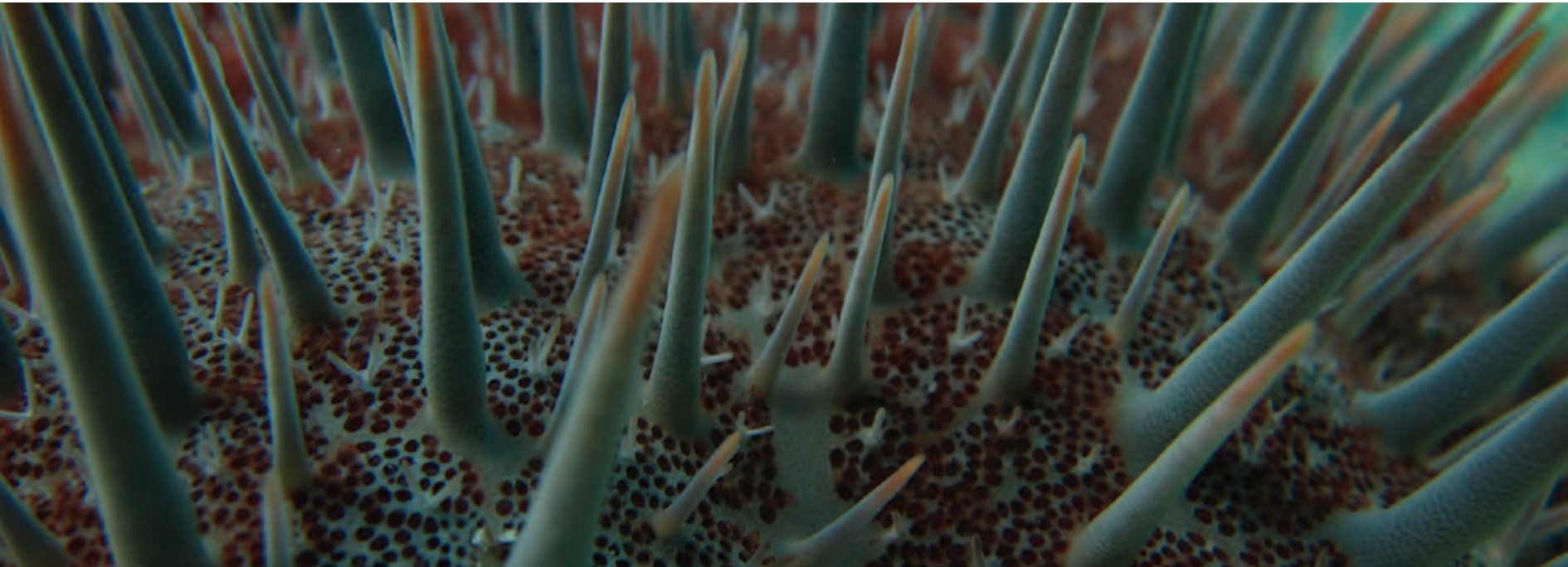
National Environmental Research Program

TROPICAL ECOSYSTEMS hub

NERP TE Hub Research Snapshot: Great Barrier Reef Biodiversity

January to June 2013 Compiled by RRRC



About the NERP

National Environmental Research Program

The overall objective of the National Environmental Research Program is to improve our capacity to understand, manage and conserve Australia's unique biodiversity and ecosystems. It will achieve this through the generation of world-class research and its delivery to Australian environmental decision makers and other stakeholders. The Program features five research hubs, including the Tropical Ecosystems Hub.

The Tropical Ecosystem Hub

The Tropical Ecosystem Hub is a $61.89m investment that address issues of concern for the management, conservation and sustainable use of the World Heritage listed Great Barrier Reef and its catchments; tropical rainforests, including the Wet Tropics World Heritage Area; and the terrestrial and marine assets underpinning resilient communities in the Torres Strait.

www.nerptropical.edu.au

Image to the left: RRRC

Front cover Image: Close up of crown of thorns starfish's spines (*Acanthaster planci*) from Forrester Reef. The spines of the crown-of-thorns are extremely sharp and toxic. *LTMP*

Contents

Introduction

Great Barrier Reef Biodversity

The TE Hub supports 38 research projects, with fifteen focused on Biodiversity within six Programs:

- Historical and current condition of the Great Barrier Reef
- Cumulative impacts on benthic biodiversity
- Movements and habitat use by marine apex predators
- Effectiveness of spatial management on the Great Barrier Reef
- Decision support systems for Great Barrier Reef managers
- Socio-economic value of Great Barrier Reef goods and services

For further information on TE Hub structure please go to:
www.nerptropical.edu.au

While cyclones cause a lot of damage to some parts of a reef other areas, are unscathed. Here branching coral continues to proliferate at Broomfield Reef. By using the manta tow technique, the LTMP can assess which areas of a reef are most impacted by disturbances like COTS and storms, as the perimeter of each reef is surveyed in this technique. *Image: LTMP*

Programs & Projects

The NERP TE Hub Great Barrier Reef Biodiversity Node

Program 1: Historical and current condition of the Great Barrier Reef
Project 1.1: Monitoring status and trends of coral reefs of the Great Barrier Reef
Project 1.2: Marine wildlife management in the Great Barrier Reef World Heritage Area

Program 5: Cumulative impacts on benthic biodiversity
Project 5.1: Understanding diversity of the Great Barrier Reef: Spatial and temporal dynamics and environmental drivers

Program 6: Movements and habitat use by marine apex predators
Project 6.1: Maximising the benefits of mobile predators to Great Barrier Reef ecosystems: the importance of movement, habitat and environment
Project 6.2: Drivers of juvenile shark biodiversity and abundance in inshore ecosystems of the Great Barrier Reef
Project 6.3: Critical seabird foraging locations and trophic relationships for the Great Barrier Reef

