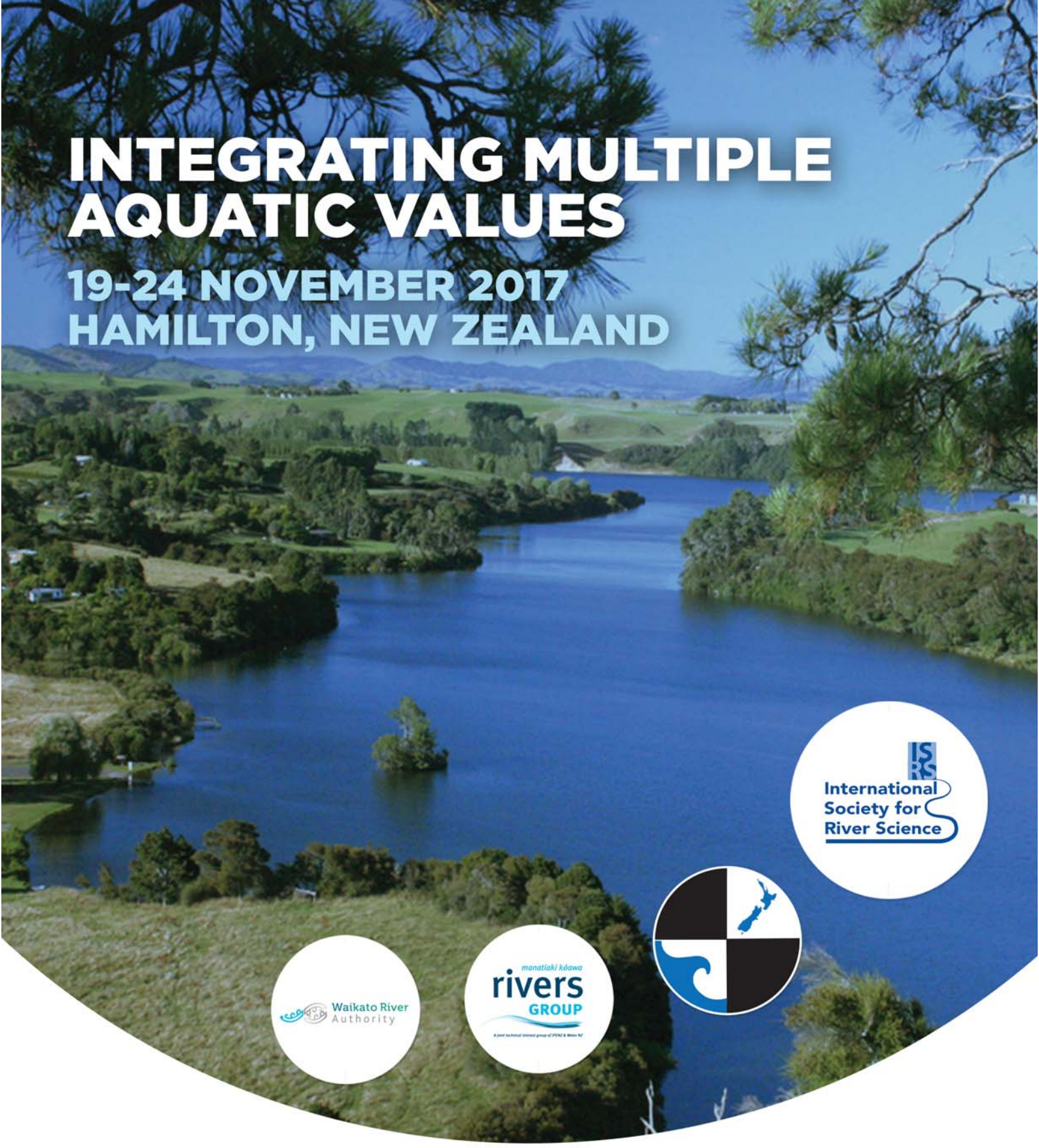

The 5th Biennial Symposium of the International Society for River Science
In association with the IPENZ/Water NZ Rivers Group (NZRG)
and the New Zealand Freshwater Sciences Society (NZFSS)
In Partnership with the Waikato River Authority (WRA)

www.imav2017.com

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Thank you to all our sponsors and supporters. This conference is made possible only through the commitment of many individuals and groups.

