National Environmental Research Program

TROPICAL ECOSYSTEMS hub

NERP Tropical Ecosystems Hub

GBR Water Quality Research Snapshot
July to December 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.

Great Barrier Reef Water Quality Node

The TE Hub supports 38 research projects, with seven focused on GBR Water Quality within four Programs:

- Assessing Ecosystem Condition and Trend
- Water Quality of the Great Barrier Reef and Torres Strait
- Cumulative Impacts on Benthic Biodiversity
- Managing for resilient tropical systems

About this publication

This publication is a snapshot of the progress within the projects of the NERP TE Hub for the period July to December 2013.

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

Front Cover Image: Not all dead. Living Acropora corals exposed during low tide in June 2013 during field work in the Keppel Islands. Much of the live Acropora corals in the region were killed during the 2011 and 2012 flood events. *Leonard (UQ)*

CONTENTS

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

Assoc. Prof. Jian-xin Zhao & Prof. John Pandolfi, UQ

Project Background

There is an absence of a reliable chronological tool that can be used to correlate episodes of ecological change and degradation with potential stressors and to reconstruct same site records of coral community change of millennial time scales. Such a tool can provide baselines against which to compare recent coral community change. This project uses modern radioactive dating methods to search for temporal shifts in abundance and/or community composition among coral death assemblages. The purpose of the research is to create a baseline for making decisions for conservation, mitigation and adaptation measures.

Project Progress

Results in this reporting period have focused on the outputs from the U-series dating including:

- U-series dating of 50 dead massive Porites colonies from the Palm Islands region reveal several periods of mortality that are significantly correlated with maximum sea surface temperature anomalies.
- U-series dating of 80 coral samples obtained from short reef-matrix cores extracted from the Frankland Islands region of the Wet Tropics suggests that:
  - All cores extend back to the earliest time of European settlement with base ages ranging from 1860-980AD. This provides an ideal opportunity for detailed ecological comparison before and after European settlement
  - Reef slope accretion rates are heterogeneous for the last 1,000 years, but overall accretion rates are high (comparable to the mid-Holocene).
- U-series dating of cores from the Keppel Islands region reveal episodic reef accretion over the past 6,000 years, with a remarkably low accretion rate or cessation of reef growth during late Holocene, followed by renewed, fast accretion in recent time.

Other outputs have focused on the trace element ratios of Li/Mg and B/Mg being tested as sea surface temperature (SST) proxies. These proxies are compared with other traditional SST proxies typically measured in corals (e.g. Sr/Ca, Mg/Ca). The use of these proxies will provide temperature information that is not affected by biological processes (e.g. calcification), as has been documented to occur for Mg/Ca and Sr/Ca.

The combination of calcification and trace element data will be used to provide a more complete understanding of the environmental factors controlling calcification rates in corals of the GBR, particularly the combined effects of temperature, terrestrial runoff and changes to the seawater-carbonate parameters on the reef. This will allow this project to provide a better prediction of changes in corals under future scenarios of climate change and reduced water quality.

Reef flat coring, Stone Island. *Image: Ryan (JCU)*

High water clarity is important for healthy inshore coral reef ecosystems. *Image: Katharina Fabricius*

Project 4.1: Tracking coastal turbidity over time and demonstrating the effects of river discharge events on regional turbidity in the Great Barrier Reef.

Dr. Katharina Fabricius, AIMS

Project Background

Deteriorating water clarity caused by suspended particles in river discharge diminishes light availability for corals, seagrasses and macroalgae. Turbidity increases may significantly affect marine ecosystems as these particles also carry nutrients, pollutants and diseases. This project investigates the relationship between changes in land based runoff and clarity of coastal waters for each GBR region in the decade since 2002. The purpose of this research is to guide the understanding of the impacts of land uses, including agricultural, coastal and port developments on light availability to critical GBR habitats.