Program 8: Effectiveness of spatial management on the Great Barrier Reef
Project 8.1: Monitoring the ecological effects of the Great Barrier Reef zoning plan on mid and outer shelf reefs
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 8.3: Significance of no-take marine protected areas to regional recruitment and population persistence on the Great Barrier Reef

Program 9: Decision support systems for Great Barrier Reef managers
Project 9.1 Dynamic vulnerability maps and decision support tools for the Great Barrier Reef.
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

Program 10: Socio-economic value of Great Barrier Reef goods and services
Project 10.1: Social and Economic Long Term Monitoring Programme (SELTMP)
Project 10.2: Socio-economic systems and reef resilience

Researcher Profile

Dr. Hugh Sweatman

Australian Institute of Marine Science (AIMS)

Dr. Sweatman is a Senior Research Scientist at AIMS and leads the Long-term Monitoring Program for coral reefs of the Great Barrier Reef. He trained as a behavioural ecologist working on reef fishes and has worked on the GBR and in the Caribbean (Panama). His research interests have broadened to processes of disturbance and recovery on reefs, particularly as applied to the GBR. After graduating, he worked briefly at University of Sydney then spent three years as a post-doc at the Smithsonian Tropical Research Institute in Panama. From 1990 he was a post-doc at James Cook University, initially studying fish predators of Acanthaster planci, then the effects of feeding fishes around tourist pontoons (Reef CRC). In 1995 he came to AIMS to lead the Long-term Monitoring Program.

A crown-of-thorns starfish eating one of its favourite types of corals, tabulate Acropora. Crown-of-thorns starfish are not usually found out in the day, until they are large adults, or the density of starfish is high.
Image: LTMP

Project 1.1: Monitoring status and trends of coral reefs of the Great Barrier Reef. *Project Leader: Dr. Hugh Sweatman, AIMS*

Project Background

This project continues a unique data set that documents long-term trends in coral reef communities of the Great Barrier Reef (GBR). Regular surveys of fish, coral and coral predators such as crown-of-thorns starfish on 47 reefs since 1992, provide the 'big picture' on the condition of reefs on the GBR and how they are changing over time. The project employs a range of surveying techniques to detect events likely to have large-scale impacts on reef health, such as coral bleaching, coral disease, cyclones or crown-of-thorns starfish outbreaks.

Project Progress

Recent surveys for the status of the Great Barrier Reef have revealed that the numbers of reefs with destructive densities of crown-of-thorns starfish is as high as has ever been recorded in 28 years of surveys – nearly all inshore and mid-shelf reefs between Cooktown and Lizard Island have outbreak densities. The apparent gradient in size of the starfish suggests that the outbreaks in the north are older, and so outbreaks have been reported in the Cairns region and can be expected to be much more evident in the next 12 months. If this is indeed the start of the fourth recorded wave of outbreaks, it will be interesting to see if the reduced coral cover on reefs between Innisfail and Townsville following Cyclone Yasi changes the dynamics of the wave.

The numbers of juvenile corals (<10cm diam) on reefs in the southern and central GBR has increased in each survey since Cyclone Hamish in 2008, an early sign of recovery – but substantial recovery depends on there being a period of at least a decade without widespread intense disturbances.

Work on this project alternates with that for Project 8.1: Monitoring the ecological effects of the Great Barrier Reef Zoning Plan on mid and outer shelf reefs

A diver surveying the reef for juvenile corals. *Image: Michelle Jonker*

Researcher Profile

Professor Helene Marsh

James Cook University (JCU)

Professor Helene Marsh is Distinguished Professor of Environmental Science and the Dean of Graduate Research Studies at James Cook University. She is a Fellow of the Australian Academy of Technological Sciences and Engineering and Co-Leader of the Species of Conservation Concern program of the Australian Government's National Environmental Research Program (NERP) Tropical Ecosystems Hub.

Professor Marsh's extensive research interests include: marine conservation biology; marine natural resource management; Indigenous marine resource management; establishing priorities for conservation intervention; and marine wildlife population ecology, especially life history, reproductive ecology, population dynamics, diet, distribution, abundance and movements of dugongs and coastal dolphins.

Policy outcomes resulting from her work include significant contributions to the science base for the Dugong Sanctuary established in Torres Strait; dugong management in the Great Barrier Reef Marine Park, especially the Dugong Protection Areas and 'no-take' areas to protect dugongs in marine zoning plans; and the establishment of a Commonwealth Ministerial Taskforce to Investigate the Sustainability of Indigenous Hunting of dugongs and turtles.

Dr. Mark Hamann

James Cook University (JCU)

Dr. Hamann is a Principal Research Fellow and Senior Lecturer in James Cook University's School of Earth and Environmental Sciences. He is also a member of the IUCN Marine Turtle Specialist Group and serves as a Regional Vice Co-Chair for the Australasia region. He also has an active role in developing marine turtle conservation programs in Viet Nam and Malaysia.

Dr. Hamann's postdoctoral work included development of community-based projects for the monitoring and management of marine turtles in Torres Strait and his main research interests lie in minimising human impacts on tropical marine wildlife and their habitats, and includes assessment of marine wildlife vulnerability (i.e. marine turtles, dugong and inshore dolphins) to climate change and coastal development, and understanding the role of marine turtles and dugongs in coastal environments. He is also interested in understanding the mechanisms of turtle dispersal and distribution, and impacts of plastic pollution on marine animals.

Project 1.2: Marine wildlife management in the Great Barrier Reef World Heritage Area.
Project Leaders: Professor Helene Marsh and Dr. Mark Hamann, JCU

Project Background

Marine mammals (dugongs and dolphins) and turtles are facing threats from human activities such as fishing, pollution and coastal development. The project team is using monitoring, genetics, satellite tracking and remote sensing techniques to determine the distribution and status of inshore dolphins in the northern Great Barrier Reef World Heritage Area (GBRWHA); to estimate the size of the dugong population along the GBRWHA coast; and to better understand the role of green turtles and dugongs in coastal ecosystems. The project is also working with Traditional Owners to protect these species, all of which have high conservation and cultural value.

