TropWATER

Centre for Tropical Water and Aquatic Ecosystem Research

REPORT 2011~2013

JAMES COOK UNIVERSITY
AUSTRALIA

Cultural acknowledgement

TropWATER wishes to acknowledge the Australian Aboriginal and Torres Strait Islander peoples as the Traditional Owners of the lands and waters where we operate our business. We honour the unique cultural and spiritual relationship to the land, waters and seas of First Australian peoples and their continuing and rich contribution to James Cook University and Australian society. We also pay respect to ancestors and Elders past, present and future.

Disclaimer

Report compilation: Ian McLeod, Agnès Le Port, Susan Lesley, Damien Burrows and Yvette Williams.
Report design: Tony Cowan, Zephyrmedia
Cover Photo: The tropical freshwater crayfish, *Cherax wasselli*. Photo: Brendan Ebner.

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Solutions for Government, Communities and Industry

Vision

Providing global leadership in tropical water and aquatic ecosystem research.

Who we are

TropWATER – The Centre for Tropical Water and Aquatic Ecosystem Research, is an amalgamation of aquatic expertise from across James Cook University. It brings together over 130 research and support staff and over 80 post-graduate students. TropWATER provides a unique opportunity for multidisciplinary research activities by integrating JCU's aquatic expertise into one cohesive research group, which covers the full spectrum of freshwater, estuarine and marine waters, with expertise from ecology, water quality, hydrology, engineering, physics, oceanography, modelling and resource economics

Our mission

TropWATER aims to conduct influential research in fields related to water science, resource management and the ecology of water ecosystems, with a special focus on achieving sustainable use of water resource systems and water ecosystems. Our overall goal is to secure the future of water ecosystems and maintain their critical functional processes. Our Centre has a strong, but not exclusive, focus on tropical water systems, both in Australia and internationally. It is concerned with major issues in water science, including water resources, water quality and aquatic biodiversity, in relation to economic, social and environmental needs, constraints and change.

Institutional setting

James Cook University (JCU) is one of the world's leading educational and research institutions focusing on the tropics. With campuses in Townsville, Cairns, Brisbane, Mackay, Mount Isa and Thursday Island in Australia, and in Singapore, it is ranked in the top 4% of universities by the respected Academic Ranking of World Universities produced by the Shanghai Jiao Tong University. JCU continues to be ranked at Level 5 (well above world standard) for Environmental Science and Management and for Fisheries, in the 2010 Excellence in Research for Australia rankings.

It is number one internationally for citations on coral reef ecology, the highest ranked Australian university for citations in ecology and the environment over the past 10 years, and it leads Australia for articles in the top 15 journals in marine and freshwater biology. JCU ranked second in the Times Ranking for Environmental Sciences in 2011.

Photo: Matt Curnock

From the Director

It is with great pleasure that I introduce the first report of The Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER). Although a new centre in its current form, TropWATER's core operations are embedded in a long history. In 2012, after 25 years of successful operation, the Australian Centre for Tropical Freshwater Research (ACTFR) amalgamated with aquatic researchers from across James Cook University (JCU) to form TropWATER. The aim of this restructure was not only to refresh the mission and expand the scope of the original ACTFR, but also to bring together all the aquatic expertise spread across various research and teaching units at JCU into one cohesive research group. Thus TropWATER consists of staff that are employed directly by the centre and staff who are employed in other (mostly teaching) units at JCU. The long-established core unit has been maintained as a separate financial and research entity under the TropWATER umbrella. Currently there are more than 90 staff employed directly by TropWATER and 40 members from various other JCU units. In addition, 80 postgraduate students are affiliated with TropWATER.

The restructure and formation of TropWATER coincided with a period of dramatic growth. Over 2012-2013, the research income, staff numbers and publication outputs of the directly employed TropWATER staff, tripled. Whilst a significant part of this growth was the acquisition of a world-leading seagrass research group from the Queensland Government, substantial growth also occurred across the freshwater ecology (especially mining), catchment to reef, and coastal and mangrove ecology parts of our operations. Nearly all of this growth can be attributed to our success in attracting industry and other sources of non-traditional research funding. This is testament to our long-held view, originally established by the founders of ACTFR, that diversifying our sources of research funding will provide long-term viability. Attracting such funding comes from being very well connected with the needs and requirements of stakeholders and clients and takes a dedicated effort to establish and maintain the necessary professional relationships.

In what are very testing times for tertiary institutions and research providers, I believe our continued strong performance and growth is testament to our well-established reputation in delivering practical applied outcomes to a wide range of clients (government, industry and community) that provide this non-traditional funding. Dedication to our original founding mission of being a provider of knowledge, and both basic and translational research to northern Australia, has proved a reliable long-term strategy.

Whilst substantial recent growth in our size is very pleasing, I am most pleased at the breadth of topics that TropWATER now covers. We are approximately equally well spread across freshwater, estuarine and nearshore coastal ecosystems and many of our projects and staff work across this continuum. Equally pleasing is the spread we have achieved across ecology, chemistry, hydrology, oceanography and socio-economic sciences, again with many staff straddling these disciplines, breaking down boundaries. I hope this report can do justice to the true breadth and impact of our work in tropical Australia and more broadly throughout the tropics internationally.

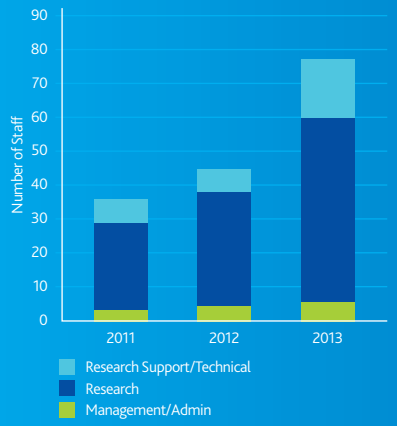
Dr Damien Burrows
Director of TropWATER and Team Leader of the Freshwater Ecology Group

People

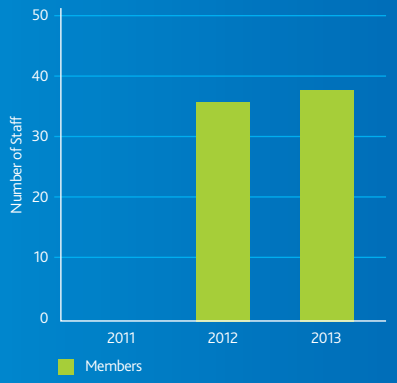
TropWATER staff and members are based in many locations around the world

Most TropWATER staff are based at the new spacious and modern Australian Tropical Sciences and Innovation Precinct (ATSIP) on JCU's Townsville Campus. This building sees us co-locating with CSIRO and includes a custom-built aquarium complex and a state of the art water quality laboratory. Over 30 staff are based at JCU's Cairns Campus, where our seagrass research group and laboratory is located.

TropWATER Staff 2011-2013



TropWATER members 2011-2013



TropWATER Staff 2011–2013

Director

Dr Damien Burrows

Principal Research Scientists

Mr Jon Brodie
Mr Barry Butler
Dr Rob Coles
Dr Norm Duke
Dr Michael Rasheed
Dr Jim Wallace
Dr Eric Wolanski

Senior Research Scientists

Mrs Katie Chartrand
Dr Aaron Davis
Dr Michelle Devlin
Dr Brendan Ebner
Dr Lionel Glendenning
Dr Cassie James
Dr Jessie Jarvis
Dr Steve Lewis
Mr Len McKenzie
Dr Jane Mellors
Dr Shelley Templeman
Dr Paul York
Dr Nathan Waltham
Ms Jane Waterhouse

Research Scientists

Dr Jorge Alvarez-Romero
Ms Kathryn Berry
Mrs Zoe Bradey
Mrs Catherine Bainbridge
Ms Alex Carter
Dr Faye Christidis
Mrs Caroline Coppo
Dr Eduardo Da Silva
Miss Jaclyn Davies
Dr Jennifer Debose
Mr James Donaldson
Mr Louise Johns
Ms Dominica Loong
Mr Jock Mackenzie
Ms Skye McKenna
Dr Dominique O'Brien
Dr Caroline Petus
Miss Tonia Sankey
Mr Jason Schaffer
Ms Naomi Smith
Dr Susan Sobtzick
Miss Helen Taylor
Dr Colette Thomas
Mr Dieter Tracey
Dr Amelia Wenger
Ms Apanie Wood

Adjunct Scientists

Dr Kathy Burns
Dr Emre Turak
Dr Carden Wallace

Technical Officers

Miss Rachael Amies
Mr Jaap Barendrecht
Mr Geoff Endo
Ms Louise Johns
Ms Jessica Leech
Mr Paul Leeson
Mr Mark Leith
Mr Glenn Morgan
Mr Trent Power
Ms Tonia Sankey
Mr Lloyd Shepherd
Mr Tony Squires
Ms Naomi Smith
Ms Zoe Tasker
Ms Sarah Toxward
Miss Samantha Tol
Mr Dieter Tracey
Mr Rudi Yoshida

Seagrass Laboratory

Ms Annegret Jaeppelt
Mr Brandon Jarvis
Ms Jane Lloyd
Ms Vanessa Pearson
Mrs Carissa Reason
(Laboratory Manager)
Ms Emma Scott
Ms Alysia Sozou
Ms Zoe Tasker
Ms Elizabeth Zeller

Water Quality Laboratory

Mr Patrick Cunningham
Ms Carol Lennox
Ms Yoko Nitanai
Ms Fiona Small
Ms Tara Tangney
Ms Hayley Threlkeld
Mrs Michelle Tink
(Laboratory Manager)

Management/Administration

Mrs Tricia Boyd
Mrs Tracey Canhan
Ms Susan Lesley (Centre Manager)
Dr Ian McLeod
(Communications Manager)
Ms Karen Wood

Members

Dr Ellen Ariel
Mr Daniel Atwater
Dr Ronald Baker
Dr Adrian Bass
Professor Mike Bonnell
Ms Martha Brians
Dr Kathy Burns
Mr Sean Campbell
Professor Peter Case
Dr Taha Chaiechi
Dr Faye Christidis
Ms Caroline Coppo
Dr Bithin Datta
Professor Lynne Eagle
Associate Professor Richard Faulkner
Dr Julia Hazel
Professor Mal Heron
Dr Neil Hutchinson
Dr Jasmine Jeffries
Professor Dean Jerry
Mr Ross Johnston
Associate Professor Wenxian Lin
Dr Alessandra Mantovanelli
Professor Helene Marsh
Associate Professor Niels Munksgaard
Dr Paul Nelson
Professor Rocky de Nys
Dr Damian O'Grady
Professor Richard Pearson
Dr Brad Pusey
Associate Professor Wayne Read
Professor Peter Ridd
Dr Phil Schneider
Ms Janine Sheaves
Professor Marcus Sheaves
Associate Professor Scott Smithers
Dr Thomas Stieglitz
Professor Natalie Stoeckl
Professor Ninghu Su
Dr Guangzhi Sun
Dr Sizhong Sun
Dr Sarah Tweed
Dr James Whinney
Dr Eric Wolanski
Professor Lucy Wyatt

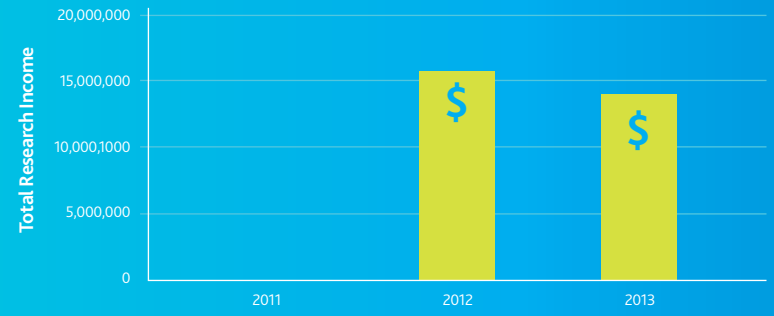
Income

TropWATER is comprised of over 90 directly employed staff and over 40 members who are employed through other JCU organisational units. See the From the Director section for further details.

TropWATER research income

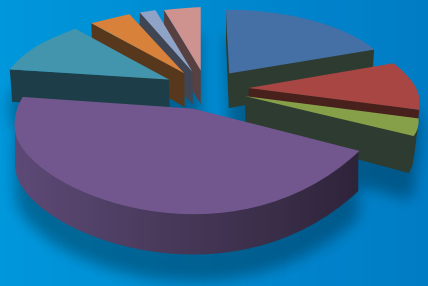
TropWATER staff research income

TropWATER member research income

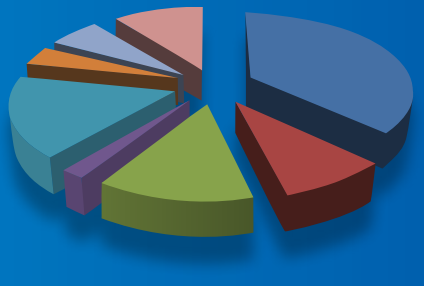


TropWATER staff research income by category

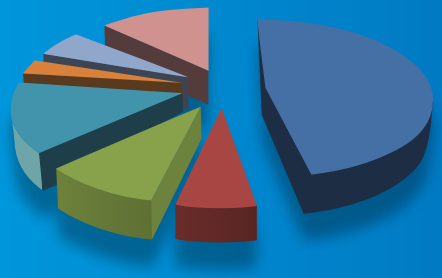
2013 Total Income $8,362,367



2012 Total Income $3,903,165



2011 Total Income $3,147,851



- Government/NRM Groups
- Government Research Agencies
- NERP/ARC
- Ports Monitoring
- Mining Industry
- Misc Research/Consultancy
- Water Quality Laboratory
- JCU Budget

TropWATER headquarters Townsville

2011-2013 Highlights

Projects

- TropWATER expanded significantly in late 2012, through acquiring a world-leading seagrass group. The Seagrass Ecology Group, based on JCU's Cairns Campus, now has over 30 staff and conducts research throughout the tropics.
- TropWATER's **MangroveWatch program** – a community-science partnership, has expanded considerably. We have undertaken extensive mangrove and coastal health assessments in 7 countries (Vietnam, Tonga, Samoa, Fiji, Vanuatu, Solomon Islands, New Caledonia) as well as conducted training courses on this methodology in Thailand, India and the USA. Within Australia, we have applied this approach to >10,000km of shoreline across Queensland, the Northern Territory and Western Australia, working with numerous government, community, industry and Indigenous groups in delivering the program, especially along remote northern coastlines.
- We continued our long-standing monitoring of seagrass meadow health around most Queensland ports. Many of these meadows have been monitored for more than a decade providing an invaluable dataset on long-term trends and changes. This research not only delivers key environmental information for the management of port activities but has also resulted in significant advances in the science and knowledge of tropical seagrass ecology.
- We performed a range of services for several major mining and refinery operations in northern and western Queensland. These services included water quality analyses and field studies, monitoring the health of aquatic communities around mines and refinery sites, and analyses of stream sediments. Such activities not only assist with environmental monitoring obligations, but also provide valuable scientific data in remote areas where such data are scarce.
- Developing northern Australia has become a leading political and social issue in recent years. Having worked on applied environmental issues in northern Australia for 27 years, TropWATER is well-placed to be contributing to this debate. Many of our projects have a strong focus on reducing and managing irrigation developments, expected to be a key feature in northern development. Additionally, we are major knowledge providers to the mining and ports industries, covering the full spectrum of habitats from catchment to coast.
- We partnered with CSIRO to work on the Flinders Gilbert Agricultural Resource Assessment (FGARA) project, a $6 million federal government funded initiative examining the feasibility of irrigation development in those two key northern catchments.
- We continued to play a leading role in the monitoring of herbicides and pesticides from the paddock to the reef, with the aim of evaluating their risk to both freshwater and marine ecosystems. Advances in the 2012-2013 period included improved modelling of herbicide loss from paddocks and research. These advances demonstrated the value of improved management practices, which reduce herbicides loss from farms without loss of productivity. Several of these studies continue to influence State and Federal Government policy.
- TropWATER has established itself as a major research provider in the Torres Straits, working on a wide range of projects covering seagrass ecology, dugong and marine turtle management, mangrove and coastal health, marine water quality, shipping risks, freshwater habitats, invasive fish and indigenous ranger monitoring programs.
- We hosted the symposium 'Fish use of mangroves and tidal wetlands: biological drivers, physical constraints and regional variation' in October 2013, where local and international scientists met to identify the key knowledge gaps and opportunities to advance research on fish use of tidal wetlands and coastal systems.
- Kathy Burns, Eric Wolanski and collaborators showed that coal particles could be transported from coastal loading facilities to the outer GBR by wind and ocean currents. In two published papers they discussed the potential impacts of coal dust pollution and suggested management changes that could reduce the release of coal dust.

Publications

- Estuaries of Australia 2050 and beyond - a new book by TropWATER's Eric Wolanski was released in 2013. The book offers a synthesis of the environmental status of iconic Australian estuaries and bays by eminent Australian scientists, and describes what Australian estuaries will look like in 2050 and beyond based on socio-economic decisions that are made now, and changes that are needed to ensure sustainability.
- Norm Duke wrote the book 'Mangroves of the Kien Giang Biosphere Reserve Vietnam'. Kien Giang is one of the largest biosphere reserves in South East Asia and describes the high diversity of mangroves and habitats found in this area. The book was published in 2012 and was prepared for the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.
- TropWATER researchers led by Damien Burrows authored the Wet Tropics Management Authority

2012-2013 report on the '**State of the Wet Tropics**'. This report examined and summarised the knowledge gained for aquatic ecosystems in the Wet Tropics region of North Queensland over the last 25 years and resulted in a summary of the current state of aquatic habitats, biota and ecological processes within this region.

- Jon Brodie led a multidisciplinary group of scientists from JCU, AIMS, CSIRO, CQUniversity, the Queensland Government and C2O Consulting in the preparation of the Federal Government's '**2013 Scientific Consensus Statement: Land use impacts on Great Barrier Reef water quality and ecosystem condition**'.
- A Special Issue of the Marine Pollution Bulletin titled '**Catchment-to-reef continuum: Case studies from the Great Barrier Reef**' (2012, 65, 4-9) was coordinated by Michelle Devlin (TropWATER) and Britta Schaffelke (AIMS). This presented an overview of the current science addressing the inter-connectivity between the water quality and ecological condition of the coastal and inshore areas of the GBR and the land-use and processes on the adjacent catchments. This Special Issue brought together authors from several different research and management agencies, including many from TropWATER. This Special Issue has been cited over 500 times since its publication in 2012.
- Cassie James led a modelling team that completed a **major report** on predicted changes to the distribution of hundreds of freshwater biota species across the entire Australian continent for the National Climate Change Adaptation Research Facility (NCCARF).
- Colette Thomas' paper titled 'Balancing the trade-offs between ecological and economic risks for the Great Barrier Reef (GBR): a pragmatic conceptual framework', was awarded the 2012 Risk Management Paper of the Year by the Journal Human and Ecological Risk Assessment. The research focuses on the inter-relationships between land use, reef health and tourism, drawing upon the Tully River catchment as a prototype case study.

