During the second year, researchers will distribute the questionnaire, by mail, to a random sample of residents throughout the GBRCA - using Dilman's (2000) total design method (to maximise response rates). They will also enter data, and undertake preliminary data analysis (mostly using descriptive statistics);

iii) During the last 18 months of the project, researchers will
   a. use more sophisticated analytical techniques to explore the extent to which the different measures of relative value (those derived using CV and Larson's technique), importance and satisfaction differ across different stakeholder groups;

b. compare and contrast valuation approaches to gain insights into the importance of income as a driver/setter of priorities when using traditional valuation techniques and to gain insights that will allow researchers to further develop non-monetary valuation techniques;
c. use insights from (iv) to identify priorities for management and/or monitoring and to make predictions about the way in which community 'values' and priorities may change in the future as the 'mix' of stakeholders change
d. finalise publications associated with the research.

ACTIVITY B: The relative importance of different attributes of reef 'health' to visitor satisfaction.

As for Activity A, researchers working on this activity will develop the list of 'attributes' to be assessed (or 'valued') using information from previous studies, and also using information from key regional stakeholders (particularly representatives from GBRMPA, from tourism associations, and scientists with knowledge of attributes of reef 'health') to ensure relevance of the information generated. But while developing that questionnaire, they will also keep the long-term monitoring program that was started by MTSRF going. Specifically,

i) During year one of the project, researchers will run the same survey (i.e. identical questionnaire and sampling method) used by Prideaux *et al.* in previous years – thus continuing to collect crucially important data to add to the long-term tourism monitoring database.
ii) also during year one, researchers will review the literature and work closely with key stakeholders to
   a. Identify and characterize core attributes (or 'values') of reef health for assessment. At least one of the attributes will be associated with water quality, to facilitate connections with Activity C, and one attribute will be associated with 'identity' to allow researchers to test whether the GBR is an important part of the identity of people living outside the GBRCA (e.g. elsewhere in Australia or the world).
   b. Identify and characterize other 'values' (e.g. employment, or income) to be compared with those core attributes, so that managers are able to assess trade-offs between core reef attributes and other 'values'
   c. Construct a survey instrument that contains many of the core questions used in Prideaux's survey (and is hence capable of continuing the long-term monitoring program) and that also contains questions which will allow one to assess the relative importance of attributes of reef health to the tourism industry using both traditional money-based valuation techniques (e.g. contingent valuation) and Larson's non-monetary based technique; and
   d. Pre test elements of the year two survey to calibrate items that emerge from discussions about the data to be collected in the following year.
iv) In year two, the 'new' questionnaire will be distributed to tourists in a variety of locations throughout the GBRCA including areas in and around Cairns, Townsville and the Whitsundays. This will ensure that we capture a wide variety of tourists and other travelers (e.g. grey nomads, temporary workers). Visitors travelling to Magnetic Island will also be included, so that data collected in this activity can be used to help inform and contextualize information generated from activity C (which focuses on sediment loads from the Burdekin – the impacts of which affect tourists using the reefs in and around Magnetic Island). Researchers will also enter data, and undertake preliminary analysis (mostly using descriptive statistics).
v) In year three researchers will
   a. run a third survey – like that used by Prideaux in his MTSRF project but possibly also including some extra questions developed in year two to ensure continuation of the long-term monitoring work and to provide an opportunity to follow up on issues identified in the year 2 survey.
   b. use more sophisticated analytical approaches to explore the extent to which the different measures of relative value (those derived using CV, expenditure attributable and Larson's technique), importance and satisfaction differ across different types of tourists;
   c. use insights from the above to identify priorities for management, marketing and monitoring and to make predictions about the way in which tourist 'values' may change in the future as the 'mix' of tourists changes, and also as the health of the reef changes.

ACTIVITY C: Economic pressures and water quality

Work will progress in two sequential steps

STEP 1: Develop proxies for WQ, Rain, Land-use, Economy

- Rain: Sediment loads are affected by the level and distribution (spatial and temporal) of rain. Researchers will, therefore, use data from the bureau of meteorology (BOM) to develop indices of rainfall, rainfall intensity and rainfall variability. This is a non-trivial task because the BOM data provides daily, point-source rainfall data, but the water quality data is annual, and relates to the entire catchment. So researchers will firstly need to determine which data 'points' should to be included (e.g. all weather monitoring stations in the Burdekin Catchment, or only some – if so, which ones) and they will then need to determine how best to spatially aggregate those observations to generate a single 'rainfall' figure for the Catchment (perhaps calibrating approaches with the help of researchers such as Scott Wilconson of CSIRO who has considerable expertise on sedminent transport and deposition). Moreover, the rainfall observations will also need to be aggregated across time to produce meaningful proxies for rainfall intensity and rainfall variability that can be included in the model. Previous researchers have sought to characterise climatic variability using the (statistical) moments of the distribution (e.g. mean, standard deviation, skewness). But more recently, researchers working in the field of finance have sought to develop methods of capturing 'tail risks' sourced from extreme events, including, but not limited to techniques such as: the Value-at-Risk (VaR) approach; Conditional VaR (also named tail VaR); and expected shortfall (Artzner *et al.* 1997, 1999). It is these, more sophisticated approaches to measuring risk that will be adapted and used to characterise rainfall variability in the Burdekin. If possible, we hope to be able to compare some of these measures with other indicators of rainfall signature (like those generated by Isdale, 1984, and Gagan *et al.*, 1996), to gain some indication of the efficacy of these measures of rainfall and rainfall variability.

  This task will be completed in year 1, the remaining work associated with this activity (listed below) will be completed in year two.
- Land use/management: Land use and land management practices are known to influence sediment loads. Researchers will thus collect historical data relating to land use (e.g. % grazing) and land management (e.g. stocking rates). This information will, of necessity, be at a coarse, 'all of catchment' scale.
- Socioeconomics: It is hypothesized that other socio-economic factors are likely to be important – particularly those which serve to make it more/less profitable to increase stocking rates and/or to use land more intensively. As such, researchers will include measures of beef prices and population.
- WQ: Researchers will use measures of trace elements and fluorescence from coral core samples to draw inferences about sediment loads in the Burdekin over a 300 year time horizon (150 years before and after European settlement on the catchment ~ 1860). This has already been done, using just 10 years of data from both the coral samples and sediment monitoring stations to calibrate results. Researchers involved in this activity will collect an additional coral core sample that will enable them to re-calibrate previous estimates using 20 years (as opposed to 10 years) of overlapping data. Sediment loads can then be correlated with the historical development of the catchment.

STEP 2: Test the statistical significance of proxies in the equation WQ = f(Rain, Land-use, socioeconomics), using multivariate techniques such as regression (Although ordinary least squares regression is unlikely to be suitable given, for example, the fact that the proxies will be but poor measurements of true variables and that there likely to be defined relationships between the independent variables – e.g. land use practices dependent upon socio-economic conditions. As such, approaches such as two-stage least squares regression may be required; it may also be necessary to use maximum likelihood, as opposed to regression).

Project-level Outputs/Outcomes/Benefits

<table>
<tr><th>OBJECTIVE</th><th>OUTCOMES</th></tr>
<tr><td>1) Improve our understanding of a diverse range of stakeholder views on the relative ‘value’ of the different goods and services provided by the reef</td><td>This information will be of immediate use to the GBRMPA, to the tourism industry, to the fishing industry, to other managers and policy makers concerned with the GBR.

It will, for example, allow those working in the GBRMPA to determine whether different sectors of the community (e.g. those associated with the mining, agricultural or tourism sectors) think that market values (e.g. income from fishing or tourism) are more or less ‘important’ than non-market ‘values’ (e.g. cultural/bequest values or ‘sense of identity’). The enhanced knowledge and understanding of these relative ‘values’ will help in publicizing the importance of the reef, in prioritizing conservation initiatives, and in gauging the likely reaction of different sectors of the community to initiatives that may affect different types of ‘values’.

This information is useful by and of itself, but will also enable researchers to make predictions about the way in which community ‘values’ <u>might</u> change in the future, as population both increases and changes in composition (e.g. higher or lower percentage of some stakeholder groups, each with differing preferences).</td></tr>
<tr><td>2) improve our understanding of the relative importance of different attributes of reef health to a range of different types of tourists</td><td>This information will be of immediate use to the GBRMPA, to the tourism industry, to other managers and policy makers concerned with the GBR.

By clearly identifying what different types of tourists think is ‘of value’, this research will provide crucially important information to those wishing to promote tourism in this region (or to those wishing to promote particular types of tourism or visitor segments).

Moreover, these improved understandings will allow one to

• make predictions about the way in which the values and preferences of tourists might change in the future, as tourist numbers change in both volume and composition (e.g. higher or lower percentage of some groups, each with differing preferences).
• make predictions about the way in which tourism satisfaction visitation rates, revenues and hence regional incomes might change in response to changes in reef health</td></tr>
<tr><td>3) continue the long term tourism monitoring work started by Prideaux in MTSRF</td><td>This information is crucial for the tourism industry – particularly given the recent down-turn in visitor numbers. The long term monitoring of visitor patterns enables changes in visitor segments to be identified allowing the tourism industry and associated sectors to make major changes in their product mix or alternatively change marketing strategies. Other outcomes include, being able to:
• Identify changing patterns in the use of social media as an information source
• Identify changes in the manner that bookings are made (i.e. online vs. travel agents)
• make predictions of further demand for travel experiences (based on past trends)
• Make predictions on changes in demand for visiting the GBR</td></tr>
</table>

OBJECTIVE	OUTCOMES
4) improve our understanding of the way in which external socio-economic pressures (such as rising commodity prices and population growth) have, historically, affected water quality and thus (indirectly) reef resilience.	This information will be of immediate use to the GBRMPA, to other managers and policy makers concerned with the GBR and to researchers interested in the interface between biophysical and socio-economic systems. It will provide information about the relative importance of different types of contributors to water quality (rainfall patterns versus prices). This is particularly important for those wishing to develop a long term monitoring program since it allows one to determine whether economic indicators such as commodity prices provide useful information about pressures facing the reef (or whether other indicators, such as aggregate rainfall, or the variability of rainfall should be used, instead). It will also allow one to draw inferences about the way in which future changes in the global economy (e.g. rising beef prices) might impact upon water quality (and thus reef resilience) and will improve our understanding of the efficacy of methods borrowed from the financial econometrics literature for characterising climatic variability using readily available data from sources such as the BOM. Moreover, the outputs will also be able to be used in correlation with NERP project "Tracking coastal turbidity …" by Fabricius, Brodie and others so as to be able to hindcast turbidity levels near coral reefs in Cleveland Bay and around Magnetic Island over the last 100 years, and the research will improve our understanding of methods for using coral samples to draw inferences about water quality. The results will also be able to be used for more precise and robust target setting for sediment reduction from the Burdekin River such that ecologically acceptable turbidity levels are present in inshore waters of the Burdekin region.
5) Improve our ability to assess the relative importance (or 'value') of different market and non-market goods and services using both monetary and non-monetary approaches.	This information will be of immediate use to the GBRMPA, to other managers and policy makers concerned with issues the GBR and to researchers interested developing better methods for assessing the 'value' of non-market goods. This project will allow researchers to compare state-of-the art non-monetary valuation techniques with more 'traditional' valuation techniques highlighting the strengths and weaknesses of each. As such, the project is likely to make a substantial contribution to the valuation literature, and will provide managers throughout the world with an illustrated, easy to understand, example of a cost-effective, robust, and equitable means of assessing the relative value (or importance) of market and non-market goods and services. It will thus increase the capacity of researchers, industry, agency managers and planners to assess some of the socioeconomic values associated with the GBR – a particularly important contribution if seeking to implement a long-term monitoring program that requires one to collect repeated measures of 'value' over time.
6) use insights from all of the above to identify potentially useful indicators (and methods for measuring those indicators) for long term monitoring	Information about the relative importance of: • different goods and services produced by the reef – to residents; • different attributes of reef health - to tourists; and • the relative contribution of economic versus biophysical 'pressures' on water quality, will allow one to identify key variables (and associated indicators, and assessment/measuring techniques) that could be used in future (LT) monitoring programs.

OBJECTIVE	OUTCOMES
	Moreover, improvements in techniques for measuring those indicators will decrease the cost of future monitoring programs.

Key Risks Assessment

Possible risks	**Level of Risk and Proposed management strategy**
Loss of key staff due to unforseen events may delay progress	Relatively low risk because multiple researchers are involved with this project, and because the larger consortium has the capacity to draw on additional staff expertise from partner organisations. The key researcher on this project has already demonstrated a long-term commitment to northern Australia, and JCU has the capability to attract high quality applicants if key positions need to be filled.
Extreme weather conditions caused by unseasonable weather may delay some planned fieldwork activities.	Relatively low risk: extreme weather conditions may delay the timing of particular tasks but typically also offer opportunities for serendipitous research. Moreover, researchers have allocated a year for data-collection activities, so an occasionally unseasonable event is unlikely to cause significant issues.
Risks to personnel during field work, especially in remote locations	Relatively low risk: there are OHS issues relating to field research but is unlikely to restrict field activities. JCU has detailed OHS plans and procedures covering field operations and these will be strictly applied.
Poor or weak relationships with key regional stakeholders make data collection difficult	Relatively low risk: we have already established good working relationships with some stakeholders in this region (including Traditional Owners, Tourism operators, staff in the GBRMPA, some pastoralists, mining and fishing groups).
Low levels of adoption and limited uptake of research outputs by land managers and other end-users lead to poor research outcomes	By engaging with land-holders and other key stakeholders during the early phases of this work, we hope to ensure that our work is relevant and of interest – thus increasing the chance of adoption and uptake.

Indicative funding over life of project	**JCU**	**CSIRO**	**TOTAL**
AWP 1	**115,000**		**115,000.00**
AWP 2	**282,000**	**20,000**	**302,000.00**
AWP 3	**266,000**	**23,000**	**289,000.00**
AWP 4	**87,000**	**7,000**	**94,000.00**
TOTAL	**750,000.00**	**50,000.00**	**800,000.00**

AWP 1 – July 2011 – Jun 2012 Project Funding and Partnerships

Contributing Organisation	**Cash**	**In-kind**	**Total**
NERP	115,000		115,000
JCU		195,600	161,600
CSIRO			0
Portland State University[1]		39,500	39,500
Total	**115,000**	**235,100**	**316,100**

[1] to be confirmed

AWP 2 – July 2012 – June 2013 Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	302,000		302,000
JCU		124,000	124,000
Portland State University[1]		41,000	41,000
GBRMPA		10,000	10,000
Total	**302,000**	**175,000**	**477,000**

[1] to be confirmed

AWP 3 – *July 2013 – June 2014* Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	289,000	-	289,000
JCU	-	29,600	29,600
Portland State University[1]	-	43,000	43,000
GBRMPA	-	10,000	10,000
Total	**289,000**	**82,600**	**371,600**

[1] to be confirmed

AWP 4 – *July 2014 – December 2014* Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	94,000	-	94,000
JCU	-	45,900	45,900
Portland State University[1]	-	22,000	22,000
GBRMPA	-	5,000	5,000
Total	**94,000**	**89,900**	**183,900**

[1] to be confirmed

Appendix A

<table>
<tr><th>COMMENTS / FEEDBACK FROM THE WORKING GROUP
(numbered items are those sent directly to Natalie Stoeckl; bullet points are those from the working-group spreadsheet)</th><th>Action taken</th></tr>
<tr><td>1. The critical aspects of the project that were considered the greatest priorities among GBR stakeholders was the economic value of goods and services provided by the GBR and the different attributes of reef health that contribute to visitor satisfaction.
• Inclusion of visitor satisfaction essential
• Recognises the importance of economic valuation</td><td>Effort (and hence budget) has been allocated accordingly – with approximately 450k devoted to the activity focused on the economic value of goods and services; approx 250k on the attributes of reef health that contribute to reef health; and the remainder (just 100k) looking at the link between economic activity (prices) and water quality.</td></tr>
<tr><td>2. Significant engagement with managers and end-users should be undertaken during the scoping and implementation of the project
• Managers and end-users must be engaged in the scoping and implementation of this project</td><td>Managers and end-users will be involved in the development of the survey instruments, and provided with regular updates. This will ensure that the project collects information that is of direct relevance to them. It will also ensure that managers and end-users are aware of what the research team is doing, and the type of information the project is generating, thus maximising the chance of uptake/adoption.</td></tr>
<tr><td>3. Tourism, fisheries and all reef dependent industries must be included.
• Needs to incorporate input from commercial fishers and indigenous stakeholders
• QSIA priorities are studies looking at attitudes - public perceptions of both resource user and nonuser groups – attitudes towards the resource and current management regime. Also evaluating socioeconomic impacts of closures - displaced effort. With the increasing trend to introduce regional type fisheries management these studies would be valuable on evaluating community perceptions and expectations</td><td>A wide variety of industries and stakeholders will be included in two ways. First, the large-scale survey of residents of the GBRCA will capture both resource user and non-resource user groups. It will also include persons whose main source of employment or income (e.g. business owners) derives from a wide variety of different industries (including, but not limited to, those involved in tourism, fishing & shipping). As such, we will seek the views of a wide variety of people involved in many different industries (nb: we will do everything we can to ensure that we also capture the views of Indigenous people, and will include an item on the survey that allows us to differentiate respondents by Indigeneity; but it is well outside the resources of this project to properly ‘engage’ Indigenous stakeholders from many different regions – proper engagement is extremely time-consuming and very expensive). Second, a wide variety of industries will considered when assessing the relative ‘value’ of goods and services (e.g. consumptive goods such as fish, and also intangible, ‘non-use’ goods) produced by the GBR. As such, we will be able to assess the degree to which different people ‘value’ different goods and services.</td></tr>
<tr><td>4. Links with Reef Rescue R&D (eg. Whitten et al.) should be examined</td><td>We have spoken with Stuart Whitten, Peter Donagy and John Rolfe; and will continue to engage with them over the course of the project (there are structural avenues to facilitate this – e.g. John Rolfe and Natalie Stoeckl co-supervise two PhD students). The projects do not overlap, but could each provide the other project with useful supplementary and contextual information that will value add to both.</td></tr>
<tr><td>5. The project should work with Nadine Marshall (Leader of Project 41: Design of a long-term monitoring programme of the social and economic dimensions of the GBR) to capitalise on synergies, particularly regarding the collection and analysis of data describing various socio-economic indicators.</td><td>Marcus Lane and Nadine Marshal (CSIRO), Margaret Gooch (of GBRMPA), and Natalie Stoeckl have worked together during this latest development stage to ensure that this project and Nadine’s complement (rather than replicate) each other. Natalie Stoeckl is now on the steering committee of Nadine’s project, so there is a organisational structure to enable these two projects to capitalise on synergies.</td></tr>
</table>