Project Progress

Using support from the GBRMPA and QDEHP satellite tags have been attached to six green turtles residing in Shoalwater Bay, between Rockhampton and Mackay. The tracking was done concurrently with a Queensland Department of Environment and Heritage Protection (QDEHP) project, which attached satellite tags to dugongs in the same area. Tracking data from 5 to 6 months indicates that turtles use a small home range encompassing the intertidal reaches, whereas dugongs have a larger home range spanning across much of the deeper water habitats in the central bay. The turtle tracks may be followed at http://www.seaturtle.org/tracking/index.shtml?keyword=108468.

Inshore Dolphin Project Scoping Field Trip (November 2012).
Kanthanumpu land and sea country in the Lockhart River region. *Image: Helen Penrose (JCU)*

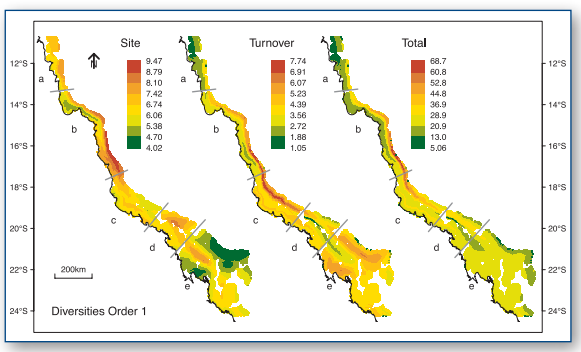
Researcher Profile

Dr. Glenn De'ath

Australian Institute of Marine Science (AIMS)

Dr. De'ath is a Principal Research Scientist, biostatistician and ecological modeller at AIMS. His interests lie in the development of statistical and mathematical models and their application to complex biotic and environmental data. He has been intimately involved with the establishment of water quality guidelines, the regionalisation and rezoning of the GBR, the re-design of the AIMS Long Term Monitoring Program to assess the effects of the rezoning, and the development of the e-Atlas. He has also developed freely available statistical software, now widely used by many researchers across many disciplines.

Dr. De'ath is currently involved in research into the effects of climate change, water quality and crown-of-thorns starfish on the Great Barrier Reef, and in modelling the effects of environmental drivers on spatial and temporal change in diversity within ecosystems. Other work includes development of statistical and ecological models and methods, particularly with regard to multivariate regression trees, principal curves, extended dissimilarity, aggregated boosted trees and multinomial diversity models.



Site, turnover and total diversities of seafloor fish on the Great Barrier Reef.

Project 5.1: Understanding diversity of the Great Barrier Reef: Spatial and temporal dynamics and environmental drivers.
Project Leader: Dr. Glenn De'ath, AIMS

Project Background

Little information is available on the diversity of the GBR, or the mechanisms responsible for pattern. This project is mapping the diversity of biota and environments of the GBR, in order to relate biotic diversity to spatial, environmental and temporal drivers. The project is based on existing long-term and large-scale data from the GBR including the long term monitoring program on coral cover, data on density of crown-of-thorns starfish and seafloor diversity, large-scale diversity surveys of octocorals and corals, water quality and coral bleaching history, satellite derived sea surface temperature and ocean colour history data, and tropical cyclone path and intensity information from the Bureau of Meteorology.

Project Progress

The analysis of biological diversity along environmental gradients on the GBR has been made possible with the development of a new conceptual framework and statistical tool. The project team also completed the publication of a high profile analysis of spatial and temporal trends in coral cover on the GBR, and the drivers of change. These new tools have been applied to the large GBR Seabed Biodiversity data set, and changes in inter-reefal fish communities assessed along environmental gradients and nine GBR-wide maps produced on inter-reefal fish diversities.

Permanent transects on inshore reefs that are surveyed every year to quantify changes of the condition of the coral communities. Close examination of the composition and condition is used for the assessment of impacts of land runoff and other disturbances on inshore reefs of the GBR. *Image: AIMS Water Quality and Ecosystem Health Team*

Researcher Profile

Dr. Michelle Heupel

Australian Institute of Marine Science (AIMS)
James Cook University (JCU)

Dr. Heupel is an ARC Future Fellow jointly based at AIMS and JCU. Her postdoctoral experience includes a period at the Center for Shark Research at Mote Marine Laboratory in Sarasota, Florida where she was a principal researcher in the Elasmobranch Behavioral Ecology Program. She is currently a member of the Threatened Species Scientific Committee, a member of the IUCN Shark Specialist Group, and acts as a Subject Editor for the International Journal of Marine and Coastal Fisheries.

Dr. Heupel is currently involved in projects examining the long-term residence and movement patterns of coastal and reef predators including sharks, rays and large bony fishes. This research will include defining how individuals use space in relation to human activities (i.e. fishing, marine park zoning, boating) and environmental change (i.e. response to salinity, temperature change or extreme weather events).

A tagged blacktip reef shark fitted with an acoustic transmitter.
Image: Michelle Heupel

Project 6.1: Maximising the benefits of mobile predators to Great Barrier Reef ecosystems: the importance of movement, habitat and environment.
Project Leader: Dr. Michelle Heupel, AIMS & JCU

Project Background

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 Great Barrier Reef, where there is a complex mosaic of areas open and closed to fishing. 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.

This project aims to define the extent of movement of mobile predator species in coastal and reef ecosystems. It also aims to determine the factors that lead to changes in residency and movement; the role that active mobility plays in connecting populations; and the appropriate management responses.

Project Progress

To date more than 200 transmitters have been deployed in thirteen species of reef predator in the Townsville Reefs region and 259 in predators in the Capricorn Bunker Group reefs for comparative analyses.