Awards

- Eric Wolanski was awarded the first Estuarine & Coastal Sciences Association Lifetime Achievement Award in 2012. He was presented with the award in front of 600 scientists from 54 countries at a gala dinner in Mestre, Italy.
- The Australian Coastal Society presented Jon Brodie with the inaugural Queensland Coastal Conference Award in 2013 for his "outstanding contribution to coastal management".
- TropWATER Director Damien Burrows won and completed a prestigious Queensland Government-Smithsonian Fellowship in 2012, spending 4 months visiting Smithsonian Institution research stations in Maryland, Florida and Belize.
- A turtle conservation documentary featuring the research of Ellen Ariel made the finals of the Aurora TV Festival Awards. The documentary titled 'Sending the gungu home' highlighted research and conservation work related to turtles in Australia.
- Norm Duke was made President of the International Society for Mangrove Ecosystems (ISME) in 2012.

Key partnerships

National

Australian Institute of Marine Science (AIMS) is a Government funded marine research agency recognised internationally for its leadership in research into tropical marine environments and their aquatic resources. TropWATER and AIMS staff have many research collaborations on the impacts of natural and human-related activities on marine, coastal and catchment environments.

Commonwealth Scientific and Industrial Research Organisation (CSIRO) is a renowned government funded scientific institution with sites throughout Australia and overseas. TropWATER shares their Townsville building with CSIRO's Townsville-based staff. TropWATER's research collaborations with CSIRO include assessing the environmental implications of proposed agricultural development along the Flinders and Gilbert waterways in the Gulf of Carpentaria.

Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) is a Government department which supports a diverse research program spanning environmental regulation and scientific research promoting the conservation and sustainable use of Australia's natural resources. TropWATER's SEWPaC funded research activities include climate change and human related factors, which may have an impact on the GBR and aquatic waters in northern Australia.

Great Barrier Reef Marine Park Authority (GBRMPA) is funded by the Federal Government to monitor and ensure human-related activities are ecologically sustainable in the GBR Marine Park. To meet these obligations, GBRMPA supports TropWATER research, which assesses and monitors the impacts of land management practices on water quality and marine ecosystem health in the Marine Park.

Various Queensland Government departments collaborate closely with TropWATER. These include **Maritime Safety Queensland (MSQ); Dept. Environment and Heritage Protection; Dept. Science, Information Technology, Innovation, and Arts; Dept. Natural Resources and Mines; Dept. Agriculture, Fisheries and Forestry;** and **National Parks.**

National Climate Change Adaptation Research Facility (NCCARF) is a Government organisation, which harnesses and communicates the knowledge of climate change research to government decision makers. TropWATER researchers led a large modelling exercise where freshwater refugia in a changing climate were identified throughout Australia. TropWATER also participated in an NCCARF-funded partnership between JCU and Charles Darwin University, which provided tools and management options to Natural Resource Management (NRM) bodies to assist decision-making in relation to climate change.

Natural Resource Management (NRM) regions are established across Australia to plan and deliver programs, which support productive and sustainable industries and land use. Backed by 'Caring for our Country' funding, in conjunction with regional NRM bodies in the Tully and Burdekin areas, TropWATER researchers work with farmers and graziers to implement and test new management techniques aimed at improving water quality emanating from catchment areas to the GBR.

Queensland Port Authorities (North Queensland Bulk Ports Corporation, Gladstone Ports Corporation, Ports North and Port of Townsville). The Queensland port authorities are responsible for managing Queensland's commercial and community ports and are a key research partner funding many of TropWATER's seagrass, marine habitat and water quality programs. These include the Queensland ports seagrass monitoring program that has been collecting key seagrass information for more than 20 years in all of Queensland's tropical commercial ports as well as innovative research to develop environmental management thresholds.

Torres Strait Regional Authority (TSRA) is a government authority which supports programs that benefit Torres Strait Islanders and their way of life. TropWATER researchers have been funded by TSRA to undertake a number of projects from mapping and assessing the resilience of seagrass meadows to climate change, to monitoring water quality, intertidal seagrass and other emergent wetland communities within the Torres Strait. This work is often undertaken in partnership with the Torres Strait Indigenous Land and Sea Rangers as a means of up-skilling rangers and increasing their stewardship in natural resource management.

Wetland Care Australia (WCA) is a not-for-profit organisation, which works towards achieving healthy wetlands in healthy catchments. As part of the WCA program, TropWATER researchers monitor the efficiency of aquatic weed control programs and water quality impacts from the establishment of artificial wetlands to treat runoff from agricultural lands.

Wet Tropics Management Authority (WTMA) is a government-funded agency established under the World Heritage Convention to administer legislation and set policies and procedures, which govern activities and land use within the Wet Tropics of Queensland World Heritage Area. TropWATER scientists were funded by WTMA to contribute to a report to Queensland and Australian parliaments, which analysed and identified opportunities for improvement in the management of the Wet Tropics aquatic systems and associated water resources.

Wildlife Preservation Society of Queensland (WPSQ) is a non-profit community-based environmental organisation with over 5000 supporters across the state. They actively work with TropWATER's Mangrove Watch and Seagrass watch programs in South-east Queensland.

International

Bay of Plenty Regional Council (New Zealand) promotes and manages the environmentally sustainable use and development of regions in the Bay of Plenty. TropWATER provides advice to the Council on shipping-related environmental issues in the Council's marine areas.

Earthwatch Institute is an international environmental charity, which brings individuals from all walks of life together with world-class scientists to improve scientific understanding. TropWATER scientists are funded by Earthwatch to lead teams of individuals who actively participate in surveying the status and condition of mangroves and freshwater wetland habitats in northern Queensland and the Torres Strait.

International Union for Conservation of Nature (IUCN) is a global environmental organisation, which provides advice and support to government and non-government organisations on environmentally sustainable development. TropWATER researchers were funded by the IUCN to facilitate floristic surveys and map mangroves and tidal wetlands in Tonga, Samoa, Fiji, Vanuatu and the Solomon Islands.

World Wildlife Fund (WWF) is one of the world's leading international conservation organisations working to deliver innovative solutions that meet the needs of people and the environment. TropWATER researchers are working with the WWF to ascertain risk factors associated with the declining health of green turtle populations in GBR catchment areas.

Major areas of research focus

Ports and coastal facilities

The expansion of port facilities across northern Australia is a high profile issue, especially on the northeast coast in proximity to the GBR. TropWATER is uniquely placed to develop the applied science and monitoring solutions required for successful environmental management of ports, with science expertise across the broad range of fields required and a track record of turning that science into applied solutions for ports and shipping management. In addition TropWATER encompasses units that develop specific cutting edge monitoring equipment and maintains a fleet of vessels and monitoring equipment in house to maintain capability.

TropWATER staff and members have been working with port authorities on applied research and monitoring programs at numerous sites for over 20 years, developing long-term datasets that not only answer management-related questions, but that have greatly advanced the fundamental science around marine ecology, especially that of seagrasses, which form the largest component of our work in ports. Even with this long history, the recent expansion of interest in port facilities has created significant growth for TropWATER. TropWATER currently conducts environmental monitoring in all the major ports of North Queensland – Gladstone, Hay Point, Mackay, Abbot Point, Townsville, Mourilyan Harbour, Cairns (Trinity Inlet), Thursday Island, Weipa and Karumba. Our port-related research includes benthic habitat mapping, seagrass monitoring, mangrove health assessment, dugong and turtle health and population monitoring and water quality, long-term logging of turbidity and light penetration characteristics, artificial engineered seascapes as fish habitat, dredging monitoring and modelling and remote sensing analysis of sediment plumes. More than 50 of our staff and centre members have been involved in these various activities. Our staff sit on technical expert panels related to port development in Gladstone, Karumba, Weipa, Hay Point, Abbot Point and Darwin Harbours. With continued expansion and necessary maintenance dredging of port facilities, this will remain an area of focus for us. **An overview of our seagrass work in Queensland ports can be found on the TropWATER website**.

TropWATER conducts research around all the major ports in north Queensland

TropWATER's research into freshwater ecology is highly relevant to new developments in the north

TropWATER has been conducting research in northern catchments for more than 20 years.

Northern development

The potential for developing northern Australia has emerged in recent years as a leading political and social issue, especially in relation to utilisation of water and aquatic resources. Through 27 years operating in northern Australia and with such a large and diverse group of scientists, TropWATER is very well-placed to make a major contribution to various aspects of the northern development agenda. We have worked extensively in both intensively developed and almost undeveloped catchments. Through our conduct of long-term monitoring for various government agencies and mining companies, we possess some of the largest water quality and aquatic ecology datasets in the region, some now stretching to 20 years of annual monitoring.

TropWATER has a long history working on management of aquatic resources in the major irrigation districts of northern Australia – e.g. Burdekin, Mareeba-Dimbulah, Wet Tropics, Mackay district. In established irrigation areas, TropWATER has many projects covering the management of freshwater and coastal aquatic habitats. Here, major issues have developed in regard to water quality, aquatic weed invasion, loss of seasonal flow in streams and reductions in biodiversity. Recently, we have studied the impacts of the Burdekin Falls Dam on downstream water quality and have also been working on restoring wetlands and fish passage in the Burdekin floodplain, as well the establishment of artificial wetlands as fish habitat and for water quality polishing, within heavily developed catchments. All of the lessons learned here will be invaluable in planning for new developments to minimise environmental impacts.

TropWATER's Catchment to Reef Research Group have many projects aimed at reducing agricultural runoff to marine receiving environments, predominantly the GBR. These projects are conducted jointly with many government, research and industry partners, and include working on the ground with farmers in direct trials to reduce losses of sediment, nutrients and pesticides. Our work in this area has influenced state and federal government policy and achieved considerable success in reducing losses of these key contaminants. The application of these on-farm management methods will be crucial in any new irrigation development in the north.

TropWATER are also working on science to underpin the development of new irrigation projects in currently underdeveloped locations. We were partners in the Commonwealth-funded North Australia Water Futures Assessment (NAWFA) and we have recently partnered with CSIRO in the delivery of the $6 million Flinders Gilbert Agricultural Resource Assessment (FGARA), a comprehensive examination of the feasibility of irrigation development in those two northern catchments. We are conducting additional studies underpinning potential irrigation development in the Gilbert catchment.

In addition to biophysical studies of development, our work also covers socio-economic issues. Natalie Stoeckl and colleagues have investigated the different impacts of 'development' on Indigenous and non-Indigenous people in the Daly River catchment, in northern Australia; a region experiencing relatively rapid agricultural development. The analysis builds upon the work of several inter-related but independent projects conducted over 6 years (2006-2011). This work integrates economic, hydrological, ecological and socio-cultural information providing new empirical insights about the potential impact of different types of development on water resources, aquatic habitats and on both Indigenous and non-Indigenous people.

The TropWATER team with TSRA Land and Sea Rangers on Boigu Island

The Torres Strait

The islands of the Torres Strait are of particular environmental and cultural significance. TropWATER conducts a wide variety of projects in Torres Strait. This work is all done in close partnership with the Torres Strait Regional Authority (TSRA) Land and Sea Management Unit. We work closely with their Indigenous Land and Sea Rangers, who participate in nearly all our fieldwork.

Our seagrass team have been mapping, monitoring and studying seagrasses, reefs and coastal habitats in the region for 15 years. This work lead by Michael Rasheed, Alexandra Carter and Helen Taylor includes establishing that the region contains the largest continuous extent of deep water seagrass mapped anywhere in the world. Our seagrass work in Torres Strait includes developing a seagrass atlas for the region, planning for shipping accidents, studying dynamics and recovery of seagrass beds, resilience to climate change, and assessing the health of seagrasses in the Dugong Sanctuary and in the Port of Thursday Island. A community seagrass monitoring program - the **Torres Strait Observer Program** (see our website for details on this program), led by Jane Mellors, has operated for 9 years, using Land and Sea Rangers from 8 islands and also involving local school children.

Through a National Environment Research Program (NERP) grant, we have assessed the condition of 463 km of shoreline on 20 islands, via boat and helicopter. Every single day of this work has been conducted with the field assistance of Land and Sea Rangers from each of the 20 islands assessed. In addition, we have established a Mangrove Watch program with the rangers, whereby, after completing a 2-day training course, they collect data on mangrove and shoreline condition in our absence, sending the data to ourselves for further analysis. To date, over 20 rangers from a dozen islands have received our Mangrove Watch training and have recorded video footage of mangrove condition along 151km of shoreline across 15 islands. We have assessed biomass and carbon stocks of mangroves across 31 plots on 5 islands, showing them to have carbon stocks comparable to that of some of the major mangrove forests of South East Asia. Biodiversity surveys of 20 islands have more than tripled the number of mangrove tree species recorded on most islands and detected two mangrove tree species new to Australia.

The southern coastline of Papua New Guinea has established populations of numerous pest fish species from all over the world and these may potentially enter Australia via the Torres Strait. TropWATER confirmed the first populations of one of these species – climbing perch (from South East Asia) on two islands in the northern Torres Strait. Continued surveys, led by Damien Burrows and Nathan Waltham, conducted jointly with TSRA and local indigenous rangers, has shown these fish populations are well established. Our pest fish survey work has also uncovered 31 native species of fish, 8 of which are new records for the region. TropWATER is developing ongoing community education programs with local agencies in order to prevent further pest fish incursions. Reports and pest fish fact sheets are available from the **Torres Strait – A New Frontier for Freshwater Fish Invasions into Australia**, pages of the TropWATER website.

Helene Marsh and Mark Hamann have for many years, led programs into the ecology and sustainable use of dugongs and marine turtles, respectively. Nine aerial surveys of dugongs, using standard methodology, have been conducted since 1987 and this data was recently summarised in a TropWATER report. The dugong population of Torres Strait is currently estimated at 16,000, a globally significant population. Current ongoing work on marine turtles involves capture-mark-recapture projects to quantify the reproduction rates of green and flatback turtles, plus satellite tracking to map migratory pathways. Recent tracking indicates that flatback turtles breeding in Torres Strait migrate through International waters and reside in areas as far away as Indonesia and the Kimberley coast of Western Australia.

Eric Wolanski and international collaborators have modified, improved and applied the SLIM model to study the water circulation in the Torres Strait. This model is a non-structured grid model, making it possible to have fine resolution near islands and reefs where the currents vary significantly in a short distance, and a coarse resolution in open waters where high resolution is not needed. In addition, Eric added an oceanographic data set spanning nearly thirty years of his previous work at AIMS, enabling verification of the model. The model predicts that yearly-averaged net east-west flow through the Torres Strait is small to negligible, in agreement with field data. The model also reveals the prevalence of highly energetic tidal flows around shoals, reefs, islands and reef passages, and that the net water circulation in Torres Strait is characterised by events lasting a few days to three weeks, and there is no such thing as a typical 'mean' water circulation.

We have also completed an assessment of water quality issues for the Torres Strait. The range of issues covered included discharge of mining-associated metal pollution transported down the Fly River, increasing oil palm plantations, new ports and mines, land clearing, local sewage and stormwater discharge on the islands, and shipping issues (dredging, oil spills, ship groundings, shipyards). The report produced by Jane Waterhouse, Jon Brodie and colleagues, '**Hazard assessment of water quality threats to Torres Strait marine waters and ecosystems, NERP Project 4.4**', provides the first assessment of current and potential water quality issues in the Torres Strait Region. Subsequently, we recommended, and have now established the beginnings of a long-term monitoring program for the region using combinations of field data, logging equipment and satellite image processing.

Underwater cameras are an effective way to research fish ecology

Underwater camera station used to continuously monitor a seagrass plot

Identification of benthic biota

Novel uses of underwater video for research

TropWATER is using video applications across a wide range of projects to develop an understanding of tropical freshwater, estuarine and coastal marine ecosystems in Australia. The application of new technologies has seen novel and informative filming both above and below the water line.

The Seagrass Ecology group is leading the way with video-based monitoring comprising a core part of its business. This includes characterising seagrass, macro-algae and benthic macro-invertebrate (epifauna & infauna) communities using various configurations of underwater videography and time-lapse photography. This surveillance work is incorporated into long-term monitoring programs throughout Queensland, providing extensive coverage of the GBR lagoon.

A CCTV camera system with a real-time monitor, towed from a research vessel provides live footage for observations and recording. The system incorporates a mounted camera, sled and sled net to capture surface benthos (semi-quantitative bottom sample) and is used to confirm benthic macro-invertebrates, algal and seagrass habitat characteristics observed on the monitor.

A similar CCTV camera system using a mounted camera on a fixed-frame quadrat is used to survey shallow water areas where SCUBA diving capabilities are limited. Latest advancements for the Seagrass Group have included the development of a camera housing with inbuilt wiping system to maintain a time-lapse library at long-term monitoring sites to capture seagrass dynamics, bioturbation and other evidence of sediment disturbance.

This technology was developed by Mark Leith, who has led the way in engineering solutions to collect high resolution and foul-free imagery. The permanent camera systems enable tracking of changing seagrass communities in relation to environmental parameters. This is especially advantageous under inhospitable conditions including poor weather, which inhibit boat access in open water environments.

The Coastal and Estuarine Ecology Group are using underwater video for a range of fish and habitat projects. Videos have been used to investigate predator hotspots and deep water estuarine habitats in tropical Australia, with a major focus on mangrove habitats, increasing our understanding of the extent of penetration of fish species and assemblages into the mangrove forests in relation to tidal level. Similar work is being done in freshwater and estuarine systems in PNG.

Underwater video technology is being used by Nathan Waltham to examine the use and functional role of urban-engineered structures (port developments, jetties, marinas, rock break walls), to better inform management decisions aimed at achieving fisheries conservation and protection.

Brendan Ebner, James Donaldson and Jason Schaffer from the Freshwater Ecology Group are collaborating with key researchers from a range of institutions (Murdoch University, Australian National University, and Griffith University) in using baited and un-baited cameras to survey fishes and aquatic reptiles in rivers of the Pilbara, Kimberley, Gulf of Carpentaria and Wet Tropics. This research is pioneering the use of video for surveys of fish, crayfish and aquatic reptiles in Australia.

There are also new projects underway. Nathan Waltham is examining the organisation of freshwater fish assemblages in dry seasonal waterholes by deploying baited cameras. During the wet season flow each year, freshwater fish escape the confines of discrete dry river system waterholes and access habitats necessary for completing their lifecycles, awaiting the next wet season and the waterway reconnection. Understanding these fundamental processes in waterholes in dry river systems will assist planning decisions relating to agricultural development proposed in northern Australia. As flow ceases, waterholes are left with a new fish assemblage that must again survive the impending dry season.

The Freshwater Ecology Group collaborated with the Ewamian Rangers and researchers from the Department of Science, Information Technology, Innovation and the Arts, to perform a rapid survey of aquatic fauna at Tallaroo Station (Gulf of Carpentaria). This included using baited cameras to assess fish assemblage composition. Tallaroo has recently been handed over to the Ewamina People and this provided a privileged opportunity for ecologists to learn about some of the cultural heritage and history of those lands.

In December 2013, Brendan Ebner was an invited keynote speaker of the inaugural Western Australian Freshwater Fish Symposium. He spoke about Australian applications of underwater video to freshwater fish research, and made special note of insights gained into the ecology of threatened species in temperate Australian rivers and species richness estimates in tropical rivers.

Cassie James and Damien Burrows have commenced aerial filming of riparian habitats as part of rapid assessments of invasive riparian and in-stream aquatic weeds in the Russell River, in the Wet Tropics region. This work is being supported by underwater video surveys of fish assemblages comparing heavily weeded and weed-free sections of riverbanks.