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WATER + ENERGY

CONTENTS	PAGE

WELCOME

Welcome from the ISRS President

As President of the The International Society for River Science (ISRS) I welcome you to this conference. I trust you will find it enjoyable and informative and that it will further your understanding of the complex freshwater environments that we call rivers. I am sure that all of you have the passion to further your knowledge of not only the scientific understanding of river ecosystems but also societal use and appreciation of rivers. Rivers not only provide society with tangible benefits such as water and power but a multitude of intangible benefits that enhance the well-being of people. The challenge from a management perspective is to integrate the multiple values we put on rivers and maintain the processes that sustain resilient river ecosystems that can accommodate environmental change. Finally, I can think of nowhere better than New Zealand to have an international conference focusing on rivers. The rivers of New Zealand, I know have many pressures put upon them, but the more "near-natural ones, are iconic globally.

Enjoy the conference and as well as meeting old friends, I hope you also make new ones.

Dave Gilvear
President of the The International Society for River Science

Welcome from the NZFSS President

On behalf of the New Zealand Freshwater Sciences Society (NZFSS), I warmly welcome you to the Integrating Multiple Aquatic Values conference in Hamilton, New Zealand's 4th largest city and the hub of the Waikato Region. The Waikato Region is home to New Zealand's largest lake (Lake Taupo), to its longest river (the mighty Waikato River), and to extensive peat wetlands (e.g., Whangamarino Wetland). So, Hamilton is a perfect place to hold our freshwater conference and to host the many international freshwater scientists who are visiting New Zealand to share their knowledge and experiences. Hamilton is also the heart of the region of the Tainui Iwi, a confederation of four ancestral Māori tribes which arrived in New Zealand around 800 years ago on the Tainui Waka (canoe). The Tainui tribes have a long history of interaction with the watery places of the region and a rich culture of kaitiakitanga or stewardship/guardianship of the waterways.With these rich cultural and freshwater contexts embracing the conference, we are bound to learn a lot from each other and to be inspired and invigorated in our work on freshwater ecosystems.

Enjoy, and make the most of the conferences.

Marc Schallenberg
President of New Zealand Freshwater Sciences Society

Welcome from IPENZ/Water NZRG President

It is a great privilege and pleasure to welcome all delegates to the Integrating Multiple Aquatic Values conference on behalf of the Engineering New Zealand/Water New Zealand Rivers Group (NZRG). This symposium provides a fantastic opportunity for delegates from across the world to share the stories of the rivers, lakes, streams and wetlands they are working on from a wide perspective of values and local constraints. I am really looking forward to hearing the challenges and successes that everyone has had over the past 12 months and collectively learning how we can do even better over the next 12 months. A particularly warm welcome to those delegates that have travelled great distances to attend and I'm sure you will thoroughly enjoy the symposium and the amazing environment that New Zealand has to share with you.

Kia ora koutou katoa

Kyle Christensen
President of The Water New Zealand Rivers Group

CONFERENCE COMMITTEE

- **Kevin Collier // The University of Waikato**
- **Natasha Grainger // Department of Conservation**
- **Kyle Christensen // Christensen Consulting**
- **Brendan Hicks // The University of Waikato**
- **Michael Pingram // Waikato Regional Council**
- **Paul Franklin // NIWA**
- **Julian Williams // Waikato River Authority**
- **Elizabeth Graham // NIWA**
- **Tom Moore // The University of Waikato**
- **Jennifer Price // Kessels Ecology**

GENERAL INFORMATION

Registration Desk

If you require any assistance throughout the conference please see the conference organisers at the Registration Desk on the Ground Floor.

A Conference Notice Board will be placed at the Registration Desk and will be used to display conference information, programme changes, announcements and messages. Please check the board regularly.

Cell Phones

Please ensure that cell phones and/or pagers are turned off, or silent, during all presentations.

Name Badges

Delegates are requested to wear their name badges to all sessions and social functions. Committee members will be wearing green lanyards, delegates blue lanyards. Student helpers will be wearing red University of Waikato T-shirts, please ask them for directions and local knowledge.

No Smoking

There is no smoking allowed inside the venue.

Internet

Wireless internet broadband is complimentary, instructions are as follows:

1. Go to the network sharing centre of your device
2. Select Claudelands under wireless network connection
3. Click select. This will then connect to the internet
4. Click on a web browser
5. CLDS Internet home page will appear – enter your username and password here
   USERNAME = imav2017
   PASSWORD = imav

*If your home page is defaulted elsewhere, enter www.claudelands.co.nz and the internet home page will appear

Parking

Car parking is available on site for visitors in the Heaphy Terrace Car Park via Gates 1 or 1b, and on the surrounding streets.

