ARI

MAGAZINE
Issue 5

Australian Rivers Institute

FEATURE ARTICLES IN THIS ISSUE:

Griffith UNIVERSITY
Queensland, Australia

DIRECTOR'S WELCOME

It is with great pleasure that we bring you another edition of the ARI Magazine. The regularity of our production has been patchy through the COVID pandemic. The delay in this edition means that we have much to talk about, as I summarise here and in the articles that follow from our staff and students.

Firstly, there has been a change to the Director role at the Australian Rivers Institute. I was appointed Director in November last year after filling the Acting Director position when Prof Stuart Bunn stepped down in July 2022. We also welcome the new Deputy Director of ARI, Professor Fred Leusch.

As the article on Stuart's achievements in this edition shows, I have big boots to fill. Stuart led the Australian Rivers Institute from its establishment in 2006 and has guided it through the ups and downs of variable funding cycles in the Australian water industry and, more recently, a challenging environment to sustain major international collaborative research programs. Stuart has led from the front, building national and international recognition for the Institute as a leader in interdisciplinary water research.

Despite the external pressures, the Australian Rivers Institute has grown steadily over the past six or so years, building up a large cohort of PhD students and early-career researchers in increasingly diverse areas of water research. Part of this diversity is encompassed by the Coastal and Marine Research Centre, led by Director Rod Connolly, and the International WaterCentre, led by Acting Director Regina Souter.

The past year has seen the passing of International WaterCentre (IWC) Director, and Professor of Practice Mark Pascoe. As described in the article on Mark by Assoc Prof Brian McIntosh, Mark's passing was a major shock and deeply affected the many people who worked closely with him. His hallmarks of generosity, encouragement, and empowerment of the people around him are now required as IWC regroups under Dr Regina Souter's leadership, and the International WaterCentre now has major research initiatives in the Pacific, and in February this year, it hosted the International Water and WASH Futures Conference in Brisbane, achievements that would have been deeply gratifying to Mark if he had been here.

The Australian Rivers Institute is delighted to have Gomeroi man, Dr Phil Duncan as an Industry Adjunct. Griffith University awarded Phil an Honorary doctorate in 2022 in recognition of his long-term commitments to water policy and advocacy for Indigenous connections to land and water. Phil's appointment signals a new opportunity and a major initiative beginning in 2023 to develop a cultural competency and Indigenous engagement framework for ARI staff and PhD candidates. As described in articles in this edition by Prof Sue Jackson, Dr Fernanda Adame Vivanco and Dr Ben Stewart-Koster, we have a long journey ahead but a powerful connection to forge that is ultimately designed to help us manage land and water sustainably.

In 2022, we ratified a Strategic Plan for the Institute. This plan has several major initiatives including:

- Alignment of our researchers and research programs with the UN Sustainable Development Goals
- Links to industry as we seek new opportunities supported by the Commonwealth Government for collaborations of university staff and students with industry
- A strong impact agenda demonstrating how our research can support plans and policies to improve the sustainability of land and water management

I am excited about these opportunities and am interested in connecting with you as you read about the breadth and depth of our research in this edition of the ARI magazine.

NEWS

PHIL DUNCAN AWARDED HONORARY DOCTORATE FOR INDIGENOUS WATER ADVOCACY

A proud Gomeroi man, Phil Duncan, was awarded an honorary doctorate by Griffith University in recognition of his work protecting waterways and preserving Indigenous knowledge and education. Dr Duncan gave the graduates acceptance speech at the Griffith University graduation ceremony in July, 2022.

Dr Duncan is an Industry Adjunct Fellow with the Australian Rivers Institute.

The honorary doctorate recognises Dr Duncan's sustained contributions to national water policy and management and advocacy for greater respect and understanding of Aboriginal connections to water.

"Accepting this honorary doctorate is an extremely proud moment for my family and me, and for the people I work with to bring about change," Dr Duncan said.

"In the Aboriginal worldview, people and country, including lands, waterways, wetlands and seas, are independent entities that are intrinsically linked. We share a symbiotic relationship with our land and waters."

"I will strive to increase Aboriginal voices in environmental management and conservation."

Professor Stuart Bunn of the Australian Rivers Institute said, "Dr Duncan has collaborated with the ARI for over a decade, supporting researchers and providing advice and guidance on major research initiatives."

"We look forward to continuing our work together to improve the exchange of cultural and traditional knowledge on freshwater ecosystems between Indigenous people and western scientists and to guide Indigenous capacity building in water research and management."

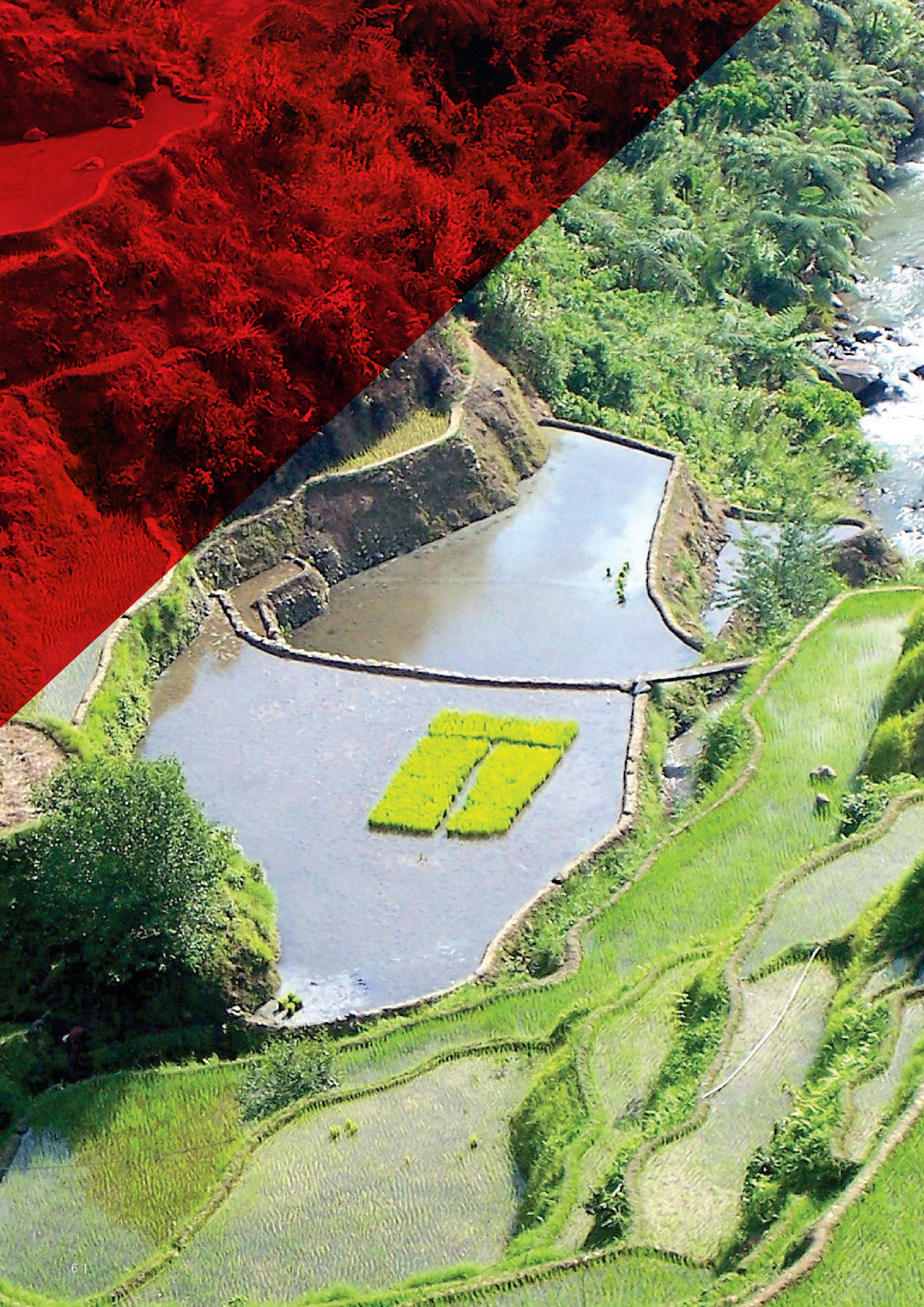
With more than 30 years of experience in water management and a deep connection to Australia's Indigenous community, Dr Duncan has provided strategic advice and leadership to key Indigenous organisations, universities, and state and federal government agencies.

Since 2020 Dr Duncan has served in the government-appointed independent board of the Natural Resources Access Regulator, which is responsible for strategic decision-making for natural resources, and helps to shape and change attitudes to water law compliance in NSW.

His understanding of community and the cultural importance of water also made him the perfect candidate to serve as the Chair of the Basin Community Committee of the Murray-Darling Basin Authority.

"Greater uptake of Indigenous knowledge and our cultural science can benefit Australian society. Aboriginal people need to be involved in decision-making that affects the natural environment," Dr Duncan said.

"We need to be able to care for our country and be involved in repairing our country."



JOINT AGREEMENT TO ADVANCE AGRICULTURAL LAND AND WATER MANAGEMENT IN THE PHILIPPINES

An Implementation Agreement between Griffith University and the Department of Science and Technology (DOST) Philippines is set to advance soil, ecological land and water management in agriculture.

The scientific and technological cooperation agreement will include a joint PhD program, academic exchange, masters program support, and training programs, all of which will contribute directly to implementing the United Nations' Sustainable Development Goals.

Associate Professor Anik Bhaduri, from the Australian Rivers Institute, said the PhD program would involve joint supervision of 17 PhD students in partnership with universities in the Philippines.

"It will produce critical global and local regional research that considers ecosystem services including climate change resilience and adaptation strategies, enhancing communities' resilience, and restoring and avoiding further land, water and soil degradation," Associate Professor Bhaduri said.

"This partnership is desperately needed as both Australia, and the Philippines will face extreme weather events and ecological changes due to climate change."

Academics from Griffith University and universities in the Philippines will meet to identify connections between research and policy in natural resources development, management and governance, including how research can help open policy windows.

"This agreement will enable the next generation of practitioners to focus on key planning challenges, adopt and capitalise on state-of-the-art science, technology, and problem and response assessment tools, to promote the expanded use of integrated and ecosystem-based approaches to design future agricultural systems," Associate Professor Bhaduri said.

The program will be working closely with leading Griffith research institutes and centres, including the Australian Rivers Institute, the Centre for Planetary Health and Food Security, and the Griffith Business School.

"This partnership is a fantastic opportunity to allow our academics to achieve impact internationally," Griffith Sciences Dean (Research) Professor Paulo de Souza said.

"We value the partnership with DOST in the Philippines and look forward to further strengthening our collaboration."

"This partnership is desperately needed as both Australia, and the Philippines will face extreme weather events and ecological changes due to climate change."

PROFESSOR STUART BUNN PROFILE

Professor Stuart Bunn, one of Australia's leading freshwater scientists, member of the Earth Commission, and Fellow of the Australian Academy of Science, stepped down as Director of the Australian Rivers Institute after a decade and a half of service.

Over the past 15 years as Director, Professor Bunn has overseen the development and growth of the Australian Rivers Institute to become one of Australia's preeminent research enterprises for catchment, river, and coastal science.

Under Stuart's leadership, ARI was recognised as the number one global water security think tank by the '2020 Global Go To Think Tank Index Report'. This report was based on the institute's ability to provide superior, innovative research and strategic analysis on water security public policy and promote access to an adequate quantity and quality of water to sustain the livelihoods, health, and socio-economic development of people around the world.

This international recognition of the institute's research and efforts to work with industry, decision-makers, and the broader community to improve the management of our water resources is a reflection of the steady hand and work ethic that has steered ARI for the past 15 years.

Stuart arrived at Griffith University in 1988 from Canada on a 4.5-year fixed-term appointment as a Lecturer in the School of Environment. He moved to a continuing academic position shortly after and, in 1993, was tasked with co-leading the National Riparian Lands Programme for Land and Water Australia.

He took over as Director of the Centre for Catchment and In-stream Research (CCISR) in 1996 and continued in a research-only role when the University joined the CRC for Freshwater Ecology in 1999. Responding to the University's new research centres policy, he oversaw a wave of mergers; first, the CCISR with the Centre for Land Management in 2003 to form the Centre for Riverine Landscapes, and its subsequent merger with the Centre for Aquatic Processes and Pollution in 2006 to create the Australian Rivers Institute.

A freshwater ecologist by training, he relished the opportunity to lead an institute that in his words "takes a source-to-sea philosophy bringing together researchers from a diverse range of disciplines, including aquatic ecology, biogeochemistry, geomorphology, soil science, climate and modelling, social sciences, resource economics and law to support the rehabilitation, sustainable use and conservation of aquatic ecosystems."

In his research, Stuart pursued questions that addressed the fundamental structure and function of freshwater ecosystems and provided practical tools and guidance to inform policy and management. His primary research interests in the ecology of river and wetland systems have emphasised the science underpinning river management.

"My research seeks to determine the primary sources that sustain consumers, especially for growth and reproduction, and where (and when) these high-quality resources are available. I have also been particularly interested in understanding how human activity impacts these key processes," Professor Bunn said.

Stuart has championed combining field-based measurements with remote sensing and laboratory analysis of stable chemical isotopes and other chemical tracers to answer these fundamental research questions and explored these questions across different biomes.

"My freshwater research has focused on everything from small temperate forest streams to arid dryland rivers, and tropical floodplain wetlands to estuaries and everything in between."

"We developed projects on large arid zone rivers that had, until then, been poorly studied and established a whole program of research on the large river-floodplain systems of northern Australia."

This work was conducted on expansive areas like floodplain river systems that spread across northern Australia and was only made possible through Stuart's ability to bring together and manage large multi-disciplinary teams with expertise in diverse fields like remote sensing, statistical modelling, hydrology, aquatic botany, fish ecology and isotope geochemistry.

His research has resulted in over 300 publications, most in peer-reviewed journals, and these currently attract over 1,900 citations per year, with an average of over 90 citations per article. Most citations (>75%) are from international authors representing over 160 countries.

In addition to contributing to a deeper ecological understanding of freshwater ecosystems, Professor Bunn has played a direct role in water policy, actively pursuing research to address management challenges for freshwater systems at national and international levels.

At a national level, the importance of Professor Bunn's contribution to water policy and management can be demonstrated in the significant government-appointed positions he has held including Director of Land and Water Australia (1999-2002); Commissioner of National Water Commission (2008-2012); and Member of the Murray-Darling Basin Authority (since 2018; Acting Chair 2020).

"An important part of my research has been to expand our knowledge of how human-induced changes to flow regimes and land use, and associated changes in water quality affect freshwater ecosystems and to use this understanding to guide policy and management."

He has published key papers on the impacts of anthropogenic activities on river ecosystems and developed tools to assess and report on ecosystem health. Working closely with natural resource management groups, state government and landholders, he has also developed practical river and riparian management guidelines.

During his time as ARI Director, Professor Bunn also made significant contributions to the challenges in sustainable water management at the global scale through international collaborations as a member of the Global Water System Project, a member of the International Planning Committee for the Sustainable Water Future Programme and one of 19 members of the Earth Commission. These global collaborations have culminated in high-profile papers in Nature, Science and several recent publications on the Sustainable Development Goals, targeted at the UN community.

Stuart was also appointed as a Lead Author in Working Group 2 (Terrestrial and Inland Water Systems), for the IPCC Fifth Assessment Report and was the convenor of the 'Water Resources and Freshwater Biodiversity Research Network' for the National Climate Change Adaptation Research Facility.

During this time at Griffith University, Stuart has supervised and mentored over 40 PhD students (20 as primary supervisor) and nine postdoctoral fellows and has supported many visiting international students.

But just because he has stepped down as ARI Director doesn't mean he has plans to slow down any time soon. He aims to continue his international collaborations with the Earth Commission and support the Institute's partnerships with UNESCO and the Tropical Water Research Alliance in Brazil.

While Professor Bunn has stepped down as Director of the Australian Rivers Institute, hopefully, it will still be a while yet before he retreats to a shed somewhere in Evans Head to spend his time building handmade boats instead of research partnerships

"My research seeks to determine the primary sources that sustain consumers, especially for growth and reproduction, and where (and when) these high-quality resources are available. I have also been particularly interested in understanding how human activity impacts these key processes,"

COLLABORATION AND COMPASSION – REFLECTIONS ON THE LIFE AND PRACTICE OF MARK PASCOE

Associate Professor Brian S. McIntosh, International WaterCentre

At the heart of the International WaterCentre (www.watercentre.org) lies a spirit of collaboration mixed with a strong passion for building capacity to drive change across the water sector in Australia and globally. This collaboration and passion were fostered by an extraordinary water leader, Mark Pascoe, the Founding CEO of the International WaterCentre, who sadly passed away in 2022.

We remember Mark for many reasons. His physical presence – he was large man – but mainly for the way he embodied and practiced his values. It is impossible to capture a man in a few words on paper, but hopefully, this provides a sense of who he was and how he impacted and inspired others.

Everyone matters

Mark's career had seen him lead a major urban water utility, Brisbane Water. He had been the Deputy Director of the International Water Association and CEO of the International WaterCentre. He was Chair or Member of many different Boards and Advisory Groups, including, most recently, the Asia Pacific Water Forum.

Despite holding significant executive positions, Mark was always found at conferences and events talking with anyone, in fact, with everyone. He actively sought out others and responded positively to every approach, taking the time to sit down, listen and engage. He could see the value and the potential in every person and always offered words and contacts to help realise that potential.

He believed in people and in providing encouragement and advice, and this mentoring style was subtly woven into his style as a manager and leader within the IWC.

Bringing people together

At the heart of integrated water management (IWM) is collaboration. Collaboration is borne of a generosity of spirit and a willingness to accommodate and work with others. Mark practiced IWM daily in this sense.