Research themes

Freshwater Ecology

Leader: Dr Damien Burrows
Providing scientific advice for the management of agriculture, mining and water extraction impacts on freshwater ecosystems, including habitat protection, wetland restoration and the control of invasive species.

Research scientists

Mr Barry Butler, Mr James Donaldson, Dr Brendan Ebner, Dr Cassie James, Professor Dean Jerry, Professor Richard Pearson, Dr Brad Pusey, Mr Jason Schaffer, Dr Michelle (Shelly) Templeman, Dr Jim Wallace, Dr Nathan Waltham.

Research support staff

Dr Faye Christidis, Mr Glenn Morgan, Mr Trent Power, Mr Tony Squires

Our freshwater ecology work is largely based accross northern Australia. Where the dominant land uses are cattle grazing, cropping and mining, so these are strong elements of our work program. Along the more developed northeast coast of Australia, urban areas and intensive agriculture are major areas of focus for us.

Most of Australia's freshwater runoff occurs in the tropical north, yet outside of the northeast coast, most rivers are unregulated and levels of development are generally low. Thus, there is significant potential for further development in these relatively remote and undeveloped catchments, and this currently has strong political and social support. We are actively studying freshwater ecosystems in these areas to understand their ecology and underpin potential future development scenarios.

Much of our work has a very applied focus and thus, we work closely with community, industry and government on solving actual management issues in our region. This results in a broad spectrum of projects being undertaken. In addition to our research, we work actively to inform public policy, influence public and corporate environmental behaviour and advise a range of environmental decision makers. To this end, we have made a significant impact upon the understanding and management of northern Australian freshwater ecosystems.

Projects

Long-term environmental impact monitoring and assessment

TropWATER has undertaken a number of projects across North Queensland and the Northern Territory to evaluate the ongoing ecological health of terrestrial, riparian and freshwater systems in the region. Our clients include industry, government and non-government organisations. As much of our research is conducted on behalf of resource managers, information transfer and adoption at local scales is typically efficient and direct. The broad level of expertise TropWATER staff provide in this regard enables our staff to participate in a number of expert advisory panels, convened in connection with various government resource management initiatives. This also provides an avenue for knowledge transfer to a broader audience.

Locally, we have undertaken annual monitoring of water and sediment quality, invertebrates and riparian vegetation at the Department of Defence's Townsville Field Training Area, in the upper Burdekin catchment for more than 20 years. As a result, we have developed one of the largest such datasets for Australian savannah streams. This monitoring program has recently expanded to include the upper Fanning River catchment, also part of the upper Burdekin.

We also maintain a long-term association with two of the major metal refineries in Townsville, undertaking a number of aquatic and vegetation monitoring programs on their behalf in both freshwater and estuarine environments.

Further west, TropWATER undertakes aquatic monitoring (water quality, sediment quality and aquatic fauna) at several of the larger mines in the minerals province, northwest of Mt Isa. We have conducted regular monitoring at some of these sites since 2005. These ongoing programs provide useful, high quality, medium-length datasets, which are rare in an otherwise data-deficient region. In addition, we have undertaken baseline ecological studies for another proposed operation in the same region. The data obtained from these ongoing projects is employed in conjunction with ecotoxicological data to develop site-specific water quality guidelines for local aquatic ecosystems.

Recently we have been engaged to develop and implement 'Receiving Environment Monitoring Programs' for closed mines in the Charters Towers and Darwin Region. These programs have been designed to monitor and evaluate post-closure operations to determine if there are any ongoing legacy impacts from mining activities.

Although a number of the impact assessment and monitoring studies conducted by TropWATER over the past twenty years have been conducted on an ad-hoc consultancy basis, this work has increased the knowledge base of an understudied region. It has also contributed substantially to the overall understanding of the links between natural and anthropogenic pressures, water quality, limnology and ecological processes in tropical freshwater ecosystems. The challenging nature of some of these programs has allowed the opportunity to develop and test new methods for assessing their condition. We are able to utilise the base provided by these projects to add value to research topics on top of some of these programs.

Northern Territory sinkholes

Scattered around the Northern Territory are many sinkholes, which over thousands of years have filled with dust, dirt, plant material and other particles from the surrounding environment. Today, many of these sinkholes exist as small, shallow lakes with a thick layer of sediment above the bedrock. In a JCU, Charles Darwin University and University of Wollongong collaboration, a project led by Michael Bird (JCU) is attempting to unearth whether prehistoric human activity caused the Australian environment to tip irreversibly from its natural state to an anthropogenic state, maintained by fire. This involved drilling core samples from sinkholes in order to extract environmental records of the flora and fauna in surrounding areas.

Peter Ridd (TropWATER) led a team, which joined forces with Michael Bird and his crew during several weeks of intensive fieldwork around both the Katherine and Arnhem Land Regions in the Northern Territory, which contain valuable information on vegetation and fire environments over the past 100,000 years. Their geophysics expertise played a vital role in determining optimal drilling locations for preliminary core samples. The deepest core taken following the geophysical sediment profiling of these sinkholes was 21.7m.

Three two-week field trips were carried out and over 15 sinkholes were investigated. Seismic surveys were performed along the dry perimeter of the sinkholes. A 24-geophone array recorded the travel time of seismic energy from a source (sledgehammer on a steel plate) to each sensor. The travel time of the seismic energy provides information on the depth and densities of the sediment layers. Analysis of these cores is currently underway.

Resistivity measurements of Northern Territory sinkholes

Using environmental DNA as a tilapia surveillance tool

The spread of tilapia, an invasive fish species, has the potential to have adverse affects on coastal and inland fisheries. An invasive animals Cooperative Research Centre (CRC) project has begun trialling a new method for early detection of tilapia in North Queensland waters. The project, led by Dean Jerry, uses environmental DNA (eDNA) to detect the presence or absence of tilapia in rivers, streams or other water bodies. This

Invasive tilapia threaten native Australian waterways

method works by collecting DNA that is shed into the water through faeces, mucus and cells, and does not require actually seeing or catching the fish.

eDNA technology has been used in the United States, Japan and Europe to detect rare and endangered species, as well as other invasive fish such as carp. The CRC project has successfully implemented the eDNA technology on known populations of tilapia in the Ross River and ornamental ponds. The project now plans to better understand the sensitivity of this technology and the persistence of eDNA under different environmental conditions. Ultimately, eDNA could be used as an additional or alternative surveillance tool to traditional methods for monitoring tilapia infestations to assist in control and eradication programs.

Freshwater crabs - species population structure and evolution in seasonal rivers

Freshwater crabs are amongst the most unheralded of freshwater fauna. They mostly live in ephemeral habitats and as they are not often caught by standard sampling methods, are therefore rarely studied and thus very little is known about them. Many new species await discovery and we believe they may be useful as indicators of health in ephemeral streams where there are few other suitable indicator species. In 2012, Nathan Waltham, in collaboration with Jane Hughes (Griffith University), and Peter Davie (Queensland Museum) commenced a project using DNA sequence information to examine freshwater crab species diversity and their isolation and resistance to landscape change. This model is particularly relevant in the vast dry catchments of northern Australia, where most streams exist as disconnected pools, joined only during seasonal flows. Freshwater crabs are an ideal test species of this model because viable populations exist despite their poor dispersal characteristics and low fecundity.

Freshwater crabs are but one species challenged with climate-induced changes to flow, habitat destruction, and continuing pressure from introduced species. Data from this research will provide insights into crab diversity and connectivity, and more broadly has important conservation planning outcomes for tropical river systems.

Examining freshwater crab isolation and resistance to landscape change

Discovery of unrecognised fauna boosts freshwater fish species biodiversity in North Queensland streams

Brendan Ebner has surveyed numerous small coastal streams for freshwater fishes in the Australian Wet Tropics. The result has been a doubling of the number of species previously recorded in many small stream catchments of the region. He attributes this increase to two factors; firstly, the application of a snorkel based technique that he and colleague Paul Thuesen apply to survey whole catchments, and secondly, the discovery of a previously unrecognised fauna in the Australian context. The amphidromous fauna (which means they have marine larvae but a freshwater juvenile and adult phase) comprises species commonly found in neighbouring Pacific Islands, including Fiji, New Caledonia and the Solomon Islands, but has only been recently recorded in the Australian Wet Tropics

There has also been some preliminary ecological research on some of the rarer species, including the critically endangered Opal cling goby, ***Stiphodon semoni***. Brendan Ebner suggests a major practical implication of these surveys is a need to protect, plan and better understand small coastal creek ecosystems in the greater Cairns Region.

The critically endangered Opal cling goby, Stiphodon semoni

State of the Wet Tropics Report 2012-2013

In 2013, TropWATER, led by Damien Burrows, authored the Wet Tropics Management Authority 2012-2013 report on the 'State of the Wet Tropics'. This report examined and summarised the knowledge on aquatic ecosystems gained for the Wet Tropics region of North Queensland over the last 25 years, much of which has been produced by TropWATER. It resulted in a summary of the current state of knowledge of aquatic habitats, biota and ecological processes within this region and future management challenges for these systems.

While half of the region's environment is well protected by World Heritage listing, much of the remaining area has been cleared and developed for urban and agricultural purposes. Although the Wet Tropics World Heritage Area (WTWHA) was historically designed for the protection of terrestrial habitats, freshwater habitats consisting mainly of upland areas and escarpments are also well protected. However, most of the freshwater fish species occur outside the protected area in heavily modified lowland streams. Some of the key findings of the report were:

- New species of fish, turtles and crustaceans are still being discovered. Stream-dwelling frog species have suffered massive declines in distribution and abundance, with four species extinct or near extinction.
- Nine exotic fish species have been introduced and become naturalised in the Wet Tropics. There are few options available for removal of unwanted fish once they have become established. Early detection and prevention of further introductions is a priority.
- In the Wet Tropics lowlands, up to 80% of wetlands have been lost to development, and the remainder are in a perilous state and in urgent need of rehabilitation. In contrast, most upland streams are in very good condition. However, in all areas, the greatest freshwater management issues include the loss of riparian vegetation and its replacement by aquatic and riparian weeds, fish passage barriers and poor water quality runoff.
- Freshwater habitats link the WTWHA to the GBR. Connectivity between these two World Heritage Areas is high, especially during flood events.
- The potential effects of climate change have not been studied for freshwater ecosystems. Whilst air temperature is widely predicted to increase, how this will translate into stream temperatures is unclear as the effect is non-linear. The effects of climate change upon canopy cloud interception, which is a major supplier of moisture and stream flow in the dry season, is predicted to decline as clouds become less abundant at lower elevations.
- Despite the abundant rainfall, water resources are currently not readily available for consumptive use. Consumer demand for water is high and increasing rapidly, yet because of the high conservation values of the region, options for locating water storages are limited, leading to potential resource use conflicts in the future.

These biennial reports are used by the WTMA to raise areas and issues of concern to government for the management of the WTWHA and the surrounding region.

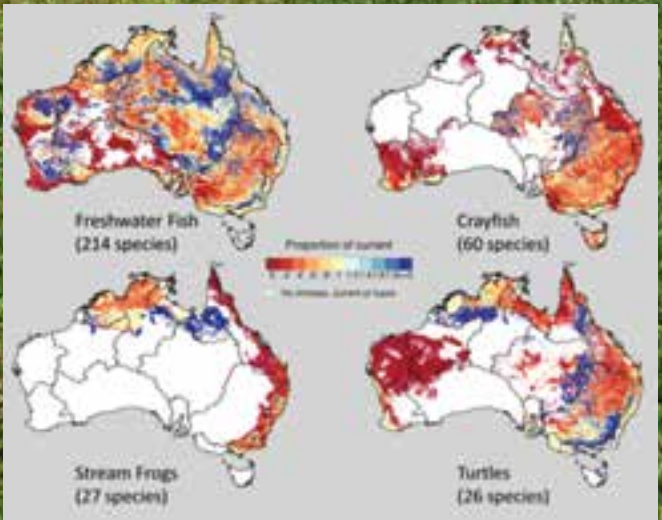
Freshwater refugia in a changing climate

Freshwater ecosystems contain a high biodiversity and are vulnerable to climatic changes due to their limited extent and connectivity. With severe climatic changes predicted for Australia, identifying areas and habitat refuges that could shelter species from the worst impacts of climate change is a management and conservation priority.

The project, led by Cassie James (TropWATER) and Jeremy VanDerWal (Centre for Tropical Biodiversity and Climate Change at JCU), has identified freshwater regions that will remain stable in the future, and those that will not. Many regions will likely experience climates and events well outside their current range of variability, and we predict significant changes in community structure and ecosystem assemblages. In these areas of instability, refuges will be of high priority, especially areas where temperature changes are buffered by vegetation or topographic shading. Significant changes in the perenniality of streams and waterholes, particularly in the southwestern region of Australia, are also predicted.

This project also outlined climate change adaptation options for Australian freshwater systems. Possible range expansions and contractions were modelled, and the merit of different adaptation options was discussed. Some key common factors emerged, making it possible to highlight areas of conservation priority. For example, high-quality

The lower Barratta Creek surface dominated by floating water hyacinth



Proportionate change in environmental space suitable for freshwater biota between current and 2085 under RCP8.5. Figures represent the 50th percentiles across 18 GCMs. (Blue indicates gains in environments suitable for species and red indicates losses in environments suitable). Source: James et al. (2013)

refuges tend to have high climatic and habitat stability (but high habitat heterogeneity at larger spatial scales), and a level of uniqueness within their surroundings. However, favourable refuges may be compromised by anthropogenic threats that alter landscapes and connectivity patterns. Minimising these threats will be a crucial component in the adaptation of freshwater ecosystems to climate change.

Currently these researchers are working with and providing data to Natural Resource Management (NRM) groups, such as the Monsoonal Cluster NRM and North East Catchment Management Authority, to enable climate change impacts modelling to be carried out for freshwater systems at a regional scale of use.

Temperature tolerance of tropical freshwater fishes

Temperature is arguably the most important water quality parameter. Not only does it have a direct influence upon habitat suitability for aquatic biota, but it also is a major modifier of a wide variety of physical, chemical and biological processes. Despite this, very little is known about temperatures typically found in northern Australian waters or about the tolerances of aquatic fauna to these temperatures. As part of the North Australian Water Futures Assessment, TropWATER undertook an evaluation of stream temperature in northern Australia and preliminary studies of faunal tolerance to elevated temperature.

Existing water temperature data from across northern Australia were sought for compilation. Almost 11,000 records of water temperature from >550 locations across North Queensland, the Northern Territory and Western Australia (Kimberley) were compiled. In addition, we retrieved >904,000 data points from 130,477 days of continuous temperature logging at 34 sites in Queensland and we deployed 30 temperature loggers at 21 sites in North Queensland during 2011-2012 to compile the most comprehensive temperature dataset available.

Our understanding of the tolerance and adaptation abilities of aquatic biota to changing thermal regimes is rudimentary. This requires considerable experimental tolerance data to redress. In preliminary laboratory temperature tolerance experiments, we tested 383 individuals from 7 fish and 4 crustacean species. Barramundi were the most tolerant species tested, including being more tolerant than spotted tilapia, an introduced African species which is popularly considered to be particularly tolerant to warm water (see Report 12/01 Preliminary Studies of Temperature Regimes and Temperature Tolerance of Aquatic Fauna in Freshwater Habitats of Northern Australia). Our experimental temperature tolerance studies are continuing.

Management and rehabilitation of wetlands within intensively developed agricultural catchments

TropWATER has a long history of working on wetland management within intensively developed agricultural catchments and floodplains. The Burdekin irrigation district, the location for much of our work over many years, is the largest irrigation district in northern Australia and serves as an ideal example of how to manage irrigation development, especially now that developing irrigation projects in northern Australia is high on state and national political agendas. Our recent projects have revolved around maintaining habitat values in the Barratta Creek section of the Burdekin floodplain. Irrigation development around this creek largely only opened up relatively recently, in 1994, and despite planners leaving a significant riparian corridor to protect the values of this creek, it has been steadily degrading due to various pressures associated with the surrounding developments. Our most recent work has examined the impacts of persistent tailwater (waters located immediately downstream from a hydraulic structure such as a dam) and irrigation-related drainage on the freshwater and mangrove habitats on the Barratta floodplain.

Mangroves provide crucial habitat for many fish species. Photo: Matt Curnock

Coastal and Estuarine Ecology

Leader: Professor Marcus Sheaves
Researching the ecology of tropical estuaries, coastal wetlands and near-shore ecosystems, and approaches to controlling and repairing human impacts on them.

Research scientists

Dr Kátya Abrantes, Dr Ellen Ariel, Dr Ronald Baker, Dr Adam Barnett, Dr Kathy Burns, Dr Catherine Collier, Dr Norm Duke, Dr Mark Hamann, Dr Julia Hazel, Dr Neil Hutchinson, Mr Ross Johnston, Professor Helene Marsh, Mr Jock McKenzie, Dr Ian McLeod, Janine Sheaves, Associate Professor Scott Smithers, Dr Susan Sobtzick, Dr Thomas Stieglitz

Research support staff

Ms Martha Brians

The Coastal and Estuarine group focuses on developing an understanding of the nature and functioning of the complex mosaic of habitats that comprise estuaries, coastal wetlands and nearshore ecosystems. This includes evaluating the role of connectivity in ecosystem functioning and nursery ground provisioning, quantifying food webs and understanding their structural complexity using stable isotope and dietary studies. The group also focuses on gaining a more precise understanding of fisheries ecology, and developing climate change and sea level rise strategies that support ecological and fisheries values. They provide research and monitoring to support wetland repair projects, and develop and integrate hi-tech techniques (video, sonar) for ecosystem studies.

Projects

Coastal urban seascapes

Urbanisation replaces natural shoreline habitat with built infrastructure. While this engineering satisfies standards and budget outcomes, it often results in loss of biodiversity. Understanding how coastal development alters biodiversity and function cannot advance by simply documenting change. Robust experimental programs that provide novel engineering solutions that maximise biodiversity are also needed.

Nathan Waltham is leading research, in collaboration with Marcus Sheaves, investigating the utility of estuaries as productive and viable areas for fisheries production. Combining mensurative and manipulative experiments, Nathan aims to build a knowledge hub around coastal urban seascapes, where this knowledge will contribute to the generation of best practices designs for coastal engineering structures that balance engineering integrity and human safety, with ecosystem protection and conservation.

Use of flathead mullet (*Mugil cephalus*) in coastal biomonitoring studies

A recent paper in Marine Pollution Bulletin (2013, 69, 195-205) takes a global look at the use of *Mugil cephalus* (flathead mullet) as a bioindicator in coastal pollution studies. A review of 50 studies found that although flathead mullet are globally distributed and are a popular choice in biomonitoring studies worldwide, most studies focus on human exposure implications, and lack standardised methods leading to major inconsistencies among studies.

The work, led by Nathan Waltham, showed that fish were safe to eat in many places, but problems exist in heavily industrialised regions. Recommendations in the article would achieve benchmarking and cross-continent comparisons. The authors argued that a more consistent approach to biomonitoring is necessary, and using this fish species offers the opportunity to compare coastal areas across the globe in terms of contamination.

Flathead mullet, Mugil cephalus. Photo: Matt Curnock

What habitats do fished tropical species utilise at different life stages?