COMMENTS / FEEDBACK FROM THE WORKING GROUP (numbered items are those sent directly to Natalie Stoeckl; bullet points are those from the working-group spreadsheet)	Action taken
• Projects 41 & 42 must be aligned so they are complementary	
6. The project should engage with Steve Sutton and Renae Tobin to explore possible contributions that they may make to the project, particularly in the area of fisher and fisheries information	Renae Tobin is now part of the project, providing expertise in fisheries socio-economic research and also providing opportunities to link with the fishing industry and other researchers working on the fishing industry.
• Requires high level integration with MTSRF Transition Project Team.	This project continues the momentum of previous MTSRF projects (led by Bruce Prideaux) which established a monitoring program for tourists in FNQ. Bruce Prideaux is also involved in this GBR project – and we can thus ensure that substantial sections of the tourism questionnaire (designed to assess the relative importance of attributes of reef health) 'match' those used in the earlier MTSRF projects. This will ensure that our research serves the dual purpose of (a) providing NEW information; and (b) continuing to collect data which the tourism industry has found to be particularly useful, thus adding to an existing database and facilitating the monitoring of long-term trends in the tourism industry. The latest release of data was well received by the industry.
• Must recognise and incorporate indicators work already done for fisheries and other aspects.	Members of the project team have strong links with Margaret Gooch who is on the National Indicators working group and Renae Tobin (one of the project's researchers) developed indicators for GBR users and inshore fisheries stakeholders under MTSRF and FRDC funding, respectively. The questionnaire will be developed slowly, carefully, and in consultation with the literature, managers, end-users and other scientists. This will ensure that the work recognises and incorporates indicators (and other work) done for fisheries and other aspects.
• Consider evaluating the social and economic effects of regulation v/s non regulations and relate this to practice change behaviour, land condition and water quality outcome	Activity C will explore the impact of a range of variables on water quality in the Burdekin. Some of the proxies used in the proposed model may provide some information about the impact of different regulations or land management practices (e.g. the introduction of drought-master cattle; stocking rates) on water quality – but we do not have the resources to extend the research to properly evaluation these important considerations.
• QSIA priorities also include evaluating socioeconomic impacts of closures - displaced effort. With the increasing trend to introduce regional type fisheries management these studies would be valuable on evaluating community perceptions and expectations.	We do not have the resources to extend the research to properly evaluate the socioeconomic impacts of closures-displaced effort (that would require a bio-economic model, calibrated for the GBR and coastal catchments).

Appendix B – valuation in the GBR

The GBRMP produces many important goods and services – some of which know quite a bit about (e.g. tourism and fishing) and some of which we know relatively little – e.g. many cultural and aesthetic values. Yet despite the fact that many management problems (associated with conserving the Reef's values) or marketing problems (associated with attracting and managing the region's many tourists) could, arguably, be better handled if more were known about some of these other these aesthetic, biodiversity and other values, relatively little is known about them (Stoeckl *et al.* 2011). This is at least partially attributable to the fact that it is exceedingly difficult to determine how best to quantify their 'values'. It is all the more challenging to determine how to monitor these 'values'.

Economists have long recognised that (a) price is not synonymous with 'value'; and that (b) there are a multiplicity of values associated with the environment. They have coined terms such as: "total economic value" (TEV); "direct use value"; "indirect use value" and "non-use value"[d] to help describe those 'values' and a vast body of literature on different techniques for attempting to derive monetary estimates of the magnitude of those 'values' now exists (see: Getzner *et al., 2005;* Bateman *et al.,2002;* Rietbergen-McCracken and Abaza, 2000; Garrod & Willis, 1999; and Willis *et al., 1999,* for detailed reviews). Suffice to say here, none of the methodologies (often called 'valuation' techniques) are flawless, most are surrounded with at least some controversy vis-à-vis the 'accuracy' of final estimates, each requires different types of information as an input, and each produces (sometimes subtly) different information as output. Researchers thus need to be cognizant of the type of information that is required by managers and policy makers when designing economic valuation projects.[14] Otherwise, their chosen techniques may not be capable of producing information that is useful in a given decision-making context.

To be more specific, some valuation methods are only able to generate a monetary estimate of the 'total economic value' of a region, or the 'total value' of activities associated with a region (e.g. tourism revenues). These types of estimates are particularly useful if (a) seeking to describe the current state of affairs (for example, determining that tourism is a more significant generator of incomes in a region than is manufacturing) or if (b) seeking to address 'all-or-nothing' management/policy questions such as: what losses would the region suffer if the entire wet tropics area ceased to exist? But this type of information is not completely lacking in the GBRMP (See Stoeckl *et al.* 2011 for a review of the relevant literature). Moreover, managers in the GBRMPA are rarely faced with all or nothing choices (reef or no reef). So whilst more information is almost always useful, it would be erroneous to claim that one could fill a 'critical' information gap by generating an estimate of the total economic value of the GBR (or of the total economic value attributable to, for example, tourism).

But that does not imply that valuation studies have little to offer; indeed it is quite the contrary. Rather than all or nothing choices, today's business leaders, managers and policy makers are more likely to be asked to make choices 'at the margin'. They may, for example, need information that helps answer questions such as:

- What losses would the region suffer if development eroded (rather than erased) some of the region's values (e.g. if declines in water quality and clarity affected tourism or biodiversity values)?
- Would more people (tourists) come to the GBR if we could improve resource 'y'?
- What compensation should be sought (monetary or otherwise) if development 'x' takes place?
- How are preferences and priorities likely to change in the future?

There are many different valuation techniques that generate information which could help address those questions, since they allow one to assess the degree to which environmental values are affected by changes in other spheres and since they allow one to differentially assess the effect of change across individuals and/or stakeholder groups. As argued by Heal (2000), it is essential to progress beyond the realm of simply estimating total value; one needs to move on to the process of assessing the impacts of potential 'changes' so that it is possible to alter incentives, and then (ultimately) behaviour.

That said, it is worth noting that one cannot simply 'borrow' information from another context and apply it to the GBR[11]: 'changes' need to be assessed on a case by case basis. The key problem here, is that there are an infinite number of 'changes' that have already, or could potentially, impact upon regions such as the GBR (or any environmental area for that matter) and there are literally millions of individuals who might either suffer, or benefit, from those changes. So it is vitally important to find robust, cost-effective, easily understandable and equitable techniques for conducting such evaluations; if only because many may be required – particularly if seeking to develop a long-term monitoring program.

[11] There are many problems associated with the use of benefit transfer techniques (see TEEB, 2009).

Moreover, it is evident that one needs to work with valuation techniques that can adequately measure, compare, and prioritise a variety of different use and non-use values; many of which are NOT closely associated with the market. For example: DSEWPAC is interested in biodiversity values; the GBRMPA is interested in a range of different values (e.g. tourism, fishing and cultural); the tourism industry interested in the relative importance of a range of different 'values' as attractants to the region; and there is considerable evidence to suggest that a large proportion of the 'values' which residents hold are essentially non-market – particularly in this region[12]. As such, one all but inevitably needs to consider the use of stated preference techniques, since (like other techniques) they are able to assess the impact of 'change' and (unlike other techniques) they are able to assess both market and non-market (also non-use) values such as *aesthetics*.

This 'basket' of techniques includes methods such as *Contingent Valuation* and *Choice Modeling.* All stated preference techniques are open to criticisms for their hypothetical nature, and choice modeling can be critiqued for its complexity, but if implemented correctly, these approaches can be both robust and relatively cost-effective. However, most stated preference techniques (indeed most valuation techniques) use either actual or intended expenditures. Since both actual expenditure and expressed willingness to pay are a function of ability to pay, these techniques produce estimates which are, essentially, weighted averages. In this case, the weights are a function of income / wealth. As such these traditional valuation techniques give greater voice to the priorities (or values) of the wealthy than to the priorities (or values) of the poor and thus fail the 'equity' criterion.

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Program 11: Resilient Torres Strait Communities

Program 11 will have a single large project designed to assist key decision makers in the Torres Strait community to build a resilient future based on sustainable environmental use. The program will deliver information on the value of ecosystem services underpinning Torres Strait livelihoods within the cultural frame of the region. The program will deliver information on resource sharing with Treaty Villages in the Western Province of PNG and improved methodologies to support emerging sustainable industries in the region. A mechanism to repatriate knowledge in culturally appropriate ways will continue to be developed and used to raise awareness of environmental issues and build community resilience in Torres Strait.

Project 11.1: Building resilient communities for Torres Strait futures

Project Leader and Host Organisation:

James Butler, CSIRO

Project Team

Name	Organisation	Role
James Butler	CSIRO	Livelihoods, ecosystem services and resilience
Erin Bohensky	CSIRO	Futures analysis
Yiheyis Maru	CSIRO	Resilience analysis
Tim Skewes	CSIRO	Systems modeling
Vincent Lyne	CSIRO	Systems modeling
Wayne Rochester	CSIRO	Statistical analysis
Ian McLeod	CSIRO	GIS
Jack Katzfey	CSIRO	Climate projection downscaling
John Rainbird	TSRA	Climate adaptation planning
Vic McGrath	TSRA	Community engagement
Miya Isherwood	TSRA	Sustainability planning
Annabel Jones	AFMA	Fisheries management
John McDougall	DSEWPAC International Section	Torres Strait Treaty coordination
Clayton Harrington	DFAT	Torres Strait Treaty coordination

**70,000 p.a. AFMA co-funding for travel and operating.* + In-kind

Summary Table of End-users

Organisation	Organisational Contact	Email
TSRA	Damian Miley John Rainbird	Damian.miley@tsra.gov.au john.rainbird@tsra.gov.au
AFMA	Shane Fava	shane.fava@afma.gov.au
Queensland Government	John O'Halloran	John.OHalloran@dip.qld.gov.au
DSEWPAC International Section	John McDougall	John.McDougall@environment.gov.au
DFAT	Clayton Harrington	clayton.harrington@dfat.gov.au
DSEWPaC	Fiona Fraser Shaun Barclay Kate Thomann Kate Sanford-Readhead	Fiona.fraser@environment.gov.au Shaun.barclay@environment.gov.au Kate.thomann@environment.gov.au Kathryn.sanford-readhead@environment.gov.au

Project Duration

Start Date: 1st July 2011 End Date: 31st December 2014

Project Description / Task Objectives

The Torres Strait is a region of rich natural and cultural values, with tight linkages between its environmental assets, ecosystem services and the livelihoods of communities that rely upon them. The Torres Strait Treaty explicitly aims to protect these communities' livelihoods, and improve them through sustainable economic development. As Australia's northern border with Papua New Guinea (PNG), however, the region is under increasing pressure from PNG population growth, mining development and exploitation and pollution of shared Torres Strait resources. 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. This uncertain future will present challenges for achieving resilient Torres Strait communities, but may also provide opportunities for sustainable economic development (e.g. ecotourism, payments for ecosystem services, aquaculture, sustainable fisheries). In order to prepare for this future it is important to make predictions of potential changes, and then pro-actively plan for them rather than await change and respond re-actively.

Through participatory scenario planning with Torres Strait and PNG communities and stakeholders, informed by integrated ecosystem and climate modeling, this project aims to explore potential future scenarios for the region, and identify 'best bet' strategies to protect livelihoods and achieve sustainable economic development. This will respond in part to the 2010 Senate Foreign Affairs, Defence and Trade Committee Inquiry, which recommended an analysis of the vulnerability of the Torres Strait to climate change and other future pressures. The project will assist the delivery of ongoing TSRA, DSEWPAC and DFAT initiatives promoting climate adaptation, alternative livelihoods and economic development in the region, including:

- The TSRA's community climate change adaptation plans under the Torres Strait Climate Change Strategy;
- The Torres Strait Treaty's Joint Advisory Committee and Environmental Management Committee's objectives of achieving food security and alternative livelihoods in the Western Province, PNG;
- The Torres Strait and Northern Peninsula Regional Plan;
- The TSRA's Sustainable Land Use Plans;
- The Integrated Service Delivery Framework

Key Objectives

1. Enhance the design and delivery of relevant policies and strategies to build sustainable communities, including the Torres Strait Treaty, Torres Strait Climate Change Strategy, Sustainable Land Use Plans, the Torres Strait and Northern Peninsula Regional Plan, and the Integrated Service Delivery Framework.

2. Explore possible changes in future environmental and socio-economic drivers in the Torres Strait (e.g. climate change, PNG development, fuel prices), and their impacts on ecosystem services and livelihoods;

3. Identify communities likely to be impacted by changes, and their capacity to adapt;

4. Explore potential alternative livelihood opportunities, and 'best bet' strategies and policies required to progress them at a local community and/or regional scale;

5. Enhance the awareness of Torres Strait and PNG stakeholders and communities about the future, and empower them to meet sustainability challenges and opportunities;

Project / Task Methodology

Using data synthesis and modeling from the Torres Strait NERP Program's Theme 1 and 2, combined with participatory scenario planning this project aims to engage community and regional stakeholders to explore potential future environmental and socio-economic drivers and their impacts on the Torres Strait's ecosystem services and livelihoods. From these exercises communities and stakeholders will identify alternative livelihood opportunities and 'best bet' strategies required to build sustainable and resilient communities, and the policies needed to implement them.

The project will follow a 3-stage process which aims to integrate scientific knowledge with local knowledge held by communities, Land and Sea Rangers and government agencies (see figure below):

Stage 1 (July 2012–June 2013): Regional stakeholders' scenario planning, involving workshops with Australian and PNG regional stakeholders.

Stage 2 (July 2013–June 2014): Community scenario planning, involving workshops with selected Australian and PNG communities identified in Stage 1 as having vulnerable livelihood systems

Stage 3 (July–December 2014): Integration of stakeholder and communities' perceptions, involving workshops between regional stakeholders and the case study communities.

Stage 1 will be preceded in July 2011 – June 2012 with the following preparatory research activities:

a) Downscaled climate projections to 8 km^2 for 2030, 2060 and 2090 for Torres Strait and Western Province, PNG, using the CSIRO-BoM Conformal-Cubic Atmospheric Model;

b) Synthesis and projections of human population and socio-economic trends in Torres Strait and Western Province, PNG for integration with Theme 2 ecological models;

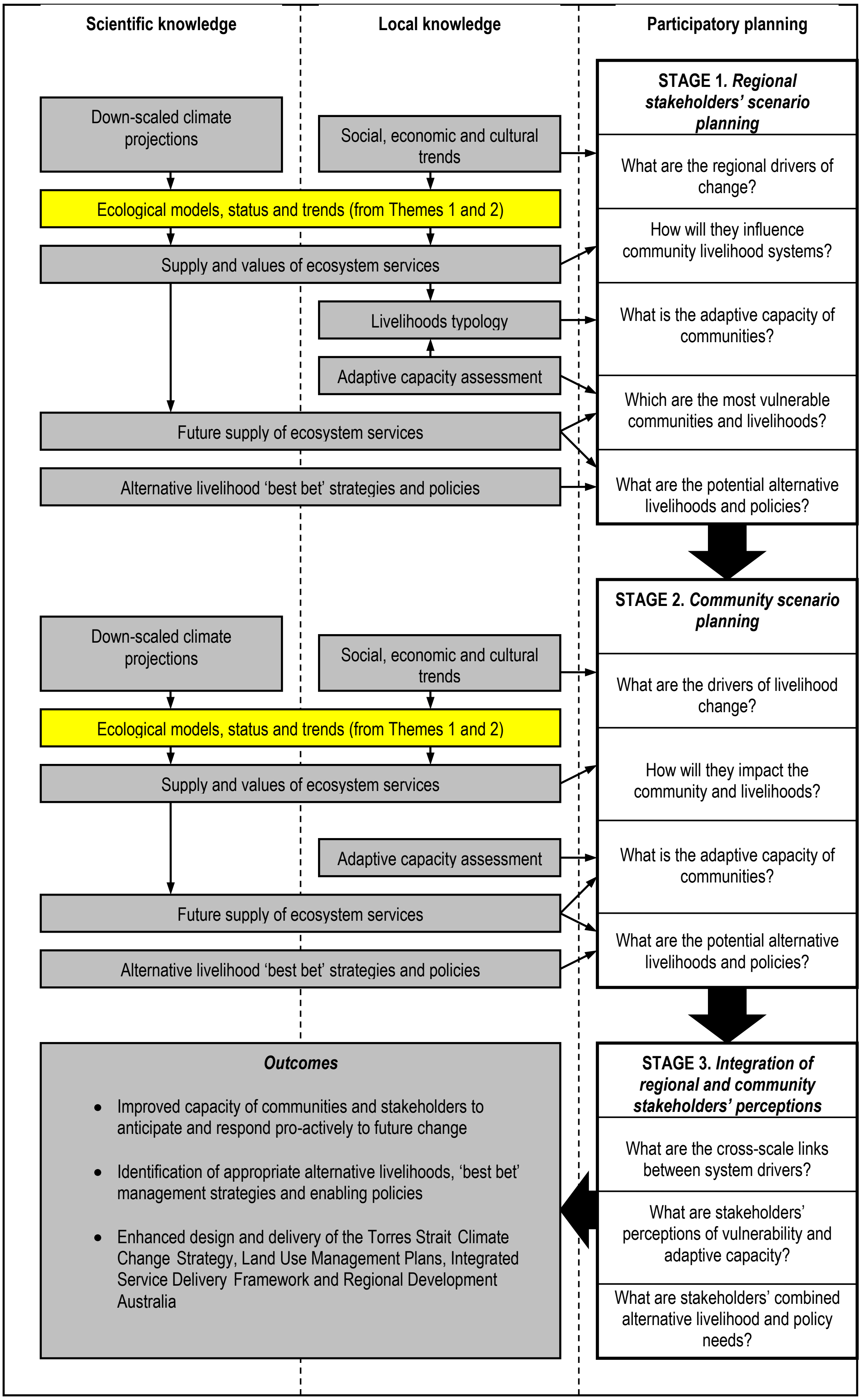
c) Identification and valuation of ecosystem services underpinning Torres Strait livelihoods and other beneficiaries;

d) Typology of Torres Strait and PNG Treaty Villages' livelihoods based on collation of existing data (e.g. ABS for Australia) and surveys (e.g. PNG Treaty Villages);

e) Collation and integration of status and trends data (from Theme 1) and ecological models (from Theme 2).