He built networks rather than empires and always sought to add value rather than dominate. He invested time in building relationships and trust, deeply appreciating that these two ingredients are fundamental to bringing about change. Mark listened and was able to help weave together ideas into single visions, sometimes simply by bringing the right people together, and sometimes through more active conceptualisation and cognitive work.

Having fun

Mark revelled in spending time with people, travelling to events and meetings, having a nice glass or two of pinot noir, and laughing with others. He had a terrific ability to laugh with others and help create an atmosphere of convivial collegiality. He helped to create the contexts and support that led to silliness on many occasions, including memorably once in a public square in Brisbane where he and the team at IWC danced and sang to the Dugong Rock.

The team at the International WaterCentre all miss Mark. He has left an enormous hole which continues to be visible, such as when we expected to, but didn't see him ambling along talking with others at the 2023 Water and WASH Futures conference. But, he left a terrific model of practice – how we might each, daily, embody what Integrated Water Management is about – relationships, trust and people—and having fun.

Vale Mark! Cheers and Slainte!


Water leadership for the future
Water, Sanitation Hygiene – WASH
Griffith UNIVERSITY
INTERNATIONAL WATERCENTRE
10 YEARS
OF BUILDING GLOBAL WATER LEADERSHIP CAPACITY

PARTNERSHIP TRIO JOIN FORCES TO TACKLE METHANE EMISSIONS

A new targeted research program to address landfill methane emissions has united Griffith University, Zeotech and Cleanaway.

On December 14, 2022, Griffith hosted representatives of Zeotech and Cleanaway at its Nathan campus, to discuss the collaborative research program due to commence in the new year.

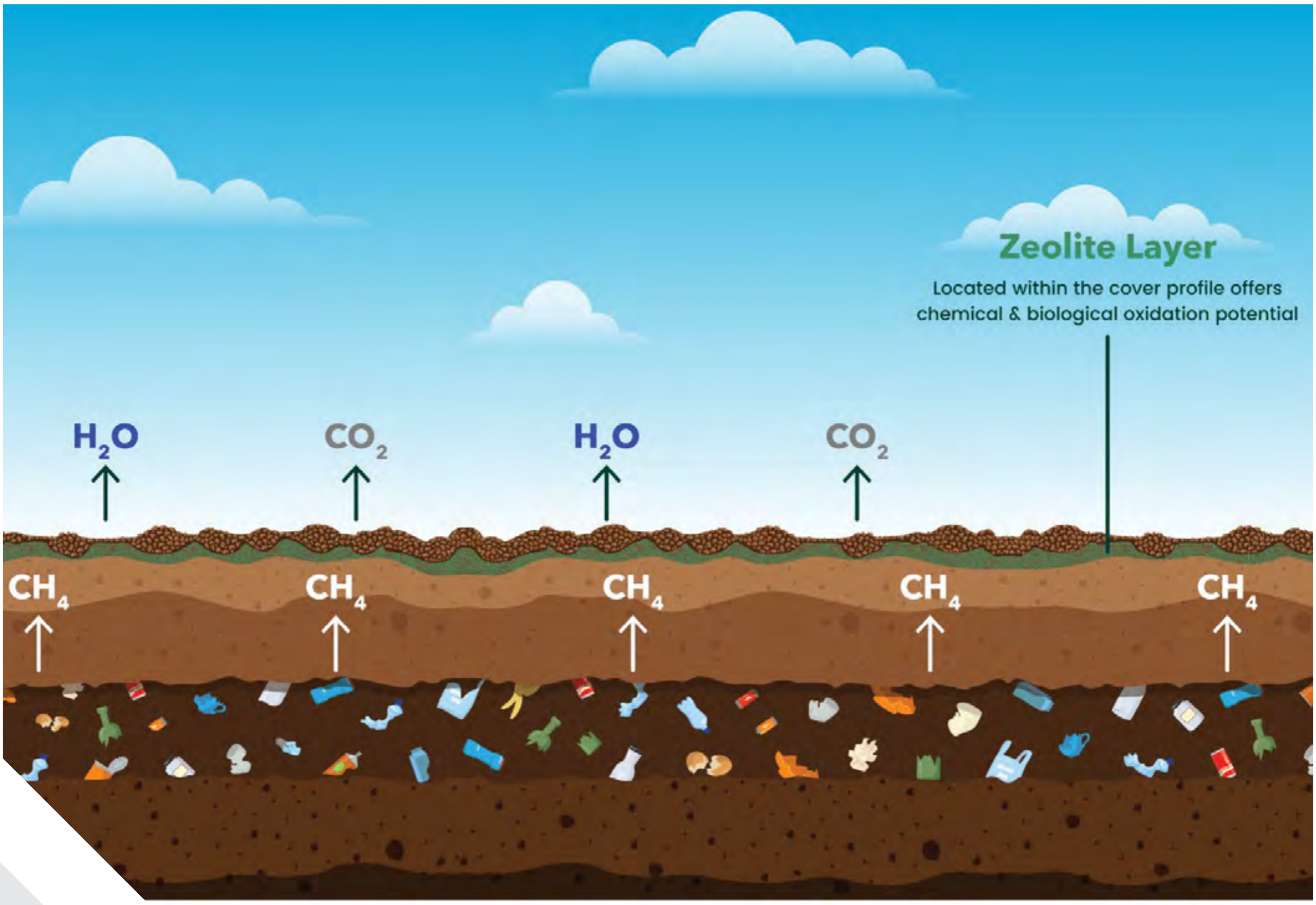
Griffith and Zeotech are already partnering on a substantial program, exploring agricultural applications for the company's manufactured zeolites.

Manufactured zeolites, such as those developed by Zeotech, possess high gas exchange and high surface area, and consequently their application to landfill cover soils could significantly reduce methane emissions by boosting methane oxidation rates through promoting chemical and biological activity in the soils.

Methane is a powerful greenhouse gas with a global warming potential more than 80 times greater than carbon dioxide in the first 20-years following atmospheric release. On 23 October, 2022, Australia pledged to reduce methane emissions by 30 per cent by 2030, as part of the Global Methane Pledge.

The application of a layer of manufactured zeolite to landfill capping soils could function to intercept and oxidise methane emitted from the underlying refuse, thereby reducing GHG emissions.

The new program involves 12 months of multi-stage targeted research to develop and validate the application of Zeotech products for controlling landfill methane emissions.



The research program will also be undertaken in collaboration with Cleanaway Waste Management Limited, Australia's leading waste management, and industrial and environmental services company. The project will incorporate lab-based characterisation and infield trials aimed at establishing scientific and economic validation for potential Zeotech product applications for methane emission control.

Dr Chris Pratt, from Griffith's School of Environment and Science and Australian Rivers Institute, said "We are excited to be working with key partners on such a valuable project which could help a traditionally hard-to-abate problem by reducing greenhouse gas emissions, and potentially support Australia's recent pledge to reduce methane emissions by 30 per cent by 2030."

Dr Taku Ide, Head of Carbon at Cleanaway, added "We are excited to collaborate with both Griffith University and Zeotech to explore new and innovative application of zeolite to reduce fugitive methane from landfills. Success of this research can help Cleanaway deliver on its 1.5°C aligned emissions reduction targets."

Peter Zardo, Managing Director of Zeotech, added "Griffith identified methane control as offering the best near-term opportunity for zeolites to reduce GHG emissions in a carbon-centric scoping study undertaken early 2022 and it's pleasing to attract Cleanaway as an industry collaborator and work together, with Griffith, to develop solutions to tackle methane's impact on sustainability."

DR MICHAEL SIEVERS TALL POPPIES RECIPIENT FOR RESEARCH ENHANCING COASTAL RESTORATION BY INCLUDING ANIMALS

Dr Michael Sievers was named as one of 12 winners in the 2022 Queensland Young Tall Poppy Science Awards for his research into how animals can be better included in environmental restoration projects, their response to environmental change, and how evaluation of their habitat can be improved.

His most recent research in this field has shown how animals can have enormous impacts on coastal restoration, both positive and negative.

Published in BioScience, the authors demonstrate how a broader knowledge of the interactions between particular animal species and restored coastal habitats could be better incorporated into restoration planning, implementation, and evaluations to maximise the success of global efforts to restore coastal systems.

"With ecosystems becoming increasingly lost and degraded, restoration has become one of the key challenges of the 21st century," said Dr Sievers, ARC DECRA Fellow at the Australian Rivers Institute.

"For this reason, numbers of coastal ecosystem restoration projects are increasing, but efforts and investments must be targeted to mitigate and reverse habitat and biodiversity loss most effectively."

One aspect crucial for effectively restoring habitats like seagrass, mangroves, and corals is being largely overlooked, namely the explicit consideration of the role of non-habitat forming animals such as fish, crustaceans and bivalves in the restoration process.

"Restoration without animals is like gin and tonic without the gin; there's something important missing, it doesn't quite work, and it's unlikely to achieve the desired outcome," Dr Sievers said.

Animals can perform critical functions and services within an ecosystem that are essential for the persistence and resilience of the system as a whole and which restorations seek to enhance. Such processes can spur vegetation growth.

"Translocating clams into restored seagrass, for example, can cause seagrass patches to expand to five times the size of those without clams, primarily due to their ability to increase the availability of nitrogen," Dr Sievers said.

"For saltmarshes, placing mussels alongside the transplanted vegetation similarly enhances plant growth and leads to an expansion of the saltmarsh by 50% due to reductions in sulphur and increased nutrient levels."

But it's not all roses; some animals can be bad for restoration. While mega-herbivores like green sea turtles and dugongs can improve seagrass seed germination, they can also detrimentally overgraze seagrasses. On a smaller scale, the presence of lugworms that turn over the sediment can disturb planted seagrasses, the researchers point out.

"When we're armed with this knowledge about animal interactions during the restoration process, we can remedy it. For instance, adding a barrier underneath transplanted seagrass can reduce the interactions between seagrass and the lugworm enhancing seagrass growth by 50-140%."

By identifying when, why, and how to directly incorporate or manipulate animals in coastal restoration, we can improve outcomes for habitat-forming species like mangroves, seagrasses and corals.

By providing a framework to identify and undertake such actions, we hope to encourage scientists and managers to consider animals' contribution for coastal restoration planning, implementation, and monitoring.

CENTRE FOR MARINE & COASTAL RESEARCH

Researchers at Griffith's Coastal and Marine Research Centre (CMRC) are working to create positive solutions for conserving and managing coastal and marine spaces.

"Our work at the CMRC is directed at increasing our understanding of coastal dynamics, water quality, aquatic ecology, human interference and the impacts of climate change, said Professor Rod Connolly, Director of the Coastal and Marine Research Centre, "as well as improving management strategies for urban catchments, floodplains and water resources."

"We aim to put theory into practice for the greater good, using research and teaching programs, community engagement initiatives and partnerships to help communities build coastal resilience, protect their environment and plan for the future."

With more than 50 researchers across 12 specialist teams, the CMRC is a recognised world leader in coastal, estuarine and waterway research and management.

In an era of increasing climate change impacts, one particularly important focus of the CMRC is the positive and negative roles of tropical macroalgae in the functioning of coral reefs.

The CMRC's Coral Reef Algae Lab provides fundamental knowledge on coralline algae, calcareous algae critical to reef building, coral resilience and restoration.

"Our research from the Great Barrier Reef (GBR) informs critical science for the management of the GBR and management strategies for the conservation of reef ecosystems in general," said Associate Professor Guillermo Diaz-Pulido.

"We are driven by broader physiological, ecological, biogeochemical and conservation questions related to tropical macroalgae and coral reef ecosystems."

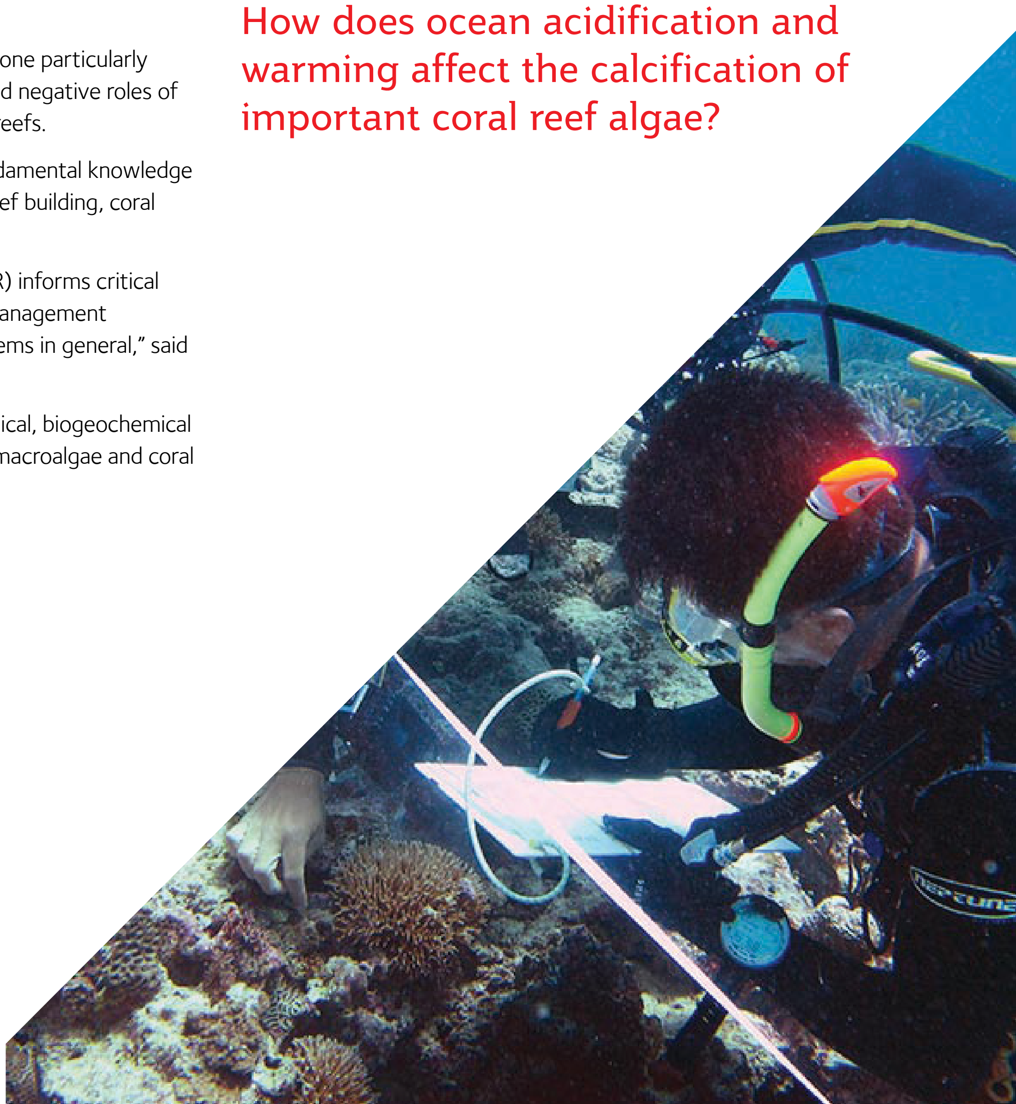
The Coral Reef Algae Lab is answering the following research questions:

Ocean acidification due to increased carbon dioxide dissolving into the water from human emissions profoundly impacts marine systems, particularly coral reefs.

"Our group studies the effect of ocean acidification on fleshy macroalgae and coralline algae in the Great Barrier Reef," said Professor Diaz-Pulido.

"We've found some fleshy macroalgae potentially benefiting from ocean acidification, while coralline algae, which have limestone skeletons, are very soluble in low pH seawater, making them highly sensitive to ocean acidification."

How does ocean acidification and warming affect the calcification of important coral reef algae?



What is the contribution of coralline algae to coral reef growth and resilience?

Crustose coralline algae (CCA) calcifies red algae that contribute to reef resilience by providing cues that enhance coral larval settlement. Coral reef growth and construction depend to a large extent on the ability of coralline algae to calcify and glue (or cement) the reef framework.

“Despite their importance to the Great Barrier Reef, the diversity of CCA species is poorly known,” Professor Diaz-Pulido said. “We are trying to fill this knowledge gap and are finding that this is a highly diverse group, with many new species of algae undescribed to science.”

How does water quality influence macroalgal ecology and coral reef processes?

Competition between corals and macroalgae is intense in coral reefs. Understanding the mechanisms by which corals and algae interact and the drivers mediating these interactions is critical to reef management.

“Our group investigates the spatial and temporal variability in macroalgae, the causes of these distributions under ocean acidification and the effect of varying water quality, and the consequences for reef conservation,” Professor Diaz-Pulido said. “Understanding the ecological dynamics of macroalgae is critical for addressing the causes and consequences of macroalgal blooms in coral reefs.”

How can we use macroalgae to support reef restoration?

The Great Barrier Reef contributes more than $6.4 billion each year to the Australian economy, yet reefs are declining, with modelling suggesting many will soon be lost.

“Our Lab is actively involved with developing and implementing techniques to restore reef ecosystems,” Professor Diaz-Pulido said. “It is well known that many larvae prefer to settle on or adjacent to crustose coralline algae (CCA). We are generating critical information on CCA-larval interactions to optimise the settlement and recruitment of core coral species.” The team is also looking at testing strategies to control macroalgal fouling to minimise competition with the young corals.

Through this research, the Coral Reef Algae Lab aims to understand the causes and consequences of macroalgal abundance in reefs and how human activities affect algae and their interactions with corals.

INTERNATIONAL WATERCENTRE IN 2022

2022 was a year of wonderful highs and sad lows for the International WaterCentre (IWC). With great sadness, we lost our founding CEO, Professor of Practice Mark Pascoe. Many people across these networks have felt the loss of Mark, and of course is felt deeply by our team at IWC. We share a tribute to Mark's contributions to Australia's and the international water sectors in this magazine. We are pleased to announce we are planning an annual networking event in Mark's honour, recognising his love for water people the world over.