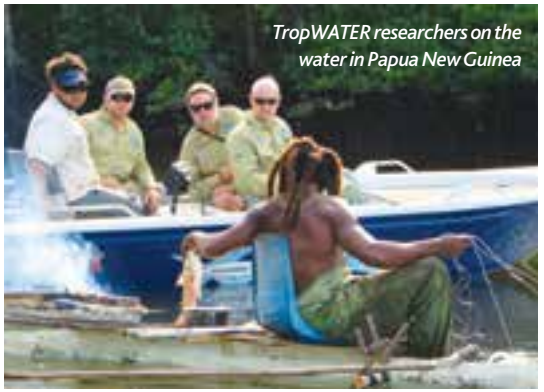
The health and longevity of fisheries depend on access to critical habitats appropriate to each particular life-history stage. While many key fisheries habitats are under threat from rapidly increasing coastal development, management of those habitats is severely hampered by a poor understanding of these life-history stage habitat requirements. This project, funded by the Fisheries Research and Development Corporation, aims to develop an understanding of the life-history habitat needs of coastal and estuarine fish species to provide the basis for (a) strategic decisions on the optimal siting of developments, (b) directing the development of coastal infrastructure, and (c) directing environmental offsets to optimise their benefits to fisheries, as well as providing the information needed to populate coastal habitat maps that will also be key contributors to these outcomes.

The project combines cutting-edge video, acoustic and sonar techniques to identify habitats used by small juveniles, with the knowledge on habitat relationships of commercial and recreational fishers, to understand how the habitat needs of fish change throughout their lives. This is supported by micro-chemical and stable isotope techniques to determine the history of habitat use of individual fish and understand the food webs that support their use of different habitats.

Sport fisheries ecology – the Niugini black bass project

Niugini black bass (*Lutjanus goldiei*) are considered by many as the world's toughest fighting sport fish. They live in the coastal streams and rivers of Papua New Guinea (PNG) where they are captured by small-scale subsistence fisheries and are the target of a small but growing catch-and-release sport fishing industry. In late 2013, a ten-year project funded by the Australian Centre for International Agricultural Research and the Papua New Guinea National Fisheries Authority (NFA) began.

The aim of the project is to empower NFA, PNG Tourism Promotion Authority, and business and community groups, to sustainably develop, grow and manage the expanding



TropWATER researchers on the water in Papua New Guinea

sport fishing industry in PNG. This industry has the ability to provide stable alternative livelihoods and new income streams to support food security for PNG's coastal villages. To grow a sport fishing ecotourism industry that will support livelihoods into the future, it is essential that managers have the information they need for a well-planned fishery. Our research to support management has a multidisciplinary approach and focuses on the following areas: ecology, sport fishing best practices, socio-cultural considerations, village business models, tourism as a development tool, and leadership.

Dugong and turtle management in the Great Barrier Reef World Heritage Area and Torres Strait

A research team led by Helene Marsh and Mark Hamann set out in November 2013 to conduct aerial surveys for dugongs and marine turtles in the northern GBR and Torres Strait, as part of two NERP funded projects. Key objectives were to (a) inform dugong management in the Great Barrier Reef World Heritage Area (GBRWHA) by continuing the time series of aerial surveys to monitor dugong distribution and abundance, and (b) determine relative density of dugongs and marine turtles.

Susan Sobtzick and Helen Penrose (JCU Cairns) led a team of 12 people during 5 weeks of aerial surveys using small fixed-wing aircrafts. Surveys covered 25,000 km^2 along the coastline of North Queensland from Cooktown to the tip of Cape York, and around 40,000km^2 in the Torres Strait. Over 230 individual transects were flown totalling around 11,500 km in length. Observers recorded the locations and details of numerous dugongs, marine turtle and other marine megafauna sightings, and data analyses are ongoing.

Mangrove health assessment - Pacific Islands

In partnership with the Mangrove Ecosystems for Climate Change and Livelihoods (MESCAL) program of the International Union for Conservation of Nature (IUCN), Norm Duke and Marcus Sheaves led projects to investigate the health of mangrove and mangrove fish communities in Fiji, Tonga, Samoa, Vanuatu and Solomon Islands. Field trips to each set of islands also included training local staff in mangrove assessment techniques. A series of reports covering mangrove health, estuarine fish community status, carbon biomass stocks and revision of the mangrove plants of each island were produced. Staff from the member islands also visited TropWATER for a follow-up writing workshop near the project end. Norm Duke also received funding to examine mangrove rehabilitation projects in New Caledonia subject to mining-related disturbance, which will also result in the production of a book on the Mangroves of New Caledonia.

Mangrove health assessment – Australia

TropWATER supports the MangroveWatch program - a community-science partnership that works with many communities across northern Australia. Major projects locations are in Moreton Bay working with Brisbane Airport Corporation, Wildlife Preservation Society Queensland, SEQ Catchments, OceanWatch and the Quandamooka Indigenous rangers where >50 community volunteers have filmed a total of 178km of shoreline for our assessment to date and the program is continues to expand. Several projects on behalf of Brisbane City Council and urban landcare groups have examined the health and status of mangroves in the Brisbane River (including assessments before and after the 2011 floods) and various coastal suburbs. In conjunction with the Noosa Integrated Catchment Association, we assessed the health of mangrove shoreline along 70km of the river and associated marine lakes, providing a permanent digital video record of their baseline status.

Aerial surveys are an effective way to survey dugong populations

Local people are trained in mangrove assessment techniques

Citizen science drives many mangrove health assessments in Australia

Healthy seagrass beds in the Torres Strait

Seagrass Ecology

Leader: Dr Rob Coles
Leading research into tropical seagrass ecosystems, specialising in monitoring and applied research with a focus on advising management agencies responsible for coastal development and port management.

Research Scientists

Ms Catherine Bryant, Ms Alexandra Carter, Ms Katie Chartrand, Ms Jaclyn Davies, Dr Jessie Jarvis, Ms Skye McKenna, Dr Len McKenzie, Dr Jane Mellors, Dr Michael Rasheed, Ms Carissa Reason, Ms Helen Taylor, Dr Paul York

Research support staff

Mr Jaap Barendrecht, Ms Annegret Jaeppelt, Mr Brandon Jarvis, Ms Louise Johns, Ms Jessica Leech, Mr Paul Leeson, Mr Mark Leith, Ms Jane Lloyd, Ms Tonia Sankey, Ms Emma Scott, Mr Lloyd Shepherd, Ms Naomi Smith, Ms Alysha Sozou, Ms Zoe Tasker, Ms Samantha Tol, Ms Sarah Toxward, Mr Rudi Yoshida

In 2012, the Seagrass Ecology Group transferred to TropWATER from the State Government Department of Agriculture Fisheries and Forestry. The group pioneered tropical seagrass mapping methods and, starting in the 1980s, identified much of the known distribution of coastal and deepwater seagrasses in tropical Australia. Since that early work, the group has maintained and developed an extensive research, assessment and monitoring program on tropical seagrass ecology.

The group specialises in tropical research with a specific interest in the Indo Pacific region, but also manages projects that extend globally. It has six general areas of scope, which include:

- Trend analysis
- Ecosystem health
- Impacts, resilience and recovery
- Risk analysis
- Policy advice
- Indigenous engagement

Projects

The Great Barrier Reef Marine Monitoring Program

Seagrass meadows play a critical role in the GBR ecosystem. They are highly productive habitats that provide food for turtles and dugongs, as well as nursery grounds for many species, including commercially important fish and prawns. The largest threat to seagrass of the GBR is poor water quality. Sediments, nutrients and pesticides contained in catchment run-off have been identified as a key threat as they can result in declines in water quality. This can affect seagrass and other important habitats as well as the marine animals they support, while having a detrimental effect on tourism and fishing industries.

Since 2003, GBRMPA in partnership with the Australian and Queensland Governments, have committed to a Reef Water Quality Protection Plan (Reef Plan). Under this plan, governments are working with farmers and graziers to halt and reverse the decline in the quality of water flowing into the GBR by improving land management practices and monitoring the results. The Reef Plan is guided by scientific consensus statements, the latest in 2013, which showed poor water quality is continuing to have a detrimental effect on Reef health. The Marine Monitoring Program (MMP) is a key component of the Reef Plan and a collaborative effort between government, community, scientists and managers. It assesses water quality and the condition of seagrass and coral reefs in the inshore GBR lagoon. Monitoring the impact of local water quality on seagrass meadows is a key indicator for evaluating the long-term health and resilience of the wider ecosystem.

The MMP is led by Len McKenzie and Catherine Collier with the support of Richard Unsworth (Swansea University) and Michelle Waycott (University of Adelaide). Seagrass is monitored at 45 sites in 21 locations from Hervey Bay to Shelburne Bay (Cape York). Sites are measured before and after the wet season and include 12 inshore (coastal and estuarine) intertidal sites, eight offshore (reef) intertidal sites and four offshore (reef) subtidal sites. Seagrass abundance, species composition, reproductive effort, epiphytes (plants that grow on other plants), temperature, and light and tissue nutrient status are all monitored. Abundance, species composition and reproductive effort indicate the current condition of seagrass and the capacity of meadows to recover from disturbances, such as cyclones. The tissue nutrient status of seagrass and the extent of epiphyte growth on leaves provide an indication of the quality of the surrounding waters.

As part of the Reef Plan Paddock to Reef Integrated Monitoring, Modelling and Reporting Program, information from MMP is combined with data collected at the paddock and catchment level to produce an Annual Report Card. This summarises the health of the Reef and its catchments, actions being taken to reduce the loads of pollutants, and subsequent results. The Report Card assesses progress towards Reef Plan's long-term goal, which is to ensure that by 2020 the quality of water entering the reef from broad scale land use has no detrimental impact on the health and resilience of the GBR. The Report Cards can be viewed at **www.reefplan.qld.gov.au**.

Seagrass monitoring at Green Island

Queensland ports seagrass monitoring

A long-term seagrass monitoring and assessment program has been established in the majority of Queensland's commercial ports. TropWATER developed the program in partnership with the various Queensland port authorities.

A strategic long-term assessment and monitoring program for seagrasses in port locations provides managers and regulators with key information on the status of seagrasses within ports, and information that can be used to plan and implement port development and maintenance programs that will have a minimal impact on seagrass. Seagrasses are sensitive to changes in water quality, so provide an ideal indicator of overall marine environmental health within the port. The program also provides an ongoing assessment of the most threatened seagrass communities in the State.

In many locations monitoring has been ongoing for more than a decade, with some for over 20 years providing an invaluable dataset on long term trends and changes. The program not only delivers key information for the management of port activities to minimise impacts on seagrasses but has also resulted in significant advances in the science and knowledge of tropical seagrass ecology. It has been instrumental in developing tools, indicators and thresholds for the protection and management of seagrasses and an understanding of the drivers of tropical seagrass change and feeds into regional assessments of the status of seagrasses.

Critical intertidal habitats of the Great Barrier Reef Inner Shipping Route

We surveyed critical intertidal habitats adjacent to the GBR Inner Shipping Route (ISR). Surveys focused on the Bathurst Bay region (2012) and the South Warden Reef to Howick Group region (2013), and built on survey data collected from the Princess Charlotte Bay region in 2011. The ISR between Cape Flattery and Torres Strait is recognised as a Marine Environment High Risk Area due to shipping

accidents and oil/chemical spills, with high environmental sensitivity and a lack of important environmental information.

Helicopter surveys collected data on seagrass, algae, coral and oyster habitats. A habitat vulnerability matrix and GIS mapping identified areas at high, moderate and low risk from shipping accidents. This information was included in the GIS database for the Oil Spill Response Atlas (OSRA), an important resource to aid decision-making and emergency response to shipping accidents and oil spills. Critical Marine Habitats in High Risk Areas atlases were also produced in addition to the OSRA GIS layers.

Helicopters are often used to survey intertidal seagrass

Characterising light thresholds for tropical seagrasses and developing adaptive management tools for coastal development

A change in the availability of light is one of the primary factors affecting the distribution of seagrass. Many of the human activities along the coast, including coastal and port infrastructure development, can have a direct impact on the amount of light reaching seagrasses, creating a need to develop ecologically relevant thresholds and tools to manage these activities. Government regulators have increasingly called for an ecological-based approach to managing dredging impacts, and have identified seagrasses as a key indicator of water quality, as well as an important fisheries habitat.

We have developed the world's first light-based management strategy for seagrass, using locally derived light thresholds, and have implemented this approach as part of a dredge management plan for a major port expansion project. The work utilised *in situ* shading studies, long-term light and seagrass monitoring, and lab-based manipulative experiments to derive locally relevant values that were adapted into traditional turbidity-based monitoring programs. This research also focused on identifying a rapid toolkit for measuring sub-lethal seagrass stress induced by low light. Ongoing investigations with collaborators at University of Technology Sydney (UTS) have identified a promising suite of gene expression markers that may be used to ensure seagrass health in areas at risk from major coastal development.

The success of this research program has significant implications for seagrass habitat management worldwide. Integrating science with management outcomes is a key focus of ports and regulators, and our program is now sought after nationwide as a model of success for both environment health and port development.

Torres Strait seagrass: climate, disturbance and trends

A partnership program with the TSRA is providing essential research on seagrass within the Torres Strait. The research component of the seagrass program is of critical importance in understanding Torres Strait seagrass resources. Research focuses on the climatic drivers of seagrass change, seagrass recovery following disturbance, and habitat sensitivity to shipping traffic, accidents and oil spills. This information is vital in effective planning for

Seagrass monitoring at Lizard Island

management of dugong and turtle populations, and other fished species dependent on seagrass habitats.

Specific outcomes of the program have included:

- TropWATER and Torres Strait community research networks providing education, training and support for seagrass research and monitoring;
- Increasing the number of trained rangers;
- Documenting the relationship between change in seagrass meadows and environmental factors such as light availability, water temperature, rainfall and tidal exposure;
- Investigating the ability of Torres Strait seagrasses to recover;
- Estimating the productivity of Mabuiag Island seagrasses, compared with other globally important ecosystems;
- Compiling a comprehensive atlas and GIS database of marine habitats in the Torres Strait, including seagrasses, algae and coral, in areas sensitive to shipping accidents and oil spills;
- An understanding of seasonal change in Torres Strait deep water seagrasses in the Dugong Sanctuary.

Torres Strait intertidal seagrass habitat monitoring

The Torres Strait intertidal seagrass observers program, managed by Jane Mellors, began in 2004. It combines education and training exercises that develop skills and proficiency in field-based seagrass monitoring. It currently includes 17 intertidal monitoring sites across eight islands: Thursday Island (Waiben), Horn Island (Ngarupai), Hammond Island (Keriri), Mua, Badu, Mabuiag, Iama and Mer.

In 2012, the program was recognised as a successful case study for improving governance and leadership by Julia Gillard in her 'Closing the Gap' report and speech. The training undertaken by the students and the rangers is being recognised by the Queensland Studies Authority as credit towards their school certification and Conservation and Land Management certification, respectively.
Each year of the program has seen more students and rangers become skilled in seagrass monitoring, increasing their knowledge of seagrass habitat. They now recognise that the conservation and wellbeing of this habitat is strongly linked to the survival of *Ailan kastom* – their way of life. In keeping with this link, Tagai secondary students involved in the monitoring have named themselves *Meskep Kawbuzig* (intertidal warriors) and developed their own logo.

The data collected so far within this project points to healthy seagrass patches that vary inter-annually in a seasonal manner driven by weather patterns. A qualitative comparison to the status of seagrass meadows along the GBR has also been undertaken, suggesting that seagrasses in the Torres Strait are in better shape than those along the east coast of Queensland.

Indigenous Land and Sea Rangers surveying seagrass in the Torres Strait

Seagrass and dugong feeding

Dugong feeding trail metrics were analysed in several tropical intertidal seagrass meadows in the Cairns and Townsville region. The aim was to better understand which components of a seagrass meadow are used by dugong as food. Results show dugongs feeding in the GBR region prefer areas of high biomass rather than particular species or levels of nutrients. Similar results have been found in the Torres Strait, suggesting this is a consistent pattern in the tropics. This research by Samatha Tol was supervised by Rob Coles and Brad Congdon (School of Marine and Tropical Biology, JCU). The results from this study will contribute to conservation efforts for dugong and aspects will be expanded into a PhD project in 2014.

Dugong feeding trails through seagrass beds

Modelling seagrass distribution and risks to seagrass

In 2012, the Seagrass Group, in conjunction with Alana Grech from JCU's ARC Centre of Excellence for Coral Reef Studies, published the results of two workshops and a web based survey examining the risk to seagrass across global bioregions. The research focused on linking impacts with threats to seagrass and comparing the results for different parts of the world in a quantitative way.
Urban, port and industrial runoff, and agriculture were consistently ranked high. Other impacts varied across the world reflecting the nature of seagrass species and meadows and specific issues. Generally, seagrass scientists saw climate change factors as having a low impact, but there were marked differences in results between the northern and southern hemispheres.

Seagrass distribution in the Great Barrier Reef Marine Park Authority

This is an on-going team effort that is now concentrating on the implications for management of seagrass meadows in the GBRWHA, and on potential seagrass propagule movement as a way to evaluate likely pathways for recovery after losses at scales of tropical storm events.

Coral coring. Photo: Eric Matson

Catchment to Reef Processes

Leader: Mr Jon Brodie
Research leaders in tracing the sources of pollutants (sediments, nutrients and pesticides) from different land uses, and measuring their impact on habitats such as mangroves, seagrass and coral reefs.

Research scientists

Ms Zoe Bainbridge, Ms Kathryn Berry, Dr Kathy Burns, Ms Caroline Coppo, Dr Eduardo da Silva, Dr Aaron Davis, Dr Michelle Devlin, Dr Steve Lewis, Dr Dominique O'Brien, Dr Caroline Petus, Dr Colette Thomas, Dr Emre Turak, Mrs Jane Waterhouse, Dr Eric Wolanski

Research support staff

Mr Dieter Tracey

The Catchment to Reef Processes Research Group is one of Australia's leading research groups in the study of environmental issues along the 'catchment to reef continuum', from the headwaters of the Great Barrier Reef (GBR) catchments to the outer reef. Research undertaken by the group includes tracing the sources of pollutants (sediments, nutrients and pesticides) from different land uses (cattle grazing, sugar cane, horticulture and urban) within catchments, the transport and dispersal of land-based pollutants in coastal and marine environments, the quantification of pollutant loads to the GBR lagoon from end-of-catchment monitoring and coral core proxy records, the exposure and risk of land-based pollutants to coastal wetland, mangrove, seagrass and coral reef ecosystem, and the modelling of ecohydrological and oceanographic processes in estuaries and the GBR.

Projects

Linking land-use practices to sediment impacts on the Great Barrier Reef

Changes in land use, such as clearing native vegetation or heavy grazing, can result in increasingly muddy water with high levels of suspended sediment being transported by rivers to coastal marine areas, with negative impacts on coral reef ecosystems. Preventing excessive sediment from reaching the reef requires a better understanding of the sources of erosion, and the processes that transport it, so effective land-based watershed management strategies can be put into place. A review paper written Zoe Bainbridge, Jon Brodie and Stephen Lewis, and led by CSIRO scientist Rebecca Bartley, used the Burdekin River Basin in North Queensland as a case study to understand these processes (Science and the Total Environment (2013), 468-469, 1138-1153).

This research found that only a small proportion of the sediment eroded upriver makes it to the mid and outer GBR. The type of sediment that is transported offshore is usually fine clay. However, larger particles are likely to be deposited closer to shore and are likely to be remobilised by strong tides and windy weather. The authors suggest that maintaining vegetation cover over 75% would reduce runoff and prevent sub-surface erosion.

