ARI

Australian Rivers Institute

MAGAZINE
Issue 4

FEATURE ARTICLES IN THIS ISSUE:

Griffith UNIVERSITY
Queensland, Australia

DIRECTOR'S WELCOME

Professor Stuart Bunn

After an unavoidable delay, I welcome you to this edition of the Australian Rivers Institute Magazine.

Looking back over the past year, it is quite remarkable to see how well staff and students in the Institute have responded to the challenges brought on by the COVID pandemic and pursued new opportunities. As a result, the Institute has continued to grow. Travel restrictions may have changed the way we engage with international partners, but several significant initiatives are progressing well. While there have been some interruptions to field work and planned workshop meetings, most research projects are also still on track. However, we acknowledge the impact the pandemic is having on our international students and research staff – not only those who have been unable to take up positions here but also our current members who have family and friends overseas.

Earlier this year, we were thrilled to receive international recognition as the world's leading think tank for "water security" in the 2020 Global Go To Think Tank Index Report produced by the University of Pennsylvania. This is a testament to the sustained effort of staff and students in the Institute to provide innovative research, strategic analysis and public engagement on a wide range of policy issues under the broad definition of water security. The announcement coincided with our decision to lead a rebid for a new Cooperative Research Centre for Water Security, which was submitted in August this year. We are hoping to raise over $40m from research and industry partners and seek matching funds from the Commonwealth's CRC program. The bid has strong support from across the water sector, including peak bodies, NGO's, water utilities, local governments (city and rural) and a broad range of commercial entities.

In 2020, the International WaterCentre (IWC) was formally brought into the University, hosted within the Australian Rivers Institute. IWC began in 2005 as a partnership between four leading universities, including Griffith, and the Queensland Government. For the past few years, IWC has been a wholly owned subsidiary of the University and co-located with ARI in the Samuel Griffith building at our Nathan Campus.

The recent changes have strengthened opportunities for collaboration in research and training. This issue of the ARI Magazine covers a small part of IWC's recent achievements in one of their core areas of research on Water, Sanitation and Hygiene (WASH).

ARI staff have continued to shine as leaders in their respective research fields over the past year. Dr Fernanda Adame, Dr Hannah Franklin and Dr Shime Ziajahromi received three of the four Advance Queensland Fellowships awarded to Griffith University in 2020. Professor Sue Jackson was awarded an ARC Special Research Initiative grant on the formation and evolution of cultural values and practices relating to water in the Murray-Darling Basin. More recently, Dr Chris Brown has been awarded a prestigious ARC Future Fellowship.

This edition of the magazine is broad in scope and highlights the breadth of talent we have, and the range of research topics we cover in the Institute. It includes a topical article from ARI's Deputy Director David Hamilton on the effects of climate change on water storage – a serious issue for water security globally. Dr Mischa Turschwell dives into the risks associated with the Belt and Road Initiative and its potential affects on marine biodiversity, a significant piece of research covering the largest infrastructure project ever undertaken. Many Australians have experienced recent bushfires, with 11 million hectares burnt over the past decade, and Professor Chengrong Chen's article covers the significant changes that have occurred to our soil due to large scale bushfires. Professor Rod Connolly showcases the innovative work that is being done under the Global Wetlands (GLOW) Project on AI and fish monitoring. Also, Associate Professor Jim Smart explains the major opportunities and challenges to increasing investment in nutrient offsetting to facilitate cost-effective catchment restoration.

I trust you enjoy this latest instalment on the work of the Australian Rivers Institute.

The Australian Rivers Institute has been named the number one global think tank in water security in the '2020 Global Go To Think Tank Index Report'.

NEWS

AUSTRALIAN RIVERS INSTITUTE NAMED NUMBER ONE GLOBAL WATER SECURITY THINK TANK

The Australian Rivers Institute (ARI) was recently named the number one global water security think tank by the '2020 Global Go To Think Tank Index Report'.

A testament to our researchers hard work

ARI was announced the top water security think tank based on its ability to provide innovative research and strategic analysis on water security and public policy as well as its work promoting access to an adequate quantity and quality of water to sustain livelihoods, health and socio-economic development of people around the world.

"We are thrilled to receive international recognition of the institute's research efforts throughout work with industry, decision makers and the broader community to improve the management of our freshwater resources," said ARI Director, Professor Stuart Bunn.

"The Australian Rivers Institute takes a source-to-sea philosophy to provide knowledge to support the rehabilitation, sustainable use and conservation of aquatic ecosystems.

"It brings together researchers from a range of science disciplines, including aquatic ecology, biogeochemistry, geomorphology, soil science, climate and modelling, together with social sciences, resource economics and law."

The award was bestowed by The Think Tanks and Civil Societies Program of the Lauder Institute, University of Pennsylvania, who research the role institutes play in governments and civil societies around the world.

The annual Global Go To Think Tank Index ranks the world's leading think tanks in a variety of categories with the help of a panel of more than 1796 peer institutions and experts from academia, public and private institutions and governments.

The index is used by academics, journalists, donors and the public to connect with the leading centres of research around the world as a number one think tank index.

"Receiving this recognition will increase the public profile of the Australian Rivers Institute and its work towards water security and is the culmination of sustained work with NGOs, national and international funding agencies and philanthropic donors," said Professor David Hamilton, ARI Deputy Director.

"Recognising the importance of water security and the development of new tools to improve water management have assured sustained growth of the institute over the past three years."

"We are thrilled to receive 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 freshwater resources," said ARI Director Professor Stuart Bunn.


SIR SAMUEL GRIFFITH CEN

THE BIG MOVE - IWC JOINS ARI

Brian S. McIntosh,
Associate Professor of Integrated Water Management
International Water Centre

A central challenge of our time is to build capacity to mitigate and adapt to climate change. This challenge is accentuated in Australia, where there is frequent drought and flooding rains. The International WaterCentre (IWC) seeks to meet this challenge with systemic and trans-disciplinary thinking and action.

The Situation

If we want water security, we need to change the way that we think about and act to solve complex water management challenges. With drying landscapes, changing rainfall and increasingly severe episodic floods, there is a significant amount of water infrastructure in need of repair or replacement. Water security will help to avoid a VUCA future – volatile, uncertain, complex and uncertain.

The vision for the International WaterCentre (IWC) remains as relevant now as it did when the IWC was formed in 2005 – Water Leadership for the Future. To be able to innovate and adapt to the changing and highly VUCA world of water that is emerging around us, we need to build the capabilities and capacities of individuals, organisations and networks of organisations.

IWC offers a range of services to strengthen and build water management and leadership capacities. This is achieved through customised training, micro-credentials and digital badges, professional postgraduate degrees, applied research projects and communities of practice and professional networks.

Supporting this expertise are the applied research interests of IWC personnel and easy access to and leverage from an extensive network of partners including, importantly from within Griffith University (GU).

Griffith is our home and this means more expertise

Now that IWC is part of GU it is well positioned and better able to collaborate with the water expertise that GU has to offer, including the Australian Rivers Institute, School of Environment and Science, Cities Research Institute, School of Engineering and Built Environment and the Griffith Business School including the Asia Institute.

A broad range of expertise has been enlisted for a major US $2.6m project on strengthening Integrated Water Resource Management education in Afghanistan, in winning online training work from the World Health Organisation (WHO), and in being able to assemble a fantastic team for the Master of Catchment Science (MCS), a new professionally oriented GU degree launched in 2020 and led and managed by IWC.

The MCS is a world first degree that blends natural sciences (hydrology, ecology, water quality sciences, soil science, geomorphology, river restoration science) with data/computational sciences (coding, data wrangling, remote sensing, GIS, modelling, monitoring and instrumentation), and economics. The MCS will develop an integrated skill and knowledge set for restoring and protecting catchments and the broad range of social, economic and environmental services that we obtain from them. Combined with the existing Master of Integrated Water Management, and the Graduate Certificate of Water Leadership and Certificate of Water Leadership, IWC offers a broad suite of water management and leadership education programs, from the quantitative and technical to the human oriented.

Beyond education the IWC runs a range of Water and Sanitary Hygiene (WASH) research projects funded through the Water for Women fund, hosts international WASH events for Department for Foreign Affairs and Trade (DFAT), runs two professional communities of practice and is a key contributor to the Asian Development Bank's Asian Water Development Outlook.

The vision for the International WaterCentre (IWC) remains as relevant now as it was when IWC was formed in 2005 - Water Leadership for the Future.

IWC CENTRAL IN WORLD LEADING WATER SECURITY INDEX

IWC and ARI researchers were central in developing the Asian Development Bank's world leading water security index, the Asian Water Development Outlook (AWDO) 2020, released late last year.

Important work for important outputs

Over the past two years, researchers from ARI and IWC have established and managed a number of the criteria on key dimensions used by the AWDO to rank the water security of 49 countries in the Asia-Pacific region.

"The AWDO is one of the most comprehensive and holistic water security indexes available," says Research Fellow Lachlan Guthrie from IWC, who led the development and management of a key dimension related to Rural Household Water Security.

"It recognises the essential, but relatively small volume, of water used by the world's most vulnerable people in rural households," he said.

Despite Asia's impressive growth in economic and social welfare during the last decades, 1.5 billion people living in rural areas and 0.6 billion in urban areas still lack adequate water supply and sanitation.

Of the 49 Asian and the Pacific countries assessed, the water security index identified 27 that face serious water constraints on economic development and 18 that have not sufficiently protected their inhabitants against water-related disasters.

"Importantly, the AWDO 2020 has included an environmental perspective on water security," said Research Fellow Ben Stewart-Koster from ARI who led the development of the Environmental Water Security aspect of the security index.

"Countless examples around the world show that water security is severely reduced because of unhealthy aquatic ecosystems.

"The work we did on the AWDO provides a platform to start to address this and has the potential to improve the water security of countries in the region."

Griffith University was also involved with the creation of the Urban Water Security section of the AWDO, which was led by a team from the University of Queensland.

"It is great to be involved in the confluence of such a strong group of water researchers," says Professor Mark Pascoe from IWC who oversaw the project.

"Griffith University's involvement in the Asian Water Development Outlook confirms our reputation as world leaders in water governance and integrated water management."

Countless examples around the world show that water security is severely reduced because of unhealthy aquatic ecosystems"

NEW TOOL SHOWS WATER SECURITY VITAL FOR FIGHTING COVID-19 IN INDO-PACIFIC

In support of the Australian Government's Partnerships for Recovery policy, the Australian Water Partnership (AWP) has launched the COVID-19 Water Security Risk Index, developed by Griffith University researchers.