There were many achievements by IWC in 2022.

The Water Leadership Program was at full capacity, taking 30 Australian-based water professionals through a journey of developing and practicing leadership skills. IWC also delivered the 6-week online Team Leadership course for Young Water Professionals to three cohorts in 2022, with 80 emerging leaders from across the water industry attending. It is pleasing to see the demand for water leadership skills continue to grow – a recognition of the critical importance of these skills for bringing about positive change. Building on the ten-year success of the Water Leadership Program, IWC is launching our international water leadership "Pathway Program". This tiered program offers low-cost leadership skill development to international water professionals and practitioners, to improve the accessibility to much-needed water leadership courses.

It was a busy year for our Engagement activities, with members of our Queensland Water Modelling Network (QWMN) and the Flood Community of Practice (Flood CoP) programs enjoying reengaging face-to-face after a significantly disrupted 2021. The QWMN delivered 14 community-of-practice events, both online and face-to-face, with a highlight being the event exploring water modelling through an indigenous Australian cultural lens, which was codesigned and led by indigenous water professionals. The partners of the Flood CoP convened a critically important event briefing 30 journalists on the fundamentals of flood management and debunking flood myths – an event that was welcomed by Brisbane's media sector.

The Water and WASH Futures Knowledge Forums program – a partnership between IWC, the Australian Government Department of Foreign Affairs and Trade, the Asian Development Bank, the World Bank, the Water for Women Fund, and the Australian Water Partnership – delivered an online symposium on climate change and water, with more than 800 participants from 90 countries. This was an important lead-in event to the successful in-person Water and WASH Futures conference held in Brisbane in February 2023. This conference was last held five years' ago and there was positive energy among the 415 participants from 55 countries who had gathered to share practices and policies to improve water management, water supply, sanitation and hygiene and work towards achieving SDG6 in the face of climate change. The opening of the conference by Griffith University's Vice-Chancellor and President Professor Carolyn Evans, the Minister for International Development and the Pacific the Hon Pat Conroy, and Australia's Ambassador for Climate Change Kristen Tilley, together with representations from high-level delegations from World Bank and Asian Development Bank, demonstrated the importance of this issue. The plenary panel discussions featured a mix of Australian and international cases to explore the challenges of applying climate science to water management, the need to integrate it with local knowledge, and the critical importance of regulator-service provider relationships in the evolution of climate-resilient water services. More than 130 presentations on critical water and WASH issues were shared, with another 50 posters presented during the inaugural Mark Pascoe Networking and Poster session. The conference was a huge success – with more than 250 delegates staying the full five days – first and foremost enjoying the much-missed opportunity to expand professional networks and learn from others facing similar challenges across the world. The IWC looks forward to the next conference, which Department of Foreign Affairs & Trade has announced will be held in approximately two years.

IWC
International WaterCentre

IWC was also busy with online and face-to-face training courses during 2022. Engagement occurred with four cohorts of professionals from across the Pacific, Asia and Northern Africa, in the Climate Change and Water short courses – a partnership with the Australian Water Partnership (AWP) – and delivered with inputs from academics across Griffith University and partnering institutions. With further support from AWP and the Asian Development Bank, IWC provided an online course in Digital Technologies for a Climate Resilient Water Sector. More than 70 participants from 20 countries in the Asia-Pacific region attended this course, with presenters from Griffith University and the broader water sector in Australia. In partnership with Alluvium and with funding from AWP, IWC co-delivered online and in-person training for national, provincial and district staff from the Department of Water Resources in Lao People's Democratic Republic, as part of the development of an Integrated River Basin Management Plan for the Nam Xam Basin.

Applied research led by the IWC team in 2022 included the completion of five major research projects totalling $3.2 million, funded by the Australian Government Department of Foreign Affairs and Trade. The research projects addressed critical water management, water supply, sanitation and hygiene challenges in Australia's neighbouring countries, and were conducted in partnership with local universities, civil society organisations and governments in Solomon Islands, Fiji, Vanuatu, and Indonesia. The IWC website shares many of the research outputs and includes a combination of journal articles and impactful practice guides and policy briefs (www.watercentre.org/research).

Two large, applied research projects, funded under Australia's Water for Women Fund, will explore water security and sanitation issues in rural and urban populations in several Pacific Island countries. These research projects total $1.6 million and will run until December 2024, and are a significant component of IWC's growing Pacific Water Research Program.

Looking forward to 2023 and beyond, the IWC team started the year by revisiting our strategic directions and goals. Its mission is "Challenging the way people think and act about water to tackle complex water problems". Its vision is "water ecosystems that are healthy and resilient, with sustainable economies and social justice, and in which people enjoy good health and wellbeing and can realise their desired quality of life". IWC will continue to build on strengths and capabilities in Education, Engagement and Training, Research, and share future activities in these areas.

RESEARCH GROUP SPOTLIGHT

ARI-TOXICOLOGY RESEARCH GROUP

Last year was a grim season for sea turtles in Queensland's bay region, with more than ten times the usual number of sick and dying animals – over 100 turtles – pulled from the water.

The Australian Rivers Institute Toxicology Research Group (ARI-TOX) is investigating the potential role of chemical pollution on green turtle strandings on the Fraser Coast following the major flooding events in early 2022.

A mystery disease impacting green sea turtle shells has also been evident since the recent major flood events in the region.

"We are finding a large number of turtles with sections of skin and scales shedding from the upper part of their shell, which has become soft and spongy, and which, in extreme cases, is leaving bones exposed," said ARI-TOX marine ecologist and eco-toxicologist Dr Jason van de Merwe.

"As yet we don't know if this disease or the strandings have a bacterial, viral or parasitic cause or if it is caused by pollutants, or both. If it has a pollutant-based cause, which pollutant is it, and does it just depend on whether that pollutant is present or absent?"

"During large flooding events, chemical pollutants, such as pesticides and industrial chemicals, are often washed into coastal areas, where they can then accumulate in the resident sea turtles. Many of these chemicals have known effects on humans and other animals, so we are investigating how they're contributing to the observed increase in strandings of green turtles."

Researchers at ARI-TOX collaborate with the Department of Environment and Science to capture green turtles foraging in the waters of Hervey Bay adjacent to pollution sources in river mouths and urban outflows while also assessing turtles in the eastern bay areas further away from potential pollution sources. The general health and demographics of the green turtle population were recorded during this sampling, including size and age, indicators of body condition, breeding status. Blood samples were also collected from each turtle; the latter for ARI-TOX to perform a more detailed assessment on health and toxicology.

"Our role is to determine the amount and types of metals, and organic contaminants found in these sea turtles and investigate whether there are any links to the health and demographic data collected," Dr van de Merwe said.

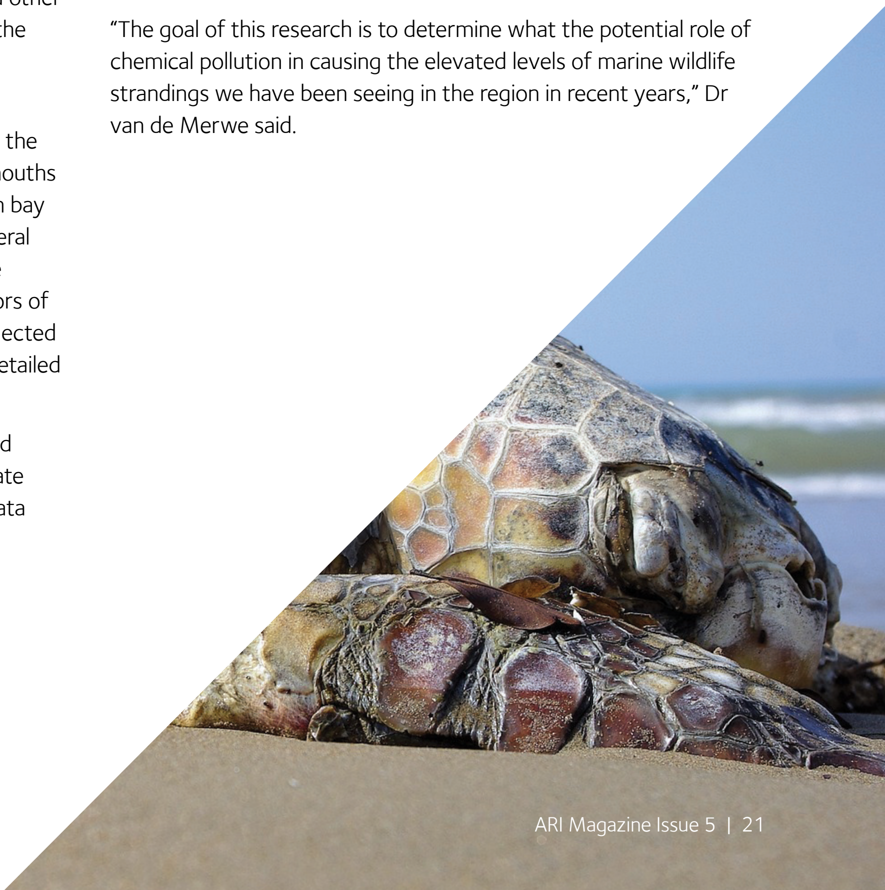
"We measure metals using well-established analytical techniques. However, due to the vast array of organic pollutants found in the marine environment, we measure the toxicity of the blend of organic contaminants extracted from each turtle sampled."

"To ensure that we're testing the specific combination of contaminants built up inside the turtles, we concentrate the mixture of organic contaminants found in a sea turtle blood sample, perform a series of dilutions of this concentrate, and, using a novel sea turtle specific cell-based toxicity assay, exposed turtle cell cultures from ARITOX's Marine Wildlife Cell Bank (http://aritox.com/mwcb/) to this concentration gradient."

"These assays will allow us to understand if the level of pollutants found inside the turtles is toxic to their cells, and if not, how much it has to increase to cause a toxic response."

In a separate component of the project investigating the impacts of flooding on marine wildlife, the ARI-TOX team also collaborates with Sea World and wildlife hospitals to measure the chemical contamination of stranded sea turtles, dolphins and dugongs in South East Queensland.

"The goal of this research is to determine what the potential role of chemical pollution in causing the elevated levels of marine wildlife strandings we have been seeing in the region in recent years," Dr van de Merwe said.



GRIFFITH SEA JELLIES RESEARCH LAB

Jellyfish are renowned for ruining a day at the beach, but there's much more to sea jellies than their painful sting. Jellies are one of the most ancient groups of animals and have been forming blooms in the world's oceans for more than half a billion years.

They are voracious predators of plankton and, in turn, are an important food source for predators including fish, birds and other jellyfish. Because their faecal pellets and carcasses sink, they also help counter carbon pollution by transferring enormous amounts of carbon to the deep sea, where it is locked away from the atmosphere for thousands of years.

The propensity of some species to form spectacular population blooms, and their sometimes painful and occasionally dangerous stings, means that jellies frequently impact coastal industries and people.

The Griffith Sea Jellies Research Lab team focuses on understanding jellyfishes' population dynamics from local to global scales, their responses to changing ocean conditions and their interactions with people and coastal industries.

The Griffith Sea Jellies Research Lab is a unique collaboration between Griffith University and Sea World and one of only a few state-of-the-art research facilities in the world specifically designed for studying jellyfishes. Located within Sea World's 'Sea Jellies Illuminated' exhibit, the glass walls of the lab enable the ~1.6 million people who visit Sea World each year to observe our researchers at work.

The visitors' area outside the lab provides a wealth of information about the biology and ecology of jellies and, in collaboration with Surf Life Saving Queensland, includes information on the beach (and jellyfish) safety.

This unique laboratory offers the public a rare opportunity to see behind the curtain and watch research scientists at work while also learning about the biology of jellyfish.

The Griffith Sea Jellies Research Laboratory is currently working on three major projects aimed at managing interactions between jellyfish, coastal industries, and communities:

- Supported by the Blue Economy Cooperative Research Centre and in collaboration with the three leading salmon farmers in Australia, Tassal, Huon Aquaculture and Petuna, we are using artificial intelligence to create a system that automatically detects incursions of jellyfish into Tasmania's salmon farms.
- At Ningaloo Reef in Western Australia, and with support from The Minderoo Foundation (a philanthropic organisation dedicated to driving change) we are developing methods to detect the environmental DNA of dangerous Irukandji jellyfish. Monitoring the traces of DNA that Irukandji shed into their environment will enable us to better understand where and when Irukandji jellyfish occur, enhancing safety for thousands of people who visit the Ningaloo region each year to swim with whale sharks.
- In collaboration with oceanographers at the University of New South Wales and Surf Life Saving Australia, we are developing a forecasting system that will enable people to avoid beaches that are most likely to be impacted by bluebottles.

The Griffith Sea Jellies Research Lab team focuses on understanding jellyfishes' population dynamics from local to global scales, their responses to changing ocean conditions and their interactions with people and coastal industries.

SOIL ENVIRONMENTAL BIOGEOCHEMISTRY RESEARCH GROUP

The Soil Environmental Biogeochemistry Research Group is currently leading exciting research unravelling how soil carbon responds to warming in fire-affected ecosystems due to climate change.

The three-year Discovery Project funded by the Australian Research Council is a collaboration with institutions in Australia, New Zealand, Germany, the USA and Panama aims to discover the continent-wide pattern of soil carbon response to warming in fire-affected ecosystems across Australia and to reveal the biogeochemical mechanisms underlying fire's role in shaping the temperature sensitivity of soil respiration.

"Fire has modified over 40% of the Earth's land surface, and wildfire frequency is predicted to increase under global warming," said Professor Chengrong Chen, who leads the Soil Environmental Biogeochemistry Research Group and the 4R Waste Hub at the Australian Rivers Institute.

"Australia is one of the most fire-affected countries in the world, and fire intensity and frequency on this continent is predicted to increase under a warming climate."

"Our goal is to use this project to understand how fire changes the flux of carbon from the soil to the atmosphere in a warmer climate, using a multi-disciplinary approach."

The Soil Environmental Biogeochemistry Research Group aims to use this research to improve ability to predict the terrestrial ecosystem-to-atmosphere fluxes of carbon and their feedback to climate under the increasing frequency of fire.

Initial work on the project has seen the group setting up warming chambers in a fire-affected forest site at Peachester State Forest on Queensland's Sunshine Coast, in which the temperatures are adjusted to mimic those predicted under climate change scenarios

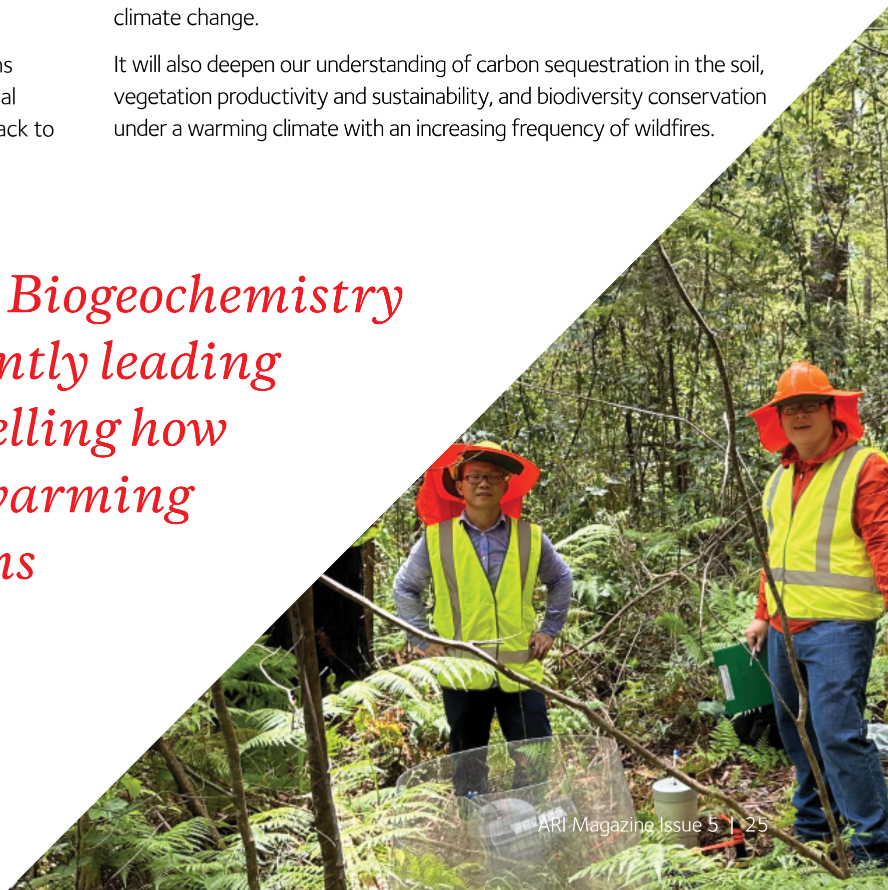
"Inside of these warming chambers we are monitoring a host of soil biogeochemical characteristics to gain a clear and quantitative understanding of the impacts of warming and fire on the soil and the flux of carbon dioxide into the atmosphere," Professor Chen said.

"New knowledge generated from this project on a warming-induced increase in carbon dioxide release from soils in fire-affected landscapes will contribute greatly to current soil carbon and Earth-system models, allowing us to develop more accurate predictions of terrestrial ecosystem-to-atmosphere fluxes of carbon and the corresponding impacts this has on climate change."

This research will help provide the scientific basis for developing sound climate change mitigation strategies and fire management regimes, contributing to social-ecological resilience to wildfire and climate change.

It will also deepen our understanding of carbon sequestration in the soil, vegetation productivity and sustainability, and biodiversity conservation under a warming climate with an increasing frequency of wildfires.

The Soil Environmental Biogeochemistry Research Group is currently leading exciting research unravelling how soil carbon responds to warming in fire-affected ecosystems due to climate change.