Assessment of the relative risk of degraded water quality to ecosystems of the Great Barrier Reef

The main water quality pollutants of concern for the GBR are enhanced levels of suspended sediments, excess nutrients and pesticides added to the GBR lagoon from the adjacent catchments. A risk assessment method was developed and applied to the GBR to provide robust and scientifically defensible information for policy makers and catchment managers on the key land-based pollutants of greatest risk to the health of coral reefs and seagrass

The contribution (%) of fine (less than 63 µm) sediment to the watershed outlet from each of the major sub-watersheds in the Burdekin based on monitoring data (2005–2009). The figure takes into account particle size and dam trapping of the sediment, and provides a description of the dominant erosion process delivering the sediment

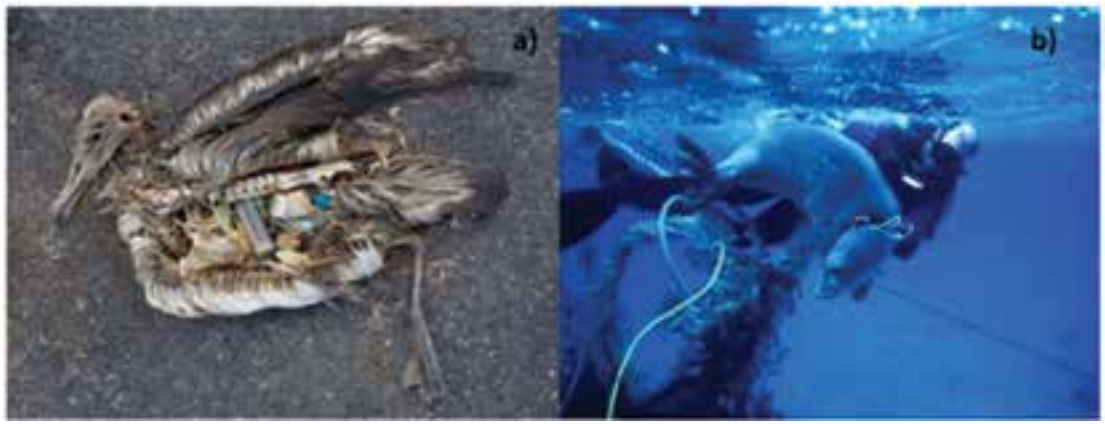
meadows. We analysed the differential risk of pollutants to management regions within the GBR, and ranked them using a relative assessment technique. The combined assessment of marine water quality results with end of catchment pollutant load information allowed us to draw conclusions about the overall risk of pollutants to the GBR. The study found that coral reefs and seagrass meadows were at greatest risk in the Wet Tropics Region, followed by the Fitzroy and Burdekin Regions. In conjunction with information on pollutant generation from dominant land uses in the GBR catchments, the results are being used to inform future investment priorities for reducing pollutant runoff to the GBR. The methods developed here are relevant for application in other management settings where a combination of information from a range of sources is required, and where weighting of factors may be desirable. This project was funded by the Queensland Government's Reef Water Quality Program.

Unrecognized pollutant risks to the Great Barrier Reef

Although management efforts regarding agriculture related issues are necessary to improve the health of coastal and marine environments within the GBR, current management plans do not address many of the 'non-Reef Plan' pollutants of concern for the GBR, which are associated with waste and water discharge from urban areas, and activities related to mining, shipping, and ports.

Largely unrecognised pollutants of concern for the GBR include trace metals, polycyclic aromatic hydrocarbons, marine debris, microplastics, endocrine disrupting chemicals, coal dust and pharmaceuticals. Many of these substances are recognised as potential threats to coastal and marine ecosystems worldwide, however a lack of understanding of these pollutants limits appropriate management in Australia. In a preliminary step to reduce this knowledge gap, a team led by Jon Brodie reviewed existing literature on the occurrence, status, distribution and impacts of "less monitored" pollutants on global marine ecosystems. This ongoing research, presented in Report No. 13/23 'Unrecognised pollutant risks to the Great Barrier Reef', aims to inform the management of risks to biota, and facilitate future research and management efforts.

In a related project, Kathryn Berry collaborated with Mia Hoogenboom (JCU), Nora Hall and Llew Rintoul (Queensland University of Technology) on a project on



Images of marine debris: a) a juvenile albatross has starved to death as a result of consuming too much plastic, b) a diver tries to free a seal entangled by a derelict net. Sources: a) aquascapeconservation.org, b) coastalcare.org

microplastic contamination. Their research reports the first evidence of microplastic ingestion by scleractinian corals, as well as the occurrence of microplastics in marine waters adjacent to inshore coral reefs on the GBR.

The Reef Rescue Marine Monitoring Program

The Reef Rescue Marine Monitoring Program (MMP) undertaken in the GBR lagoon assesses the long-term effectiveness of the Australian and Queensland Government's Reef Water Quality Protection Plan and the Australian Government Reef Rescue initiative. The MMP was established in 2005 to help assess the long-term status and health of GBR ecosystems and is a critical component in the assessment of regional water quality as land management practices are improved across GBR catchments. The program forms an integral part of the Reef Plan Paddock to Reef Integrated Monitoring, Modelling and Reporting Program supported through Reef Plan and Reef Rescue initiatives. Scientists in the Catchment to Reef Research Group lead the component that investigates terrestrial discharge into the Great Barrier Reef.

The Reef Rescue Research and Development 'Pesticides' Program

This program examines the chemical properties (soil/water half-lives), transport behaviour, exposure and risk of several herbicides used in the GBR catchment area. It also quantifies the agronomic and water quality benefits of using alternative or new herbicide products, as well as the adoption of improved management practices such as banded or shielded spraying.

The research found that the half-lives of herbicides vary for certain soil types and can be markedly different to their published values, and that the majority of herbicides are transported in the dissolved phase and are highly persistent (long water half-lives) in waterways. These data have been used to improve modelling of herbicide loss from paddocks and to better quantify the risk of herbicides in the GBR. Finally, the program demonstrates the value of improved management practices to reduce the losses of herbicides from farms without any loss of productivity.

Spot spray rainfall simulation trials were conducted to examine the potential for improved spray technology to reduce surface runoff losses of herbicides from cane paddocks

Modified sprayers decrease herbicide runoff to Great Barrier Reef by 90%

Irrigation and rainfall runoff from farm fields is a common source of pesticide contamination of waterways in many agricultural regions around the world. In Queensland, the runoff of photosystem-inhibiting herbicides is a major concern due to their potential impact on the GBR. A recent collaborative study between TropWATER, CSIRO, and local cane farmers, compared the relative water quality benefits of emerging precision herbicide application technologies (shielded spraying), with conventional application techniques in the Burdekin sugar industry.

Our research showed that the precision application of two commonly used soluble herbicides (diuron and atrazine) decreased the average total load of both herbicides moving off-site by 90% compared with the more traditional spraying approaches. This research, recently published in Science of the Total Environment (2014, 466-467, 841-848) demonstrates that precision application of herbicides is a highly effective way of minimising off-site movement of these herbicides in drainage water from furrow irrigated sugarcane farms.

Close up of a shielded spray applicator which reduces runoff of herbicides by 90%

Torres Strait marine water quality monitoring

Knowing the status of water quality in the Torres Strait is important for the health of people, turtles, dugongs, fish and the sea. The potential incursions of pollutants into the Torres Strait Region associated with large-scale mining development in southern PNG catchments have been identified as the most immediate priority for investigation. TropWATER is leading a long-term monitoring program, which is assessing the feasibility and costing of sampling and analysis of heavy metals within the Torres Strait.

The objectives of the program are to design and implement a monitoring program that will report on the status of water quality in the Torres Strait using satellite images and models of tides and currents. This information will provide an update and expansion of the baseline study undertaken almost 20 years ago. The long-term project will provide a new understanding of the risks from future large-scale development in PNG on the Torres Strait.

Achievements so far have included a desktop hazard assessment, drawing on new knowledge of circulation patterns in the Torres Strait from hydrodynamic modelling and remote sensing imagery. The report produced by Jane Waterhouse, Jon Brodie and colleagues, 'Hazard assessment of water quality threats to Torres Strait marine waters and ecosystems, NERP Project 4.4', provides the first assessment of current and potential water quality issues in the Torres Strait Region.

Studying water quality in the Torres Strait

Herbert River Water Quality Monitoring Program

This program was initiated by stakeholders in the Herbert River Catchment to provide scientifically robust water quality data to estimate nutrient and pesticide pollutant loads discharging through the Herbert Catchment.

The project also provided an insight into the relative concentrations of reef pollutants on a sub-catchment and paddock scale.

The monitoring data, collected since 2011, has become a valuable resource for landholders and managers within the Herbert Catchment to inform decision makers when improving land management practices. The project management team is currently in negotiation with the funding bodies to obtain support to establish an annual monitoring program within the Herbert Catchment on a smaller scale to maintain long-term data collection within this catchment. Hinchinbrook Shire Council, Tablelands Regional Council, the Sugar Research Development Corporation, and the Queensland Government support this project.

Herbert water quality monitoring program participants

A flood of information – pictures from space improve management of the Great Barrier Reef.

Caroline Petus, Michelle Devlin and Michael Rasheed are using freely available images from NASA satellites to help protect the GBR from polluted land run-off. They have developed a new technique that analyses the images to assess coastal water quality from space by mapping the extent, nutrient content and muddiness of flood plumes.

Many important habitats in the GBR, such as coral reefs and seagrass are in decline and one important driver of this decline is poor water quality. Heavy rains and cyclones during the wet season scour mud and pollutants, such as fertilisers and pesticides, from land. The resulting river flood plumes are the main way polluted water travels to the GBR. Traditional methods of monitoring flood plumes required scientists to use submerged data loggers, or boats and helicopters to gather water samples. These methods are expensive, labour intensive, and samples cannot be collected everywhere.

Our researchers are leading two studies that use this new technique. Satellite time-series provide the spatial and long-term window necessary for understanding water quality variability inside GBR coastal waters, and provide the baseline information to assess changes to important ecosystems, such as seagrass meadows. These studies are first steps towards the development of river plume risk maps for GBR seagrass and coral ecosystems.

Combined with ecological and *in situ* water quality data, the information will help researchers understand the impact of flood plumes, ultimately leading to cost-effective and better management of the GBR.

The 'Catchment-to-Reef Continuum' a Marine Pollution Bulletin Special Issue

This Special Issue (2012, 65), edited by Michelle Devlin, presented an overview of the current science addressing the inter-connectivity between the water quality and the ecological condition of the coastal and inshore areas of the GBR, and the land-use and processes on the adjacent catchment. The case studies in the Special Issue highlight the significance of the iconic GBRWHA and the concern for its conservation, as well as provide an opportunity for scientists and managers to consider the lessons learned as examples to better identify and manage the consequences of catchment runoff from extensive agricultural development in the GBR.

Flood plume moving out into the coast from the mouth of the Burnett River

Special Issue of Marine Pollution Bulletin

The Special Edition includes 27 articles derived from a session on GBR water quality at the Conference on the Challenges in Environmental Science and Engineering held in Cairns, Australia in 2010, jointly organised by TropWATER. The Special Issue brought together authors from several different research and management agencies, including many from TropWATER, all working towards a sustainable and resilient reef. The research papers provide a useful baseline upon which to build further ecosystem understanding and the continuous improvement of resource management and conservation efforts. Articles in this Special Issue authored by TropWATER scientists have been cited over 500 times.

Water Quality and Contaminants

Leader: Dr Bithin Datta
Researching the management of water quality in industrial settings. We specialise in modelling surface and groundwater contaminant transport, predictions and remediation.

Research scientists

Professor Rocky de Nys, Associate Professor Wenxian Lin, Associate Professor Wayne Read, Dr Phil Schneider, Dr Guangzhi Sun

The Water Quality and Contaminants group works with large-scale, regional monitoring, management, detection and prediction of water contamination. Our research brings together unique expertise to be able to deal with the complex issues of modelling, prediction and remediation of various regional scale water contamination problems. While the methodologies being developed are at the cutting edge of research, and are universally applicable, our focus is on the tropics. Our main goal is the sustainable, economically efficient use of water resources in the tropical environment.

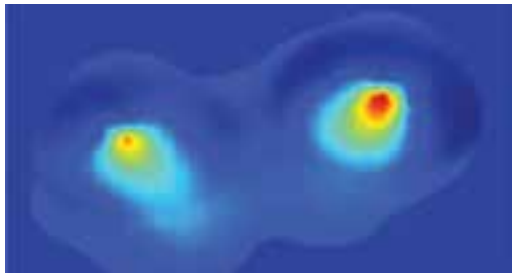
Projects

Environmental forensics: finding and managing the hidden sources of groundwater pollution

Management and remediation of contaminated groundwater aquifers is a critical issue in many parts of the world. The first step in designing a remediation program for a polluted aquifer is to find out where the pollution is coming from. This is a challenging task as contamination is generally detected many years after the pollution source became active, and may have travelled a long way from the source.

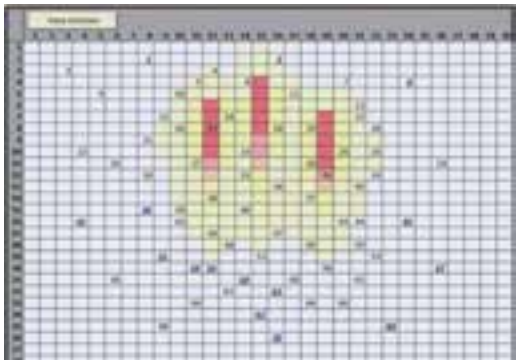
Bithin Datta and the Cooperative Research Centre for Contamination Assessment and Remediation of Environments (CRC-CARE) are developing software, which can be used to (a) estimate the magnitude, location and time of activity of sources of pollution, and (b) design optimal contamination networks, which can be implemented in contaminated aquifers. The two user-friendly software programs are:

- **Contamination source identification software (CARE-GWSID)**
  This software is able to identify the active contamination sources and the corresponding contaminant fluxes during different stress periods. It has the potential to incorporate real life aquifers including 3D flow and transport, and can consider heterogeneous and homogenous study areas, and various study periods.



Contaminated aquifer and the pollution plume

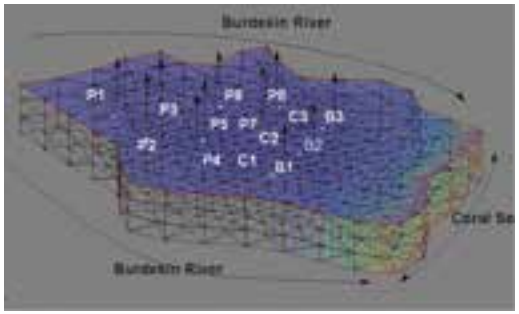
- **Pollution monitoring network design (CARE-GWMND)**
  This software is used to determine the optimal locations for implementing monitoring wells in the field in order to meet user-defined objectives to address site-specific groundwater management problems. CARE-GWMND uses an Excel interface which serves as a user-friendly front-end and as a master program which integrates different modules. The software consists of three major components: a data interpolation model, groundwater flow and solute transport simulation model, and an optimisation model that can solve three different objective functions, addressing different groundwater management scenarios.



CARE-GWMND software output highlighting the optimally chosen well locations delineating the plume boundary

Management of saltwater intrusion into coastal aquifers

Coastal aquifers are a major source of freshwater in many parts of the world. However, the increasing population growth and industrial development in coastal zones puts stress on the available freshwater resources. In coastal areas, freshwater and seawater maintain equilibrium, with the heavier seawater underlying the freshwater due to the hydrodynamic mechanism. Large-scale saltwater intrusion problems occur when the interface between fresh and saline groundwater moves in an upward and/or inland direction. This displacement can be caused by groundwater extraction, sea level changes, and land reclamation and excavation. Once salinity intrusion occurs, long-term measures incurring huge costs are required to remediate contaminated aquifers.



Burdekin Delta study: 3D view of the well field with well locations, control points and boundaries

The aim of this research was to develop a cost-effective methodology for regional scale management to simultaneously maximise groundwater extraction and prevent saltwater intrusion. We ran numerical models to simulate the aquifer responses to various scenarios of future groundwater extraction. New methodologies using artificial intelligence tools were applied to produce regional-scale management strategies that ensure sustainable use of coastal aquifers. These methods have recently been applied to the Lower Burdekin where extensive groundwater extraction for sugarcane cultivation is resulting in increasing intrusion of saltwater into the aquifer.

Nutrient recovery from wastewater

This project, led by Phil Schneider, focuses on the underlying mechanisms involved with the recovery of phosphorus from wastewater streams, such as piggery effluents, municipal wastewater and even human urine. Our focus has been on the recovery of phosphate minerals, such as struvite, which is composed of equal parts of

magnesium, nitrogen and phosphorus. Struvite is very similar in nature to the scale that forms in a kitchen jug, and needs to be carefully coaxed from nutrient-rich solutions.

Although the demand for phosphate fertiliser is increasing worldwide, the availability of economic phosphate rock reserves is in decline. As such, there is a need to develop processes to up-cycle phosphorus back into the human economy, thus reducing our dependency upon these limited mineral phosphate reserves. If we wish to recover struvite in crystalline or pelletised form (which is convenient for storage, transport and land application of struvite fertiliser), we also need to consider the best way to engineer these mineral phosphate particles. Ultimately, the goal of this work is to develop mathematical models of struvite particle formation so that process equipment can be more confidently designed and operated at the lowest price possible.

Phosphorous can be recovered from piggery effluent. Image source: Guido Gerding

Macrolagal Biofuels and Bioproducts Project

The Macroalgal Biofuels and Bioproducts Project, led by Rocky de Nys, provides the research, development and demonstration of macroalgal biomass as a feedstock for renewable fuels and bio-products, such as fertiliser, animal feeds, human foods and nutraceuticals, while providing cost-effective reductions of CO_2 emissions from major carbon emitters in Australia. This is a collaborative program with industry-partner MBD Energy and the Advanced Manufacturing CRC, and the Australian Renewable Energy Agency.

This project is the first in Australia to demonstrate the use of freshwater and marine macroalgae (large multicellular algae including seaweeds) for the development of renewable fuels and bioproducts. It is also the first to integrate the production of macroalgae into wastewaters from aquaculture, agriculture, energy generation and the mining and mineral processing industries. The intensive culture of macroalgae integrated into power stations and other carbon emitters utilises CO_2, with consumption proportional to the scale of culture. In this process the algal biomass can be used to produce renewable fuels (biocrude), biomass energy, algal meal as an animal feedstock, biochar and fertilizers.

We have developed a sustainable method to sequester CO_2 from heavy carbon emitters, and the bioremediation and re-use of wastewater, thereby enhancing the sustainability and value of Australia's agri-product, energy and mineral resources industries. Outcomes have resulted in the implementation of pilot-scale macroalgal culture at hectare scale pilot plants at Stanwell Energy's Tarong power station (Tarong, Queensland), Pacific Reef Fisheries (Ayr, Queensland) and Coral Coast Barramundi (Guthalungra and Kelso, Queensland).

Constructed wetlands, a system for water pollution control

In many parts of the world, the discharge of liquid and solid wastes into waterways has seriously damaged water quality. Constructed wetlands are man-made, ecological systems for water pollution control. Guangzhi Sun is currently a joint-investigator in two research projects funded by the Chinese Ministry of Environmental Protection and National Natural Science Foundation, to study pollutant removal efficiencies and process modelling in constructed wetlands.