The project will be dependent on eliciting and integrating expert and local knowledge and perceptions. As well as Torres Strait community members and councillors, Torres Strait NERP researchers, TSRA Land and Sea Management Unit officers and Land and Sea Rangers, the following stakeholders and researchers will be engaged:

- James Cook University climate impact and adaptation research (Karen McNamara and Kevin Parnell)
- AFMA
- Queensland Government
- DFAT
- Joint Advisory Committee (JAC) of the Torres Strait Treaty
- JAC Environment Management Committee
- FAHCSIA
- PNG National Fisheries Administration
- Western Province Administration
- AusAID


Scientific knowledge
Local knowledge
Participatory planning
STAGE 1. Regional stakeholders' scenario planning
Down-scaled climate projections
Social, economic and cultural trends
What are the regional drivers of change?
Ecological models, status and trends (from Themes 1 and 2)
Supply and values of ecosystem services
How will they influence community livelihood systems?
Livelihoods typology
What is the adaptive capacity of communities?
Adaptive capacity assessment
Which are the most vulnerable communities and livelihoods?
Future supply of ecosystem services
Alternative livelihood 'best bet' strategies and policies
What are the potential alternative livelihoods and policies?
STAGE 2. Community scenario planning
Down-scaled climate projections
Social, economic and cultural trends
What are the drivers of livelihood change?
Ecological models, status and trends (from Themes 1 and 2)
Supply and values of ecosystem services
How will they impact the community and livelihoods?
Adaptive capacity assessment
What is the adaptive capacity of communities?
Future supply of ecosystem services
Alternative livelihood 'best bet' strategies and policies
What are the potential alternative livelihoods and policies?
Outcomes
• Improved capacity of communities and stakeholders to anticipate and respond pro-actively to future change
• Identification of appropriate alternative livelihoods, 'best bet' management strategies and enabling policies
• Enhanced design and delivery of the Torres Strait Climate Change Strategy, Land Use Management Plans, Integrated Service Delivery Framework and Regional Development Australia
STAGE 3. Integration of regional and community stakeholders' perceptions
What are the cross-scale links between system drivers?
What are stakeholders' perceptions of vulnerability and adaptive capacity?
What are stakeholders' combined alternative livelihood and policy needs?

Project Outputs/Outcomes

The project outcome will be the improved capacity of communities and stakeholders in the Torres Strait to anticipate and respond pro-actively to future sustainability challenges through:

1. Increased awareness of drivers of change at local and larger scales
2. Exploration of alternative livelihoods and 'best bet' strategies and policies
3. Increased capacity to avoid mal-adaptive strategies
4. Development of community-based holistic plans to support adaptation planning for climate change and sustainability challenges
5. Enhanced design and delivery of relevant international, national and regional policies and strategies for building sustainable and resilient communities.

Identified and assessed project hazards

Description of Risk	Assessed Risk	Risk Control measures
Difficulties engaging multiple stakeholders across Australian and PNG institutions, and organizing them to attend the Stage 1 scenario planning workshop	Medium	This risk will be mitigated by utilising existing DFAT and DSEWPAC linkages and Treaty meetings
Logistics of conducting livelihood surveys of PNG communities	Medium	This will be mitigated by collaborating with DFAT Treaty Awareness Visits for transport and facilitation
Appropriate engagement with selected Torres Strait communities.	Low	This will be mitigated by carrying out all community engagement through the TSRA's community liaison unit
Failure to achieve milestones due to dependence on outputs from other Torres Strait program projects in Theme 1 and 2	Low	The project will be able to rely on earlier data (e.g. status and trends information, climate projections) provided by MTSRF and other projects

Overall Project Budget, July 2011 – December 2014 (ARP 1, 2, 3 and 4)

	AWP 1 2011/12	**AWP 2** 2012/13	**AWP 3** 2013/14	**AWP 4** Jul – Dec 2014	**Total**
NERP					
Salary	135,579	113,905	119,174	62,050	430,708
Travel	41,483	38,279	38,143	16,720	134,626
Operating	29,038	26,796	26,700	14,904	97,438
Institutional overheads	0	0	0	0	0
Total NERP	**206,100**	**178,980**	**184,018**	**93,674**	**662,772**
In-kind					
CSIRO	188,527	185,021	190,677	98,548	662,772
Total In-kind	**188,527**	**185,021**	**190,677**	**98,548**	**662,772**
TOTAL	**394,627**	**364,001**	**374,695**	**192,222**	**1,325,544**

Project Budget

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	**Cash**	**In-kind**	**Total**
NERP	206,100		206,100
CSIRO		206,100	206,100
AFMA		70,000	70,000
Total	**206,100**	**276,100**	**482,200**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	**Cash**	**In-kind**	**Total**
NERP	178,980	-	178,980
CSIRO, AFMA	-	185,021	185,021
Total	**178,980**	**185,021**	**364,001**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	**Cash**	**In-kind**	**Total**
NERP	184,018	-	184,018
CSIRO	-	190,677	190,677
TSRA (LSMU)	-	27,992	27,992
Total	**184,018**	**218,669**	**402,687**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	**Cash**	**In-kind**	**Total**
NERP	93,674		93,674
CSIRO, AFMA		98,548	98,548
Total	**93,674**	**98,548**	**192,222**

Project 11.2: Improved approaches for detection of disease and prevention of spread in Torres Strait

Project Leader and Host Organisation

Name	Dr Susan Laurance		
Position	Senior Lecturer		
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Unit	School of Marine & Tropical Biology		
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	Cairns QLD 4870		
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Project Team

Title	Organisation	Role
Dr Susan Laurance	JCU	Ecologist
Dr Scott Ritchie	JCU & Qld Health	Entomologist

Collaborator	Organisation	Role
Dr David Hilbert	CSIRO	Mathematical modeler
Dr Greg Devine	Qld Health	Epidemiologist
Dr Hume Field	Biosecurity	Epidemiologist
Dagmar Meyer Steiger	James Cook University	M.Sc. Student

Summary Table of End-users[1]

Organisation	Organisational Contact	Email
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DSEWPaC	Joanne Nathan John McDougall Shaun Barclay Kate Thomann Kate Sanford-Readhead	Joanne.nathan@environment.gov.au John.mcdougall@environment.gov.au Shaun.barclay@environment.gov.au Kate.thomann@environment.gov.au Kathryn.sanford-readhead@environment.gov.au

[1]End-users are those organisations either directly related to the project or could benefit from the outputs of this project. All final reports will be circulated to nominated contacts prior to upload to web.

Project Duration

Start Date: 1 July 2011 End Date: 31 December 2014

Project Description / Task Objectives

Torres Strait has long been recognised as a bridge into Australia and there has been a focus on both human and wildlife diseases and their presence in the area in the past. Zoonoses, or diseases borne by animals, are of increasing concern to Australia. These diseases represent serious threats to human health, to our agriculture and to our biodiversity. In this project we will be focusing on improved methodologies for detection of disease incursions in the Torres Strait and options to mitigate the establishment and the persistence of serious diseases of wildlife in the region.

While many threats to our biosecurity are vector-borne, they differ from many of the vector-borne diseases we currently struggle against in that their vectors are often vertebrates that associate with humans and their activities, e.g. birds for avian influenza and domestic animals and flying-foxes for Hendra, Nipah and other viruses (Wibbelt *et al.* 2010). T

The demonstration that vector and people movements are sufficient to bringing serious diseases into Australia raises a number of questions; what is the likelihood of the movement of diseases into Australia and what advances can be made in detection and prevention of the establishment of these diseases.

Our previous research in a MTSRF transition project demonstrated that for mosquito vectors anthropological change and corridors of people movement increased the disease threat to forest birds and, by inference, other vertebrates. The methodologies developed in this project are applicable to Torres Strait scenarios.

Key Objectives

1. Using on-going epidemiological (BioSecurity Qld) and ecological studies and field work conducted as part of this project, to develop improved detection of wildlife disease incursions.
2. Analyse the influence inter-island and PNG Western Province traffic on insect vectors of disease and the subsequent the disease load of birds (as an indicator).
3. Use the results to identify appropriate responses for minimizing the risks associated with disease incursion for example:
   - What is the likely pattern and rate of disease spread?
   - What are the possible management and mitigation options?
   - What are the likely biodiversity conservation implications of disease incursions?

Project / Task Methodology

- This project will draw on previous work conducted in MTSRF and other projects (including Biosecurity Queensland and AQIS)
- Replicated mist netting and mosquito trapping at identified sites in the Torres Strait.
- Mosquitoes will be trapped using standard CDC light traps, baited with CO_2 when possible.
- Birds will be caught in mist nets using a standard protocol, then weighed, measured a banded after making a blood smear and saving a drop on filter paper for later gene extraction.
- Infection rates will be determined by PCR techniques previously employed in Hilbert's MTSRF project and Hilbert and Laurance's transition project.

Project Outputs/Outcomes

***Output*:** Improved methodology for detecting the establishment and persistence of disease incursions in the Torres Strait.

Outcome: Increased capacity to protect the Torres Strait biodiversity and peoples from disease incursions.

Project 11.2 Budget

AWP 1 - Project Funding and Partnerships (1 July 2011 – 31 June 2012)

Contributing Organisation	Cash	In-kind	Total
NERP	10,000		10,000
James Cook University (JCU)	50,000	50,000	100,000
RRRC	42,000		42,000
Total	**102,000**	**50,000**	**152,000**

AWP2 - Project Funding and Partnerships (1 July 2012 – 31 June 2013)

Contributing Organisation	Cash	In-kind	Total
NERP			
James Cook University (JCU)	40,000	40,000	80,000
RRRC	32,000		32,000
Total	**72,000**	**40,000**	**112,000**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	-	-	-
James Cook University (JCU)	-	30,000	30,000
RRRC	32,000	-	32,000
TSRA	-	TBC	TBC
Total	**32,000**	**30,000**	**62,000**

Program 12: Managing for Resilient Rainforests

Program 12 will have four projects designed knowledge to assist environmental managers, industry, indigenous, and community groups to manage the Wet Tropics bioregion. This is a complex and often highly contested landscape with many competing interests. The four projects will determine the most effective approaches to collaborative governance, planning and co-management of biodiversity within Indigenous Protected Areas; the most appropriate ways to develop a carbon market within the Wet Tropics region; the best approaches to managing and accelerating revegetation including potential management interventions particularly in the rainforest uplands; and the social and economic value of environmental icons of the Wet Tropics rainforest and their contribution to northern Queensland.

Project 12.1: Indigenous co-management and biodiversity protection

Project Leader and Host Organisation

Name	Dr Rosemary Hill		
Position			
Organisation	CSIRO		
Unit			
Postal Address		**Delivery Address**	
	PO Box 12139	Cairns Campus, ATFI (E2) Building,	
	Earlville BC QLD 4870	McGregor Road, Smithfield, QLD, 4879.	
Phone	07 40 595 013	**Fax**	
Email	ro.hill@csiro.au		

Project Team

Title	Organisation	Role
Dr Ro Hill	CSIRO	Project Leader, collaborative and Indigenous planning
Dr Petina Pert	CSIRO	Researcher, geography and spatial analysis
Dr Kirsten Maclean	CSIRO	Researcher, collaborative and Indigenous planning
Traditional Owners	Indigenous Protected Area projects and others	Co-Researchers, Indigenous protected area planning and management
Mr David Hinchley	Terrain NRM	Research collaboration, total in-kind contribution across Terrain's biodiversity and Indigenous planning teams
Ms Toni Baumann	AIATSIS	Research collaboration with AIATSIS Native Title Unit joint management of conservation areas project, in-kind contribution
Ms Ellie Bock	Regional Advisory and Innovation Network (RAIN) Pty Ltd	Research collaboration, in-kind contribution in association with Girringun Aboriginal Corporation IPA and co-management initiatives
Mr Nigel Hedgcock	WTMA	Research collaboration
Ms Leah Talbot	ACF	Research collaboration
Assoc Prof Allan Dale Assoc Prof Natalie Stoeckl	JCU	The governance and planning, Indigenous peoples and iconic biodiversity projects within the NERP Tropical Ecosystems Hub (Rainforest) will link through a "Social and Economic Scientists' Coordination Group" to ensure collaboration on data collection, analysis and theory-building. Linkages will also be made with the "Systematic conservation planning" project within the "Resilience and Adaptation" strand.

Summary Table of End-users[1]

Organisation	Organisational Contact	Email
Rainforest Aboriginal Peoples	Network of Traditional Owner organisations contactable through the Rainforest Aboriginal Peoples' Alliance	rapacoordinator@gmail.com
Girringun Aboriginal Corporation	Mr Phil Rist, EO,	eo@girringun.com.au
Wet Tropics Management Authority	Mr Andrew Maclean, ED	andrew.maclean@derm.qld.gov.au
Jabalbina Yalanji Aboriginal Corporation	Mr Michael Friday, CEO,	ceo@jabalbina.com.au
Department of National Parks, Recreation, Sport and Racing	Mr Bruce Rampton, Team Leader, Native Title Joint Management	bruce.rampton@nprsr.qld.gov.au
Department of Environment and Heritage Protection	Ms Lyn Wallace, Manager Cape York Peninsula Program	lyn.wallace@derm.qld.gov.au
Central Wet Tropics Institute for Country and Culture Aboriginal Corporation	Ms Joann Schmider	joann@comunityacets.com.au
DSEWPaC	Mr Bruce Rose and Ms Fiona Fraser, Indigenous Protected Areas and Indigenous Policy Mr John Hunter, Indigenous Land Management Facilitator Kate Thomann (Indigenous Policy Section) Marcus Sandford (Indigenous Protected Areas Section) Kirsty Altenburg (Heritage and Wildlife Division) Kate Sanford-Readhead (Sustainability, Policy and Analysis Division)	Bruce.Rose@environment.gov.au Fiona.Fraser@environment.gov.au JohnP.Hunter@nrm.gov.au kate.thomann@environment.gov.au Marcus.sandford@environment.gov.au Kirsty.attenburg@environment.gov.au Kathryn.sanford-readhead@environment.gov.au
Mandingalbay Yidinji	Mr Dale Mundraby, Executive Officer	Dale@nqlc.com.au
Terrain NRM	Ms Carole Sweatman, CEO Mr Steve McDermott, Manager Planning	caroles@terrain.org.au stevem@terrain.org.au
Cape York Peninsula Scientific and Cultural Advisory Committee	Prof Nigel Stork	nstork@unimelb.edu.au

[1] *End-users are those organisations either directly related to the project or could benefit from the outputs of this project. All final reports will be circulated to nominated contacts prior to upload to web.*

Project Duration

Start Date: 1st July 2011 End Date: 31st December 2014

Project Description / Task Objectives

Planning systems, governance structures and institutions that capture the traditional knowledge and associations of Indigenous peoples into biodiversity decision-making and management remain elusive. Key planning initiatives in the wet tropics region have advanced the institutional capability to engage Indigenous peoples into biodiversity management, including the Wet Tropics Regional Agreement, the Aboriginal Cultural and Natural Resource Management Plan, several Indigenous Land Use Agreements (ILUA), and the nomination for national heritage listing of the Aboriginal cultural values. Nevertheless, both government agencies and the Rainforest Aboriginal Peoples identify that a gap remains between the current status and aspirations for equitable co-management arrangements of conservation areas, including the Wet Tropics World Heritage Area (WTWHA). The Girringun, Eastern Kuku-Yalanji, and Mandingalbay Yidinji Indigenous Protected Area (IPA) consultation projects underway are showing potential as an effective means of capturing Indigenous knowledge and values into conservation decision-making and management. IPAs may provide a means to integrate rights-recognition (through ILUA and native title), cultural-values recognition (through heritage listing) and engagement in management (through NRM arrangements) as an effective platform for co-management. On the other hand, Traditional Owners are also engaging with national park management planning in the wet tropics region, and opportunities exist to make these collaborations more effective in delivering mutual benefits for biodiversity conservation and integration of Indigenous rights, cultural knowledge and management practices. This project will undertake co-research with Indigenous peoples and protected area managers to further investigate the potential of IPA and other collaborative models and tools to engage Indigenous values and world views, and to identify the conditions under which these arrangements lead to effective protected-area joint management.

The overall goal of the project is to interrogate the capability of Indigenous Protected Areas, and other collaborative planning models and mechanisms, to provide the means for recognition of Indigenous knowledge and values, and joint management of the Wet Tropics World Heritage Area between Governments and Rainforest Aboriginal people, in partnership with communities.

Project Activities/Method

Key Objectives

The key objectives of the research are:

1. To develop and test through co-research with Indigenous peoples effective approaches to collaborative governance, planning and co-management of Indigenous Protected Areas and parks as a means of delivering biodiversity and Indigenous cultural conservation in the WTWHA.
2. To evaluate and assess if, how, under what conditions and why Indigenous protected areas and other collaborative models and tools (e.g. country-based and collaborative national park planning, cultural mapping, cultural indicators) integrate social values and institutions at the landscape scale to deliver effective joint management for biodiversity and cultural conservation.
3. To consider the implications of Indigenous engagement in management of the WTWHA for Australia's national and international biodiversity and cultural conservation obligations.