Enabling risk identification

The index enables governments, communities, and development organisations to identify risks and prioritise water-related responses in the Indo-Pacific. Supported by the AWP, researchers at Griffith University's International Water Centre and the School of Medicine have collaborated to develop the innovative Index, drawing on readily available global datasets.

Building on the Asian Development Bank's Asian Water Development Outlook approach, as well as public health risk frameworks, it considers factors that influence a country's vulnerability to respond to COVID-19 risks from a water security perspective.

"The index enables us to identify the points of concern for each country and prioritise the most appropriate water-based interventions to reduce a country's risk of COVID-19 impact in short-term and build long-term resilience," said Research Fellow Lachlan Guthrie, the project leader.

He said while the ability of people to wash their hands is vitally important, it was only one of many important water-related factors that influence risk.

"We've been able to show that water can play a major role in the response to and recovery from COVID-19, not just hygiene which is obviously very important.

"In the majority of Pacific countries, for example, there are a relatively small number of cases, which reflects their ability to delay a COVID-19 outbreak from 'sparking'. However, when their borders reopen they would be at extremely high risk due to poor access to water and sanitation, and having the highest mortality risk factors in the Asia-Pacific."

Associate Professor Anne Roiko, from the School of Medicine at Griffith University, who led the public health angle of the project said their work on the index highlighted the critical role of water in understanding and dealing with the pandemic.

"In our framing of the COVID-19 Water Security Risk Index, we integrated elements of environmental and public health, biomedical science, economics, engineering, water, sanitation and hygiene."

Research Fellow Guthrie says their work was a great starting point.

"What is exciting, is the potential to collaborate with other researchers and stakeholders and address specific and equally important challenges as we learn more about the SARS-CoV-2 virus and what strategies minimise its impacts."

AWP CEO, Professor Nick Schofield, emphasised Australia's role in helping its neighbours.

"This index is supporting COVID-19 preparedness, response and recovery activities across the Indo-Pacific to secure our region's health, wellbeing and stability in these challenging times."

"The index enables us to identify the points of concern for each country and prioritise the most appropriate water-based interventions to reduce a country's risk of COVID-19 impacts in the short-term and build long-term resilience," says Research Fellow Lachlan Guthrie.

WASH? WASH WHAT? WHAT IS WASH?

By Rosie Sanderson and Dr Regina Souter

We tend to use our ironic acronym loosely, habitually, with limited regard for our listeners' comprehension: it's the 'hour of comfort', when everyone, worldwide, wants to turn on a tap, go to the toilet, wear clean clothes, and yes, wash. Bodies, faces, children, hands, to wash. Water to drink. A safe and dignified place to defecate. We all need Water, Sanitation and Hygiene (WASH).

The Importance of WASH

In 2021, an estimated 2.2 billion people worldwide do not have access to safe drinking water and 4.2 billion have nowhere to defecate. Access to safe, affordable WASH in homes, schools, health care facilities and workplaces is a crucial public health determinant that influences the health and wellbeing of populations on par with only the most critical health challenges.

Inequalities in WASH manifest in both access to and participation in the provision of WASH services. These inequalities cut across gender, abilities, faith, wealth, ethnicity, and age, amongst other lived experiences. In one of Australia's nearest neighbours, the Solomon Islands, preventable diarrhoeal disease, largely attributable to inadequate WASH, causes one in four deaths in children. Women and girls in particular often carry the burden of inadequate WASH access. For a large proportion of the world, a functioning water tap or flushing toilet is provided by a relatively well-resourced public or private utility. However, for the far greater proportion, WASH programs are required to fill the gap, working with the most underserved people to improve WASH outcomes. This is not only an infrastructure problem – it also requires the capacity and resources to design, install,maintain and manage those systems, and crucially the need to work with user behaviours, preferences, and local resource constraints.

WASH does not exist in a vacuum, however, and cannot be isolated from broader ecological, social, economic, and political systems. The management of water resources on catchment scales, for example, critically intersects with WASH but is usually poorly unified. We see the consequences of this everywhere. Large cities can have vast water demands and simultaneously pose serious pollution risks to receiving water catchments by releasing treated and untreated sewage. In communities in the Pacific, broader catchment activities such as logging and mining have compromised water security of the people who have lived there for generations. The UN Environment Program (UNEP) has concluded that one-third of rivers in Asia, Africa and Latin America are affected by severe faecal pollution that results in transmittal of pathogens.

As WASH researchers, we aim to provide evidence to improve policies and practices related to WASH outcomes, delivered as programs, projects or services provided by government, utilities or the private sector. WASH interventions have been occurring for decades, with mixed success, so more and better evidence is required. At the International WaterCentre, we conduct a wide range of research, including explorative and formative research, action research, and evaluations of existing WASH services and projects.

In an ongoing project led by Dr Regina Souter, we are investigating and trialling innovative ways to advance the inclusiveness, sustainability, and resilience of community WASH outcomes in the Pacific. One of our trials works with the Guadalcanal Provincial Government of Solomon Islands to provide "Technical Backstopping"– regular, in-village and problem-based technical support, to progressively and practically build capacities to solve water management problems.

The breadth of our research means we work closely with WASH professionals and practitioners and with WASH users. Crucial to any success is the strength of our partnerships. Over time and with sustained effort, we have built vibrant relationships with in-country research partners, including national and regional universities. Without these collaborators and partners, our reach, understanding, level of societal integration and impact would be significantly reduced.

So, next time you watch the river flowing under the bridge, remember your morning 'hour of comfort' – and think about what your access to WASH for the health of that river and its people.

ARI FEMALE RESEARCHERS POWER AHEAD

Early last year Griffith University was awarded four Advance Queensland Fellowships by The Minister for Innovation and Tourism Industry Development. Three of these were awarded to outstanding female ARI researchers, Dr Fernanda Adame, Dr Hannah Franklin and Dr Shima Ziajahromi.

Women in STEM

This is an amazing result for ARI and even more specifically for the representation of Women in Stem. ARI has a growing number of female researchers in the Institute who are becoming leaders in their individual fields.

"This funding from Advance Queensland is helping us with some truly unique and innovative projects. With this we will gain some major insight into how we can better manage our agriculture, water and environments from our individual research projects," says Dr Fernanda Adame.

"My project is investigating how wetlands can improve water quality of the Great Barrier Reef, a critical area of research to understand how "green solutions" on land could improve the future viability of the reef," says Dr Fernanda Adame.

Dr Hannah Franklin has her eyes set on determining how natural river processes treat water in the Queensland region.

"We rely heavily on healthy waterways for clean drinking water. My collaborative project with Seqwater and Healthy Land and Water is helping us understand how natural river processes improve water quality. Once we understand these processes we have the ability to recommend ways to enhance beneficial functions that can sustain healthy waterways in Queensland."

Dr Shima Ziajahromi's Advance Queensland Fellowship is investigating the impact that microplastics in biosolids are having on agricultural land and soil biota. Currently, biosolids (treated wastewater that forms a sludge) is sprayed onto agriculture farmland throughout Queensland.

"Everyday bioslid is sprayed onto farms to help increase soil productivity and this bioslid carries trillions of microplastics. We need to understand what negative effects this is having on agricultural land. I really hope my research will help inform the agricultural industry and government on cropping land management in Queensland," says Dr Shima Ziajahromi.

Dr Ziajahromi is currently analysing biosolid samples collected from 13 wastewater treatment plants across New South Wales , South Australia and Queensland to provide information about quantity, type and composition of microplastics in biosloids.

As these projects progress, we will keep you updated. Congratulations to our AQ recipients.

"It's great to see that Women in STEM are leading the way at Griffith in securing Advance Queensland funding, and it's even more exciting that all three of us are from the Australian Rivers Institute," says Dr Fernanda Adame.

PROJECT UPDATES

GLOW PROJECT

2020 was an exciting year for ARI's Global Wetlands Project (GLOW). In June, the first ever globally comprehensive syntheses of seagrasses, "Out of the Blue: The Value of Seagrasses to the Environment and to People" was published by UNEP-WCMC. GLOW Director Professor Rod Connolly, Research Leader Dr Chris Brown and PhD Candidate Laura Griffiths contributed significantly to this work and co-authored the report which aims to improve understanding of the importance of seagrasses and provide conservation and management recommendations.

GLOW Research Fellow Dr. Michael Sievers has utilised the global standard for assessing the risk of ecosystem collapse, *"the IUCN Red List of Ecosystems framework"*, and is working alongside international collaborators and some of the framework developers to assess the coastal wetlands of Moreton Bay, the Indian Sundarbans mangroves, the seagrasses of Ria de Aveiro, Portugal, and the mangroves of the Eastern Cape, South Africa.

GLOW Research Fellow Dr. Ryan Pearson led a publication in *Science* describing the widespread changes in human behaviour triggered by COVID-19, suggesting that intentional implementation of several recovery strategies to create a 'new normal' could have simultaneous benefits for both biodiversity and human health. GLOW has produced a total of 15 first author publications in 2020 with additional publications expected by the end of the year.

In recognition of their hard work and dedication, GLOW Director Rod Connolly was awarded The Vice Chancellor's 2020 Research Excellence Award for Research Supervision while Research Leader Dr. Chris Brown was a finalist in the Eureka Prize for Excellence in Interdisciplinary Scientific Research for his work on Ridge to Reef Fisheries.

GLOW researchers also attended and lead sessions at the Global Mangrove Watch Virtual Workshop Series. The team presented work that showcased global datasets on mangrove loss to predict the future for mangrove forests and how these predictions can inform on the restoration actions needed to achieve ambitious targets for mangrove conservation.

Key Publications

- Bryan-Brown et al. (2020). Global trends in mangrove forest fragmentation. *Scientific Reports* https://www.nature.com/articles/s41598-020-63880-1
- Sievers et al. (2020). Integrating outcomes of IUCN red list of ecosystems assessments for connected coastal wetlands. *Ecological Indicators* https://doi.org/10.1016/j.ecolind.2020.106489
- Sievers et al. (2020). Indian Sundarbans mangrove forest considered endangered under Red List of Ecosystems, but there is cause for optimism. *Biological Conservation* https://doi.org/10.1016/j.biocon.2020.108751
- Tulloch et al. (2020). Linking threat maps with management to guide conservation investment. *Biological Conservation* https://doi.org/10.1016/j.biocon.2020.108527
- Turschwell et al. (2020). Multi-scale estimation of the effects of pressures and drivers on mangrove forest loss globally. *Biological Conservation* https://doi.org/10.1016/j.biocon.2020.108637
- Pearson et al. (2020). COVID-19 recovery can benefit biodiversity. Science https://doi.org/10.1126/science.abc1430

BUILDING CATCHMENT RESILIENCE PROJECT

The Building Catchment Resilience Project is nearing the final phase of its prototype model which will help practitioners and other stakeholders to prioritize investments in catchment restoration for sediment and nitrogen control.