IN FOCUS

USING BIOPHYSICAL SCIENCE AND INDIGENOUS KNOWLEDGE TO MONITOR WETLAND CHANGE

Dr Fernanda Adame Vivanco, Senior Research Fellow

Like much of the world, wetlands in Australia face unprecedented challenges due to climate change and other human activities. Invasive species, temperature increases, rainfall variability and water extraction all negatively affect wetland health and people's relationship to the environment.

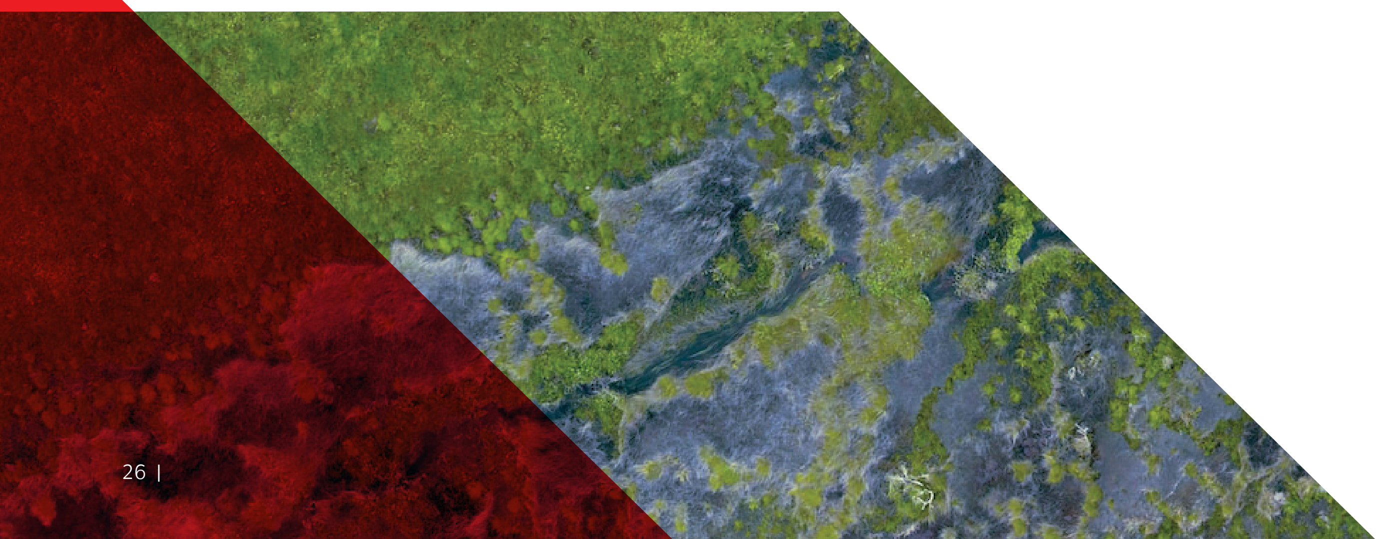
With the health and expanse of wetlands in decline worldwide, there is an urgent need to improve their management and bolster restoration activities. At a minimum, wetlands deemed of international importance under the Ramsar Convention on Wetlands require assessment of their baseline and ongoing monitoring. Satellite Earth Observations and drones can be powerful tools for this type of wetland monitoring. However, they do have limitations when it comes to spatial range and availability over time.

A fundamental way to confront these limitations and help improve the success of wetland management and restoration is to use western scientific analysis of changes in wetland water, soil and vegetation and long-term indigenous knowledge of the landscape that can fill information gaps.

Our current research shows how a spatial imagery visualisation tool that detects long-term (1988 to 2021) changes to wetland coverage, along with indigenous knowledge, can improve our understanding of the baseline wetland conditions, how the wetlands have changed over time, and provide a mechanism for their ongoing monitoring.

In various wetlands around Australia, we compared the results obtained using a spatial imagery tool with the local observations of Traditional Owners. We found that the two forms of information followed similar trends and complemented each other, providing a valuable monitoring tool to manage the problems wetlands like those on Stradbroke Island are currently facing.

Minjerribah (Stradbroke Island), a sand island of high wetland diversity, is the home of the Nunukul, Ngugi and Goenpul people, who have inhabited the island for over 25,000 years. Due to the natural filtering capacity of the island's sand and its healthy wetlands, the water it produces is very high quality, requiring little treatment. For this reason, Seqwater sources more than 50% of the water needed for Redlands Council from Minjerribah, a whopping 8,250 ML every year. With the population continuing to grow, the Elders of Minjerribah are concerned about water extraction's effects on the wetlands. They are especially concerned about those of cultural importance like Bummiera or Brown Lake, one of the few unique dune or perched lakes of eastern Queensland, which they have reported to be diminishing in size.



Our spatial visualisation tool was used to confirm the Elders' observations that the open water area and aquatic vegetation cover of the lake decreased since the Millennium drought occurred in Australia between 2001 and 2009. While Elders suspect water extraction is the primary culprit, it is only one of several possibilities. Recent increases in the lake and vegetation coverage following the heavy rainfalls of the past three years show how difficult it is to disentangle climatic variations from anthropogenic pressures and natural cycles of wetlands. In these circumstances, continuous monitoring of lakes like Bummiera with our visualisation tool is crucial in helping resolve the cause of these changes to the lake and subsequently inform the Traditional Owners of the island on how best to manage their water resources and the appropriate water extraction levels for the island.

This is an example of the concept known as "seeing with both eyes"; the merging of scientific spatial visualisation tools with indigenous knowledge. The combination is a clear example of how lived experiences complement photographic imagery and demonstrates how wetlands have changed in an easily understood visually engaging way. Only after clearly understanding how wetlands have changed and the driving forces behind these changes can we best determine how to act upon the changes, with suggested solutions and long-term ongoing monitoring.

The spatial visualisation tool developed with our partners in Geosciences Australia is a way of addressing the challenges that wetlands are facing in times of climate change. It is a valuable monitoring tool and is an essential early warning of changing water levels and aquatic plant coverage necessary if we are to avoid catastrophic changes in wetlands.

Combining indigenous and scientific knowledge will be crucial to support decision-making around the threats the world's wetlands will face in the near future, the potential solutions to implement, and the subsequent monitoring of any management actions taken to ensure success.

UNCOVERING THE CHANGING RHYTHMS OF RIVERS AND PEOPLE

Professor Sue Jackson

Our worlds are full of rhythms – events that follow a pattern like seasons, tides, work shifts, religious rituals, school holidays. Some of the world's most culturally significant rhythms relate to the movement of water in rivers.

Rivers follow rhythmic changes; they flow with the seasons and respond to longer climatic shifts and often to the actions of people. In turn, people and their societies are shaped by the rhythm of rivers.

This relationship where nature and people's social habits are synchronised with the rise and fall of river water over time is referred to as river rhythmicity, in a new paper that describes the critical implications of this idea for river conservation and water management.

Across the world, rivers are being disrupted and the changes to their flow are causing corresponding changes to peoples' relationships with rivers. Dams have modified the flow regimes of more than 60% of the world's largest rivers by changing the size, frequency, duration, timing, and flow rate.

The river flows used for hydropower are manipulated, or re-scheduled, to coincide with daily periods of high electricity demand by pulsing releases of water downstream of dams. These changing patterns of river flow disturb the river habitat, fish, and plants and can endanger the relationships people have developed with rivers over many centuries.

River conservation and water management need to better understand the relationship between changing water flows in a river and the resultant riparian communities, both human and natural, that make up a dynamic riverscape.

River rhythmicity provides a framework that can unify riparian human communities, academic disciplines from the physical and social sciences and the humanities, and water agencies in approaching the research and management of rivers. It can serve as a lens to better understand how we shape the rivers of the world and, in turn, are shaped by them, revealing the implications of changing riverine rhythms for riparian communities.

In northern Australia, for example, large tropical rivers with rhythmic high-flow pulses, have a greater richness of fish species, a more stable bird population, and elevated rates of riparian forest production than rivers of more arid regions. Great Australian rivers like the Daly (Northern Territory), Fitzroy (Western Australia) and Mitchell (Queensland) receive nearly all their water between November and March, so the life cycles of animals, plants and humans are centred around these flows and rhythmic patterns.

The relationship between large river systems with rhythmic annual floods and biodiversity directly dictates local people's fishing patterns. Indigenous people of tropical Australia obtain a significant proportion of their protein from 'wild foods', including aquatic species. Because the cycles of food collecting for those people participating in customary modes of subsistence are dependent on the water level, it's not a stretch to say the river flow directs the daily rhythm of life in these communities.

Rivers are the seasonal supermarkets of north Australia, accounting for between 13-23% of the food consumed in Indigenous households, but this needs to be accounted for in official estimates of food production and needs to be better protected by water management decisions. Agriculture is often given priority in water allocation decisions, for example when new dams are promoted to grow export crops, but if the relationship between local food security and the rhythmic flow of these rivers was made clearer, we could protect their flows instead of degrading them.

But it's not just First Nations communities who live by and rely on the rhythmicity of rivers. The impacts to changing river flows can be wide-ranging, effecting all river communities and commercial interests downstream, who rely on aquatic foods generated by rivers and their seasonal flows. For example, new research by Griffith University shows that in the Gulf of Carpentaria, the banana prawn and barramundi fisheries, and the broader estuarine ecosystem in general, rely heavily on the flow to the estuaries and floodplains. As the nutrient-poor coastal waters in the Gulf rely on big flooding events to 'recharge' nutrients required for growth and productivity, changes in flows can significantly affect the subsequent year's catches. High-flow years not only carry valuable nutrients downstream, leading to big yields in the following season, it also supports increased growth and productivity for future years.

If governments choose to proceed with major plans to dam and develop the rivers of northern Australia, the drastic changes to the rhythmicity of these rivers could significantly disrupt the livelihoods of many communities who rely on these resources.

Altering the flow of these seasonal rivers through developments like the proposed Hell's Gate Dam or the Bradfield Scheme to divert water to irrigate and drought-proof western Queensland affects not only the resources that the rivers provide but also how people experience an altered riverine environment, and how they interact with the rivers they've known so well, and with their broader community.

River rhythmicity focuses attention on the lived human experience of riverhood. In a recent paper on the topic, we use practical case studies to describe the interconnected rhythmic patterns which shape the lives of river-dwelling peoples across the globe.

For example, the life of Solomon Carriere, a Cree-Métis man from the ice-covered Saskatchewan River in northern Canada, reveals the practical experience of a life lived in rhythm with the rivers of his homelands. In Solomon's father's time, all daily activities were intricately tied to the seasonal ebb and flow of the river, from freezing over autumn to the melt waters of spring.

"My family goes back four generations in this special place, my ancestors much further. My father taught me pima-amat-si-magon, that the water is alive," recalls Solomon.

He and his brothers worked this stretch of river in the mid-1900s. Their life was one of constant movement, being in the right place at the right time to harvest plants, wildlife, fish, and other natural resources that provided a living.

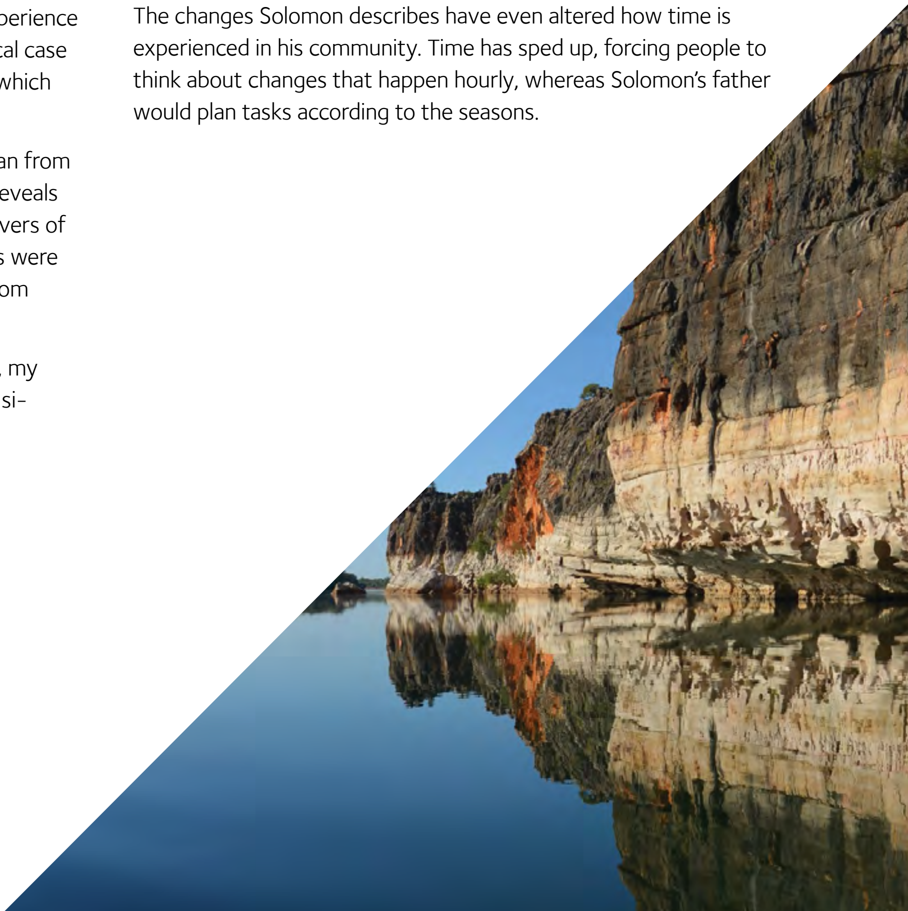
Now with a dam upstream that strategically times the release of water, the rhythm of his ancestors has been completely changed. The daily fluctuations in energy production, and water levels to meet morning and evening peak demands, have eroded the river's banks to a far greater extent than before dams were built, and the change to ice conditions has compromised popular winter activities such as ice-fishing.

"Once winter sets in, we need to deal with ice conditions... But it's now much less predictable," Solomon said. "Water comes out of the dam and either lifts the ice or runs over the top of it. Bubbles weaken it. So, I've gone through the ice several times with snowmobiles or dog teams. I've lost equipment, but gladly not my life."

"In the spring there is still high water, but it depends a lot on how much the dam is letting go. I never know for sure if there'll be enough water to get around... Too high or too little water means I cannot provide for my family.

"In the autumn, we really have to work around the water we're getting (from the dam) ... Sometimes we need to cut day trips short because we might get stuck somewhere."

The changes Solomon describes have even altered how time is experienced in his community. Time has sped up, forcing people to think about changes that happen hourly, whereas Solomon's father would plan tasks according to the seasons.



The life of Lilia Java, a Kokama woman from the tropical floodplains of the western Amazon region of Colombia, near the border with Perú and Brazil, provides another clear example of a life lived in rhythm with the river. She too talks of how changing water flows have affected the river rhythmicity of her people living on the riverbanks of the Amazon and her community's responses.

"Recently, because of climate change and deforestation, the changes in seasons have been more noticeable," said Lilia. "We've had to change our strategies and way of working in our chacras [small agricultural plots]."Changing climate and over-harvesting from the forest have altered the availability of resources for fish and reduced the predictability of crop-growing areas, forcing the community to look elsewhere for arable land and fishing grounds. For Lilia and her community, the regularity of the seasons has changed. The wet months were once reliably from the beginning of November to May, and dry months from May to November.

"In terms of water levels during the year, now we don't have established dates [for low-water and high-water seasons] as we did many years ago," she said.

"We don't have certainty that from May to November will be a [dry] low-water period. The water remains and when it doesn't recede, it harms the river edges and it harms us because in past times when river water receded, the river edges were used for planting crops like vegetables and rice - all short-term crops. These changes have meant that we have to look for other places for planting and even for fishing."

These accounts reveal profoundly rhythmic patterns of peoples' lives and engagements with the river and river-driven fluctuations of the world around them. Speaking to riverine people about their daily lives reveals the constant movement of 'river time', which is made up of regular anticipated events, tasks and routines that respond to periodic changes in river flow.

This type of *'river time'* synchronises communities, creating a shared sense of identity and regulating social life. Solomon and Lilia are embedded in the world in which they live and speak of their rivers as alive, with the capacity to create life.

As Lilia Java explains, "for us, water and land are intertwined, and together they produce life, and it's our own life." For river-dwelling people like Solomon and Lilia any alteration of the riverscape in which they are embedded has the potential to disrupt cycles and cultural practices crucial for the survival of whole communities.

These individual stories highlight how activities such as dam construction, climate change and deforestation can disrupt the rhythmicity of rivers for surrounding communities, both natural and human, by inducing significant and catastrophic changes in river flows and markedly reducing the regularity of seasons.

Their accounts illustrate the irreplaceability of riverine rhythms and the strong desire of riparian communities to maintain and centre relationships with rivers forged from generations of observation, engagement and communal practices of care and reciprocity.

A renewed attention to river rhythmicity is necessary to reveal the intimate relationships between people and rivers that persist and evolve despite disruptions caused by dams or other changes to river flows. This type of local and diverse knowledge is vital if we are to foster more sustainable relations with rivers.

An approach centred on river rhythmicity can enhance the research dialogues crucial to that endeavour and provide a fuller understanding of the dynamic interactions and riverscape features that are highly valued by local communities.

DAMS AND THE FALSE SENSE OF WATER SECURITY

Professors Fran Sheldon and David Hamilton

Talk of 'big dams' to ensure water security, and 'unlock regions' to increase agriculture, has started again with the proposed $5.4 billion Hells Gate Dam on the upper Burdekin River in Queensland, and the upgrade or replacement of Dungowan Dam, in the Peel River valley near Tamworth, New South Wales. So, what is our interest in these dams and why are they staggeringly expensive? The damming of rivers to meet human water, energy and transport needs is nothing new and has occurred at different scales for millennia. While ancient dams were small earthen-walled structures, the modern versions are often concrete engineering behemoths.