Constructed wetland for landfill leachate treatment

Constructed wetland on a farm for agricultural effluent treatment

The Magnarotte

Oceanography

Leader: Professor Peter Ridd
Physical oceanography of the Great Barrier Reef and tropical estuaries, measuring the effects of sediment and nutrient runoff from land and developing high-tech, low-cost monitoring tools, and ocean surface radar applications.

Research scientists

Mr Daniel Atwater, Mr Sean Campbell, Professor Mal Heron, Dr Jasmine Jeffries, Dr Alessandra Mantovanelli, Dr James Whinney, Professor Eric Wolanski, Professor Lucy Wyatt, Dr Thomas Stieglitz

The physical oceanography is one of the primary factors that affect the ecosystems of coastal areas, and how these ecosystems may be affected by coastal development or changes in the input of sediment and nutrients from the land. The tides and currents are primary drivers for the transport of fish and coral larvae as well as other organisms such as crown of thorns starfish. Waves dominate the processes of resuspension and deposition of sediment around coral reefs, seagrass meadows and other coastal settings.

One of the primary focuses of this research is the effects of sediment and nutrients on coral reefs in natural conditions and when dredging is occurring. Corals and seagrasses may be smothered by sediment or killed by prolonged reduction of light due to resuspended sediment or the proliferation of organic material caused by nutrient enrichment. This issue has become a major focus on the northern Australian coast with the recent expansion of port facilities.

Measurement of physical parameters is central to oceanography and we have a group dedicated to developing new instrumentation to support our work. This work has included the development of an inexpensive current meter, satellite tracked drifters for measuring current and water turbidity in rivers and the sea, and sediment deposition sensors.

Projects

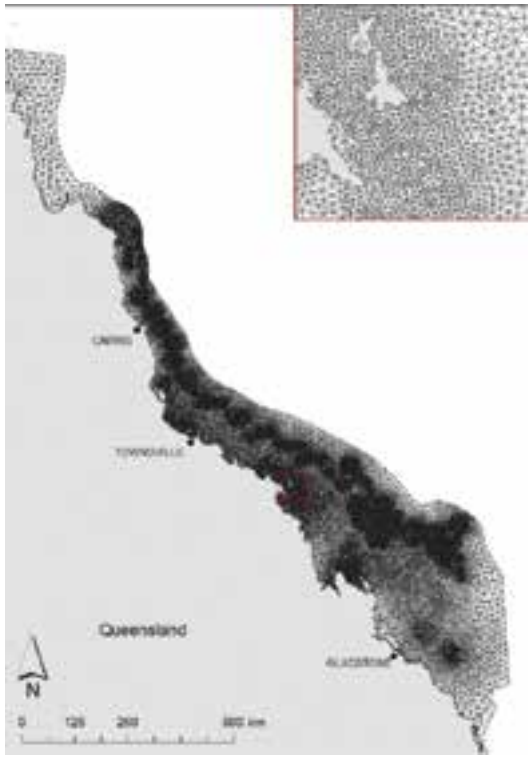
Modelling of the water circulation in the GBR and Torres Strait

Over the past few years, Eric Wolanski and his collaborators have modified, improved and applied the SLIM model to study the water circulation in the GBR and in the Torres Strait. This model is a non-structured grid model, making it possible to have fine resolution near islands and reefs where the currents vary significantly in a short distance, and a coarse resolution in open waters where high resolution is not needed. In addition, Eric added an oceanographic data set spanning nearly thirty years of his work at AIMS, enabling model verification in most areas of the GBR.

A 2D whole-GBR model exists at fine scales, but this requires parallel computing. For most applications, it is sufficient to use a coarse grid for the whole GBR and a fine scale grid in localised areas, such as the Whitsundays Islands area and the Torres Strait. The 2D model provides tides and currents at every point in the mesh.

This model has been used to study the dynamics of hypersaline waters in the dry season in the GBR, the 'sticky water' effect enhancing the retention of coral and fish larvae in areas where reefs are numerous, and to study the general water circulation in the whole GBR and in the Torres Strait. For the Torres Strait, for example, the model predicts that yearly-averaged net east-west flow through the Torres Strait is small to negligible, in agreement with field data. The model also reveals the prevalence of highly energetic tidal flows around shoals, reefs, islands and reef passages, and that the net water circulation in Torres Strait is characterized by events lasting a few days to three weeks, and there is no such thing as a typical 'mean' water circulation.

The model has been further developed to study the trajectory of floating particles (marine debris) in the GBR in order to predict where they land and pollute beaches, and to predict the connectivity between seagrass meadows in Torres Strait. The model has also been developed into a 2.5 D model to study the fate of fine sediments in Cleveland Bay following Ross River floods and cyclones, and the fate of turtle hatchlings in the GBR. More recently, the model has been modified to include larval fish directional swimming in order to study the recruitment of the stripey snapper at One Tree Island. PhD student Philippe Dealandmeter has recently developed a 3D model to study the dynamics of water and sediment in the Burdekin River plume.



Modelling mesh

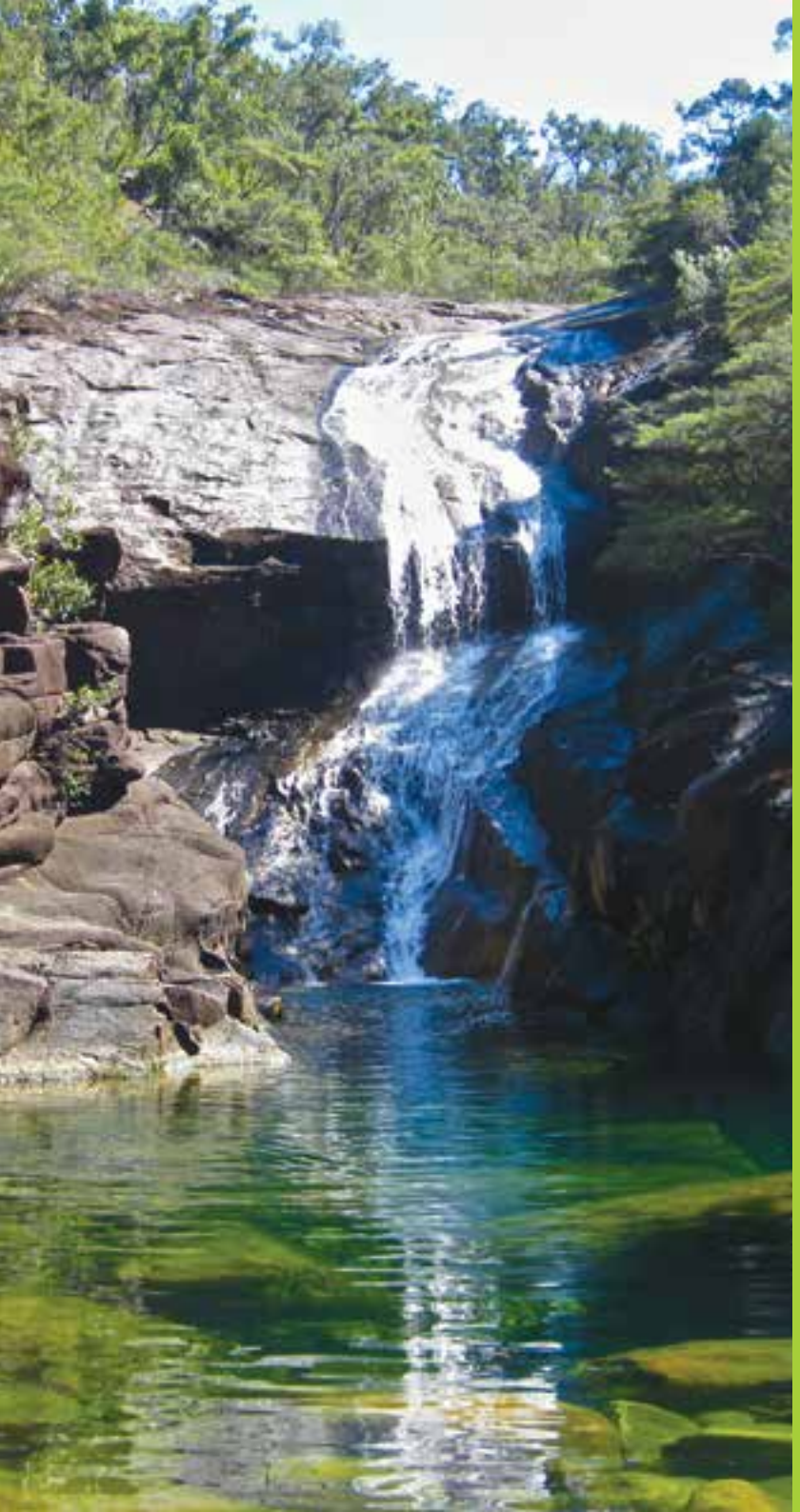
Development of high-tech low-cost monitoring equipment

TropWATER oceanography researchers, led by Peter Ridd, have developed a range of specialised environmental monitoring instruments.

The Magnarotte is a current meter used to measure the speed of water movement. It consists of a cylindrical buoyant object with a tether. The cylindrical shape is used as this increases low current sensitivity. Tilt and tilt direction is measured with a tilt sensor (accelerometer), as well as an electronic compass (magnetometer) and converted to current speed and direction. This new instrument has higher accuracy, storage capacity and sampling rate that the original version (the Marotte).

We have also developed specialised 'river drifters'. These are floating sensor platforms consisting of a microcontroller, GPS, satellite communications system and marine sensors. River drifters are designed to float down flooded river systems and collect turbidity data. Overall, turbidity gives an idea of the sediment being transported in the river system, while the change in turbidity as the drifter travels down the river shows the locations of sediment inputs. River drifters can also be used to monitor dredging operations. They have been deployed in the Johnstone River during a flood to measure water turbidity. This showed that water turbidity gently falls as the water enters the GBR lagoon. Tracks have also been obtained from the Herbert River.

Drifter and drifter tracks



Hydrology

Leader: Dr Marc le Blanc
Advising management on sustainable use of surface and groundwater water resources. Measuring effects of hydrological processes on aquatic ecosystems, and detecting surface-groundwater interactions using remote sensing.

Research Scientists

Dr Adrian Bass, Professor Mike Bonnell, Associate Professor Richard Faulkner, Associate Professor Niels Munksgaard, Dr Paul Nelson, Dr Damian O'Grady, Professor Ninghu Su, Dr Sarah Tweed, Dr Jim Wallace

Our hydrological research focuses on the interactions between river flow and aquatic ecology, providing critical knowledge required for the management and sustainable use of surface and groundwater water resources. Our team specialises in quantifying the effects of high wet season (flood) and low dry season river flows on aquatic ecosystems, and detecting surface-groundwater interactions using remote sensing. We also have expertise in rainforest hydrology, with an emphasis on understanding how the canopy water balance controls ecological conditions and the potential impacts of climate change.

Projects

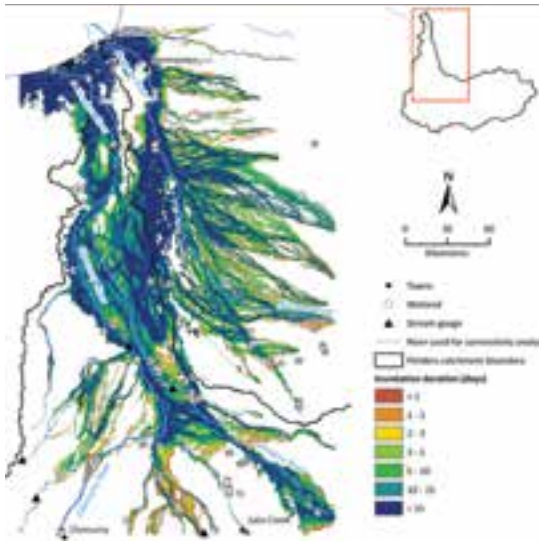
Climate and development impacts on riverine fish refugia in northern Australia

Most rivers in northern Australia are ephemeral and they break up into a series of in-stream waterholes during the long dry season. These waterholes provide vital refugia for fish and other aquatic species. Our research investigates how the suitability of these habitats evolves as the dry season progresses, and from the process models developed, predicts the potential impacts of climate change and irrigation development, both of which contribute to reduced water levels and thus habitat quality and potentially desiccation, of refugial waterholes. Persistence of refugial waterholes through the dry season is assessed via remote sensing techniques in conjunction with our ecological studies.

Temperature logger deployment in a waterhole

Hydrodynamic modelling of wetland connectivity on floodplains

The connectivity of floodplain wetlands is a key factor in their ecological condition and is a vital part of the life cycle of many fish species. In collaboration with CSIRO, we have developed a unique application of hydro-dynamic modelling that quantifies the timing and duration



Inundation duration across the Flinders and Norman catchment floodplains for the large flood in 2009. Reproduced from Dutta et al., 2013

of wetland connectivity during floods. The results of this model are being correlated with fish diversity and abundance so that predictions of how changes in climate and/or floodplain management affect the opportunity for fish to move across floodplains between habitats, can be made.

Hydro-ecological interactions in Australia's tropical rainforest

Epiphytes that depend on rainfall and cloud deposition on the rainforest canopy

These World Heritage listed rainforests contain unique plants and animals that are a product of the climate in which they evolved. Our research builds on the foundational rainforest hydrology studies carried out by CSIRO, by exploring how the rainforest canopy water balance might affect the occurrence of epiphytes and other canopy species. We also model how future changes in climate could affect rainforest hydrology and the *in situ* and downstream biota that depend on it.

Agricultural development and climate impacts on river pool habitats

Jim Wallace and Nathan Waltham have worked closely with CSIRO scientists on the Flinders and Gilbert Agricultural Resources Assessment project in northern Australia. TropWATER led research on the likely impacts of agricultural development and climate change on aquatic ecological assets in the Flinders and Gilbert catchments. As flow declines and the development of in-stream pools in these catchments progresses during the dry season, the TropWATER team monitored the suitability of pool habitats for fish by recording water temperature, dissolved oxygen levels and associated fish species. By relating ecological conditions to pool size and river flow, critical ecological thresholds may be identified below which the pool habitat becomes sub-optimal. This research can then be used to assess how river flow changes due to climate change and or agricultural development might impact in-stream pool aquatic habitats.

Photo: Matt Curnock

Socio-economic Systems and Natural Resource Management

Leader: Professor Natalie Stoeckl
Focusing on the interactions between people and aquatic systems. Engaging with local communities to learn more about the way in which humans affect and are affected by their environment.

Research scientists

Professor Peter Case, Dr Taha Chaiechi, Dr Amy Dietrich, Professor Lynne Eagle, Dr Sizhong Sun

Throughout the world, most of the threats to aquatic and coastal ecosystems are anthropogenic – caused by, for example, the overuse of surface and groundwater, the pollution of fresh and saltwater, resource extraction, and habitat alteration. Recognising the central role that humans play, we focus on the interactions between people and aquatic systems, looking for ways of influencing and/or managing those systems for a sustainable future. Geographically, our research focuses on northern Australia, South East Asia and the Pacific. Working closely with local communities, we combine insights from those 'on the ground' with insights from a variety of western-science disciplines to learn more about the way in which humans affect, and are affected by, each other and their environment.

Our research investigates linkages between socioeconomic and ecological systems, with a focus on water. On the one hand, we explore what economy does to the environment (water quantity and quality), and on the other, what the environment (water quantity and quality) does to the economy.

Projects

We are involved in a broad range of projects across northern Australian tropical rivers, the GBRWHA, the WTWHA, and in the Philippines.

Socioeconomic systems and reef resilience

This project focuses on relationships between socio-economic systems and the GBR. It comprises three interrelated activities, which seek to improve our understanding of (a) resident and tourist views about the relative value of key ecosystem services that are provided by the reef, (b) tourist views about the relative value of key attributes of reef health, and the likely consequence of its deterioration, and (c) the extent to which variations in beef prices, the exchange rate and other socioeconomic variables influence water quality in the GBR.

We collected data from more than 1,500 residents of the GBR catchment area and more than 2,500 visitors. We also collated data from the 1930s through to current times about beef prices, wages, cattle numbers, rainfall and sediment loads in the Burdekin Catchment, exploring the relationship between them. We found widespread agreement among both residents and visitors that intrinsic environmental values are more important than other values, such as industrial development, and that water quality and clarity are a key, and inseparable part of that. Moreover, potential future reductions in ocean water clarity were perceived by residents as having a more negative impact on their wellbeing than a 20% increase in prices.

As regards part (c): we constructed econometric time-series models of the last 100 years in the Burdekin Catchment to explain the relationship between water quality (controlled for climatic conditions and rainfall) and economic variables. We demonstrated that changes in the economy, including changes to the world price of beef and gold, are fundamentally linked to water quality and that prices may be having a more significant impact nowadays than 50 years ago.

This large collaborative project was undertaken by a large multi-disciplinary team led by Natalie Stoeckl and was funded by the Tropical Ecosystems Hub of the NERP.

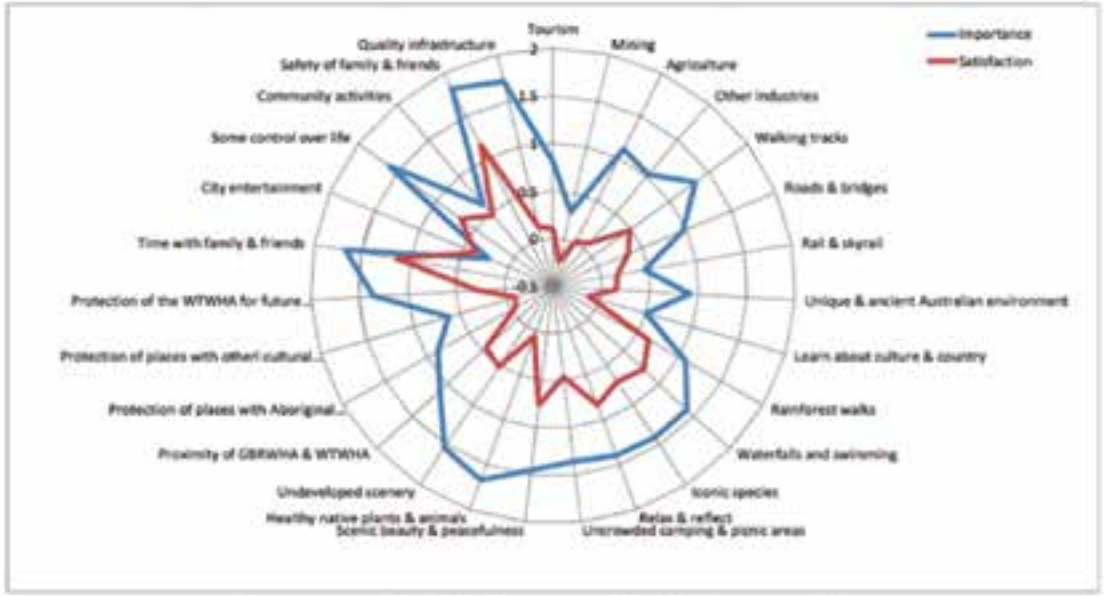
Relative social and economic values of residents and tourists in the Wet Tropics World Heritage Area

This project, also funded by the Tropical Ecosystems Hub of the NERP, focuses on the ecosystem services provided by the WTWHA to residents and tourists. Natalie Stoeckl, Michelle Esparon and Silva Larson are key researchers on this project, with considerable input from Marina Farr.