The Building Catchment Resilience project is well over the halfway point in its initial development phase. Funded by the Potter Foundation, Griffith University, the Queensland Government, Queensland Urban Utilities, Seqwater, the Port of Brisbane, QUT, Healthy Land and Water, the Lockyer Valley Regional Council and Water Technology, the project aims to create a cutting edge decision support framework to guide cost-effective mitigation of source pollution in catchments.

The analytical tool currently under development builds on predictions from catchment models and costs and integrates these into a multi-objective trade-off analysis. Costs and benefits from management actions are being spatially represented, quantified, and visualized. Additional benefits for flood mitigation are included for different management scenarios. The tool is being developed to be a flexible framework that can be adapted now for use in different catchments and management objectives.

The development of the software systems and the Multi Objective Simulated Annealing (MOSA) that underpins the framework has made significant progress. A partially functional MOSA framework creating Pareto front solutions has been achieved and linked to the visualisation tool, with QUT creating a working prototype of the ViseR visualisation tool.

Critical work, completed to date has focused on the development of the sediment, nitrogen and restoration cost models that underpin the analytical framework. A MOSA input file for sediment has been developed. The sources and sinks of particulate and dissolved nitrogen have been investigated to develop the MOSA nitrogen input file while the opportunity and implementation costs of various management scenarios have been investigated to develop the MOSA economic input file.

Critical next steps in the project involve refining the software, modelling and visualisation tools. Stakeholder engagement which was delayed by the COVID 19 crisis, is now underway.

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DEPUTY DIRECTOR'S OPINION

By Professor David Hamilton

WHAT WILL CLIMATE CHANGE MEAN FOR WATER STORAGES?

Recent funding from Water Research Australia to support a consortium of researchers to work on the effect that low reservoir levels has on water quality is providing impetus to better understand the effects of climate change of water storages. These storages are vital for water security and many are also important for irrigation and recreation.

Water quality as reservoirs dry

There is increasing certainty that we can expect a warmer world in the future with surface waters of lakes and reservoirs already warming at rates higher than those of the atmosphere. There is much less certainty, however, about what other changes in climate might be expected and how they may affect water storages. For example, different climate models indicate that rainfall in Southeast Queensland (SEQ) may increase or decrease, depending on the model used and the future time period, although there is widespread consensus that summers will be wetter and winters dryer. Wind speeds are even more difficult to predict with climate models but are important because wind affects mixing in water storages and evaporation from catchments, including the water storages.

There is increasing certainty that we can expect a warmer world in the future; surface waters of lakes and reservoirs around the world are already warming at rates higher than those of the atmosphere.

The weather is changing - what can we expect?

As we link climate models to catchment and water storage models, we are beginning to better understand the ramifications of increasing temperature from climate change. Increases in temperature increase the rate of evaporation of water from catchments, to an extent that we should expect that runoff to many water storages will be substantially reduced by the middle of this century. Elevated water temperature of surface water of storages will also increase the duration when they are thermally stratified and stable (usually 9-10 months of the year in deeper systems in SEQ), with warm surface waters overlying cooler bottom waters. Reduced duration of water column mixing is important because mixing acts like a renewal mechanism, restoring oxygen in bottom waters, improving water quality, and oxidising potent greenhouse gases like methane that are released from water storages in large quantities.

Climate change will therefore pose new challenges for managing water security. It will mean that we will need to look at all aspects of our water use, and integrate grey (e.g., water treatment plants) and green (e.g., restoring riparian vegetation) infrastructure for water life-cycle assessments at the catchment scale.

IN FOCUS

QUEENSLAND'S OYSTER BIODIVERSITY

Dr Carmel McDougall

The use of DNA-based identification techniques has revealed unexpected oyster diversity in Queensland's waters.

An oyster is an oyster, right? Well, that is what you might think when assessing species by looks alone, but the DNA tells a different story!

Dr Carmel McDougall and her collaborators have amassed a collection of over three hundred oyster specimens from between the Gold Coast and Cooktown. Sequencing and phylogenetic analysis of these oysters demonstrated that Queensland hosts many more species than previously appreciated – fourteen species were detected in total.

Amongst these oysters are well-known species such as the Sydney rock oyster, the milky oyster, and the tropical black-lip oyster. However, the survey revealed a few surprises, such as the presence of a small, undescribed species right under our noses in Moreton Bay, and a recently established exotic species in the Cairns region.

The primary driver for this research was to generate background data to support the current push for expansion of oyster aquaculture to alternative species. Commercial farming in Queensland is currently limited to the Sydney rock oyster in the south-east. Expanding beyond this species, particularly to a tropical oyster, would significantly increase the scope for production and enable farmers to reduce risk through diversification. The study not only identified new candidates for exploration but also provided important data on species distribution that can be used to assess the feasibility of each species for aquaculture, and for the management and legislation of any emerging industry.

The results are also relevant to a number of shellfish reef restoration projects that are ongoing or planned in Queensland. Carmel's research group is currently collaborating with the Noosa Biosphere Reserve Foundation and Ecological Service Professionals Pty Ltd to document oyster diversity in the Noosa Estuary, and the results will be used to inform the design of a larger shellfish reef restoration project.

The results have been summarised in a 'Guide to Queensland's intertidal oysters', available for download at http://bit.ly/oysterbkt.

This research was supported by funding from the Queensland Government Advance Queensland Research Fellowship Program and the Fisheries Research and Development Corporation.

AUSTRALIA'S FIRST MARINE WILDLIFE CELL BANK

Dr Jason Van De Merwe

Marine wildlife, such as sea turtles, dolphins, sea lions, dugong, whales, sharks and rays face numerous threats from human activities and disease. However, research into the biology and health of marine wildlife has been limited by the ethical logistical constraints of conducting research on these large, often endangered, species.

Cell cultures are an increasingly valuable, ethical and novel tool for research into biological processes and health assessment of humans and animals. However, their application in marine wildlife research has been limited, largely driven by the lack of available cell cultures for these animals. Until now, that is. Researchers at the Australian Rivers Institute, Dr Jason van de Merwe, Dr Kimberly Finlayson, Dr Liesbeth Weijs and Professor Frederic Leusch have recently established Australia's first Marine Wildlife Cell Bank.

The Marine Wildlife Cell Bank currently includes 26 fully characterised and validated cell cultures from brain, heart, lung, kidney, liver, small intestine, ovary, testis and skin tissues, originating from three sea turtle species (green, loggerhead and hawksbill), and five mammals, including the common bottlenose dolphin, the Burrunan dolphin, the Risso's dolphin, the Blanville's beaked whale and the dugong.

These cell cultures are cryopreserved in a facility at Griffith University (Gold Coast campus), and available cultures can be accessed via a web-based, searchable database (http://aritox.com/mwcb/) that includes details of all 26 cell cultures (species, tissue type and culture ID), as well as contact details and instructions on how to request cell cultures for research projects.

The establishment of this Marine Wildlife Cell Bank provides national and international researchers with an easily accessible resource of cell cultures for conducting research into the biology and health of marine wildlife. This will facilitate significant contributions to the management and conservation of Australia's unique marine wildlife.

FERTILISER RUNOFF

Dr Edoardo Bertone

New sensors and machine learning to understand fertiliser runoff from farms: a way forward to minimise environmental impact and optimising productivity

The problem

Nitrate fluxes in water systems due to fertiliser runoff can create substantial environmental and health issues, particularly in rural communities, where efficient and reliable water treatment processes are not always available. Despite current research efforts, it is reported that for certain crops such as sugarcane, which contribute over AUD$2 billion every year to the Australian economy, (mainly in Queensland), up to 60% of the applied nitrates from fertilisers are lost from targeted soil sites. Furthermore, significant parts of Queensland's sugarcane farming regions have estuaries leading directly to the Great Barrier Reef World Heritage area, implying that excess application of fertilisers leads to elevated nutrients in waterways, exacerbating potential environmental issues. This emphasises the need for more robust monitoring and modelling methods to optimise fertiliser usage.

While common monitoring methods rely on low-frequency manual sampling, new generation optical sensors provide an opportunity to collect high-frequency data which, combined with machine learning approaches, can shed light on short-term nitrate fluctuations, which is invisible to traditional sampling. Data can be compared with vital fertilizer operational parameters such as weather and farm practices. However, to date, these sensors have not been widely deployed due to reliability issues caused by interference in the optical detection processes, and sometimes logistic and economic issues with installation and maintenance of sensors in rural, remote locations.

Project partners

- Mr Martin Luna Juncal, Mr Timothy Skinner, Dr Kelvin O'Halloran, Prof. Rodney Stewart (Griffith School of Engineering and Built Environment)
- Mr Lawrence Hughes (Griffith Centre for Coastal Management)
- Xylem Analytics Australia
- Logan City Council
- Queensland Department of Agriculture and Fisheries

The research project

Australian Rivers Institute researcher Dr Edoardo Bertone, in collaboration with colleagues from the Griffith School of Engineering and Built Environment and the Griffith Centre for Coastal Management, has led the design and development of a mobile water quality monitoring station. This can be safely positioned next to rivers and creeks which pumps water back into the station where it is analysed at 30-minute frequencies. The station is self-sufficient, with energy generated by solar panels and stored in batteries. The raw water is analysed by a number of optical/fluorescence sensors, including two nitrate sensors. The data is automatically uploaded online, allowing for remote monitoring and reduced site visits.

"We completed our first pilot field study in January 2020 at Hilliards Creek in the Redlands area, at a site next to a wastewater treatment plant, followed by a second, 3-month data collection campaign at Slacks Creek for the Logan City Council" said Dr Bertone. "We had a few minor setbacks, which led us to improve to the design and resulted in a more secure and reliable station". "Data analysis showed us how nitrate levels can change very quickly, especially in response to rainfall events and tides". "This highlights the importance of high-frequency nitrate data collection, and our station allows for remote, targeted, and reliable nitrate monitoring at such required high frequencies".

Thanks to a collaboration with Queensland Department of Agriculture and Fisheries, the mobile monitoring station will be relocated to farm sites on the Sunshine Coast to collect more data. This is a great opportunity for the team to collect more data and develop a model linking nitrate concentrations to not only weather or soil conditions, but also to fertiliser usage and other farm practices. The team is confident the resulting decision support tool can help farmers to optimise the timing and amount of fertiliser to be applied. This could also lead to economic benefits for farmers as well as decreasing potential environmental issues in the area, such as algal blooms and fish kill events.