The age of modern dam building peaked in the 1970s and has resulted in more than 50,000 dams of heights greater than 15 m, controlling more than 15% of the world's annual runoff and holding back more than 6,500 km^3 of water. The history of dam building in Australia follows this global trend. Nearly all of Australia's large dams were constructed between 1950 and the early 1990s, consistent with global trends, and no large dams were completed after 1995. The construction slowdown reflects the reality that nearly all 'suitable' sites for large water storage are used. Most large water storages on the eastern coastal fringe are for urban water supply and hydropower, with some capacity for flood mitigation. West of the Great Dividing Range, dam infrastructure focuses less on water supply for urban settings and more on water supply for irrigated agriculture. This latter focus has proved particularly problematic for many regions over the last 20 years, with many water storages in the northern Murray-Darling Basin, for example, struggling to maintain water supply during the Millennium Drought, a situation likely to repeat as the climate becomes more variable.

Research across the globe demonstrates enormous environmental impacts from dam construction, including huge greenhouse gas emissions as methane is released from flooded areas.

Dams are environmentally catastrophic for rivers. Constructing a dam on a river completely changes all aspects of the river system; its flow regime, sediment transport dynamics and ecosystem processes, resulting in marked changes in biodiversity. As with nearly all river systems globally, and in Australia, impacted by dams (large and small), it is no wonder freshwater environments are the most threatened of all ecosystems; dams and other diversions frequently fragment their continuous connection of upstream to downstream. A dam causes both upstream and downstream impacts. Upstream, the once-flowing riverine environment is turned into a deep lake, a hostile environment for many riverine organisms. Downstream, the river is often 'starved' of its flow, artificially increasing the duration of low-flow conditions, a situation exacerbated by high rates of evaporation when water is stored in the reservoir area behind a dam. Dams trap sediment and nutrients, creating an often-impassable barrier for many freshwater organisms. Research across the globe demonstrates enormous environmental impacts from dam construction, including huge greenhouse gas emissions as methane is released from flooded areas. These impacts are legitimised by weightings towards the social and economic gains purported by dam construction.

Hells Gate Dam project

The Hells Gate Dam project proposes a 2,100 GL dam on the upper Burdekin River, 120 km northwest of Townsville. The rationale for the construction of the dam includes ensuring water security for north Queensland and opening up more than 60,000 hectares of land for irrigation. The Burdekin River basin covers 133,600 km^2 of the northeast coast drainage division, 90% of the catchment is already used for agriculture, with surface water supporting a small irrigation industry dominated by sugarcane and horticulture. There are already two significant surface water storages within the Burdekin catchment; Lake Dalrymple, formed by the Burdekin River Dam, and Lake Eungella on the Broken River, a tributary to the Burdekin River. The Hells Gate Dam project would disrupt the current hydrological conditions in the Burdekin River, including its irrigation industry, by storing a portion of the water that currently flows down the Burdekin and into the Coral Sea and turning it west into the upper catchments of the Flinders and Thomson Rivers.

Hells Gate Dam is one component of the controversial 'Bradfield Scheme' debated for over 80 years. Initially proposed in 1938, the Bradfield Scheme includes a system of pipes, tunnels, pumps, and dams to divert river water from the tropical north across the Great Dividing Range into the rivers of inland Australia. The underlying premise of the Bradfield Scheme is that it would increase water security in northern Australia and support inland agricultural production. However, any analysis of the implementation of the Bradfield Scheme in its entirety has generally concluded that the economic costs of building the scheme far outweigh any benefits received in agricultural production, even without including the adverse environmental outcomes of such a project. Although the Hells Gate Dam project proposes to feed water west using gravity rather than the cost-prohibitive option of pumping water over the Great Dividing Range, this will still require tunnels and pipes – expensive engineering options. Any water moved west of the Great Dividing Range moves into more semi-arid landscapes where a large proportion of natural flow is lost to evaporation or soaked up by floodplains and wetlands. In other words, the water diverted inland from the proposed Hells Gate Dam would need to be piped to exactly where it is required or there would be gross losses in transit

With climate variability increasing and water storages often reaching dangerously low levels, it is often tempting to think that building more storages or increasing the volumes of current storages increases water security. There are, however, inherent problems in this logic. Our water storages are most vulnerable in times of drought – as seen by the exceptionally low levels of storage (<15%) in many of the dams of the northern Murray-Darling Basin in early 2020 after a period of the lowest rainfall on record. Drought is somewhat unpredictable and often takes hold by stealth. Hydrological drought (reductions in river flow and, thus dam inflows) often lags meteorological drought (the reduction in rainfall). Often, by the time drought is officially declared, storages are less than 50% full. So, in a modern context, we should not continue to rely on water held in storage for water security. Instead, we must consider other options, including water recycling and desalination for coastal areas.

The debate around Hells Gate Dam, the Bradfield Scheme and other large dam projects will continue. In December 2022 the Queensland Government released a report commissioned by an independent expert panel chaired by Professor Ross Garnaut, on to the viability of a modern Bradfield-like scheme. The report concluded that is not enough consistent flow of water to support the Bradfield scheme, and that the costs far exceeded the benefits. While other options will be explored to increase regional development associated with water reliability, we should also learn from past projects; the Ord River irrigation scheme was another project designed to enhance water security and expand irrigation in northwest Western Australia. However, despite a cost of $2 billion, the project supports just 260 jobs, and the unique riverine ecosystem of the Ord River has been changed forever; a cost that is never included). Globally, the United Nations now recommends that dam construction places environmental and social factors on an equal footing with traditional technical, economic, and financial factors and recommends full participation of stakeholders to increase transparency. As river scientists, we hope these new dam-building discussions can incorporate an ecosystem lens

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RESPONDING TO FLOODING AND EROSION IN OUR CATCHMENTS – BUILDING CATCHMENT RESILIENCE

Recent extreme weather events, including flooding in Lismore and many parts of the east coast of Australia, have reinforced the vulnerability of many of our catchments to these events. A major problem has been that many headwater catchments are in poor condition from land clearing and sediment legacies, making streams and rivers 'flashy', sediments easily eroded, and nutrients readily conveyed downstream into sensitive receiving waters.

Countering these problems is not easy and has been a focus of integrated catchment management plans over some decades, but the outcomes have been patchy and recent extreme weather is demonstrating a need for even more investment, but smartly targeted at the most problematic areas.

"The processes of river and catchment degradation and effective on-ground management actions are well understood, but we need to move beyond the current incremental 'project by project' approach and develop coordinated, catchment-scale strategies that optimise investment, achieving multiple benefits for the least cost," said Professor David Hamilton, the Director of the Australian Rivers Institute.

Professor Hamilton emphasises an alignment of Building Catchment Resilience with many of the issues raised in the State of the Environment report released in 2021, which identified a lack of confidence in water system management and a persistent problem with quantying and implementing restoration efforts that have multiple benefits for productive agricultural landscapes, biodiversity, carbon sequestration, water management and socio-cultural wellbeing.

The Australian Rivers Institute, working alongside partners Queensland University of Technology (QUT) and Water Technology, have developed a tool that seeks to address many of these issues. The development of the tool has been funded by the Potter Foundation and has also been supported by the Queensland Government, Port of Brisbane, Lockyer Regional Council, Healthy Land & Water, Seqwater and Urban Utilities.

Building Catchment resilience is a data-driven, investment decision-making tool designed to optimise investments in catchment restoration. It uses recent advances in geospatial systems to input land, water, and economic data, and explore options for river and catchment rehabilitation to reduce erosion and associated pollutants, minimise flood risk and capture co-benefits such as carbon sequestration, and improvements in biodiversity and stream health. Importantly, and using advanced visualisation software developed by the Viser Lab at QUT, the tool provides stakeholders with an opportunity to have an interactive and immersive experience in the catchment. This is important for building consensus among stakeholders who may have different priorities in terms of the outcomes they seek from restoration actions.

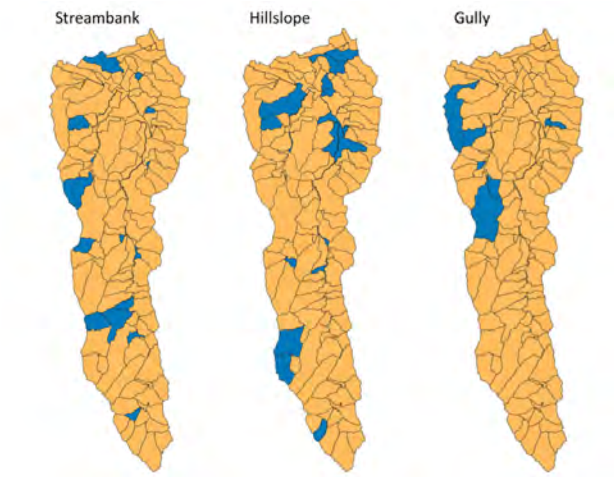
Application of the tool

The tool has been applied to the flood-prone Laidley Creek catchment, southeast Queensland. This catchment suffered a devastating flood in 2011, with severe environmental, social and economic consequences.

"The benefits and costs of each management action in the catchment are quantified and visualised to illustrate the trade-offs between key objectives, with selected solutions spatially represented in optimal scenario maps," said Professor Bunn, who foresaw the value of a tool that could optimise investments in catchment restoration and demonstrate the relationship of upstream and downstream areas in a catchment for a range of stakeholders.

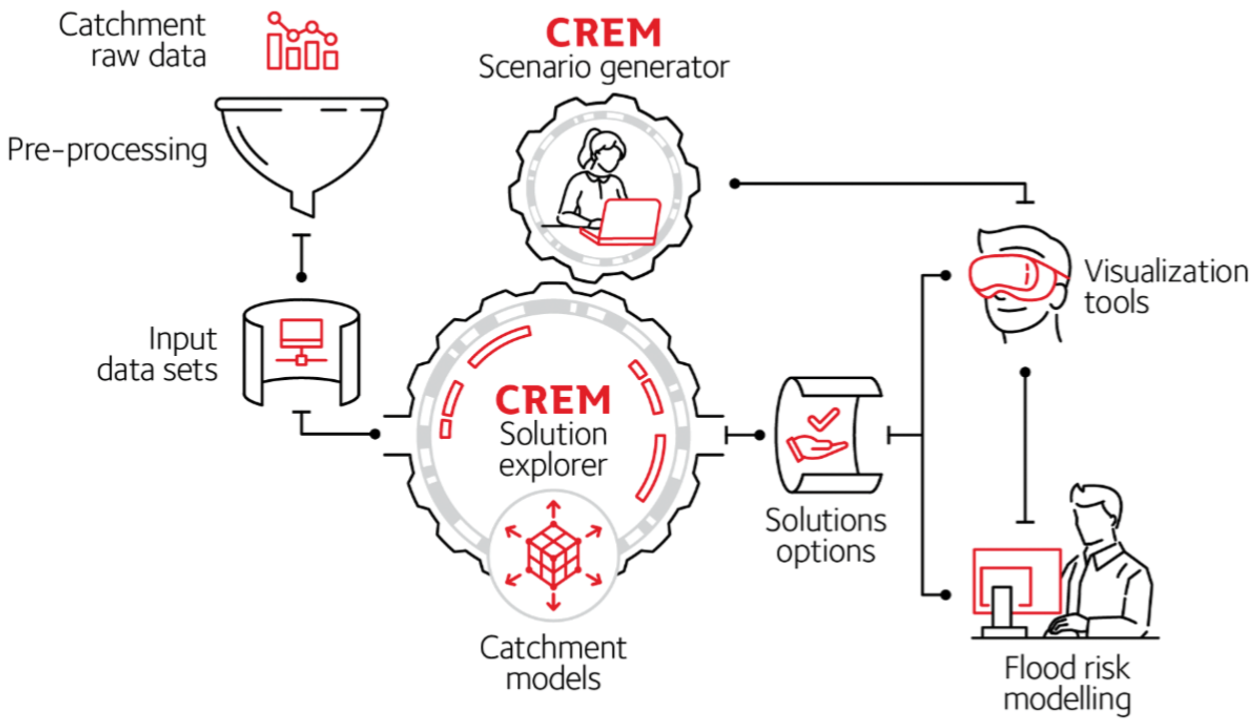
The result is a range of possible areas, broken down by sub-catchment or planning unit, in which different management actions are implemented for hillslopes, gullies and streambanks.

The Building Catchment Resilience project has recognised the need and value of an interdisciplinary team to advance current approaches for visualisation and communication of modelled data for environmental management options.



Map of the Laidley catchment in South East Queensland, showing 174 planning units in the 3862 km^2 area of the catchment with those in blue representing optimal areas where restoration of streambank, hillslope or gully could occur for a specific restoration cost.

Additional information can also be found on the Building Catchment Resilience website (www.catchmentresilience.org).



Decision support framework for the Building Catchment Resilience tool. Input data sets are developed using modern geospatial tools to drive a Catchment Resilience Exploration Modeller (CREM). The CREM tool provides hundreds of possible solutions for achieving optimised outcomes for restoration cost and retaining nitrogen and sediment on land. These solutions can be explored and specific scenarios of interest generated according to their priorities. The scenarios are visualised and can be tested for their benefits in reducing flooding.

RESEARCH HIGHLIGHTS

MEETING OF THE WATERS: BLENDING TRADITIONAL KNOWLEDGE WITH BIOPHYSICAL SCIENCE OF A RIVER

Dr Ben Stewart-Koster, Senior Research Fellow

Griffith University researchers partnered with Traditional Custodians to tell the story of how science interweaves with the Traditional Knowledge of Wawu Budja (the Mitchell River).

The Mitchell River Story Map, a collaboration between researchers with the National Environmental Science Program (NESP) and the Mitchell River Traditional Custodian Advisory Group (MRTCAG), is an innovative and accessible way to bring together the latest research on the Mitchell River with the cultural knowledge of Gugu Yalanji seasons.

“Scientific approaches can teach us how these ecosystems function, but often our science is only ‘new knowledge’ if we ignore the wealth of traditional knowledge that has existed for thousands of years,” said Dr Ben Stewart-Koster, project lead at the Australian Rivers Institute.

“In this project, powerful relationships were developed with the project leaders, which enabled us to draw on the Gugu Yalanji knowledge, values and wisdom that is essential for the advancement of water science on Wawu Budja,” said Dr Ruth Link, Chairperson of MRTCAG, lawyer and Gugu Yalanji woman.

The clans of the upper and middle catchment of the river, the Western Gugu Yalanji, Mbabaram, Wokomin and Kuku Djungan, are represented by the Mitchell River Traditional Custodian Advisory Group (MRTCAG) and the Traditional Custodians of the lower catchment are the Kokoberra, Yir Yoront (or Kokomnjen) and Kunjen clans.

The environmental, cultural, and economic values of the Mitchell River catchment in far north Queensland and the pressure for river development, with proposed dams, irrigation expansion and other forms of agriculture, has made it the focus of environmental research for decades.

Dr Stewart-Koster and Dr Link point out that past research hasn’t always been so integrative or made available in a format relevant to the people who need it for decision-making.

“Historically, scientific research has ignored First Nations people, which has excluded traditional knowledge and cultural values from decision-making processes,” Dr Link said.

“MRTCAG wants to work with western scientists like NESP and Australian Rivers Institute to make sure the knowledge and solutions make spiritual, economic, scientific, cultural, social, political, and emotional sense for current and future generations.”

The Story Map format presents findings about the environmental water needs for the Mitchell River in a user-friendly way, with Traditional knowledge of the Gugu Yalanji seasons at the heart of the story.

Dr Link stated that MRTCAG seeks to help scientists “respect and understand the complex knowledge of our deep understanding of place and our commitment to living according to the five seasons.”

“We aligned the knowledge systems around stories of floods, climate change and dams, the links between the latest research on algae as the powerhouse of Gulf wetlands/rivers and coastal productivity for fish, prawns and migratory shorebirds, and details how a healthy Mitchell River ecosystem delivers millions of dollars to the economy,” Dr Stewart-Koster said.

The dynamic web-based interface includes:

- maps of floodplain inundation over the past two decades
- models of rates of algal productivity which can tell us how much food is available for fish and other animals
- food web analyses showing what foods invertebrates and fish eat, and where the aquatic ‘supermarket’ is, and
- models of fish movement across the catchment

The research findings are accompanied by Yalanji designs from Natarsha Bell that manifest the traditional knowledge articulated in the story map.

“Each of these designs was developed by Natarsha to reflect the hearts and minds of the lead researchers who published the findings told in the story map,” Dr Stewart-Koster said.

“Most importantly, the story map shows the power and the value of traditional knowledge and western science.”

“It shouldn’t surprise us when scientific findings are closely aligned with what Traditional Custodians know, since they have been studying their Country for over 60,000 years.”

For the Gugu Yalanji, western science needs to investigate and examine how to live according to the seasons.

“The cultural knowledge of Gugu Yalanji, Mbabaram, Wokomin and Kuku Djungan is invaluable to NESP research projects as solutions are holistic and address [both] the science questions and the need to heal Country,” stated Dr Link.

“At MRTCAG we refer to Dr Stewart-Koster as Guyu, which in our language refers to the catfish. The catfish is our people’s favourite fish.”

“As NESP’s science leader on the Mitchell River, Dr Ben Stewart-Koster has taken the time to understand our relationship with NESP and western science and has taken the time to develop a strong relationship with us through truth-telling and by not focusing on western concepts of time.”

“These powerful developments are leading to the synergy of western science and cultural knowledge that will benefit the health and well-being of Wawu Budja within seven generations. A journey we, as First Nations people, are committed to.”

UNRAVELLING HOW CLIMATE, POLLUTION AND RUNOFF COMBINE IN COASTAL ECOSYSTEMS

Associate Professor Chris Brown

“With the onset of climate change, coastal and marine ecosystems are threatened on more than one front from stressors such as rising ocean temperatures, poor water quality and pollution.”