Project / Task Methodology

The research will use qualitative and participatory social science methodologies from the discipline of human geography, linking Indigenous co-governance theories with practice, while facilitating capacity building in research partnerships. Co-research methods with Indigenous peoples and park managers will ensure a participatory approach to research design and implementation. The research will adhere to the AIATSIS (2010 Draft) Guidelines on Ethical Research in Indigenous Studies. Key agencies that are critical potential partners in co-management arrangements in the region, including the Wet Tropics Management Authority, the Queensland Department of Environment and Resource Management, the

Australian Department of Sustainability, Environment, Water, Population and Communities, and Terrain NRM will be engaged throughout the research. Techniques of institutional, stakeholder and values identification, utilizing qualitative interview, participant observation and documentary data analysis, will be applied in action research settings that enable real-world solution testing and evaluation.

Project Outputs/Outcomes

The project will deliver tested mechanisms for co-governance and collaboration between Indigenous peoples, government managers, and other key partners, for biodiversity and Indigenous cultural conservation of protected areas in the region.

(i) To develop and test effective approaches to collaborative governance, planning and co-management of Indigenous Protected Areas and parks	Enhanced capacity of Traditional Owners and Wet Tropics World Heritage Managers to engage equitably in protected area governance, planning and management, including through testing and refinement of the new National Guidelines on IPA Management Plans
(ii) To evaluate and assess conditions under which IPAs and other collaborative mechanisms are effective	Clear justification of and conditions for IPA and co-governance models to deliver joint management of the Wet Tropics World Heritage Area
(iii) To consider implications for Australia's national and international biodiversity and cultural conservation obligations.	Enhanced capacity of Australian and Queensland Governments to deliver national and international obligations to recognize traditional knowledge and associations of Indigenous people into biodiversity management and decision-making

Project Budget

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	98,130		98,130
CSIRO		73,130	73,130
Australian Institute of Aboriginal and Torres Strait Islander Studies		10,000	10,000
Terrain NRM		10,000	10,000
Regional Advisory and Innovation Network (RAIN) Pty Ltd		10,000	10,000
Total	**98,130**	**103,130**	**201,260**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	98,701		98,701
CSIRO		75,701	75,701
Australian Institute of Aboriginal and Torres Strait Islander Studies		10,000	10,000
Terrain NRM		10,000	10,000
Regional Advisory and Innovation Network (RAIN) Pty Ltd		10,000	10,000
Total	**98,701**	**105,701**	**204,402**

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	98,164	-	98,164
CSIRO	-	74,164	74,164
Australian Institute of Aboriginal and Torres Strait Islander Studies	-	10,000	10,000
Terrain NRM	-	5,000	5,000
WTMA	-	5,000	5,000
Australian Conservation Found.	-	5,000	5,000
Regional Advisory and Innovation Network (RAIN) Pty Ltd	-	5,000	5,000
Total	**98,164**	**104,164**	**202,328**

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	50,005		50,005
CSIRO		38,772	38,772
Australian Institute of Aboriginal and Torres Strait Islander Studies		5,000	5,000
Terrain NRM		5,000	5,000
Regional Advisory and Innovation Network (RAIN) Pty Ltd		5,000	5,000
Total	**50,005**	**53,772**	**103,777**

Risk management plan

Description of risk	Assessed risk	Mitigation Strategies
Multi-disciplinary team, dispersed geography will not coordinate research	Low	Experienced project leader, team members with a track record of working effectively. Team communication and meeting plan as part of method.
Failure to achieve uptake of results by the end-users	Low	End-users engaged in development of framework for testing through the research. Workshops/meetings will be convened with key end-users at various key project stages to ensure engagement and delivery of results in useful form.
Failure to engage Traditional Owners effectively in the research.	Medium	The research will adhere to the AIATSIS Guidelines for Ethical Conduct of Research in Indigenous Communities, and the overall method and data collection protocols be approved by CSIRO's Social Science Human Research Ethics Committee. A co-research approach underpins the method
Physical strain injury from use of computer, telephone and other equipment	Low	Covered by CSIRO HSE risk treatment plans

Project linkages

Project	**Research Priorities**				**Links to others projects, NERP hubs or external collaborative projects**	
	NERP	**GAP**	**WTMA**	**TERRAIN**	**TE NERP Hub proj #**	**Other**
Indigenous peoples and protected areas	1, 3, 4	1	A, C, E	1, 2, 4, 5	1, 23, 6, and projects noted above	AIATSIS, National IPA Guidelines (DSEWPaC), WfHC Flagship social/cultural values

Project 12.2: Harnessing natural regeneration for cost-effective rainforest restoration

Project Leader and Host Organisation
Carla Catterall (Griffith University); Luke Shoo (University of Queensland)

Name	Prof Carla Catterall		
Organisation	Griffith University		
Unit	Environmental Futures Centre, School of Environment		
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	170 Kessels Road		
	Nathan QLD 4111		
Phone	07 3735 7499	**Fax**	07 3735 7459
Email	c.catterall@griffith.edu.au		

Project Team

Title	Organisation	Role
Prof. Carla Catterall	Griffith Uni	Project leader
Dr. Luke Shoo*	Uni. of Qld	Project co-leader
Ms Kylie Freebody	Griffith Uni/Tablelands Reveg Unit	Project researcher/practitioner liaison
Dr. Kerrie Wilson	Uni. of Qld	Project researcher
Ms Wendy Neilan	Griffith Uni	Project researcher
Ms Debra Harrison**	Terrain/Griffith Uni	Project advisor/Terrain liaison
Dr. John Kanowski	Australian Wildlife Conservancy	Project advisor
Ms Deborah Pople	WTMA	Project advisor/WTMA liaison
Mr Dave Hudson	CVA	Liaison - landholder and works

* FTE load of Shoo on project will increase to 1.0 in 2013-2014 (half funded by the Research Hub for Environmental Decisions).
** Harrison's appointment will be funded by Terrain, through contract with RRRC, for work on environmental project information management, including a time component in areas related to the present project.

Summary Table of End-users[1]

Organisation	Organisational Contact	Email
WTMA	Steve Goosem Deborah Pople Bruce Jennison Max Chappell	Steve.Goosem@wtma.qld.gov.au Deb.Pople@wtma.qld.gov.au Bruce.Jennison@wtma.qld.gov.au Max.Chappell@wtma.qld.gov.au
Terrain	Carole Sweatman Steve McDermott Rowena Grace Penny Scott	caroles@terrain.org.au stevem@terrain.org.au rowenag@terrain.org.au pennys@terrain.org.au
QNPRSR	Andrew Millerd	Andrew.millerd@nprsr.qld.gov.au
QDEHP	Keith Smith	keith.smith@ehp.qld.gov.au
DSITIA	Don Butler Peter Scarth	don.butler@science.dsitia.qld.gov.au Peter.Scarth@science.disitia.qld.gov.au
FNQROC	Travis Sydes	t.sydes@cairns.qld.gov.au
CVA	Dave Hudson	dhudson@conservationcolunteers.com.au
DSEWPAC	David Calvert Belinda.Brown Kate Sanford-Readhead	David.calvert@environment.gov.au Belinda.Brown@environment.gov.au Kathryn.Sanford-Readhead@environment.gov.au

[1]*End-users are those organisations either directly related to the project or could benefit from the outputs of this project. All final reports will be circulated to nominated contacts prior to upload to web.*

Project Duration

Start Date: 1st July 2011 End Date: 31st December 2014

Project Description / Task Objectives

The project is focused on naturally regenerating forests (regrowth) and their potential to offer a much needed low cost option to restore critical habitat over large areas. It will assist decisions about how to most efficiently restore biodiversity to degraded rainforest landscapes, by providing new knowledge about the outcomes of lower-cost regrowth (including potential for minimum intervention management). This knowledge will directly complement existing information about outcomes of active higher-cost reforestation (tree-planting) enabling a proper evaluation of the cost and benefits of a full suite of restoration approaches. This will help planners and practitioners to choose the most appropriate restoration method for any particular ecological and economic context. The project will combine three inter-related approaches: field investigation and data analyses of how regrowth rainforest develops and how it differs from replanted rainforest; information synthesis and field trials of novel approaches to accelerate regrowth development; and landscape analysis to identify areas of highest potential for low-cost regrowth.

This research addresses several priority NERP policy questions including the broad goals of landscape connectivity, linking reserves to off-reserve conservation management, and providing evidence needed to prioritise management actions. It relates specifically to Q3 (building resilience; especially in relation to climate refugia, buffers), Q2.1 (capacity to evaluate ecosystem health, including predictive modelling) and Q1.5 (carbon benefits from biodiversity interventions). It also is relevant to WTMA Research Strategy 2010-2014 priority research area D (habitat management and restoration) and specifically addresses High Priority research Q76-80 (achieving cost effective techniques for large-scale ecological restoration of degraded sites). Quantification of the value of restoration and regrowth in maintaining and improving ecosystem function was recently rated 9 out of 195 highest-value research gaps by end-users and research providers in the Wet Tropics region (MTSRF extension project 42).

Key Objectives

The project has three objectives, which are inter-related and will be pursued concurrently, with increased emphasis on Objective c towards the end of the project.

(a) Quantify the rate and pattern of development of vegetation during rainforest regrowth following cessation of agricultural use, and how this compares with the outcomes of publicly-funded restoration by tree-planting.

(b) Investigate, trial and promote emerging technologies for the acceleration and redirection of rainforest regrowth, to overcome ecological barriers or thresholds that inhibit rainforest redevelopment (in collaboration with WTMA Caring for Our Country project).

(c) Identify locations and situations where passive restoration (unassisted regrowth) is a preferable alternative to high-cost active restoration (replanting).

Timing. Most field work and analysis for Objectives (a) and (b) is planned for the years 2011-2013 (with the majority in 2012 and 2013), and with an increased emphasis on Objective (c) in 2013 and 2014, with a total budget target of 342K. In Year One (12 months, July 2011 - June 2012), scoping, site selection and fieldwork for Objective (a) will be completed; a review/synthesis for Objective (b) will be prepared; potential trial sites and methods for Objective (b) will be identified; and consultation and information compilation for Objective (c) will be conducted.

Project / Task Methodology

The work will focus on the biodiversity-rich and climate-sensitive Wet Tropics uplands, where previous research by the Project Leaders into biodiversity outcomes of tree-planting projects (Catterall) and likely future landscape-scale climate refugia (Shoo) provides a strong basis for this project.

Objective (a): Outcomes and rate of regrowth vs replanting

There is great interest in the potential for regrowth to “rescue” tropical forests from the otherwise inevitable cascade of biodiversity loss from land clearing coupled with future climate change. However, there is intense international controversy about the potential for regeneration success, making it near-impossible for managers to decide when and where low cost passive restoration may be preferred to high cost active restoration. In this Task we will assess ecosystem redevelopment during regrowth by field measurement. Accessible regrowth sites that vary in age and landscape context will be selected using a combination of local knowledge, analysis of existing map/GIS information (eg, SLATS, previous CSIRO analyses, recent work by Terrain) and aerial photography. Other environmental properties (such as soil type and elevation) will be controlled in the design. Vegetation development will be measured using methods developed in the MTSRF Revegetation Monitoring Toolkit (Kanowski *et al.* 2010). The sites’ landscape context (including the amount of nearby forest) will also be measured (from maps/photos). Existing data (from MTSRF work) for reference sites of rainforest and pasture will be supplemented by a limited number of additional reference sites, and used as a benchmark for vegetation recovery. Development rates will be analysed and compared with similar measurements previously obtained from different-aged replanted sites (MTSRF, Catterall *et al.* data).

This component will be lead by Catterall, with involvement of Freebody (planning, fieldwork), GU RA (analysis and possibly some fieldwork) and Shoo (planning, interpretation). It will also provide an information basis for Objective (b) and intersect with Objective (c)

Objective (b): Emerging approaches to regrowth management.

The development of spontaneously-occurring regrowth may be seriously inhibited by ecological barriers and thresholds, which include (1) the suppression of tree seedling germination and growth by non-native pasture grasses and herbs, (2) potential suppression of native regrowth by non-native shrubs, (3) limits to seed recruitment set by distance from source forest or lack of visits by frugivorous seed-dispersers, and (4) lack of slow-developing habitat elements for fauna. There is considerable potential for active intervention to remove such barriers to the regrowth process (e.g., by strategic use of herbicide, enrichment seeding or planting, addition of structures). However, the practitioner and landholder communities are understandably reluctant to move away from costly replanting methods in the absence of evidence for the success of other approaches. Both Leaders of this project (Catterall, Shoo) are the scientific collaborators in a current Caring for Our Country (CfOC) project lead by WTMA, “Mobilising landholders to improve landscape connectivity in the Wet Tropics”. Funding in the CfOC project is very practice- and community- focused. It will enable liaison with some landholders and is planned to include initial proof-of-concept development of limited regrowth acceleration trials. In this Task we will develop the scientific knowledge and approaches that are needed to more systematically and comprehensively determine the potentials and limitations of regrowth management. Because of its novel nature and real-world spatial scale, aspects of this work must be undertaken in a framework of high uncertainty, although the potential pay-offs from success are large. Work in this task will include several components: (1) a synthesis of current international and local approaches to manipulation for regrowth acceleration (MRA), based on both published literature and interviews with practitioners; (2) development of a “notional menu” of diverse potential approaches to MRA relevant to the Wet Tropics uplands; and (3) documentation and establishment of selected approaches and associated cost, with the involvement of practitioners.

This component will be lead jointly by Catterall and Shoo, with involvement of Freebody (planning, fieldwork), Wilson (cost of approaches), stakeholder organisations and landholders (including WTMA, TREAT, TKMG, Terrain, TRC, CVA).

Objective (c): Deciding where to utilise natural regrowth in landscape restoration.

Natural regrowth has considerable potential for low cost restoration of rainforest over large areas (given some uncertainties which are addressed in Objectives a and b), and currently occupies a considerably larger land area than has been planted at high cost for either biodiversity or timber. This raises the question of when and where we should adopt a more passive approach to restoration and allow vegetation to recover with limited intervention (as opposed to capital intensive active intervention). It is highly likely that the occurrence of regrowth is driven by predictable factors, and that we can therefore increase the certainty of expected future outcomes of regrowth if these factors are known. This Task will compile and analyse information about the spatial occurrence and age of regrowth in the Wet Tropics uplands, to identify landscape factors (such as distance from primary forest, slope, aspect and past land uses) that constrain or facilitate its development. Initially, information will be compiled through liaison with organisations and researchers with recent or current involvement in regrowth mapping in the study region (including DERM, CSIRO and Terrain). The major product of this Task will be a map identifying high suitability areas for regrowth establishment (rate and possibly quality) across remaining degraded parts of the landscape. This spatial information (combined with knowledge of time lags and estimated cost of alternative restoration approaches - Objectives a and b, MTSRF, Catterall *et al.* data) will then be integrated into a formal decision analysis to identify situations where passive restoration represents a more cost effective management option than active restoration in meeting restoration objectives. The later outcome is made possible through collaborative links (including co-funding half salary for Shoo over two years) with the NERP Research Hub for Environmental Decisions. Importantly, Objective c will provide necessary information to help managers select optimum approaches to restore degraded land (active or passive) in high priority locations identified by systematic conservation planning (Pressey project, JCU).

This component will be lead by Shoo, with involvement of Wilson (decision analysis), Catterall (planning, interpretation), and GU RA (as required).

Project Outputs/Outcomes
(Note: asterisked outputs/outcomes would be delivered by June 2012; others from late 2012-2014)

Objective (a): Outcomes and rate of regrowth vs replanting

- Information scoping of regrowth ages and landscape context in the Wet Tropics uplands, in relation to previous mapping (joint from Objectives a,c) **
- Established research network of accessible different-aged regrowth sites, suitable for current and future research **
- Data on vegetation development during regrowth
- Paper on developmental rates of regrowth compared with replanting

- Fact Sheet on outcomes, management and optimal locations for natural regrowth (user focused; joint from Objectives a,b,c)

Objective (b): Emerging approaches to regrowth management.

- Synthesis paper on approaches to managing and accelerating regrowth **
- List of potential management interventions to accelerate regrowth development relevant to the Wet Tropics uplands **
- Regrowth acceleration trials (subject to landholder agreement and stakeholder liaison)
- Fact Sheet on outcomes, management and optimal locations for natural regrowth (user focused; joint from Objectives a,b,c)

Objective (c): Deciding where to utilise natural regrowth in landscape restoration.

- Information scoping of regrowth ages and types in the Wet Tropics uplands, in relation to previous mapping (joint from Objectives a,c) **
- Analysis of factors that constrain or facilitate development of regrowth
- Map identifying high suitability areas for regrowth establishment across degraded land
- Decision Analysis to identify situations where passive restoration (natural regrowth) represents a more cost effective management option than active restoration (replanting) in meeting restoration objectives
- Fact Sheet on outcomes, management and optimal locations for natural regrowth (user focused; joint from Objectives a,b,c)

Expected Benefit of your project to end-users, community, DSEWPaC etc

The project's findings will be highly relevant to the information needs of a very wide range of community groups, government and non-government agencies (including those listed elsewhere in this proposal) involved in land restoration or responsible for management of regrowth vegetation. We will generate the basic information needed to compare the likely return on investment resulting from active and passive approaches to restoration. This will enable land mangers to make informed decisions about whether to pursue low cost passive or high cost active approaches to the restoration of degraded land. We will also generate spatial predictions of the likely outcome of natural regeneration in different land contexts. This will help government agencies and landholders to better forecast change in vegetation extent and condition resulting from passive regeneration over defined time-frames. These outcomes will be beneficial to private enterprises interested in capitalising on emerging carbon markets and government agencies charged with the responsibility of promoting retention of regrowth vegetation on private land to meet biodiversity targets and reduce national and state-wide carbon emissions.

Delivery of results to end-users and adoption of findings

Project leaders Catterall and Shoo have a very strong track record in communicating and engaging with end-users, including the production of materials for community education. Delivery of information will be assisted by:

(1) interactive involvement of various stakeholder organisations throughout the project, especially with respect to Objective (b), including provision of information, planning, and implementation (WTMA, TREAT, TKMG, Terrain, TRC, CVA; see above);

(2) joint roles of some project staff who work both within the project and in stakeholder organisations (Freebody – GU and Tablelands SC; Harrison – GU and Terrain);

(3) spoken presentations and updates to stakeholders, as the opportunity arises including the RLRRWG (Regional Landscape Repair and Resilience Working Group);

(4) production of a user-focused Fact Sheet on regrowth (incorporating information from all project Objectives);

(5) publication in the scientific literature, with wide availability through Google searches;

(6) searchable web delivery of information and reports through both the RRRC website and websites of GU and UQ.