Key messages

- For some crops, over 50% of the nitrate applied as fertiliser can be lost, causing economic and environmental damage.
- New generation nitrate optical sensors were calibrated using lab data collection and modelling, considerably improving their reliability in the field.
- A mobile water quality monitoring station was built, able to collect and analyse river water every half an hour.
- Collected high-frequency, calibrated nitrate data showed short-term fluctuations, largely undetected with traditional monitoring.
- It is hoped such data, coupled with machine learning, will lead to a decision support tool to minimise fertiliser runoff.

RESEARCH HIGHLIGHTS

"A project of this extraordinary magnitude may be an ideal opportunity for a central governing body to incorporate ecological best practice and sound trans-boundary conservation actions into development at a near global scale" says Professor Rod Connolly.

THE DANGERS TO MARINE BIODIVERSITY FROM THE NEW 'SILK ROAD'

Dr Mischa Turschwell

China's 'Belt and Road Initiative' (BRI) is set to be the largest and most ambitious infrastructure project ever undertaken, at an estimated cost of US $8 Trillion by 2049. A total of 71 nations are now involved in the project, which represents over one third of the world's GDP and two thirds of the world's population.

Marine conservation implications

The project is being termed the 'New Silk Road', and it aims to link Europe, East Africa and Asia, through a network of terrestrial and maritime trade routes. The project proposes massive upgrades and expansion of rail and road networks, as well as major ports in key trade locations.

ARI researchers, Dr Mischa Turschwell, Dr Chris Brown, Dr Ryan Pearson and Professor Rod Connolly have recently estimated the impact on marine ecosystems in the proposed BRI maritime development on areas including the impacts of port expansion and increased shipping traffic on threatened species and habitats.

"We estimated that the proposed development could impact approximately 55,000 hectares of seagrass, 8,500 hectares or coral, 4,000 hectares of mangroves and 2,000 hectares of saltmarsh – the equivalent area of 69,500 football fields," said Dr Mischa Turschwell.

"These ecosystems not only provide habitats for thousands of species they also produce key ecosystem services, many of which people economically benefit from. They offer blue carbon storage, contribute to healthy fish stocks for fisheries, provide coastal protection from storms and protect coastal communities against sea level rise," said Professor Rod Connolly.

They also found that over 400 threatened marine species could be affected by port infrastructure development and more than 200 threatened species were at risk from an increase in shipping traffic and noise pollution.

Opportunities for conservation for China's Belt and Road Initiative

"The potential environmental impacts from the project's development will stretch across borders and nations. However, this project can be seen as a great opportunity to establish international frameworks that improve environmental practices, and subsequent outcomes from these developments, compared to having no standardized environmental safeguards," says Dr Mischa Turschwell.

The researchers suggest there are several ways to reduce impacts to biodiversity from BRI infrastructure development such as: monitoring and managing dredging activities around ports to help to minimise impacts to ecosystems and species. Reducing the frequency and duration and also timing dredging activities can also assist to reduce the effect of light limitation on seagrasses, as well as fish species that are known to be vulnerable in juvenile stages.

The research team also highlight that changes to how ships operate in environmentally sensitive areas, restricting vessel speeds or changing routes, especially during important migratory and feeding seasons for marine mammals.

The researcher's hope that their findings can help inform policies that can mitigate some of the damage that the project could have on marine ecosystems.

Note: For more information on this topic see The Conversation article written by Dr Mischa Turschwell here: https://theconversation.com/chinas-belt-and-road-mega-plan-may-devastate-the-worlds-oceans-or-help-save-them-150176

FISH USES

Associate Professor Mark Kennard

Fish are more than just food: Exploring the diverse ways that fish are useful to society

Fish Biodiversity is Incredible

Fish are one of the most biodiverse vertebrate groups on the planet, playing important roles in ecosystems, supporting considerable commercial and recreational fishing industries, and providing a major source of protein and nutrients for much of the world's human population.

The multiple intrinsic, ecological, socioeconomic and cultural values of fish are relatively well-recognized. Indeed, most people rarely think about fish other than as pets, a recreational prize, a basis for inspiration or worship, or as a source of protein or income. Much less appreciated are the diverse additional ways that fish have contributed to human societies over multiple millennia.

Associate Professor Mark Kennard and a group of friends and close collaborators from the USA, France and Brazil have just published a paper exploring the many uses of freshwater and marine fishes. They focus on the contributions of fish to manufacturing and industry, technology, health and sexuality, tools and weapons, apparel and jewelry, musical instruments, and as curios, souvenirs and attractions.

Promoting Fish Sustainability

Their research demonstrates that the relationship between humans and fish is much more than food, and the different ways people use fish continues to grow rapidly, posing new questions and challenges.

Rising concern about environmental sustainability related to overfishing and intensive aquaculture production has prompted increased interest in reducing waste and maximizing use of by-products of the fishing industry, and this is leading to novel and creative use of fish.

The team hope that increasing awareness of the ways in which fish are used by our societies will help to promote the conservation, sustainable management and ethical treatment of fish now and into the future.

Julian D. Olden, Jean R. S. Vitule, Julien Cucherousset & Mark J. Kennard (2020). There's more to fish than just food: Exploring the diverse ways that fish are useful to human society. Fisheries 45: 453-464. https://doi.org/10.1002/fsh.10443

"Most people rarely think about fish other than as pets, a recreational prize, a basis for inspiration or worship, or as a source of protein or income."

"Unfortunately, microplastics have now been found in almost every location they have been looked for: deep ocean trenches, Himalayan snow, and the Arctic."

MICROPLASTICS: WHERE ARE THEY NOW? YOU'RE IN FOR A SURPRISE!

Microplastics is the term we commonly use to describe plastic particles smaller than 5 mm in size, and they occur either from the degradation of larger plastic debris (e.g., plastic bottles and bags) or as microscopic components of consumer products (e.g., microfibres in synthetic clothing or microbeads in personal care products).

What are Microplastics?

Over the past five years, there has been increasing concern about the occurrence of microplastics in our environment. Like their larger plastic cousins, microplastic particles can last for decades in the environment without degrading. Unfortunately, microplastics have now been found in almost every location they have been looked for: deep ocean trenches, Himalayan snow, and the Arctic. Their widespread presence has raised concerns about potential adverse effects, and we're not fully aware of the damage their presence is having on fragile ecosystems and species early research into this area is not positive.

The link between wastewater and microplastics

Wastewater treatment plants are a known pathway of microplastics into the aquatic and terrestrial environments, particularly for synthetic fibres from clothing. While wastewater treatment plants are often quite efficient at reducing microplastics in wastewater (with typically greater than 90% reduction from influent concentrations), the sheer volumes treated and the amount of microplastic particles in raw sewage still translate into millions of microplastic particles released from individual wastewater treatment plants daily.

It is important to note that microplastic particles do not easily degrade therefore, while they are removed from the wastewater, they are not destroyed. Instead, it is expected that microplastics will be recovered in sludge, the solid waste produced during wastewater treatment. In recent agricultural production methods, sludge is increasingly being used as a biosolid to enhance soil quality and nutrients in agriculture. This raises concerns that microplastics from sludge could contaminate agricultural lands.

Our Research

ARI researchers Dr Shima Ziajahromi, Dr Peta Neale and Professor Frederic Leusch, with colleagues from the Western Australian Water Corporation, conducted an audit of microplastics in three Australian wastewater treatment plants.

Their study confirmed that wastewater treatment plants were indeed very effective at removing microplastics from wastewater with only 0.2-1.8% of microplastics in influent left in the treated wastewater effluent, but surprisingly biosolids (i.e., sludge) contained 8-16% of the microplastics in the influent.

The majority (69-79%) of microplastics were in fact removed right at the start of treatment, during preliminary screening and grit removal. This is an important finding for microplastic management in Australia, as material removed during preliminary treatment is sent to landfill. This emphasises the importance of landfill management to mitigate further risk to our fragile environment.

Advance Queensland Research Fellow, Dr Shima Ziajahromi's will be focusing on the residual risk posed by that 8-16% of microplastics in biosolids – stay tuned for more!

CAN TREES CONTROL ALGAL BLOOMS – YOU'D BE SURPRISED

By Professor Michele Burford

Researchers in the Burford group have recently discovered that fallen leaves can play an important role in controlling algal blooms. The list of reasons why trees are so important to our ecosystems continues to expand.

Algae - it can ruin more than just your holiday

Summer is a time when Australian families are enjoying our waterways. Be it fishing, swimming, snorkelling, or kayaking, during summer you are likely to encounter people enjoying quality outdoor time. However, a disappointing surprise can present itself when arriving at the destination only to find signs indicating the waterways are 'closed', or the presence of green scums on the water surface, due to the occurrence of a blue-green algal bloom. This common ecological problem not only puts a stop to your holiday's aquatic activity plans, but also increases the costs of water treatment and can have major effects on the plants and animals in our waterways.

What's to blame?

Nutrients coming from the land, e.g. fertilizers, soil erosion, are a major cause of algal blooms, and planting trees along waterways is one commonly accepted way to reduce nutrient runoff. This is because trees take up nutrients from the soil in order to grow. But trees have another role, as we have recently found. Researchers in Professor Michele Burford's research team, the Burford Group, have discovered that when leaves are wet they leach organic molecules which can inhibit blue-green algal blooms. Undertaking the research the team used a combination of novel techniques not previously applied to freshwater systems. Their findings may help explain why waterways surrounded by vegetation may have less problems with blue-green algal blooms than other waterways. This gives us a fresh perspective on trees, showing that they don't just control algal growth by shading, they may also be chemically controlling growth.

Collaborators

This study was conducted by researchers and students at Griffith University with support from Seqwater, Healthy Land and Water and the Australian Research Council.

Research Publication

This article was based on two research papers, both were published in the journal, Science of the Total Environment.

- Amanda D. Neilen, Anthony R. Carroll, Darryl W. Hawker, Katherine R. O'Brien, Michele A. Burford (2019). Effects of photochemical and microbiological changes in terrestrial dissolved organic matter on its chemical characteristics and phytotoxicity towards cyanobacteria, Science of The Total Environment,Volume 695, https://doi.org/10.1016/j.scitotenv.2019.133901.
- Hannah M. Franklin, Anthony R. Carroll, Chenrong Chen, Paul Maxwell, Michele A. Burford (2020). Plant source and soil interact to determine characteristics of dissolved organic matter leached into waterways from riparian leaf litter, Science of The Total Environment, Volume 703, https://doi.org/10.1016/.scitotenv.2019.134530.

"Algal blooms are a major issue for water security globally and in Australia. We have seen the damage algal blooms have had on Murray-Darling Basin and the issues Florida have had with the recent 'red tide' epidemic. As our climate changes, we can expect more algal blooms - but is there a simple solution to help reduce these blooms?"

