National Environmental Research Program

TROPICAL ECOSYSTEMS hub

A Synthesis of NERP Tropical Ecosystems Hub GBR Water Quality Research Outputs 2011-2014

Compiled by RRRC

Water quality in the Great Barrier Reef

The National Environmental Research Program (NERP) funded water quality research under the Tropical Ecosystems Hub to address issues of concern for the management, conservation and sustainable use of the Great Barrier Reef (GBR) and its catchments. These water quality projects set out to advance the understanding of catchment and marine processes that impact on GBR water quality and on the resilience and health of GBR ecosystems.

NERP research projects investigated water quality and climate effects on the GBR, pesticides and fine sediments and their potential impacts on GBR ecosystems, cumulative impacts on coral and seagrass communities, long-term historical records of change in the GBR and revised spatially complex risk assessments of terrestrial inputs and coastal development. This understanding is essential to developing effective management responses that promote ecosystem resilience and reverse the decline in water quality.

Water Quality issues

Water quality in the GBR has long been recognised as being a state of decline. Exposure to land-sourced pollution arising from rapid expansion of agriculture and urbanisation in the catchment has been identified as an important factor in the decline in coral reef and seagrass condition in the GBR.

River discharges carrying land-based pollutants cause changes in water quality conditions that result in both acute (severe) and chronic (long-lasting) stress on inshore coral reefs and seagrass meadows. Different rates of exposure to land-sourced pollutants have important consequences for the degree of decline that coral reefs and seagrass meadows may suffer.

The greatest water quality threats to the GBR are first from nitrogen discharge and the associated crown-of-thorns starfish (coral predator) outbreaks and secondly fine sediment discharge, which reduces light to seagrass and inshore coral reefs. Pesticides also pose a risk to freshwater and inshore and coastal habitats.

Farmers who have adopted best practice land management have reduced total pollutant loads from their farms and this is a significant step towards the goal of halting and reversing the decline in water quality to the GBR. This reduction, however, has not been sufficient to reduce loads to ecologically sustainable levels. The latest scientific consensus statement states that greater effort is required to achieve the ultimate goal of no harmful impacts on the health and resilience of the reef ecosystem. In addition to this improvement, transformational and innovative changes in farming technologies may be necessary to achieve some water quality targets that are currently required under Reef Plan*.

* www.reefplan.qld.gov.au.

Photo: WAYNE SPENCER

NERP Water Quality Research Outcomes have improved our understanding of issues surrounding key water quality issues. A correlation between river flow and GBR turbidity was shown. Studies showed that reductions in sediment and nutrient loads of the Burdekin River are likely to significantly improve water clarity downstream of the river mouth and across the central GBR during that wet season and following dry season. Examination of river flows in the Fitzroy, Mackay Whitsunday, Cape York and Wet Tropics NRM regions found that for coastal, inshore and lagoon areas, except in Cape York, photic (light) depth was strongly negatively related to freshwater discharges of the main rivers. Declines in light penetration started at the onset of river floods, and water clarity typically took 150-260 days to improve.

NERP research improved knowledge of pesticide exposure in marine waters. Results indicate that exposure to high light and diuron (herbicide) together increases negative impacts on seagrass photosynthesis. The sensitivity of seagrass to herbicide exposures increased at both high and low temperatures and light levels indicating that the cumulative effects of physical environment pressures may increase risks posed by herbicide exposure under certain flood-plume conditions. "Simulation" experiments revealed long half-lives for some herbicides (over 550 days) and that temperature and light affected degradation, likely due to shifts in microbial communities. This research indicates that degradation of herbicides would be low during flood plumes and is the first relevant persistence data for herbicides under tropical marine conditions. This data can now be directly applied to spatial risk assessments for herbicides in flood plumes.

Managers also require information on cumulative pressures and how to prioritise their responses to most effectively deal with multiple stressors impacting on vulnerable ecosystems over different time periods and at different scales (**Figure 1**). Studies of cumulative pressures and ecologically relevant thresholds used a series of laboratory based and field experiments to assess the impacts of multiple pressures, particularly increased water temperatures and ocean acidification. In many cases, the combination of stressors showed additive effects, thus clearly suggesting that reduction of pollutants from improved land-management can decrease the impacts of climate change. Work on carbon chemistry suggests that inshore GBR reefs are more vulnerable to ocean acifidification potentially due to human-induced changes in the water column from land runoff. A series of experiments to investigate single effects of temperature or the combined effects of temperature and food (microalgal) increases on crown-of-thorns starfish larvae showed that temperature was a strong driver of larval response to food increases, with results suggesting that climate change has aggravated crown-of-thorns starfish outbreaks.