(7) reporting to DSEWPaC via RRRC.

Collaboration and research linkages, including with other NERP hubs
This project involves new collaboration between research groups in two Universities: Griffith and UQ. There is also a further link to the NERP Research Hub for Environmental Decisions, through a joint funded Postdoctoral position (Shoo) and involvement from Kerrie Wilson.

There is high potential for further complementarity and links to JCU-based researchers in the NERP Tropical Ecosystems Hub (Williams – rainforest biodiversity monitoring and modelling, Pressey – systematic conservation planning). Shoo has retained an Adjunct position at JCU and has a successful track record of collaboration with these researchers. Shoo will build on existing collaborative research engagement with DERM including the Remote Sensing Centre and the Queensland Herbarium.

Project 12.2 Budget

The Table below shows the split across years and organisations, with details in the Tables beneath.

Organisation	2011-12	2012-13	2013-14	July-Dec 2014	Total all years
Griffith Uni	57,180	80,690	47,656	5,989	191,515
Uni of Qld	6,270	37,560	70,894	35,761	150,485
Total NERP	**63,450**	**118,250**	**118,550**	**41,750**	**342,000**

All Years – 2011-2014 Project 12.2 Funding and Partnerships

Contributing Organisation	Cash	In-kind*	Total
NERP	342,000	0	342,000
Terrain	155,000	53,590	208,590
WTMA	0	66,750	66,750
AWC	0	20,000	20,000
Griffith Uni	0	392,743	392,743
Uni of Qld	0	357,522	357,522
Total	**497,000**	**890,604**	**1,387,605**

*In addition to the above there would be further in-kind contributions in networking and communication, for example through FNQROC/RLRRWG, TREAT, Qld DERM
*UQ in-kind in 2013-14 includes half of Shoo's salary funded by the NERP Research Hub for Environmental Decisions (ie Shoo works jointly across 2 NERP hubs).

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind*	Total
NERP	63,450	0	63,450
Terrain	0	14,375	14,375
WTMA	0	32,650	32,650
AWC	0	7,500	7,500
Griffith Uni	0	132,396	132,396
Uni of Qld	0	52,936	52,936
Total	**63,450**	**239,857***	**303,307**

*GU's in-kind includes 20K committed cash contribution by internal transfer.
In addition to the above there would be further in-kind contributions in networking and communication, for example through FNQROC/RLRRWG, TREAT, Qld DERM.

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind*	Total
NERP	118,250	0	118,250
Terrain	79,000	15,295	94,295
WTMA	0	20,300	20,300
AWC	0	5,000	5,000
Griffith Uni	0	106,252	106,252
Uni of Qld	0	95,026	95,026
Total	**197,250**	**241,873**	**439,123**

*In addition to the above there would be further in-kind contributions in networking and communication, for example through FNQROC/RLRRWG, TREAT, Qld DERM.
*UQ in-kind includes half of Shoo's salary funded by the NERP Research Hub for Environmental Decisions (ie Shoo works jointly across 2 NERP hubs).

AWP 3 (July 2013 to June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind*	Total
NERP	118,550	0	118,550
Terrain	40,400	15,870	15,870
WTMA	0	9,200	9,200
AWC	0	5,000	5,000
Griffith Uni	0	110,269	110,269
Uni of Qld	0	138,800	138,800
Total	**158,950**	**279,139**	**438,089**

*In addition to the above there would be further in-kind contributions in networking and communication, for example through FNQROC/RLRRWG, TREAT, Qld DERM.
*UQ in-kind includes half of Shoo's salary funded by the NERP Research Hub for Environmental Decisions (ie Shoo works jointly across 2 NERP hubs).

AWP 4 (July 2014 to December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind*	Total
NERP	41,750	0	41,750
Terrain	0	8,050	8,050
WTMA	0	4,600	4,600
AWC	0	2,500	2,500
Griffith Uni	0	44,326	44,326
Uni of Qld	0	70,761	70,761
Total	**41,750**	**130,237**	**171,987**

*In addition to the above there would be further in-kind contributions in networking and communication, for example through FNQROC/RLRRWG, TREAT, Qld DERM.
*UQ in-kind includes half of Shoo's salary funded by the NERP Research Hub for Environmental Decisions (ie Shoo works jointly across 2 NERP hubs).

Identified and assessed hazards

Description of Risk	Assessed Risk	Risk Control measures
Failure to appoint suitable personnel	Low	The listed project team already includes personnel with the necessary specialist skills to successfully complete the project. One project researcher (a Research Assistant based at Griffith University) has yet to be recruited under the project. However, we are confident that we will be able to appoint a suitable person with the necessary skills to fulfil the requirements of this position.
Failure to obtain data	Medium	It is envisaged that a network of suitable sites to study regrowth vegetation will involve some land under private ownership. Low engagement of particular landholders therefore has the potential to restrict access to potential study locations. To minimize this constraint we have: built redundancy into the experimental design such that the project is not dependent on any particular land holding; and included personnel and End-users on the project team that already have well established professional relationships with key land holders in the study area.
Departure of key project personnel	Low	Loss of salary support is expected to be the most likely reason for departure of key project personnel. We have specifically included in the budget sufficient salary support to retain all personnel not on continuing contracts for the duration of the project.
Failure to achieve outcomes due to dependence on outputs from other projects	Low	We will liaise with organisations and researchers to obtain data on the spatial distribution and age of regrowth vegetation in the study region. However, we are not dependent on specific products from other projects. We are confident that data sharing agreements can be negotiated to obtain the necessary primary satellite data products from DERM and we have included personnel on the project with the necessary experience and capacity to develop the secondary products if needed.
Failure to achieve uptake of results by end-users	Low	Uptake of results will be maximised through a number of initiatives. We will: convene interactive meetings with stakeholder organisations throughout the project to discuss planning and implementation and to exchange information (see End-user summary table above); include in the project staff that work both within the project and in stakeholder organisations (Freebody – GU and Tablelands SC; Harrison – GU and Terrain); undertake spoken presentations and updates to stakeholders, as the opportunity arises including the RLRRWG (Regional Landscape Repair and Resilience Working Group); produce user-focused Fact Sheet; deliver information and reports through both the RRRC website and websites of GU and UQ; and, report to DSEWPaC via RRRC.

Project 12.3: Relative social and economic values of residents and tourists in the WTWHA

Project Leader and Host Organisation

Name	Prof Natalie Stoeckl		
Position	Professor of Economics		
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Project Team

Title	Organisation	Role
Natalie Stoeckl	JCU	Project co-leader; Economist
Silva Larson	JCU	Project co-leader; Social Scientist
Michelle Esparon	JCU	Assistance with preparation of questionnaires, administration of surveys, data entry, data collation, statistical analysis; assistance with writing of reports and papers
Social and Economic Scientists collaboration group (Alan Dale, Ro Hill, Natalie Stoeckl)	JCU, CSIRO,	Coordinate activities and objectives across socio-economic projects within the Rainforest Hub so as to maximise collaborative opportunities

Summary Table of End-users[1]

Organisation	Organisational Contact	Email
Wet Tropics Management Authority	Andrew Maclean, Executive Director	andrew.maclean@wtma.qld.gov.au
Terrain NRM	Rowena Grace	rowenag@terrain.org.au
Alliance for Sustainable Tourism	John Courtenay	Johncourtenay1@bigpond.com
Department of National Parks, Recreation, Sport and Racing	Andrew Millerd, Area Manager, Wet Tropics Highlands Scott Buchanan Partnerships and World Heritage, QPWS	andrew.millerd@nprsr.qld.gov.au scott.buchanan@ehp.qld.gov.au
Department of Environment and Heritage Protection	Lyn Wallace, Manager Cape York Programs Engagement Ecosystem Outcomes Department of Environment & Heritage Protection	lyn.wallace@ehp.qld.gov.au
Tourism Tropical North Queensland	Rob Giason	rob.giason@ttnq.org.au

DSEWPaC	David Calvert TBC Karl Newport Peter Latch	David.calvert@environment.gov.au Anthony.whalen@environment.gov.au Karl.newport@environment.gov.au Peter.latch@environment.gov.au

[1]*End-users are those organisations either directly related to the project or could benefit from the outputs of this project. All final reports will be circulated to nominated contacts prior to upload to web.*

Project Duration: 2.5 years

Start Date: 1st July 2012 End Date: 31st December 2014

Project Description / Task Objectives

The Wet Tropics World Heritage Area (WTWHA) contains many iconic symbols such as cassowaries, mahogany gliders, waterfalls, outstanding biodiversity, and spectacular scenic vistas. Indeed, the region literally abounds with nature's gifts, and it is because of these 'values' that the region was awarded world heritage status. Yet despite the fact that many management problems (associated with conserving the region's biodiversity or heritage values) or marketing problems (associated with attracting and managing the region's many tourists) could, arguably, be better handled if more were known about these aesthetic, biodiversity and other values, relatively little is known about them. This is at least partially attributable to the fact that it is exceedingly difficult to determine how best to quantify their 'values'.

Economists have long recognised that (a) price is not synonymous with 'value'; and that (b) there are a multiplicity of values associated with the environment. They have coined terms such as: "total economic value" (TEV); "direct use value"; "indirect use value" and "non-use value"[d] to help describe those 'values' and a vast body of literature on different techniques for attempting to derive monetary estimates of the magnitude of those 'values' now exists (see: Getzner *et al., 2005;* Bateman *et al.,2002;* Rietbergen-McCracken and Abaza, 2000; Garrod & Willis, 1999; and Willis *et al., 1999,* for detailed reviews). Suffice to say here, none of the methodologies (often called 'valuation' techniques) are flawless, most are surrounded with at least some controversy vis-à-vis the 'accuracy' of final estimates, each requires different types of information as an input, and each produces (sometimes subtly) different information as output. Researchers thus need to be cognizant of the type of information that is required by managers and policy makers when designing economic valuation projects.[14] Otherwise, their chosen techniques may not be capable of producing information that is useful in a given decision-making context.

To be more specific, some valuation methods are only able to generate a monetary estimate of the 'total economic value' of a region, or the 'total value' of activities associated with a region (e.g. tourism revenues). These types of estimates are particularly useful if (a) seeking to describe the current state of affairs (for example, determining that tourism is a more significant generator of incomes in a region than is manufacturing) or if (b) seeking to address 'all-or-nothing' management/policy questions such as: what losses would the region suffer if the entire wet tropics area ceased to exist? But this type of information is, arguably, not completely lacking in the WTWHA: data from the Australian Bureau of Statistics and research such as that of Driml's (1994) and Prideaux and Falco-Mammon's (2007) investigations of the recreation use value of the wet tropics provides us with a relatively good understanding of the current state of affairs – particularly in the tourism industry. Moreover, managers in the WTWHA are rarely faced with all or nothing choices (rainforest or no rainforest). So whilst more information is almost always useful, it would probably be erroneous to claim that one could fill a 'critical' information gap by generating an estimate of the total economic value of the WTWHA (or of the total economic value attributable to, for example, tourism).

But that does not imply that valuation studies have little to offer; indeed it is quite the contrary. Rather than all or nothing choices, today's business leaders, managers and policy makers are more likely to be asked to make choices 'at the margin'. They may, for example, need information that helps answer questions such as:

- What losses would the region suffer if development eroded (rather than erased) some of the region's values (e.g. if new roads affected aesthetic or biodiversity values)?
- Would more people (tourists) come to the region if we could improve resource 'y'?

- What compensation should be sought (monetary or otherwise) if development 'x' takes place?
- How are preferences and priorities likely to change in the future?

There are many different valuation techniques that generate information which could help address those questions, since they allow one to assess the degree to which environmental values are affected by changes in other spheres (such as road construction, expanding population, changing visitor mix) and since they allow one to differentially assess the effect of change across individuals and/or stakeholder groups. This latter issue (of identifying winners and losers), is particularly important in the context of 'environmental offsets' or 'payments for environmental services': one needs accurate information about the distribution of costs and benefits associated with changes to the environment if one is going to design equitable and efficient payment, offset or 'compensation' systems. As argued by Heal (2000), it is essential to progress beyond the realm of simply estimating total value; one needs to move on to the process of assessing the impacts of potential 'changes' so that it is possible to alter incentives, and then (ultimately) behavior.

That said, it is worth noting that one cannot simply 'borrow' information from another context and apply it to the WTWHA[13]: 'changes' need to be assessed on a case by case basis. The key problem here, is that there are an infinite number of 'changes' that have already, or could potentially, impact upon regions such as the WTWHA (or any environmental area for that matter) and there are literally millions of individuals who might either suffer, or benefit, from those changes. So it is vitally important to find robust, cost-effective, easily understandable and equitable techniques for conducting such evaluations; if only because many may be required.

Moreover, it is evident that one needs to work with valuation techniques that can adequately measure, compare, and prioritise a variety of different use and non-use values; many of which are NOT closely associated with the market. For example: DSEWPAC is interested in biodiversity values; WTMA is interested in aesthetic values; the tourism industry interested in the relative importance of a range of different 'values' as attractants to the region; and there is considerable evidence to suggest that a large proportion of the 'values' which residents hold are essentially non-market – particularly in this region[14]. As such, one all but inevitably needs to consider the use of stated preference techniques, since (like other techniques) they are able to assess the impact of 'change' and (unlike other techniques) they are able to assess both market and non-market (also non-use) values such as *aesthetics*.

This 'basket' of techniques includes methods such as *Contingent Valuation* and *Choice Modeling.* All stated preference techniques are open to criticisms for their hypothetical nature, and choice modeling can be critiqued for its complexity, but if implemented correctly, these approaches can be both robust and relatively cost-effective. However, most stated preference techniques (indeed most valuation techniques) use either actual or intended expenditures. Since both actual expenditure and expressed willingness to pay are a function of ability to pay, these techniques produce estimates which are, essentially, weighted averages. In this case, the weights are a function of income / wealth. As such these traditional valuation techniques give greater voice to the priorities (or values) of the wealthy than to the priorities (or values) of the poor and thus fail the 'equity' criterion.

Nevertheless, there is a paucity of research on non-monetary methods of attempting to assess the relative importance of different values within the economics literature[15] and almost no public recognition of the crucial role that income plays in supporting and reinforcing the priorities of the wealthy when monetary methods are used to inform policy. Mackey *et al.* (2001) outlined a conceptual approach for trying to quantify *aesthetic* values in the Cape York Peninsula, and Carmody and Prideaux's (2009) study provides some very useful background information on community attitudes, perceptions and use of the WTWHA; highlighting key attributes (e.g. protecting plants and animals, providing economic opportunities) of the region which residents feel are particularly important. Some non-monetary methods for generating quantitative assessments of the relative

[13] There are many problems associated with the use of benefit transfer techniques (see TEEB, 2009).

[14] Larson, 2009 found that economic factors comprised just 35% of all factors that contribute to 'well-being' in the Cardwell and Whitsunday Shires; Delisle, 2009 found that market-based factors comprised less than a third of 'values' associated with traditional Dugong hunting n the Torres Strait

[15] There is some in the Anthropology and Sociology literature, but these disciplines often generate rich qualitative information. And it can be difficult to find ways of incorporating qualitative information into a policy / decision making context.

importance of a range of different 'values' have been trialed in and around North Queensland (See: Larson, 2009; Delisle, 2009; and Stoeckl *et al.*, 2010a and 2010b for published examples)[16] and early indications are that these non-monetary approaches may have much to offer (even if working with difficult values such as those associated with 'culture' and particularly when dealing with communities when there are significant gaps between rich and poor). But none of the applied trials (using either monetary or non-monetary techniques) have adequately considered aesthetic values in this region (a particularly problematic issue – of importance to regions throughout the world), only one considered biodiversity values (Larson, 2009), none have compared the 'values' of residents and tourists, and none have considered an entire suite of values that are core to the WTWHA in the context of current management problems.

Key Objectives over the lifetime of the project

This project will fill critical information gaps about the relative importance of key attributes (or 'values') associated with the WTWHA to a variety of different stakeholders and about the way in which those 'values' might be effected by a range of external influences (e.g. different types of economic development, increases in population, changes in the mix of visitors). It will also fill a critical methodological gap – testing and refining both 'traditional' and state-of-the art techniques for generating estimates of the relative importance of those 'values'.

More specifically, the project will:

1. Improve our understanding of the relative importance or 'value' of the WTWHA's key environmental attributes (that include, but are not limited to aesthetic and biodiversity values) to different stakeholders (e.g. Tourists, Indigenous and Non-Indigenous Residents, the owners of different types of businesses).
2. Allow researchers to make predictions about the way in which resident and tourist 'values' and thus management, conservation and marketing priorities may alter in the future as both population and tourist numbers change.
3. Improve methods for assessing 'values'. This project will compare state-of-the art non-monetary valuation techniques with more 'traditional' valuation techniques highlighting the strengths and weaknesses of each. As such, the project is likely to make a substantial contribution to the valuation literature, and will provide mangers throughout the world with an illustrated, easy to understand, example of a cost-effective, robust, and equitable means of assessing the relative value (or importance) of non-market goods and services (such as aesthetics).

The table on the following page shows the way in which each of those objectives links to the gaps and research priorities identified of the working party, NERP and WTMA

Year one objectives (to be completed by June, 2013)

By the end of the first year of the project, researchers will have

1. worked alongside other members of the *social and economic coordination group* as well as with staff at WTMA, Terrain, and members of key tourism organizations (listed on page one) to
    a. Identify and characterize core attributes (or 'values') of the WTWHA for assessment
    b. Identify and characterize other 'values' (e.g. development of roads, employment, or income) to be compared with those core attributes, so that managers are able to assess trade-offs between WTWHA and other 'values'
2. used information from (1) to develop an effective survey instrument for
    a. measuring the relative value of core attributes of the WTWHA;
    b. comparing those values with other monetary and non-monetary 'values' which decision makers often need to consider;

[16] Other relevant research in progress includes the work of PhD student Michelle Esparon who is using monetary and non-monetary methods to assess the importance of eco-certification to tourists in the WTWHA.