Preliminary examination of shark movements in the Townsville reefs region has revealed a variety of patterns. Grey reef sharks tend to stay around the reefs at which they were captured, with few moving between reefs. Such sharks would have varying levels of protection from fishing depending on marine park zoning at the capture reef. In contrast, bull sharks move broadly within the reef network, moving in and out of marine park zones regularly. This species has also been observed to move inshore, to Orpheus Island and Cleveland Bay, and alongshore as far as Moreton Bay. Such bull shark movements result in varying amounts of time in protective zones. Blacktip reef sharks also move from inshore regions to Townsville reefs, suggesting connectivity between inshore and offshore components of this population.

PhD student Mario Espinoza suturing a grey reef shark during transmitter implantation. *Image: Michelle Heupel*

Researcher Profile

Dr. Colin Simpfendorfer

James Cook University (JCU)

Dr. Simpfendorfer is the Director of the Centre for Sustainable Tropical Fisheries and Aquaculture at JCU. He has had more than 25 years experience researching sharks, and has published extensively in the scientific literature on shark biology, ecology, fisheries and conservation. His expertise on sharks has been recognized by his appointment as the Co-Chair of the IUCN's Shark Specialist Group and as the Chair of the Australian Fisheries Management Authority's Shark Resource Assessment Group.

Dr. Simpfendorfer's research interests include: status and sustainable use of elasmobranch populations; science for the conservation of elasmobranch populations; nursery areas for sharks; and analytical tools for acoustic monitoring studies.

PhD student Audrey Schlaff releases a juvenile blacktip reef shark at Orpheus Island. Fitted with an acoustic tag, this animal is being tracked for up to two years to better understand how juvenile sharks respond to changes in their environment. *Image: Colin Simpfendorfer (JCU)*

Project 6.2: Drivers of juvenile shark biodiversity and abundance in inshore ecosystems of the Great Barrier Reef.
Project Leader: Dr. Colin Simpfendorfer, JCU

Project Background

This project is investigating changes in the biodiversity of sharks in inshore nursery areas along the Great Barrier Reef (GBR) coast. The aim is to understand how different factors, such as habitat, season, zoning and environmental parameters, such as discharge from rivers and streams, affect the abundance and diversity of sharks along the central GBR coast.

Project Progress

Shark nursery area surveys are providing information on spatial variation of juvenile shark occurrence along the GBR coast and have identified that at least 17 species of sharks use this region. Different species occur in different bays, indicating that maintenance of diverse habitats will be important for ensuring conservation of shark assemblages in this region. This result also suggests that utilisation of multiple bays along the coast may provide advantages to shark populations through Portfolio Effects including repeated use of narrow ranges of habitats or areas for reproduction; and the production of relatively stable numbers of offspring. These effects increase population stability despite environmental variation at small spatial scales.

Acoustic telemetry (i.e. tracking) is used to better understand the role of environmental factors as drivers of movement in juvenile sharks. Data collection is nearing completion and preliminary data indicate that many juvenile sharks spend long periods within their nursery areas. This suggests that they may have relatively high tolerances to variation in environmental conditions. However, extreme environmental perturbations do appear to result in movements. For example, most shark species left their normal ranges before Cyclone Yasi crossed the coast; returning only after conditions had normalised. At smaller spatial scales, juvenile stingrays exploit spatial variation in temperatures in the intertidal and in mangrove stands to maintain their preferred body temperatures.

Measuring a hammerhead before it is released. The nursery survey has released hundreds of tagged sharks that will help to understand the movements and growth of a range of shark species. *Image: Peter Yates*

Researcher Profile

Dr. Brad Congdon

James Cook University (JCU)

Dr. Congdon is Reader in Ecology at JCU (Cairns). As a research academic and field ecologist, he has had more than 30 years experience of applying ecological and evolutionary theory to the management and conservation of animal and plant species. He has a special interest in seabird conservation and has worked extensively with seabirds both in Australia and overseas. His current research is focused on understanding how changing ocean conditions impact seabird breeding success throughout the Great Barrier Reef and Coral Sea ecosystems. His research group was the first to demonstrate that seabirds are sensitive indicators of multiple climate-change impacts on top predators in these areas and have established that rising sea-surface temperatures are a major conservation issue for seabirds of the Great Barrier Reef.

Global Positioning System (GPS) device deployment on a masked booby - Swains Reefs, GBR. *Image: K. Verlis*

Project 6.3: Critical seabird foraging locations and trophic relationships for the Great Barrier Reef. *Project Leader: Dr. Brad Congdon, JCU*

Project Background

This project aims to identify and map foraging grounds for boobies and shearwaters; overlay satellite derived information on biophysical oceanographic characteristics; quantify prey availability; and establish linkages between areas, population processes, anthropogenic activity, and environmental effects including climate change.

Project Progress

Adult wedge-tailed shearwaters of the Capricorn-Bunker Region use near-colony foraging grounds to feed their chicks. Foraging activity at these sites appears linked to local upwellings associated with an eddy system in the lee of the bathymetry of the southern GBR. Some sites also appear to be heavily influenced by river flood plume dynamics and associated nutrient pulses. Adults on longer self-provisioning trips routinely travel to distant foraging grounds in the Coral Sea Region. These areas are characterised by steep bathymetric change, and associated large-scale oceanographic features such as frontal systems and eddies. Both near-colony and distant foraging locations can vary among seasons, but many birds consistently go back to specific locations within and between seasons. Current data are preliminary but confirm that many important foraging sites are outside the GBRMP management zone, and that foraging activity overlaps significantly with known commercial fishing activity.

