CRC Reef Research Centre

Established and supported under the Australian Government's Cooperative Research Centres Program

www.reef.crc.org.au

Catchment to Reef: Water Quality Issues in the Great Barrier Reef Region.

9-11 March 2004, Townsville.

Conference abstracts.

Edited by:
David Haynes[1,3] and Britta Schaffelke[2, 3]

[1]Great Barrier Reef Marine Park Authority
[2]CRC Reef Research Centre
[3]James Cook University

Australian Government
Great Barrier Reef Marine Park Authority

Australian Government

Australian Institute of Marine Science

AM

JCU James Cook University

Rainforest CRC

CRC REEF RESEARCH CENTRE TECHNICAL REPORT No 53

CRC REEF RESEARCH CENTRE TECHNICAL REPORT NO. 53

Catchment to Reef: Water Quality Issues in the Great Barrier Reef Region.

9-11 March 2004, Townsville.

Conference Abstracts.

Edited by

David Haynes[1,3] and Britta Schaffelke[2,3]

[1]Great Barrier Reef Marine Park Authority
[2]CRC Reef Research Centre
[3]James Cook University

CRC Reef Research Centre provides research solutions to protect, conserve and restore the world's coral reef ecosystems. CRC Reef Research Centre is a knowledge-based partnership of coral reef managers, researchers and industry. Partner organisations are Association of Marine Park Tourism Operators, Australian Institute of Marine Science, Great Barrier Reef Marine Park Authority, Great Barrier Reef Research Foundation, James Cook University, Queensland Department of Primary Industries, Queensland Seafood Industry Association and Sunfish Queensland Inc.

Established and supported under the Australian Government's Cooperative Research Centres Program

CRC Reef Research Centre Ltd
PO Box 772, Townsville
Queensland 4810 Australia
Phone: 07 4729 8400
Fax: 07 4729 8499
Email: info@crcreef.com
Web: www.reef.crc.org.au

National Library of Australia Cataloguing-in-Publication entry

Catchment to reef : water quality issues in the Great Barrier Reef region, 9-11 March 2004, Townsville ; conference abstracts.

Bibliography.
Includes index.
ISBN 1 876054 95 6.

1. Water quality - Queensland - Great Barrier Reef Region - Congresses. 2. Watersheds - Queensland - Great Barrier Reef Region - Congresses. I. Haynes, David, 1958- . II. Schaffelke, Britta, 1962- . III. CRC Reef Research Centre. (Series : CRC Reef Research Centre technical report ; no. 53).

363.73947

This publication should be cited as:
Haynes D, Schaffelke B (eds). 2004. Catchment to Reef. Water Quality Issues in the Great Barrier Reef Region. 9-11 March 2004, Townsville. Conference Abstracts. CRC Reef Research Centre Technical Report No. 53. CRC Reef Research Centre, Townsville.

Published by CRC Reef Research Centre, PO Box 772, Townsville, Queensland 4810 Australia.

FOREWORD

Water quality science is central to the management of the Great Barrier Reef. We have come to understand that deteriorating water quality in coastal waters is a major threat to the inshore Reef, and that action needs to be taken. Science and Scientists have been instrumental in ensuring not only that we understand the problem, but also in supporting an appropriate response, culminating in the release of the State and Commonwealth Government's *Reef Water Quality Protection Plan* in October 2003. The Plan has the goal of halting and reversing the decline in water quality within the next ten years.

It is now more than four years since researchers working in the field of water quality, and other interested parties met in a conference to exchange their knowledge on current developments in water quality research relevant to the Great Barrier Reef region. This *Catchment to Reef: Water Quality Issues in The Great Barrier Reef Region* conference, co-organised by the Great Barrier Reef Marine Park Authority, CRC Reef Research Centre, Australian Institute of Marine Science, Australian Museum, James Cook University and Rainforest CRC will be of major interest to all concerned with the future of the Reef.

The proceedings of this Conference will be published in a special edition of the international journal *Marine Pollution Bulletin*, to produce a benchmark of our current state of knowledge of Great Barrier Reef water quality. Subsequent forums are being planned to ensure scientists and practitioners can meet to develop solutions using the knowledge presented at this conference.

Andrew Skeat
Executive Director
Great Barrier Reef Marine Park Authority

TABLE OF CONTENTS

CATCHMENT TO REEF- CONFERENCE PROGRAM

Oral presentations

Day 1 - Tuesday 9 March		
7.30 - Registration opens		
Time	Speaker	Title
8.50	Andrew Skeat (GBRMPA)	Conference Opening Address
Session 1: Catchment sources		
9.00	McKergow, Brodie, Prosser, Hughes, Furnas, Hunter	Sources of sediment and nutrient exports to the Great Barrier Reef
9.20	Furnas, Mitchell, Skuza, Wright	River discharge of nutrients from dry tropical rivers of the Great Barrier Reef catchment
9.40	Rayment	Sugarcane's footprints on water quality in reef catchments of Queensland
10.00	Butler, Crossland, Pearson	Temporal dynamics of stream water quality during a storm event in a catchment dominated by sugarcane cropping
10.20	Post	Sources and sinks of sediments and nutrients in semi-arid grazing lands of the Burdekin catchment
10.40	**Morning Tea**	
11.20	Rasiah, Armour, Duncan, Cogle	An overview of nitrate in groundwater in Great Barrier Reef catchments: a case study in the Johnstone catchment
11.40	Cox, Moss	An overview of the Queensland Environment Protection Agency long term water quality monitoring program in central and northern Queensland
12.00	Faithful, Finlayson	Water quality assessment for sustainable agriculture in the wet tropics – a community approach
12.20	Lukacs	Wetlands processes in tropical Queensland and their influence on water quality
12.40	**Lunch**	
Session 2: Transport and fate		
13.40	McCulloch	Impact of European settlement on sediment and freshwater runoff into the inner Great Barrier Reef
14.00	Brando, Dekker, Oubelkheir, Marks	Daily to weekly large scale monitoring of water quality from the river to the Ocean across the Great Barrier Reef
14.20	Ridd, Larcombe, Thomas, Whinney	A comparison of water turbidity on coral reefs along the Queensland coast.
14.40	Wolanski	Coral reef ecohydrology: quantifying the need for integrated watershed-based management activities and marine conservation
15.00	Eyre, Ferguson, Webb	Nutrient cycling in shallow subtropical coastal systems

15.20	**Afternoon Tea**	
16.00	Stieglitz, Ridd, Brunskill, Heron, Burrage, Hancock	Submarine groundwater discharge along the central Great Barrier Reef coastline
16.20	Webster, Ford	Estimating nutrient budgets in tropical estuaries subject to episodic flows
16.40	Ford, Robson, Tillman, Webster	Organic carbon inputs, outputs and dynamics in the Fitzroy estuary
17.00	Devlin, Brodie	Flood processing of river material in Great Barrier Reef waters
17.20	**Close**	

Day 2 - Wednesday 10 March		
Time	Speaker	Title
Session 3: Ecosystem indicators of water quality		
9.00	Codi-King, Humphrey	A review of fish biomarkers in tropical coastal waters.
9.20	Perna, Cappo, Burrows	Fish habitat decline and recovery in the Burdekin River.
9.40	Lough	Historical environmental perspectives from massive corals
10.00	Bengtson-Nash, Eaglesham, Müller	Application of a novel phytotoxity test for the detection of herbicides in Hervey Bay and the Great Sandy Strait
10.20	Koskela, Lee, Venables, Fraser, Koskela, Fryar	Catchment modifications and temporal variation in water quality in Nelly Bay (Magnetic Island), Great Barrier Reef Marine Park.
10.40	**Morning Tea**	
11.20	Stauber, Apte, Jones, Simpson, Vincente-Beckett, Johnson, Duivenvoorden	A risk based approach to contaminants in Port Curtis
11.40	Furnas	The other ninety percent, plankton responses to enhanced nutrient availability in the Great Barrier Reef lagoon
12.00	Brodie, Fabricius, De'ath, Okaji	Are increased nutrient inputs responsible for more outbreaks of crown-of-thorns starfish? An appraisal of the evidence
12.20	De'ath, Fabricius, Okaji, Brodie, Day	Increased chlorophyll levels lead to increased frequency and severity of outbreaks of the crown of thorns starfish (Acanthaster planci) on the Great Barrier Reef
12.40	**Lunch**	
Session 4: Water quality impacts on tropical marine plants		
13.40	Mellors, Marsh, Waycott	Responses of sediments and seagrasses to nutrient enhancement in two Halophila ovalis meadows
14.00	McMahon	Herbicide contamination and seagrass health: a case study in southern Queensland

14.20	McKenzie, Lee Long, Yoshida	Green Island seagrass monitoring and dynamics.
14.40	Harrington, Fabricius, Negri	Synergistic effects of diuron and sedimentation on the photophysiology and survival of crustose coralline algae
15.00	Albert, O'Neil, Waite, Lukondeh, Rose, O'Sullivan, Salmon	Land-based factors associated with blooms of the Cyanobacterium Lyngbya majuscula
15.20	**Afternoon Tea**	
16.00	Duke, Bell	Extensive dieback of mangroves associated with agricultural herbicides in the Mackay region: serious implications for marine habitats of the Great Barrier Reef Marine Park
16.20	Udy, Longstaff, Costanzo, Jones	Using nitrogen stable isotope ratios of macroalgae to monitor changes in the extent of sewage impacts in Moreton Bay
16.40	Schmidt, Stewart, Moss, Dennison	Nitrogen ecophysiology of Heron island, a Great Barrier Reef coral cay
17.00	Brando, Dekker, Phinn, Roelfsema	Mapping and monitoring coastal environments using remote sensing
17.20	**Close**	

Day 3 - Thursday 11 March 2004		
Time	Speaker	Title
Session 5: Water quality impacts on coral reef ecosystems		
9.00	Smith, Devlin, Haynes	Size structure, recruitment and post-recruitment survival of nearshore corals in the Great Barrier Reef wet tropics
9.20	Fabricius, De'ath, McCook, Turak, Williams	Coral, algae and fish communities on inshore reefs of the Great Barrier Reef: Ecological gradients along water quality gradients
9.40	Hutchings, Peyrot-Clausade	Influence of land runoff on rates and agents of bioerosion of coral substrates
10.00	McCook, Birrel, Diaz-Pulido, Willis	Interactions between benthic algae, water quality and reef disturbance and recovery
10.20	Shaw, Jones, Shaw, Müller	Concentrations and phytotoxicyt of PSII herbicides on corals of the Great Barrier Reef
10.40	**Morning Tea**	
11.20	Negri, Vollhardt, Cantin, Humphrey, Jones, Willis, Fabricius	Effects of the herbicide diuron on the reproduction and early life stages of coral
11.40	Hoegh-Guldberg	Changing environmental envelopes. Degraded coral reefs or coral reefs off Sydney?
12.00	Thompson, Sweatman	Historical information on benthic communities of inshore reefs of the Great Barrier Reef
12.20	Done	Water quality targets: what changes can we expect in coastal coral reefs?

12.40	**Lunch**	
Session 6: Contemporary water quality research and monitoring issues		
13.40	Phinn, Dekker, Joyce, Roelfsema, Brando, Wettle	The current and near future applications for detection and monitoring of seagrass, macro-algae and coral reefs
14.00	Waycott, Duke	Research needs and strategies for future interpretation of seagrass and mangrove status and trend
14.20	Haynes, Brodie	Great Barrier Reef water quality ecosystem monitoring: future directions and management approaches
14.40	Moss, Brodie	Queensland water quality guidelines and their application to Great Barrier Reef World Heritage Area waters
15.00	Greiner, Herr, Brodie, Haynes, Audas, Roth.	A triple-bottom-line assessment of basins within the Great Barrier Reef catchment in relation to their sediment, nutrient and pesticide discharges and potential impact on the Great Barrier Reef
15.20	**Afternoon Tea**	
16.00	Shaw	Future scenarios for the Great Barrier Reef in response to pressures and current strategies. How can science address the issues?
16.20	Thomas, Ridd	Development of innovative sensors for inshore coral reef monitoring
16.40	Costanzo, Watkinson, Murby, Bates, Micalizzi	Emerging pollutants: the case of antibiotics in the aquatic environment
17.00	Lawrence, Bennett, Johnstone, Shaw	Adaptive management and its role in managing Great Barrier Reef water quality
17.30	**Close**	

Poster presentations

Session 1: Catchment sources	
Hunter, Amour	Nutrient exports from sugarcane catchments
O'Reagain, Fraser, Brodie, Bushell, Holloway, Faithful, Haynes	Runoff and sediment loss under different grazing management strategies in the upper Burdekin
Rohde, Dougall, Packett,Stevens, Wallace, Noble, Carroll	Source to sea: using two rainfall events within the Fitzroy Basin as case studies in tracking pollutants
Bartley, Olley, Henderson, Prosser, Hughes, McKergow, Lu, Brodie, Bainbridge, Roth	A sediment budget for the Herbert River catchment, North Queensland, Australia
Session 2: Transport and fate	
Furnas	Regional variations in water column nutrients and other water quality parameters in Great Barrier Reef waters
Session 3: Ecosystem indicators of water quality	
Clarke	Arsenic levels in a commercial crab from tropical coastal waters. An evaluation of the risk associated with consumption
Session 4: Water quality impacts on tropical aquatic plants	
Coles, McKenzie, Campbell, Short	Approaches to protecting seagrass meadows in north-eastern Australia and the western Pacific
Longstaff, Dennison	Light requirements of seagrasses in north-east Australia
Mellors, Waycott, Marsh	Variation in biogeochemical parameters across intertidal seagrass meadows in the central Great Barrier Reef region
Session 5: Water quality impacts on coral reef ecosystems	
Haynes, Carter, Gaus, Müller, Dennison	Organochlorine and heavy metal concentrations in blubber and liver tissue collected from Queensland (Australia) dugong (*Dugong dugon*)
Gaus, O'Donohue, Connell	An assessment of risks to dugongs from exposure to dioxins
Russell, McDougall	Rehabilitation of reclaimed coastal wetlands influenced by acid sulfate soils: effects on water quality and fish assemblages
Session 6: Contemporary water quality research and monitoring issues	
Udy, Longstaff, Pantus	Monitoring marine ecosystem health: novel approaches from SE Queensland, Australia
Hodge, Longstaff, Steven, Thornton	Rapid underway water quality monitoring: Development and application for the Great Barrier Reef

LAND-BASED FACTORS ASSOCIATED WITH BLOOMS OF THE CYANOBACTERIA *LYNGBYA MAJUSCULA*.

Simon Albert[1], Judith O'Neil[1], David Waite[2], Tredwell Lukondeh[2], Andrew Rose[2], Cherie O'Sullivan[1], Tim Salmon[3].

[1] Marine Botany Group, Centre for Marine Studies, University of Queensland, St Lucia, QLD 4072, Australia
[2] Centre for Water and Waste Technology, University of NSW, Australia
[3] School of Microbiology, University of NSW, Australia

Over the past ten years, nuisance blooms of the toxic cyanobacteria *Lyngbya majuscula* have been increasing in frequency and severity in Moreton Bay, QLD. Blooms occur in shallow marine and estuarine environments attached to benthic substrates, such as seagrass. There are many human and ecological health issues associated with large (kms^2) blooms of *L. majuscula*. A substantial research effort is underway to elucidate both causes and impacts. As a nitrogen fixing cyanobacterium, *L. majuscula* productivity is stimulated by both phosphorus and iron. This study aims to determine potential sources of these elements, which contribute to *L. majuscula* proliferation. High levels of organic carbon in catchments surrounding bloom sites provide both a source and transport mechanism for bioavailable iron to enter the marine environment. The supply of bioavailable iron to coastal waters increases significantly during high rainfall events, and may play a role in bloom stimulation and maintenance. A significant proportion (36%) of the study catchment is a managed pine plantation, during plantation clearfelling large amounts of organic material enters the system. Soluble organic material from these pine plantations significantly stimulates the photosynthetic capacity of *L. majuscula* during laboratory trials. Parallel studies have also shown organics derived from pine plantations form soluble iron complexes far more rapidly than other natural organics. Trials are currently underway to assess potential plantation management options to reduce the loads of organic carbon into the estuarine and marine environment, and thus help mitigate the impacts of *L. majuscula* blooms.

A SEDIMENT BUDGET FOR THE HERBERT RIVER CATCHMENT, NORTH QUEENSLAND, AUSTRALIA

Rebecca Bartley*[1], Jon Olley[2], Anne Henderson[3], Ian Prosser[4], Andrew Hughes[5], Lucy McKergow[5], Hua Lu[5], Jon Brodie[6], Zoe Bainbridge[6], Christian Roth[3]

[1] CSIRO Land and Water, P.O Box 780, Atherton, QLD 4883, Australia
[2] CSIRO Land and Water, GPO Box 1666, Canberra, ACT 2601, Australia
[3] CSIRO Land and Water, Townsville, QLD 4811, Australia
[4] Land and Water Australia, GPO Box 2182, Canberra, ACT 2601, Australia
[5] Formerly CSIRO Land and Water, Canberra, ACT 2601, Australia
[6] James Cook University, Townsville, QLD 4811, Australia

* Author to whom correspondence should be addressed

A combination of spatial modelling, sediment tracing techniques and water-quality data were used to determine the major source of fine sediments in the Herbert River Catchment, Queensland, Australia. Using modelling, hillslope erosion was predicted to be the dominant source of sediment, contributing 52% of the total sediment load at the estuary. Gully and stream bank erosion contributed equal loads to the estuary (~24%). The ^{137}Cs concentrations measured in this study support the modelled predictions for contributions from different land-uses. Results from modelling and sediment tracing also predicted similar ratios of hillslope to channel erosion. The total suspended sediment loads predicted for the downstream freshwater limit of the catchment are within 10% of longer term measured values. These results suggest that the modelling approach used in this study is useful for determining sediment budgets for large tropical catchments.

APPLICATION OF A NOVEL PHYTOTOXICITY TEST FOR THE DETECTION OF HERBICIDES IN HERVEY BAY AND THE GREAT SANDY STRAIT

Susan Bengtson-Nash[1], Geoff Eaglesham[2], Jochen Müller[1]

[1] National Research Centre for Environmental Toxicology, 39 Kessels Road, Coopers Plains, QLD 4108, Australia
[2] Queensland Health and Scientific Services, Brisbane, QLD, Australia

A novel phytotoxicity test which uses inhibition of photosynthesis as an endpoint measure of toxicity, has been developed. The technique utilises pulse amplitude modulated (PAM) fluorometry and has been validated for diuron, under laboratory conditions. The level of detection (LOD) was determined as 0.01 ug/L diuron (in potable waters), hereby functioning at European Guideline levels. Recently, the test was combined with solid phase extraction (SPE) and incorporated into a field assessment investigating the role of herbicides on the deteriorating health of seagrass along the southeast Queensland coast. Water samples were obtained from river, estuarine and marine systems during both wet and dry periods and were analysed by both LC-MS and with the phytotoxicity assay. The cumulative, phytotoxic activity measured with the phototoxicity assay correlated very strongly (~98%) with results obtained by LC-MS analysis, indicating that 98% of phytotoxic activity could be explained by the quantified herbicides in the water samples.

The monitoring of water quality is a key task for managers of environmental and public health. Our study showed that the phytotoxicity assay is both viable and would prove a highly practical and informative addition to any aquatic assessment.