Griffith University researchers are unravelling how stressors like climate change, pollution, dissolved nitrogen, and sediment from run-off are having combined effects in coastal ecosystems.

Two studies published in Ecology Letters and Proceedings of the Royal Society B reveal combining increasing ocean temperatures, pollution or dissolved nitrogen with the reduced light caused by sediment in the water can either amplify or reduce the impact of these stressors individually on seagrass or algal growth.

"Crucially, we show that the combined effects on seagrass and algal growth can vary significantly dependent on the amount of the two stressors and duration of exposure," said Dr Mischa Turschwell, Adjunct Research Fellow at the Australian Rivers Institute.

"With the onset of climate change, coastal and marine ecosystems are threatened on more than one front from stressors such as rising ocean temperatures, poor water quality and pollution."

"To effectively look after these coastal ecosystems, managers need a thorough understanding of the effects these human-induced changes have, both individually and in combination."

Associate Professor Chris Brown, head of the Seascape Models group at the Australian Rivers Institute and the Coastal and Marine Research Centre, lamented that "to-date most attempts to discover how such stressors interact, using data pooled from multiple studies, have failed to find consistent predictions for combined effects."

"Few generalities for the combined effects of these stressors have been seen, with meta-studies based on multiple pasts studies on the same stressors often yielding conflicting results."

With far too many potential stressor combinations for researchers to ever hope to measure them all, accurate models are needed that can predict how potential environmental stressors interact.

The team built a model to predict how temperature and light interact to affect seagrass photosynthesis and growth, including an animal that consumed the seagrass.

"Using the model, we assessed the combined effect of both the temperature and the light in the water, altering the amount of both and how long they were exposed for," Dr Turschwell said.

"Surprisingly, our model revealed how combining the same two stressors could amplify or mitigate their individual consequences for seagrass growth.

"The combined impact on seagrass relied heavily on the changing amounts of the stressors. For example, when higher levels of light loss were combined with temperature, the interactive impact became stronger.

"When organisms that eat seagrass were added to the model to better simulate real life systems, the combined effect temperature and loss of light on seagrass growth changed yet again."

To determine if these models are a true indication of what happens when water quality stressors are combined, PhD candidate Olivia King conducted experimental studies on the interactive effects of three common stressors; a herbicide (diuron), dissolved inorganic nitrogen and reduced light (due to sediment).

Pollution in coastal water, such as herbicides in runoff from agriculture and sediment from erosion can affect the growth of important algae species.

"Our results confirmed the complexity of multiple interacting stressors on these coastal ecosystems," Ms King said.

Similar to finds using the model, Ms King's study of multiple stressors like diuron and reduced light could either amplify or reduce their individual effects, depending on the changing amounts of these pollutants, how long they're exposed, or the biological response being looked at.

"This research clearly shows why it has been so difficult in the past to get a clear picture of how more than one stressor interact, because their combined effect can vary with factors like duration and the amount used."

"To develop consistent patterns of these interactions we need to learn how stressors change with context and develop experiments accordingly that run over extended time scales, with treatments across gradients of stressor levels."

There is an urgent need to better understand the combined impact of the multiple simultaneous stressors affecting the marine environment in order to provide useful predictions on the highest priority stressors for managers of marine ecosystems to tackle.

"Water quality on the great barrier reef, for example, is managed using guidelines that currently only consider one pollutant at a time," Associate Professor Brown said.

"Our work shows the need, and process for, updating water quality guidelines for the Great Barrier Reef and other important ecosystems to account for the amplifying effects of multiple pollutants.

"Similarly, the combined effects of pollutants and increasing warming clearly indicate that water quality guidelines need to consider how increasing levels of climate change will interact with pollution."

The authors suggest that combining experimental studies with models is the best way to understand how multi-stressors combine to impact coastal ecosystems.

TAKING A BIOCHEMICAL SNAPSHOT OF SEA TURTLE HEALTH

Dr Steve Melvin, Research Fellow

New Griffith research is using biochemical profiles from the blood of sea turtles as a tool to monitor the health of populations in the wild.

Published in Comparative Biochemistry and Physiology, the researchers used metabolomics, which measures the by-products of physiological processes, to determine if environmental conditions or the way in which they were captured can affect their health.

"As iconic but threatened species, there is considerable interest in adapting cutting-edge analytical techniques to evaluate the health of wild populations of sea turtles," said Dr Steve Melvin a Research Fellow at the Australian Rivers Institute.

"Nuclear magnetic resonance spectroscopy is a powerful technique that can provide a metabolic fingerprint of the physiological processes taking place in an animal. It gives a direct indication of an organism's health and how external conditions influence an animal's physiological response.

"Being non-lethal, metabolomics provides an attractive method for comparing populations of threatened species like sea turtles, and to understand how the environment they are living in impacts their health. However, few studies have used this method to evaluate wild populations of sea turtles."

This study is the first to compare the biochemical profiles of resting and active turtles from coastal and reef locations, sampled across multiple seasons in Southeast Queensland.

"Our results show clear differences in the chemical fingerprints of turtles living in different locations, which can be attributed to varying diet or forage quality and potentially different levels of exposure to stressors like chemical contaminants between coastal and reef sites," Dr Melvin said.

"We also observed clear markers of physical exertion in animals captured while active, using a method called the 'rodeo' technique, which was absent in turtles sampled while resting."

Turtles sampled from one location over 8 months had only modest differences in the metabolome over time, suggesting the technique is flexible and not prone to confounding factors.

"When evaluating the health of sea turtles, or other marine creatures in the wild, site characteristics like the quality of an animals' food source, the amount of pollution and whether they are resting vs active appear to have a far bigger influence on turtle physiology than the effect of seasonal changes," Dr Melvin said.

"Our study offers a real-world example of how an untargeted metabolomic technique, which provides a non-invasive snapshot of physiological health, can contribute towards the monitoring and management of sea turtle populations and serves as an example for the monitoring of other marine megafauna species across large areas and time scales in the wild."

This study is the first to compare the biochemical profiles of resting and active turtles from coastal and reef locations, sampled across multiple seasons in Southeast Queensland.

SWITCHING TO A TERRESTRIAL FERAL PIG DIET HELPED BOOST CROC NUMBERS

Professor Stuart Bunn

New research suggests that a growing feral pig population supported the conservation success story of one of Australia's largest carnivores, the estuarine crocodile.

Griffith University researchers contributed to the study published in Biology Letters which compared the diet of present-day crocodile populations in Kakadu and around Darwin with that of museum specimens collected in the same area ~50 years ago.

Professor Stuart Bunn, said "the museum specimens were collected at a time when the crocodiles had been heavily hunted and their population was extremely low."

The research suggests the hunting pressure that removed crocodiles from the river and floodplain systems, meant those remaining fed predominantly on marine prey. But results show over the last 50 years that there has been a significant, clear-cut shift in preference within the estuarine crocodile population in the Northern Territory, away from marine food webs.

"As the crocodile population has recovered, they've moved back into the extensive river/floodplain systems in the Northern Territory and now seem to be much more dependent on terrestrial prey," Professor Bunn said.

"Competition for food resources within the recovering crocodile population, together with an increase in hoofed animals like feral pigs on the floodplains, are likely key drivers of this dietary shift.

"Without the local surge in feral pig abundance over the last 50 years and the crocodiles' shift in diet, the substantial growth in their numbers would not have been possible."

The work is based on a comparison of the carbon and nitrogen signatures in the bones of museum specimens with those of present-day animals.

"We measured the naturally occurring carbon and nitrogen isotopes extracted from the crocodile's bones and other tissue which are derived directly from the animal's diet," said Professor Bunn. "This gives truth to the old adage 'you are what you eat'."

"Crocodiles in the Northern Territory today had significantly lower values of both carbon-13 and nitrogen-15 isotopes, reflecting a shift from marine food sources to terrestrial prey.

"Stable isotope analysis is a very powerful tool to understanding not only animal diets, but also the overall flow of energy in food webs within and between aquatic and terrestrial ecosystems."

Given the growth in crocodile numbers and biomass in the Northern Territory, the authors suggest they are helping to control the feral pig population in that state.

"At the same time, these apex predators are increasing the flow of land-based nutrients into the river, floodplain and estuarine aquatic ecosystems," Professor Bunn said.

This study highlights the significance of prey availability in contributing to large carnivore population recovery.

"Without the local surge in feral pig abundance over the last 50 years and the crocodiles' shift in diet, the substantial growth in their numbers would not have been possible."

“With large-scale regeneration projects being extremely costly and labour intensive, natural regeneration, where the vegetation regrows via the seeds already stored within the landscape, can be a cost-effective alternative approach to restoring large agricultural areas.

RESTORING ABANDONED AGRICULTURAL LAND IN THE MURRAY-DARLING BASIN

Dr Peta Zivec, Adjunct Research Fellow

A Griffith study has found the amount of diverse seeds stored in abandoned land in the Murray-Darling Basin (MDB) and essential paddock trees, make the region highly resilient to agriculture.

Published in Restoration Ecology, the study investigated the ability of semi-arid landscapes in the northern MDB to store seeds in soil seed banks, animal scat and in leaf litter and assessed the species richness, abundance and composition of these seed banks.

"Restoring abandoned agricultural lands is vital for the Murray-Darling Basin to revive the key ecological functions and services the river and its surrounding regions once provided," said Australian Rivers Institute former Adjunct Research Fellow, Dr Peta Zivec, who recently took up a postdoctoral research position with the Swedish University of Agricultural Sciences.

"With large-scale regeneration projects being extremely costly and labour intensive, natural regeneration, where the vegetation regrows via the seeds already stored within the landscape, can be a cost-effective alternative approach to restoring large agricultural areas.

"Our research shows that in the northern MDB, stored seed banks are important contributors to the natural regeneration of farmland, primarily for understory and midstory plant species, but less so for taller trees."

The seeds essential for natural restoration to occur can be stored in various seed banks within the landscape. This study reveals how the key seed banks of soil, leaf litter and animal scats, contribute differently to the regenerative capacity of land once used for agriculture.

"Soil as a seed bank stored the most diversity of species out of the three seed bank types, although these were dominated by annual herbaceous species, plants with few woody parts," Dr Zivec said.

"Animal scat contained high numbers of germinated seedling, indicating that native animals in the region like kangaroos and emus play a key role in transporting seeds in these semi-arid landscapes.

"While leaf litter had the highest abundance of tree and shrub species of all the seed banks, making it an important source for the regeneration of woody vegetation, the actual number of tall tree seeds was very low."

The sparsity of overstory tree species in these seed banks and the fact that very few tree seedlings germinated stresses the crucial role that established vegetation, such as paddock trees, play as a seed source for natural regeneration and their key contribution to the overall biotic resilience of the landscape.

"When attempting the natural regeneration of abandon farm landscapes, it is, therefore, essential to protect and enhance existing vegetation and paddock trees as a constant source of fresh seed for taller trees in regenerating areas," stated Dr Zivec.

EARLY CAREER RESEARCH SPOTLIGHT

EARLY-CAREER RESEARCHER, DR CAITIE KUEMPEL

ARI Early Career Researcher and Lecturer, Dr Caitie Kuempel is a conservation scientist who is using her interests in sustainable seafood, land-sea interactions, and conservation planning to find ways to meet the needs of a growing population while minimising impacts on the environment – particularly the oceans.

From paleontology to conservation

Despite growing up in the middle of the United States, I have always been fascinated by the ocean. Being far from any modern-day oceans, initially, my research focused on the next best thing, oceans of the past. During my undergraduate degree, I explored the speciation in Diploria – a type of brain coral found in the Caribbean, a painstaking task that involved hours in a geology lab cutting thin sections of coral and carefully measuring the dimensions of the features of each sample.

While interesting, lab work and I were not compatible. After a 3-month summer field course in Friday Harbor, Washington, immersed in the marine environment, there was no looking back – I'd found my calling.

In my Master's degree, I analysed herbivore dynamics on coral reefs off the Caribbean coast of Panama – coincidentally, where the fossil corals from my undergraduate research were collected. It was everything I hoped it would be. I loved the reef ecosystem and being in the water. My time in this environment stirred a shift in my research interest towards trying to help ensure that ocean ecosystems were adequately protected and effectively managed into the future.

A PhD in conservation at The University of Queensland (UQ) exposed me to the support of great mentors and colleagues in this field. Through this, I gained invaluable experience across many scales of spatial planning – from measuring progress towards international policies to on-the-ground prioritisation exercises in Indonesia and Papua New Guinea.

I returned to the United States for a postdoc at the National Centre for Ecological Analysis and Synthesis, where I strengthened my data, and open science skill sets by tackling pressing challenges related to food production and the environment. Here, I developed a clear passion for research that better quantifies and enhances our understanding of how humans impact our environment and helps identify efficient solutions for both nature and people in this changing world.

This realisation sent me back to Australia for a position with UQ and the World Wildlife Fund that combined these passions, developing the research agenda and management and evaluation framework for the Coral Reef Rescue Initiative (CRRI). CRRI works across seven countries (Indonesia, the Philippines, Cuba, Fiji, Tanzania, Solomon Islands and Madagascar) that have reefs identified as less vulnerable to climate change. Due to their importance for future coral reef populations, my work aimed to better protect and manage these reefs while strengthening community resilience through diversified skills and livelihood opportunities in the face of a rapidly changing climate.

A desire to build my own research group and teaching portfolio led me to my current position at Griffith University with the Australian Rivers Institute. With my developing research group, the Conservation Action Team, I hope to create a network of quantitative scientists that synthesise new and existing data to quantify the what and where of human impacts to help prioritise management actions. My work largely falls within four main themes: 1) impacts of food production, 2) spatial conservation planning, 3) land-sea interactions and 4) achieving conservation targets.

Photo credit: Bruce Rocherieux

Photo credit: Graham Edgar

The impacts of feeding the world

A predominant focus of my recent work is on sustainable food production. Food production is vitally important but causes significant pressures on the environment. To date, environmental assessments of food production largely focus on singular production methods and/or threats (e.g., greenhouse gas emissions). I have pioneered approaches to cumulatively map the environmental pressures of food production and to better integrate marine-based food production into these assessments, which has been published in One Earth. This work filled a critical knowledge gap in integrative spatial analyses of environmental pressures, which can lead to better models and more sustainable food policies in the future. The method was recently used to map the cumulative environmental footprint of food production globally and was published in Nature Sustainability.

My desire to inform and promote both environmentally and socially sustainable seafood production is at the intersection of my interests in sustainable food production and marine conservation. For example, the idea of linking land and seafood systems led me to think deeply about the potential similarities and differences between the rise of farming on the land (agriculture) and the rise of farming in the sea (aquaculture), published in Ocean and Coastal Management. I found considerable similarities supporting a potential paradigm shift to an aquaculture-dominant world but also several opposing factors, such as environmental awareness and collective action, that may inhibit the replacement of fisheries with aquaculture. The main conclusions support better integration across fisheries and aquaculture management and intentional planning on the balance between these two sectors.

This work's key theme was how globalisation and trade have changed modern-day food systems. Two of my recent collaborations have expanded on this theme; the first quantified the degree to which countries fish in areas with lower fisheries management, which was published in Environmental Research Letters and discussed the potential environmental and social implications of such impact displacement, while the second evaluated economic, political and social factors supporting or hindering justice across aquatic food systems, published in Nature Food, and ways to improve policies for more inclusive production and consumption.

I am expanding and applying these methodologies to answer questions about Australia's seafood production. I am particularly interested in better understanding Australian seafood's environmental footprint and pathways for seafood sustainability across the supply chain as seafood production continues to evolve. If any of these topics spark your interest or want to discuss more, please reach out!

EARLY-CAREER RESEARCHER, DR MARGARET COOK

ARI Research Fellow Dr Margaret Cook is an environmental historian whose interests lie in understanding the history of people and place and how that relationship changes in a shifting environment.

I have always been interested in people's stories and the histories of the places I visit. For me, studying history helps explain the present. It can provide the cultural and environmental context for how people live, why decisions and policies are made, and the way events unfold. For this reason, as an undergraduate, I studied social history, the study of people, then worked as a heritage consultant documenting place, and completed a PhD in history at the University of Queensland in 2018 on Southeast Queensland floods. I now call myself an environmental historian and the author of A River with a City Problem: A History of Brisbane Floods. In this book, I explore the relationship between the Brisbane River and those who live on its floodplain.

My experience as an environmental historian and my research interests in this field is what brought me to ARI as a Research Fellow working with Professor Sue Jackson on her multi-institutional study Understanding the water cultures of the Murray-Darling Basin funded by the Australian Research Council and the Commonwealth Government's Water and Environment Program for the Murray Darling Basin (MDB). We hope through our research to broaden thinking about Murray Darling Basin waters, what underlying ideas and values shape how we interact with them, and the range of social and cultural practices that depend on them.

I am currently working on a case study of the lower Murray around the Coorong and Lakes Albert and Alexandrina. The region is now an intensely regulated hydro-engineered network of weirs, locks and barrages that have dramatically altered the river's historic flow. This study considers how these changes have altered cultural practices. For example, Ngarrindjeri weavers have noted that increased salinity has reduced their supply of freshwater reeds, and the changed flow regime has allowed European Carp to flourish and reduced Murray Cod and other native species. The research investigates how this has affected recreational fishers as we record stories of loss over decades, not only the declining catches of specific fish but the erosion of the much-loved embodied experience of fishing and its associated social interactions over generations.

I have also established a Water Cultures MDB Network to connect humanities and social science scholars researching the Basin. The intent is to enhance opportunities for socio-cultural research and facilitate interaction and stronger collaborations within and beyond Australia's water research culture. In February 2023, we hosted our first public lecture on Indigenous fish traps and fish weirs on the Darling (Baaka) River.