2011 BRISBANE FLOOD – WATER QUALITY ANALYSIS

PhD Candidate Joe McMahon

The 2011 Brisbane River flood was a disaster for South East Queensland and impacted drinking water quality – with more flooding on the way, how can we reduce this impact?

The effects of La Niña

A La Niña event occured last summer. The previous time this happened it was associated with the 2011 Brisbane River flood. Although a flood of similar magnitude to 2011 did not occur this year, we have seen localised flooding across Queensland and New South Wales.

The 2011 flood transported millions of tonnes of sediment from riverbanks into the region's drinking water. We know that, replanting trees can reduce the magnitude of riverbank erosion which occurs in floods, however historically it was almost impossible to collect evidence supporting this solution at a catchment scale before and after a flood.

Our Research

In our recent research, we studied the riverbank changes endured during the 2011 Brisbane floods in a water supply catchment which was largely cleared of vegetation. Using lasers we calculated the amount of riverbank soil trees prevented from entering 62 km of the Brisbane River. We found that at locations where the most riverbank erosion occurred, around half of the original trees remain. Our analysis indicates that to cut erosion by half, we would only need to increase the wooded area from half of the original extent to three quarters.

However when looking at our study area, the majority of trees had been cleared by the early 1900s. If trees were the only factor influencing riverbank erosion, we would have expected more erosion to have occurred during the last flood, of comparable scale, to what occurred in 1974. While some erosion did occur in 1974, it was much less than during the 2011 flood. Other land use changes which have occurred since 1974 that could have influenced riverbank erosion rates are riverine sand and gravel extraction.

The river has experienced large volumes of erosion at some sites, and in other locations it has remained remarkably resilient to these land use changes.

The Future?

Our analysis suggests that current and historical land use changes, such as vegetation clearing and sand and gravel extraction along the river corridor, have contributed to the current condition of our Brisbane River study area. If we want to improve the condition of the river by large scale replanting of trees, or 'green infrastructure', practices which have contributed to changed erosion rates must also be ceased.

OPINION PEOPLE AND PERSPECTIVE:

IN RECENT YEARS 11 MILLION HECTARES OF LAND HAS BEEN BURNT – WHAT DOES THIS MEAN FOR OUR SOIL?

Professor Chengrong Chen

Fire has modified over 40% of the Earth's land surface. It is predicted that the frequency and intensity of wildfires will increase in future due to warming climates at a global scale, with Australia one of the most fire-affected countries.

More fires, more often

Recent wildfires (Jun 2019 – Feb 2020) in Australia have burnt over 11 million hectares of land, causing catastrophic damage to native flora and fauna, and drastic changes to ecosystem diversity, function and stability. It's important to note that fire doesn't only affect above ground components of the ecosystem, but also the biogeochemical processes of below ground components. These changes occur across the whole ecosystem, influencing its dynamics and function.

Our Research

Our recent global meta-analysis (Butler et al. 2018) has demonstrated a shift in ecosystem nutrient balance with an overall increase in phosphorus and decreases in carbon and nitrogen in soil. This is because fire burns off carbon and nitrogen, but phosphorus remains in soil due to different elemental burning points, leading to a phosphorus-rich signature in the soil–plant system. This will have significant implications for ecosystem diversity, function and stability.

Our long-term prescribed burning studies (Butler et al. 2019) have further indicated long-term (40 years) high frequency (biennial) prescribed burning results in severe phosphorus and nitrogen depletion in forest litter due to burning and soil erosion loss. This will further exacerbate the microbial nutrient limitation, constraining litter decomposition relative to unburned areas. However, invertebrate-driven decomposition largely compensated for the diminished capacity of micro-organisms under less frequent fires (quadrennial), suggesting that invertebrates could have an important stabilising influence in fire-affected ecosystems.

Our Results

Our results reveal that high frequency fire regimes create nutrient-poor, carbon-rich ecosystems, disrupt ecosystem processes and modify the relative functionality of micro-organisms and invertebrates. Under ongoing climate change, the increase in fire frequency and intensity will likely further aggravate nutrient limitation in the current Australian landscape.

On the other hand, fire is an essential part of ecosystem processes. In addition to aids with germination and growth of some plants, fire may transiently reverse declines in phosphorus and ecosystem productivity during the development of natural ecosystems.

Research Publication:

Muqaddas, Bushra & Lewis, Tom & Esfandbod, Maryam & Chen, Chengrong. (2019). Responses of labile soil organic carbon and nitrogen pools to long-term prescribed burning regimes in a wet sclerophyll forest of southeast Queensland, Australia. Science of The Total Environment. 706. 110-120. 10.1016/j.scitotenv.2019.136035.

REFLECTIONS ON RIVER HEALTH AND ENVIRONMENTAL FLOWS

Emeritus Professor Angela H. Arthington

Since 2005, the last Sunday of every September has been recognised as World Rivers Day. This special day marks the world's largest river related celebration. It is also a time of reflection, when Indigenous Peoples, scientists and water managers confront the realities of threats to rivers almost everywhere.

The Blog

This concatenation of impacts results in huge deprivations for millions of people whose diets, livelihoods and well-being depend directly on the ecosystem services and very existence of healthy rivers. All societies lose when we degrade rivers.

Why am I veering between celebrating rivers and this doom and gloom scenario? Perhaps because in 2020 and 2021, with all its misery and uncertainty for human life and health on our planet, brings into such sharp focus the awful effects we have had on our environment.

In 2020, at the start of my lockdown, I joined a team of lifelong colleagues and friends to produce a BLOG about the need for environmental flows to keep our rivers and wetlands healthy, biodiverse and resilient to change.

https://blog.oup.com/2020/09/bring-living-waters-back-to-our-planet/

'*Bring living waters back to our planet'* was a fitting title and the BLOG has received many hits on social media. Dare I say it has gone viral? Probably not a good analogy, actually.

The Book

Stimulated by the completion of the BLOG, I turned to a long promised review of a marvellous book by Sandra Postel - *Replenish: The Virtuous Cycle of Water and Prosperity* (Island press, 2017).

This book is packed with amazing case studies about ecosystem replenishment and revival, recovery and ecological resilience, all related to water and how we could use and manage it sustainably.

Postel asks "On balance, are rivers getting healthier, aquifers being recharged, floodplains being rejuvenated, and wetlands being expanded? Are we becoming more resilient to droughts, floods, and fire? Is the water cycle being replenished and repaired? Yes, the water cycle is broken, but one river, one wetland, one city, one farm at a time, we can begin to fix it".

I wrote "Yes, we have ample water management tools and environmental flow techniques, we know what works and what needs more research, but are we doing enough? No. Increasing the number of practical riverine restoration projects and expanding their influence from local to regional scales is the immediate challenge. Integrating water reforms with social and cultural norms, governance systems and country land and water management policies is another huge challenge. Achieving all this in contexts of population expansion, shifting societal expectations and uncertain climatic futures is the third grand challenge".

Postel's final message is very clear and I agree. "Our challenge as a society is to build resilience — the ability to cope with disturbance while continuing to function. As the stories in this book have shown, replenishing the world's natural flow of water is among the best ways to build that resilience".

Arthington, A.H. (2020). Review of Replenish: The Virtuous Cycle of Water and Prosperity. Australasian Journal of Water Resources https://www.tandfonline.com/doi/abs/10.1080/13241583.2020.1822139

ARTIFICIAL INTELLIGENCE IS REVOLUTIONISING MARINE MONITORING

Professor Rod Connolly

What an exciting time to be a marine scientist! Artificial intelligence (AI) is revolutionising the way we monitor coastal seas.

Smarter Sensors

Smarter sensors and streaming underwater video and sound have set scientists up to measure environmental indicators in more locations, more often, at less cost. AI helps analyse big data and extract actionable data from imagery.

These amazing technological advances are just in time. We're at the pointy end of decades of rapid loss and degradation of coastal habitats, topped with emerging climate impacts. We're also in a Covid-induced re-set, which is focussing attention on budgets, and is increasing expectations for environmental sustainability. There is now global impetus for restoring lost habitats, as we begin the United Nations Decade for Ecosystem Restoration (2021-2030). Major new initiatives are restoring lost coral reefs, oyster reefs, seagrass meadows and mangrove forests.

As habitats are restored, monitoring of the health of plant and animal communities is essential for assessing restoration success, and for adapting where, when and how future restoration is done. This is fundamentally important to capturing the desired benefits of ecosystem restoration. And AI will help us get there.

Managing Big Data

Having massive, continuous data streams from many places can be a manager's dream – so long as management-relevant patterns are quickly able to be determined. Alongside big data, computer intensive machine-learning (ML) methods are continuing to develop, opening up many potential applications. Working with local waterway managers, for example, Dr Ryan Pearson from the Global Wetlands Project (GLOW) team uses ML to calculate light available for seagrass growth purely from remotely collected, publically available data. This critical indicator of the health of seagrass ecosystems can now be 'measured' incredibly efficiently and cheaply, all day, every day.

Fish ID

GLOW has also developed FishID software that automatically detects, identifies and counts fish and other animals in underwater videos. The advent of cheap, reliable underwater cameras has resulted in videos becoming the method of choice for many ecological research and monitoring tasks. Manual processing of videos, however, is slow and expensive. FishID works across diverse ecosystems, from the coral of the Great Barrier Reef, to seagrass meadows, and river estuaries. GLOW also is working with The Nature Conservancy to deploy FishID at new oyster reef restoration sites.

The astounding, rapid step-change in marine monitoring requires new skills in statistical ecology and in interpretation for management application. Students and early-career researchers are being trained in techniques that see them in demand from a wide range of employers who want to adopt new technologies, and realise they need graduate employees who are tech-ready for AI science.

With new funding support for an open platform through the Australian Research Data Commons, FishID algorithms monitor the abundance and behaviour of target species in near real time, overcoming the manual processing bottleneck.

TRADING MARKETS FOR NUTRIENT OFFSETTING TO FACILITATE COST-EFFECTIVE CATCHMENT RESTORATION

Associate Professor Jim Smart

As Australia's metropolitan and suburban populations continue to increase and the effects of climate change become more acute, the rivers that flow through many of our major cities are carrying large nutrient and sediment loads from catchments whose condition has been severely degraded through agriculture, mining, and rural residential development.

A whole-of-catchment challenge

In many cases, the bays and coastal waters into which these rivers discharge are approaching, or have already reached, the limit of their natural capacity to handle these loads. This heightens the risk of toxic algal blooms, increases the cost of drinking water supply, and reduces natural capacity for handling stormwater runoff from urban development and wastewater from even the most technologically advanced sewage treatment plants. A solution to this challenge is urgently required to reinvigorate our economy post-Covid and prevent steep increases in the costs of water and sewage services.

