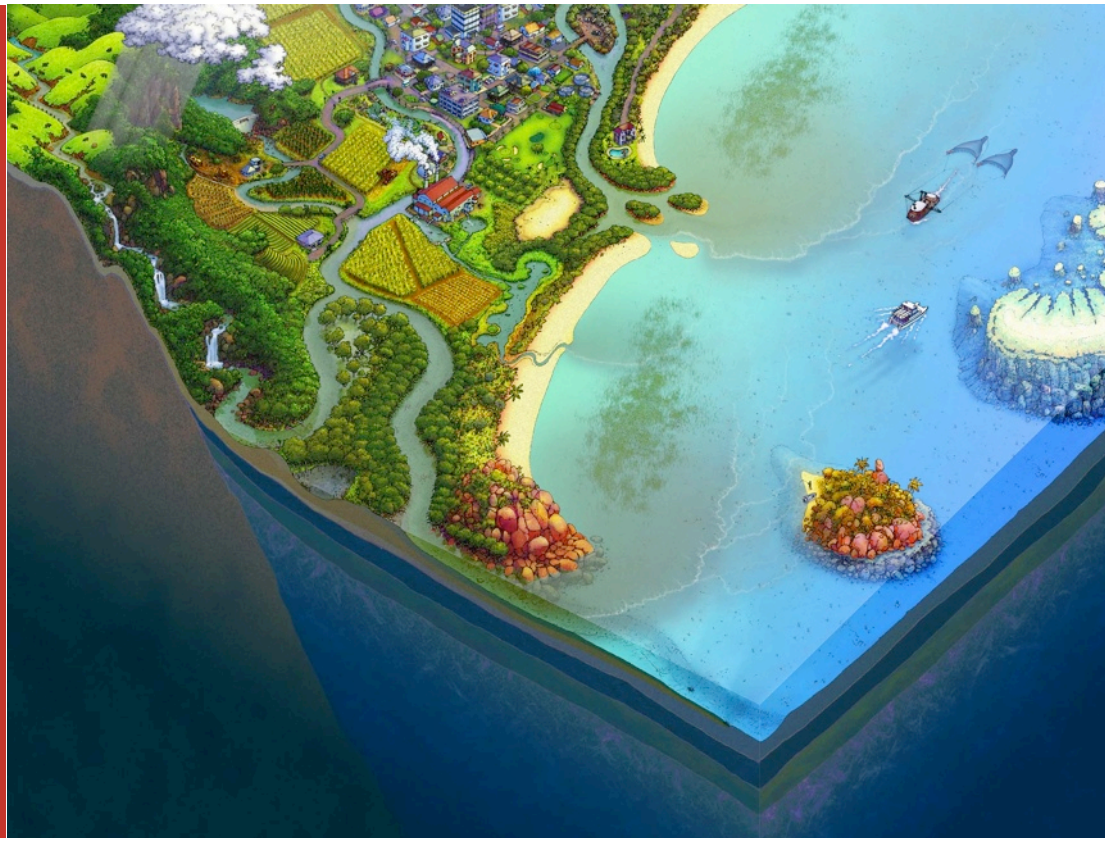
Research Update May 2006

CATCHMENT TO REEF

New tools for monitoring water quality and ecological health in Great Barrier Reef catchments



The Catchment to Reef Joint Research Progam

Richard Pearson

...is a three-year initiative of the Rainforest and Reef CRCs, which began in 2003, aimed at developing new tools to assess and monitor the health of catchments and inshore reefs of the Wet Tropics and Great Barrier Reef World Heritage Areas. As the program draws to a close (by September 2006), researchers from James Cook University, Griffith University, the CSIRO, the Queensland Department of Natural Resources, Mines and Water, and the Australian Institute of Marine Science are preparing to deliver the results of their work.

It is now accepted that the quality of water entering the Great Barrier Reef lagoon from Queensland's rivers has deteriorated since European settlement. Human activities have increased the levels of nutrients and sediments that run into the rivers and threaten the health of the waterways, wetlands and inshore reefs and seagrass beds.

The 2003 Reef Water Quality Protection Plan presents a framework for water quality monitoring and land management programs, as developed by the Commonwealth and Queensland Governments, and the Regional Natural Resource Management Boards, to help reduce the decline in the health of Queensland's catchments and inshore waters.