DAILY TO WEEKLY LARGE SCALE MONITORING OF WATER QUALITY FROM RIVER TO OCEAN ACROSS THE GREAT BARRIER REEF

Vittorio Brando, Arnold Dekker, Kadija Oubelkheir, Alan Marks

Environmental Remote Sensing Group, CSIRO Land and Water, GPO Box 1666, Canberra, ACT 2601, Australia

Past ocean colour satellite systems were designed to measure chlorophyll in clear ocean waters. To monitor and understand coastal and near shore processes more sophisticated satellite sensors were required such as the MODIS and MERIS systems. These new sensors can unravel the optical complexity of coastal waters. Their temporal frequency is high (several images a day), their spatial resolution is relatively low (300 to 1200 m pixels) and they cover a large swath of 1500 to 2000 km.
A spatial information delivery infrastructure is being built in Australia by CSIRO and GA that collects satellite-based image data over the continent and its coasts and oceans on a daily basis. Initially this system will produce daily maps of chlorophyll-a and total suspended matter. These maps will be based on field validated algorithms suited to Australian coastal waters and eventually be delivered in near real time through a web-based delivery system. Examples of these products and validation results will be presented for rivers and coastal waters of the tropical and sub-tropical coast in Queensland. A time series of water quality products derived from the January 2003 Fitzroy River flood demonstrates the capability for estimating the sediment fate. Another example is presented for nutrients and suspended matter compliance monitoring in the Douglas Shire Coastal waters.

Several important issues need to be resolved for the full development and implementation of an operational monitoring system. The challenges associated with these issues depend on the end-user requirements for satellite-based water quality monitoring information. Presentation of these challenges at a suitable forum (such as this conference) will be used to obtain feedback and structure future development of the coastal water quality monitoring system.

MAPPING AND MONITORING COASTAL ENVIRONMENTS USING REMOTE SENSING

Vittorio Brando[1], Arnold Dekker[1], Stuart Phinn[2], Chris Roelfsema[2, 3].

[1].Environmental Remote Sensing Group, CSIRO Land and Water, GPO Box 1666, Canberra, ACT 2601, Australia
[2].Biophysical Remote Sensing Group and [3].Marine Botany Group, Centre for Marine Studies, University of Queensland, St Lucia, QLD 4072, Australia

Production of accurate and reliable maps of water-quality or substrate types in coastal waters from remotely sensed data is a complex task, due to varying levels of water optical clarity. Coastal embayments are highly dynamic and create optically complex features due to oceanic tidal influences and terrestrial inputs from rivers and creeks. Our study presents innovative ways to provide reliable water quality maps in this complex environment. A processing sequence was established for Moreton Bay, southern Queensland, to enable processing of satellite or airborne images of the coastal zone to map substrate types and concentrations of particulate and dissolved organic and inorganic material in the water column. Maps showing the concentrations of organic and inorganic materials over three dates, in combination with field measurements were used to define the "domains" present within Moreton Bay. Five domains were defined from field measurements and maps of optical properties. The maps represented estimated coloured dissolved organic matter (CDOM) and tripton (inorganic particulate matter) concentrations. The five zones were: near Case 1 oceanic waters, a complex of green-brown waters (Case 2), complex near coastal areas with both turbid and clear Case 2, turbid, Case 2 and tidal channels with predominantly clear waters (Case 1 or Case 2). A method was then established and applied for mapping the location and density of *Lyngbya majuscula* and other substrates, e.g. seagrass density and macroalgae, from Landsat 7 ETM image data in shallow (< 3m depth) clear water bodies. This work represents the first stage in the design and evaluation of image processing algorithms for mapping water quality and substrate type parameters in optically complex coastal waters.

ARE INCREASED NUTRIENT INPUTS RESPONSIBLE FOR MORE OUTBREAKS OF CROWN-OF-THORNS STARFISH? AN APPRAISAL OF THE EVIDENCE

Jon Brodie[1], Katharina Fabricius[2], Glenn De'ath[2], Ken Okaji[3]

[1] Australian Centre for Tropical Freshwater Research, James Cook University, Townsville, QLD 4811, Australia.
[2] Australian Institute of Marine Studies and CRC Reef Research Centre, PMB 3, Townsville, QLD 4810, Australia
[3] Coralquest Inc., 667 Nurumizu, Atsugi, 243-0033, Japan

Outbreaks of the coral-eating crown-of-thorns starfish (*Acanthaster planci*) have caused widespread damage to coral reefs in the Indo-Pacific including the Great Barrier Reef (GBR) over the past four decades. The causes of the outbreaks are controversial and opinion is divided on whether it is a natural phenomenon or the result of human activity. The possibility of outbreaks being linked to terrestrially derived pollutants has been postulated a number of times. The most substantive causal link with terrestrial runoff is expressed in the 'larval survival hypothesis' which suggests that enhanced nutrient supply in river run-off is critical for A. planci larval survival as the larvae are food limited in 'normal' GBR shelf phytoplankton conditions; this hypotheses has been put forward to explain so called primary outbreaks. This paper examines the evidence for such a cause, focussing particularly on the GBR.

Higher loads of nutrients (nitrogen and phosphorus), particularly bioavailable nutrients such as nitrate, ammonia and phosphate, are discharged from GBR rivers, especially in the central GBR, than pre-1900. Thus elevated (above natural) concentrations of nutrients occur on the central GBR shelf in the wet season (December to March). As a response elevated biomass (compared to pre – 1990) of phytoplankton (as measured by chlorophyll concentrations) occurs on the central GBR shelf in the wet season. There are also higher proportion of larger phytoplankton (nano and microplankton, > 2 µm) compared to smaller phytoplankton (< 2 µm, phototrophic picoplankters) on the central GBR shelf in the wet season. The planktonic larval stage of A. planci occurs in late November and December coinciding with periods of high biomass of large phytoplankters in the area. Larval development, growth and survival increase almost ten-fold with doubling concentrations of large phytoplankton. Chlorophyll concentrations for December – February in the inner GBR average 0.2 µg/L in northern section (remote from human land use), but are double this (0.4 µg/L) in the central section. The combination of these lines of evidence suggests that increased A. planci outbreak frequency on the GBR may indeed be a result of increased nutrient delivery from the land.

TEMPORAL DYNAMICS OF STREAM WATER QUALITY DURING A STORM EVENT IN A CATCHMENT DOMINATED BY SUGARCANE CROPPING

Barry M. Butler, Michael Crossland, Richard G. Pearson

Australian Centre for Tropical Freshwater Research, James Cook University, Townsville, QLD 4811, Australia

Automated and manual sampling methods were used to examine short-term variations in the quality of stormwater in Lagoon Creek; a freshwater lagoon system that drains sugar-lands on the Herbert River floodplain, located on the drier margins of the wet northern catchments of Australia's Great Barrier Reef. Sampling was conducted in 2002, during a wet season that was so atypically dry that only one (36 hour-300mm) rain event generated swift-flows in regional streams. The event occurred in February, 2 months after the cane harvest. Despite the lack of prior runoff events there had been adequate rainfall to ensure that antecedent catchment conditions were surprisingly good compared to many previous years when heavy rain had fallen while harvested fields were still bare. Consequently concentrations of particulate materials in the runoff were quite moderate. The storm hydrograph was very flashy, reaching peak discharge within 12 hours and falling back to baseflow over 11 days. Notably most particulate contaminants were exported over a period of only 4 hours, and fluxes would have been grossly under-estimated if automated sampling methods had not been used. In contrast, fluxes of dissolved materials remained significant for several days during the falling limb of the hydrograph. Nitrate concentrations were very high, rising to more than 5000 µg N / L as soon as water levels fell sufficiently for soil throughflow to enter the stream. Samples from other streams and drains in the vicinity indicate a typical peak concentration range of 3000 to 10000 µg N / L. Samples taken during previous wet years contained low nitrate concentrations, but ammonia levels often exceeded 5000 µg N / L. Results show that inorganic N speciation can vary enormously depending on prevailing catchment conditions and the timing of events relative to the application of ammonia-based fertiliser. BOD levels were low compared to the high values that have sometimes been reported in farm runoff (usually during harvests), suggesting that in this case sugar and trash spilled on the soil during harvest had substantially decomposed prior to the event. However, the stormwater was still oxygen demanding and was sufficiently hypoxic to acutely threaten most aquatic animal species. The creek's water column was stratified so monitoring depth was critical for most parameters.

ARSENIC LEVELS IN A COMMERCIAL CRAB FROM TROPICAL COASTAL WATERS. AN EVALUATION OF THE RISK ASSOCIATED WITH CONSUMPTION

Joanne Clarke

Australian Institute of Marine Science, PMB 3, Townsville MC, QLD 4810, Australia
James Cook University, Townsville, QLD 4811, Australia

Arsenic is one of the most important global environmental toxicants. Originating from both natural and anthropogenic sources, arsenic is ubiquitous in the biosphere and frequently reported to be an environmental pollutant. Arsenic is naturally present in marine organisms, independent of environmental pollution and present at much higher concentrations than in terrestrial organisms.

Traces of arsenic are found in most foods with highest concentrations found in seafood. Consumption of seafood is now the major source of total arsenic intake by humans.

This study reports total arsenic concentrations measured in a commercial crab species, Portunus pelagicus, collected from tropical coastal waters (Halifax and Bowling Green Bays). Concentrations of total arsenic in the muscle of *P. pelagicus* in this study ranged between 102 and 387 mg/kg dry weight (15.8 and 107.3 mg/kg wet weight). Levels of this magnitude are rare in the literature, with the majority of arsenic values reported to be less than 30 mg/kg wet weight. Preliminary analysis of the same species collected recently from Rib Reef also indicates this elevated arsenic trend.

Arsenic is an element of unique concern because the environmental and toxicological impact is highly dependent on its chemical form. Speciation analysis is currently in progress to provide important information in relation to the toxicity of the arsenic present.

A REVIEW OF FISH BIOMARKERS IN TROPICAL COASTAL WATERS

Susan Codi-King, Craig Humphrey

Australian Institute of Marine Science, PMB 3, Townsville MC, QLD 4810, Australia

The world population is estimated to increase from 6 billion at present to 8.3 billion by 2020, with 90 percent of this growth occurring in subtropical and tropical regions. Anthropogenic stressors from industrial and domestic discharges, fertilizer and pesticide usage, and industrial emissions are likely to increase dramatically, especially in coastal waterways, which usually become the repository of pollutants released from these activities. One of the major tools for elucidating the exposure to, and effects of, environmental pollutants in the aquatic environment is the use of biological markers (biomarkers), which can be used as early warning signals of environmental degradation. These techniques can provide an inexpensive, rapid, and highly sensitive means of identifying and evaluating exposure of biota to environmental contaminants and the effects on the health of these organisms and the integrity of their ecosystem. At present, much of the work on biomarkers has been conducted in temperate regions and much of the scientific basis for employing biomarkers in tropical regions has yet to be properly explored. Biomarkers generally focus on biochemical measures but can be expanded to include: cellular, molecular, physiological and histological changes measured in any of the resident biota, from microbes to fish and birds. Teleost fish have become particularly useful organisms for biomarker studies because their biology is well characterized, readily accumulate pollutants and are important ecologically and economically. This review aims to look at the background to the use of biomarkers in tropical systems and synthesise the current state of play as well as future research priorities for biomarker research in tropical regions.

APPROACHES TO PROTECTING SEAGRASS MEADOWS IN NORTH-EASTERN AUSTRALIA AND THE WESTERN PACIFIC

Rob Coles, Len McKenzie, Stuart Campbell, Fred Short

Queensland Department of Primary Industries, PO Box 5396, Cairns, QLD 4870, Australia

Queensland, north-eastern Australia, has a prescriptive approach to seagrass protection with legal instruments and management by Government authorities. It focuses on limiting development impacts and on designating Marine Protected Areas or "No Take Zones". To be effective this approach assumes: 1) that the legal structures are robust to challenge; 2) that the location of seagrasses is known; 3) a monitoring program is in place; and 4) that enforcement is effective.

Queensland has 644,700 ha of seagrass in less than 15m of water. 28,000 ha are in Marine Protected Areas and highly protected. Actual losses from direct disturbance are small – approximately 120 ha since 1996. The prescriptive approach appears to be working. However, our community program, Seagrass – Watch has monitored large fluctuations in meadow areas resulting from sediment run off and other work has found herbicides in coastal seagrass sediments. Unfortunately, the legal instruments designed to protect marine plants, have little influence on the urban and agricultural practices in adjacent watersheds.

In western Pacific countries the four assumptions of a prescriptive approach are rarely met and, given the immediate threat to seagrasses, we are developing an approach that promotes greater citizen involvement and emphasizes the connectivity of seagrass systems with land-based activities.

EMERGING POLLUTANTS: THE CASE OF ANTIBIOTICS IN THE AQUATIC ENVIRONMENT

Simon D. Costanzo [1], Andrew Watkinson [1], E. John Murby [2], John Bates [3], Gino Micalizzi [3]

[1] National Research Centre for Environmental Toxicology, 39 Kessels Road, Coopers Plains, QLD 4108, Australia
[2] Australian Government Analytical Laboratories, Sydney, NSW, Australia
[3] Queensland Health Scientific Services, Brisbane, QLD, Australia

Despite the widespread use of antibiotics as medicines and growth promoters in Australia (>700,000 kg/yr), these chemicals have received comparatively little attention as pollutants in the aquatic environment. Antibiotics released into the aquatic environment are of concern for the following reasons: i) contamination of raw, treated and recycled water used for drinking, irrigation and recreation; ii) potential to accelerate widespread bacterial resistance to antibiotics; and iii) possible negative effects on important ecosystem bacteria (e.g. denitrifying bacteria). In this study, antibiotic concentrations were assessed in effluent discharged into aquatic environments from sewage treatment plants and intensive livestock industries in QLD, Australia. Bacterial resistance to antibiotics and effects on denitrifying bacteria in these environments were also assessed to provide information on potential ecosystem effects from these emissions.

Multiple veterinary antibiotics were detected in coastal waterways and commonly used human antibiotics were found to have made their way through a major sewage treatment plant with only minor removal. Antibiotic concentrations were found in low µg/L concentrations, similar to concentrations found in recent studies of US and European waterways. Extensive resistance to commonly used antibiotics was identified in bacteria isolated from sewage treatment plants and receiving aquatic environments. Bacterial denitrification rates were also found to be depressed following short-term exposure to a range of antibiotics.

This preliminary information regarding antibiotics in our waterways highlights the need for further investigations on sources, fates and management of wastes containing these and other pharmaceutical compounds.

AN OVERVIEW OF THE QUEENSLAND ENVIRONMENTAL PROTECTION AGENCY LONG TERM WATER QUALITY MONITORING PROGRAM IN CENTRAL AND NORTHERN QUEENSLAND

Melanie Cox, Andrew Moss

Queensland Environment Protection Agency, 80 Meiers Rd, Indooroopilly, QLD 4068, Australia

The Queensland Environmental Protection Agency (EPA) has monitored water quality in coastal catchments in Queensland as part of a regular ambient monitoring program since 1992/3. The aims of the monitoring program are to assess both condition and long-term change or trends in water quality. The purpose of this document is to report on the outcomes of the EPA long-term monitoring in central and northern regions of the state.

The EPA monitoring program is based on regular monthly monitoring. In northern and central regions it covers a total of 170 sites including freshwater, estuarine and coastal sites. The parameters monitored include nitrogen, phosphorus, chlorophyll-a, dissolved oxygen, turbidity, pH, conductivity, temperature and Secchi depth clarity. Condition was assessed by comparison of the most recent data with the Queensland Water Quality Guidelines. Trend was assessed using a censored regression technique, which allowed identification of seasonal and long-term cyclic variations as well as long-term linear trends.

Routine monthly sampling provides information about base flow condition and trend. However, this sampling strategy it is not suited to assessing loads, which requires intensive sampling during short-lived flood events.

Given the extent of the study area, it is not possible to draw specific conclusions related to water quality that apply to all areas. However, a few general conclusions can be drawn.

Condition ratings varied from catchment to catchment. In most cases, poor ratings could be linked back to the presence of a point source discharge of some sort. However, moderate ratings at many sites were unrelated to point discharges and thus may have been related to catchment condition or land use factors.

With respect to trend, at more than 75% of sites most indicators showed no trend and of those that did, a significant proportion were related to changes in point discharge quality or quantity.

A small proportion of sites showed clear trends that were unrelated to discharges and were therefore presumably due to some catchment related activity. The paucity of this type of trend is not altogether surprising as major changes in land use occur over decades, so trend detection is likely to require programs on the same time scale.

Many sites displayed medium-term (2-4 years) cycles in indicator values, possibly related to climatic cycles. Depending on the window of a trend monitoring program, these cycles can bias trends up or down. Thus, in order to be sure of detecting the prevailing long-term trends, programs of 10 or more years are required.

In this type of program, quality assurance is extremely important. Although every effort was made to maintain quality, nevertheless, over the 7-9 year time period, small changes (usually improvements) in analysis, sampling methods and instrumentation introduced changes that had to be taken into account when assessing trends. This was particularly a problem where levels of an indicator were close to the limits of detection for the method or instrument.

INCREASED CHLOROPHYLL LEVELS LEAD TO INCREASED FREQUENCY AND SEVERITY OF OUTBREAKS OF THE CROWN-OF-THORNS STARFISH (*ACANTHASTER PLANCI*) ON THE GREAT BARRIER REEF

Glenn De'ath[1], Katharina Fabricius[1], Ken Okaji[2], Jon Brodie[3], Ken Day[4]

[1] Australian Institute of Marine Studies and CRC Reef Research Centre, PMB 3, Townsville MC, QLD 4810, Australia
[2] Coralquest Inc., 667 Nurumizu, Atsugi, 243-0033, Japan
[3] Australian Centre of Tropical Freshwater Research and Department of Tropical Environmental Studies and Geography, James Cook University, Townsville, 4811. Australia.
[4] Department of Natural Resources and Mines, GPO Box 2454, Brisbane, QLD 4001, Australia

Three waves of outbreaks of the crown-of-thorns starfish *Acanthaster planci* (COTS) have occurred on the Great Barrier Reef (GBR) at approximately 15-years intervals since the early 1960s. There has been considerable debate as to the frequency and intensity of outbreaks prior to then. It has been hypothesised that COTS outbreaks are linked to terrestrial runoff, though the mechanism by which this occurs has not been established. Laboratory studies have demonstrated that the survival of COTS larvae is food-limited, with additional chlorophyll (Chl) in the water greatly enhancing survival; e.g. doubling the level of Chl from 0.2 to 0.4 mg m-3 gives an estimated 8.6 fold increase in the probability of survival. Chl surveys of the Great Barrier Reef over a period of 12 years have given us relatively precise estimates of regional variation, and show that near-shore levels in the central third of the GBR (exposed to agricultural terrestrial run-off) are 2.04 [90% CI = (1.69, 2.46)] times as high as those in the northern third (a relatively pristine area). Based on the laboratory survival study, we used the Chl survey data to estimate larval survival across the GBR.

A COTS-Coral population model was then used to simulate COTS outbreaks at both a single reef and the whole GBR level. The COTS larva stage was driven by the survival probabilities generated from the observed Chl levels. For the inner central third of the GBR with mean levels of Chl 0.4 mg m^{-3}, the simulations showed patterns of outbreaks consistent with those seen over the last 20 years – outbreaks occurring in ~15-year cycles with poor coral recovery and average cover of ~20-25%. For the inner northern third of the GBR (Chl = 0.2 mg m^{-3}), outbreaks were far less frequent – occurring in ~50-year cycles with good coral recovery and high average cover of ~50-70%. It can be argued that this regional difference in Chl levels between an agricultural influenced region and a relatively pristine region can be taken as representative of pre-agricultural times to current times. Temporal models, driven by increasing Chl, showed that transitions from "pristine" patterns of outbreaks to "contemporary agricultural influence" patterns occurred when levels of Chl were doubled. Future trends in COTS outbreaks under different Chl trajectories were also investigated.