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

Global location (GLS) device deployment on the tarsus of a wedge-tailed shearwater - Heron Island, GBR, Photo: *Image:* D. O'Hara

Researcher Profiles

Professor Gary Russ

James Cook University (JCU)

Professor Russ is a Professor in the School of Marine and Tropical Biology at JCU. His research interests on the Great Barrier Reef include studies of the biology and fisheries of reef fish of commercial and recreational fishing value (mostly serranids, lutjanids and lethrinids). Specific areas of research include age and growth, reproduction, mortality, movements, fish traps as sampling devices, catch per unit effort and stock assessment. A major area of research now and in the future, is studies of age structures of reef fish of commercial/ recreational significance on coral reefs open and closed to fishing.

Professor Russ is also undertaking long-term monitoring of reef fish populations inside and outside marine reserves in Southeast Asia. His work in the Philippines has been related to the use of marine reserves in reef fisheries management.

Dr. David Williamson

James Cook University (JCU)

Dr. Williamson is a postdoctoral fellow at the ARC Centre of Excellence for Coral Reef Studies at JCU. His research interests include larval dispersal of exploited reef fish, genetic connectivity of populations and potential export effects of marine protected areas (MPA's) within the GBR marine park. David has worked on Australian and international research and monitoring projects for organizations including the GBRMPA, the French Institute for Research and Development and the US based Smithsonian Institute.

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 Leaders: Professor Garry Russ and Dr. David Williamson, JCU*

Project Background

This project aims to assess the effects of multiple use management zoning of the GBR on reef fish, fishery target species, coral health and benthic communities. It also assesses usage patterns of recreational fishers and compliance with zoning regulations. The project has carried out Underwater Visual Census surveys on fringing reef slopes at Magnetic Island, Palm Islands, Whitsunday Islands, and the Keppel Islands. The surveys were conducted in zones that are open to fishing and those that are closed to fishing.

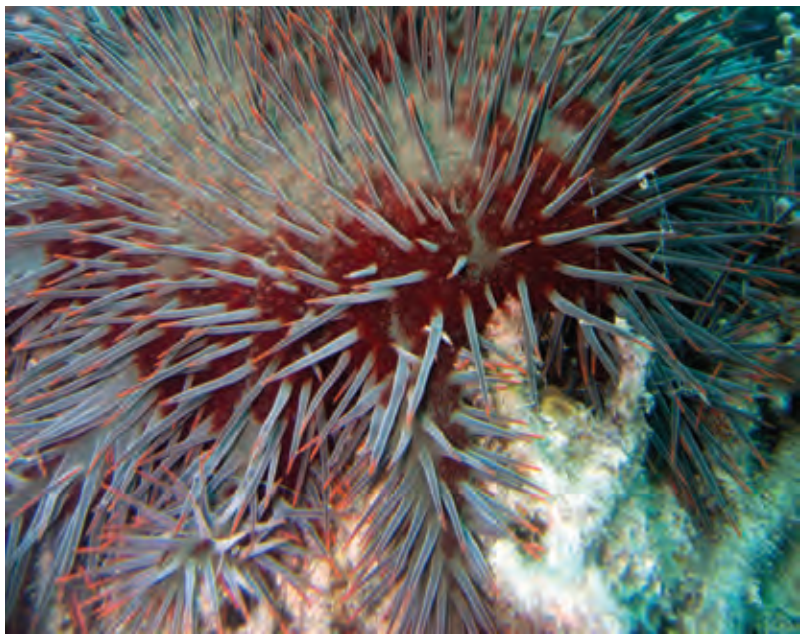
Project Progress

Coral trout (*Plectropomus* spp.) density and biomass was consistently higher on reefs within no-take marine reserves than on reefs that remained open to fishing in the Palm, Whitsunday and Keppel Island groups. Coral trout density and biomass increased rapidly within newly established reserves following their designation in July 2004. Coral trout density and biomass increased rapidly in all three island groups, within the new reserves, and reached levels equivalent to those in the old reserves (established in 1987) within 3 – 5 years of establishment (2007-2009).

Distinct differences were detected in the relative composition of the three *Plectropomus* species between island groups. In the Palm Islands, *P. maculatus* and P. *leopardus* were found in roughly equal numbers, with *P. laevis* accounting for approximately 4% of coral trout. In the Whitsunday Islands, approximately two-thirds of the recorded coral trout were *P. leopardus*, one-third were *P. maculatus*, and less than 2% *P. laevis*. In the Keppel Islands, *P. maculatus* was the dominant species, accounting for approximately 99% of coral trout, leaving *P. leopardus* and *P. laevis* at less than 1%.

Large regional differences in coral reef benthic and fish community structure were also detected between island groups, however, few if any, significant differences in community structure were detected between protected and fished zones within each island group. The greatest regional differences in benthic community structure were between the Keppel Islands and the other two regions, with branching corals dominant in the Keppels, and soft corals and a variety of hard corals dominant in Palm and Whitsunday Islands.

Furthermore, the fringing coral reefs in the Keppel Islands are also physically different from those in Palm and Whitsunday Island reefs. The Keppel reefs are dominated by hard corals; particularly *Acropora* spp., growing on an underlying low complexity reef matrix. In contrast, the reefs of Palm and Whitsunday Islands generally have more complex underlying reef structure, even in sites with a relatively low cover of live hard corals. Reef fish communities at the Whitsunday Islands were also different from the other two island groups. There were no clear and consistent effects of management zoning on fish community composition at the functional group level.



A large Crown of Thorns Starfish (Acanthaster planci), feeding on coral at Hayman Island in the Whitsunday Island group during October 2012. COTS are currently at low densities in the Whitsunday Islands and negligible reef damage has been recorded to date. *Image: David Williamson*

Researcher Profile

Professor Geoff Jones

James Cook University (JCU)

Professor Jones is a Professor in the School of Marine and Tropical Biology at JCU and maintains a large graduate group studying interactions between reef fish ecology, behaviour and life histories.