The Catchment to Reef research will provide a sound scientific basis to new monitoring tools and guidelines, which will enhance and standardise existing monitoring programs, and make them more appropriate to the tropics.

It will also identify alternative ways to measure the health of catchments and inshore reefs, and provide farmers and land managers with guidelines to help reduce loss of sediment and nutrients into waterways.

Prof. Richard Pearson, JCU

Towards best practice land management

The loss of sediments and nutrients from the land into Wet Tropics streams varies with land use and management regimes. Farmers and volunteers in the Tully/Murray, Meunga, Daintree and Barron catchments have been helping researchers from James Cook University (JCU), the Queensland Department of Natural Resources Mines and Water (NRMW) and the CSIRO to collect water samples from streams and bores after heavy rainfall.

By measuring concentrations of sediments and nutrients in streams from different land uses, the researchers can compare losses from sugarcane and banana paddocks, pine plantations grazing lands and urban areas. A comparison of losses from cane and banana plantings in the Tully/Murray and Barron catchments has shown the effect of differences in fertilizer application, soil exposure and slope of the land.

Banana paddocks generally have higher slopes and more bare ground than cane fields. Average loss of total nitrogen was higher in runoff from cane, whereas banana paddocks lost more total phosphorus and suspended sediments. By comparing losses under different land use and management, researchers will be able to recommend best management practices for a range of activities.

Event sampling - It's all in the timing

It can be difficult to obtain accurate assessments of nutrient and sediment loss in runoff during and after a flood event. Concentrations of contaminants in the water vary with the flow rate – rising, peak and falling floodwaters – as well as land use and topography.

During monitoring of runoff from banana and cane paddocks in the Tully area, JCU researchers found that the highest nutrient and suspended sediment levels occurred at the rising stage of drainage flows, just before it peaked.

While it is not easy to collect samples under these conditions, it is a vital component of the research project, as samples taken during the falling stages of floodwaters may underestimate total nutrient loads.

This is particularly relevant to measurements of Total Phosphorus (TP), derived mostly from phosphate fertilizers applied to bananas. Excess phosphate attaches to fine soil particles, which is rapidly washed away at the start of rainfall runoff. Concentrations can then decrease with further runoff as maximum flows are reached and as a flood recedes. This information has implications for timing of water quality monitoring in flood events.

Losing it...
During heavy rain the loss of sediments and nutrients into drains and streams varies with land use.

Low cost monitoring tools

With the help of Catchment Management Groups in the Wet Tropics, JCU researchers are also testing the effectiveness of 'simple' water quality measuring techniques such as nutrient test strips, simple colorimeters for nutrients and turbidity tubes for suspended solids. By testing such methods on real samples and comparing to laboratory results using sophisticated standard methods the scientists can assess the usefulness and robustness of these monitoring methods for direct landowner use.

All in the timing...
Timing is critical when collecting water samples during flood events. Banana gauged drain.

The usual suspects...
The O/E score is used to assess how much the fish community found at a specific stream location differs from what is anticipated by researchers. An O/E score of 1 indicates that all species expected to occur at a given location were observed whereas an O/E score of 0.3 indicates that many expected species were missing from that location.

Role of riverbank vegetation

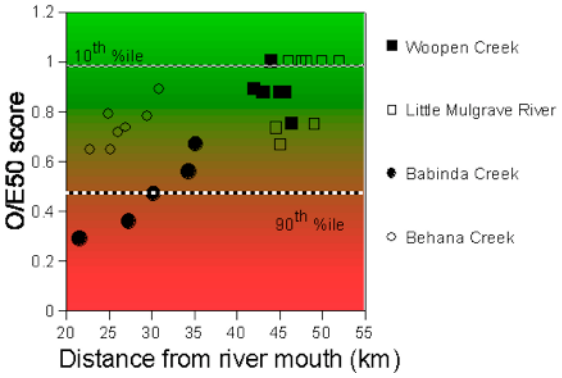
On the banks of the Daintree River CSIRO scientists are using historical aerial photos, stream profile measurements and metal pins to assess bank erosion. Pins are inserted into the banks and monitored from year to year to measure the amount of bank erosion which occurs under different conditions of riparian vegetation, stream flow, bank height and boating traffic.