FLOOD PROCESSING OF RIVER MATERIAL IN GREAT BARRIER REEF WATERS

Michelle Devlin[1], Jon E Brodie[2]

[1] Centre for Environment, Fisheries and Aquaculture Science, Pakefield Road,Lowestoft, NR33 OHT, UK
[2] Australian Centre of Tropical Freshwater Research and Department of Tropical Environmental Studies and Geography, James Cook University, Townsville, QLD 4811, Australia

Nutrient cycling processes within plume waters are markedly different from low flow periods and hence the plume nutrient cycling can change total nutrient loads, change the forms of nutrients present and also modify ratios of one nutrient to another. Our understanding of the processes occurring in addition to mixing can include, the biological uptake from dissolved to a particulate stage, sedimentation of particulate and the mineralisation or desorption of particulate to dissolved species. A number of these processes occur at the same time and thus make it difficult to determine the type of mixing relationship. Resolution of these processes helps us to understand the connection between inshore biological processes and plume delivered material.

In the initial mixing zone, water velocity is reduced and most of the river derived particulate matter settles from the plume. This is most clearly shown close to the Burdekin where suspended solid and particulate phosphorus concentrations drop to very low levels only a few kilometres from the river mouth at salinity less than 10 and low resuspension conditions. Particulate matter declines rapidly across the mixing zone, with concentrations falling to ambient levels rapidly. Conversely there can be an increase in the particulate nutrients at a greater distance and time in the plume reflecting the succession of particulate nitrogen and particulate phosphorus from algal fixation of the dissolved nutrient component.
Nitrate and phosphate concentrations generally follow a conservative mixing process, diluting in a linear pattern in relation to the salinity concentrations. There is some scattering of data at the higher salinity ranges, indicating some biological processing in the higher salinity ranges (>30 ppt), which are likely to be related to increased light availability. Ammonia concentrations are far more scattered reflecting both variations in supply, uptake and production from biological processes in the plume. Concentrations of NH_4 remain elevated in the higher salinities suggesting sources of ammonia in the plume, for example, excretion by zooplankton. Results from this work help to assess the likely effects of the river derived nutrients on Great Barrier Reef ecosystems.

WATER QUALITY TARGETS: WHAT CHANGES CAN WE EXPECT IN COASTAL CORAL REEFS?

Terry Done

Australian Institute of Marine Science and CRC Reef Research Centre, PMB 3, Townsville MC, QLD 4810, Australia
Email: t.done@aims.gov.au

The expectation in the Reef WQ plan is that meeting water quality targets at river mouths will benefit coastal reefs some kilometres distant from the river mouths. They should lead to a reduction in fluxes of nutrients, sediments and contaminants arriving at the reefs, thereby contributing to a set of circumstances that will set the ecology of degraded reefs onto a path of recovery, and thenceforth maintaining a more socially desirable reef state through time: one dominated by healthy corals, comparatively less benthic algae; abundant and diverse fishes and invertebrates. There is a sound scientific basis for these expectations in general, but a need for better understanding of the biophysical processes involved. The dilutions and biological transformations associated with runoff transport to the reefs need to be better understood, building on the work of King and others. The consequences of the reduced fluxes for coral-algal balance at the reefs need to be evaluated in the context of grazing rates on algae, building on the work of McCook, Schaffelke and others, and also taking into account seasonality, export of algal biomass, and rapid space pre-emption by encrusting corals during the algal 'down' season. The latter seemed to be very important in allowing corals to displace *Sargassum* algae at Pandora Reef during the 1980s-1990s. Inasmuch as the daily grazing incidence by fishes and invertebrates may be limited by lack of three dimensional shelter over large areas were coral structure has collapsed, consideration should be given to the temporary use of suitable rigid fish attracting devices to promote grazing rates, and hence coral recovery, in appropriate areas.

EXTENSIVE DIEBACK OF MANGROVES ASSOCIATED WITH AGRICULTURAL HERBICIDES IN THE MACKAY REGION: SERIOUS IMPLICATIONS FOR MARINE HABITATS OF THE GREAT BARRIER REEF MARINE PARK

Norman C Duke, Alicia M Bell

Marine Botany Group, Centre for Marine Studies, The University of Queensland, St Lucia, QLD 4072, Australia
Email: n.duke@uq.edu.au

Herbicides, particularly diuron, were correlated with the dieback of the dominant mangrove, *Avicennia marina*, reduced canopy condition, and declines in seedling health of 3 neighbouring estuaries in the Mackay region of NE Australia. Over the past century, catchments in many coastal areas have been altered dramatically with corresponding losses in natural vegetation and development of human landscapes. During this time, agricultural production has responded well to the demands of increasing population with improvements in farm efficiency leading to significant increases in the use of agricultural chemicals. However, with regular and episodic flow events, many of these chemicals have found there way into estuarine and nearshore water and sediments where their effects on marine habitats have largely been unquantified. Investigations over the last 2 years have shown the incident of widespread, species-specific dieback of mangroves was mostly associated with herbicides used upstream. The herbicides are therefore considered to be the most likely cause of this serious incidence of dieback. The implications of these findings are immense since they demonstrate not only the serious deterioration of protected mangrove habitat but also the potential for significant effects on other highly-valued estuarine and marine habitats, including seagrass beds and coral reefs of the GBR lagoon.

BENTHIC METABOLISM AND NITROGEN CYCLING IN SHALLOW SUB-TROPICAL COASTAL SYSTEMS

Bradley Eyre, Angus Ferguson, Arthur Webb

Centre for Coastal Biogeochemistry, Southern Cross University, PO Box 157, Lismore, NSW 2480, Australia

This presentation will provide an overview of benthic metabolism and nitrogen cycling in shallow sub-tropical coastal systems. During floods many sub-tropical coastal basins are completed flushed with fresh water and the majority of nitrogen loads are discharged directly onto the continental shelf resulting in a very low annual retention of nitrogen. The percentage of the terrestrial nitrogen load that is retained is determined by the minimum flushing of the system. Most of the carbon and nitrogen processing occurs as coastal systems recover following floods and during the dry season. Sediment biogeochemical processes play a key role in this cycling of carbon and nitrogen. For example, denitrification is the dominant pathway (56%) through which nitrogen is removed from the sub-tropical Moreton Bay. Further, in shallow coastal systems pelagic and benthic compartments are tightly coupled and much of the carbon production and metabolism occurs in the sediments. The sediments of sub-tropical coastal systems tightly recycle and conserve nitrogen by active competition for limited N resources between heterotrophs, autotrophs and chemoautotrophs. A significant proportion of the mineralised nitrogen may be removed from the microbial loop and passed up to the metazoan levels of the foodchain. Net N_2 effluxes (denitrification) are controlled by a complex interaction between the supply of NO_3 from the water column and nitrification, the supply and decomposition of labile carbon, benthic productivity and macro-fauna abundance. For example, active *Trypaea australiensis* (yabbies) burrows (22 m^{-2}) can increase net N_2 efflux rates 4 fold and *Dasyatsis fluviorum* (sting ray) wallow basins can increase net N_2 efflux 6 fold. Sediments inhabited by *Mictyris longicarpus* (solider crab) can have net N_2 efflux rates of 276 – 430 μmol m^{-2} d^{-1} compared to net uptakes (194 – 449 μmol m^{-2} d^{-1}) in their absence. Trawling has also been shown to significantly increase denitrification rates in sub-tropical systems. Overall, the rate of carbon decomposition (which can be considered a proxy for carbon loading) appears to be an important control on the efficiency with which coastal sediments recycle nitrogen as N_2.

CORAL, ALGAE AND FISH COMMUNITES ON INSHORE REEFS OF THE GREAT BARRIER REEF: ECOLOGICAL GRADIENTS ALONG WATER QUALITY GRADIENTS

Katharina Fabricius[1], Glenn De'ath[1], Laurence McCook[2], Emre Turak[1], David Williams[1]

[1] Australian Institute of Marine Science and CRC Reef Research Centre, PMB 3, Townsville MC, QLD 4810, Australia
[2] Great Barrier Reef Marine Park Authority, PO Box 1379, Townsville QLD 4810, Australia

Community structures of major groups of reef-inhabiting organisms were surveyed on 10 - 12 inshore coral reefs of the Great Barrier Reef (GBR) along water quality gradients within two regions: the Wet Tropics (WT) that is exposed to run-off from agricultural areas, and Princess Charlotte Bay (PC) that receives river flood plumes from catchments with little or no agriculture. Reefs in WT experienced higher mean suspended solids, chlorophyll, and many of the particulate and dissolved nutrients than in PC. There were also clear differences in benthic structure and the biodiversity of some of the groups investigated (three Divisions of macrophytes, hard corals, zooxanthellate and azooxanthellate octocorals, and two trophic groups of fish). Both cover and richness of hard corals and octocorals were lower, and the abundance of green macroalgae (Chlorophyta) was higher in WT compared to the PC. The community structure of fish, hard corals, octocorals, and of green and red macroalgae (but not of brown macroalgae) also differed between the regions. Due to large natural variation in seawater nutrient concentrations and ecological systems, and the few reefs surveyed, the ecological gradients within regions along the water quality gradient are naturally weak. Nevertheless, ecological gradients along the water quality gradients were found in four groups: total macrophyte cover and abundance and richness of red macroalgae (Rhodophyta) increased, and octocoral richness decreased along gradients from the clearest water to the least clear water. The community structure of octocorals was also strongly related to the water quality gradient. The effect sizes in some of the groups were large and ecologically relevant, and the directions of changes were consistent with those predicted from regional differences in water quality, with previous findings from other runoff-exposed regions, and with laboratory experiments on nutrient enrichment.

WATER QUALITY ASSESSMENT FOR SUSTAINABLE AGRICULTURE IN THE WET TROPICS – A COMMUNITY APPROACH

John Faithful[1], Wendy Finlayson[2]

[1] Australian Centre for Tropical Freshwater Research, James Cook University, Townsville, QLD 4811, Australia
[2] Catchment Coordinator , Cardwell Shire Catchment Management, PO Box 929 Tully, QLD 4854, Australia

A number of studies in north Queensland have concluded that nutrient- and sediment-rich exports occur from agricultural watersheds, particularly in runoff generated during wet seasonal rainfall events. The level of impact of these farm-based exports to receiving waters is governed by the size of the watershed, the form of agriculture activity, soil type, timing and intensity of the rainfall event, topography and vegetation cover on the watershed.

With the co-operation of a number of growers, the Cardwell Shire Catchment Management, the Barron River Integrated Catchment Management Association and Queensland Department of Natural Resources and Mines (Mareeba and Innisfail), banana and cane farms were utilised to provide a basis of comparison within and between catchments for nutrient and sediment exports from agricultural plots. Farms were characterised as primary, secondary or random sites based on the level of sampling intensity that would be required for their respective plots. An urban lakes system in Mareeba was included to provide an urban stormwater comparison with the agricultural data. Primary sites were provided with gauged v-notch weirs in drainage channels below the farming plots to collect flow data, which were also configured with rainfall gauging infrastructure.

Landholders and catchment co-ordinators were trained in sample collection and preservation techniques for nutrients, suspended solids and BOD_5 analyses. Field meters were provided for the Tully / Murray catchments to allow for the collection of physico-chemical data that could be collected in conjunction with the nutrient, sediment and BOD data.

This paper reports on the development of the project in general, discussing the difficulties and successes of establishing a community based monitoring water quality program in the Wet Tropics and makes recommendations for any future monitoring. Data is presented listing the water quality of plot drainage during wet season rainfall events, showing obvious differences between land uses and between catchments, with a number of recommendations provided to the land holders that may reduce nutrient and sediment losses from the farm plots.

ORGANIC CARBON INPUTS, OUTPUTS, AND DYNAMICS IN THE FITZROY ESTUARY.

Phillip W. Ford*, Barbara Robson, Pei Tillman, Ian T. Webster

CSIRO Land and Water, GPO Box 1666, Canberra, ACT 2601, Australia and *CRC Coastal Zone
Email: phillip.ford@csiro.au, barbara.robson@csiro.au, pei.tillman@csiro.au, ian.webster@csiro.au.

Discharge of the Fitzroy River into the Fitzroy estuary is highly episodic. Short-lived major flood events deliver high concentrations (5-10 mgL^{-1}) of terrestrially-derived organic carbon (DOC:POC ~ 4:1) to the Fitzroy estuary. Most of this material is rapidly transported through the estuary. Measurements of TOC and DOC were made at 12 stations along the estuary on 22 surveys between November 2000 and July 2002 encompassing both short-lived high flow events, and the much longer periods of minimal flow. At the end of the flood event the whole estuary is filled with highly turbid freshwater containing both POC and DOC at the original input concentrations. Post flood, primary production within the water column is suppressed due to the poor light climate. DOC undergoes bacterial metabolism and its concentration gradually declines. Much of the POC gradually settles out with the fine sediment particles. Primary production by benthic microalgae on the tidally exposed mud flats is insufficient to compensate for organic carbon lost by bacterial respiration. The whole estuary is net heterotrophic at this stage.

The light regime improves as salt water advances up the estuary and pelagic primary production increases. Consequently, the upper estuary becomes net autotrophic late in the season. However, macrotidal sediment resuspension at the mouth of the estuary ensures that there is no improvement in the light climate there, and this zone remains heterotrophic consuming much of the primary production which is mixed down estuary. We apply the novel method described at this Conference ("Estimating nutrient budgets in tropical estuaries subject to episodic flows" by Webster and Ford) to make quantitative estimates of the sizes of the sources and sinks for DOC at different times and places along the estuary, and the delivery of organic carbon to Keppel Bay.

THE OTHER NINETY PERCENT: PLANKTON RESPONSES TO ENHANCED NUTRIENT AVAILABILITY IN THE GREAT BARRIER REEF LAGOON.

Miles Furnas

Australian Institute of Marine Science and CRC Reef Research Centre, PMB 3, Townsville MC, QLD 4810, Australia
Email: m.furnas@aims.gov.au

Studies of water quality in the GBR have largely been framed by the responses of large benthic organisms (corals, algae, seagrasses) to external inputs of nutrients, sediments and other materials to reef waters. To a large extent, these benthic organisms are responding to nutrients, which have passed through pelagic communities dominated by micro-algae, protozoa and microbes (phytoplankton, flagellates, bacteria). Because of high ambient light intensities and warm water temperatures, nutrient uptake, growth, grazing and remineralisation rates are very rapid. GBR phytoplankton populations exhibit very high growth rates, ranging from < 1 to several doublings per day for individual species. Typically, the entire phytoplankton community turns over on a daily basis. High production and growth rates require rapid nutrient uptake. Relative abundances of dissolved nutrient species strongly indicate N limitation of biomass formation. Direct (^{15}N) and indirect (^{14}C) estimates of N demand by phytoplankton indicate dissolved inorganic N pools have turnover times on the order of hours. While shelf sediments typically supply only a small portion of instantaneous plankton nutrient demand, surficial sediments contain huge reserves of organic nutrients, which can be mobilized within days by water column bacteria following a cyclone or resuspension event. Similar rapid responses would also apply in long-lived (several days) river plumes. Inputs of nutrients from either internal or external sources are rapidly converted to organic matter in inter-reefal waters. Ecological responses to changed water quality may largely be a response (at several ecological levels) to enhanced organic loading based on pelagic production.

RIVER DISCHARGE OF NUTRIENTS FROM DRY TROPICAL RIVERS OF THE GREAT BARRIER REEF CATCHMENT

Miles Furnas[1], Alan Mitchell, Michelle Skuza, Margaret Wright

Australian Institute of Marine Science and [1]CRC Reef Research Centre, PMB 3, Townsville MC, QLD 4810, Australia
Email: m.furnas@aims.gov.au

Most (84 percent) of the Great Barrier Reef catchment is dry to seasonally dry, receiving less than 1,500 mm of annual rainfall. Rivers draining the dry tropics and sub-tropics are highly variable on both a seasonal and inter-annual basis due to the regional monsoonal climate and ENSO-like climate variability in the Pacific and Indian Oceans. The catchments of the Burdekin and Fitzroy Rivers comprise 64 percent of the GBR catchment, receive 53 percent of the annual rainfall and discharge 23 percent of the terrestrial freshwater input to the GBR shelf. These two rivers supply ca. 40 percent of the fine sediment input to the GBR shelf, 33 percent of the N and 38 percent of the P. Overall, dry tropical catchments are the source of 47 percent of freshwater runoff, 85 percent of fine sediment inputs, 66 percent of N inputs and 78 percent of P inputs. Volume-specific loading rates of nutrients in runoff from dry rivers is considerably higher than for wet tropical rivers. Most (ca. 80%) of the exported nutrients are in particulate form or associated with fine sediment from eroded soils. Rangeland cattle grazing is the major land use in the dry catchments. There is clear evidence that sediment and nutrient losses from grazing lands is directly related to the level of vegetation cover. Efforts to reduce the large terrestrial nutrient and sediment inputs to the GBR will be most effective if land management (grazing) practices in the dry catchments are in harmony with the natural variability of the regional climate and vegetation production.

REGIONAL VARIATIONS IN WATER COLUMN NUTRIENTS AND OTHER WATER QUALITY PARAMETERS IN GREAT BARRIER REEF WATERS.

Miles Furnas[1], Michele Skuza, Margaret Wright, Alan Mitchell, Sue Ghonim

Australian Institute of Marine Science and [1]CRC Reef Research Centre, PMB 3, Townsville MC, QLD 4810, Australia
Email: m.furnas@aims.gov.au

Concentrations of nutrients, chlorophyll and suspended solids in the GBR exhibit persistent regional and seasonal differences. These differences are related to regional-scale nutrient input (marine, terrestrial), production and recycling processes. Typically, concentrations are higher near the coast, to the south and during the summer wet season, though there are some important regional exceptions. Efforts to monitor trend and condition in water quality need to take these differences and their implications into account. Water quality standards for Australian reef waters should also be based around these variations.

AN ASSESSMENT OF RISKS TO DUGONGS FROM EXPOSURE TO DIOXINS

Caroline Gaus[1], Mark O'Donohue[2], Des Connell[3]

[1] National Research Centre for Environmental Toxicology, 39 Kessels Road, Coopers Plains, QLD 4108, Australia
[2] South East Queensland Water Corporation, Brisbane, QLD, Australia
[3] School of Public Health, Griffith University, Brisbane, QLD, Australia

High toxic potencies of dioxins and their potential to bioaccumulate have raised international concern regarding the health of wildlife and humans exposed to these compounds. Recent studies demonstrated elevated concentrations of dioxins along the coastline of Queensland, including the nearshore ecosystems of the Great Barrier Reef Marine Park. The aim of this study was to provide an initial assessment of the risks to Queensland's dugong populations associated with their exposure to these compounds.

Concentrations were elevated in dugongs as well as green turtles (up to 5700 pg PCDD/F g^{-1} lipid; 140 pg TEQ g^{-1} lipid) compared to other marine mammals and reptiles, even from areas considered polluted. A combination of high seagrass consumption rates, selective retention of toxicologically potent congeners and relatively low dioxin elimination capacities result in these elevated levels in adult dugongs. Transfer to offspring during gestation and lactation was calculated at 4% and 27% of maternal TEQ levels, respectively, resulting in relatively high exposure potentials for developing animals.

Using no-observed-adverse-effect-levels reported for mammals, a tolerable daily intake (TDI) of 10-24 pg TEQ day^{-1} was estimated for dugongs. Dugongs from three regions along the coastline of Queensland exceed this TDI by up to 20 fold, suggesting that these populations may be at risk from dioxin contamination in their habitat.

A TRIPLE-BOTTOM-LINE ASSESSMENT OF BASINS WITHIN THE GREAT BARRIER REEF CATCHMENT IN RELATION TO THEIR SEDIMENT, NUTRIENT AND PESTICIDE DISCHARGES AND POTENTIAL IMPACT ON THE GREAT BARRIER REEF

Romy Greiner[1], Alexander Herr[1], Jon Brodie[2], David Haynes[3], Donna Audas[3], Christian Roth[4]

[1] CSIRO Sustainable Ecosystems, Davies Laboratory Townsville, PMB PO Aitkenvale, QLD 4814, Australia
[2] Australian Centre for Tropical Freshwater Research, James Cook University, Townsville, QLD 4811, Australia
[3] Great Barrier Reef Marine Park Authority, 2-68 Flinders Street, P.O. Box 1379, Townsville. QLD 4810, Australia
[4] CSIRO Land and Water, Davies Laboratory Townsville, PMB PO Aitkenvale, QLD 4814, Australia

This paper presents the results of a methodology to profile and prioritise all basins within the GBR catchment in relation to their (potential) discharge of sediment, nutrient and other diffuse-source loads to the GBR lagoon – and the impact of that discharge. The methodology has been developed with help from the GBR community and experts, and results were publicly endorsed before their implementation in the Reef Water Quality Protection Plan, released in October 2003.