To date, our work in this area has involved desktop research and field studies along the lower reaches of the River Murray. I recently spent four days in the South Australian archives immersed in twentieth-century engineering reports and accounts of riverine change. The following research phase will include oral histories of the people of the river to ask how they understand the river, its flows and behaviour. This year Sue Jackson and I plan to publish several articles on the lower Murray. The Coorong research is one of the project's five case studies. The team intends to publish a co-authored book that weaves them together to address the different ways of understanding the water cultures of the Murray-Darling Basin.

Anyone interested in our research can follow our progress at the Water Cultures Network webpage or on twitter @waterculturemdb. Better still, follow the links on the webpage to join the Network.

EARLY CAREER RESEARCHER, DR ANDRÉS FELIPE SUÁREZ-CASTRO

ARI Research Fellow Dr Andrés Felipe Suárez-Castro, is an ecologist interested in using his knowledge of ecological functioning in conservation and environmental management planning to create tools to improve our understanding of what drives species distributions, how changing landscapes affect biodiversity and ecosystem services, and ultimately how data can help inform decisions to protect and restore ecosystems at the land to water interface.

Since completing his PhD, Felipe has been increasingly interested in land-water conservation approaches of marine and freshwater ecosystems, such as the ridge-to-reef conservation effort that integrates watershed and wastewater management. Before joining ARI, he compiled and used satellite imagery data to develop high-resolution maps of nutrient and sediment sources within terrestrial watersheds and their transport to coral reefs. In this role, he led a collaborative research project with a team of researchers from the University of Queensland, Griffith University and the Joint Research Centre of the European Commission to produce the first global map showing forest restoration opportunities to protect coral reefs. His research in this area opened the door to an opportunity to collaborate with the World Wide Fund for Nature, Wildlife Conservation Society (USA), and the University of Queensland to develop a global map of human pressures on tropical coral reefs.

More recently, he helped to integrate an existing soil erosion model with fire severity mapping and rainfall data to estimate the spatial extent of the post-fire sedimentation in waterways and basins and reveal the potential threat to aquatic species. The model he developed provides a method for quickly estimating the threat of sediment run-off after future fires in any fire-prone region, which has the potential to improve conservation assessments and inform emergency management interventions.

Currently, Felipe is working with Professor David Hamilton to design large-scale models to predict the effects of changes in land-use and climate on lake nutrient loads and trophic status under potential future global change conditions. Funded by an Australian Research Council Discovery Grant, and partnering with Canada (McGill University), Australia (CSIRO) and the US Geological Survey, these models validated against present-day nutrient loads, will provide essential insight into the trophic status of lakes globally under future conditions.

Felipe states that since joining ARI, "it has been an exciting and stimulating intellectual environment and has allowed me to connect with a range of researchers and stakeholders to better understand how to use novel data to design, implement and measure the success of using watershed management to protect aquatic ecosystems."

Expanding networks to study & protect global biodiversity

"Ultimately, my skills, interest and focus are on generating and understanding the key bits of information critical to ensure human impacts on natural resources and biodiversity are effectively managed. This is a challenging task as budgets are often limited and the space to accommodate human needs globally is decreasing."

With the global implications of this work, Felipe is always looking for collaborations with industry, government, and non-governmental organizations to generate tools to illustrate and quantify how integrating diverse types of data can support decision-making. For example, he recently worked with the Alexander von Humboldt Biological Resources Research Institute in Colombia, integrating remote sensing tools with social and ecological data to monitor protected areas, identify strategic conservation areas, and manage biodiversity and ecosystem services in human-dominated landscapes. These results were incorporated into the country's planning strategy to prioritise the selection of restoration areas by 2030.

This year, he received the E4 Award from the Nordic Society of Ecology, an award given to an early career researcher who has written an exceptional review. The Nordic Society of Ecology produced a video explainer of this research that studied how the relationship between functional species diversity and species richness is expected to change across spatial and temporal scales, affecting ecovsystem functions.

As a result of his high-quality research promoting the development of vertebrate ecology in tropical regions, Felipe was recently awarded the "Jorge Mono Hernández" prize of the Colombian Society of Mammalogy, which is given to outstanding researchers in recognition of their work in mammal conservation and ecology.

"My professional ambitions are to inspire the next generation of leaders and innovators capable of informing conservation policy on best management practices for multifunctional landscapes," said Felipe.

"To address these challenges, an integrative approach is needed to solve problems that can't be addressed by hydrologists or conservationists alone. I'm working towards strengthening partnerships with diverse multidisciplinary teams to achieve this goal."

EARLY CAREER RESEARCHER, DR RUPESH PATIL

Dr Rupesh Patil is a Research Fellow in environmental hydrology at the Australian Rivers Institute with a broad background in water resources management, remote sensing and GIS to deepen our understanding of Freshwater Ecology.

Globally, flow regulation and diversion have substantially altered patterns of streamflow, characterised by changes in the magnitude, duration, frequency, and timing of flow. This has flow-on effects, causing risks to riverine ecosystems, including habitat loss, decline in riverine species, extended river-floodplain disconnections, a halted flux or organic material, and a degradation in water quality.

Understanding streamflow for the management of river ecosystems requires the analysis of extensive ecological data sets of a diverse range of critical metrics, with the data continually changing due to the dynamic nature of riverine ecosystems and seasonal variability.

However, without this holistic assessment of all streamflow metrics that reflect changes in flow patterns, we develop a limited understanding of key changes in streamflow patterns, which can create risks for riverine ecosystems.

Building on a long-standing area of environmental flow research in ARI, a significant focus of my work lies in revealing the sensitivity of streamflow patterns to river regulation and climate change and its implications for ecological and environmental management.

In my PhD research at the University of Queensland, I examined the sensitivity of streamflow patterns to the effects of flow regulation and climate change is the Goulburn-Broken catchment of the Murray-Darling Basin. The Goulburn-Broken catchment is one of the most regulated water catchments of the Murray-Darling basin. Home to a significant level of biodiversity, including diverse species of riparian trees, fish, burrowing frogs, water birds, reptiles, lizards, micro-invertebrates, and mammals, the catchment has experienced severe ecological and environmental degradation following intensive river regulation and flow diversion.

The catchment ecosystem is also under constant threat from climate change, river regulation, and flow diversion, which distinctly impact streamflow patterns across the Goulburn River, making this an ideal study area to understand streamflow patterns in response to these stressors. To do so, we analysed the trends and per cent changes in daily streamflow metrics from 1977 to 2018 and the effects of changes in rainfall, regulation. Flow diversion on streamflow patterns were predicted using a generalized additive model and path analysis.The findings of this research suggest that low and medium flows in this section of the Murray-Darling Basin increased by 26% over that period, while high flows and overbank flows decreased by 31%, primarily due to flow regulation/diversion.

Research on streamflow in the Murray-Darling Basin has implications for the restoration and management of regulated rivers globally. Intensive river regulation, flow diversion and changing climate have altered the streamflow patterns of over two-thirds of rivers worldwide. This has serious global implications for floodplain and wetland ecosystems due to reduced river-floodplain connectivity, the destruction of riparian habitats, threatened native flora and fauna, and invasive species. Other implications include disturbance to the local riverine food web due to the reduced supply of sediments and nutrients, degradation of stream water quality, and ultimately the decline in riverine species populations and diversity.

Our work highlights the need to reassess environmental and ecological water requirements in a world where changing streamflow patterns is the norm to improve environmental flow practices for sustainable riverine ecosystems. Only by thoroughly understanding streamflow patterns can they be proactively managed to design long-term ecological and environmental water security goals to cope with anticipated environmental risks arising from climate change, river regulation, and flow diversion in riverine systems.

Current work: monitoring targeted at freshwater restoration actions

Rupesh is currently working with Professor Hamilton on an Aotearoa-New Zealand project within one of the National Science Challenges: Our Land & Water - Toitu te Whenua, Toiora te Wai. This project seeks to optimise monitoring for large investments currently being made in freshwater restoration in NZ. These investments require comprehensive monitoring programmes to support change detection and demonstrate value for money. Land stewards need confidence that improvements in the state of the freshwater resource are identified robustly and in a timely manner, and that causal links can be established between management actions and freshwater outcomes. The project seeks to develop a range of tools and resources to assess the performance of existing monitoring networks and suggest how the existing network may be augmented to optimise its likelihood of detecting changes from freshwater restoration actions, using both mātauranga Māori (Indigenous knowledge systems) and biophysical indicators. The research covers rivers, lakes and groundwater systems.

PHD SPOTLIGHT

HOW CLIMATE CHANGE COULD LEAD TO LARGER ALGAL BLOOMS

Mohammad Hassan Ranjbar

Griffith-led research has revealed that the decrease in wind and the higher temperatures accompanying climate change can cause bigger algal blooms in the future.

Published in Water Research, the study found that a 20% decrease in wind speed will result in algal blooms of the freshwater cyanobacteria *Microcystis* that are almost one and a half times the current size.

"The impact this decrease in wind will have on algal blooms is more than six times the effect a two degree increase in air temperature associated with climate change" said lead author Mohammad Hassan Ranjbar, a PhD candidate at the Australian Rivers Institute.

"Harmful algal blooms of the freshwater cyanobacteria *Microcystis* are a global problem and are expected to intensify with climate change. However, the impact of atmospheric stilling, the decrease in near-surface wind speed, has not been considered.

"Our research is the first to demonstrate that atmospheric stilling along with increasing air temperature can favour these buoyant, colony-forming cyanobacteria blooms."

Co-author Professor David Hamilton, Director of the Australian Rivers Institute, said the research results show that "wind speed needs to be included in any projections looking at changes in the frequency, distribution and magnitude of algal blooms under climate change."

"The decreases in wind speed, which have been forecast to occur in several regions across the globe with climate warming, reduce mixing in the water column in lakes. The reduced turbulence in the water column allows buoyant cyanobacteria to float to the surface and form blooms."

To test if wind stilling affected the distribution and biomass of cyanobacteria in the water column, the researchers applied a novel individual-based model, which they combined with a hydrodynamic model to simulate water movement in the lake.

"For the first time, our model was able to show that algal colony size changes dramatically in response to the turbulence, light, temperature, and nutrients in the water column of a shallow urban lake," Mr Mohammad Hassan said.

"Using this model, it was evident that the formation of algal blooms was far more sensitive to the atmospheric slowing of wind speed associated with climate change than it was to warming temperatures."

The authors stress that this atmospheric stilling should be included in predictions of algal blooms under climate change. Their Water Research paper was picked up as a Research Highlight by Nature Index under the headline "Toxic algal blooms will flourish with lower wind speeds".

PHD SPOTLIGHT

CONSTRUCTED WETLANDS: A BARRIER TO THE SPREAD OF MICROPLASTICS

Hsuan-Cheng Lu

A Griffith-led study has found that constructed wetlands, built to treat wastewater and stormwater runoff, act as a barrier preventing the spread of microplastics through the environment.

Published in Environmental Pollution, the researchers investigated the amount and distribution of microplastics in water and sediment at five constructed wetlands with stormwater and wastewater sources feeding into the wetlands.

"Wastewater and stormwater are both critical pathways for microplastics to enter the aquatic environment," said Mr Hsuan-Cheng Lu, a PhD candidate from the Australian Rivers Institute.

"Currently, there's little information about the potential for constructed wetlands, a commonly used wastewater and stormwater treatment system, to help diminish the flow of microplastics to the environment and their accumulation in the water and sediment of the wetlands."

As constructed wetlands are proven filter for other chemical contaminants from stormwater, the researchers investigated how well they collect and retain microplastics.

The microplastic levels were up to four times higher in the storm/wastewater entering the wetland compared to water at the outlet. Similarly, the microplastics levels found in the constructed wetland sediment were higher than most reported freshwater sediment levels, with the amount of microplastics much greater in the sediment at the wetland inlet than the outlet.

"Wetland vegetation slows down runoff water, allowing microplastics to settle into the sediment," said co-author Professor Frederic Leusch who leads the ARI Toxicology Research Program (ARITOX) at the Australian Rivers Institute.

"These initial results, gathered from Gold Coast wetlands, showed the sediment carried a higher level of microplastics than most other freshwater environments globally.

"While it doesn't sound good, it means that the wetlands act as a barrier preventing the microplastics from spreading further downstream, into our rivers and oceans."

The dominant form of microplastics was PET fibres, primarily originating from clothing and textiles. However, PE and PP from the breakdown of large plastic items, such as food packaging and bottles, were also found in the sediment.

As the study was carried out over the dry season in Queensland, more research is needed during wetter seasons and flood events to determine if wetland barriers retain the plastics under the pressures of increased water flows or whether they get washed into ecosystems downstream.

"This study is an important first step that shows constructed wetlands can not only retain the microplastics in treated water and stormwater runoff, but their sediment can also act as sinks trapping and accumulating the microplastics over time," said Mr Lu.

"The accumulation of microplastics and other pollutants in wetlands over time also raises concerns, as the constructed wetlands provide crucial habitat for wildlife in the urban landscape.

"For this reason, the logical next step is to see whether these wetland microplastic traps survive the rigours of the wet season and, together with council engineers, investigate how the accumulated microplastics can be safely removed."

PHD SPOTLIGHT

SOME LIKE IT HOT: THE ECOLOGICAL BENEFITS OF OYSTER REEFS IN TROPICAL WATERS

Marina Richardson

A Griffith-led study has reported that tropical oyster reefs have a far greater diversity of reef-building oyster species than those in temperate waters.

Published in Frontiers in Marine Science, the research shows over four times more species of reef-building oysters in the tropics compared to temperate regions. Many of these tropical species commonly create mixed-species oyster reefs.

“We expected the diversity to be higher in the tropics, but we were surprised to find how high it was, and given how little we know, we expect the number of tropical reef-building oysters will grow as research continues,” said lead author Marina Richardson, a PhD candidate at the Australian Rivers Institute and the Coastal and Marine Research Centre.

“We also found that tropical species grow much faster than temperate species, having the potential for multiple spawning seasons throughout the year as opposed to just one.”

Oyster reefs are formed over generations as oysters settle and die, leaving behind old shells which new oysters then colonise. They are found globally in coastal and estuarine environments and can form three-dimensional reef habitats that spread for kilometres.

“These reefs provide important ecosystem services including shoreline stabilisation, water filtration, nutrient assimilation, and habitat for marine species including commercially important fish and crustaceans,” said Ms Richardson.

“In many parts of the world, unsustainable harvesting, declining water quality, and coastal development have caused oyster reef declines and the loss of these ecosystem services.”

The widespread declines have sparked a worldwide movement for the restoration of oyster reefs. However, a current need for more information on tropical oyster reefs has led to their exclusion from existing global assessments and restoration efforts.

The researchers can better inform restoration by reviewing the differences between tropical and temperate oyster reefs and identifying historic tropical oyster reefs.

“In tropical Queensland, for example, the historical presence of oyster reefs was largely unknown,” said co-author Dr Carmel McDougall, an adjunct Research Fellow with the Australian Rivers Institute:

“We searched newspapers published before 1939 from coastal towns north of Seventeen Seventy for evidence of oyster reefs before oyster harvests peaked in northern Queensland and conservatively identified 94 historic reefs across 58 sites, with declines noted as early as 1902.

“Evidence that unsustainable and destructive harvesting has resulted in the decline of tropical oyster reefs shows the need to include these reefs in restoration efforts. We highlight knowledge gaps that can help guide future research and remove potential barriers to tropical oyster reef restoration.”

Since the study was published, Ms Richardson has identified and begun researching several previously undocumented tropical oyster reefs.

“These reefs are more extensive than anything we have previously found and cover areas greater than 4 hectares,” Ms Richardson said.

“We hope to document reef-building abilities of additional species in Queensland to identify new candidate oysters for use in restoration and quantify the invertebrate communities associated with these reefs.”

PHD SPOTLIGHT

THE REAL-WORLD ISN'T STATIC: UNDERSTANDING HOW FLUCTUATING STRESSORS AFFECT WETLANDS

Andria Ostrowski

Griffith University research reveals that when combinations of human-caused stressors fluctuate, replicating more realistic environmental conditions, it vastly changes their impact on wetland habitats.

Published in Ecology Letters, the study shows that when the level of stressors, like chemical pollution and reduced light conditions from sediment disturbance or algal blooms, change over time, as they would in real-world exposures, they caused more seagrass loss than when a stressor of the same intensity was constant over time.

"With ecosystems around the globe increasingly affected by human activities it's not surprising that environments are rarely exposed to a single stressor," said lead author Ms Andria Ostrowski, a PhD candidate at the Australian Rivers Institute and the Coastal & Marine Research Centre.

While it is recognised that interactions between co-occurring stressors can cause unexpected synergistic or antagonistic impacts on the environment, the effect of changing levels of stressors is less understood.

"In dynamic aquatic ecosystems stressors rarely remain static in the environment, yet we continue to conduct multi-stressor experiments that assume stressor levels remain constant," Ms Ostrowski said.

"For example, changes in tide or water flow rates mean that any potential contaminant or stressor is unlikely to remain at a constant intensity for very long in aquatic ecosystems.

"Our study, which explored what happens when stressors fluctuate, found that the way in which the chemical pollution and light reduction stressors are varied over time elicits different biological responses in seagrasses."

Seagrass, in addition to providing critical habitat for wildlife like fish, sea turtles and dugongs, stabilises sediments, stores carbon, protects coastlines, and improves coastal water quality.

"This critical habitat is disappearing globally due to simultaneous human-introduced stressors like pollutants, physical disturbance, and increasing temperatures," Ms Ostrowski said.

"By understanding how these multiple stressors interact and fluctuate under the dynamic environmental conditions that occur in coastal ecosystems and how seagrass habitats are impacted, we can better manage adverse effects.