Degraded catchments can be repaired to reduce nutrient and sediment loads and restore the natural assimilative capacity of receiving waters. However, the scale and effectiveness of restoration efforts have so far been limited because they have not been configured to deliver economic benefits to all relevant parties. Trading markets for nutrient offsetting – a whole-of-catchment approach – can provide coordinated, connected and cost-effective solutions to these problems.

What is nutrient offsetting?

In 'nutrient offsetting' a whole-of-catchment limit or 'cap' is set on the nutrient load based on what is acceptable for meeting environmental standards. Nutrient emitters, such as sewage treatment plants, can then buy 'nutrient credits' to offset the increased nutrient loads they discharge to receiving waters as populations grow. Nutrient credits are produced by catchment restoration and land management improvements upstream that reduce nutrient losses directly (e.g., through improved fertiliser management or wetland restoration) or indirectly by reducing soil erosion that carries nutrients with it (e.g., through riverbank stabilisation, gully repair). With nutrient offsetting, nutrient emitters can buy nutrient credits to offset their increasing emissions, thereby holding overall emissions within the cap. In a market-based approach, nutrient emitters buy nutrient credits from a central trading market, rather than engaging in one-on-one negotiations and land use agreements with individual catchment landholders.

Backed by robust science, an appropriately configured nutrient credit trading market can deliver win-win outcomes to all parties. By selling nutrient credits through the trading market, upstream landholders and restoration project proponents can be adequately compensated for the value delivered by improved land management and catchment repair. Purchase of suitably priced nutrient credits provides a cost-effective opportunity for downstream nutrient emitters to significantly reduce their operating and investment costs as they supply an increasing population.

How do we make it work?

Despite their potential for providing a cost-effective, win-win solutions, few nutrient credit trading markets worldwide have delivered on this opportunity. This is often because catchment restoration planning, trading market configuration, and funding mechanisms have been designed piecemeal, without collaborative involvement of all relevant parties, and because the science and modelling that underwrites the validity of the offsets has been contested and is in its infancy.

Credit suppliers, credit buyers, the Environmental Regulator (responsible for maintaining water quality), and governments are all sensitive to different forms of risk surrounding their involvement in nutrient credit trading. The credit trading market needs to be designed so that it provides adequate reassurance or compensation to all parties for their risk exposure. For governments and the Environmental Regulator, risks centre around uncertain water quality outcomes, impacts on the pricing of water supply and wastewater treatment services, and potential 'handbrakes' on economic expansion. Upstream landholders (or project proponents working in collaboration with them), as credit suppliers, will be need to be convinced that revenues from nutrient credit sales can deliver viable financial returns before they will commit sizeable upfront expenditures to bank stabilisation, gully repair or wetland creation. Downstream credit buyers need to be convinced that nutrient credits can provide a cost-effective, Regulator-approved, solution for managing their emissions liabilities before they will design nutrient offsets into their long-term operational and investment planning and thus generate bulk demand for nutrient credits. All these concerns need to be addressed if the trading market is to launch at sufficient scale to deliver on its potential.

Ground-breaking science, state of the art modelling

The Australian Rivers Institute is at the forefront of research on catchment restoration and state of the art modelling that can help deliver effective and sustainable nutrient credit trading. Led by Professor Michele Burford, Professor David Hamilton, Associate Professor Jim Smart and Professor Stuart Bunn, ARI researchers are working collaboratively with industry and government to advance the foundational science behind catchment remediation and nutrient offsetting. New scientific methods are being developed for estimating the effectiveness of catchment restoration actions in specific locations, notably the Building Catchment Resilience project report in ARI Magazines two and three, and for assessing the equivalency of different nutrient sources in terms of ecosystem effects. These validation efforts are critical so that catchment restoration actions really will offset downstream emissions effectively. The Building Catchment Resilience Project can provide a catchment-wide planning tool to help identify the most cost-effective locations for supplying nutrient credits through catchment restoration. The project team are working actively with all relevant parties to bring these innovations together to create efficient and effective nutrient offsetting solutions that can realise the full potential of nutrient trading markets for empowering catchment restoration, facilitating cost-effective economic development, and securing safe and efficient supply of drinking water and sewage treatment for our expanding urban populations.

"The Australian Rivers Institute is at the forefront of research on catchment restoration and state of the art modelling that can help deliver effective and sustainable nutrient credit trading."

LIFE AS A SCIENTIST

Dr Michael Vernarsky

I think this quote from a YouTube creator called "Filmjoy" elegantly summarizes my experience working in science: "You never really expect yourself to be where you ended up".

Where will you end up?

I grew up in a small farming community in the state of Illinois (USA) and spent time hunting and fishing. These experiences developed my interest in pursuing a zoology degree, with the intention of becoming a wildlife manager for game species, such as whitetail deer, waterfowl, and fish. However, during my undergraduate studies it quickly became apparent that I would require a Master's Degree to secure a job. Now, you might expect that my advanced studies would have focused on wildlife research, but that is not where the opportunity presented itself and my Master's project focused on endangered species in cave ecosystems.

After completing my Master's I hoped to either teach or work in natural resource management, but after six months I had this nagging urge to purse a PhD. Funny how we can be a glutton for punishment sometimes. So, I moved to a university in the southeastern USA for my PhD and continued to work in cave ecosystems.

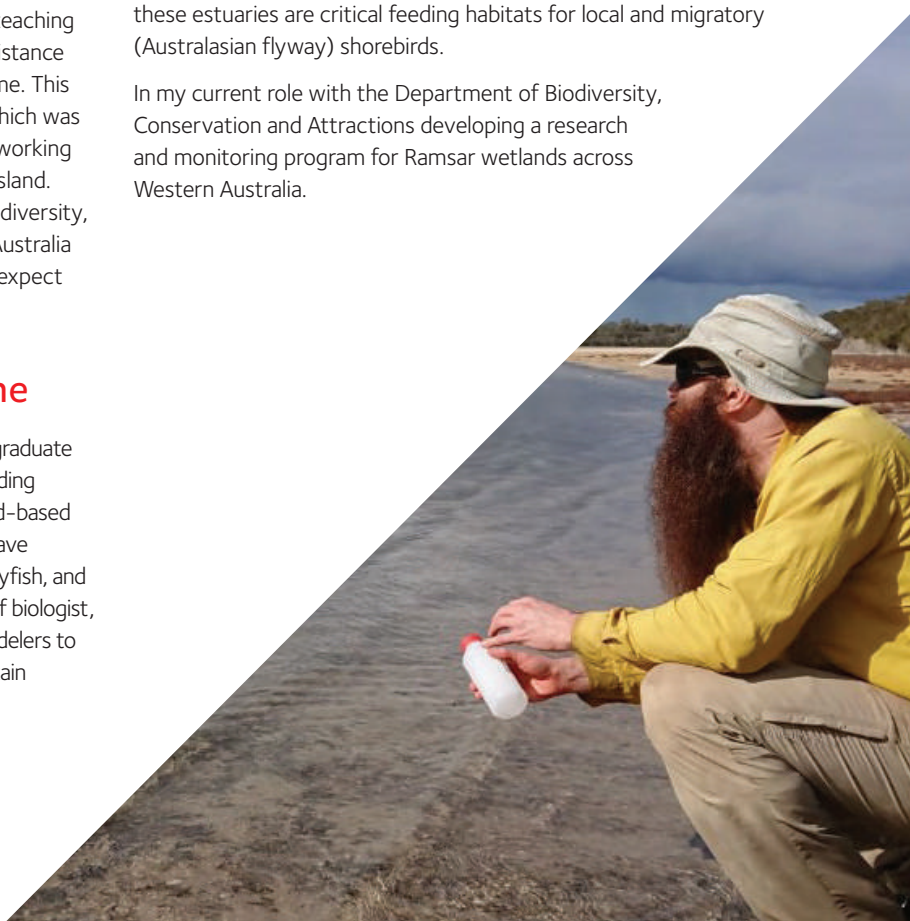
After completing my PhD I wanted to avoid research and teaching at a small university, but again chose the path of most resistance and decided to see where a career in research could take me. This time I moved west to work in Rocky Mountain streams, which was followed by a position with the Australian Rivers Institute working in wet-dry tropical rivers and estuaries in northern Queensland. Now, I am a research scientist with the Department of Biodiversity, Conservation, and Attractions (DBCA) in Perth, Western Australia working in inland salt lakes and wetlands. You never really expect yourself to be where you ended up...see what I mean.

Jack of all trades, master of none

I have developed a broad skill set over the years. During my graduate studies I described the life history traits of cave species, including growth rate, time-to-maturity, and longevity. I also used field-based experiments to understand how food availability influences cave stream community structure, including microbes, insects, crayfish, and salamanders. In the Rocky Mountains I worked with a team of biologist, fluvial geomorphologists, biogeochemists, and landscape modelers to examine the legacy effects of 19th century logging on mountain stream ecosystems (aquatic insects, trout, riparian spiders).

At the Australian Rivers Institute, I worked on two projects aimed at understanding how rivers and estuaries in northern Australian responds to dam installations and water extraction. Previous studies established that access to floodplain wetlands is critical to fish growth and reproduction in northern Australian rivers. However, the movement patterns of fish are unknown, meaning that managers do not know if fish are moving from headwater reaches to the floodplain wetlands during the wet season (~500 river km one-way) or if fish only in the lower reaches of the catchment access the floodplains. Consequently, as part of the project, tracking of the movement of fish, gobies to barramundi, throughout the Mitchell River catchment in northern Queensland was undertaken to evaluate the degree to which dams will influence fish movement. While dams can restrict fish movement, the extraction of water from rivers will likely reduce dry season flows to estuaries in the Gulf of Carpentaria. The aim of my other project was to understand how reduced flows would influence the productivity of Gulf estuaries as these estuaries are critical feeding habitats for local and migratory (Australasian flyway) shorebirds.

In my current role with the Department of Biodiversity, Conservation and Attractions developing a research and monitoring program for Ramsar wetlands across Western Australia.



LIFE AS A SCIENTIST

Dr Steven Melvin

I think most scientists would agree that a career in research can be extremely demanding, even emotionally draining at times, but also tremendously fulfilling. Science offers a unique lifestyle where creativity, perseverance and a collaborative spirit are rewarded with the flexibility to explore questions out of sheer interest and opportunities to address topics that have clear environmental, societal and economic relevance at an international level.

From Canada to Australia

Growing up in eastern Canada, I've always had a deep appreciation for nature and wildlife. Countless happy hours of my youth were spent fishing and catching frogs, which sparked a life-long interest in animal behaviour and physiology. I remember I use to study where in the stream I should fish, to increase my chances of catching a larger fish. I'd also examine the stomach contents of trout to learn what they ate, to determine the best bait to use. Looking back, I now think of these as some of my first strides in research and marvel that I managed to make a career of it.