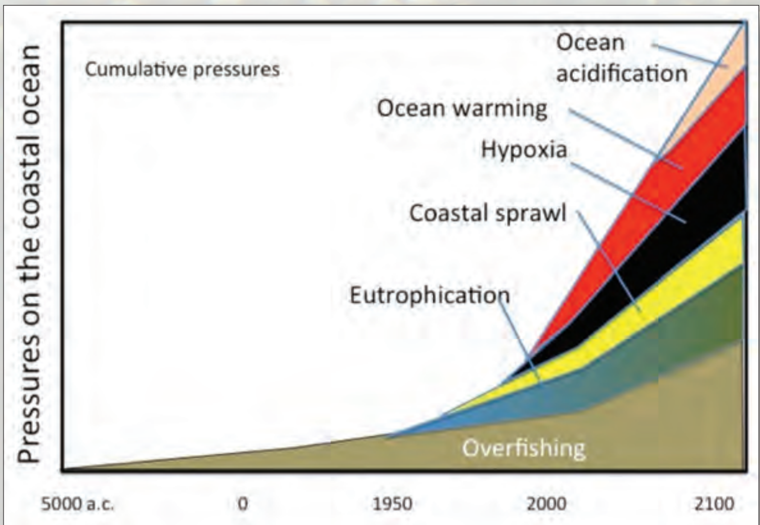

Figure 1. Conceptual diagram of six pressures that can add cumulatively to coastal oceans impacts. Coastal sprawl = habitat alteration + pollutant input.

Photo: AIMS

Extensive seagrass loss from 2009 to 2011 in the GBR at a time of above average run-off for multiple wet seasons found a link to exposure to flood plume conditions (low light, high nutrients and low salinity). High and significant correlations were found between seagrass loss and low light. Light thresholds were developed for inshore seagrass communities (**Figure 2**) as well as derived water quality thresholds relating to flood plumes components that influence light penetration (total suspended solids, chlorophyll a, and colour dissolved organic matter).

An assessment of potential scenarios for coastal development and the cumulative impacts on marine species and ecosystems provided insight into changing baselines and future impacts. Eight scenarios of coastal development for 2035 incorporated information on demand for food, minerals and coal, tourism, and environmental services. Bayesian networks developed for three marine assets – seagrass, dugongs, coral reef fish – produced general models for assessing cumulative impacts of land-use change scenarios and will provide decision-support for coastal managers.

Examination of changes in ecological and environmental conditions across the entire length of the inshore GBR, relative to historic baselines, found evidence of recent changes in coral community composition in the central GBR attributed to dramatic land use changes since European settlement (c.1850). Using palaeo-ecological and environmental approaches combined with precise geochemical techniques, the project provided millennial scale histories of reef development from Cape Grenville in the north to Hervey Bay in the south. These geochemical, geochronological and palaeoecological methods are highly innovative, and have allowed for the investigation of a range of priority stressors: (1) rising sea-level, (2) increasing sea surface temperatures, (3) ocean acidification, (4) increased sediment and nutrient discharges, (5) increased pollution from urban development, and (6) other climatic drivers such as ENSO and tropical cyclones.