When the researchers looked at seagrass responses to changes in stressor intensity for reduced light conditions paired with herbicide contamination, they found that when these stressors were out of phase (peaking at different times, referred to as asynchronous fluctuations), the amount of seagrass was reduced by more than a third (36% less seagrass biomass) compared to static stressor conditions, despite exposure to the same overall average level of stressors.

"Our results provide evidence that the biological response of ecosystems like seagrass habitats does change depending on how and when the stressors are introduced to the environment," Ms Ostrowski said.

"For this reason, past studies in which the levels of multiple stressors have been kept constant, may not provide a comprehensive understanding of real-world effects.

Co- author Dr Michael Sievers said, "The future assessment of multiple stressors needs to incorporate environmentally relevant changes in stressor levels and timing if we want to gain a more accurate understanding of real-world impacts and thus lead to the development of better conservation and management strategies, for seagrasses and other ecosystems.

PHD SPOTLIGHT

TIDAL RESTORATION TO COASTAL WETLANDS REDUCES GREENHOUSE EMISSIONS

Charles Cadier

A Griffith-led study found that restoring tidal flow to enclosed freshwater wetlands is key to reducing greenhouse gas emissions and helping meet Australia's carbon reduction targets.

Published in Restoration Ecology, the study compared the greenhouse gas emitted by impounded freshwater coastal wetlands with those from tidally connected mangroves and saltmarshes in Queensland's Burdekin catchment.

"The freshwater impounded wetlands, created when tidal flows to coastal wetlands are artificially restricted, had more than a 100-fold rates of methane emission compared to mangroves and saltmarshes," said lead author Charles Cadier, a PhD candidate at Australian Rivers Institute and the Coastal & Marine Research Centre.

Tidally influenced coastal wetlands, made up of mangroves, tidal marshes, and seagrass meadows, are known as "blue carbon" ecosystems because their soils accumulate significant amounts of carbon. Although they occupy less than 2% of the ocean area, they are responsible for nearly 50% of carbon burial in marine sediments.

"Globally wetlands have been rapidly decreasing over the last century with the change in land use affecting the capacity of coastal wetlands to sequester carbon," said co-author Dr Fernanda Adame Vivanco, a senior research fellow at Australian Rivers Institute and the Coastal & Marine Research Centre.

"When the carbon stored in soils are disturbed and exposed to oxygen, carbon dioxide is liberated to the atmosphere, converting them from sinks to sources of greenhouse gases."

Freshwater wetlands are also the single largest natural source of methane, a potent greenhouse gas 25 times more powerful than carbon dioxide in climate impacts over 100-year time scales. Freshwater wetlands are thought to account for a quarter of global methane emissions.

"The waterlogged conditions in these enclosed wetlands promote methane production by soil bacteria, emitting significantly more methane than mangroves and saltmarsh," Mr Cadier said.

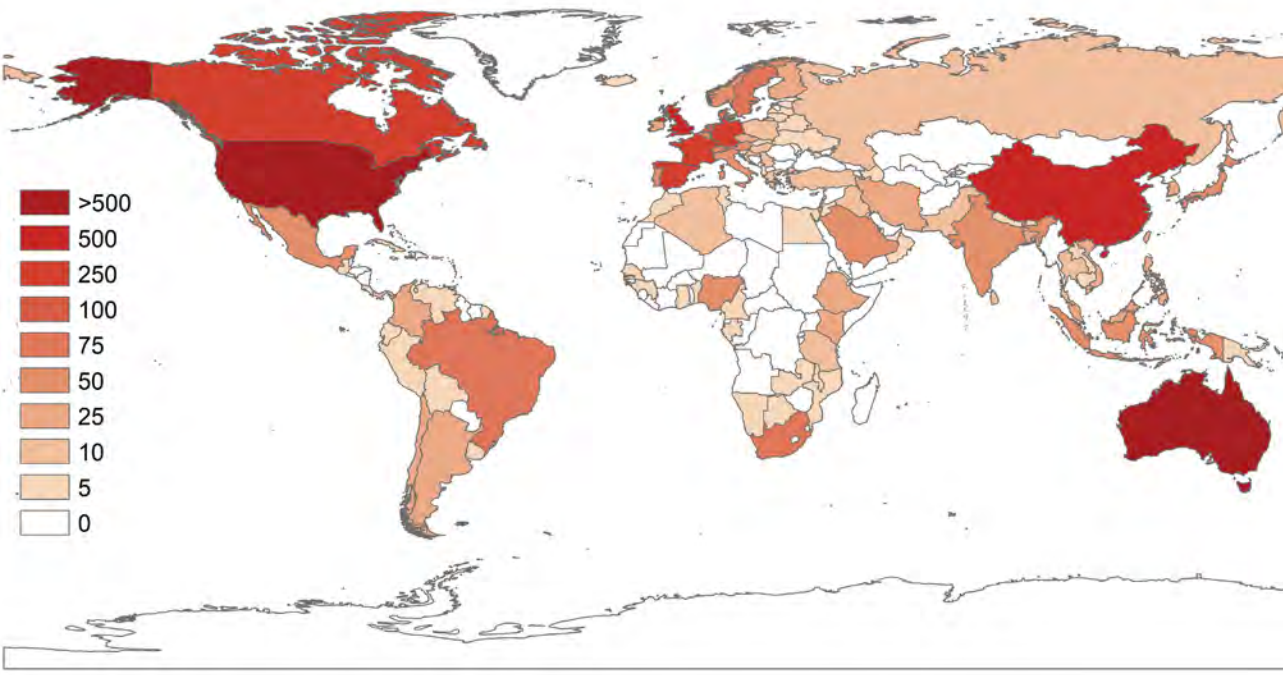
"Our research found that freshwater impounded wetlands emitted about 100 times the CO2 equivalents from mangroves and saltmarshes."

Dr Adame suggests that "restoring the tidal flow to freshwater-impounded wetlands is likely to result in significantly lower greenhouse gas emissions, specifically from reduced methane production."

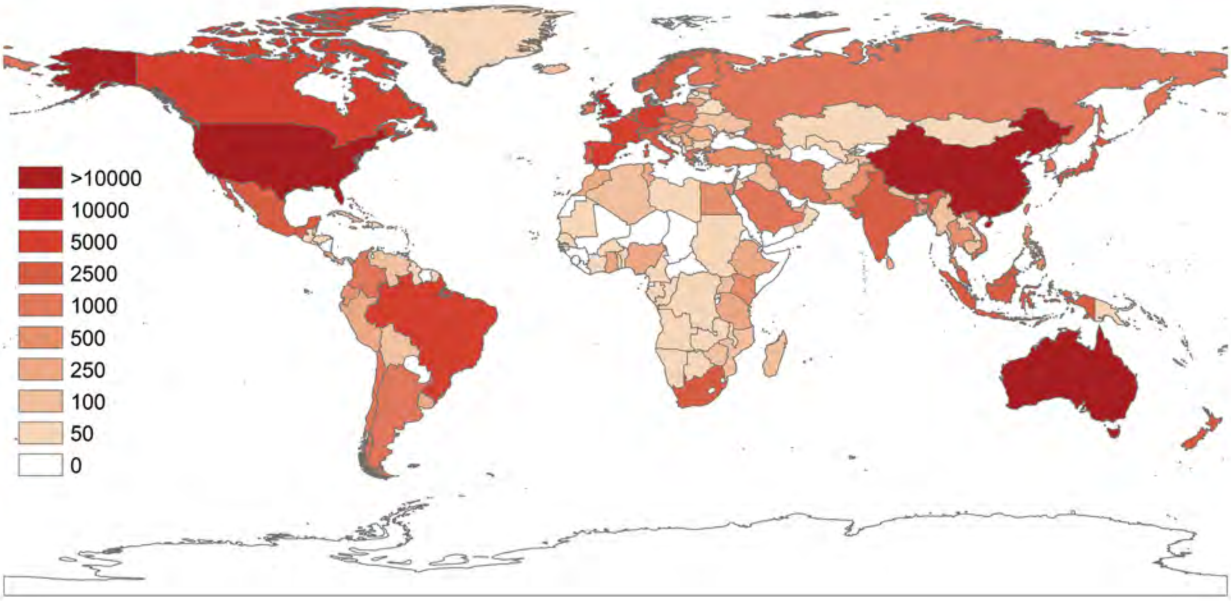
"This results from modified soil properties, favouring bacterial communities that will outcompete methane producers."

Mr Cadier concludes that "Although tidal restoration projects in the Great Barrier Reef should consider the values of each wetland type and avoid the "one size fits all" approach, the restoration of impounded freshwater wetlands can provide an emission reduction option that helps meet Australia's carbon reduction emission targets, particularly for incentives to avoided methane emissions."

Co-authored publications (2006 – 2023)



Citations (2006 – 2023)



NEW STAFF

Research

Dr Jaramar Villarreal Rosas
Dr Zainab Mahdi
Dr Jackson Stockbridge
Dr Mohammad Hassan Ranjbar
Dr Margaret Cook
Dr Natalie Jones
Dr Michael Klunzinger
Dr Jenny Fong
Dr Rupesh Patil
Dr Apsara Amarasinghe
Dr Caitie Kuempel
Dr Rebekah Grieger
Dr Cesar Herrera Acosta
Dr Jianyin (Leslie) Huang
Dr Xiangyu Liu
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Dr Sebastian Lopez-Marcano
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Professor Mark Gessner
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Dr Adeyeri Oluwafemi

Visiting Scholars

Mr Matheus Maximilian Ratz Scoarize
Ms Jue Zeng
Mr Xianglin Huang
Ms Jessica Schaub
Ms Heloise Marie

IWC staff

Dr Benny Rousso, WASH Research Fellow
Catherine Hanley, IWC Project Officer

PhD Conferrals

Laura Louise Griffiths, *Identifying Gaps in the Performance of Coastal Ecosystem Management*. Supervisor: Professor Rod Connolly & Associate Professor Chris Brown

Craig Thornton, *Effects of land clearing, land use change and land management on natural resources in the Brigalow Belt*. Supervisor: Professor Chengrong Chen & Professor Bofu Yu

Nathan Daniel McIntyre, *Phylogeography, demography and recruitment in a widespread iconic Australian bird, Gymnorhina tibicen*. Supervisor: Emeritus Professor Jane Hughes

Peta Zivec, *Natural regeneration of floodplain vegetation in semi-arid agricultural landscapes*. Supervisor: Professor Fran Sheldon

Sebastian Lopez-Marcano, *Measuring cross-habitat movements among habitat hotspots of fish with artificial intelligence*. Supervisor: Professor Rod Connolly & Associate Professor Chris Brown

Oluchi Mbachu, *Identification and quantification of microplastics in urban stormwater infrastructure: A case of bioretention*. Supervisor: Dr Chris Pratt

Gulsah Dogruer, *Assessing the impact of chemical exposure on the health of endangered sea turtles through toxicokinetics and toxicodynamics*. Supervisor: Professor Frederic Leusch & Dr Jason van de Merwe

Atiqul Islam, *Development of satellite-derived precipitation products for water resources management*. Supervisor: Professor Bofu Yu

Pirooz Pazouki, *Multi-criteria evaluation of an alternative diluted seawater RO desalination process incorporating wastewater recycling*. Supervisor: Dr Edoardo Bertone

Jagriti Tiwari, *Effect of Vegetation Cover Dynamics on Runoff and the Implication for Sediment Yield Estimation for the Great Barrier Reef Catchments*. Supervisor: Professor Bofu Yu

Naima Iram, *Greenhouse gas emissions from wetlands versus other land use*. Supervisor: Dr Fernanda Adame Vivanco & Professor Stuart Bunn

Benny Rousso, *Optimization of cyanobacteria bloom management through improved forecasting models and optical sensors*. Supervisor: Dr Edoardo Bertone & Professor David Hamilton

Olivia King, *The combined and interactive effects of multiple stressors on Great Barrier Reef ecosystems*. Supervisor: Jason van de Merwe & Chris Brown

Mohammad Hassan Ranjbar, *Individual-based modelling of cyanobacteria blooms*. Supervisor: David Hamilton, Amir Etemad Shahidi & Fernanda Helfer

Arthur Barraza, *Reproductive toxicology of sea turtles*. Supervisor: Kimberly Finlayson, Frederic Leusch & Jason van de Merwe

New PhD/Masters Candidates

Georgia King, *Instream outcomes of irrigation flow releases across the northern Murray-Darling Basin.* Supervisor: Professor Fran Sheldon

Cassidy Winter, *Assessing the leaf litter invertebrate Diversity of Constructed Green Spaces in Urban Environments.* Supervisor: Professor Samantha Capon

Pauline Lindholm, *Impacts of Invasive Invertebrate Species on Artificial Reefs, and Their Natural Products.* Supervisor: Dr Tim Stevens

Jaiden Johnston-Bates, *Plant invasion responses to modified flow regimes in dryland floodplains.* Supervisor: Professor Fran Sheldon

Mollie Stefanek, *Immune pathways in Australian native oysters.* Supervisor: Carmel McDougall

Jordan Holdorf, *Adaptive management of restoration for coastal habitats in a changing climate.* Supervisor: Associate Professor Chris Brown & Dr Melanie Roberts

Colin Burke, *Critical aquatic macrophyte habitat and importance to early life history of Neoceratodus forsteri.* Supervisor: Professor Mark Kennard, Dr Luke Carpenter-Bundhoo & Dr Hannah Franklin

Joshua Whiley, *New methods to determine hydro-ecological factors in Australian Bass* (Percalates novemaculeata). Supervisor: Professor Mark Kennard & Dr Luke Carpenter-Bundhoo

Sule Ozkal, *Water Quality Management via High-frequency Monitoring for the Protection of the Great Barrier Reef.* Supervisor: Dr Edoardo Bertone

Simran Kaur, *Investigation of the impacts of microplastics on soil microbiota.* Supervisor: Professor Chengrong Chen & Dr Mehran Rezaei Rashti

Sundus Sundus, *Developing novel cellulose-based moisture-retaining materials to mitigate drought in the soil system.* Supervisor: Professor Chengrong Chen & Dr Jia Xu

Aiza Shabbir, *Comparative analysis of groundwater management in Australia and Pakistan.* Supervisor: Associate Professor Md Sayed Iftekhar

Oscar Jurado, *Land management of diverse rubber-based systems in southern Philippines.* Supervisor: Professor Chengrong Chen & Dr Johnvie Goloran

Soren Huber, *House hunting on the GBR: What do prospective coral recruits seek in their algal dream homes?* Supervisor: Associate Professor Guillermo Diaz-Pulido

Jillian Conrad, *An ecosystem-based blue economy on Sea Country.* Supervisor: Associate Professor Jim Smart

Kamrun Nahar, *The role of soil microbial community structures and shifting to improve sodic and acidic soil health.* Supervisor: Professor Chengrong Chen & Dr Mehran Rezaei Rashti

Kai Ching Cheong, *Mapping mangrove habitat degradation in Central Indo-Pacific: implications for biodiversity.* Supervisor: Dr Fernanda Adame Vivanco & Associate Professor Chris Brown Deegoda Gamage Nimesha Senevirathne, *Processing of Anaerobic Digestate as Biofertilizer for Crop Production and Nutrient Management.* Supervisor: Dr Chris Pratt

Quynh Le Khanh Vo, *Advanced monitoring to maximise fish welfare in offshore aquaculture in Tasmania.* Supervisor: Professor Kylie Pitt

Tori Liang, *Identification of water change affected by bushfire based on remote sensing time-series.* Supervisor: David Hamilton & Brendan Mackey

Timothy Jackson, *Distribution and ecology of crustose coralline algae across the Great Barrier Reef.* Supervisor: Guillermo Diaz-Pulido & Mark De Bruyn

Mikaela Radke, *Monitoring of Xenobiotics in eco-toxicology samples through non-targeted HRMS method development.* Supervisor: Frederic Leusch & Sarah Cresswell

Jambay Jambay, *Effects of plant cover and climate change on groundwater discharge.* Supervisor: Fran Sheldon & Ali Chauvenet

Mahesh Mohan, *Characterising the enzyme and metabolic mechanisms in microbe-mediated microplastic degradation.* Supervisor: Chris Pratt & Prasad Kaparaju

Shayne Reano, *Soil nutrition management in mature rubber trees (Hevea brasiliensis) as adaptive and coping mechanisms.* Supervisor: Johnvie Goloran & Chengrong Chen

Gam Thi Nguyen, *Developing a business case to support a circular economy approach in wastewater management.* Supervisor: Md Sayed Iftekhar & Cara Beal

Krishnaveny Risheharan, *Floating mangrove wave breakers for coastal protection and production. Case Study: Queensland, Australia.* Supervisor: Fernanda Adame & Joerg Baumeister

Ikechukwu Kalu, *A new machine learning framework in subsidence monitoring by integrating GRACE-products with PolSAR.* Supervisor: Christopher Ndehedehe & Mark Kennard

Rameesha Tanveer, *Detection, removal and in-vitro bioassay determination of pharmaceuticals from wastewater.* Supervisor: Frederic Leusch & Prasad Kaparaju

Iresha Rammanda Gedara, *Wetland restoration and the recovery of ecosystem services.* Supervisor: Fernanda Adame & Michael Sievers

Kwabena Addai, *Agricultural extension services, technology adoption and household welfare in Malawi.* Md Sayed Iftekhar & Nicholas Rohde

Yasmim Leiros Meira, *Assessing past and future droughts to ensure water supply security in the face of climate change.* Edoardo Bertone & Oz Sahin

Stephanie Stack, *Humpback whale migration dynamics in a changing climate.* Supervisor: Tim Stevens & Susan Bengtson Nash

Marina Christofidis, *Assessing and planning for climate change impacts to aquaculture to inform resilient and sustainable ...* Supervisor: Chris Brown & Caitie Kuempel

Masters

Tharindu Dampe Acharige, *Occurrence of Micro-plastic in Marine Aquatic Fauna.* Supervisor: Professor Frederic Leusch

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