3. developed an effective, scientifically robust, sampling strategy for ensuring that information is collected from a range of key stakeholders.

Gaps and priorities	Objective 1: Understanding values	Objective 2: Making predictions about future values	Objective 3: Improving methods for assessing values
Research Gap 1: Long-term monitoring data, essential for decision making *Closely aligned with* WTMA A: Understanding the condition and trends of the natural and cultural environment (C)	**Minor contribution:** One complete data set which could be used as a basis for long term monitoring	**Significant contribution**: Improved understanding of the way in which values and priorities might change in response to changes in population and tourist numbers	**Significant contribution**: Improved system for measuring and thus monitoring relative values
NERP 1: Values – Understanding drivers for maintaining biodiversity *Closely aligned with* WTMA B: Understanding risks and threats to the WHA (T)	**Significant contribution**: Improved understanding of relative values (which affect business profitability, political processes and decisions, and thus work as drivers and potentially pose ‘risks’)	**Significant contribution**: Improved understanding of the way in which values, profits and priorities might change in response to changes in population and tourist numbers	**Significant contribution**: Improved system for measuring and thus monitoring changes in relative values (and associated drivers of change/risks)
NERP 4: Sustainable use of biodiversity and ecosystems *Closely aligned with* WTMA C: Sustainable use and management of the WHA (M)	**Moderate contribution**: Improved understanding of biodiversity values (relative to other use and non-use values)	**Significant contribution**: Improved understanding of the way in which values (and hence ‘use’ of the region) might change in response to changes in population and tourist numbers	**Significant contribution**: Improved system for measuring and thus monitoring relative values and uses

Gaps and priorities	Objective 1: Understanding values	Objective 2: Making predictions about future values	Objective 3: Improving methods for assessing values
NERP 5: Biodiversity Markets – costs, benefits , establishment	**Moderate contribution**: Improved understanding of (a) relative values (benefits); (b) the distribution of values across stakeholder groups; and (c) equity issues associated with biodiversity markets.		**Substantial contribution**: Improved methods for measuring and monitoring effects (including distributional / equity effects) of biodiversity markets across stakeholder groups.
MTMA E: Science / Management Partnership Performance	**Moderate contribution**: Improved understanding of relative values and of the distribution of values across stakeholder groups.		**Substantial contribution**: Improved methods for measuring and monitoring values – methods which could be transferred to other regions

Project / Task Methodology

This research will collect and analyse primary data to assess the extent to which the relative importance of key attributes (or 'values') associated with the WTWHA differ across stakeholder groups (e.g. Tourists, Indigenous and non-Indigenous residents, different types of business owners). The project will build on recent research conducted by (a) Stoeckl *et al.* (2010a, b) who used both satisfaction and 'willingness to pay' measures to investigate the relative 'value' of iconic marine species to tourists in the Northern Section of the GBR; and (b) Larson (2009, 2010a, 2010b) who developed a novel approach to gauge the relative 'value' of a range of different social, economic and ecological contributors to 'well-being' using non-monetary approaches that combine measures of satisfaction and 'importance'.

Importantly, researchers working on this project will develop the list of 'attributes' to be assessed (or 'valued') using information from previous studies, and also in conjunction with key regional stakeholders and with other members of the *Social and Economic Scientists coordination group* to ensure relevance of the information generated.

Specifically, researchers will

vi) survey literature and work closely with other members of the *Social and Economic Scientists coordination group,* (and in consultation with key personnel in WTMA, Terrain and in tourism organisations) to

   a. Identify and characterize core attributes (or 'values') of the WTWHA (e.g. cassowaries, mahogany sugar gliders, waterfalls, aesthetics) for assessment
   b. Identify and characterize other 'values' (e.g. development of roads, employment, or income) to be compared with those core attributes, so that managers are able to assess trade-offs between core WTWHA attributes and other 'values'

vii) construct a survey instrument that will allow one to assess the relative importance of those attributes using both traditional money-based valuation techniques (contingent valuation and expenditure attributable), and Larson's non-monetary based technique.

viii) distribute the questionnaire, by mail, to a random sample of residents (householders) throughout the WTWHA - using Dilman's (2000) total design method (to maximise response rates);

ix) distribute the questionnaire to tourists at the Cairns airport at different times of the year (to control for seasonality of data) in the form of an exit survey;

x) use multivariate analysis to explore the extent to which the different measures of satisfaction and relative value (those derived using CV, expenditure attributable and Larson's technique) differ across different stakeholder groups;

xi) compare and contrast valuation approaches to gain insights into the importance of income as a driver/setter of priorities when using traditional valuation techniques and to gain insights that will allow researchers to further develop non-monetary valuation techniques;

xii) use insights from (iv) to identify priorities for conservation and marketing and to make predictions about the way in which tourist and community 'values' and conservation priorities may change in the future as the 'mix' of stakeholders changes.

Project Outputs/Outcomes*/Benefits*

Information generated from the activities outlined above will allow researchers to (i) identify priorities for conservation, management and marketing (for tourism); (ii) make predictions about the way in which resident and tourist 'values' and thus management, conservation and marketing priorities may change in the future in response to changes in both population and tourist numbers; and (iii) further refine non-monetary valuation techniques, testing them against more 'traditional' economic valuation methods. The project will thus deliver outcomes that are useful to a range of different stakeholder groups (tourism organizations; conservation planners/managers; local, state and federal government bodies; and academics), as summarised in the following table:

OBJECTIVE	OUTCOMES
(i) Improve our understanding of the relative importance or 'value' of the WTWHA's key environmental attributes (that include, but are not limited to aesthetic and biodiversity values) to different stakeholders (specifically tourists and residents).	This information will be of immediate use to the tourism industry, to managers and policy makers in the WTWHA. It will, for example, allow those working in the WTMA to determine whether different sectors of the community think that key environmental 'values' are more or less 'important' than other monetary and non-monetary 'values' (e.g. family or social relations). The enhanced knowledge and understanding of the relative 'value' of these *icons* will help in prioritizing conservation and/or restoration initiatives. Moreover, by clearly identifying what different types of tourists think is 'of value', this research will provide crucially important information to those wishing to promote tourism in this region (or to those wishing to promote particular types of tourism or visitor segments). This information will be of considerable use to those seeking to market and to enhance the satisfaction of tourists in this world heritage region. This information could also be used as the 'first point' of a longitudinal database that could be used for monitoring socioeconomic values in the WTWHA.
(ii) Make predictions about the way in which resident and tourist 'values' and thus management, conservation and marketing priorities may change in the future in response to	Insights into the way in which resident and tourism values might change as population and tourism numbers change will provide those in the tourism industry, in WTWHA and other key policy makers with advance warning of changes in priorities and/or attitudes that may occur.

OBJECTIVE	OUTCOMES
changes in both population and tourist numbers;	
(iii) Improve methods for assessing 'values'.	This project will allow researchers to compare state-of-the art non-monetary valuation techniques with more 'traditional' valuation techniques highlighting the strengths and weaknesses of each. As such, the project is likely to make a substantial contribution to the valuation literature, and will provide mangers throughout the world with an illustrated, easy to understand, example of a cost-effective, robust, and equitable means of assessing the relative value (or importance) of non-market goods and services (such as aesthetics). It will thus increase the capacity of researchers, industry, agency managers and planners to assess some of the socioeconomic values associated with the WTWHA

LINKS TO OTHER PROJECTS

- This project builds upon a previous MTSRF project conducted by Stoeckl *et al.*, which looked at the relative values of Iconic Marine Species to Tourists on the GBR.

- This project also has strong links with previous MTSRF projects (led by Bruce Prideaux) which established a monitoring program for tourists in FNQ. We will ensure that sections of the tourism questionnaire used in this project 'match' those used in the earlier MTSRF projects. This will ensure that our research serves the dual purpose of (a) providing NEW information; and (b) continuing to collect data which the tourism industry has found to be particularly useful (i.e. long-term data series that allow one to monitor trends).

- This project has links to another Tropical Ecosystems NERP project in the GBR Node (specifically, activities a and b of the project entitled: *Socioeconomic systems and reef resilience* – led by Natalie Stoeckl, Silva Larson, John Brodie and Bruce Prideaux). Both this project and the GBR project, seek to learn more about the relative importance of market and non-market goods and services associated with world heritage regions; both plan to survey tourists and residents; both plan to use traditional and state-of-the art economic valuation techniques as part of the analysis; and both have similar research teams. We will ensure that both projects use similar questionnaires, sampling, surveying and analytical techniques (although there will need to be contextualisation). This has two, significant benefits: (1) it means we have been able to prune costs considerably, assuming for example that many of the significant costs associated with the development of good quality questionnaires, can be shared across both projects (indeed the costs of either one of these projects would increase if one of the two did not get approved); (2) it means that we will be able to makes some extremely useful comparisons about the 'values' which residents and tourists attribute to both the reef and rainforest – looking, for example, at the way in which those 'values' change across stakeholder group and also across space (do residents of Cairns have similar 'values' with respect to the reef and the rainforest as residents of Atherton or of Rockhampton?).

Key Risks Assessment

Possible risks	Proposed management strategy

Possible risks	Proposed management strategy
Loss of key staff due to unforseen events may delay progress	Relatively low risk because multiple researchers are involved with this project, and because the larger consortium has the capacity to draw on additional staff expertise from partner organisations. The key researcher on this project has already demonstrated a long-term commitment to northern Australia, and JCU has the capability to attract high quality applicants if key positions need to be filled.
Extreme whether conditions caused by unseasonable whether may delay some planned fieldwork activities.	Relatively low risk: extreme weather conditions may delay the timing of particular tasks but typically also offer opportunities for serendipitous research. Moreover, researchers have allocated a year for data-collection activities, so an occasionally unseasonable event is unlikely to cause significant issues.
Risks to personnel during field work, especially in remote locations	Relatively low risk: there are OHS issues relating to field research but is unlikely to restrict field activities. JCU has detailed OHS plans and procedures covering field operations and these will be strictly applied.
Poor or weak relationships with key regional stakeholders make data collection difficult	Relatively low risk: we have already established good working relationships with some stakeholders in this region (including Traditional Owners, Tourism operators, staff in the WTMA, some pastoralists and some mining groups).
Low levels of adoption and limited uptake of research outputs by land managers and other end-users lead to poor research outcomes	Relatively low risk: by engaging with key stakeholders during the early phases of this work, we hope to ensure that our work is relevant and of interest – thus increasing the chance of adoption and uptake. Moreover, RRRC is on hand to help promote and facilitate communications thus increasing the chance of uptake and adoption.

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AWP 1 (Jul 2012 – Jun 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	70,800		70,800
JCU		50,000	50,000
Total	**70,800**	**50,000**	**120,800**

AWP 2 (July 2013 – June 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	78,800		78,800
JCU		47,000	47,000
CSIRO		28,000	28,000
Total	**78,800**	**75,000**	**153,800**

AWP 3 (July 2014 – December 2015) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	78,800	-	78,800
JCU	-	50,000	50,000
Total	**78,800**	**50,000**	**128,800**

AWP 4 (July 2014 – December 2014) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	35,400	-	35,400
JCU	-	24,600	24,600
CSIRO	-	14,700	14,700
Total	**35,400**	**39,300**	**74,700**

Project 12.4: Governance, planning and the effective application of emerging ecosystem service markets to secure climate change adaptation and landscape resilience in Far North Queensland.

Project Leader and Host Organisation

Associate Professor Allan Dale, Cairns Institute, JCU.

Project Team

Title	Organisation	Role
Assoc. Prof. Allan Dale	JCU	Lead Researcher
Dr. Karen Vella	GU	Research Collaborator

Summary Table of End-users[1]

Organisation	Organisational Contact	Email
Terrain NRM	Carole Sweatman (CEO)	caroles@terrain.org.au
Cape York Peninsula NRM	Bob Frazer (CEO)	bobfrazer@capeyorknrm.com.au
Queensland Regional Groups Collective	Mike Berwick (Chair)	mikeb@terrain.org.au
WTMA	Andrew MacLean (CEO)	andrew.maclean@derm.qld.gov.au
Department of Infrastructure and Planning	Robyn Clark (Regional Manager)	Robin.Clark@dip.qld.gov.au
FNQROC	Darlene Irvine (CEO)	d.irvine@cairns.qld.gov.au
RDA FNQ&TS	Peter Doutre (ActingCEO)	pdoutre@rdafnqts.org.au

Project Duration

Start Date: 1 July 2011 End Date: 30 June 2013

Project Description / Task Objectives

This project will partner the region's key stakeholders to review, trial and evaluate the most effective governance systems and planning foundations for regional and landscape scale adaptation to climate change. In particular, within the context of these governance systems and planning arrangements, it will focus on the potential application of emerging ecosystem service markets to secure landscape-scale resilience for biodiversity in the face of climate change. The key intent of the Project will be to:

1) Design/secure the most appropriate regional governance systems and planning mechanisms needed to support regional scale adaptation to climate change;

2) Design/ secure the most effective and integrated planning arrangements for regional scale adaptation for biodiversity; and

3) guide the carbon market and other emerging ecosystem market investments towards priority biodiversity outcomes within the regional landscape.

Partnerships between researchers and decision makers are required to devise continuously improving regional governance systems and institutional arrangements for climate change adaptation. Consequently, within these systems, regional and landscape scale adaptation planning also sets the foundations required to best facilitate the strategic development and aggregation of priority carbon and other ecosystem service market products (including native reafforestation, managed regrowth, avoided deforestation, improved forest management and biodiversity credits). Such regional partnerships will enable the Project to have a high delivery impact. The Project, however, will also directly inform developing DSEWPAC policy concerning regional adaptation, and particularly, the role of regional NRM planning in guiding emerging carbon markets in Australia. Consequently, lessons from the research will inform national policy and practice concerning regional adaptation and NRM planning.

The project will be strongly coordinated with related social and institutional projects across the Rainforest hub (Pressey, Stoeckl, and Hill), with joint project planning and delivery arrangements to be established. Data developed in the project will also have relevance to the Northern GBR and Torres Hubs (linkages are envisaged with emerging cross cutting projects by Pressey and Stoeckl).

Key Objectives

In partnership with the key end-users listed, and as a result of MTSRF Transition funding, the Cairns Institute is currently working towards the development of strategic regional approaches to climate change adaptation. Within this context, the Institute is also providing strategic policy advice to regional NRM bodies across the nation concerning the development of emerging carbon-based ecosystem service markets and the use of regional NRM plans to guide market investment. The Institute is also currently supporting both the State and Commonwealth government to develop appropriate policy arrangements in this regard.

These collective agenda (adaptation planning and the application and use of emerging carbon markets) present significant policy and delivery opportunities to secure landscape-scale change with regard to terrestrial biodiversity. Given poor theoretical development in this area, however, a short term and focused evidence base is required. Hence the key research objectives are to:

- Develop and test theory concerning the governance and institutional arrangements needed for regional climate change adaptation;
- Develop and test theory concerning the integrated and effective use of regional scale adaptation planning;
- Research the most effective linkages between region planning and outcome delivery via the application of emerging ecosystem service markets, including the aggregation of carbon and other ecosystem services at regional scale; and
- In partnership with end-users, devise the practical reforms required to improve the regional governance and planning systems required and linkages needed to effectively guide carbon-based and other emerging ecosystem service markets.

Project / Task Methodology

Key activities across the life of the project will include:

1. Consolidating theoretical frameworks, national and international experience in regard to governance systems for climate change adaptation and planning;
2. Consolidating theoretical frameworks, national and international experience in regard to linking landscape scale planning to guide ecosystem service markets;
3. Exploring the theoretical literature concerning the institutional arrangements required to deliver effective aggregated carbon products that deliver regional outcomes;
4. Testing these theoretical learnings using the Wet Tropics and Cape Yorks regions;
5. Supporting the development of national policy and institutional reforms required; and

6. Working collaboratively with State and Federal governments, regional decision makers and regional NRM bodies to enable adoption of project learnings.

Project Outputs/Outcomes

Objectives	Outcomes	Outputs
1. Develop theory concerning the governance and institutional arrangements needed for regional climate change adaptation.	A stronger theoretical foundation for devising more appropriate governance systems and institutional arrangements.	Theory based publication in significant peer review journal.
2. Develop theory concerning the integrated and effective use of regional scale adaptation planning and ecosystem service market guidance.	A stronger theoretical foundation for devising more appropriate planning approaches for climate adaptation and the guidance of ecosystem service markets.	Theory based publication in significant peer review journal. Mid Term NERP report on Governance and Planning Theory.
3. Test the most effective linkages between regional planning and outcome delivery via the application of emerging ecosystem service markets, including the aggregation of carbon and other ecosystem services at regional scale; and	Knowledge developed regarding improved planning for regional climate change adaptation planning and the guidance of carbon and other ecosystem service markets.	Stronger regional partnership arrangements and knowledge in place. Publication in significant peer reviewed, but practice-oriented journal.
4. In partnership with end-users, devise the practical reforms required to improve in regional governance and planning systems required and the linkages needed to effectively guide carbon-based and other emerging ecosystem service markets.	Explicit practical reforms required in regional governance and NRM planning systems developed and trialed to effectively guide carbon-based and other emerging ecosystem service markets.	Governance systems, institutional and reforms trialed by key stakeholders. Practice informed by publication in significant peer review journal. Final integrated NERP Project Report.

Expected Benefits

The emerging Carbon Farming legislation (and other policy developments at national and state scale are driving the need for both the refinement of regional NRM plans and the development of new institutional arrangements that will enable the aggregation of diverse natural resource based products across Far North Queensland and nationally. The project will deliver tangible benefits that will:

- Result in higher quality regional NRM plans over the next three years;
- Result in these plans guiding the emerging ecosystem service market;
- Build capacity within this region to enable market mobilization; and
- Inform national and state-wide policy on both these fronts.