I apply the same curiosity in my research today, I just have better tools at my disposal. Incredible technological advancements have been made in recent years, making it an extremely exciting time to be a scientist. From motion-tracking software allowing fish behaviour to be studied to powerful analytical tools offering detailed evaluation of a huge range of cellular and molecular endpoints, the scope for research is incredible.

My research: Understanding how animals respond to environmental pollutants

An unfortunate reality of modern times is that human activities introduce a huge diversity of chemicals into the environment. As an eco-toxicologist in the Australian Rivers Institute, my research uses novel analytical tools and technologies to understand how aquatic species respond to these pollutants, and to better monitor the health of our waterways.

Many people suffer from depression and anxiety, and anti-depressants play a key role in managing the disease. However, one widely used class of anti-depressants, Selective Serotonin Reuptake Inhibitors (SSRIs), is commonly introduced into surface waters through our sewage.

One of my recent research projects examined how SSRIs impact fish behaviour. Serotonin helps regulate sleep-wake cycles, or circadian rhythms, which in fish align peak activity to coincide with times when food is available, and predators are not. I developed a technique to precisely measure circadian rhythms in fish and used this to demonstrate that concentrations of SSRIs found in the environment disrupt normal daily rhythmicity of fish.

This represents a unique use of cutting-edge technology to identify the subtle ways that common environmental pollutants are influencing aquatic species.

Traditional chemical analysis used for environmental monitoring can tell you if a chemical is present, but not if it is having an effect on wildlife. Another major focus of my research involves using powerful analytical tools like Nuclear Magnetic Resonance (NMR) spectroscopy to complement chemical monitoring, by characterising unique biochemical 'fingerprints' of organisms experiencing chemical stress. For example, one of my recent projects used NMR to identify a multi-parameter suite of biochemical metabolites that can identify when fish are exposed to toxic metals. This research has exciting possibilities for 'effects-based' monitoring, by helping to identify pollutants causing toxicological effects as a complement to chemical analysis.

LIFE AS A SCIENTIST

Associate Professor Kylie Pitt

Let's be honest, a scientific career isn't easy. As a scientist working in academia, I wear many hats; I'm a researcher, teacher, manager and administrator and trying to perform all my roles well is a constant juggle of priorities.

Wearing many hats

Yet my career in science has provided an almost unparalleled opportunity to explore the planet and to see and experience things that are inaccessible to most people. As a scientist, I can work on almost any topic I choose, in almost any place on Earth, as long as I can find the funds to support the work I do. This academic freedom is the main reason I am still excited to come to work, more than 20 years after graduating with my PhD.

Science communication is a relatively new part of being a scientist and one that I consider all scientists have a responsibility to pursue. Developing the Griffith Sea Jellies Research Laboratory, which is located within Sea World's Sea Jellies Illuminated exhibit, and on view to the public, has provided a unique opportunity to engage the public in science. It is one of the rare times that the general public can see what research scientists actually do (although I do wish they wouldn't tap on the window).

"One aspect of my job that I really enjoy is communicating with the public."

My Research

My current research on jellies covers three broad themes including understanding their population dynamics (from local to global scales), their trophic ecology (i.e., what they eat and what eats them) and their responses to anthropogenic (the study of the origins of humanity) stressors including pollutants and global change. Misinformation exists about jellyfish in the public domain but, surprisingly, also in scientific literature, where jellyfish are often portrayed as a 'nuisance species' despite only a small sub-set of jellyfish species causing problems. My research, therefore, largely focuses on separating fact from fiction and providing the evidence needed to understand how jellies will respond to changing ocean conditions. Our new lab at Sea World, which contains large numbers of specialised jellyfish aquaria, is probably the best equipped lab in the world to do this.

PhD SPOTLIGHT

MY PHD WITH THE AUSTRALIAN RIVERS INSTITUTE

Dr Lana Hartwig

My PhD

In April 2015, I began my PhD research with the Australian Rivers Institute investigating Aboriginal water rights and self-determination in the Murray-Darling Basin. This research found that Aboriginal people hold rights to less than 0.2% of all available water in the NSW portion of the Murray-Darling Basin and identified and described the waves of land and water dispossession throughout Australia's colonial history that led to this situation. The work also documented for the first time in Australia, Aboriginal peoples' water trading engagement, and their experiences and perspectives about this.

These included leading cultural geographer Professor Sue Jackson, environmental justice scholar Dr Natalie Osborne, environmental economist Associate Professor Jim Smart, and GIS Specialist Graeme Curwen. I also received invaluable mentoring from Gomeroi man and leading Aboriginal water expert, Mr Phil Duncan,the Indigenous representative on the Australian Freshwater Sciences Society Committee.

Looking to the future

Currently, I am collaborating with peak Aboriginal organisations, government agencies and ARI researchers on several policy and research projects, which are aimed at advancing outcomes for First Nations across the Murray-Darling Basin.

One of these projects focuses on amplifying Aboriginal voices in water planning and regulation processes. Over the last few years, Basin State Governments have been developing Water Resource Plans which contain new rules for ensuring sustainable water use and management at regional levels, and are crucial for delivering the Basin Plan. In this project, I work with peak Aboriginal organisations Murray Lower Darling Rivers Indigenous Nations (MLDRIN) and Northern Basin Aboriginal Nations (NBAN) as well as local Traditional Owner representatives to assess the content of these plans that addresses Aboriginal values, uses and consultation. The feedback from our assessments is returned to the Federal Government for consideration in the overall Water Resource Plan accreditation process.

I look forward to continuing my research in partnership with, and for the benefit of First Nations people into the future.

My multidisciplinary research project benefitted from the guidance of numerous ARI and Griffith University experts.

PHD SPOTLIGHT

MY PHD IN A COVID ERA

PhD Candidate Michelle Hobbs

Investigating Mussels

I commenced my PhD in early 2020, sandwiched between the Black Summer of bushfires and the Coronavirus Pandemic. At that time there was immense concern over the summer of fish kills that had plagued the Murray Darling Basin (MDB). Thousands of freshwater mussels, which can live up to 50 years, had also died from severe lack of water and soaring temperatures. Mussels are linked to the fate of fish, as their larvae attach to fish to complete their life cycle. The recovery of future mussel populations will at least partially rely on sufficient fish hosts. My "Pre-Covid" PhD plans were to investigate the mussels' ecological role and place in the food web.

"Pre-Covid", I had the opportunity to assist my supervisors, Professors Fran Sheldon and Sue Jackson on a mussel survey for the Commonwealth Environmental Water Holder, collaborating with mussel experts Hugh Jones, Nicole McCasker, Paul Humphries and Michael Klunzinger. Part way through our surveys of the northern MDB, the rains arrived. Although good news, the river levels rose in many survey sites making it difficult to find mussels hiding in deep pools and channels however, we still managed to collect valuable data on the magnitude of the droughts' impacts on mussels. This data showed that death rates in the lower Darling River were an alarming average of 97%. It is unclear how well mussel populations will recover, as there has been little evidence of reproduction in recent years.

Field surveys are always at the whim of weather and seasons, but lockdowns and border closures add additional complexity.

Covid interruptions

Also "Pre-Covid", I served on the Technical Advisory Group for the Native Fish Recovery Strategy coordinated by the Murray Darling Basin Authority. I travelled to Sydney and Canberra, at a time before quarantine, where myself a Bidjara woman, and fellow Aboriginal scientist Associate Professor Bradley Moggridge, a Kamilaroi man, worked with a diverse group of fish ecology and water experts to provide advice on riverine recovery.

Given the ongoing unpredictability of interstate travel, my PhD plans have shifted focus to local freshwater mussels of south-east Queensland. There are at least six species of large freshwater mussels in the region, though relatively little is known about their distribution and ecology.

I have been working with supervisor Associate Professor Mark Kennard on a model linking freshwater mussel distribution to environmental attributes. This will investigate what factors are most important in determining where mussels occur. The benefits of desktop-based research that make use of existing datasets are significant, being unaffected by weather and pandemics. I already value the geographic information system (GIS) and coding skills I am developing.

NEW STAFF

Research:

Dr Mohammad Bahadori
Dr Emad Kavehei
Dr Sunny Yu
Dr Shima Ziajahromi
Dr Sayed Iftekhar
Dr Mahsa Jahandideh-Tehrani
Dr Zhongming Lan

Technical:

Mr Jeremy Hauw
Ms Anna Petrova
Mr Francisco Souza Dias
Ms Briana Holgate
Ms Rebekah Grieger
Mr Simon Tabrett
Ms Leigh Gould
Mr Max Campbell
Mr Francisco Souza Dias

Professional:

Ms Jennifer Finigan
Ms Natasha Watson

Visitors:

Associate Professor Yvonne Nemcova
Ms Elena Galvanese
Ms Vladimira Dekanova
Mr Quint van Giersbergen
Professor Hiroshi Yajima
Ms Irene Caramatti
Associate Professor Tri Nguyen-Quang

IWC:

Ms Kerryn Devenny
Mr Mark Pascoe
A/Prof Brian McIntosh
Dr Regina Souter
Dr Piet Filet
Dr Lachlan Guthrie
Dr Mark Love
Ms Rosanna Sanderson
Ms Bronwyn Powell
Dr Sera Vada

New PhD Candidates:

Mr Charles Cadier, *Wetlands restoration and recovery of associated ecosystem services a win-win strategy*. Supervisor: Dr Fernanda Adame.

Ms Andria Ostrowski, *Stressors in the real world: Evaluating impacts of multiple stressors in coastal ecosystems*. Supervisor: Professor Rod Connolly.

Miss Renee Piccolo, *Feasibility of coastal marine restoration*. Supervisor: Dr Chris Brown.

Mr Cobi Vrenegoor, *Improving understanding of soil organic carbon functionalities to optimise composts and improve soil productivity*. Supervisor: Professor Chengrong Chen.

Ms Danielle Hill, I*mpacts of industry on amphibians; investigating selenium and mercury bioaccumulation and toxicity*. Supervisor: Dr Chantal Lanctot.

Mr Hsuan-Cheng Lu, *Microplastic pollution in urban wetlands and associated trophic effects in wetland biota*. Supervisor: Professor Fred Leusch.

Ms Michelle Hobbs, *Freshwater mussels of South East Queensland*. Supervisor: Professor Fran Sheldon.

Ms Ellen Ditria, *Using artificial intelligence to automate environmental monitoring and management*. Supervisor: Professor Rod Connolly.

Mr Jas Singh, *Spatial and temporal variation of phytoplankton in reservoirs of South East Queensland*. Supervisor: Professor David Hamilton

Mr Alexandre Teixeira, *Understanding Investment Pathways for Water Security in Brazil*. Supervisor: Professor Stuart Bunn.