The methodology is designed to support adaptive planning and prioritisation of basins for various management actions within a whole-of-GBR context. It integrates scientific data and expert knowledge. It performs an assessment of river basins against a number of criteria, which embody environmental, economic and social dimensions of land and water management and resulting water quality of river discharge – and its impact in coastal, estuarine and marine environment of the GBR lagoon.

The paper outlines the methodology before focusing on the catchment profiles, which comprise (1) bio-physical 'risk' generated by (potential) land-based pollutants to marine ecosystems, (2) 'risk' from (lack of) social capacity for change; (3) 'risk' from urban and agricultural future development pressure; and (4) 'risk' to (value of) marine industries.

The paper closes with recommendations how the methodology can be further developed to support the changing knowledge requirements of the RWQPP by working with the GBR community within an adaptive management framework.

SYNERGISTIC EFFECTS OF DIURON AND SEDIMENTATION ON THE PHOTOPHYSIOLOGY AND SURVIVAL OF CRUSTOSE CORALLINE ALGAE

Lindsay Harrington[1,2], Katharina Fabricius[1], Andrew Negri[1]

[1] Australian Institute of Marine Science, PMB 3, Townsville MC, QLD 4810, Australia
[2] Department of Marine Biology, James Cook University, Townsville, QLD 4811, Australia

The herbicide Diuron (N'-(3,4-dichlorophenyl)-N, N-dimethylurea is detectible in many nearshore sediment samples along the central Queensland coast. Organisms living on some of the nearshore coral reefs of the Great Barrier Reef are regularly exposed to river plumes transporting this herbicide both in dissolved form and adsorbed to soil particles. We compared the physiological responses and survival of crustose coralline algae (CCA) that were exposed to diuron and to sedimentation, separately and in combination, in controlled time course laboratory experiments. Pulse-amplitude modulated chlorophyll fluormetry (PAM) was used to quantify the build up and recovery from photosynthetic stress in common CCA species during and after short-term (0-105 hr) exposure to; 1. diuron at 6 different concentrations, 2. fine estuarine and offshore sediments free of diuron, and 3. diuron adsorbed to fine estuarine sediment. These experiments indicated the effects of sediments and diuron, when applied in isolation, were often reversible, with recovery time depending on diuron concentrations and sediment types. Significant reductions in physiological yield of CCA species were observed at nominal diuron concentrations greater than 1 $\mu g\ l^{-1}$. Exposure to fine nutrient-rich estuarine sediments reduced yields more than exposure to the same amount of fine calcareous offshore sediments. Interactive treatment effects were additive. After 24 hours exposure to fine estuarine sediments mixed with 1 $\mu g\ l^{-1}$ diuron, CCA fragment yields (F_v / F_m) reached levels below 0.2, while control fragments ranged from 0.52 to 0.61. A combined exposure to sediments and diuron retarded recovery, thus yields were still only 60% of the control after 9 days recovery in clean seawater and some fragments were dead. Our results suggest that sediment deposition and exposure to diuron can negatively affect the photosynthetic activity of CCA, with sedimentation stress being significantly enhanced by diuron. The finding of detrimental effects of simultaneous exposure to sedimentation and diuron on CCA has implications for the recruitment of the vast number of reef organisms specialized to settle on CCA, and therefore may have downstream effects on reef communities in coastal reefs exposed to terrestrial run-off.

GREAT BARRIER REEF WATER QUALITY ECOSYSTEM MONITORING: FUTURE DIRECTIONS AND MANAGEMENT APPROACHES

David Haynes[1], Jon Brodie[2]

[1] Great Barrier Reef Marine Park Authority, PO Box 1379, Townsville, QLD 4810, Australia
[2] Australian Centre for Tropical Freshwater Research, James Cook University, Townsville, QLD 4811, Australia

Run-off resulting from land based anthropogenic activities is the primary anthropogenic influence on water quality in the Great Barrier Reef World Heritage Area, Australia. In particular, runoff containing elevated sediment and nutrient concentrations as well as concentrations of agricultural pesticides such as diuron, atrazine and dieldrin pose a particular risk to local ecosystems. The potential and actual impacts of elevated pollutant concentrations in Great Barrier Reef waters range from bioaccumulation of pollutants and reduced photosynthetic capacity, through to major shifts in community structure and health of coral reef and seagrass ecosystems. Coastal and inshore coral reefs, seagrass and mangrove communities adjacent to human activity are most threatened by pollutants contained in land runoff. Management of Great Barrier Reef water quality is difficult as many of the activities causing the problems lie outside the boundaries of the Marine Park. A comprehensive strategic framework (the Reef Water Quality Protection Plan) is a recent joint State and Federal Government initiative developed to minimise pollutant loads to the Reef in land based runoff. Long-term monitoring programs are integral components of the Reef Water Quality Protection Plan to enable assessment of the effectiveness of change in catchment management strategies in improving Reef water quality and the subsequent protection of inshore ecosystems. Suggested key components of a monitoring program include monitoring of pollutant loads entering the reef in river flood waters, monitoring of the accumulation of pollutants in sediments and local biota and monitoring of the status of coastal mangrove communities and the health of inshore reefs and seagrass beds along the Great Barrier Reef coast.

ORGANOCHLORINE AND HEAVY METAL CONCENTRATIONS IN BLUBBER AND LIVER TISSUE COLLECTED FROM QUEENSLAND (AUSTRALIA) DUGONG (*DUGONG DUGON*)

David Haynes[1], Steve Carter[2], Caroline Gaus[3], Jochen Müller[3], William Dennison[4,5]

[1] Great Barrier Reef Marine Park Authority, PO Box 1379, Townsville, QLD 4810, Australia
[2] Queensland Health and Scientific Services, PO Box 594, Archerfield, QLD 4108, Australia
[3] National Research Centre for Environmental Toxicology, 39 Kessels Rd, Coopers Plains, QLD 4121, Australia
[4] Marine Botany Department, University of Queensland, St. Lucia, QLD 4072, Australia
[5] Present Address: University of Maryland, College Park, MD 20742, USA

Tissue samples of liver and blubber were salvaged from fifty-three dugong (*Dugong dugon*) carcasses stranded along the Queensland coast between 1996-2000. Liver tissue was analysed for a range of heavy metals and blubber samples were analysed for organochlorine compounds. Metal concentrations were similar in male and female animals and were generally highest in mature animals. Liver concentrations of arsenic, chromium, iron, lead, manganese, mercury and nickel in a number of individual animals were elevated in comparison to concentrations previously reported in Australian dugong. Dieldrin, DDT (and its breakdown products) and / or heptachlor-epoxide were detected in 59% of dugong blubber samples. In general, concentrations of organochlorines were similar to those reported in dugong 20 years earlier, and were low in comparison to concentrations recorded from marine mammal tissue collected elsewhere in the world. The extent of carcass decomposition or the presence of disease or evidence of animal starvation prior to death did not significantly affect carcass body burdens of metals or organochlorines. The low concentrations of pollutants present in Great Barrier Reef dugong tissue imply that the most important consequence of Queensland coastal development for dugong populations is likely to be the potential impacts of contemporary herbicides on their nearshore seagrass food resource.

RAPID UNDERWAY WATER QUALITY MONITORING: DEVELOPMENT AND APPLICATION FOR THE GREAT BARRIER REEF

Jonathan Hodge, Ben Longstaff, Andrew Steven, Phil Thornton

Queensland Environmental Protection Agency, Waterways Sciences Unit, 80 Meiers Rd, Indooroopilly, QLD 4068, Australia

Traditional water quality monitoring is restricted in spatial intensity due to the time required to deploy instrumentation and collect samples and the cost of analysis. A rapid underway water quality monitoring system has been developed for use on small to medium sized vessels and provides a cost effective, spatially intensive addition to the water quality monitoring toolkit.

Subsurface water is pumped onto a boat travelling at up to twenty knots and directed into a flow cell connected to a multiparameter water quality instrument (indicators include temperature, conductivity, turbidity, pH, dissolved oxygen and chlorophyll a). Water quality data is sent via serial and USB connections to a laptop every two seconds along with data from other instruments, which currently include a GPS unit and depth sounder. The data strings from each instrument are combined with the GPS data to provide the exact location of each sample point. The system is currently designed to integrate up to nine instruments although its modular design and recent advances in computer hardware and software allow almost limitless expansion.

An outline of the system, its limitations and examples of its application along transects in the Great Barrier Reef under dry and wet flow conditions will be presented. Insights into patterns of spatial variation will also be discussed.

The addition of an acoustic doppler current profiler (ADCP) and a towed underwater video camera are currently being trialled. Future trials will investigate expanding the system to incorporate a fluoroprobe and an in-situ nutrient analyser.

CHANGING ENVIRONMENTAL ENVELOPES. DEGRADED CORAL REEFS OR CORAL REEFS OFF SYDNEY?

Ove Hoegh-Guldberg

Centre for Marine Studies, University of Queensland, St Lucia, QLD 4072, Australia

Projecting how the impact of changing water quality is likely to change over the next 50 years is critical to any management scheme that aims to sustainably manage coral reefs into the future. How these impacts will change over this period requires insight into projected changes in coastal land use and management practice as well as knowledge of baseline land run-off and water quality. These changes are complicated by rapid changes in global climate, which have had (and will have) direct effects on both the biological, chemical and physical conditions (environmental envelope) under which reefs are growing. The interaction between water quality and climate change raises a number of key questions. Firstly, how will climate change affect rainfall and hence water quality within Great Barrier Reef? Secondly, does stress from a warmer climate mean that corals will be more or less sensitive to impacts arising from reduced water quality? Thirdly, will warmer conditions at higher latitudes mean coral reefs will shift in a poleward direction, or will proximal factors such as light quality, carbonate alkalinity and nutrient levels at higher latitudes mean that corals will be restricted more or less to their current distributions? In exploring these questions, it is clear than most questions require a more detailed understanding of the types of changes that are likely to occur under climate change. However, the following seems likely. Firstly, a drying climate (and more episodic rainfall) is likely to lead to greater amounts of sediment (and nutrient) run-off into the Great Barrier Reef lagoon. Secondly, stress from increased water temperatures and reduced calcification rates are likely to will make corals more rather than less sensitive to stresses arising from elevated nutrient, pesticides and sediment levels. Thirdly, proximal factors are likely to be all important in determining the distribution of coral reefs to higher latitudes. Reductions in carbonate alkalinity, higher nutrient levels and reduced light levels are likely to limit the poleward expansion of coral reefs. Greater detail is required about how water quality is likely to change if we are to understand the impact of our rapidly changing climate on water quality.

NUTRIENT EXPORTS FROM SUGAR CANE CATCHMENTS

Heather Hunter[1], John Armour[2]

[1] Department of Natural Resources and Mines, 80 Meiers Rd, Indooroopilly, QLD 4068, Australia
[2] Department of Natural Resources and Mines, 28 Peters St., Mareeba, QLD 4880, Australia

There is increasing development and use of predictive models to support decision-making on water quality management issues in catchments. The reliability of these models is dependent on the availability of relevant datasets for model calibration and testing. In this paper we report some key findings from a four-year project, which measured the movement of nutrients (nitrogen and phosphorus) at a range of scales from sugar cane lands to nearby waterways and groundwater. Three study sites represented contrasting climate, soils, topography and crop management practices within the Queensland sugar cane industry.

Nutrient loads exported to waterways were relatively small, from an agronomic perspective. For example, average exports (over 2 y) from a site near Bundaberg were 3.5 kg/ha/y of nitrogen and 0.4 kg/ha/y of phosphorus, equivalent to the nutrient content of around 2–4 tonnes of millable cane. Nevertheless, at some sites the resultant increases in nutrient levels downstream were sufficient to pose a threat to aquatic ecosystem health. Near Mareeba, upstream discharge of irrigation tail-water at times markedly increased stream concentrations of total nitrogen (TN) and total phosphorus (TP). This occurred particularly during the drier months between July and December in each of 3 years, when TN concentrations ranged from 0.4 to 10 mg/L and TP from 0.005 to 1 mg/L. These concentrations were up to 30 times the recommended TN concentration for protecting aquatic ecosystems, and up to 100 times that recommended for TP (ANZECC & ARMCANZ 2000). Fertilisers were applied to cane crops at this time of year.

In this paper we will present some key issues and contrasting results concerning nutrient exports from these cane-growing areas. Although the sites represented a single 'land use', there were marked differences in nutrient export issues. This emphasises the need for numerical models and other predictive tools to be based on conceptual models that represent a thorough understanding of the key processes underlying nutrient movement in catchments. Results from the study are being used to help refine current catchment water quality models for the assessment of nutrient loads exported to coastal waters of the Great Barrier Reef region.

Reference

ANZECC & ARMCANZ 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. National Water Quality Management Strategy Paper No. 4 (Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra).

INFLUENCE OF LAND RUNOFF ON RATES AND AGENTS OF BIOEROSION OF CORAL SUBSTRATES

Pat Hutchings[1], Mireille Peyrot-Clausade[2]

[1] The Australian Museum, 6 College Street, Sydney NSW 2010, Australia
[2] Centre d'Océanologie de Marseille, Chemin de la Batterie des Lions, Marseille France 13007

Annually large volumes of freshwater laden with sediment are washed down the Daintree River in North Queensland out onto the Great Barrier Reef lagoon. In order to investigate the effects of land runoff on bioerosion samples of recently killed Porites were laid at 6 sites on a cross shelf transect from Snapper Island at the entrance to the river out into the Coral Sea at Osprey Reef. Rates and agents of bioerosion were determined over 4 years and the inshore sites of Snapper and Low Isles exhibited significantly lower rates of total bioerosion than the other sites. Inshore sites were covered in heavy layers of silt which inhibited colonization and growth of microborers primarily algae which resulted in lower levels of grazing than at offshore sites but the activity of macroborers (sponges and bivalves) was very high in these sites. The macroboring communities differed between sites and over time and these were also influenced by levels of siltation. These results are compared with those found in French Polynesia where water quality greatly influenced rates and agents of bioerosion. However other factors such as overfishing may also play an important role.

CATCHMENT MODIFICATIONS AND TEMPORAL VARIATION IN WATER QUALITY IN NELLY BAY (MAGNETIC ISLAND), GREAT BARRIER REEF MARINE PARK

Riku Koskela[1], Joanna Lee[1], William Venables[2], Angus Fraser[1], Thomas Koskela[1], Ross Fryar[1].

[1] GHD Pty Ltd, GPO Box 668, Brisbane, QLD 4001, Australia
[2] CSIRO Mathematical and Information Services, CSIRO Marine Laboratories, PO Box 120, Cleveland, QLD 4163, Australia

Nelly Bay is zoned Marine Park 'A' and is located on Magnetic Island, across Cleveland Bay from the city of Townsville in Queensland, Australia. Construction of a safe harbour, ferry terminal and residential facilities within Nelly Bay commenced in October 2000. A temporary breakwater sealed the harbour during construction, with waters discharged offshore. Pre harbour opening (Oct 2001) and post harbour opening (Dec 02 – Jan 03) surveys of nutrients, chlorophyll-a and physicochemical parameters were undertaken prior to the harbour becoming operational in September 2003. Data from this study and a previous study (Brodie et al. 1989) was incorporated into a mixed effects model with survey as the fixed factor to delineate the temporal and spatial variation in water quality within this system.

Nutrient concentrations in Gustav Creek, which flows into the harbour, were substantially higher than at all other sites, indicating that Nelly Bay's urban catchment is an important source of nutrients to this system. Specifically, elevated concentrations of ammonia in Gustav Creek during the pre-opening survey were indicative of sewage contamination. This is likely to reflect the increase in population and consequent increase in sewage loads in the Nelly Bay catchment between the Brodie et al. (1989) and 2001 pre-opening surveys.

A substantial reduction in the concentrations of total nitrogen, total phosphorus, ammonia and phosphate was recorded in Gustav Creek between the pre and post-opening surveys. Diversion of sewage effluent from the Nelly Bay WWTP to a Biological Nutrient Reduction (BNR) treatment plant commissioned at Picnic Bay between the pre and post-opening surveys is likely to be the reason for this reduction.

Receiving water concentrations of ammonia, phosphate and total phosphorus were significantly higher in the 2001 pre-opening survey compared to the Brodie et al. (1989) survey, however concentrations of these parameters were somewhat lowered in the 2003 post-opening survey. This may be indicative of the influence of changes in sewage management practices in Nelly Bay on receiving water quality. Spatial variation between groups of receiving water stations, namely reef slope, offshore and control stations was small in comparison to temporal variation.

This monitoring program appears to have demonstrated the effectiveness of the diversion of sewage effluent to Picnic Bay for treatment. The implications of these results and the potential for application of pollutant export and hydrodynamic modelling to enhance the understanding and management of sewage and other discharges within the Great Barrier Reef are discussed.

ADAPTIVE MANAGEMENT AND ITS ROLE IN MANAGING GREAT BARRIER REEF WATER QUALITY

Paul Lawrence[1,2], John Bennett[1,3], Rod Johnstone[1,4], Roger Shaw[1]

[1] CRC Coastal Zone Estuary and Waterway Management, 80 Meiers Road, Indooroopilly, Brisbane, QLD 4068, Australia
Email: paul.lawrence@nrm.qld.gov.au)
[2] Queensland Department of Natural Resources and Mines, Natural Resources Science
[3] Queensland Environmental Protection Agency
[4] University of Queensland

Adaptive management (AM) is the pathway to effective conservation, use and management of Queensland's coastal catchments and waterways. While the concepts of adaptive management are not new, applications involving both assessment and management responses are indeed limited at the national scale. This paper outlines the components of a systematic framework for linking scientific knowledge, existing tools, planning approaches and participatory processes to achieve healthy regional partnerships between community, industry, government agencies and science providers to overcome institutional barriers and uncoordinated monitoring. In the Adaptive Management Framework developed by the Coastal CRC, there are six elements: (i) a core component of agreed process and facilitation between stakeholders; (ii) information collation in which stakeholder and research information are synthesised and pooled to improve an understanding of system functions and find solutions; (iii) systems analysis and vision for context analysis and a systems understanding, and a processes for community aspirations to be expressed as environmental values; (iv) plan making and trade-off analysis for management goals and targets to be established and social, economic and ecological impacts evaluated to define a preferred strategy; (v) implementation of the necessary actions; and (vi) monitoring and reviewing the effects of the plan against the agreed environmental values, management goals and targets. The framework is hierarchical to allow associated frameworks to be integrated, and represents a construct in which processes, information, decision tools and outcomes are brought together in a structured and transparent way for adaptive catchment and coastal management. Through overseas and South East Queensland examples, this paper explores AM approaches and practises. It then demonstrates the application of these to the Reef Water Quality Protection Plan using the Coastal CRC's Adaptive Management Framework

LIGHT REQUIREMENTS OF SEAGRASSES IN NORTHEAST AUSTRALIA

Ben J. Longstaff[1], William C. Dennison[2]

[1] Queensland Environmental Protection Agency, 80 Meiers Road, Indooroopilly, QLD 4068, Australia
[2] University of Maryland, Centre for Environmental Science, PO Box 775, Cambridge, MD 21613 USA

Northeast Australia has extensive and diverse seagrass meadows that have been or have the potential to be affected by reduced light availability. The primary aim of this study was to assess the complex interactions of long-term and acute light reduction (flood events) processes on the distribution and survival of these seagrasses, achieved by determining the seagrasses' minimum light requirements (MLR) and capacity to persist below MLR.