Professor Jones has worked extensively on the ecology of both tropical and temperate reefs in Australia, New Zealand, Oceania and Papua New Guinea. His research interests include ecology, behaviour and life histories of reef fishes, and their interactions with reef communities. Recent work has focussed on the local and regional impacts of natural and human disturbances to coral reef habitats and associated fish populations.

A common coral trout (*Plectropomus leopardus*) being cleaned of parasites by cleaner wrasse (*Labroides dimidiatus*) in the Whitsunday Islands. Coral trout are the primary targets of the hook and line fishery on the Great Barrier Reef (GBR). The abundance and average size of coral trout has been shown to increase within protected green zones on the GBR. *Image: David Williamson*

Project 8.3: Significance of no-take marine protected areas to regional recruitment and population persistence on the Great Barrier Reef.
Project Leader: Professor Geoff Jones, JCU

Project Background

Previous research has shown compelling evidence for green zones as an effective conservation and fisheries management tool. However, the scale over which reserves benefit fisheries by replenishing stock and the degree to which they contribute to maintaining fish populations in the long term needs to be evaluated.

This project is applying genetic parentage analysis and biophysical modelling to assess the role of marine reserve networks for coral trout (*Plectropomus* spp.) conservation and fisheries on a regional scale. Results will be valuable for marine park managers, state and Australian Government agencies, conservation organisations, fisheries managers and commercial and recreational fishers.

Project Progress

The project team has been successful in developing a genetic parentage approach for accurate assignment of juvenile coral trout to one or both parents, with greater than 99% accuracy. The markers developed are species-specific and, for the first time, can distinguish between the morphologically identical juveniles of the two main coral trout species (*Plectropomus maculatus*, *P. leopardus*). This gives the project team the ability to provide species-specific patterns of juvenile recruitment in these species. Genetic analyses have also detected a high level of hybridisation between the two coral trout species.

Biophysical model simulations provide a range of dispersal scenarios that can be tested by parentage analysis. Modelling outputs suggest a high level of self-recruitment in the three regions under passive dispersal scenarios, with limited connectivity among regions. However, with passive dispersal, only a small proportion of juveniles find suitable reef habitat. Increasing the behavioural component of models increases the connectivity at larger spatial scales and a greater overall success in recruitment. Testing of the dispersal model awaits the full genetic analysis of the sampled juveniles. Key findings about the dispersal of coral trout larvae across a 200km stretch of the GBR will be made available in the next reporting period.

Sunset over Middle Island (foreground) and Great Keppel Island in the Keppel Island group, southern GBR Marine Park. The fringing coral reefs surrounding Middle Island have been protected within a no-take marine reserve (green zone) since the late 1980's. *Image: Tane Sinclair-Taylor, June 2012*

Researcher Profile

Dr. Ken Anthony

Australian Institute of Marine Science (AIMS)

Dr. Anthony is Program Leader: Healthy and Resilient Great Barrier Reef at AIMS. His key interest is in understanding coral reef ecosystem resilience under climate and ocean change. Ken started his career in 1995 when he pursued a PhD at JCU in coral reef biology. He then evolved from a physiologist to a broad systems ecologist seeing problems through two lenses: marine science and environmental management. Ken joined AIMS in May 2011 and now works with a multidisciplinary program of more than 40 people spanning research areas from molecular biology and microbiology to ecosystem modelling at the scale of the entire Great Barrier Reef. The team works towards solving critical issues for the GBR and communicating those solutions to managers and stakeholders and the public.

Project 9.1: Dynamic vulnerability maps and decision support tools for the Great Barrier Reef.
Project Leader: Dr. Ken Anthony, AIMS

Project Background

To support management of the Great Barrier Reef Marine Park coral reef managers need decision support tools that integrate physical and biological information at a variety of spatial and temporal scales. This project is constructing vulnerability maps for the Great Barrier Reef (GBR) that combine knowledge of ocean warming, hydrodynamics and ocean chemistry with ecological responses of coral reef organisms. By combining reef vulnerability maps with social and financial criteria reef managers can optimise management planning under different environmental scenarios.

Project Progress

The project team has completed the coral resilience analyses for 60 reefs based on the AIMS Long Term Monitoring data. This work integrates with the spatial vulnerability model by helping to parameterise coral growth and mortality functions.

The first cyclone risk maps have been produced for the GBR based on the MIT (US) storm computer programs and global circulation models from the Hadley Centre (UK). The collaboration with MIT and the Hadley Centre enables us to forecast cyclone risk under different climate change scenarios. Preliminary results indicate a significant increase in cyclone risk (as probability times severity) from south to north under climate change, but without the predicted focusing of storms in the Wet Tropics as currently assumed by observations in the recent decade.

The connectivity networks for corals and COTS are now at a stage where they can be integrated with the risk modelling. This will be an area of active research in coming months when combining flood probability and consequent nutrient pulses in the north with the likelihood of COTS outbreaks and their propagation down the GBR under different cyclone scenarios.

Two stakeholder workshops were held to build consensus around key indicators and drivers of reef resilience and vulnerability. Some of the key questions that were tackled and resolved include: What characterises valuable coral reefs? What are the most effective indicators of coral reef resilience and vulnerability? How to best integrate these reef characteristics and health indicators with *Modelling, Monitoring and Management*?

Project 9.2: Design and implementation of Management Strategy Evaluation for the Great Barrier Reef inshore (MSE-GBR). *Project Leader: Dr. Cathy Dichmont, CSIRO*

Project Background

This project is developing a Management Strategy Evaluation (MSE) framework to build understanding of the key human uses and drivers of change in the inshore Great Barrier Reef (GBR), and to inform GBR stakeholders of the likely consequences, costs and benefits of particular management decisions that aim to minimise the impacts on biodiversity, particularly from inshore multi-species fisheries.

The project will deliver outcomes that are useful to a range of stakeholder organisations including local, State and Australian Government bodies, the fishing and other sectors, and conservation planners/managers.