Indicators of stream health

Wet Tropics streams and rivers support unique and diverse animal life which may provide clues to the health of the waterway. In a healthy waterway bordered by natural riparian vegetation, there are clear patterns of change in freshwater animals along the natural gradient from upland forests to the coastal lowlands. This unique biodiversity is threatened by human activities in the landscape, upsetting natural ecological processes.

Fishfinder...
Fish can be collected harmlessly in tropical streams using a method known as electrofishing.

Researchers at Brisbane's Griffith University have shown that the natural patterns of diversity in freshwater fish are lost when a waterway is modified and degraded by loss of riparian vegetation and changes in stream habitat. Under these conditions there are fewer fish species than expected and those missing have clearly been affected by the habitat changes.



A simple model based on elevation and distance from the river mouth was used to predict fish community composition at individual sites within four creeks in the Russell and Mulgrave catchments of the Wet Tropics. Most sites in the Little Mulgrave, Behana and Woopen drainages contained most, if not all, species that were expected to occur, whereas the most degraded sites on lower Babinda Creek contained fewer species than expected. Impacts due to loss of riparian vegetation and reduced habitat diversity along the waterways could be one reason why certain species are missing from lower Babinda Creek.

In the same paired catchment study in the Russell and Mulgrave catchments, James Cook University researchers have classified different stream reaches by the macroinvertebrate species they contain and their association with particular riverbed sediment sizes.

The researchers compared sites with different degrees of impact, and were able to distinguish between natural changes in the presence of different 'water bugs' and changes resulting from reduced stream health.

The Nature of things...

The different reaches of a healthy tropical stream can be classified by the "water bugs" they contain and their association with particular sediment sizes.

Below, an adult mayfly basks on a rock. A stream-living mayfly larva is pictured right. Species like this connect aquatic and terrestrial foodwebs.

This is the first detailed study of macro-invertebrates in floodplain streams in the Wet Tropics, resulting in the discovery of several new species. The work has shown how different macro-invertebrate species are affected by changes in stream habitat as a result of changes in riparian vegetation. It has highlighted the importance of riparian vegetation in maintaining in-stream biodiversity.

Information from both studies is being used to develop models of stream health, which will lead to the development of new monitoring protocols for Wet Tropics streams.

Assessing health of inshore areas

Coral reefs are exposed to runoff containing sediments, nutrients and pesticides from agricultural lands. Scientists at the Australian Institute of Marine Science are developing new tools for measuring exposure to pollutants in the marine environment. The AIMS team is investigating measures to detect stress and changes in abundances of key inshore organisms (corals and seagrasses) in response to changing water quality. The scientists are using 'biofilms', the fine coating of bacteria and microscopic organisms on sediments and artificial substrates, as a quick way to measure water quality condition. Biofilms are very responsive to changes in nutrients and fine sediments in the water, so a small sample of sediment may contain evidence of present and past exposure of a site to certain water quality conditions.

The scientists have found that the expression of certain genes in corals changes along gradients from poor to clean water. Also, the number of soft coral species on reefs exposed to poor water quality is only half that of reefs in clean inshore waters, while certain groups of macroalgae are more abundant in areas of poor water quality.

The susceptibility or corals to bleaching may also change with changing water quality. The AIMS scientists have shown that corals become darker in turbid nutrient-rich waters compared with the paler colour of corals in clean waters. The surface of darker coloured corals warms up more than that of lightly coloured corals – differences in temperatures can be as much as 2°C in bright sunlight. The dark inshore corals are therefore more susceptible to 'overheating' and bleaching during warm, sunny, calm conditions. This research provides measures of how to keep track of the health of inshore corals. It will also improve our understanding of small-scale variation in coral bleaching.

New ways to monitor marine water quality

Herbicides and insecticides used in modern agriculture can be harmful to coastal marine organisms, even at low concentrations. These low concentrations, however, make it difficult to monitor pesticide levels in the environment. New, low-cost passive samplers offer one approach to monitoring pesticides in aquatic habitats. These devices are left in the water for several weeks, concentrating low-level pollutants from large volumes of water.