We collected data from more than 400 residents (including 130 Indigenous residents, with much help from the Rainforest Aboriginal People's Alliance), and from more than 500 tourists. Here too, we found that intrinsic environmental values – including having clear rivers for aesthetics and recreation – were often considered more important than economic or market values, but that knowing that family and friends were safe was more important than all else.

Socio-economic activity and water use in the tropical rivers region

In work recently published in *Biological Conservation* (2013 (159), 214-221), Natalie Stoeckl and colleagues investigated the different impacts of 'development' on Indigenous and non-Indigenous people in the Daly River catchment, in northern Australia; a region experiencing relatively rapid agricultural development. The analysis builds upon the work of several inter-related but independent projects conducted over 6 years (2006–2011). Its contribution is to integrate economic, hydrological, ecological and socio-cultural information providing new empirical insights



Importance and satisfaction scores – non-Indigenous residents

about the potential impact of different types of development on water resources, aquatic habitats and on both Indigenous and non-Indigenous people.

Our analysis indicates that different types of economic 'development' impact upon groups within society and on the environment in different ways. As expected, the 'high-water use agricultural development' scenario has the most detrimental effect on the environment, with relatively modest financial returns. But the financial returns to Indigenous people were up to five times less than those to Industry and to non-Indigenous people.

The research concludes that if proper assessments are done, we may find that conservation land uses, which tend to align more closely with current Indigenous cultural prerogatives, may more effectively promote the wellbeing of this region's residents (both Indigenous and non-Indigenous) than more orthodox types of 'development'.

Macroalgal biofuels and bioproducts project

We are exploring ways in which environmental degradation can be reversed in an economic way. This project is a collaborative venture with the Macroalgae team from JCU, and funded by the Australian Renewable Energy Agency. Michelle Esparon and Natalie Stoeckl quantified the economic value of reusing wastewater to produce algae that can then be used in animal and crop production. Our economic analyses go beyond simple financial analysis, and encompass a wide range of other benefits to the economy, such as social benefits of employment creation and ecological benefits of improvement of quality of degraded waters.

Preliminary results suggest that macroalgae may not be economically viable on its own, but could prove its worth when integrated with other industries that release wastewater (e.g. fish farms, pig farming or waste treatment plants). The potential benefits of co-locating could include not needing to 'pay' for water and/or nutrients (good for algae producers), and participating industries not 'paying' to treat water. The key question remains: Which industry would be best to co-locate with?

Clear water was identified as the most important factor by residents and visitors alike
Photo Matt Curnock

TropWATER Water Quality Laboratory

Laboratory Manager:
Mrs Michelle Tink

Laboratory technical staff

Mr Patrick Cunningham, Ms Carol Lennox, Ms Yoko Nitanai, Ms Fiona Small, Ms Tara Tangney, Ms Hayley Threlkeld

TropWATER's Water Quality Laboratory provides both a water quality assessment service for JCU's research and consulting projects, and a commercial analytical service to government agencies and industry. While our focus is on the analysis of water, wastewater and related samples, our staff expertise also includes experience in many facets of water quality research. This includes providing support for studies that examine freshwater streams, rivers, wetlands and reservoirs, ground waters and marine waters. In 2013 the laboratory performed over 28,000 analyses on over 5,000 samples.

Laboratory staff in 2013

TropWATER's Water Quality Laboratory has high quality modern instrumentation Photo: Raul Posse

Capabilities and expertise

- Design and implementation of monitoring programs
- Sampling of water, sediment and biota
- Analysis of waters, wastewaters, sediments and biological tissue samples
- *In situ* monitoring and data logging
- Interpretation of analytical results and statistical analysis of water quality data
- Discharge license compliance monitoring
- Testing of water and wastewater treatment efficiencies

In addition, Laboratory staff have established working links with other JCU Centres and analytical facilities. This enables them to draw on the experience of specialists from a wide variety of disciplines, which provides the capability to address the diversity of water quality issues and adopt a holistic approach to water quality evaluation.

Equipment and resources

TropWATER's Water Quality Laboratory is located in modern, custom-built laboratories in the Australian Tropical Sciences and Innovation Precinct (ATSIP). The new facilities include capacity for standard titrimetric, colorimetric and gravimetric analysis techniques, supported by a range of high quality modern instrumentation, which enhances the efficiency of routine analyses and provides sophisticated state-of-the-art investigation capabilities.

Equipment

- Three channel ALPKEM Flow Solution auto-analyser
- 2 x three channel O.I. Analytical Flow Solution IV, Segmented Flow auto-analysers
- Shimadzu UV-Vis Spectrophotometer
- Gallery Discrete Analyser (allowing us to offer a 24 hour turn around for FRP, NOX & NH_3 analysis)
- Access to freezers and refrigerated storage areas allowing efficient storage of large numbers of samples

In October 2013 we commissioned a new LIMS (Laboratory Information Management System). Our new system has been set up to import data direct from both in-house result formats and sub-contracted laboratory formats, minimising data entry errors and resulting in a more efficient data storage environment.

Research support

In order to provide expert advice, develop new techniques and process research-related analyses, the Water Quality Laboratory works closely with research staff and postgraduate students from JCU and other universities. In recent years, support has been provided for a wide range of projects, including those associated with:

- Sediment and nutrient run-off from farmed and grazed upper-catchment areas to the GBR
- Identifying pesticides in river systems in agricultural areas
- Monitoring water quality in flood plumes following extreme water events (e.g. cyclone Yasi)
- Environmental impacts on wetland areas surrounding mining and other industrial activities

Commercial clients

Water quality services provided for commercial clients in Government and Industry are primarily related to the environmental monitoring of water for physiochemical parameters and metals, nutrients, salts and bacteria. Examples of clientele and services provided include sugar mills, aquaculture facilities and mining operations, the horticulture industry (water and bore water), and water quality testing for swimming pools.

Graduate training

Number of Postgraduate students and completions 2011-2013

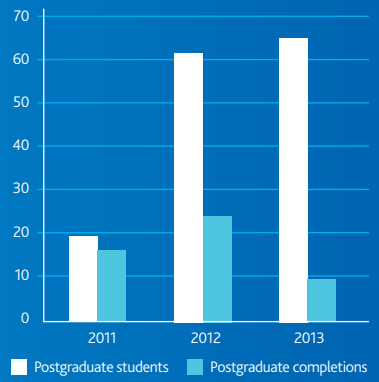


Photo provided by Danswell Starrs

Student members -2013

PhDs

Muhammad Abdul Wahab
Thermal Stress and Marine Sponge Holobionts: Mirobes Cells and Populations.

Zaher Al-Agwan
Management Effectiveness Evaluation of the Marine Protected Area of Socotra Island, Yemen.

Zulgerel Altai
Urban Water Demand Management in Ulaanbaatar, Mongolia.

Alex Angell
Quantitative Changes In Amino Acids Related to Nitrogen Content and Growth Rate in The Green Seaweed Ulva Ohnoi.

Daniel Atwater
Looking inside and outside DeaSonde data

Zoe Bainbridge
Tracing the Sources and Fate of Suspended Sediment from the Burdekin River Catchment to the Great Barrier Reef Lagoon

Suzanne Berthelsen
Interactions between Vegetation and Silicon Cycling in the Wet Tropics

Melissa Bos
Stakeholder values of Coral Reef Goods and Services in the Great Barrier Reef, Australian and the Main Hawaiian Islands

Murray Bower
Asymmetric Tropic Roles in Connected Systems - the Roles of Transients vs Residents

Max Burns
Investigations of Struvite Dissolution Kinetics.

Diana Castorina
People Building Stronger Regions: an Empirical Investigation into the Determinants of Migration

Christophe Cléguer
Informing Dugong Conservation Across a Multiple Spatial-Temporal Scales in a Tropical Reef Ecosystem: New Caledonia as a Case Study.

Michelle Cooper
Sediment Dynamics of a Large Tropical River System

Hoc Tan Dao
Genetics and Recruitment of Spiny Lobsters (*Panulirus ornatus* and *P. homarus*) in South East Asia/Australia

Joshua Davidson
Energy Harvesting for Marine Based Sensors.

Benjamin Davis
Temporal Nekton Dynamics in Tidal Floodplain Wetlands.

John Dawson
Climate Change and the Geomorphological Response of Reef Islands of the Great Barrier Reef

Dominique D'Lima
Irrawaddy Dolphin-human Interactions at Chilika Lagoon, Orissa, India

Jose Antonio Domingos
Optimizing Barramundi Production through Early Prediction of Growth

Michelle Esparon
The Role of Certification in Advancing the Sustainable Tourism Agenda: A Case Study of the ECO Certification Scheme in the Wet Tropics World Heritage Area (WTWHA).

Marina Farr
Exploring the Marginal Values of Key Marine Species to Different Stakeholder Groups (Tourism, Commercial and Recreational Fishing Sectors)

Boga Figa
Population Dynamics and Resilience of the River Herring (*Nematalosa papuensis*): a Keystone Tropical Freshwater Species.

Bjoern Gosch
Prospecting Tropical Algal Biodiversity of High Biomass Yield Algae.

Rie Hagihara
Linking Behavioural Based and Population Based Assessments to Achieve Conservation of Dugongs.

Ashlee Johnson
Nekton Recruitment Process as a Measure of Ecological Health in Dry Tropical Estuaries.

Patrice Kalangi
Diffusion Processes in the Coastal Region

Ruth Kamrowski
Light Pollution on Nesting Beaches: Implications for Sea Turtle Conservation Efforts.

Mehdi Khatamifar
Using Different Waste Polymers in Biodiesel as Additives for Simultaneous Waste Recycling and Improving Diesel Engine Performance.

Milena Kim
The Influence of Governance on Species Prioritization - a Case Study from Queensland

Basiita Komugisha
Genetic Characterisation and Artificial Breeding of *Bagrus dokmak* (Forsskal, 1775) from Uganda East Africa.

Richard J. Lane
Are Financial Statements Limited as Corporate Governance Tools/Mechanisms?

Johanna Leonhardt
Detection of Past Exposure to the Herpesvirus Causing Fibropapillomatosis (FP) in Green Turtles, *Chelonia mydas* Along the Great Barrier Reef.

Rachael Macdonald
Water Turbidity in the Inshore Great Barrier Reef

Lorenna Machado
Mitigation of Methane Emissions from Ruminant Livestock by Macroalgae

Hugh Macintosh
Competition and coexistence in tropical Australian shipworms.

Hasan Mahmud
Investigation of Displacement Ventilation and Cooling Systems

Ross Marchant
Image Analysis Using Monogenic Signals

Carlo Mattone
Biodiesel as Bioremediation to Oil Spills: Effects on the Invertebrates Fauna.

John McLean
Influence of Southern Oscillation on Tropospheric Temperature

Nicolas Neveux
Macroalgal Biomass as Feedstock for Biocrude Production.

James Newton
Investigating the genetics of thermal tolerance and adaption to temperature amongst populations of Australian barramundi (*Lates calcarifer*)

Noto Prabowo
Cation Retention and Supply by Sumatram Soils under Oil Palm

Om Prakash
Development of Methodologies for Optimal Monitoring and Source Characterization in Contaminated Groundwater Aquifers

Heather Robson
The Use of Environmental DNA as a Tool in Detecting Invasive Species and Community Structure in Freshwater Ecosystems

Nicholas Rockett
Ground Water/Surface Interactions in Australian Tropical Rivers.

Emma Ryan
Inshore Reef Growth on the Central Great Barrier Reef: Identifying the Signatures of Sea Level Constraint, Sea Level Change, Storms and Human Impacts.

Jason Schaffer
Assessing the Ecological Effects of River Regulation and Anthropengic Disturbance on Bimodally Respiring Freshwater Turtles in the Fitzroy and Burdekin River Catchments in Tropical Northeastern Australia.

Katrin Schmidt
The ecological role of tadpoles in rainforest streams

Hong Shen
Investigating the Impacts of Climate Variation and Change on Water Resources in the Murray Darling Basin

Takahiro Shimada
Behaviour of Foraging Loggerhead and Green Turtles in Morten Bay Australia.

Justin S. Smith
Nesting behaviour and reproductive biology of the Hawksbill Sea Turtle in the Torres Strait Islands

Alifereti Tawake
Livelihood Benefits of Adaptive Co-management of Hand Collectable Fisheries in Torres Strait and Fiji

Erica Todd
Evolutionary Biogeography of Australian Riverine Turtles.

Julie Tsatsaros
Refining Water Quality Objectives in the Wet Tropics Using a Community Based Approach.

Paul Whittock
Understanding Risk to Marine Turtles from Expanding Industrial Development in Northern Western Australia.

Jessica Williams
Searching for practical solutions to sea turtle poaching in Mozambique

Masters

Michael Ellison
Extreme Algae: Application of Seaweeds for Bioremediation of Industrial Waste Water

Rochelle Ferris
Identification and Assessment of Available Hawksbill Turtle Habitat in Northern NSW and a Review of Existing Tag Return Data.

Iain Goodrick
Changes in Soil Organic Matter in Areas of Tropical Grassland Planted with Oil Palm.

Kristin Keane
The Impacts of Cyclones on Turtle Nesting Beaches.

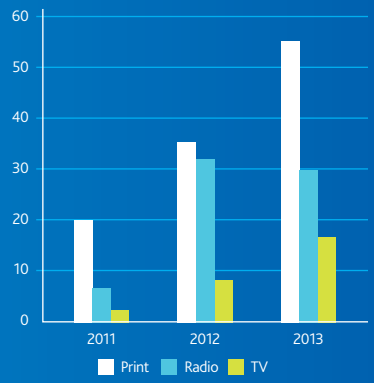
Krista Stegemann
Spatio-temporal Patterns in Predatory Behaviour at a Predation Hot Spot in North Queensland Australia

Media exposure

TropWATER places a high value on maintaining a strong public profile. This is evidenced by the number of collaborations with government departments, community and industry groups and the number of presentations to local and regional forums.

The Centre also has a strong media profile. From 2011 to 2013, member activities were cited in hundreds of newspaper and website articles, and members participated in at least 100 television and radio interviews.

Media exposure 2011-2013



Scientist heads off to Smithsonian

A JAMES Cook University scientist will be taking his talents to the prestigious Smithsonian Institution in the US.

Dr Damien Burrows, director of the university's Australian Centre for Tropical Freshwater Research, will undertake a four-month fellowship at the institution early next year.

The 41-year-old said he was excited to work alongside the world's leading scientists and hoped to apply his new knowledge to restoring damaged mangroves in North Queensland.

"To work with some of the best minds in the world is a once-in-a-lifetime opportunity," he said.

Dr Burrows, who grew up in Townsville, said he dreamed of working at the Smithsonian Institution as an undergraduate at the university.

The Smithsonian was founded in Washington in 1846 and is the world's largest museum and research complex.

Dr Burrows, an ecologist, will study the impact of insect herbivores – bees, caterpillars and scale insects – on mangroves in Australia and North and Central America.

He will be based in Washington but will also spend time at the Smithsonian's various coastal institutes to further his research.

"I will be studying patterns of mangrove herbivory in Panama, Belize and Florida.

"I will be comparing this to data I have for Australia," he said.

Anthony Galloway

MANGROVE RESEARCH: Dr Damien Burrows will study at the Smithsonian Institution in the US

Seagrass study shows recovery in port harbour

Mara Pattison-Sowden
Senior Reporter

DESPITE Gladstone harbour's major dredging project, a study has found that Gladstone's seagrass is thriving, with a better spread than other Queensland ports.

The James Cook University study found seagrass – a vital food source for dugongs – had been increasing in the Western Basin since November 2011.

Gladstone Port Corporation welcomed the study saying it proved the additional safeguards it put in place for the current dredging project helped to decrease its impact on the marine environment.

JCU Aquatic Ecosystem researcher Dr Michael Rasheed said previous reductions in seagrass across the eastern coast including Gladstone were attributed to regional drivers of change including heavy rainfall, severe flooding events and cyclones.

Gladstone and Townsville were the only locations where coastal seagrass had significantly recovered since then, according to the JCU study.

"The increase in seagrass for Gladstone is welcome news and has occurred despite the Western Basin dredging program being conducted during this period," Dr Rasheed said. "This good news needs to be taken with some caution, as seagrass, particularly in the inner harbour, remains in a vulnerable state."

GPC CEO Leo Zussino said he was "thrilled" the study had shown minimal impact, despite more than 14 million cubic metres of dredging that took place in the Gladstone Port between November 2011 and November 2012.

"One of the most interesting things about the recovery in Gladstone was that the slowest recovery was in Rodds Bay where there is no (dredging) activity taking place," he said.

"These are obvious issues we need to have further information to understand but the intense monitoring adds a lot of value to understanding the seagrass, which was the significant requirement we were asked to protect during this massive dredging project."

Mr Zussino said it was important the GPC continued to review the Curtis Coast Coastal and Marine Resource report on a five-yearly basis to ensure it was minimising, mitigating and compensating for the impacts that dredging had on the marine environment in Gladstone's harbour.

Part of the study was funded by GPC under requirements to protect and manage seagrasses.

KEY FINDINGS:

- Seagrass significantly increased in five of the 15 monitoring areas from 2011 to 2012.
- Dugong and their feeding trails were seen for the first time in the South Trees Region, providing positive signs of recovery.
- It may take some time for seagrass areas to reach pre-flood (2009) levels.

> "This good news needs to be taken with some caution
>
> Dr Michael Rasheed

Cane spray shield cuts run-off by 90%

AN INNOVATIVE approach to sugarcane plantation weed management trialled in select Great Barrier Reef catchments has shown a 90% reduction in run-off of highly soluble herbicides into waterways.

In the lower Burdekin region of northern Australia, scientists from CSIRO's Water for a Healthy Country Flagship program trialled a new technique for applying herbicides to raised beds of furrow irrigated sugar cane by using a specially adapted shielded sprayer.

The technique minimises the likelihood of herbicides such as diuron, atrazine, ametryn and hexazinone coming into contact with irrigation water.

Many of the herbicides used in the region are PSII herbicides that are known to harm reef ecosystems.

These waters discharge into the internationally recognised Great Barrier Reef World Heritage Are[a] the Ree[f]

Improved farming techniques such as the shielded sprayer help keep herbicides on-farm and have potential to have a significant and positive impact on water quality in the GBR.

"The conventional application of herbicides in furrow-irrigated sugarcane production is to broadcast spray across the whole field using boom sprayers, which applies herbicides to both beds and furrows," said CSIRO research leader, Dr Rai Kookana.

"Irrigation water then carries the herbicides with the tail water into the drainage channels, into nearby creeks and rivers and potentially into the GBR lagoon."

Dr Kookana said further testing would provide valuable data.

"These trial results are extremely encouraging and clearly demonstrate that the use of precision herbicide application technologies by the industry, including using shielded sprayers for furrow-irrigated sugarcane cultivation, can be highly effective in reducing herbicide run-off," Dr Kookana said.

said the geography of the region meant almost the entire flow from the Burdekin River Irrigation Area in the dry season (from July to January) was made up exclusively of irrigation water from sugarcane and other cropping.

"The trials show that while there will certainly be some herbicide loss following the first irrigation or rainfall event, the marked decreases in losses documented in this study – a reduction of to 90% – could lead to significant improvements in off-site water quality, particularly during the dry season," Ms Oliver said.