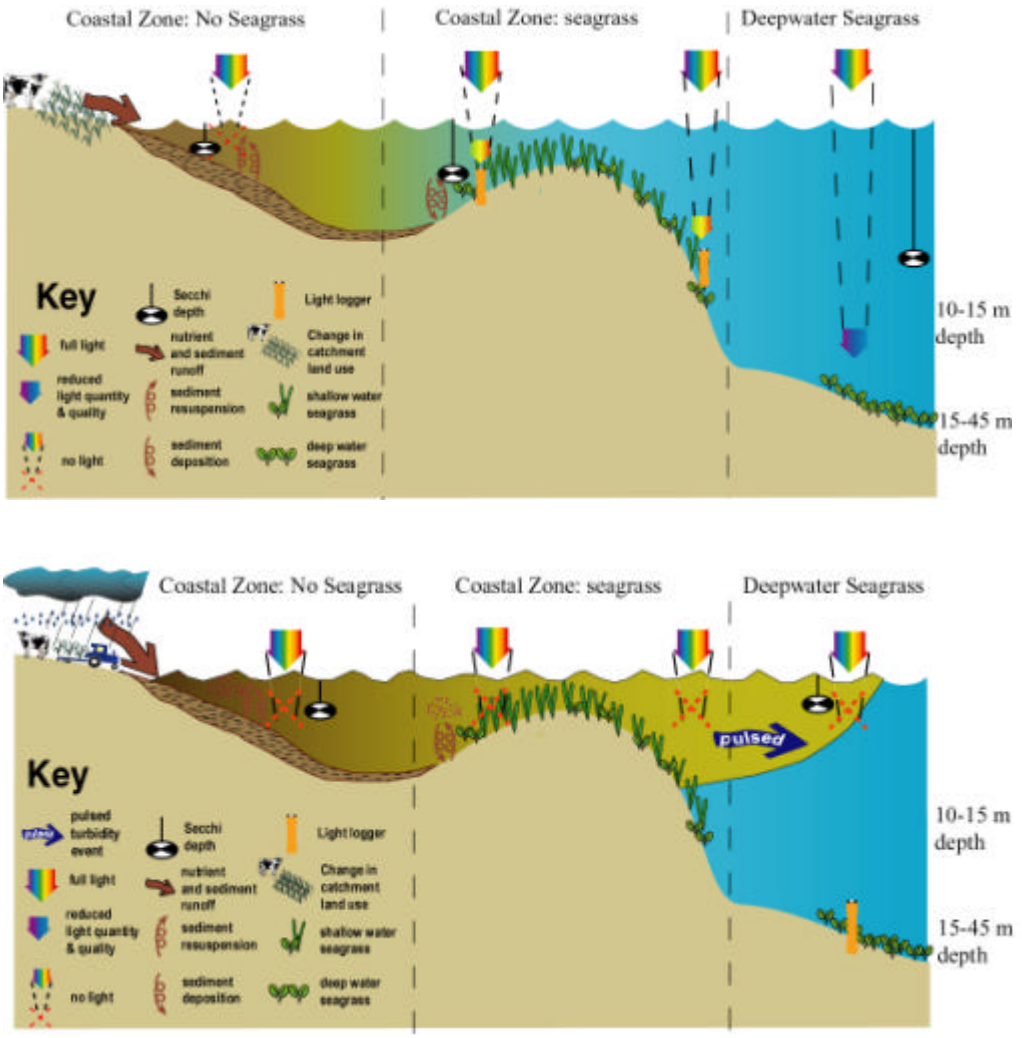

Figure: Conceptual models illustrating long-term and acute light reduction processes and the interaction with seagrass distribution and survival.

The present study focused on the dominant species in three distinct habitats: monospecific *Zostera capricorni* meadows in Moreton Bay; a mixed *Halodule pinifolia*, *Halophila ovalis* meadow in the Gulf of Carpentaria; and deepwater mixed *Halophila ovalis*, *Halophila spinulosa* meadows in Hervey Bay.

Long-term availability of light was identified as the primary environmental factor affecting the maximum depth limit of *Z. capricorni* and *H. pinifolia*. Both species displayed similar long-term light requirements (~10 mol photons m^{-2} d^{-1}) and survived to a depth of 3 m. *Halophila ovalis* had a much lower MLR at approximately 3 mol photons m^{-2} d^{-1} and survived at depths greater than 15m.

The impact of acute light reduction on seagrass survival was diverse, with each species displaying a different degree of tolerance. *H. pinifolia* was the most resilient of the species studied, persisting for up to 78 days in darkness followed by *Z. capricorni* (55 days) and *H. ovalis* (40 days).

These results are interpreted to explain current seagrass distribution along the entire northeast Australian coastline. *Z. capricorni* has high light requirements and limited tolerance below its MLR; therefore this species will tend to inhabit regions with infrequent floods and higher quantities of light. *H. pinifolia* had a greater capacity to persist below its MLR and hence has a broader ecological niche than *Z. capricorni*. *H. ovalis* has the broadest ecological niche of the species studied. The low MLR of this species facilitates its survival in low light environments such as deep water. However, rather than persisting through acute light deprivation events, this species relies on a life history strategy (rapid germination, growth and seed production, germination and growth of seeds in low light) to facilitate rapid recovery once the event has passed.

HISTORICAL ENVIRONMENTAL PERSPECTIVES FROM MASSIVE CORALS

Janice M. Lough

Australian Institute of Marine Science, PMB 3, Townsville MC, QLD 4810, Australia
Email: j.lough@aims.gov.au

Massive colonies of *Porites* from the Great Barrier Reef (GBR) contain luminescent lines made visible when coral slices are exposed to ultra-violet light. These lines occur during episodes of lowered seawater salinity associated with river flood plumes. An earlier study of luminescent lines in over 200 small *Porites* colonies from 30 reefs of the GBR demonstrated that the occurrence and intensity of the lines are a robust proxy for spatial and temporal variations of freshwater runoff from the mainland (Lough et al 2002). Reefs of the GBR can be divided into three groups: those that never see freshwater; those that see freshwater but not every year; and those that see freshwater every year. The location of these three groups is closely linked to the relative distance of the reef across the continental shelf and the average water depth between the reef and the mainland. Luminescent lines in corals, therefore, provide a means to track the historical occurrence and intensity of freshwater (and whatever maybe contained in the freshwater) impacting reefs of the GBR. Visual assessment of luminescent lines has now been extended to long coral cores from AIMS' collection. This provides new perspectives on the historical frequencies of major flood events at inshore and midshelf reefs along the length of the GBR.

Reference
Lough, JM, Barnes DJ and McAllister FA 2002. Luminescence lines in corals from the Great Barrier Reef provide spatial and temporal records of reefs affected by land runoff. Coral reefs 21: 333-343.

WETLAND PROCESSES IN TROPICAL QUEENSLAND AND THEIR INFLUENCE ON WATER QUALITY

George P. Lukacs

Australian Centre for Tropical Freshwater Research, James Cook University, Townsville, QLD 4811, Australia

Wetlands are often seen as cure-alls for the ills of our catchments. Wetlands are claimed to have recuperative powers, able to strip out contaminants whilst simultaneously providing habitat, flood detention and places to catch fish or watch birds. In reality, the evidence available to support these functions is small, often contradictory and mostly based on artificial systems designed to meet particular needs (eg wastewater treatment).

There is little doubt that a variety of wetland processes exist that can influence water quality. In many sites, contaminant transformation and retention is viable; however, the potential to extrapolate to catchment management is limited. Equally, the potential to harness the filtration and detention capacity of wetlands to whole of catchment management is constrained by the realities of established land uses and needs of resource managers.

Wetlands do influence water quality but their potential to mitigate water quality problems needs to be placed in the context of 1) the natural water quality of wetlands, 2) types of wetlands and their inherent processes, 3) the catchment condition and 4) a variety of community expectations.

INTERACTIONS BETWEEN BENTHIC ALGAE, WATER QUALITY AND CORAL REEF DISTURBANCE AND RECOVERY

Laurence McCook[1,2], Chico Birrell[2,3], Guillermo Diaz-Pulido[2,3,4], Bette Willis[3]

[1] Great Barrier Reef Marine Park Authority, PO Box 1379, Townsville, QLD 4810, Australia
[2] Australian Institute of Marine Science and CRC Reef Research Centre, PMB 3, Townsville MC, QLD 4810, Australia
[3] James Cook University, Townsville, QLD 4811, Australia
[4] Universidad del Magdalena, Colombia

Recent research provides strong evidence that water quality impacts on coral reefs often involve the inhibition of recovery after disturbances (such as cyclones, freshwater kills, bleaching, Crown-of-thorns), rather than the previously assume, nutrient-enhanced algal overgrowth of corals. After a disturbance, dead coral substrate is almost universally colonised by various forms of benthic algae (turfs, corallines and fleshy macroalgae). In suitable conditions, the thickness of the algae is controlled by herbivore grazing, and corals are able to successfully settle and grow amidst the algal mat, eventually resulting in the recovery of coral populations. In a less optimistic scenario, the algal mat may become thick enough, and often trap sediments, resulting in a microhabitat that strongly inhibits successful coral colonisation, survival and growth.

This seminar will review evidence for several key aspects of this scenario. These include:

- the effectiveness of healthy corals in preventing algal overgrowth; the ubiquitous colonisation by benthic algae of dead coral and bare substrates;
- the stronger impacts of benthic algae on coral settlement and recruitment than on established corals;
- differential effects of different algae on coral recruitment; and
- synergistic impacts of algae and water quality on coral recruitment: e.g.
- greater significance for nutrient effects on algae; or
- inhibition of coral settlement due to algal trapping of sediments.

IMPACT OF EUROPEAN SETTLEMENT ON SEDIMENT AND FRESHWATER RUNOFF INTO THE INNER GREAT BARRIER REEF

Malcolm McCulloch

Research School of Earth Sciences, Australian National University, Canberra, ACT 2000, Australia

European settlement and accompanying landuse changes, has had a profound effect on the Australian landscape. In the river catchments bordering the GBR, pastoral grazing, cultivation, mining, urban development and land clearing associated with these activities has led to significant increases in sediment and associated nutrients reaching the coral reefs of the inner GBR. Direct quantification of the magnitude of long-term changes is mainly limited to studies of the several inshore reefs impacted by the Burdekin river. These studies show that from the 1870's onwards there has been a five- to tenfold increase in the sediment load delivered by this system. The Burdekin has one of the largest catchments (second only to the Fitzroy river) and is the single most important source of sediment into the GBR. Here we examine in detail the relationship between the intensity of cattle grazing, short-term climate variability (i.e. droughts and floods) and resultant suspended sediment loads delivered by the Burdekin river. We show that there is a strong link between increased cattle numbers such as occurred during the mid-late 1970's and increased sediment fluxes. This situation is exacerbated during drought-breaking floods. In addition we show that freshwater runoff into the inner GBR has increased significantly, a consequence of reduced vegetation cover, compacted soils and hence reduced water infiltration rates. Finally it is argued that contrary to previous suggestions, turbidity in the inner GBR has also increased as a result of enhanced sediment supply. Although turbidity is predominantly controlled by wind driven resuspension events, previous workers have mistakenly assumed that sediment supply is not a limitation. Following European settlement as much additional sediment has been delivered to the inner GBR as during the previous ~1000 years. Due to the relatively long time constants for sediment isolation, together with an imbalance in the sand/silt fraction, it is estimated that ~1/2 of the resuspended load presently contributing to turbidity is of recent (post 1870) origin. This work suggests that the combination of greatly enhanced sediment and nutrient fluxes entering the GBR, together with more pervasive freshwater flood plumes, maybe having even greater ecological consequences than hitherto thought.

GREEN ISLAND SEAGRASS MONITORING AND DYNAMICS.

Len McKenzie[1], Warren Lee Long[2], Rudi Yoshida[1]

[1] CRC Reef Research Centre / Queensland Fisheries Service, Northern Fisheries Centre, PO Box 5396, Cairns, QLD 4870, Australia
[2] Wetlands International – Oceania, PO Box 787, Canberra ACT 2601, Australia

It has long been believed that the expansion of Green Island seagrass meadows in the 70s and 80s were the result of poor water quality on the reef, a consequence of increases in tourist visitation and increased nutrients emanating from the adjacent sewage outfall. Untreated sewerage effluent was discharged onto the Green Island reef for twenty years until December 1992 when tertiary treatment facilities were established. The present study investigates differences in seagrass meadows at Green Island prior and post implementation of tertiary treatment.

In 1992 a survey of intertidal and sub-tidal areas surrounding Green Island mapped 127.5 ±6.0 ha of seagrass habitat. Seven seagrass species were recorded in the survey area. *Thalassia hemprichii* was the most widely distributed species and *Syringodium isoetifolium* the rarest. Species of *Halodule, Cymodocea* and *Halophila* were also fairly widely distributed.

In mid 1993, the sedimentary nutrients were examined at 18 sites around Green Island, representing the main seagrass communities present. It was found that significantly high amounts of interstitial and adsorbed ammonium and orthophosphate were present in both the lagoon and reef flat sediments. The presence of such a large nutrient pool suggested that the distribution and abundance of seagrasses on Green Island would possibly continue to increase and that significant changes in species composition may occur over time.

Remapping of the distribution and abundance of seagrass was conducted in mid-late 1993, 1994, 1997 and 2003. Although the area of seagrass has increased slightly, the above ground biomass significantly increased in both the lagoon and on the reef flat. The most dramatic change however, has been the seagrass species composition, with the species *Syringodium isoetifolium* now dominating most of the lagoon meadows. Implications of these changes in the seagrass composition and abundance on Green Island to sea turtle, dugong and fisheries management are discussed.

SOURCES OF SEDIMENT AND NUTRIENT EXPORTS TO THE GREAT BARRIER REEF

Lucy McKergow [1,2], Jon Brodie[3], Ian Prosser[2], Andrew Hughes[2], Miles Furnas[4], Heather Hunter[5]

[1] Department of Geography, University of Otago, PO Box 56, Dunedin, New Zealand
[2] CSIRO Land and Water, GPO Box 1666, Canberra, ACT 2601, Australia
[3] Australian Centre for Tropical Freshwater Research, James Cook University, Townsville, QLD 4811, Australia
[4] Australian Institute of Marine Science, PMB 3, Townsville MC, QLD 4810, Australia
[5] Queensland Department of Natural Resources and Mines, 80 Meiers Road, Indooroopilly, QLD 4068, Australia

To begin to manage sediment and nutrient exports discharging to the Great Barrier Reef, it is essential to identify the sources of sediment and nutrient that are exported to the coast. The present study used the models, SedNet and its nutrient version ANNEX, calibrated using water quality data, to identify the sources, sinks and transport of sediment and nutrients river link by river link, as it is transported to the coast. Significant modifications were made to the models, including (1) estimation of nutrient sources by land use, and (2) speciation of nitrogen and phosphorus, and (3) modifications to river and reservoir transport functions in an effort to account for the event based nature of tropical systems. The modelling shows that catchments with high levels of land clearing, beef grazing and/or fertilized cropping show the greatest increases in sediment and nutrient export compared with natural conditions. Hillslope (soil) erosion is the dominant process supplying 63% of sediment to the rivers. Gully erosion and riverbank erosion are relatively minor sources at the GBR catchment scale, although they are important in some catchments. Overall, 70% of sediment exported to the coast comes from just 20 % of the total catchment area. Areas of high contribution are all relatively close to the coast. The spatial patterns of total N and P contribution to streams largely reflect the soil erosion predictions. Hillslope erosion is by far the largest source of particulate nutrients because of its dominance as a sediment source and the higher nutrient concentrations on surface soils. Gully and riverbank erosion make up less than 10% of the total nutrient sources. Our results predict that about 30% of total nitrogen and 15% of total phosphorus are moving as dissolved fractions in runoff. This study has identified catchments with disproportionately high levels of contribution to the coast and targeting these should be a priority. Continued model development, particularly for nutrients, is required to increase the level of agreement between modelled and measured exports.

HERBICIDE CONTAMINATION AND SEAGRASS HEALTH: A CASE STUDY IN SOUTHERN QUEENSLAND

Kathryn McMahon[1]

[1] Marine Botany Group, Centre for Marine Studies, University of Queensland, St Lucia, QLD 4072, Australia
Email: k.mcmahon1@uq.edu.au

The occurrence and potential effects of herbicides on seagrass health was investigated in the Hervey Bay region, southern Queensland. Water and sediment samples for herbicide content were collected from intertidal seagrass meadows and the adjacent tributaries on two occasions, during a potentially low (dry season) and potentially high (wet season) herbicide application period. A suite of parameters to assess seagrass health were also measured. Herbicides were detected in fresh, estuarine and marine waters and sediments at low concentrations (below detection – 160 ng L^{-1}). There was a decrease of approximately one order of magnitude in herbicide concentration from fresh water to marine sites. Herbicide concentrations in water samples decreased by half between the potentially high (wet season) and potentially low herbicide (dry season) application periods. During a river flow event after heavy rain, a maximum of 4 300 ng L^{-1} of herbicide was detected in the Mary River. The most common herbicide detected from a suite of eight was diuron, potentially the most toxic. There were no detectable effects on seagrass health from the presence of low concentrations of herbicides (< 50 ng L^{-1}). The concentrations found in the field are below the level shown to inhibit seagrass in laboratory experiments. However, there may be impacts from long-term exposure to low concentrations of herbicides and potentially lethal exposure during flood events. A conceptual model is proposed for potential impacts to seagrass from herbicides in light of the dynamic nature of seagrass meadows in tropical habitats.

RESPONSES OF SEDIMENTS AND SEAGRASSES TO NUTRIENT ENHANCEMENT IN TWO HALOPHILA OVALIS MEADOWS

Jane Mellors[1, 2], Helene Marsh[1], Michelle Waycott[3]

[1] School of Tropical Environmental Studies and Geography, James Cook University and CRC Reef Research Centre, Townsville, QLD 4811, Australia
[2] Queensland Fisheries Service, Queensland Department of Primary Industries, PO Box 1085, Townsville, QLD 4810, Australia
Email: jane.mellors@dpi.qld.gov.au
[3] School of Tropical Biology, James Cook University, Townsville, QLD 4811, Australia

Sediment nutrient levels were raised above ambient conditions using Osmocote® fertilizer at different application rates of N only, P only, and combinations of N + P, within two *Halophila ovalis* meadows at different times of the year. The two *Halophila ovalis* meadows had different sedimentary regimes and were at different stages of development. Low and high levels of fertilizer addition did not consistently raise sediment nutrients incrementally, but did raise them above ambient. Overall, the response of plant biomass to increased nutrients was limited and complex. Seagrasses at Bolger Bay displayed primary P limitation during the senescent season and a trend for P limitation during the growing season. This meadow has a sedimentary regime dominated by clay mineralogy with small sediment grain sizes, high ambient nutrient levels and low seagrass biomass and high plant tissue nutrients. All these factors are thought to play a role in how *Halophila ovalis* responded to nutrient additions at Bolger Bay.

In contrast seagrass at Picnic Bay showed no nutrient limitation during the senescent season, but in the growing season there was primarily N limitation with secondary P limitation. The factors thought to influence this seagrass response at Picnic Bay, was the sedimentary regime (sediments dominated by carbonate mineralogy with coarser grain particle sizes, higher Eh, higher pH, lower percent organic content, higher percent carbonate content, lower ambient nutrient levels) and the higher ambient seagrass biomass and lower percentages of plant tissue N and P compared to Bolger Bay. Other factors that influenced the overall outcomes of the experiment included the behaviour of Osmocote®, the amount of Osmocote® presented to the rhizosphere, the experimental effect of disturbing the rhizosphere with the application of the fertilizer, and the time of year.