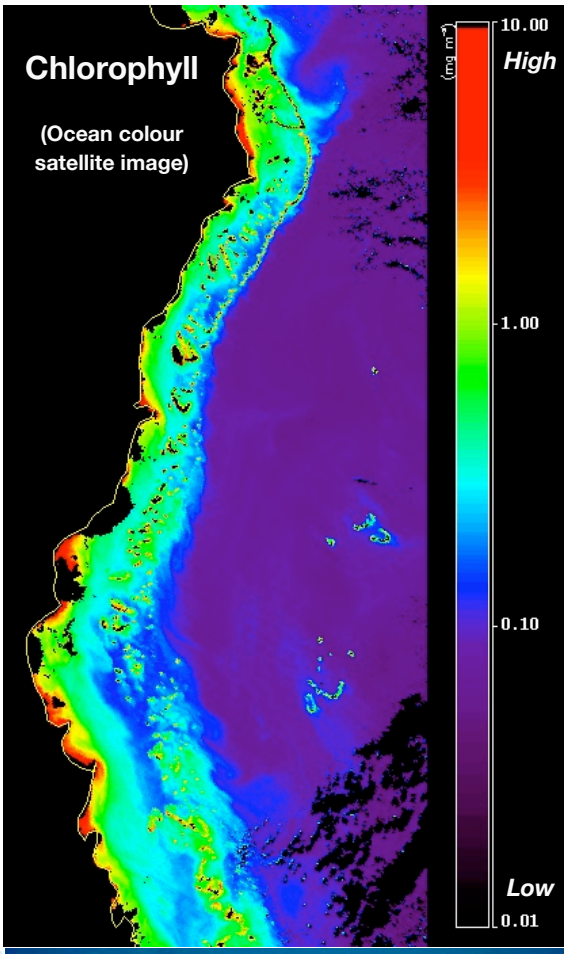
Research conducted under the Catchment to Reef program has provided the first baseline measurements of herbicide concentrations in wet tropics rivers and coastal waters and tested protocols for effective monitoring of organic pesticides. These methods are now being applied in the marine monitoring program for the Reef Water Quality Protection Plan.

Marine monitoring from space

Nutrient availability in coastal waters of the Great Barrier Reef is most conveniently monitored by measuring the concentration of chlorophyll in plankton. The large size of the Great Barrier Reef makes it difficult and expensive to frequently sample broad areas.

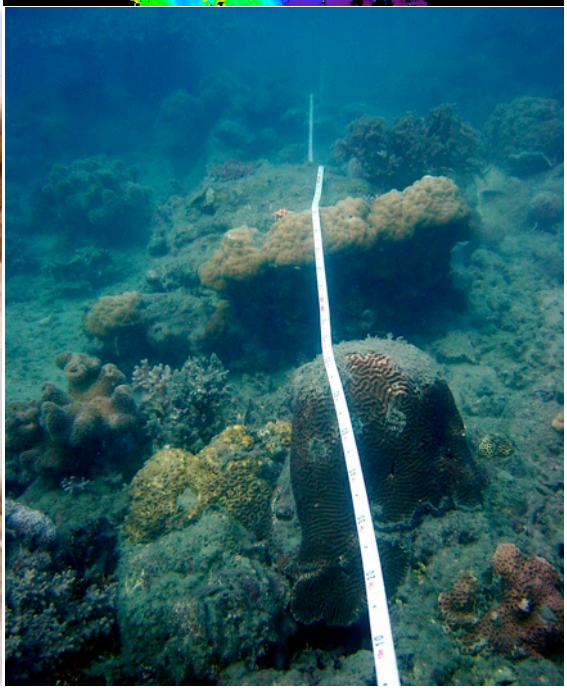
An alternative approach is to calculate chlorophyll concentrations from satellite images of ocean colour. A variety of factors affect the accuracy of chlorophyll estimates based on satellite imagery, especially the amount of suspended sediment and other particles in shallow coastal waters. A research project within the Catchment to Reef program has been investigating approaches to improve the accuracy of satellite-derived chlorophyll estimates.