According to Jon Brodie of James Cook University the amount of some herbicides in creek and estuarine waters during this period regularly exceeded Australian water quality guidelines and could potentially affect, for example, coastal seagrass.

The results of the study have been published in the International Journal Science of the Total Environment.

Tilapia found in Burdekin

by John Anderson

A TOWNSVILLE angler who caught two tilapia at Greenvale last weekend says it is proof the exotic fish has now muscled its way into the length and breadth of the Burdekin River system.

David Smith caught two tilapia, one in a yabbie trap and one on his line, while fishing at Greenvale Station, 240km northwest of Townsville.

"I've been going there for 15 years, but this is the first time I've caught tilapia," he said.

Mr Smith said that if tilapia had made it as far upstream as Greenvale they must be all along the 732km-long Burdekin River, as well as its major feeder streams which include the Belyando, Clarke, Suttor, Basalt and the Bowen and Broken rivers.

"It's too late now. You'll never stop them. There goes our black bream (sooty grunter) fishing in the Burdekin. They'll eat all the young black bream," he said.

Tilapia are fast breeders and aggressive food competitors that will eat almost anything including the eggs of other fish. The highly prized freshwater table fish known as the eel tailed catfish or "jewie" lays its eggs in calm water within a circle of stones.

Scientists such as Dr Damien Burrows from the Centre for Tropical Freshwater Studies at James Cook University say that eggs such as these will fall prey to the tilapia, which favour slow-moving streams with sandy bottoms.

Tilapia were first known to be present in Burdekin tributary Keelbottom Creek in 2004.

Distinguished academic and Oxford University Rhodes Scholar Professor Hugh Possingham from the University of Queensland's School of Biological Science said history showed it was almost impossible to get rid of highly invasive species such as tilapia a[nd] which infest wa[ters] in southern Aus[tralia]

He said tilap[ia] like carp in that[t] out-manoeuvre[d] fish species.

He said wor[k] undertaken by [a] connected with [the] ay-Darling Bas[in] mission, CSIRO Research and [the] ive Animals Co[op] Research Cent[re] cused on p[ro] "daughterless

The goal of th[e] was to block [a] gene that wo[uld] carp to proc[reate] male offsprin[g] that if this wo[rked] cessful it wou[ld] translate to t[he]

Reef 'at risk' from coal dust

by Ian Frazer

ian.frazer@townsvillebulletin.com.au

COAL loaders near Bowen and Mackay must be covered, Townsville scientists argue after finding coal dust on the reef off Mackay.

JCU oceanographer Prof Eric Wolanski and freelance marine scientist Dr Kathy Burns say their two separate studies show new risks in increasing coal shipments from the North.

Last year, Dr Burns monitored the flow of tiny, sticky particles from the Mackay coastline 40 nautical miles to the reef on the continental shelf break.

Prof Wolanski and PhD student Fernando Andutta carried out modelling last month showing the dust could be carried from Abbot Point on typical ocean currents between Bowen and Cape Upstart.

They plan submissions to the federal inquiry now under way on the proposed $6.2 billion expansion of Abbot Point.

Wolanski

Last week Federal Environment Minister Tony Burke allowed another nine months for an environmental impact statement on the State Government's proposal to lift export capacity from 50 million tonnes to 400 million tonnes a year.

Prof Wolanski said the economics of coal mining were based on an explicit cost to the environment.

"To cut costs, companies do not cover places where they store coal or the conveyor belts carrying coal for shipping," he said.

"So far all the stories about the impact of increased coal loading are about dredging for ocean channels – there have been none about this.

"The very fine, naturally buoyant coal particles fall and are blown of the loaders into the sea and wind, tides and currents carry them to offshore reefs.

"Covering the coal will be costly, but that will be the coal industry's contribution to keep the reef clean."

Dr Burns, who carried out her study with PhD student Diane Brinkman while working for the Australian Institute of Marine Science says potentially harmful chemicals and bacteria stick to the particles in transit.

These contaminants posed a much greater risk to life on the reef than the coal.

All coal ports needed to clean up their operations.

"Gladstone is an absolute mess with the coal dust everywhere," she said.

Mary mangroves are just pristine

MAT NOTT

A TEAM of mangrove experts has described the mangrove wilderness of the Mary River estuary as pristine after a taxing trek through its reach.

"Some say you would have to be raving mad to take a recreational hike slogging through deep mangrove mud and boggy tidal creeks, surrounded by sand flies and biting mossies," Dr Norm Duke, vice-president of the International Society of Mangrove Ecosystems and creator of Mangrove Watch, said.

"And, they would be right – but what a sight, and what a treasure we have on our very doorstep."

Dr Norm Duke, from James Cook University, and his colleagues from the recently formed Mangrove Watch group spent all day walking the saltpans and mud flats of the area between the Mary River and German Creek.

They checked out the health of the environment and also noted 10 different mangrove varieties.

They were guided by passionate local mangrove explorer and long-time resident Lindsay Titmarsh.

Part of the group's route followed the path of Mr Titmarsh's 2008 circumnavigation of the Mary River.

"Lindsay wanted to share his experience with some big-city mangrove experts," Dr Duke said.

Dr Duke said MangroveWatch started with community volunteers in Hervey Bay, Bundaberg and Tin Can Bay.

Now the program is growing rapidly and has a presence in the Torres Strait – and is set to expand internationally following successful workshops in Thailand.

This expansion is possible due to Federal Government grants, more recently from the Australia-Thailand Institute for the new James Cook University mangrove science hub.

Mangroves at the mouth of the Mary River are largely undisturbed because they are so isolated. The mangroves show few signs of the degradation witnessed in many other estuaries in south-east Queensland.

MANGROVE FOREST: Margaret Duke, Norm Duke, Jock Mackenzie, Jess Mahy, Julian O'Mara-Bottom, and Apanie Wood scramble through a grey mangrove. PHOTO: CONTRIBUTED

Rare eel studied in captivity

A Mareeba CSIRO scientist has begun a new three-year project to educate the public about freshwater science and conservation issues.

Dr Brendan Ebner is employed as a researcher with James Cook University and the CSIRO in Atherton.

His aim is to "try to re-engage the public with issues of sustainable water resource use by reconnecting them with their environment through flagship species".

One of the species he is using is a little known freshwater moray eel, pictured right, that had only been identified once before he began looking at the animal about three years ago.

"This is the only species of some 200 species of moray that lives in freshwater," Dr Ebner said.

"Before I moved up here [to Mareeba] three-and-a-half years ago, as far as I knew only one of this animal had ever been seen in Australia."

His interest in fish ecology was sparked by working on his grandfather's commercial fishing boat for about 20 years and noticing that "some of the fisheries that I was working with were going pear shaped" and that perhaps his activities were part of the cause of it.

The scientific interest in the freshwater moray led to a BBC documentary crew filming the eel in Cape Tribulation and Mareeba in specially set up tanks on his property. The documentary will be released next year.

Dr Ebner and a number of other fish ecologists from the far north Queensland region recently published a scientific paper in the international *Journal of Fish Biology* describing the distribution of the species in the wet tropics.

Public outreach and engagement

TropWATER takes public outreach and engagement seriously, delivering scores of public talks and hundreds of conference and workshop presentations. We manage numerous capacity building projects with Torres Strait Islanders and Indigenous communities around northern Australia. We have been involved in a number of forums (e.g., Reef Rescue, Reef Water Science Policy) where we have presented results to farmers and industry stakeholders. We have been working with agriculture industry groups such as Canegrowers and Agforce Queensland and individual farmers, including setting up farms to make experiments possible and delivering public talks to share results with local communities, then providing this critical information to government departments for management plans and reporting.

We have been a driving force in explaining the science of the impacts of port development to the public and through articles in *The Conversation* (33,000 readers in 2012-2013), scientific presentations in conferences, and public talks. Jon Brodie has been interviewed for numerous news, current events and documentaries. Rob Coles and Mike Rasheed also provided advice on port management through independent panels, port advisory committees and direct advice to State and Commonwealth Government agencies reflecting TropWATER's reputation as a provider of quality science.

Len McKenzie maintains the Seagrass-Watch website providing a gateway into much of the latest information on seagrass monitoring. Len and others in the team in Cairns provide the Secretariat for the World Seagrass Association and are active in seagrass issues globally.

Stephen Lewis and Aaron Davis took lead roles in teaching the next generation of aquatic scientists teaching courses on hydrology to JCU students, and many Cairns maths and marine science students have enjoyed lectures and field trips with the Seagrass Ecology Group.

Seagrass-Watch

Seagrass-Watch is a scientific monitoring and science-based education program, where scientists, coastal managers and local stakeholders from across the globe collaborate to assess the status of their seagrass meadows to provide an early warning of coastal ecological decline. Developed in Queensland over 15 years ago, the program uses standardised global monitoring protocols at over 350 sites across 19 countries. Anyone can participate in Seagrass-Watch, as it responds to local needs, and includes some elements of citizen science. Seagrass-Watch implements a standardised, non-destructive, seagrass assessment and monitoring protocol that has rigorous quality assurance and quality control procedures. The program identifies areas important for seagrass species diversity and conservation. The information collected can be used to assist the management of coastal environments and to prevent significant areas and species being lost.

Seagrass-Watch HQ, the global headquarters of the program, is hosted at TropWATER in Cairns, and led by Len McKenzie and Louise Johns. The role of Seagrass-Watch HQ is to develop scientifically rigorous protocols and strategies for seagrass resource assessment, to manage and validate data, provide and develop training, facilitate the establishment of networks and to continue the development and expansion of the program. Seagrass-Watch HQ also ensures that the program is producing data of high quality, ensuring time and resources are not wasted.

The Seagrass-Watch program provides early alerts about coastal environmental problems before they became intractable. For example, during the dredging and reclamation stages of a coastal development in the Whitsundays, monitoring identified the onset of sedimentation on adjacent seagrass meadows and early intervention ensured they were not completely lost. The program has improved our understanding of seagrass ecosystem dynamics, including seagrass recovery after losses from flooding and other climatic events. The consequences of global climate change are also being tracked. Findings from the program have contributed to Ramsar and World Heritage Area assessments, regional and local management plans and reports on the health of the GBR. The program also works closely with Indigenous groups throughout tropical Australia, assisting with the management of dugong and turtle habitats. Collaborations as exemplified by Seagrass-Watch are essential to protect our valuable seagrass meadows. For more information, visit **www.seagrasswatch.org**.

Seagrass-Watch monitoring in Broome

Seagrass-Watch monitoring in Dhimurru

Seagrass-Watch monitoring in Singapore

MangroveWatch

The objectives of MangroveWatch are to promote the education and training of community members for the monitoring and assessment of tidal wetlands (as mangroves, tidal saltmarsh and saltpans), and to disseminate expert knowledge, images and observations concerning tidal wetland ecosystems.

MangroveWatch, hosted by TropWATER, is a not-for-profit company supporting community science partnerships for assessments of coastal and estuarine condition using current scientific monitoring techniques. Community participants collect geo-referenced shoreline video to be assessed and disseminated by TropWATER experts. The program promotes community awareness and advocacy through identification of specific threats, quantification of natural resource benefits, prioritisation of management actions and baseline monitoring of shoreline health.

The partnership program watches threatened coastal ecosystems using low cost HD video and GPS in an innovative data gathering program using Shoreline Video Assessment Methodology (S-VAM). The method delivers an effective and easy way of monitoring impacts and changes to coastal margins. A further innovation to visualise collected data, called ShoreView, is currently in development. This online facility will be freely available for public access and use.

More than 500 people have been trained for MangroveWatch monitoring, including Indigenous enthusiasts like the land-sea rangers in Torres Strait, and many active retirees.

For more details, please see our website for specific and current activities: **www.mangrovewatch.org.au.**

MangroveWatch in the Daintree has eager Earthwatch volunteers making a world of difference!

Since 2012, MangroveWatch and Earthwatch have together hosted up to two survey trips each year. Each trip was led by TropWATER mangrove scientists Norm Duke and Jock Mackenzie. Each year in the program, mysteries about mangroves have been uncovered by citizen scientists working in the wet tropical conditions of north-eastern Australia. Participants are amazed to find themselves involved in cutting edge scientific research, helping preserve globally endangered tidal wetlands. They learn how important these places are, and why we need to protect them. While doing useful research is an adventure in itself, there is the added benefit of working in the truly exotic setting. Australia's wet tropics are like no other. Significant findings focus on direct human influences affecting runoff, pollutant loads and shoreline stability, coupled with indirect factors like climate change and sea level rise. Specific advances range from the discovery of new mangrove species, to measurements of river health, the impacts of severe tropical storms and flooding, quantification of typically rich mangrove carbon reserves, plus gaining a better knowledge of how mangrove forests develop and grow. Participants have much to learn, and so do the scientists. By working together, these surveys are providing additional new insights into the importance and status of mangroves.

EarthWatch team hard at work

Science Communication

TropWATER Online

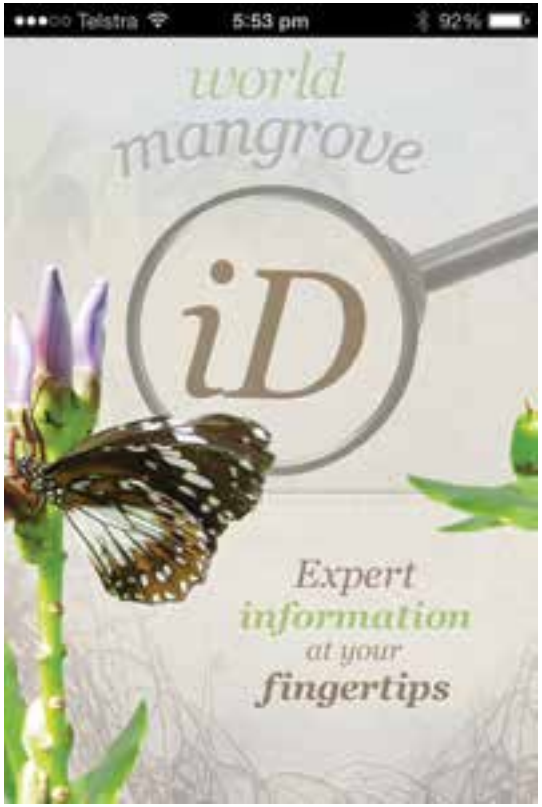
TropWATER launched their new website **www.TropWATER.com** in May 2012. By the end of 2013 the website had 42,626 page views from almost 7,000 visitors. The ever-growing website contains hundreds of pages of information and >1000 scientific documents available for download. News and events are constantly updated and most projects are described in detail. TropWATER also maintains an active presence on **Twitter** (>1000 followers), **Facebook**, **Google+** and **Youtube**. Web addresses for these can be found in the Contacts Section of this document.

Symposium: Fish use of mangroves and tidal wetlands – biological drivers, physical constraints, and regional variation

In October 2013, over 20 local and international scientists met at the TropWATER Centre in Townsville to identify the key knowledge gaps and opportunities to advance research on fish use of tidal wetlands and coastal systems. The workshop consolidated an area of research strength within TropWATER and positions it as a leader of a consortium comprising local, national, and international experts advancing the field of coastal fish research. Special guests at the workshop were Lawrence Rozas from NOAA Fisheries in Lafayette Louisiana and Ivan Nagelkerken from the University of Adelaide. Other participants joined us from other universities and government organisations from Singapore to South Australia.

World Mangrove iD App for iPhone and iPad

The 'World Mangrove iD' app for iPhone and iPad is a living expert guide to all mangrove plants worldwide. It is just like having your very own mangrove expert on call. The guide provides more than 800 images, 100 world distribution maps and authoritative botanical descriptions of all 85 mangrove plant species, hybrids and varieties occurring worldwide; plus a selection of 15 common associated plants you are likely to come across. The information and data presented provides the latest botanical information from Norm Duke's Mangrove Flora Project, conducted over the last three decades. The purpose of the guide is two-fold: one, to show the diversity and distribution of these plants; and two, to improve our knowledge of them. This app is available from the iTunes store and an Android version is shortly to be released. In 2014, we intend preparing a similar app specifically for Australian mangrove species.



Dr Eric Wolanski is a prolific writer of scientific books and journal articles

New book: Estuaries of Australia in 2050 and beyond

This book, by Eric Wolanski, addresses the questions: Is Australia's rapidly growing human population and economy environmentally sustainable for its estuaries and coasts? What is needed to enable sustainable development? The book reports detailed studies of 20 iconic Australian estuaries and bays by leading Australian estuarine scientists. That knowledge is synthesised in time and space across Australia to suggest what Australian estuaries will look like in 2050 and beyond based on socio-economic decisions that are made now, and changes that are needed to ensure sustainability. The book also has a Prologue by Mr Malcolm Fraser, former Prime Minister of Australia, which bridges environmental science, population policy and sustainability.

Research planning in Papua New Guinea
Photo: Jon Rawlinson

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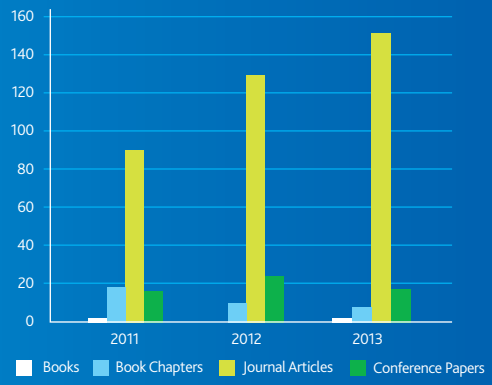
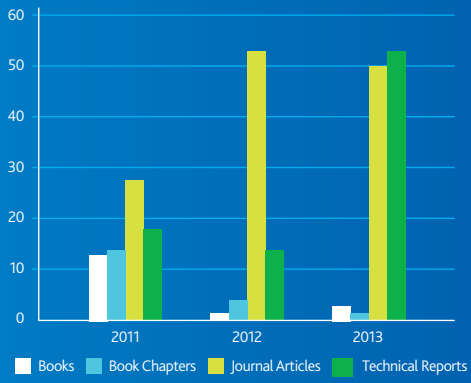


Staff Publications



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Acronyms

AIMS
Australian Institute of Marine Science

ATSIP
Australian Tropical Sciences and Innovation Precinct

CRC
Cooperative Research Centre

CSIRO
Commonwealth Scientific and Industrial Research Organisation

FGARA
Flinders Gilbert Agricultural Resource Assessment

GBR
Great Barrier Reef

GBRMPA
Great Barrier Reef Marine Park Authority

GBRWHA
Great Barrier Reef World Heritage Area

IUCN
International Union for Conservation of Nature

JCU
James Cook University

MMP
Marine Monitoring Program

MSQ
Maritime Safety Queensland

NCCARF
National Climate Change Adaptation Research Facility

NERP
National Environmental Research Program

NFA
National Fisheries Authority

NRM
Natural Resource Management

PNG
Papua New Guinea

SEWPaC
Department of Sustainability, Environment, Water, Population and Communities

TropWATER
The Centre for Tropical Water and Aquatic Ecosystem Research

TSRA
Torres Strait Regional Authority

UTS
University of Technology Sydney

WCA
Wetland Care Australia

WTMA
Wet Tropics Management Authority

WWF
World Wildlife Fund

WTWHA
Wet Tropics World Heritage Area

Papua New Guinea is an emerging area of research focus for TropWATER
Photo: Ian McLeod

TropWATER

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