Project Progress

Results to date indicate that:

- Mean annual water clarity was strongly related to the annual freshwater discharge of the large Burdekin River; and that
- The decline in photic depth is strongly correlated with the increased flow of the Burdekin River over the past six years.

This work shows clearly that long term signals of turbidity in the dry season are related to the extent and duration of wet season flow and the input of high sediment loads. The model animations from this project showed that suspended sediment from river plumes forms turbid plumes just below the surface of the lower salinity plume.

This sediment deposits on the seafloor under the river plume as a muddy coastal wedge. This muddy layer is then available over many months after the wet season, and can be slowly eroded away during strong wind events, creating higher turbidity conditions in the dry season for several months after the end of the wet season. Modelling is progressing to fully quantify the dynamics of that mud layer during the dry season.

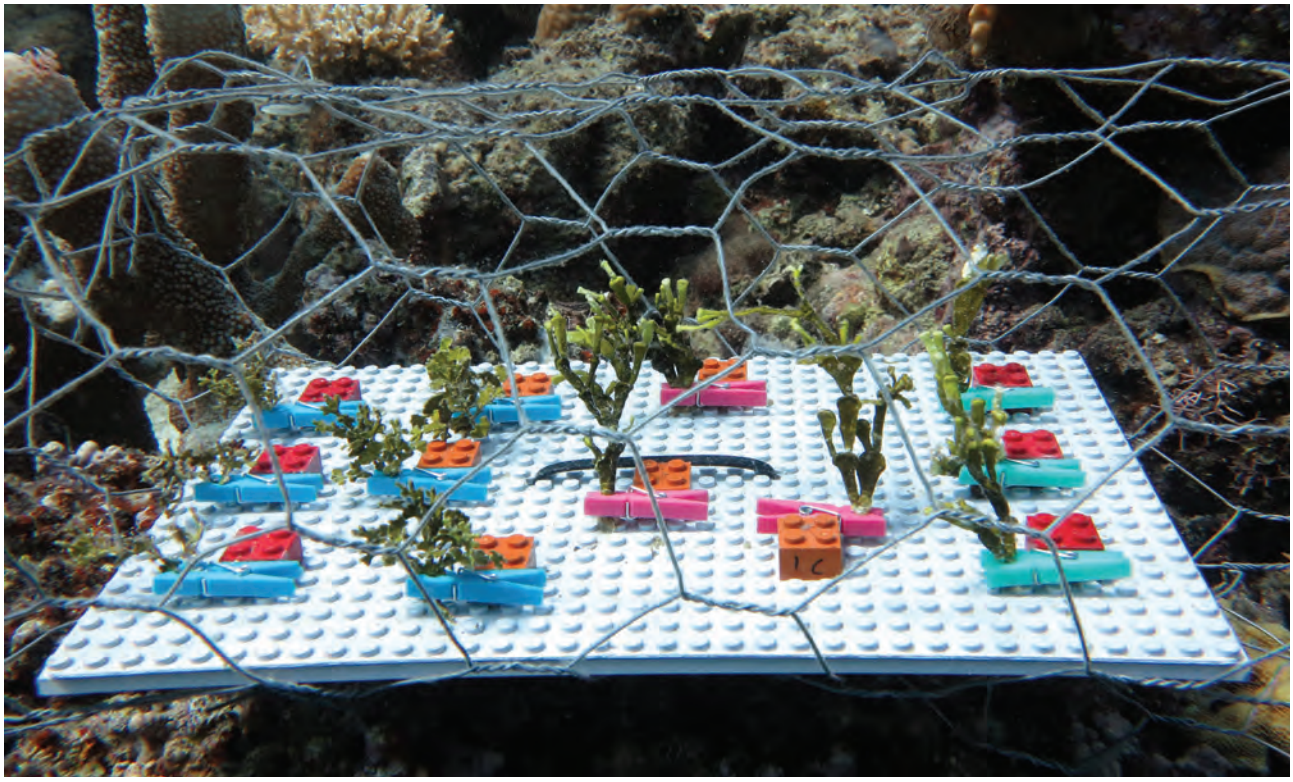
This project has successfully linked the increase of sediment from the Burdekin River to increasing turbidity during the dry season. Thus sediment loads would and do have a measurable impact on ecology both through the acute impact of floods and the more chronic impacts of increasing dry season turbidity. Reducing terrestrial runoff of nutrients and sediments should therefore measurably improve water clarity in the GBR, leading to significant ecosystem benefits.