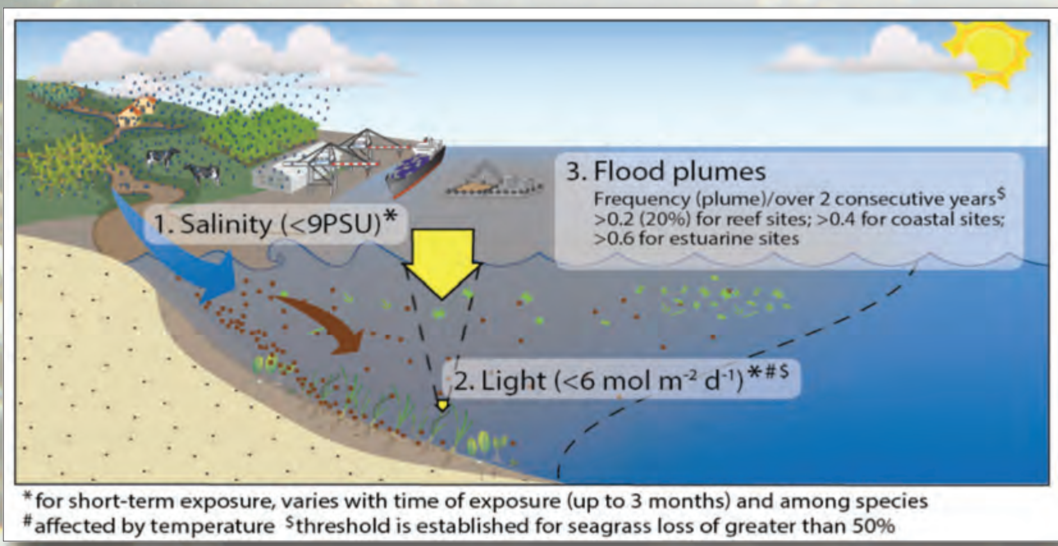

Figure 2. Summary of salinity, light and flood plume thresholds .

Research informing policy and management

For the NERP water quality theme, there has been a strong link to previous research (and monitoring) efforts (e.g. CRCs, MTSRF, Paddock to Reef (P2R), Scientific Consensus Statement (SCS)), links to other research programs (e.g. Reef Rescue R&D, P2R) and pathways into current management and institutional arrangements. Integration across all these programs and processes are essential to develop management solutions for science, policy and management of water quality in the GBR. NERP projects have always worked in conjunction with several other key research programs to ensure that the information is clear, accessible and practical for use from the upstream catchment to the marine environment. There are linkages between researcher and managers involved in a cross section of catchment to marine water quality projects which has been utilised and improved through the inputs into the risk assessment, the Scientific Consensus Statement and the Outlook Report.

NERP Tropical Ecosystems research has generated significant outcomes for informing the design and implementation of water quality monitoring, evaluation and conservation programs. These details have been applied to the GBR Outlook Report 2014, a GBR risk assessment, evidence for the 2013 Scientific Consensus Statement for GBR Water Quality, and the GBR Strategic Assessment 2014.

A GBR-wide risk assessment provides information for policy makers and catchment managers on the key land-based pollutants of greatest risk to inshore coral reefs and seagrass meadows (**Figure 3**).

Projects such as these NERP water quality projects provide the detailed information required to build an understanding of the evolving pressures the reef faces and the ability of the GBR to continue to be a functioning, healthy ecosystem in face of a changing landscape and climate.

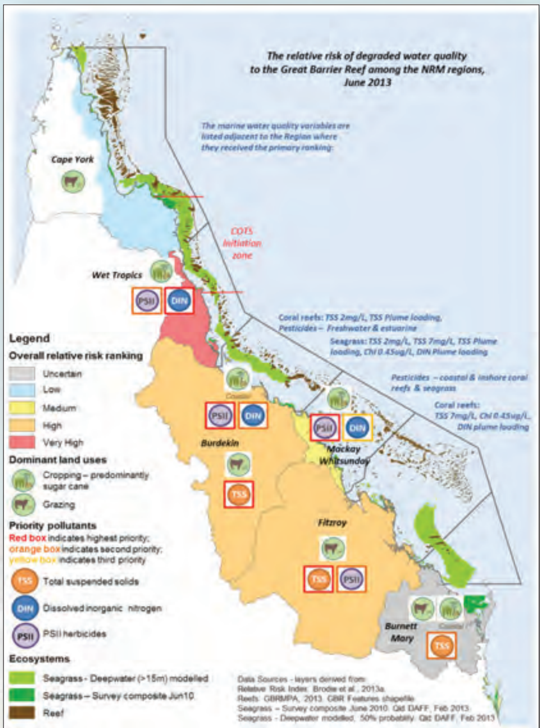

Figure 3. Assessment of the relative risk of degraded water quality to Great Barrier Reef coral reefs and seagrass. The map shows the dominant land uses and priority pollutants and results of the overall relative risk ranking in each NRM region.

Australian Government

Department of the Environment

Reef & Rainforest RESEARCH CENTRE

Photo: RRRC