Contact Numbers

For assistance please call Lea Boodee from On-Cue Conferences on **021 1170916**

GENERAL INFORMATION CONTINUED

Meals
All catering will be served on level 1 in the Arena Upper Concourse.
If you have advised us of your special dietary requirements, these have been forwarded to the caterers at Claudelands and will be available on a separate table individually marked.
At the Conference Dinner, please make yourself known to the waiting staff and they will make the necessary arrangements for your special meal. If you have any dietary requirements that we are not aware of, please see the Conference Organisers at the Registration Desk on arrival at the conference.
On Sunday 19 November and Friday 24 November, lunch packs will be provided for the field trips. Field Trip lunches will be placed on the coaches ready for departure. If you have informed us of your special dietary requirements, your lunch pack will be labelled for you.

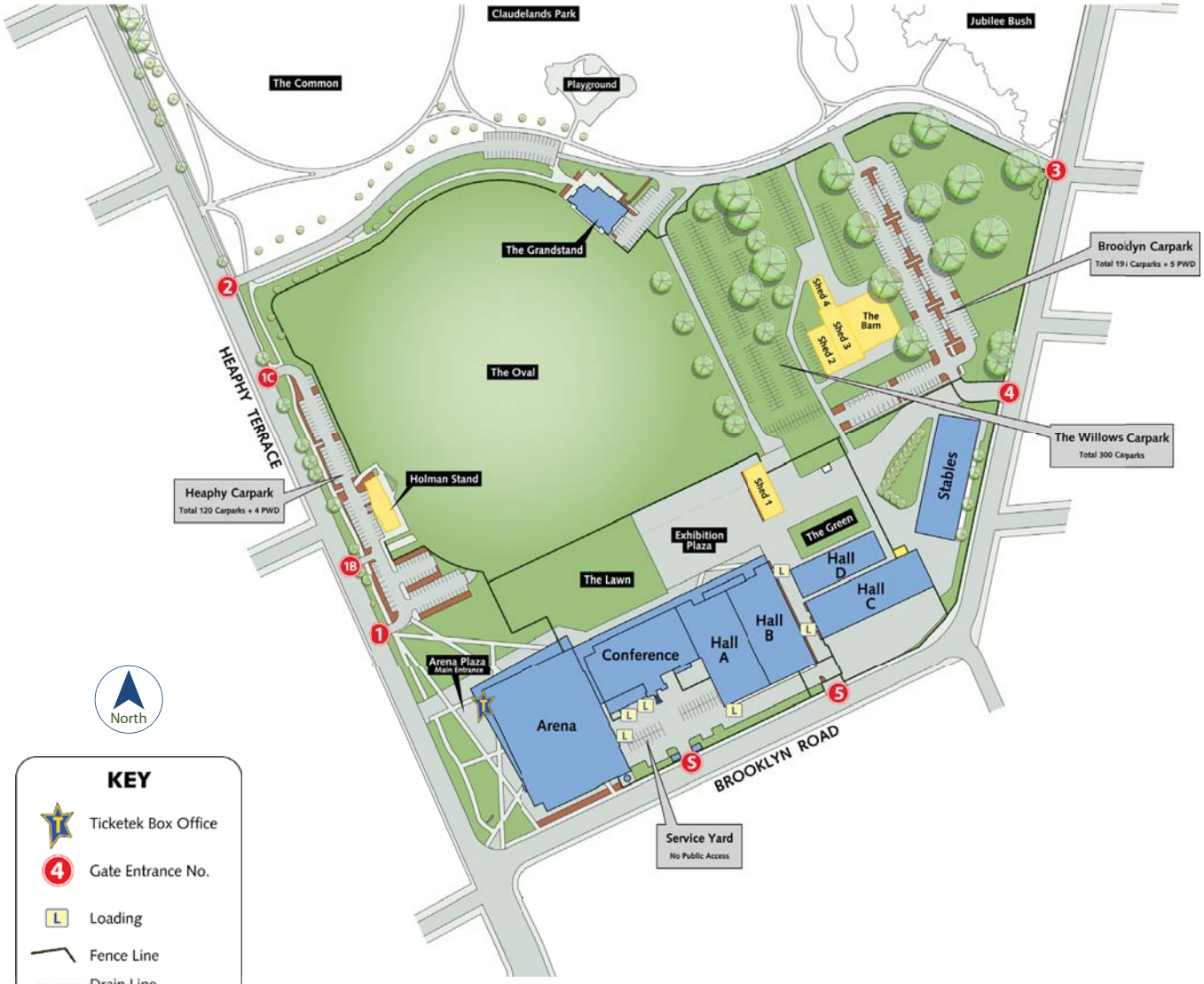
Loading Talks
Please load your presentation in the "Board Room" located next to the Registration Desk on the Ground Floor.
This room is also available as a speaker prep room.