Identified and Assessed Hazards

The project is considered low risk because of the strong delivery record of the lead researchers and existing end-user engagement arrangements.

Description of Risk	Assessed Risk	Risk Control measures
Departure of key project personnel	Medium	Alternative delivery agents have been identified in this unlikely event.
Failure to achieve outcomes due to dependence on outputs from other projects	Low	Strong collaborative alliances among a wide range of regional NRM bodies will ensure this remains a low risk.
Failure to obtain data	Medium	High level of collaborative arrangement in place with Regional NRM Bodies at national scale.
Failure to achieve uptake of results by end-users	Medium	Formal linkage has been institutionalized between this project and the national and regional work of Regional NRM Bodies. Other end-users will also be formally engaged throughout the project.

AWP 1 (July 2011 to June 2012) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	60,000		60,000
JCU		60,000	60,000
Total	**60,000**	**60,000**	**120,000**

AWP 2 (July 2012 to June 2013) Project Funding and Partnerships

Contributing Organisation	Cash	In-kind	Total
NERP	60,000		60,000
JCU		60,000	60,000
Total	**60,000**	**60,000**	**120,000**

Program 13: Knowledge Brokering and Communications

Project 13.1: e-Atlas

Project Leader and Host Organisation

Name	Dr Eric Lawrey		
Position	e-Atlas System Developer		
Organisation	Australian Institute of Marine Science		
Postal Address		**Delivery Address**	
	PMB 3		
	Townsville QLD 4810		
Phone	07 4753 4116	**Fax**	07 4772 5852
Email	e.lawrey@aims.gov.au		

Project Team

Title	Organisation	Role
Dr Eric Lawrey	AIMS	Project leader, systems developer, map data preparation, training
Gael Lafond	AIMS	Programmer for the website and mapping tools
Libby Evans-Illidge	AIMS	Torres Strait consultation, contents planning, content writing and editing, outreach
Kate Osborne	AIMS	Content planning, data output design, writing
Dr Glenn De'ath	AIMS	Spatial models, tool and system development
Roland Pitcher	CSIRO	Facilitate upload of CSIRO Torres Strait data holdings, content planning, data output design
Tim Skewes	CSIRO	Facilitate upload of CSIRO Torres Strait data holdings, content planning, data output design
Ian McCleod	CSIRO	Facilitate upload of CSIRO Torres Strait data holdings, data output design

Summary Table of end-users

Organisation	Organisational Contact	Email
GBRMPA	Cherie Malone Fergus Molloy	cherie.malone@gbrmpa.gov.au fergus.molloy@gbrmpa.gov.au
WTMA	Steve Goosem	steve.goosem@wtma.qld.gov.au
JCU	Alana Grech Michelle Devlin	alana.grech@jcu.edu.au michelle.devlin@jcu.edu.au
AODN	Pauline Mak	pauline.mak@utas.edu.au
Reef Plan Secretariat	Chris Chinn	Chris.Chinn@premiers.qld.gov.au
Reef Rescue	Kevin Gale	Kevin.Gale@environment.gov.au
AIMS oceanography	Richard Brinkman	r.brinkman@aims.gov.au
AIMS Data Centre	Mark Rehbein	m.rehbein@aims.gov.au
CSIRO Marine & Atmospheric	Mike Herzfeld	Mike.herzfeld@csiro.au
TSRA	John Rainbird Damien Miley Melanie Smith	John.RAINBIRD@tsra.gov.au Damian.Miley@tsra.gov.au Melanie.SMITH@tsra.gov.au
AFMA	Annabelle Jones	Annabel.jones@afma.gov.au
DAFF (TBC)	Ian Jacobsen (TBC)	
DEHP	John Bennett	John.Bennett@ehp.qld.gov.au
Terrain NRM	Fiona Barron (TBC)	fionab@terrain.org.au
NQ Dry Tropics	Ian Dight	Ian.dight@nqdrytropics.com.au
Reef Catchments	Carl Mitchell	carl.mitchell@reefcatchments.com.au
Fitzroy Basin Association	Nathan Johnston	Nathan.Johnston@fba.org.au
DSEWPAC	Kevin Gale Peter Wright Jeanette Muirhead John McDougall Kate Sanford-Readhead	kevin.gale@environment.gov.au peter.wright@environment.gov.au Jeanette.muirhead@environment.gov.au John.mcdougallenvironment.gov.au Kathryn.Sanford-Readhead@environment.gov.au
BOM	Jamie Treleaven Frank Erjiang Fu	J.Treleaven@bom.gov.au F.Fu@bom.gov.au
Tagai College	Tim Hillier	thill207@eq.edu.au

[1] *End-users are those organisations either directly related to the project or could benefit from the outputs of this project. All final reports will be circulated to nominated contacts prior to upload to web.*

Project Duration
Start Date: 1st July 2011 End Date: 31st December 2014

Project Description / Task Objectives
Existing research data is often underused. Much of it is not readily accessible or else not in a form useful for potential end-users, limiting the ability for science to inform environmental decision making and policy development, or inform the wider community.

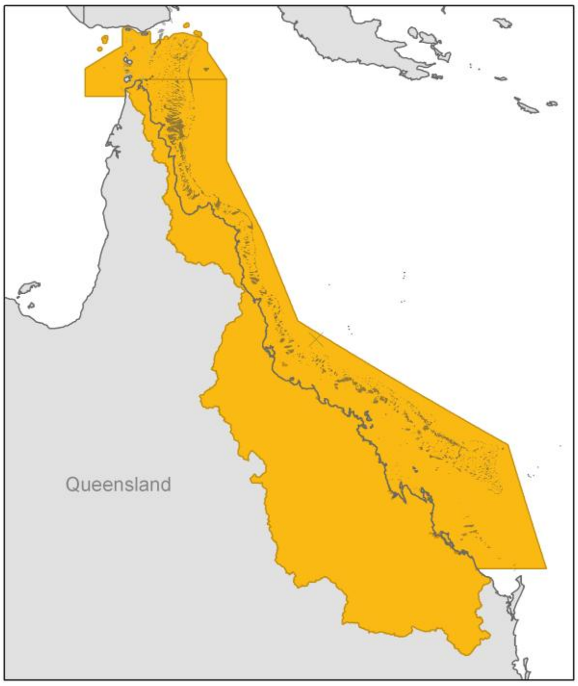

Figure 1 The above map shows an overview of the bounds of the NERP TE Hub projects represented by the e-Atlas.

The e-Atlas is a website, mapping system, and set of data visualisation tools for presenting research data in an accessible form to allow greater use of this information. Its primary goal is to provide awareness of what research has been done at a given location and/or on a given topic, and for it to provide map visualisations of key datasets to support the work of environmental managers. Its secondary goal is to provide, where possible, open access to research data and their associated visualisation products, to the general community.

Under the NERP the e-Atlas will serve as the primary data and knowledge repository for all NERP TE Hub projects capturing and recording their research outcomes and making them available to research end-users in a timely, readily accessible manner. It will host meta-data records and project data products for all research datasets, and provide an enduring repository for raw data[17]. It will also develop and host web visualisations to allow previewing and interaction with project data. This will assist scientists with data discovery and allow environmental management to ready access and investigate research data.

Each node of the NERP TE Hub (Rainforest, GBR, Torres Strait) has a strong connection with its corresponding regional management agencies (WTMA, GBRMPA, TSRA). The e-Atlas will work closely with each of these agencies and other research end-users to establish the systems, tools, products and form of information that will maximise the benefit from each the NERP TE research projects.

The e-Atlas was established as a MTSRF project to capture and communicate research outcomes. The following shows some examples of the existing system:

Front page: http://e-atlas.org.au/
Dataset page: http://e-atlas.org.au/content/gbr-jcu-bathymetry-gbr100
Mapping system (showing water quality data): http://maps.e-atlas.org.au/mmp/
Article: http://e-atlas.org.au/content/relationship-between-corals-and-fishes-great-barrier-reef

[17] As per the NERP TE Data Management Protocol all projects are required to store their raw data in an enduring repository which can be the e-Atlas or a suitable institutional repository such as the Tropical Data Hub (JCU) or the AIMS data centre.

Key Objectives
This project will utilise best practice knowledge management for research data and extend the approach based on engagement with researchers and research users. The key objectives for the project are:

1. Ensure that research outcomes of all NERP TE Hub projects are captured, recorded and made available to end-users in a readily accessible manner, utilising best practice knowledge management for research data and extending the approach based on engagement with end-users. This includes a data repository, a meta-data repository, data visualisation, and research documentation.
2. Develop visualisations for all NERP TE Hub spatial and non-spatial data and make them available in a manner suitable for fostering research collaboration and to develop key datasets for use by environmental managers and policy makers.
3. Integrate the e-Atlas with the NERP TE Hub management website and any website associated with the Reef Rescue R&D program.
4. Maintain existing content in the e-Atlas, which includes MTSRF data. This will involve migrating and upgrading the presentation of legacy data to be compatible with future changes.
5. Expand the range of non-NERP data available through the e-Atlas to include datasets that provide context for the research data in the system, as well as priority datasets requested by key end-users.
6. Develop a Torres Strait e-Atlas that will make available all Torres Strait NERP research as well as TSRA data holdings and priority historical Torres Strait research data including CSIRO's data holdings. Additionally:
    a. Customise the front-end of the Torres Strait e-Atlas website and mapping system to meet the needs of Torres Strait Rangers, TSRA, and other Torres Strait based users.

    b. Build capacity in TSRA staff, Torres Strait rangers, and other Torres Strait e-Atlas end-users to maximise the use and value of the Torres Strait e-Atlas as an interface to Torres Strait research outputs. This will be provided through training and the development of training tools (manual, DVD tutorials, etc).
7. Collaborate with other knowledge management initiatives including the Australian Ocean Data Network, Tropical Data Hub, Atlas of Living Australia, Research Data Australia, the Torres Strait Traditional Ecological Knowledge system to ensure that the e-Atlas utilises and complements these initiatives.
8. Adapt the e-Atlas system to overcome impediments to its adoption by key end-users, and continue its development as needed by project objectives and to meet the expectation of end-users.
9. Maintain and expand the e-Atlas hosting to ensure the website is fast, reliable and secure.

Project / Task Methodology
This project will utilise the tools and data delivery 'back-end' established in the e-Atlas project funded by MTSRF. This system will be further developed based on stakeholder feedback and as required by project activities. This core system will provide a user-friendly and flexible data platform for NERP TE Hub project outputs, delivered via a normal web browser. Research content will be presented using images, diagrams, maps (online interactive maps, offline PDF maps, Google Earth maps) and text articles. Content will generally be available publically, although the e-Atlas will support access controls to allow research results to be shared with management agencies, prior to general publication of the content.

Objective 1: Capturing NERP TE Hub research outcomes
The e-Atlas will capture the research outcomes using a number of mechanisms, including meta-data records, project summaries, links to project technical reports and journal papers, and map visualisations.

1. *Data repository:* The e-Atlas will provide a data repository for all projects accessible through the e-Atlas website. The e-Atlas will be hosted at the Australian Institute of Marine Science (AIMS) and backed up as per the *AIMS IT Disaster Recovery and Business Data Continuity Plan*. AIMS has agreed to provide a long term commitment to continue the hosting the e-Atlas after the completion of the NERP TE Hub.
2. *Meta-data repository:* The e-Atlas will adopt a standards based approach to meta-data in line with best practice. The e-Atlas will develop, in collaboration with researchers, meta-data records (based on the ISO19139 MCP standard) for all NERP TE Hub projects. These meta-data records will describe the data created as part of the research, recording the nature of the data and the methodology used in its production. A new meta-data repository will be established for e-Atlas (based on ANZ-MEST and AIMS Meta-data viewer software) which will allow its meta-data records to be exported to Research Data Australia. Each meta-data record will be presented in a user-friendly manner by using the AIMS Meta-data viewer and will be discoverable through Google. These meta-data records will describe the research data, not its interpretation or the overall results of the research, for this we use a research summary page.
3. *Project research summary pages:* The key research results will be captured by hosting a brief summary of the key research findings for each research project. These pages will be a condensed version of the research outcomes described in the full research technical reports and will allow environmental managers and policy makers to quick assess to the scope of the research and the key findings in a timely manner. Access control will be implemented to allow key end-users to access critical material in a timely manner while still ensuring opportunity for researchers to publish results in scientific journals These pages will allow both non-spatial and spatial data to be captured. These summary pages (in effect a mini-website for each project) will act as a portal for accessing more detailed products such as meta-data, data downloads, interactive maps, technical reports, publications and links to the NERP TE Hub management website. These summary pages will act as a suitable reference point for linking to the research from the GBRMPA Outlook report.

   These pages will complement the NERP TE Hub management site; the e-Atlas pages will focus on research knowledge where as the management website will provide project management.

   The content for the research summary pages will be developed by the research providers as part of their project reporting using a template developed by the e-Atlas team. The e-Atlas team will convert the summary reports to web pages for upload on the e-Atlas, as well as provide assistance with production of maps.

Objective 2: Visualisation of NERP TE Hub research data

1. *Dataset previews:* The e-Atlas will work with researchers to provide map previews for all key research data. These visualisations will allow interactive access and will allow results from multiple projects to be easily combined and compared against each other, assisting in development of high level synthesis knowledge and allowing researchers to more easily evaluate research data prior to establishing collaborations with the data providers.

   For non-spatial data the most appropriate preview will be discussed with the data provider, some possible types include: diagrams, graphs, images, text, snippets of the data in a table or a database structure diagram.

   For spatial data maps will be produced and made available in a variety of formats to ensure they can be easily used by all end-users. They will be available in the e-Atlas web mapping client, available through the Australian Ocean Data Network portal, available as Google Earth files (KML) and as publication maps on request from researchers. The e-Atlas will work closely with end-users to ensure the formats of the maps suit their needs and with data providers to ensure the data is presented in a suitable manner. The e-Atlas will work with GBRMPA to ensure that the map data is in a form suitable for the development of publication maps for the Outlook report.

   To assist in the process of developing valuable visualisation products for each research project the e-Atlas team will meet with both the end-users and project leaders to establish deliverables to the e-Atlas.

   The process of taking research data and making it web enabled, suitable for interactive visualisations, is non-trivial for most datasets with it varying between 2 days and 3 months of work per dataset depending on the nature, size, and format of the data. To keep within the e-Atlas budget each of the research projects will, as a minimum, be provided with a basic dataset visualisation that provides a preview of the data. The form of these previews will developed in collaboration with each NERP TE Hub project and will vary based on the research outcomes. As a minimum, each project will have a site map outlining the type of research performed at each site. Having a preview of the data allows end-users to quickly establish the scope and nature of the data far better than simply meta-data records, without the need to obtain and process the raw data.

2. *Advanced dataset visualisations:* In addition to basic previews a number of key priority datasets (as determined by end-users) will be developed as much more detailed and interactive visualisations. These visualisations might be for use by environmental managers or for broader community awareness of the research.

3. *External visualisations:* For some projects, the visualisation products will be developed as part of the projects themselves, and hosted by the research institution. An example of this is Project 3.1 Rainforest Biodiversity by Steve Williams. In this case, due to the volume of data and the specific requirements for its delivery, the visualisation will be developed by the Tropical Data Hub (TDH) and hosted by JCU. In this case the e-Atlas will work with the TDH to maximise the integration of their visualisation products with the e-Atlas system.

Objective 3: Integration with the NERP TE Hub management website

The e-Atlas will be integrated with NERP TE Hub management website and any website associated with the Reef Rescue R&D program. This will involve upgrading of the e-Atlas website (from Drupal 6 to Drupal 7) and collaborating with the teams building these websites. This integration between these sites will allow each site to focus on its designated role, but allow appropriate content to be linked and integrated without duplication.

Objective 4: Maintain and migrate legacy e-Atlas data

1. *Migrate legacy website and data content:* As the e-Atlas systems are upgraded and changed to meet the project objectives the existing content in the e-Atlas, established in the MTSRF, will be migrated and upgraded accordingly. This will include the migration of and reformatting of existing meta-data records into the new meta-data repository established as part of objective 1.2. In addition to this the existing website content will be migrated into the new version of the e-Atlas website setup for objective 3.

2. *Rework and migrate existing GBR maps:* Some of the existing datasets in the e-Atlas will be reworked to correct mistakes and to improve their presentation and flexibility to take advantage of the new mapping system used by the e-Atlas. The bulk of this work will be the rework and migration of the 400 existing GBR-wide spatial interpolation layers produced by Glenn De'ath. This rework will incorporate feedback to present the maps in a way that will improve confidence in the interpolation maps through improved clipping, access to measurement data and provide better meta-data.

Objective 5: Expand the content of the e-Atlas to provide broader contextual information for NERP outcomes and cater to research user priorities

1. *Add ALA and AODN data layers:* A wide range of data layers (not from the MTSRF or NERP programs) will be added to the e-Atlas sourced from existing public Web Map Services (WMS). These reference data layers will be chosen based on those that complement the research data layers. This will include the integration of 300+ layers from Atlas of Living Australia (ALA) and 50+ datasets from Australian Ocean Data Network (AODN). These layers will significantly add to the content available through the e-Atlas, at a relatively low cost as these layers have already been prepared. The bulk of the work associated with this task is associated with integrating with the ALA and obtaining of rights to redistribute these layers.

2. *Reference datasets:* A range of priority data layers will be added to the e-Atlas based on the requests from end-users. These data layers will typically provide context for the research data particularly for environmental management. An example of this would include Queensland landuse (DERM) which is used for coastal ecosystem management.

3. *WTMAps:* The e-Atlas will also provide the public web delivery of Wet Tropics Vegetation Mapping (WTMAps) dataset as a multi-level zoomable map. This flagship dataset for WTMA provides highly detailed vegetation mapping for the Wet Tropics region. It will be of great value to terrestrial

rainforest researchers, wet tropics and coastal ecosystem management, and the general community. Due to the size of the dataset there has not, until now, been a delivery mechanism that would allow the full display of this dataset via the web. The e-Atlas will provide that mechanism.

4. The Wet Tropics Vertebrate Atlas with 200 species distribution maps (provided by Professor Steve Williams and developed as part of MTSRF) will be made available through the e-Atlas.