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

Dr. Andrew Negri, AIMS

Project Background

Pesticides, particularly herbicides from agricultural sources, have been detected all year round in coastal waters of the GBR except in the remote Cape York region. This project identifies the herbicide concentrations that cause chronic stress in marine biota and will use that information to refine pollution targets for the GBR. These data are combined with information on herbicide persistence, water quality and climate to contribute to cumulative risk models and the development of policy designed to protect the GBR from the cumulative effects of pollution and climate change. The purpose of the research is to guide management of the use of agricultural chemicals.



Field transplantation experiment to assess the impacts of a natural CO2 enriched environment on calcifying green algae. *Image: Nikolas Vogel (AIMS)*

Project Progress

Results to date include:

- The final analysis of the chronic exposure experiment of two seagrass species to Diuron and
- 12-month flask experiment to measure degradation of the seven herbicides in natural seawater at varying temperature and light conditions

For the two seagrass species exposed to diuron, the negative impacts have included decreased survival, growth, photosynthesis, energy storage/allocation and changes in pigments concentrations and ratios.

The long-term flask experiment to measure degradation in seven herbicides in natural seawater at 25°C, 31°C and in the dark and light has been completed (365 days duration in total). Results indicate that Diuron, Atrazine, Hexazinone and Tebuthiuron are very persistent in seawater (half-lives of years), while 2,4-D, Metolachlor and Glyphosate are less persistent.

Very little degradation of these seven herbicides is expected over the course of flood plumes resulting in the transport and impact of these pesticides in the marine environment. The study found that, for Glyphosate, with the half-life at 25°C in low-light for 47 days, extending to 267 days in the dark at 25°C and 315 days in the dark at 31°C, which is the longest persistence reported for this herbicide.

This study demonstrates glyphosate is moderately persistent in the marine water under low light conditions and is highly persistent in the dark. Little degradation would be expected during flood plumes in the tropics, which could potentially deliver dissolved and sediment-bound glyphosate far from shore.

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

Dr. Sven Uthicke, AIMS

Project Background

Increasing temperatures, ocean acidification 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. This project uses complementary laboratory and field experiments to investigate the combined impacts of these threats on key reef species groups, such as corals, foraminifera, Crown of Thorns Starfish and rock boring sea urchins. The purpose of this research is to guide future land use management decisions.

Project Progress

Several experiments investigated the effects of light reduction and ocean acidification on two seagrass species, Halimeda and corals. For many (but not all) species and factors, it is clear that improving light availability by reducing land runoff will provide more resilience in the future in the presence of climate change and ocean acidification.

Experiments were conducted that investigated the influence of ocean acidification on the thermal bleaching susceptibility of two species of corals. Results indicate

that increases in pCO_2 can reduce the severity of thermal bleaching in some coral reef corals. It is hypothesised that increases in primary productivity under ocean acidification, facilitated by alleviation from carbon limitation, can support the costly physiological processes that allow corals to resist bleaching. How this interacts with competitive processes, such as growth via calcification, remains unknown.

Experiments have been conducted during the October and November coral spawning events to determine what effect sedimentation, temperature and organic nutrient enrichment have on the early life history stages of two coral species, examining embryo fertilisation success, larval development, larval respiration and recent recruit calcification under different combinations of these stressors. Assays to assess coral recruit calcification under different combinations of sediment and organic enrichment treatments are being trialled.