Project Progress

Qualitative modeling has been applied successfully in an expert and community forum. Non-scientific stakeholders were able to intuitively contribute to the development of these models in the community forum and the results were very similar to those from the expert forum.

A review of all stated objectives in Mackay showed a large range of different sources of these objectives, from State government agencies such as QDAFF, to local Council, NRM groups and industry. Most of these were available on the web and grey literature accessible to the public. There is a lot of overlap between these different objectives. The LMAC and its reference group were able to consolidate a long list of objectives into a short list of priorities. In a workshop environment, the consolidated objective list was placed into a hierarchy tree with the highest levels divided into: "Protect and restore inshore environmental assets", "Improve governance systems (i.e. leadership, institutions, rules and decision-making processes involved in managing inshore biodiversity)" and "Improve regional economic and social well-being". The review highlighted a lack of over-arching or bridging objectives that bring all the different users and components of the system together. These were added in the governance section as "Increase management integration" which contained the branches of "Increase policy integration", "Increase regulatory integration" and "Increase implementation integration".

The next stage is to use an Analytical Hierarchical Process to undertake a relative objective weighing exercise. An Excel model was developed for stakeholders to use, and this weighting was successfully undertaken by the Mackay reference group.

Researcher Profile

Dr. Cathy Dichmont

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Dr. Dichmont is a Stream Leader in the Northern Fisheries and Ecosystems Research Program at CSIRO. She has a national and international reputation in stock assessment, modeling natural systems, natural resource management, shared fisheries stocks, and management strategy evaluation and has been a principal investigator in numerous collaborative and multi-disciplinary projects over her career. She has over 20 years of experience in temperate and tropical marine ecosystems at international and regional levels and was also a key contributor to the bio-economic model that aided the development of the prawn fishing industry in the Gulf of Carpentaria for which she and her team received the CSIRO medal for Research Achievement. Cathy is a member of several state, national and international fishery advisory, and steering committees, including the Gladstone Healthy Harbour Independent Science Panel.

Researcher Profile

Professor Bob Pressey

James Cook University (JCU)

Professor Pressey is Chief Investigator, ecological modeller at the ARC Centre of Excellence for Coral Reef Studies at JCU. He is also a conservation planner with extensive experience in marine, freshwater and terrestrial environments. His experience includes seven years as a private environmental consultant, working mainly on survey and conservation evaluation of freshwater wetlands and nineteen years as a research scientist with the New South Wales National Parks and Wildlife Service, focused on semi-arid and forest ecosystems. During this time, Professor Pressey contributed to the establishment of the field of systematic conservation planning. He has been in his current role since 2007, with marine (as well as terrestrial and freshwater) research projects across Australia, through the Asia-Pacific region, and further afield.

Black noddies in a Pisonia tree at Wilson island. Sea birds such as black noddies are important to coral cay vegetation: transporting nutrients from ocean to land. *Image: Mirjam Maughan (JCU)*

Project 9.3: Prioritising management actions for Great Barrier Reef islands. *Project Leader: Professor Bob Pressey, JCU*

Project Background

The aim of this project is to develop an explicit decision-making framework for cost effective management actions across the islands of the Great Barrier Reef. A sub-region for the decision support model was selected. Islands in the selected sub-region are diverse and include inshore islands in the Keppel region to the Capricorn-Bunker group and offshore in the Swains group.

Project Progress

The key variables to be used in the decision making tool have been identified. For example: threats to island features that cannot be managed will not be included in the "threat" category, but will be taken into account when estimating the likelihood of success.

The number of variables was also reduced to make the project realistic and manageable: although there are 434 islands, only half of those have a national park or "Commonwealth Island" tenure, and it is likely that money made available by government (the end-user of this project) will be spent on those islands.

Initial analysis was performed to identify challenges ahead. Those include datasets from different sources not having the same island boundary, and in some instances not even overlapping. Reasons include the scale, source, purpose or date of creation of the dataset. Before future analysis can happen, a project-specific dataset needs to be created with one boundary covering all datasets within each island. Other challenges include the gaps that still occur within datasets. So, aside from identifying which datasets to use for which theme, and which themes have no data available, the project also has to identify existing datasets for gaps within the theme. Expert questionnaires and workshops will be used to fill those data gaps.

Invasive plants and animals, such as this prickly pear on Middle island, are some of the threats to the values of Great Barrier Reef Islands. *Image: Mirjam Maughan (JCU)*

Researcher Profile

Dr. Nadine Marshall

Dr. Marshall currently leads the Northern Australian chapter of the Social and Economic Sciences Program at CSIRO, and manages a portfolio of projects across a range of primary industries, including cattle grazing, farming, tourism and commercial fishing as well as coastal communities along the Great Barrier Reef. Her research focuses on the relationship between people and natural resources for the purposes of better understanding how strategies can be developed that protect environmental goals whilst minimising any associated social impacts. Key interests include social resilience, adaptive capacity, resource dependency, vulnerability and social and economic monitoring. Nadine's current projects include leading the Social and Economic Long Term Monitoring Program, and other projects that focus on climate change adaptation.

Project 10.1: Social and Economic Long Term Monitoring Programme (SELTMP).
Project Leader: Dr. Nadine Marshall, CSIRO

Project Background
This project is engaging with stakeholders in the region to design and implement the initial stages of a long-term social and economic monitoring program. The program is also providing information for coastal planners and managers about local and regional communities, traditional owners, marine tourism, commercial and recreational fishing, catchment industries, ports and shipping. The addition of a long-term social and economic monitoring program will augment existing long-term biophysical monitoring of the Great Barrier Reef (GBR) and increase the effectiveness of its management.