Mr Kenneth Horrigan, *Exploring the nexus between cultural ecosystem services and environmental-economic accounts*. Supervisor: Associate Professor Jim Smart.

Miss Kushani Perera, *Analysing the risk of airborne microplastics to human health*. Supervisor: Professor Fred Leusch.

Mr Md. Hafiz All Hosen, L*inking Humpback Whale Chemical Exposure To Effect: Taxon Specific In-vitro Toxicity Assessment*. Supervisor: Professor Fred Leusch.

Mr Vishal Rajendrap Chuliparambil, *Phytocap water balance performance using biosolids-ameliorated coal overburden (BACO)*. Supervisor: Professor Bofu Yu.

Sana Ajaz, *Assessing biofiltration with pre-chlor(am)ination for the removal of PPCPs and their transformation products during drinking water treatment*. Supervisor: Professor Frederic Leusch.

Mr Yahui Che, *Predicting the frequency and areal extent of dust-storm events in eastern Australia*. Supervisor: Professor Bofu Yu

Ms Katie Turlington, *Linking ecological health and sound in freshwater ecosystems using machine learning.* Supervisor: Dr Simon Linke

Ms Jessica Strickland, *Forensic detection of Irukandji jellyfish using eDNA.* Supervisor: Professor Kylie Pitt.

Miss Marina Richardson, *Understanding the diversity of remnant east-coast shellfish reefs to inform restoration design.* Supervisor: Dr Carmel McDougall.

Miss Nikolina Nenadic, *Unlocking the aquaculture potential of Australia's native oysters.* Supervisor: Dr Carmel McDougall.

Mr Kane McManus, *Developing and testing new methods to measure effects of nutrient stressors on ecosystems.* Supervisor: Professor Michele Burford.

Mr Maxwell Mallett, *Hydro-Ecological Determinants of Fish Health and Condition in the Murray-Darling Basin.* Supervisor: Associate Professor Mark Kennard.

Mr Joshua Dyke, *Valuing indigenous culture and its role in the decision-making process for natural resource management*. Supervisor: Associate Professor Jim Smart.

Ms Alexandra Dixon, *Understanding the water cultures of the Murray Darling Basin.* Supervisor: Professor Sue Jackson.

Mrs Bronwyn Bosomworth, *Estimating soil erodibility using multiple erosion modelling frameworks.* Supervisor: Professor Bofu Yu.

Miss Ya Zhang, *Prevention of maturation to improve resilience and growth of the Australian greenlip abalone Haliotis laevigata.* Supervisor: Dr Carmel McDougall.

Mr Reuben De Cocq Van Delwijnen, *Arid soil fungal ecology*. Supervisor: Associate Professor Samantha Capon.

PhD Conferrals:

Dr Amaal Ghazi Yasser Al-Saadi, *Use of molecular markers to examine patterns of connectivity among a number of invertebrate species.* Supervisor: Professor Fran Sheldon.

Dr Dale Bryan-Brown, *Seeds, swamps and satellites: connectivity and fragmentation in mangrove forests.* Supervisor: Dr Chis Brown.

Dr Luke Carpenter-Bundhoo, *Quantifying multi-scaled movements of Australian riverine fish to inform environmental flow management and conservation.* Supervisor: Professor Mark Kennard.

Dr Yota Harada, *Role of sesarmid crabs in carbon sequestration by sub-tropical mangrove forests.* Supervisor: Professor Rod Connolly.

Dr Lana Hartwig, *Aboriginal water rights in New South Wales: Implications of water governance reform for self-determination.* Supervisor: Professor Sue Jackson.

Dr Lu Yao, *Controls over carbon and nutrient dynamics in wetland soils: an ecological stoichiometry perspective.* Supervisor: Professor Chengrong Chen.

Dr Ellie Bergstron, *Carbon physiological strategies across dominant Great Barrier Reef crustose coralline algae in the context of evolutionary history and global change.* Supervisor: Associate Professor Guillermo Diaz-Pulido.

Dr Kaitlyn O'Mara, *The Effects of Floods on Estuarine Fisheries and Food Webs.* Supervisor: Professor Michele Burford.

Dr Christina Howley, *Natural and Anthropogenic Drivers of Water Quality in the Normanby Basin and Princess Charlotte Bay, Cape York Peninsula, Australia.* Supervisor: Professor Michele Burford.

Emad Kavehei, *The net carbon footprint of green stormwater infrastructure; bioretention basins.* Supervisor: Dr Fernanda Adame

Dr Carolina Olguin Jacobson, *Responses of jellyfish to pesticides across different life-history stages.* Supervisor: Professor Kylie Pitt.

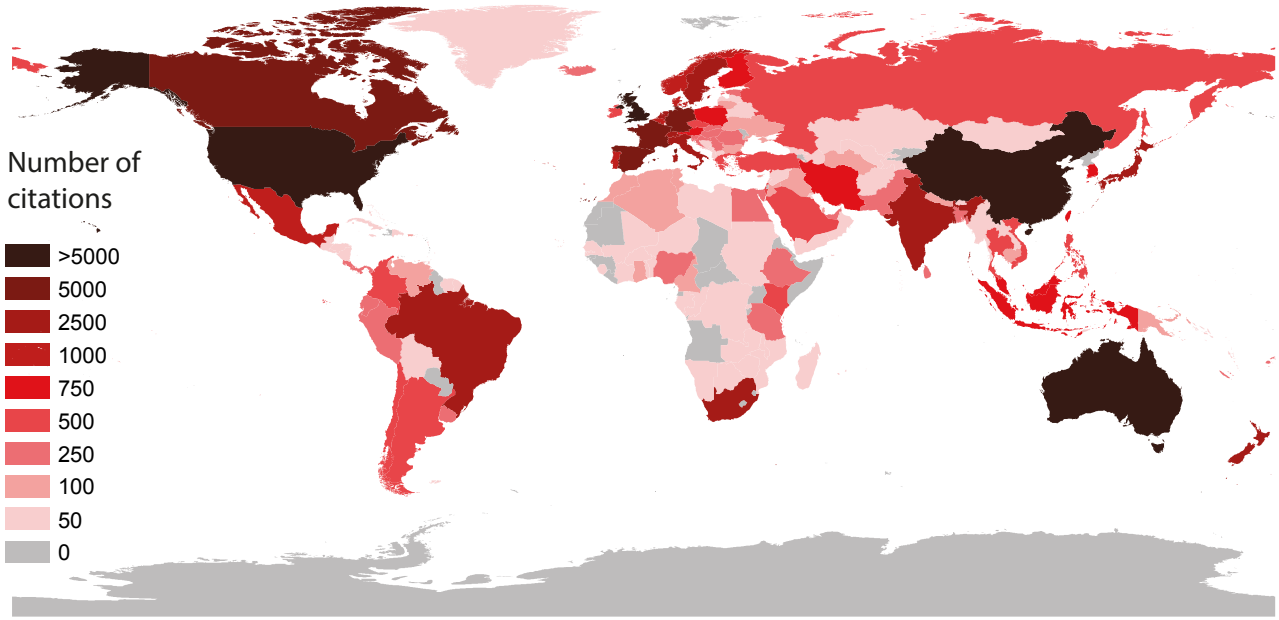
Dr Sheldon Rey Boco, *Physiology, behaviour and inter-species interactions of jellyfish under changing ocean conditions.* Supervisor: Professor Kylie Pitt.

Dr Robert Brier, *Correcting precipitation prediction with numerical weather models in real-time.* Supervisor: Professor Bofu Yu.

Dr Priya Philip, *Long-term rainfall variations and their impacts in the South West of Western Australia,* Supervisor: Professor Bofu Yu.

Dr Emilia Decker, *Ecoacoustics as a novel tool to characterize, investigate and monitor freshwater streams .* Supervisor: Dr Simon Linke.

ARI researchers have a strong network of international collaborators and our science is having a significant impact around the world



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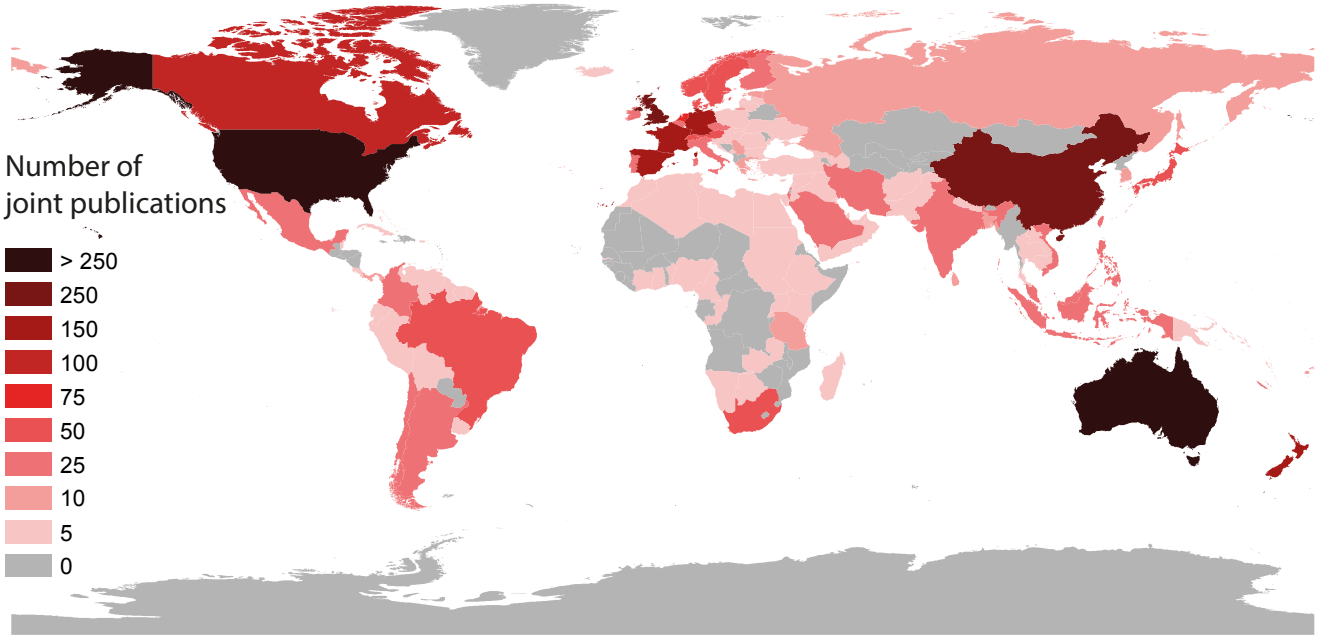

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