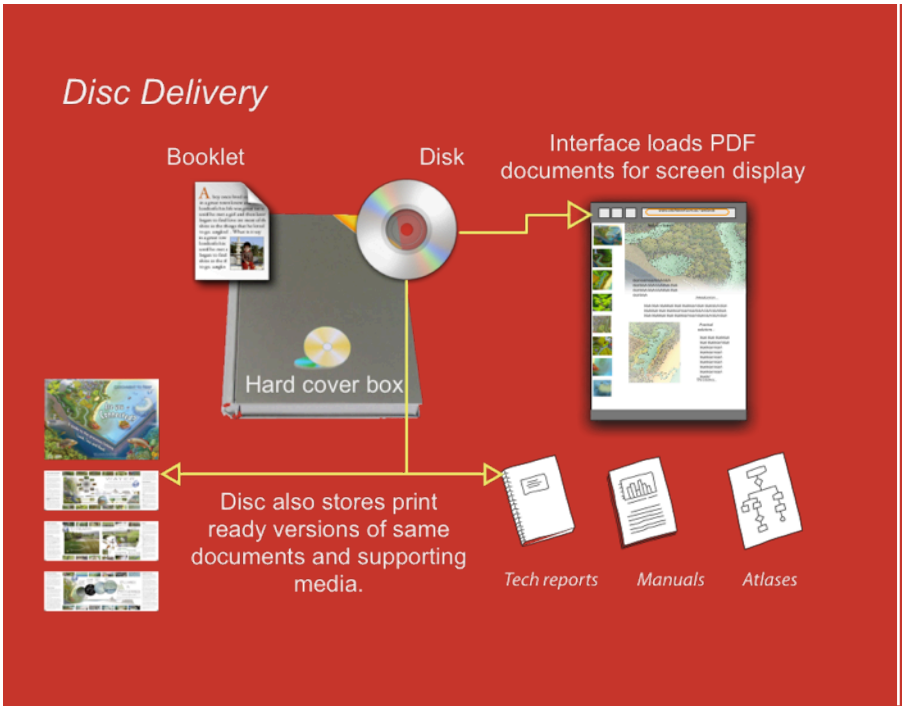
A key part of this research is making careful simultaneous shipboard measurements of ocean colour, chlorophyll, and suspended sediment concentrations for comparison with remotely sensed imagery. The results are leading to improved methods for correcting satellite-derived chlorophyll estimates for the effects of suspended particles in coastal waters.



Dark and dirty...
Differences in colour in the coral *Acropora millepora* is measured with the Coral Health Chart (University of Queensland).

The light corals (right) are from clear water offshore reefs. the dark corals are from a turbid inshore reef, (Fabricius, 2006).





Disc delivery...
Distribution of major findings will be by interactive disc. An accompanying colour booklet provides an overview of program findings and a guide to exploring the manuals, technical reports, atlases and popular products contained on the disc.

Print ready versions of all documents are also included.

Catchment to Reef
product overview

The findings of Catchment to Reef research will be delivered through an interactive DVD and accompanying synthesis booklet, in a range of products tailored for different interests. Some of these products can be directly used by individual farmers or community-based organisations, while others are designed for use by researchers and management agencies. Since the program began in 2003 over sixty publications reporting results of the various research tasks – refereed scientific papers, books and book chapters, conference papers and reports – have been published or are in press or preparation. There is an international interest in the Catchment to Reef scientific solutions from those facing similar problems around the world, and our researchers will continue to be invited to present papers at national and international conferences.

Catchment to Reef science will form the basis of a series of technical reports covering:

- Aspects of water quality monitoring (comparisons under different land uses; groundwater studies; Daintree riverbank erosion; farm-based water quality monitoring methods);
- Impacts of land use and riparian disturbance on the ecology of streams; and
- Indicators of health of marine inshore ecosystems.

From the technical reports two monitoring manuals will provide guidance for technical practitioners, Natural Resource Management bodies, land managers and monitoring groups, focused on:

- The basis for water quality monitoring in tropical Queensland catchments – the 'whys and wherefores' of water quality monitoring and issues related to different land uses and riverflow; and...
- Integrated river health monitoring protocols for tropical streams, with guidelines for use of alternative indicators of waterway health, based on assessments of water plants, fish, invertebrates and riparian vegetation.