Project Progress
Results from the national survey reveal that the Great Barrier Reef (GBR) is considered Australia's "most inspiring" landmark with the majority of people associating the words beauty, coral and fish with the icon and only 16% of people associating negative words such as endangered, fragile, under threat, etc. The majority of Australians feel proud to have the GBR listed as a World Heritage Site and also feel a responsibility to protect it; perceiving climate change and pollution (from land and sea) as the biggest threats. Fifty percent want to visit the GBR in the future and forty percent have already done so. Lastly, CSIRO is the organisation that Australians trust most when it comes to reporting on environmental issues.

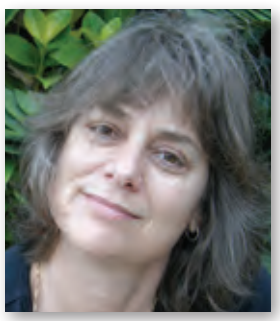
Project 10.2: Socio-economic systems and reef resilience.
Project Leader: Professor Natalie Stoeckl, JCU

Project Background
The Great Barrier Reef (GBR) is famous for its spectacular coral, rich biodiversity and natural beauty. However, none of these important assets are bought or sold in the marketplace, so none are explicitly 'valued' with a price. Recognising that absence of price does not mean absence of value, this project seeks to improve our understanding of these non-market 'values' to a variety of different stakeholders. How important are pristine beaches, iconic marine mammals or healthy coral reefs to the community, tourists and the tourism industry? How would people feel if some of these 'values' were degraded, that is, if water clarity declined, or if fish were less abundant?

Project Progress
Data collected from approximately 3,000 people suggests that if water clarity deteriorated, the region could lose substantial tourism revenues (fewer visitors and/or shorter visits implies less tourist expenditure). Also, healthy reef fish, no visible rubbish, and healthy coral reefs were more important to residents overall quality of life than other factors. Residents indicated they would be willing to pay to help 'fix' some of the threats to the reef, most indicated: "*I am not prepared to pay unless people throughout Australia pay too*".

Across both tourist and resident samples, environmental factors were considered to be more 'important' to overall quality of life (residents) or as an attractant to come to the region (tourists) than economic factors such as ability to earn money from regional industries, and/or high quality accommodation and having 'price match budget'. Note that numbers will change as more data are added; more sophisticated analysis is planned over the next 1.5 years).

Having first established that it is possible to use econometric modelling methods to model stream-flow rainfall interactions in the Burdekin, the project has now developed a 'prototype' model that combines variables from both economic and biophysical systems to look at factors contributing to sediment loads in the Burdekin River. The model is an econometric one (specifically, a time series vector auto regression model), using historical data that goes back as far as 1938. The model allows for statistical testing for the impact of changes in socio-economic factors (such as increases in wages or beef prices) on sediment load, while controlling for bio-physical influences (such as temperature, rainfall and 'extreme events'). Not only does this model provide useful information for those interested in the Burdekin River Catchment, but the general modelling approach may have wide applicability in a variety of contexts.



Researcher Profile

Professor Natalie Stoeckl
James Cook University (JCU)

Professor Natalie Stoeckl is with the Faculty of Law, Business and Creative Arts and the Cairns Institute at James Cook University. She describes herself as an economist with a keen interest in the environmental and social/distributional issues associated with economic growth. Natalie has extensive experience with a variety of non-market valuation techniques. What distinguishes her from many other economists is her track record of collaborative, cross-disciplinary research using models that combine economic, environmental and social variables to explore interactions between socio-economic and ecological systems. She has published widely in both national and international forums and supervises many research students.

Researcher Profile

Dr. Eric Lawrey

Australian Institute of Marine Science (AIMS)

Following completion of a PhD on modelling improved techniques for wireless communication, Dr. Eric Lawrey took up the position of Chief Technical Officer at Code Valley; a software engineering company researching a new way of developing software using distributed computing. In 2008 Dr. Lawrey joined AIMS as the e-Atlas developer and in 2011 took over as project leader for the e-Atlas, where he now focuses on data processing and stakeholder engagement.

Dr. Lawrey's current research interest is in design and development of the e-Atlas web platform, enabling knowledge developed through environmental science to be spatially visualised and told as data driven stories. This work includes development of web technology for delivery of the content, tools for processing environmental data and base-maps for the Great Barrier Reef, its catchments and the Torres Strait.

Project 13.1: e-Atlas. *Project Leader: Dr. Eric Lawrey, AIMS*

Project Background

This project is further developing the e-Atlas which is a website, mapping system and set of data visualisation tools for presenting research data in an accessible form that promotes greater use of this information. The e-Atlas serves as the primary data and knowledge repository for all NERP Tropical Ecosystems Hub projects, which focus on the Great Barrier Reef, Wet Tropics rainforest and Torres Strait. The e-Atlas captures and records research outcomes, making them available to research-users and hosts meta-data records, providing an enduring repository for raw data. It is also developing and hosting web visualisations to allow viewing of information using a simple and intuitive interface. In doing so the e-Atlas is assist scientists with data discovery and allowing environmental managers to access and investigate research data.

Project Progress

The e-Atlas (http://e-atlas.org.au) has a new front page, revised meta-database and individual project pages have been established as have links with the NERP TE Hub website. The project leader has now received data contributions from many NERP projects and is working closely with TSRA to integrate e-Atlas with their Integrated Management Strategy.

Additions and updates include shearwater seabird feeding tracks (Project 6.3 Brad Congdon); long term monitoring program (LTMP) COTS density modeling, update and animation; a new version of Atlas mapper (http://code.google.com/p/atlasmapper) and Torres Strait monitoring reef pages (http://e-atlas.org.au/ts/nerp-te/aims-monitoring-health-torres-strait-reefs-2-3).

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Department of Sustainability, Environment, Water, Population and Communities

Reef & Rainforest Research Centre

RRRC
PO BOX 1762, Cairns QLD 4870
07 4050 7400
enquiries@rrrc.org.au