Outputs from all experiments under this project have provided a wealth of data to our knowledge on interactive stressors on keystone coral reef organisms.

Project 5.3: Vulnerability of seagrass habitats in the Great Barrier Reef to flood plume impacts: light, nutrients, salinity.

Dr. Catherine Collier, JCU

Project Background

Seagrass meadows are a vital habitat in tropical coastal ecosystems. However, ongoing monitoring indicates that seagrass meadows are in decline in the GBR. Seagrass meadows are exposed to a range of stressors from altered light, nutrients and salinity that reduce their capacity to recover after major disturbances. This project uses complementary laboratory and field experiments to investigate the cumulative impacts of exposure of seagrass meadows to diminished light, increased nutrients and decreased salinity for the purpose of predicting thresholds to be used in future risk assessments. The purpose of this research is the development of guidelines for the protection of seagrasses.

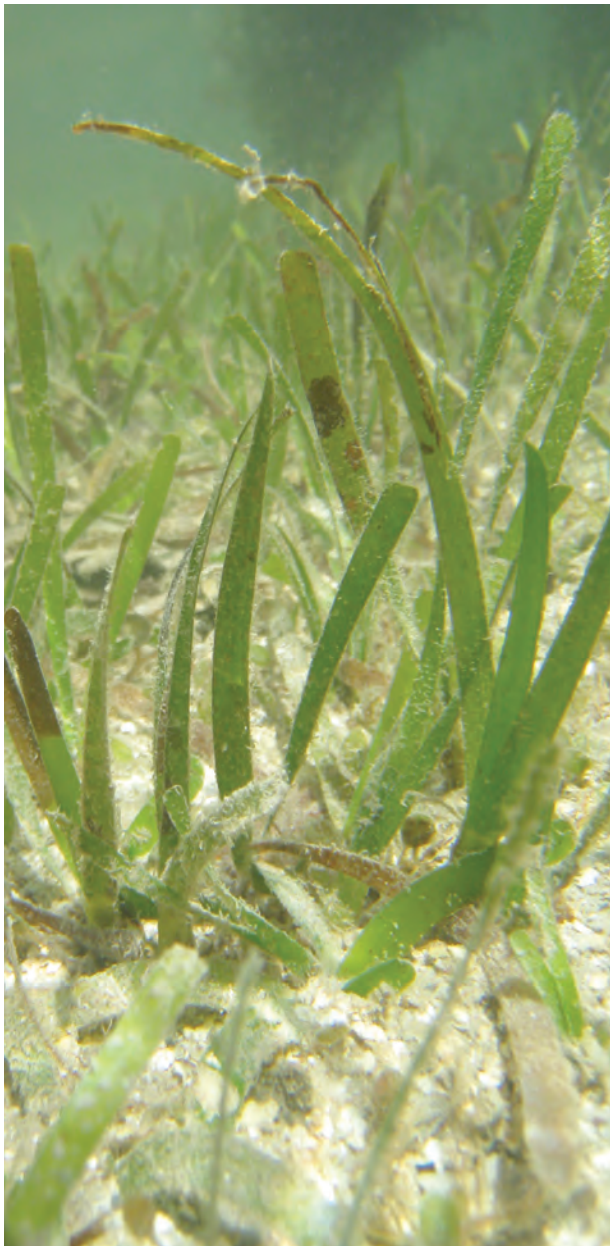
Project Progress

The project experimentally tested combinations of salinity, light and nutrients with combinations being dependent on: (1) previous knowledge; (2) management priorities; (3) research objectives; and, (4) Logistics. The project team also tested lethal and sub-lethal indicators, which were selected following a global literature review. The project also mapped water quality in relation to seagrass decline.

In this milestone period, sub-lethal indicators of seagrass stress were analysed based on results of two previous experiments. All sub-lethal indicators were sensitive to environmental change. By comparison of results to the long-term marine monitoring program (MMP), GBR seagrasses are likely to be both nutrient replete and light limited. These findings will contribute to MMP indicator selection and report card development.