5. *RRMMP data:* Make available Reef Rescue Marine Monitoring Program (RRMMP) content delivered to the e-Atlas. Use similar presentation and visualisation tools as per the NERP-TE projects.

Objective 6: Torres Strait e-Atlas

1. *Torres Strait e-Atlas overview:* A public Torres Strait e-Atlas website will be developed based, as a starting point, on the existing e-Atlas system. This site will provide public access to a comprehensive record of spatial research data covering the Torres Strait region. It will be presented using an accessible user-friendly platform that can run in a normal personal computing environment via an internet connected web browser. Its structure and format will be tailored for Torres Strait Rangers and Tagai College, as well as the TSRA, DSEWPaC, and researchers.

2. *Historical CSIRO data holdings:* CSIRO will develop map layers and data products for the Torres Strait e-Atlas from its extensive historical data holdings. The number and specifics of which datasets will be developed will be prioritised by the Torres Strait end-users in discussion with CSIRO and the e-Atlas team to ensure the most useful datasets are developed within the resource limits of the project. If the datasets are remotely hosted at CSIRO then they will be delivered and setup to meet e-Atlas standards (that will be developed with end-users) to ensure consistent delivery of all e-Atlas products, regardless of the source.

3. *Torres Strait e-Atlas content:* The Torres Strait e-Atlas website will incorporate:

    - NERP TE Hub outputs (metadata, articles, and data) presented as mapping layers.
    - Reference map datasets for the region (public satellite imagery, points of interest, special area boundaries, bathymetry, maritime boundaries, etc)
    - Pre-NERP Torres Strait research data, especially CSIRO data holdings.
    - TSRA/LSMU data holdings, such as the Terrestrial Biodiversity Project, Sea Country Planning Project, and other LSMU datasets, with development of appropriate data management access arrangements to ensure the protection of sensitive information.

    Further datasets and outputs from historical TS research (AIMS, CSIRO, TSRA, DEEDI, JCU, AFMA, CRC, MTSRF), suitable for upload into e-Atlas, will be identified. This activity will link with and draw on existing collations of articles and datasets, especially those which have already been processed into GIS layers, to maximise the efficiencies and comprehensiveness of the e-Atlas and avoid duplication of effort. It will draw heavily on Torres Strait data holdings and numerous data layers at CSIRO including those compiled in the Torres Strait Marine Research Repository (CSIRO staff are in the project team to facilitate this). The project will also link to Dr Alana Grech's (JCU) project, which is processing GIS layers from selected TS datasets including those of TSRA (including the Terrestrial Biodiversity Project, Sea Country Planning Project, and other LSMU datasets), JCU, and three layers from CSIRO research associated with TS seabed mapping. Upload of the selected datasets will be pending appropriate data use arrangements (see 4 above). The e-Atlas team will collaborate with the team developing the Traditional Ecological Knowledge system to identify possible connections between the two projects.

    Note: In AWP1 the Torres Strait e-Atlas will focus on making available data holdings of the TSRA.

4. *Torres Strait end-user engagement:* The e-Atlas team will liaise with Torres Strait based end-users to prioritise and rationalise the datasets to be uploaded, identify and resolve IP and data access issues especially around sensitive data, identify the data product formats of preference to meet their needs; and take direction for the design and utility of a customised Torres Strait e-Atlas front-end. This will be achieved through a range of consultation and engagement measures including annual workshops with key end-users (TSRA, AFMA and Tagai College) to identify prioritise datasets, implementation and to provide training and capacity building.

5. *Torres Strait e-Atlas customisation:* The front-end of the website and mapping system will be customised to suit the needs of Torres Strait Rangers and the TSRA. The form of this project will be determined in consultation with the TSRA and Torres Strait Rangers during AWP 2 (2nd workshop). This timing is to allow the end-users to trial the prototype Torres Strait e-Atlas system, based largely on the existing e-Atlas system, before determining priority feature changes. This activity will focus on identifying the major hurdles to the adoption of the e-Atlas in everyday use, and addressing those.
6. *Torres Strait e-Atlas training and capacity building:* A user manual and other training tools will be developed. In-house training with TSRA and TS rangers in e-Atlas use and application will be provided as part of the annual workshop.

Objective 7: Collaborate with similar initiatives
The e-Atlas team will work to establish functional collaborations with other government initiatives similar to the e-Atlas to maximise comprehensiveness of the e-Atlas and avoid duplication of effort. The e-Atlas will share technical knowledge, software, and content and work toward standardised implementation of systems where there are common goals.

1. All map layers developed and hosted by the e-Atlas will be exported to the Australian Ocean Data Network and be available in their portal. This will improve the discoverability of the research.
2. The e-Atlas will integrate of 300+ layers from Atlas of Living Australia and 50+ datasets from Australian Ocean Data Network, significantly adding to the content available through the e-Atlas. The bulk of the work associated with this task is integrating with the meta-data provided by these providers and obtaining of rights to redistribute these layers
3. The e-Atlas team will work with the Tropical Data Hub (JCU) to assist them in the design of the visualisation of Project 3.1 Rainforest Biodiversity (Prof. Steve Williams) to ensure that where possible the outcomes can be integrated with the e-Atlas mapping system.
4. All meta-data records produced will be exported to Research Data Australia.

Objective 8: e-Atlas system development to ensure end-user utilisation and adoption
The e-Atlas systems will be developed to:

1. Implement the system changes required to meet objectives 1 – 8. This development is necessary as it provides the framework that will allow the e-Atlas to integrate with other websites, provide improved access to meta-data within the mapping system, allow the e-Atlas to handle more data layers, combine layers from multiple data sources and provide access control over datasets.
2. Incorporate end-user feedback to improve the usability and value provided by the system.
3. Adapt the systems or content to overcome any impediments to its uptake within key end-users. This will include improving support to allow ArcMap users to create and use the e-Atlas content in the production of their own environmental reporting products such as the GBRMPA Outlook report. This work will also include adapting the mapping system to ensure that it works well with private data.
4. Add features required to support new dataset types and improve the interactive access to the hosted data.
5. Allow the e-Atlas to host non-public (or pre-release) datasets, accessible by password access control. This will allow environmental managers to access prepublication research data and will allow the e-Atlas to host datasets that can not be made publically available due to restrictive licenses.
6. Release the AtlasMapper (e-Atlas web mapping client) code as required by GPL licensing.

Objective 9: Maintain reliable, fast and secure hosting
This objective involves ensuring that the services provided by the e-Atlas are reliable, fast enough, and secure. This is achieved by:

1. Rebuilding the e-Atlas host server to the latest version of the server operating system to remove legacy software that may act as a security risk.

2. Installing digital certificates to secure the login (using https) used by the access control over data layers.
3. Maintaining the offsite e-Atlas backup server. This server provides a mirror of the e-Atlas if the primary server is down for any reason.

Project Outputs/Outcomes

- Meta-data records for all NERP TE Hub projects, hosted in a meta-data repository harvestable by Research Data Australia.
- Research summary pages hosted on the e-Atlas that will collate key research outcomes and products including technical reports, meta-data records, key data available for download (where possible), map products, links to NERP TE Hub management website. These pages will allow the research to be highly discoverable (with the internal e-Atlas search, and through Google), quickly assessed by end-users, provide access to more detailed research information, be easily linked to from external reports (such as the GBRMPA Outlook report) and will complement the NERP TE Hub management website.
- Preview maps of all NERP TE Hub spatial research data. These maps will be provided in a range of formats to ensure they can be accessed on any computer. This will include access to map layers using a web browser, PDFs, and Google Earth KMLs. The form and level of access to the research data will be determined by licensing and discussions with the data providers. Maps developed for the e-Atlas will be available as a public Web Map Service (WMS) suitable for integration with external mapping systems and desktop GIS software (such as ArcMap and QGIS). All layers will be exported and made available through the Australian Ocean Data Network (AODN) web portal.
- The development of a fast, flexible and state of the art mapping client (called the AtlasMapper) designed to run on any web browser and allow the integration of, and interaction with, map layers from a range of sources. This software will be made available as an open source software project. It will be developed to meet the needs of the e-Atlas end-users to maximise the utilisation and accessibility of the available map data.
- A Torres Strait e-Atlas that allows access to NERP research, prioritised historical research and reference data, providing a comprehensive information system for the region. Where licensing permits, data and maps will be made publically available. The Torres Strait e-Atlas front-end will be customised and targeted training provided, to ensure that the e-Atlas is both accessible and used by key end-users, including TSRA, TS rangers, researchers, TS community, and DSEWPaC.
- Fast, reliable and secure hosting of the e-Atlas web site and mapping system, ensuring that end-users can rely on its services.
- Key non-NERP datasets (as determined with end-users) will be visualised and made available through the e-Atlas mapping system including Wet Tropics Vegetation (WTMAps) dataset and the Vertebrate Atlas (Williams, JCU) developed under MTSRF. The WTMAps will be made available publicly as a zoomable map showing all 5 levels of this very large dataset. For the Vertebrate Atlas (Williams, JCU) the distributions of 200 species across the wet tropics regions will be visualised.
- An interactive web based mapping system containing layers from MTSRF research (~400 layers), NERP TE Hub research (100 – 400 layers), existing reference layers (~30 layers), Torres Strait layers from historical data (80 – 200 layers), and additional reference layers harvested from Atlas of Living Australia (300+ layers) and the Australian Ocean Data Network (50+ layers) making the e-Atlas the most comprehensive data resource for the region.

Expected benefit for end-users

- An accessible and user-friendly platform that delivers the most comprehensive compilation of ecological information about terrestrial and marine tropical ecosystem in Queensland, including the Torres Strait, along with the latest research results.
- The tools and capacity for environmental managers and key stakeholders to readily access information regarding the state of knowledge for a given area or ecosystem.

Linkages

- The e-Atlas will provide services and links to the NERP TE Hub management website. We will work with the team developing this website to ensure the e-Atlas is compatible.
- NERP TE Hub knowledge brokering and communications program. This program will provide much of the written material for articles and meta-data to the e-Atlas.
- The websites and data centres of appropriate management agencies (GBRMPA, TSRA, WTMA).
- Other data visualisation initiatives including Atlas of Living Australia, Australian Ocean Data Network, and the Tropical Data Hub (JCU).

Identified and assessed hazards

Description of Risk	Assessed Risk	Risk Control measures
Failure to achieve significant uptake with end-users	Medium	Significant engagement with end-users to identify how the e-Atlas can be made more relevant, and to identify barriers to adoption within GBRMPA, TSRA and WTMA and other e-Atlas users
Content from projects not suitable for the e-Atlas end-users	Medium	The outcomes to be delivered to the e-Atlas will be discussed with each of the NERP TE Hub projects in AWP 1. The requirement of a project summary suitable for the e-Atlas will be included in the project reporting process of the NERP TE Hub. Templates and examples will be provided to assist researchers in what is expected.
Failure to provide data in a form most desired by end-users due to restrictions in data licenses	Medium	The e-Atlas team will work with data providers to establish the most open form of the data (or most useful preview of the data) that is acceptable to them. We will develop improved visualisation methods that provide a better preview of the data, without access to the data. We will also work with GBRMPA, TSRA, and WTMA to find a suitable way for them to integrate their private data with e-Atlas layers.
Failure to provide a reliable website, due to hosting outages	Low	An independently hosted backup server for the e-Atlas site has been setup. It automatically hosts a mirror of the site in the event of an outage of the primary server.
Slow performance due to increased traffic on the site	Low	The current server capacity should allow for an increase in site traffic of greater than 10 -20 times without a significant drop in performance.
No further funding is found for e-Atlas system development past AWP 2	Medium	The current funding for the project only covers system development (by Gael Lafond) for the first two years of the project. As much system development as possible will be done in the first 2 years of the project.
Failure to obtain key historical data	Low	Good relationships will be established with the data custodians in each of the management agencies. CSIRO staff have been included in the project budget.
Failure to achieve uptake by the TSRA and TS community	Medium	Workshops/meetings will be convened with key end-users at key project stages to ensure engagement and appropriate products. Targeted training for end-users.
Web based delivery of e-Atlas not suitable for Torres Strait due to limited internet access	Medium	Based on feedback from TSRA we will develop the ability to produce printed maps suitable for offline use.

Project Budget

TOTAL REQUESTED FROM NERP (Jul 2011 – Dec 2014): 1,048,065

AWP 1 (July 2011 to June 2012) Project Funding

Contributing Organisation	Cash	In-kind	Total
NERP	290,000		277,471
AIMS		303,361	303,361
CSIRO		23,588	23,588
Total	**290,000**	**326,949**	**616,949**

AWP 2 (July 2012 to June 2013) Project Funding

Contributing Organisation	Cash	In-kind	Total
NERP	277,471		277,471
AIMS		401,697	401,697
CSIRO		24,898	24,898
Total	**277,471**	**426,595**	**704,066**

AWP 3 (July 2013 to June 2014) Project Funding

Contributing Organisation	Cash	In-kind	Total
NERP	309,552	-	309,552
AIMS	-	327,480	327,480
CSIRO	-	25,335	25,335
TSRA (LSMU)	-	18,740	18,740
Total	**309,552**	**352,815**	**662,367**

AWP 4 (July 2014 to December 2014) Project Funding

Contributing Organisation	Cash	In-kind	Total
NERP	171,042		171,042
AIMS		184,930	184,930
CSIRO		11,580	11,580
Total	**171,042**	**196,510**	**367,552**

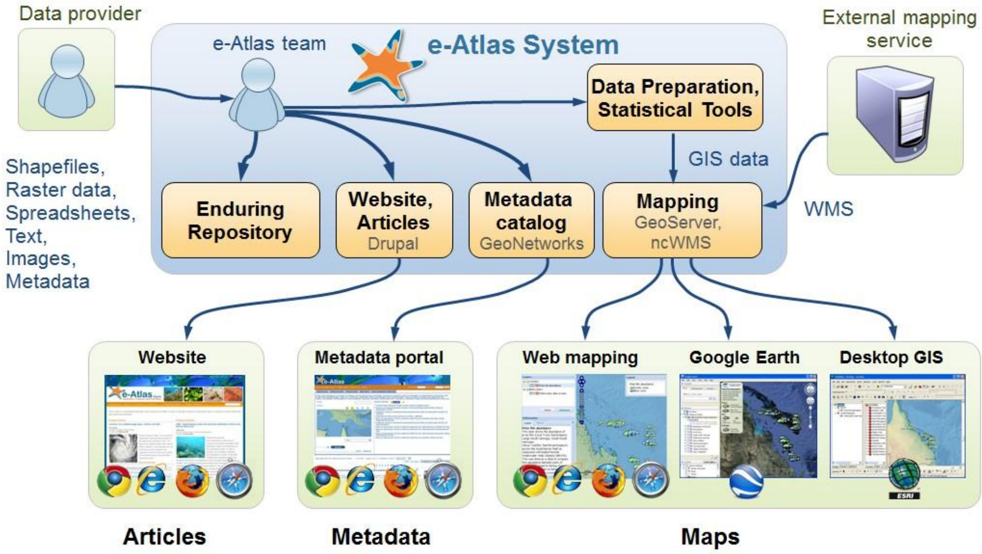

Figure 1 Structure of the e-Atlas along with workflow of research outcomes (data and documentation) through to the presentation of this material on the web. Note: All the software components in the system are open source.

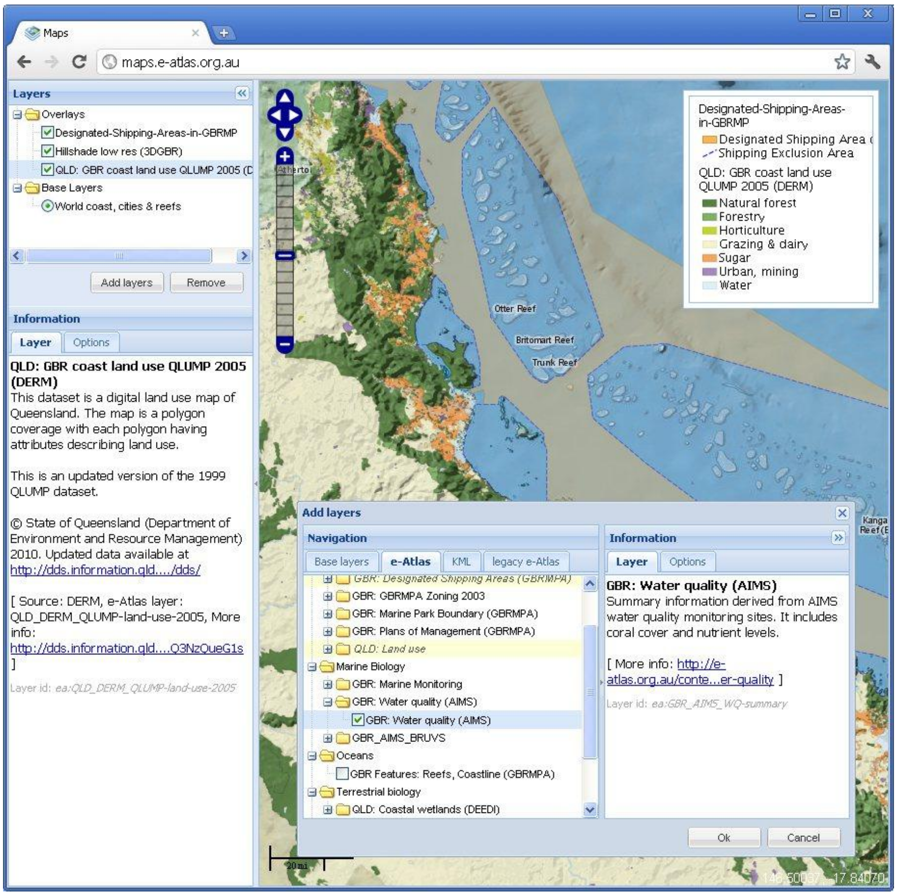

Figure 2 Screenshot of the mapping client for the e-Atlas (AtlasMapper) currently in development. It allows layers to be investigated, compared and styled. In the future it will allow the map to be saved, exported for use on any website, and printed to a graphic for use in a report.