VARIATION IN BIOGEOCHEMICAL PARAMETERS ACROSS INTERTIDAL SEAGRASS MEADOWS IN THE CENTRAL GREAT BARRIER REEF REGION

Jane Mellors[1, 2], Michelle Waycott[3], Helene Marsh[1]

[1] School of Tropical Environmental Studies and Geography, James Cook University and CRC Reef Research Centre, Townsville, QLD 4811, Australia
[2] Queensland Fisheries Service, Queensland Department of Primary Industries, PO Box 1085, Townsville, QLD 4810, Australia
Email: jane.mellors@dpi.qld.gov.au.
[3] School of Tropical Biology, James Cook University, Townsville, QLD 4811, Australia

Surveys of 11 locations representative of the intertidal coastal seagrass beds in the central Great Barrier Reef region to date indicated that the chemical environment (Eh and pH) was typical of other intertidal areas. Sandy sediments had low porosity, silt-clay sediments high porosity. Most locations sampled were characterised by terrigenous sediments with low organic content. Sediment nutrient adsorbed:porewater ratios indicated that most nutrients were bound up in the adsorbed phase. Porewater nutrient levels were generally at the lower end of the published range for both NH_4^+ and PO_4^{3-} suggesting potential N and P limitation of seagrass growth. Molar ratios of porewater N:P were large, indicating levels of porewater PO_4^{3-} low relative to NH_4^+. Levels of adsorbed nutrients were higher than those recorded from comparative studies, particularly for adsorbed NH_4^+. Molar ratios of adsorbed N:P were small indicating that the pool of P relative to N is large. Standing crop measurements of all seagrass species were generally low with roots and rhizomes representing the largest fraction of plant biomass. The ratio of N:P for plant tissue nutrients were highly variable and indicated the influence of location on seagrass nutrient status. All sites dominated by *Halodule uninervis* sites and *Halophila ovalis* recorded higher % N and % P than the critical values proposed by Duarte (1990) as indicative of nutrient limitation.

QUEENSLAND WATER QUALITY GUIDELINES AND THEIR APPLICATION TO GREAT BARRIER REEF WORLD HERITAGE AREA WATERS

Andrew Moss[1], Jon Brodie[2]

[1] Queensland Environment Protection Agency, 80 Meiers Rd, Indooroopilly, QLD 4068, Australia.
[2] Australian Centre for Tropical Freshwater Research, James Cook University, Townsville, QLD 4811, Australia.

The ANZECC Guidelines for Fresh and Marine Water Quality (2000) provide default guideline values for a wide range of indicators. However, the ANZECC Guidelines also place a strong emphasis on the need to develop more locally relevant guidelines. As is stated in the Guidelines "It is not possible to develop a universal set of specific guidelines that apply equally to the wide range of ecosystems in Australia and New Zealand". The purpose of the Queensland Water Quality Guidelines is to address this need for local guidelines. It aims to provide guideline values and reference data that are specific to a range of Queensland regions and water types. In the short term, the guidelines will focus mainly on physico-chemical and a few biological indicators. In the longer term it is envisaged that it will contain a wider range of biological indicators as well as habitat indicators.

The paper first briefly describes how the Queensland Water Quality Guidelines fit into the water management process in Queensland and how the guideline values would be applied in Queensland.

Secondly, the paper describes in generic terms the processes used to determine and apply local guidelines including:

Defining **water types** for which guidelines are to be set
Defining **reference sites** for each of these water types
Calculating **guideline values** based on reference data sets from each water type
Application of guideline values

Issues associated with each of these processes are discussed.

The Great Barrier Reef (GBR) Region, including both the catchment of the GBR and the Great Barrier Reef World Heritage Area, has been the subject of extensive water quality studies over the last twenty years. Thus considerable water quality data is available to develop local and regional guideline values. The paper gives an example of how local guidelines would be derived and applied using real data from the GBR Region.

EFFECTS OF THE HERBICIDE DIURON ON THE REPRODUCTION AND EARLY LIFE HISTORY STAGES OF CORAL

Andrew Negri[1], Claudia Vollhardt[1], Neal Cantin[1,2], Craig Humphrey[1], Ross Jones[3], Bette Willis[2], Katharina Fabricius[1]

[1] Australian Institute of Marine Science, PMB 3, Townsville MC, QLD 4810, Australia
[2] Department of Marine Biology, James Cook University, Townsville, QLD 4811, Australia
[3] Centre for Marine Studies, The University of Queensland, Brisbane, QLD 4072, Australia

The herbicide Diuron, widely used for weed control and as an antifoulant, has been detected in the coastal waters and sediments of Queensland. The broadcast spawning corals *Acropora millepora* and A. tenuis and the brooding coral *Pocillopora damicornis* were used in laboratory experiments to examine the potential effects of diuron on the early life history stages of these corals. The fertilisation of *A. millepora* oocytes, which are not host to symbiotic dinoflagellates, was not inhibited at diuron concentrations of up to 1000 µg L^{-1}, while metamorphosis was only significantly inhibited at 300 µg L^{-1} diuron. *P. damicornis* larvae contain symbiotic dinoflagellates when released from the parent colony, but were able to undergo metamorphosis after 24 h exposure to diuron at 1000 µg L^{-1}. One week old *P. damicornis* recruits on the other hand were as susceptible to diuron as adult colonies over a 96 h exposure, with expulsion of symbiotic dinoflagellates (bleaching) and polyp bail-out observed at 100 µg L^{-1} (Fig. 1). Pulse amplitude modulated (PAM) chlorophyll fluorescence was used to evaluate the effects of diuron on the photosynthetic efficiency of symbiotic dinoflagellates in one week old *P. damicornis* recruits. A significant drop in the photosynthetic efficiency ($\Delta F / Fm'$) was recorded after 2 h at 1 µg L^{-1} and this declined further over the course of a 96 h exposure. Adult A. tenuis colonies exposed to 10 µg L^{-1} diuron for 2 months prior to spawning exhibited low lipid content, however normal fertilization and metamorphosis were recorded for gametes and larvae derived from the exposed colonies.

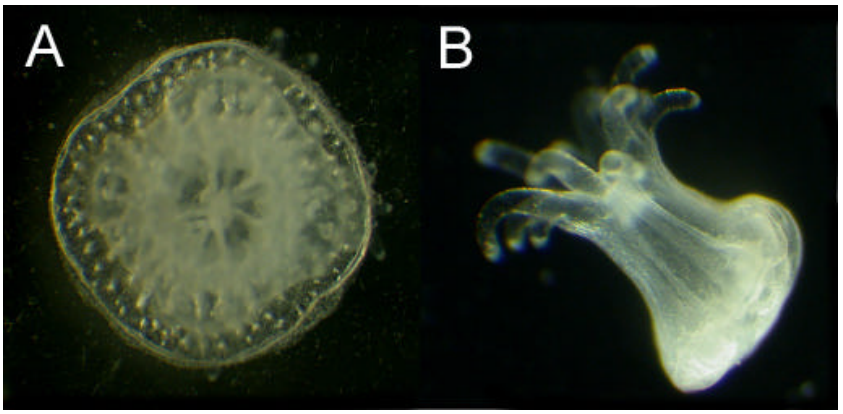

Figure 1. One Week old *P. damicornis* recruits after exposure to 100 µg L^{-1} diuron: A) Bleached recruit. B) Swimming polyp following escape from a bleached recruit.

RUNOFF AND SEDIMENT LOSS UNDER DIFFERENT GRAZING MANAGEMENT STRATEGIES IN THE UPPER BURDEKIN

Peter O'Reagain[1], Grant Fraser[2], Jon Brodie[3], John Bushell[1], Chris Holloway[1], John Faithful[3], David Haynes[4]

[1] Department of Primary Industries, PO Box 976, Charters Towers, QLD 4820, Australia
[2] Natural Resources and Mines, 80 Meiers Rd, Brisbane, QLD 4068, Australia
[3] Australian Centre for Tropical Freshwater Research, James Cook University, Townsville, QLD 4811, Australia
[4] Great Barrier Reef Marine Park Authority, PO Box 1379, Townsville, QLD 4810, Australia

Increased sediment loss resulting from unsustainable grazing management in the upper Burdekin catchment has been identified as a major threat to water quality in the Great Barrier Reef Lagoon. To test the effects of different grazing management strategies on soil and nutrient loss, five 1 ha mini-catchments were established in 1999 under different grazing management regimes on a sedimentary landscape south of Charters Towers. Reference samples from creeks and rivers in the district were also collected opportunistically during runoff events.

In general, soil and nutrient loss were relatively low across all grazing strategies due to a combination of good cover (range: 100 – 50 %), low slope and low rainfall intensities. Consequently, water quality was high across all strategies with relatively low levels of total suspended sediment (range: 8 – 309 mg/L), total N (range: 101-1670 ug/L) and total P (range: 14-150 ug/L). Treatment differences are however likely to become more obvious as time progresses and the impacts of the different grazing strategies on land condition become more apparent.

In contrast to the mini-catchments, water samples collected from rivers and creeks displayed significantly higher levels of total suspended sediment (range: 10-6010 mg/L), total N (range: 650-6350 ug/L) and total P (range: 50-1500 ug/L). These discrepancies can be largely attributed to the marked differences in slope, geology and cover between the catchments of some of the watercourses sampled and those of the mini-catchments. In particular, samples from creeks draining the hillier, grano-diorite landscapes contained consistently higher loads of sediment relative to those draining flatter landscapes of sedimentary origin.

The present data suggest, that at least on the relatively flat, sedimentary landscapes, extensive cattle grazing is compatible with achieving high levels of water quality, provided high levels of ground cover are maintained.

FISH HABITAT DECLINE AND RECOVERY IN THE BURDEKIN RIVER

Colton Perna[1], Mike Cappo[2], Damien Burrows[1]

[1] Australian Centre for Tropical Freshwater Research, James Cook University, Townsville, QLD 4811, Australia
[2] Australian Institute of Marine Science, PMB 3, Townsville MC, QLD 4810, Australia

Around 80% of the coastal freshwater wetlands along north east Queensland's tropical coast have been lost to development. Many of the remaining wetlands are in a perilous state due to catchment development and exotic species invasion. There can be little doubt that the productivity of several key fish species that depend on coastal wetlands of the Great Barrier Reef Marine Park and World Heritage Area has been significantly reduced compared to pre-European levels. Typical of this situation are the wetlands and lagoons of the Burdekin River floodplain. Among the many ills affecting these remnant wetlands, the most significant result from dominance by exotic weeds such as paragrass and water hyacinth, and from loss of natural connectivity with estuaries. In altered hydrological regimes lacking a normal drying cycle, water hyacinth quickly grows over the surface of open waters, blocking out sunlight, eliminating submerged aquatic plants and algae, and disrupting food chains. This also results in chronically low dissolved oxygen in the underlying water column due to lack of photosynthetic oxygen production and consumption of oxygen by the massive biomass created by decaying organic matter (e.g. exotic plants).

Many Australian fishes and some important crustaceans require seasonal access between freshwaters, estuaries and oceans to complete their life-cycle. For example, juvenile and sub-adult barramundi and mangrove jack penetrate far upstream into freshwaters. In the Burdekin catchment, estuarine connectivity is restricted by major weirs, bund walls, drop boards and chemical barriers created by poor water quality associated with weed infestations, thus reducing the productivity of these fisheries.

The perilous state of these lagoons prompted community action to restore some of them. Surveys from 2000-2003, showed that estuarine-breeding species were present in only a few of the lagoons where they would normally be expected to occur, confirming the enormous reduction in species diversity and potential productivity resulting from loss of estuarine connectivity. Weed infested lagoons had virtually no oxygen present and contained very few fish species. The dominant fish present were those able to breath directly at the waters surface by gulping mouthfuls of air. When water hyacinth was mechanically harvested from the lagoons, oxygen levels increased and the number of fish species doubled. Cleared lagoons were rapidly recolonised by fish from nearby remnant lagoons that had retained good habitat conditions (riparian vegetation and limited water hyacinth) and refuge populations of freshwater fishes. In the absence of such refuges, the recovery of the cleared lagoons would have been greatly restricted. Hatchery-bred barramundi stocked within cleared lagoons are showing good growth rates but their survival will depend on the continued management of the aquatic weeds. Following weed clearing, regular management is required to prevent the weed mats reforming.

Although the cleared lagoons now have a healthier complement of freshwater fish species, this is only half the fauna naturally expected to be present, with the absentees mostly estuarine / marine species. Restoring estuarine connectivity in these systems by identifying and either removing or modifying barriers, would significantly increase the fishery values of the GBR Marine Park and WHA.

THE CURRENT AND NEAR FUTURE APPLICATIONS FOR DETECTION AND MONITORING OF SEAGRASSES, MACRO-ALGAE AND CORAL REEFS

Stuart Phinn[1], Arnold Dekker[3], Karen Joyce[1], Chris Roelfsema[1,2], Vittorio Brando[3], Magnus Wettle[3]

[1] Biophysical Remote Sensing Group and [2] Marine Botany Group, Centre for Marine Studies, University of Queensland, St Lucia, QLD 4072, Australia
[3] Environmental Remote Sensing Group, CSIRO Land and Water, GPO Box 1666, Canberra, ACT 2601, Australia

An overview will be presented for mapping submerged aquatic vegetation, including seagrasses, macroalgae and coral reefs, to identify the type(s) of information able to be measured and mapped, along with its expected accuracy. Further consideration is given to the procedures necessary for using remotely sensed data and field data to monitor changes to aquatic environments and provide relevant information for management of estuarine, coastal and reef environments. The review covers current and next–generation commercially available image data sets, along with techniques used for mapping water depth, water column constituents, substrate type and substrate biophysical properties (e.g. seagrass density / biomass). Each type of image data and processing technique has an application domain, in terms of type of environment and spatial scale, to which it can be applied to provide accurate results. Details are also provided on how spatial information derived from remote sensing contributes to understanding water quality impacts on tropical aquatic plants and coral reef ecosystems. To illustrate the state of the art in this area examples are presented from the Great Barrier Reef, from individual site to regional scales, covering simple habitat or substrate mapping to more complex mapping of depth and biophysical features. Limitations of each technique and the need for field data are discussed to provide a realistic assessment of the "usefulness" of the image data and techniques. This presentation will also include a discussion how to bridge the current (apparent) gap between the research based image products and the limited uptake of these products by end-users.

SOURCES AND SINKS OF SEDIMENTS AND NUTRIENTS IN SEMI-ARID GRAZING LANDS OF THE BURDEKIN CATCHMENT

David Post

CSIRO Land and Water, Davies Laboratory, Townsville, QLD 4811, Australia
Email: David.Post@csiro.au

CSIRO Land and Water have been monitoring the discharge of water and sediments from a number of sub-catchments of the Burdekin River since the 1999/2000 wet season. In the last two wet seasons, this monitoring was extended to include nutrients and heavy metals. We have now collected enough data to make a preliminary assessment of :

1. The impact of grazing on the yield of suspended sediment, nutrients, and heavy metals from small (<100 km^2) sub-catchments of the Burdekin River.
2. A comparison between the suspended sediment yield of the upper Burdekin River (above Sellheim, 36,390 km^2) and the Bowen River (above Myuna, 7,200 km^2).
3. An assessment of the sources of suspended sediment at the small catchment scale (~10 km^2). This assessment was made using a combination of field measurement techniques, air photo interpretation and the SubNet model.
4. An evaluation of the impact of scale on the discharge of water, sediments, and nutrients.

This presentation will present the results of 5 years of water quality monitoring from two small, grazed catchments in the upper Burdekin; 3 years of monitoring from four relatively ungrazed catchments in the Townsville Field Training Area; 2 years from a larger sub-catchment in the upper Burdekin and the Burdekin at Sellheim, and 1 year from the Bowen River at Myuna.

I will also present results from an intensive monitoring and modelling program in the Weany Creek (13.5 km^2) sub-catchment which has allowed us to construct a material budget accounting for the main sources, transport, and sinks of sediment within this catchment, as well as an assessment of sediment export from the catchment. We were able to show in detail which stream sections (and their associated catchment areas) contribute to suspended sediment loads, and whether this sediment comes from hillslope, gully/bank erosion, or both, as well as where bedload deposits are likely to accumulate.

AN OVERVIEW OF NITRATE IN GROUNDWATER IN GBR CATCHMENTS: A CASE STUDY IN THE JOHNSTONE CATCHMENT

Velupillai Rasiah, John D. Armour, Ian H. Duncan, Lex Cogle

Dept. of Natural Resources and Mines, PO Box 1054, Mareeba, QLD 4880, Australia.

Nitrate-N concentrations in groundwater (GW) are usually assessed for suitability for human consumption (trigger value of 10 mg/L, ANZECC & ARMCANZ 2000), but that relating to aquatic ecosystem health requirement is limited (trigger value of 0.01 mg/L). Nitrate data are available for catchments from Mossman in the north to Kolan-lower Burnett in the south (e.g. 1395 bores reported by Hunter et al. 2003). However, for most catchments, the data are based on sampling programs with limited distribution in time and space. We investigated the dynamics of GW and nitrate from shallow, medium, and deep aquifers in the Johnstone River Catchment and assessed the impacts of these dynamics on aquatic ecosystem health requirement. GW depth and NO_3-N concentration were measured for 4 years to September 2002 in 39 piezometers installed at depths between 5.2 and 90 m under fertilized sugarcane (*Saccharum officinarum*-S) in different locations in the catchment. The depth to GW from the surface varied between 0 to 18.9 m. The median depth was 0.9 m to 17.3 m and the 20th percentile was 0.3 m to 16.1 m. The GW usually rose from early January and fluctuated throughout the wet season (January - May), receded rapidly in June and then gradually decreased to levels that existed before January. The fluctuations were more rapid in shallow aquifers (5 to 20 m), followed by medium (20 to 40), and deep (40 to 90m). However, these data from selected bores does not show progressive rise in GW under cropping, particularly in shallow aquifers. The mean nitrate-N concentration in the 39 piezometers was 33 to 1899 mg L^{-1}. Significant negative associations existed between the mean, median and 20th percentile nitrate concentration and the depth of groundwater in the piezometers. Nitrate-N concentration increased with decreasing GW depth implying that nitrate was imported into GW by the incoming water through the profile and exported in the GW that left the profile, probably by lateral or base flow. In 10 out of the 39 piezometers, the nitrate concentration ranged from 31 to 300 µg L^{-1}, 301 to 600 µg L^{-1} in 12 piezometers, 601 to 1000 µg L^{-1} in 9 piezometers and > 1001 µg L^{-1} in 3 piezometers. Nitrate-N concentrations in 90% of the bores were higher than the maximum ANZECC trigger value proposed for the sustainable health of streams, freshwater lakes and reservoirs, wetland, and marine ecosystems. The variability in nitrate-N concentrations and the rapid fluctuations in GW level clearly demonstrate the spatio-temporal variation across the catchment. However, the recorded dynamics may not be truly representative because variability in shallow GW was dominated by events of short duration less than the sampling interval. We propose well-planned monitoring schemes for GW and nitrate dynamics to provide reliable estimates of nitrate N-loading into aquatic ecosystems because the GW is believed to be discharging into aquatic ecosystems in this region.

References

ANZECC & ARMCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. National Water Quality Management Strategy Paper No. 4 (Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra).

Hunter H, Witting N, Clarke R, Raymond M (2003) 'Water quality in sugar cane catchments in Queensland.' Qld. Dept. of Natural Resources & Mines, Report No. 3, Brisbane.