A final experiment tested the effects of light and temperature on seagrass and developed light response curves using abundance and growth as indicators. These results were used to model time and temperature dependent environmental thresholds associated with seagrass protection ranging from 100% protection through to 0% protection (i.e. complete seagrass loss). These findings will directly contribute to the establishment of guideline values for seagrass protection.

Mapping of water quality condition in relation to seagrass decline has been finalised through the development of loading models, which were updated from the original exposure models, and the frequency of plume water types. Mapping the frequency of water types occurring during the wet season was particularly successful at identifying areas with substantive seagrass decline. These findings can be utilised to develop and update existing risk models.



Seagrass meadows on the Great Barrier Reef form a buffer between catchments and the reef trapping sediments and absorbing nutrients. *Image: Catherine Collier (JCU)*

Project 9.4: Conservation planning for a changing coastal zone.

Professor Bob Pressey, JCU

Project Background

The coastal zone of the GBR has been subject to intensive development that has led to degradation of coastal ecosystems. Systematic conservation planning determines the best spatial use of limited conservation resources to minimise the loss of valued aspects of the natural world in the future. This project creates a modeling 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 GBR lagoon. The purpose of this research is to model scenarios of future land use in the coastal zone to assist conservation planning.

Project Progress

Results to date have identified and characterised a novel approach in the field of systematic conservation planning. This new scientific approach was called scenario-based systematic conservation planning. It is being used as a new conservation method for areas subject to rapid change with multiple, complex stressors. Coastal zones around the world are the most significant examples of such areas and the GBR coastal zone is a perfect case study to exercise this innovative and original approach in order to understand which terrestrial coastal areas should be most protected against coastal development to ensure the least effects on coastal ecosystems.

The land use change planning methodology is complete and eight scenarios of land use change have been produced. A separate methodology was applied to include associated marine uses in the coastal zone (e.g. shipping) in each scenario. Overall, spatially-explicit scenarios of land and marine use change are being developed for the GBR coast to 2035.

This project is also developing a way to look at cumulative impacts of all coastal development on the GBR marine ecosystems. This has been identified as critical information required in the draft strategic assessment produced by the Queensland Government. The combination of in-depth conceptual models to assess impacts of all types of coastal development and expert elicitation is being developed as part of this project to improve the understanding of cumulative impacts of development all along the GBR coast within a spatial framework.

Project 13.1: e-Atlas

Dr. Eric Lawrey, AIMS

Project Background

The e-Atlas 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. 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

In the last six months the e-Atlas team has focused on the development reference datasets and the development of the Torres Strait e-Atlas.

An improved basemap, called the *Bright Earth e-Atlas Basemap* was developed and released. It focuses on Queensland mainland and Great Barrier Reef, highlighting the natural environment and the areas of human influence rather than a traditional roadmap such as Google Maps. This new basemap was requested by and delivered to the BOM eReefs Water Quality Dashboard team and is now the default basemap for the e-Atlas.

In November 2013 a series of workshops was run in the Torres Strait to road-test the progress-so-far on the Torres Strait e-Atlas with representatives from key end-users including the TSRA, AFMA and Tagai College. This workshop provided valuable feedback to the team helping to identify several areas of priority development and problems with server performance under load, which have now been largely resolved.

Prior to the workshop the new Torres Strait e-Atlas was setup including a regionally branded section of the e-Atlas website, a regionally specific mapping portal and a regionally specific metadata search tool. Four general knowledge articles were written and added to the new site covering the topics of seagrass, dugongs, shipping and water quality. In addition to this a new satellite and aerial imagery basemap was developed for the Torres Strait region.

In June 2013 all NERP TE projects submitted spatial information about their project activities to the e-Atlas. These are now available as a series of maps from the e-Atlas site.

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The Reef and Rainforest Research Centre administers the Australian Government's National Environmental Research Program Tropical Ecosystems Hub.

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