The manuals will be important references for anyone involved in monitoring the health of tropical catchments. It is also planned to prepare a field guide for water quality monitoring in the tropics – a simple, practical 'how to' for agency and community members working in the field, to be developed in collaboration with staff of the National Action Plan for Salinity and Water Quality (NAPSWQ) Program, to avoid duplication.

Through other partnerships the Catchment to Reef program will also produce interactive atlases of macroinvertebrates and fish to guide the identification of commonly found tropical species and indicators of catchment health, and user-friendly guidelines to improve understanding of nutrients and best management practices for landholders.

An award-winning fish book!

If you want to identify fish in your local creek and learn about its biology and tolerance to changes in water quality you can refer to a new book, published through CSIRO Publishing, *Freshwater Fishes of North-eastern Australia* (2004), authored by Catchment to Reef researchers Brad Pusey, Mark Kennard and Angela Arthington of Griffith University. The book contains details of the ecology and biology of 79 fish species found in the north, and includes an enormous amount of previously unpublished material. In 2005, the book won the prestigious Whitley Award, the most sought-after award in zoological publishing in Australia. The book (ISBN 0643 06966 6) can be purchased online at:

http://www.publish.csiro.au/nid/18/pid/3922.htm

Are you Connected?

Early in 2006 the Catchment to Reef program released a colour eight-page booklet and A2 poster - ***Are you Connected?*** *A guide to the processes linking Land, Sea and Reef.*

Aimed at the interested person it provides a plain language overview of the ecological connections between plants and animals in our tropical waterways, river catchments and reefs.

Through a series of double page spreads the booklet illustrates the process of ecosystem connectivity, stream and wetland processes and the fate of sediments and nutrients that enter the marine system.

Booklet/poster kits have been widely distributed and are proving to be a popular resource for schools, catchment groups and land managers.

Kits can be obtained from Niall Connolly at James Cook University:
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The future of Catchment to Reef

With the closure of the Rainforest CRC and CRC Reef in late September 2006, it is anticipated that the activities of the Catchment to Reef program will be further developed under a Water Quality research theme within the new Commonwealth funded Government Marine and Tropical Science Research Facility (MTSRF).

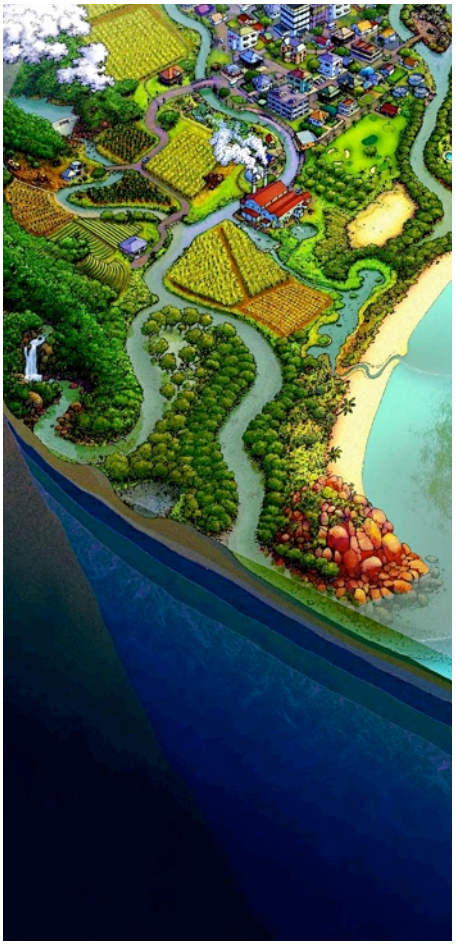
Three programs within the Water Quality theme will focus on:

- Catchment to reef connectivity (materials transport, and health of the reef);
- Water quality and ecological health within catchments; and
- Integration of social, economic and biophysical aspects of resource management.

This future research will build on the work of the current Catchment to Reef program, and other CRC Rainforest and CRC Reef research over many years, and will include work to identify additional indicators of changing health of waterways and wetlands, and critical thresholds of change. Future research will also contribute to the production of report cards for monitoring components of the health of Great Barrier Reef catchments.

The transition from the current Catchment to Reef program to the upcoming MTSRF Water Quality Research Program will be facilitated through the support of the Commonwealth Department of Environment & Heritage (DEH) - the MTSRF managing agency.

This transition will ensure continuity between the two research programs.



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