SUGARCANE'S FOOTPRINT ON WATER QUALITY IN REEF CATCHMENTS OF QUEENSLAND

George E. Rayment

Queensland Department of Natural Resources and Mines, 80 Meiers Road, Indooroopilly, QLD 4068, Australia
E-mail: George.Rayment@nrm.qld.gov.au

The *Protecting the Environment* Program of the former Cooperative Research Centre for Sustainable Sugar Production (CRC Sugar) focused considerable effort as an "honest broker" on defining the footprint of sugar cane on water quality in catchments where the crop is grown in eastern Australia. Although the land area dedicated to sugarcane is relatively small, the crop is grown predominantly in environmentally sensitive parts of 21 catchments from the Mary to the Daintree now covered by the joint Queensland and Commonwealth Governments' *Reef Water Quality Protection Plan* for catchments adjacent to the Great Barrier Reef. The presentation covers the extent to which contemporary sugar cane production exerts pressure on local and downstream water quality. This includes elucidation of a sugar-specific cause of oxygen depletion in local waterways adjacent to cane fields. The knowledge base was strengthened by a major literature review, from awareness of contemporary soil phosphorus fertility levels (mostly higher than necessary), and from experience gained from monitoring water quality for over three years through to 2003 in six main cane drains in northern New South Wales. Brief details are also provided of findings from three CRC Sugar sponsored publications produced by the Department of Natural Resources since late 2000 on water quality monitoring at sites in several "sugar" catchments.

The water quality monitoring of main drains of northern New South Wales largely overcame a weakness of river water quality monitoring that typically integrates the effects of adjacent and upstream multiple land uses. It was found that despite overwhelming dominance of sugarcane in the main-drain catchments, water quality was quite variable notwithstanding similar cultural practices and relatively small distances between the main drains. Moreover, the participative nature of that study demonstrated that at least for pesticides, it was possible to lower the incidence of detectable residues quite quickly by encouraging local growers to change formulations and application practices. That study provided good grounds to seek locally applicable water quality guidelines for nutrients, rather than on relying on generic guidelines that sometimes differ surprisingly at State borders.

A COMPARISON OF WATER TURBIDITY ON CORAL REEFS ALONG THE QUEENSLAND COAST

Peter Ridd[1], Piers Larcombe[2], Séverine Thomas[1,3], James Whinney[1]

[1] School of Mathematical and Physical Sciences, James Cook University, Townsville, QLD 4811, Australia.
[2] Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Pakefield Road, Lowestoft, Suffolk NR33 0HT, UK
[3] Reef HQ, Great Barrier Reef Marine Park Authority, 2-68 Flinders Street, Townsville, QLD 4810, Australia

This presentation will give a summary of water turbidity data collected, using self-logging instrumentation, over the last decade from various sites within the GBR lagoon, mainly from nearshore reefs. This summary allows a comparison to be made of different reefs and regions. The summary will show data from Princess Charlotte Bay, Alexandra Shoals, the Frankland Islands, Dunk Island / Mission Beach, Paluma Shoals, and Magnetic Island / Cleveland Bay.

High turbidity events at all sites were primarily associated with strong winds causing rough weather. Sites close to inshore sediment wedges recorded the highest turbidities. These occurred on Magnetic Island, Paluma Shoals and Lugger Bay where turbidities exceeding 200 NTU were recorded. Calibration of turbidity to Suspended Sediment Concentration at Magnetic Island indicated that such high turbidities corresponded to concentrations of ca. 1000 µg / l.

Only one event occurred where elevated turbidity could confidently be attributed to a flood plume. This occurred at the Nelly Bay reef flat and was due to runoff from a small creek that discharged within 200 m of the instrument.

A comparison between reefs in Princess Charlotte Bay and close to Dunk Island, comparing these regions is a focus of a CRC Reef Research Centre project, indicates that the reefs around Dunk Island are significantly more turbid.

SOURCE TO SEA: USING TWO RAINFALL EVENTS WITHIN THE FITZROY BASIN AS CASE STUDIES IN TRACKING POLLUTANTS

Ken Rohde[1], Cameron Dougall[1], Robert Packett[2], Scott Stevens[3], Ian Wallace[2], Robert Noble[2], Chris Carroll[2].

[1] Department of Natural Resources and Mines, P.O. Box 19, Emerald, QLD 4720, Australia
[2] Department of Natural Resources and Mines, P.O. Box 736, Rockhampton, QLD 4720, Australia
[3] Department of Natural Resources and Mines, LMB 1, Biloela, QLD 4715, Australia

Water quality in the river basins draining into the Great Barrier Reef continues to be an issue. The Fitzroy River basin, the largest basin draining to the reef, discharges an average of four million tonnes of sediment per annum directly into the Great Barrier Reef lagoon.

The basin experiences a semi-arid to sub-tropical climate, with average annual rainfall ranging from 500 mm in the northwest to 1000 mm in the east. This rainfall consists of both depressional and tropical thunderstorms of high intensity and short duration. Extreme episodic rainfall events within the Fitzroy River basin are not uncommon. Daily rainfall totals of 480 mm were recorded in the Clermont area in December 1916, 204 mm at Capella in March 1994, and 416 mm at Bauhinia Downs in February 1997.

In January 2002, up to 400 mm was recorded in seven hours across an area of 280,000 ha (40% dryland cropping) within the Comet River sub-basin. Flow and water quality samples were collected at various locations from the Comet River ("source") downstream to the Fitzroy River at Rockhampton ("sea"). Results show that 440,000 tonnes (1.5 t/ha) of sediment was discharged down the Comet River from the less then 1% of the Fitzroy Catchment. 40% of this sediment reached the Fitzroy River at Rockhampton, 600 km downstream. Atrazine and diuron were also detected in both river systems.

In the Dawson River and lower Fitzroy River sub-basins, 250 mm was recorded in February 2003. Water quality samples were collected throughout the stream network, and analysis is yet to be completed, but shows large amounts of sediment and pesticides moving within the system.

This paper will use the rainfall events of 2002 and 2003 as case studies to monitor and research the impacts of large episodic rainfall events from source to sea within the Fitzroy River basin.

REHABILITATION OF RECLAIMED COASTAL WETLANDS INFLUENCED BY ACID SULFATE SOILS: EFFECTS ON WATER QUALITY AND FISH ASSEMBLAGES

John Russell, Andrew McDougall*

Northern Fisheries Centre, Queensland Department of Primary Industries, PO Box 5396 Cairns, QLD 4870, Australia
*Present Address: Department of Natural Resources and Mines, PO Box 1143, Bundaberg, QLD 4670, Australia

An area of ~ 700 ha of mostly tidal wetlands at East Trinity adjacent to Cairns in north Queensland was reclaimed ostensibly for agriculture in the early 1970's. The wetlands were isolated from tidal inundation through the construction of a levee with tidal gates on the major creeks. The reclamation disturbed potential acid sulfate soils that resulted in periodic discharges of acid into coastal waterways causing deterioration of water quality and occasional fish kills. The Queensland Government purchased the East Trinity site in 2000 and a management plan was subsequently developed to rehabilitate the acid sulfate soils through application of lime and reinstating limited tidal inundation. The fish, crustaceans and water quality in the impounded area of Hills and Firewood creeks at East Trinity were monitored monthly over a 13-month period to quantify differences that occurred following these changes to onsite management practices. The Department of Natural Resources and Mines originally planned to initiate controlled tidal exchange and liming to keep the pH of the creek waters at or above pH 6. While lime was routinely added to watercourses on the site, the controlled tidal exchange in Hills Creek did not eventuate during this study. However, a series of mechanical failures in the existing tidal gates resulted in some tidal exchange in both creeks over much of the period thereby simulating the effects of controlled reflooding. Water quality parameters including pH, dissolved oxygen, salinity and turbidity were measured 'in situ' and, as well, surface water samples were collected and further analysed for dissolved aluminium, iron, calcium, silica, total organic carbon and sulfate. During the study, there was a modest increase in fish species diversity in Hills Creek, but monthly species richness was variable. In contrast, both the species diversity and richness in Firewood Creek declined during the study even though limited tidal flow to the creek had been restored. During the 2001/02 wet season there was only one significant rainfall event that occurred in late February. This event caused the pH in Firewood Creek to drop below 4 and resulted in elevated dissolved aluminium (6 mg L^{-1}) and iron concentrations (18 mg L^{-1}) in the surface waters. Consequently, there was a minor fish kill within the impounded section of this creek. The water quality in Hills Creek during the study was mostly within normal limits. The future management of the site is discussed.

NITROGEN ECOPHYSIOLOGY OF HERON ISLAND, A GREAT BARRIER REEF CORAL CAY

Susanne Schmidt[1], George Stewart[2], Gordon Moss[1], William C. Dennison[3]

[1] Department of Botany, University of Queensland, Brisbane, QLD 4071, Australia
[2] Faculty of Science, University of Western Australia, Nedlands, WA 6907, Australia
[3] Centre for Environmental Science, The University of Maryland, Cambridge MD 21613, USA

From a global perspective, most Australian terrestrial and aquatic environments are nitrogen (N) poor. Coral cays constitute a proportion of the islands that form part of the Australian Great Barrier Reef (GBR). Some coral cays are areas of extreme N enrichment due to seabird rookeries. Seabirds on Heron Island deposit up to 1000 kg N ha^{-1} a^{-1} as guano, and these N deposition rates exceed those of highly N polluted areas elsewhere. We investigated how coral cay vegetation is adapted to the high-N environment of seabird rookeries, how N is distributed within the cay, and whether seabird-derived N impacts on the surrounding marine environment. This was addressed using N compound analysis, ^{15}N labelling and ^{15}N natural abundance ($\delta^{15}N$) techniques.

Guano-derived uric acid is hydrolysed to ammonium (NH_4^+) and gaseous ammonia (NH_3). NH_4^+ undergoes nitrification, and NH_4^+ and nitrate (NO_3^-) were the main N forms detected in the soil. Despite high NO_3^- availability in soil, uptake, transport and storage of NO_3^- by plants, NO_3^- was not the main N source for coral cay plants. Using ^{15}N labelled substrates it was shown that plants from seabird rookeries have a high capacity to assimilate NH_4^+, are able to metabolise uric acid, but have low rates of NO_3^- assimilation.

It is concluded that NH_4^+ is the principal source of N used by plants growing at seabird rookeries, and that the presence of NH_4^+ in soil and gaseous NH_3 in the atmosphere inhibits assimilation of NO_3^- and possibly uric acid. Soil $\delta^{15}N$ increased with density of seabirds and successional age of the plant community, with beach and forest soil $\delta^{15}N$ of 4.7and 11.3 ‰, respectively. Average foliar $\delta^{15}N$ of plants at the forest was 9.5 ‰ reflecting the ^{15}N enrichment of seabird guano ($\delta^{15}N$ 9.9 ‰), compared to $\delta^{15}N$ 6.5 ‰ of plants of from sites with lower seabird density. Casuarina, a N_2 fixing tree dominating the beach fringe, had foliar $\delta^{15}N$ of 2.4 to 4.2 ‰ indicating that Casuarina has a low reliance on bird-derived N. Plants growing at rookeries had higher average N contents (3 % N) than plants growing at the beach (1.5 % N), demonstrating further that seabird-derived N is not distributed uniformly across the cay.

While there is no evidence for horizontal re-distribution of bird-derived N throughout the cay, vertical movement of N occurs since the aquifer under the Heron Reef contains seabird-derived N leached from the cay. The aquifer has low concentrations (10 µM) of NH_4^+ but high concentrations (1 mM) of NO_3^- with high $\delta^{15}N$ of 7.9 ‰ which qualifies NO_3^- as a potential tracer for seabird derived N. $\delta^{15}N$ of macroalgae from the Heron reef and adjacent Wistari reef without seabird rookeries were 2.7 to 3.8 ‰ suggesting that reef macroalgae do not utilise seabird-derived N as a main N source. At a site beyond the reef crest of the Heron reef, macroalgae had elevated $\delta^{15}N$ of 5.2 ‰ indicating that there may be locations where NO_3^- leaches from the aquifer and is assimilated by macroalgae. N relations of Heron Island vegetation are compared with other reef islands and a conceptual model for N fluxes based on $\delta^{15}N$ relations of Heron Island is presented.

CONCENTRATION AND PHYTOTOXICITY OF PSII HERBICIDES ON CORALS OF THE GREAT BARRIER REEF

Chris Shaw[1,2], Ross Jones[2], Melanie Shaw[1], Jochen Müller[1]

[1] National Research Centre for Environmental Toxicology, 39 Kessels Road, Coopers Plains, QLD 4108, Australia
[2] Centre for Marine Studies, University of Queensland, St Lucia, QLD 4072, Australia

Corals and seagrasses of Queensland face a potential threat from herbicide contamination of near-shore waters. Herbicide residues have recently been detected in many areas along the Queensland coastline. Herbicide contamination of the estuarine and marine environment in Queensland has therefore become a key concern. Available data will be summarised in this presentation.

Furthermore we will evaluate factors that are responsible for the high risk posed by herbicide contamination. Firstly, key human activities associated with herbicide application are concentrated along the coastline, including intensive agriculture, home garden use and antifouling on boats and marine infrastructure. Secondly, high rainfall along the coast combined with their high polarity (water solubility) and relative persistence facilitates off-site transport of selected herbicides from agricultural and urban areas into estuarine and marine environments. Thirdly, the mode of action of some herbicides and their relative potency give them the potential to affect primary producers that are an integral part of the GBR ecosystem.

In addition to the exposure evaluation we thus present toxicity data of herbicides on corals. Furthermore we demonstrate results from a novel approach where we evaluated the toxicity of herbicide / pollutant mixtures on photosynthesis of symbionts of the coral *Seriatopora hystrix*. For this, we used novel passive sampling techniques for time-integrated extraction of polar pollutants including herbicides. The extracts were then used to expose intact coral pieces and impacts on photosynthetic efficiency were measured continuously as an endpoint using a prototype of the underwater IMAGING PAM™. These assays showed that environmentally relevant concentrations equivalent to approximately twice the concentrations found in the Brisbane River noticeably reduced photosynthesis in the corals. Exposure equivalent to approximately six times Brisbane River concentration reduced photosynthesis more than 1µg L^{-1} of diuron standard.

FUTURE SCENARIOS FOR THE GREAT BARRIER REEF IN RESPONSE TO PRESSURES AND CURRENT STRATEGIES. HOW CAN SCIENCE ADDRESS THE ISSUES?

Roger Shaw

CRC for Coastal Zone, Estuary & Waterway Management, Meiers Road Indooroopilly, QLD 4068, Australia
Email: roger.shaw@nrm.qld.gov.au

Scenarios

Scenario planning is a participatory process that has been commonly used by organisations and others to consider the future and seek appropriate responses. It has not been widely applied to complex, natural resource management issues. However, scenarios are useful to integrate different knowledge, ecological values and scientific understanding with future expectations by considering trends, drivers, uncertainties, discontinuities, wildcards and critical events. The scenarios, as stories, can be used in a holistic way to test strategy, policy and planning options, and proposed research against the risks, uncertainties and opportunities that may arise.
Simple examples of scenarios for the GBR based on optimistic, realistic and pessimistic options for the future will be presented to illustrate the value of the approach.

Challenges for scientific input

Scientific input is critical in the co-development and validation of the scenarios and the preferred actions. Challenges for science are:
Synthesising the quantitative and causal relationships with qualitative data across differing spatial and temporal scales where human interventions and episodic events interact;
Estimating the resilience of socio and environmental systems to ensure the preferred actions will in fact be effective over the longer term; and at minimal social and economic cost
Jointly developing management actions that can enhance the resilience of natural systems to withstand shocks under pressure and reorganise when necessary;
Developing integrating frameworks using collages of linked meta-models to predict likely responses of systems to combinations of pressures.

Scenarios and the scientific synthesis form a key part of the systems analysis and vision component of adaptive management, a preferred approach where there are unknown relationships and uncertainty.

SIZE STRUCTURE, RECRUITMENT AND POST-RECRUITMENT SURVIVAL OF NEARSHORE CORALS IN THE GREAT BARRIER REEF WET TROPICS

Luke Smith[1], Michelle Devlin[2,3], David Haynes[2]

[1] Australian Institute of Marine Science PO Box 83, Fremantle, WA 6959, Australia
[2] Great Barrier Reef Marine Park Authority, PO Box 1379, Townsville, QLD 4810, Australia
[3] Present Address: CEFAS Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk NR33 0HT

Inshore coral reefs in the wet tropics of Queensland are regularly exposed to flood plumes from coastal river systems, and it has been postulated that this chronic exposure may be linked to their recent decline and failure to recover. To investigate a link, the demography of inshore coral communities was quantified over two years (1999 to 2000) at three reef-systems with varying levels of exposure to flood plumes (High Island > Frankland > Fitzroy). Size-structure of populations and their rates of recruitment, post-recruitment survival, and juvenile growth were measured at each reef system. All measured variables and parameters differed greatly between the reef-systems. Fitzroy Island reefs, which are least exposed to flood plumes, had rates of recruitment that were up to eight times higher than High Island reefs, which are most plume exposed. Furthermore, there was a high abundance of juvenile and adult corals at Fitzroy reefs, while few were present at either High or Frankland Island reefs. In contrast, the rates of growth and survival of juveniles at the Fitzroy Island reefs were lower than at the exposed reefs. The lack of adult corals at exposed reefs is probably related to their recent histories of disturbance from crown-of-thorns and coral bleaching. However, the lack of subsequent recovery is likely to be a consequence of low levels of coral recruitment. If a stock-recruitment relationship exists for these reefs, then the lack of adult colonies would, in turn, explain the low recruitment levels. Alternately, direct or indirect effects of chronic exposure to poor water quality conditions may have resulted in less suitable substrata for larval settlement at these reefs. These biological results support those of recent risk assessments, which identify High Island reefs as being at greater risk of anthropogenic impacts than Frankland or Fitzroy Island reefs, based on their distances from river mouths, proximity to agricultural land use and frequency of plume inundation.

A RISK ASSESSMENT APPROACH TO CONTAMINANTS IN PORT CURTIS

Jenny Stauber[1], Simon Apte[1], Mary-Anne Jones[2], Stuart Simpson[1], Vicki Vincente-Beckett[3], Rod Johnson[3], Leo Duivenvoorden[3]

[1] Centre for Environmental Contaminants Research, CSIRO Energy Technology, PMB 7, Bangor, NSW 2234, Australia
[2] Queensland Natural Resources and Mines, PO Box 736, Rockhampton, QLD 4720, Australia
[3] Centre for Environmental Management, Central Queensland University, Bryan Jordan Dr, Gladstone, QLD 4680, Australia

Contaminants of potential concern to aquatic biota and human health were investigated in the Port Curtis estuary, using a screening level risk assessment approach. Contaminant concentrations in water, sediments and biota (oysters, mud whelks, mud crabs and seagrass) were compared to reference sites and guideline values. Risk to humans through ingestion of contaminated seafood, was assessed by measuring contaminant concentrations in fish, mud crabs and prawns collected from Port Curtis and calculating hazard quotients using risk assessment methods.

Concentrations of dissolved metals in waters of the Port Curtis estuary were below ANZECC / ARMCANZ (2000) guideline values, suggesting low risk of these contaminants in Port Curtis. Only TBT, an antifouling paint used on large vessels, exceeded guideline values in some samples, as is typical of large international ports. In sediments, TBT also exceeded guideline values, particularly in the marina and Fisherman's Landing areas. Concentrations of arsenic, nickel and chromium also exceeded guideline values, but were also high in the reference zone, suggesting that they may be of natural origin. Naphthalene in sediments in the mid-Harbour were also identified as contaminants of potential concern. Despite the low concentrations of metals in waters and sediments, oysters, mud whelks, mud crabs and sea grass were generally enriched in metals, particularly in the Calliope Estuary and mid Harbour. However, elevated concentrations of some metals were also found in biota from the reference areas. Further work to determine whether the source of the metal enrichment was due to food uptake, fine particles or exposure to pulse events is currently being undertaken.

In the human health screening risk assessment, only mercury in barramundi was identified as a potential risk and this risk is not unique to Port Curtis.

SUBMARINE GROUNDWATER DISCHARGE ALONG THE CENTRAL GREAT BARRIER REEF COASTLINE

Thomas Stieglitz[1,2], Peter Ridd[1], Gregg Brunskill[2], Mal Heron[1], Derek Burrage[3], Gary Hancock[4]

[1] Marine Geophysical Laboratory, School of Mathematical and Physical Sciences, James Cook University, Townsville, QLD 4811, Australia
[2] Australian Institute of Marine Science, PMB 3, Townsville MC, QLD 4810, Australia
[3] The University of Southern Mississippi, MS, USA
[4] CSIRO Land and Water, GPO Box 1666, Canberra, ACT 2601, Australia

For many scientists, the paradigm that "water flows from the land to the sea via rivers" seems to be too self-evident to question. This is particularly so in the Great Barrier Reef (GBR) region, a World Heritage Area, where to date little is known about incidence and magnitude of submarine groundwater discharge (SGD) from coastal aquifers into the near-shore ocean. In this talk, an overview of SGD in the central GBR region is presented.

Recent work provides evidence for SGD to occur in a variety of geological settings, originating from both unconfined and confined coastal aquifer system. Four hydrogeological settings of SGD in the region are presented: (1) recirculation of seawater through animal burrows in mangrove forests, (2) fresh SGD from unconfined aquifers as a narrow coastal fringe of freshwater along Wet Tropics beaches, (3) SGD as a result of interaction of perched freshwater wetlands in coastal dune systems and the ocean in form of localised freshwater springs in the intertidal zone. (4) offshore SGD from confined submarine aquifer systems comprised of riverine paleochannels incised into the shelf.

DEVELOPMENT OF INNOVATIVE SENSORS FOR INSHORE CORAL REEF MONITORING

Séverine Thomas[1], Peter Ridd[2]

[1] Reef HQ, Great Barrier Reef Marine Park Authority, 2-68 Flinders Street, Townsville, QLD 4810, Australia
[2] School of Mathematical and Physical Sciences, James Cook University, Townsville, QLD 4811, Australia

Sediment accumulation is a frequently required parameter in environmental and management studies, and it may impact on coral reefs health significantly under some circumstances. However, accurate measurements of sediment accumulation are often limited due to a lack of adequate instrumentation, in particular for monitoring with a high temporal resolution. Therefore, an instrument has been developed to continuously measure short-term sediment deposition *in situ* in riverine or coastal zones, with a high resolution in both deposited thickness (order of 20 μm) and time (order of 2 hours). The Low Impact Sediment Deposition sensor (LISD) is an optical backscatter sensor that sits flush with the sea bottom and is connected to a separate logging unit. This presentation briefly describes the new instrument and presents field applications relevant to inshore coral reefs monitoring. Accumulation records were obtained with the LISD at three sites where fringing coral reefs grow: Magnetic Island on the Great Barrier Reef, Ishigaki Island in tropical Japan, and Lihir Island in Papua New Guinea. Thanks to a temporal resolution in the order of one hour, the influence of various parameters - such as tidal forcing, current, waves, or sediment dumping related to anthropogenic activity - over sedimentation can be investigated.

HISTORICAL INFORMATION ON BENTHIC COMMUNITIES OF INSHORE REEFS OF THE GREAT BARRIER REEF

Angus Thompson, Hugh Sweatman

Australian Institute of Marine Science, PMB 3, Townsville MC, QLD 4810, Australia

A relatively small proportion of the coral reefs of the GBR occur within 20 km of the shoreline, but it is these inshore reefs that are most at risk from reduced water quality. A current project, funded by the CRC Reef Research Centre, has dual aims of surveying the benthic communities on inshore reefs along much of the GBR coastline and of gathering together and synthesising information from past surveys, many of which are in "grey" literature. We present the results of that literature search, which will form a background to the surveys of current reef status. There is practically no quantitative information from before 1980.

USING NITROGEN STABLE ISOTOPE RATIOS (?^{15}N) OF MACROALGAE TO MONITOR CHANGES IN THE EXTENT OF SEWAGE IMPACTS IN MORETON BAY.

James Udy, Ben Longstaff, Simon Costanzo, Adrian Jones

Marine Botany Group, Centre for Marine Studies, University of Queensland, St Lucia, QLD 4072, Australia
Email: j.udy@uq.edu.au

During the past decade the use of stable isotopes to investigate transport pathways of nutrients in aquatic ecosystems has contributed new understanding and knowledge to many aspects of ecology; from the trophic structure of food webs to the spatial extent of nutrient discharges. At the same time aquatic monitoring programs around the world have become more interested in quantifying ecosystem health rather than simply measuring the physical and chemical properties of water (nutrients, pH, temperature and turbidity). A novel technique was initiated in 1998 (Costanzo et. al., 2001) as part of the development of the Ecosystem Health Monitoring Program in S.E. Queensland Australia (EHMP) using changes in the δ^{15}N value of the red macroalgae *Catenella nipae*, to indicate regions impacted by sewage nitrogen. Sewage plume mapping, using the δ^{15}N of *C. nipae*, has demonstrated that over the past 5 years there has been a large reduction in the magnitude and spatial extent of δ^{15}N enrichment at sites close to sewage treatment plants (STP's) discharging into Moreton Bay (Figure 1). This manuscript will discuss how the d^{15}N signatures of the *C. nipae* in the plume at the mouth of the Brisbane River have declined since it was first sampled in 1998 and will evaluate causes that may be responsible for these variations. A series of laboratory experiments were conducted to investigate how environmental conditions influence the d^{15}N signature of *C. nipae* over the incubation period. These data will be used to discuss the observed in situ decline in d^{15}N in an attempt to determine if the reduction can be attributed solely to improvements in the wastewater discharge.

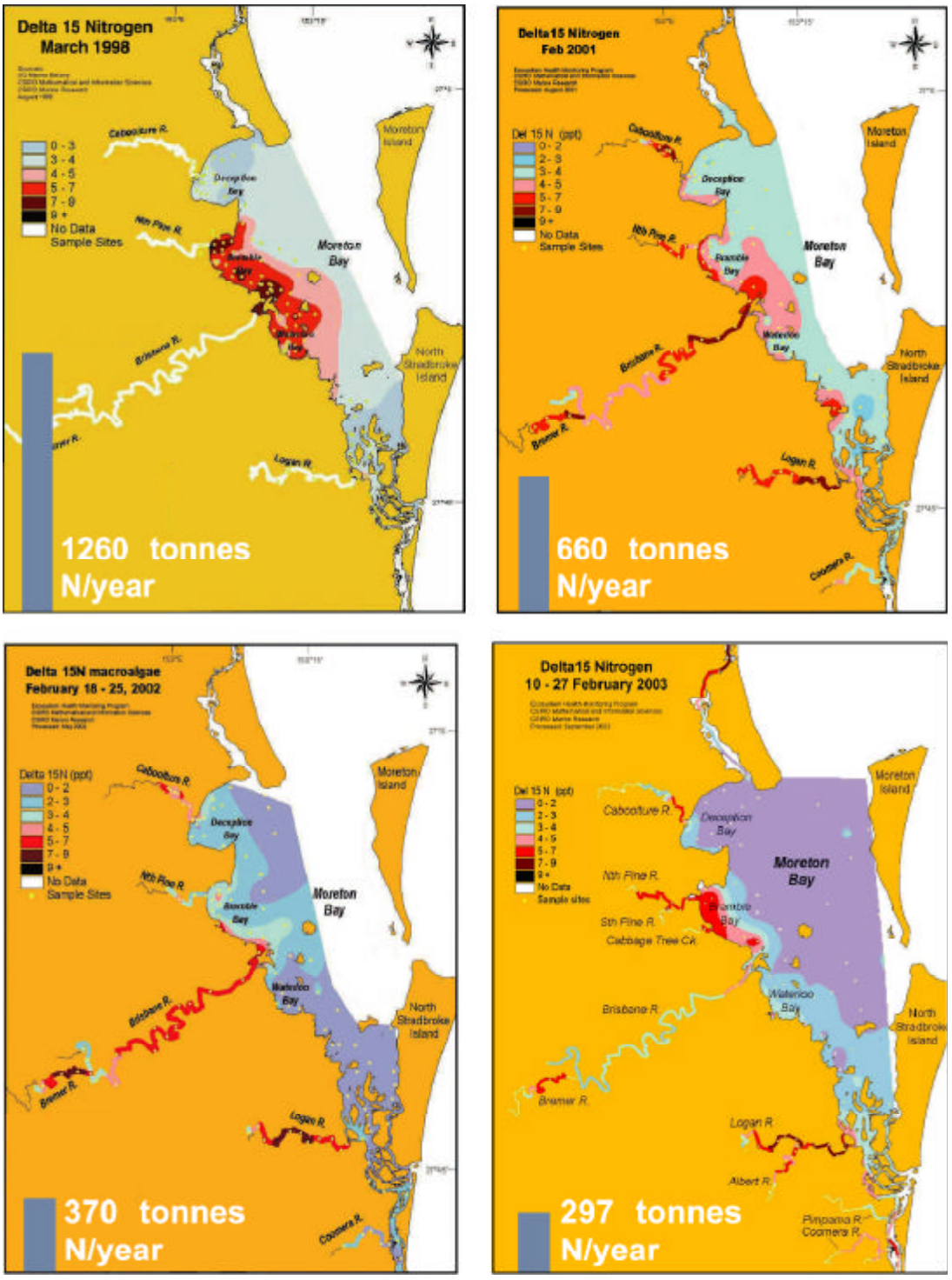

Figure: The extent of sewage plumes in Western Moreton Bay has decreased since 1998. This coincides with Sewage Treatment Plant upgrades with blue bars indicating the total nitrogen loads from Luggage Point and Redcliffe Sewage Treatment Plants.

Reference
Costanzo, SD, O'Donohue MJ, Dennison WC, Longeragan NR and Thomas M 2001 A new approach for detecting and mapping sewage impacts. Marine Pollution Bulletin: 42, 149-156.

MONITORING MARINE ECOSYSTEM HEALTH: NOVEL APPROACHES FROM S.E. QUEENSLAND AUSTRALIA.

James Udy[1], Ben Longstaff[2], Francis Pantus[3]

[1] Marine Botany Group, Centre for Marine Studies, University of Queensland, St Lucia, QLD 4072, Australia
[2] Queensland Environmental Protection Agency, 80 Meiers Rd, Indooroopilly, QLD 4068, Australia
[3] CSIRO Marine Research, PO Box 120, Cleveland, QLD 4163, Australia
Email: j.udy@uq.edu.au

The Ecosystem Health Monitoring Program in S.E. Queensland Australia (EHMP) reports on the ecosystem status in terms of the natural resources management objectives which strive to improve and protect waterways by reducing human impacts. EHMP integrates monitoring programs in the freshwater, estuarine and marine environments of S.E. Queensland by measuring many different aspects of ecosystem health. This poster focuses on the estuarine and marine program, which was developed in 1998 and began field monitoring in January 2000. The program is based on a conceptual model that integrates our current understanding of the estuarine and marine waterways of the Moreton region with community-derived environmental values (Fig 1). It uses both traditional water quality parameters (turbidity, dissolved oxygen, salinity, pH, temperature, Chl a, nutrients) and new approaches ($\delta^{15}N$, coral and harmful algal surveys and spatial and temporal analysis of data) at 250 sites throughout south east Queensland to determine if zones of human impact are increasing or decreasing in the estuarine and marine habitats from Noosa south to the Qld / NSW boarder. EHMP monitoring and reporting takes into account both temporal and spatial variability and provides an annual report card and technical report that indicates the proportion of waterways in different regions that meet the environmental objectives (Fig. 2).

Key objectives of management agencies are to ensure critical habitats remain intact and that the areal extent of impacted / degraded zones does not increase. The water quality and biological information collected by EHMP allows us to evaluate the ecosystem and community benefits of investments in environmental protection (such as improved sewage treatment, stormwater management and catchment management).

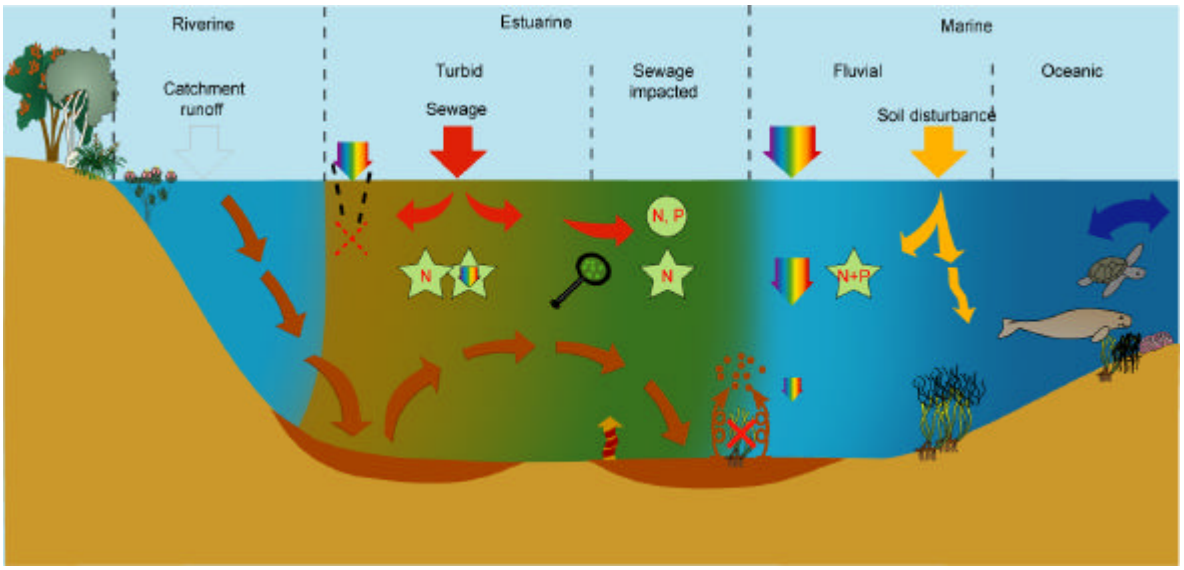

Figure 1: Conceptual model for the Moreton Bay region depicting the key processes, human impacts and critical habitats

Figure 2: The report card is released every year as a synthesis of how well each waterway is meeting its water quality objective.

RESEARCH NEEDS AND STRATEGIES FOR FUTURE INTERPRETATION OF SEAGRASS AND MANGROVE STATUS AND TREND

Michelle Waycott[1], Norm Duke[2]

[1] School of Tropical Biology, James Cook University, Townsville, QLD 4811, Australia
Email: michelle.waycott@jcu.edu.au
[2] Centre for Marine Studies, University of Queensland, St Lucia, QLD 4072, Australia
Email: n.duke@mailbox.uq.edu.au

Despite the high profile seagrass and mangrove communities have in the public arena, there remains a lack of basic biological data in key areas limiting our ability to understand the impacts of changing water quality on these communities in the Australian tropics. Both seagrass and mangrove communities are comprised of a diverse array of organisms and are recognised as playing a crucial role in filtering the inputs from catchments into adjacent marine ecosystems. Today we have evidence of seagrass and mangrove declines due to catchment derived inputs such as the loss of seagrass in Hervey Bay or the die-off of mangroves in Mackay. However, controversy has surrounded the interpretation of these observations as being anthropogenically influenced. In part, these controversies have resulted from the lack of basic biological information on the dominant species of these ecosystems, seagrasses and mangroves.

Strong links have been established between declines in seagrass meadows as a result of reduced light availability from increased turbidity, suspended sediments or phytoplankton blooms, or due to sediment accretion physically smothering the meadows. Thus we can say that seagrasses growth in the GBR is limited by light, disturbance and nutrients. Small-scale losses are common where particular meadows decline and recover due to both natural and anthropogenic perturbations. Similarly mangroves have declined due to clearing to make way for coastal developments and where land clearing has changed catchment runoff and excessive nutrient or pollutant inputs. Thus, at present key indicators and causes of seagrass and mangrove declines in the GBR region are needed that include a comparison of natural disturbances and known anthropogenic disturbances.

As a fundamental element of organismal biology, species reproductive strategies indicate their survival strategies. Both seagrass and mangrove species have the ability to reproduce both sexually and clonally. These alternative reproductive strategies differ across species and location in both groups. Improving our understanding of these life history strategies and the influence that changes of water quality will have on them will provide a basis for interpreting ongoing environmental change. Thus studies of the spatial and temporal dynamics of seagrass and mangrove communities, including information of growth strategies, are needed to interpret ongoing monitoring of water quality in the Great Barrier Reef.

ESTIMATING NUTRIENT BUDGETS IN TROPICAL ESTUARIES SUBJECT TO EPISODIC FLOWS

Ian Webster, Phillip Ford

CSIRO Land and Water, GPO Box 1666, Canberra, ACT 2601, Australia
Email: ian.webster@csiro.au
Email: phillip.ford@csiro.au)

Most common techniques for estimating material budgets within estuaries (e.g. LOICZ) rely on the estuary being in a quasi-steady state; that is, the distribution of material within the estuary is changing over timescales that are long compared to the characteristic flushing time of the estuary. The discharge of the Fitzroy (as with most rivers in tropical Australia) is highly episodic with high discharges occurring over periods of few weeks interspersed with sometimes long periods of little or no flow. Measurements were obtained along the Fitzroy Estuary on 22 surveys between November 2000 and July 2002. During this period, discharges were highly variable and elevated for 2 months and small at other times. This unsteadiness in discharge negates the assumptions that the distribution of material along the estuary had evolved in a regular way between sampling trips and that concentrations in-between times could be estimated by simple interpolation. This circumstance renders the regular LOICZ-style approach to estimating budgets for the Fitzroy invalid.

Here, we estimate budgets including internal sources/sinks using an approach that circumvents the difficulties associated with variable flow between sampling surveys. As does the LOICZ approach, salinity distributions can be used to infer the mixing properties of the estuarine system, but here these distributions are used to calibrate a dynamical model of mixing and exchange that accounts for the temporally variable transport properties of the estuary between survey times. Starting from the measured concentrations of a substance along the estuary from of a particular survey, the model is used to predict the time evolution of concentration in response to long-estuary transport as well as to prescribed inputs of substance along the length of the estuary. Finally, the sizes of these inputs are adjusted so that the modelled and measured concentration distributions for the following survey match one another. Thus, this inverse method estimates the sizes of the material inflows and outflows along the estuary that are necessary to produce the measured changes in substance distribution from each survey to the next.

CORAL REEF ECOHYDROLOGY: QUANTIFYING THE NEED FOR INTEGRATED WATERSHED-BASED MANAGEMENT ACTIVITIES AND MARINE CONSERVATION.

Eric Wolanski

Australian Institute of Marine Science, PMB 3, Townsville MC, QLD 4810, Australia

The major present strategy for coastal reef management is to rely on marine protected areas. Managers draw a line on a map around coral reefs, inside of which extractive and destructive activities are prohibited or regulated. This management practice arose from the perception that coral reefs were robust and would have no difficulty in recovering from occasional human impacts from land runoff, whatever land use management applied in the adjacent catchments. This management practice invariably fails where coral reefs are found near land and where human activities within adjacent watersheds contribute to the decline of water and substratum quality. Indeed, field observations revealed that corals are prevented from recovering or re-establishing themselves on surfaces covered by mud, cyanobacteria or fleshy algae.
There is a need to provide a management tool to both land-use managers and reef managers to foster cooperation and mutual recognition of the connectivity between land and reefs, so as to enable long-term use of land and reef resources in a sustainable manner. One such tool is a predictive ecohydrology model of the health of coral reefs impacted by land use activities in adjacent catchments. The model has now been used in Australia Great Barrier Reef, Guam, Tanzania and Palau.

The model could be used in an operational sense :

- to produce clear management options that include defining the level of remedial measures on land in order to getting back to water and substrate quality that allows corals and other reef organisms to successfully reproduce and recruit.
- to recommend the best location of Marine Protected Areas so to maximize connectivity and cross-recruiting of corals and fisheries.
- to develop alternative management options for reef uses, including targeting only carnivorous fish and protecting herbivorous fish.