Poster Presenters
The Poster boards are located on level 1 in the Arena Upper Concourse. Please put your poster on the board allocated (see author index of the handbook for your poster number). Posters must be displayed before 3:00pm on Monday 20 November. Velcro dots will be provided.

Session Chairs
Please can all session chairs be in their room at least 10 minutes prior to the start of the session. Please ensure that you are familiar with the microphones and the lectern equipment so that you can advise your presenters. It is very important that talks are only allowed their allotted time so that talks start and finish on time and so delegates can move between sessions to hear different talks.

Social Media Policy #imavnz
Similar to many other scientific societies, the New Zealand Freshwater Science Society encourages open discussion on social media and other outlets at our annual conference. In order to find a balance between embracing social media and protecting authors' work, we set forth the following guidelines:
1. Delegates are allowed to discuss all aspects of an oral or poster presentation at IMAV2017 on Twitter in text form. This includes discussion of the background, questions, methods, results and conclusion. An example Tweet might be: "Jo Bloggs: kereru abundance has increased 40% on the Banks Peninsula since 2000". This DOES NOT include the right to photograph or video any parts of a talk with the intention of posting it on social media.
2. A presenter may decide to allow full coverage of their presentation on social media, including photos and video. The audience will be notified of this at the start of a talk either verbally or by use of the Twitter symbol on the title slide. For posters, this can be determined by asking the presenter or, if they are absent, when the Twitter symbol is displayed on the poster near the author's names. If this symbol is not present on a poster or slide and you do not have verbal permission from the presenter, please do not post photos to social media.

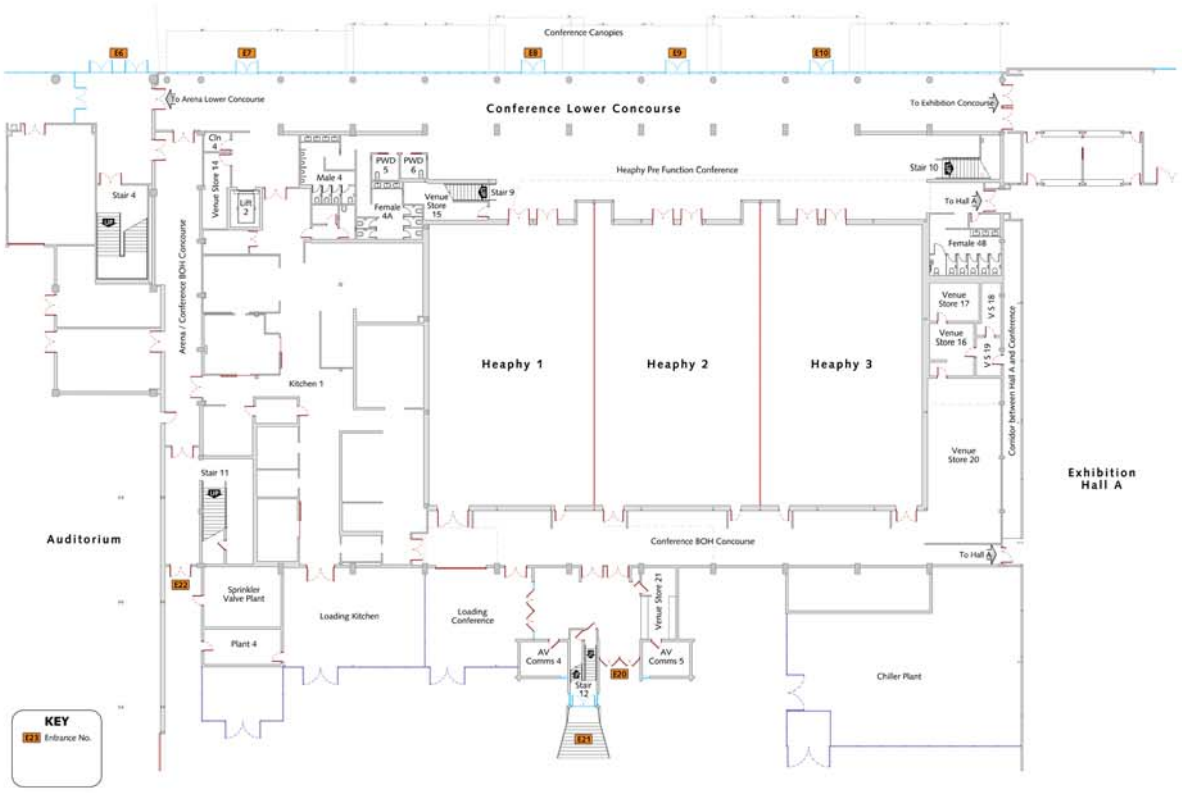
CONFERENCE VENUE MAP



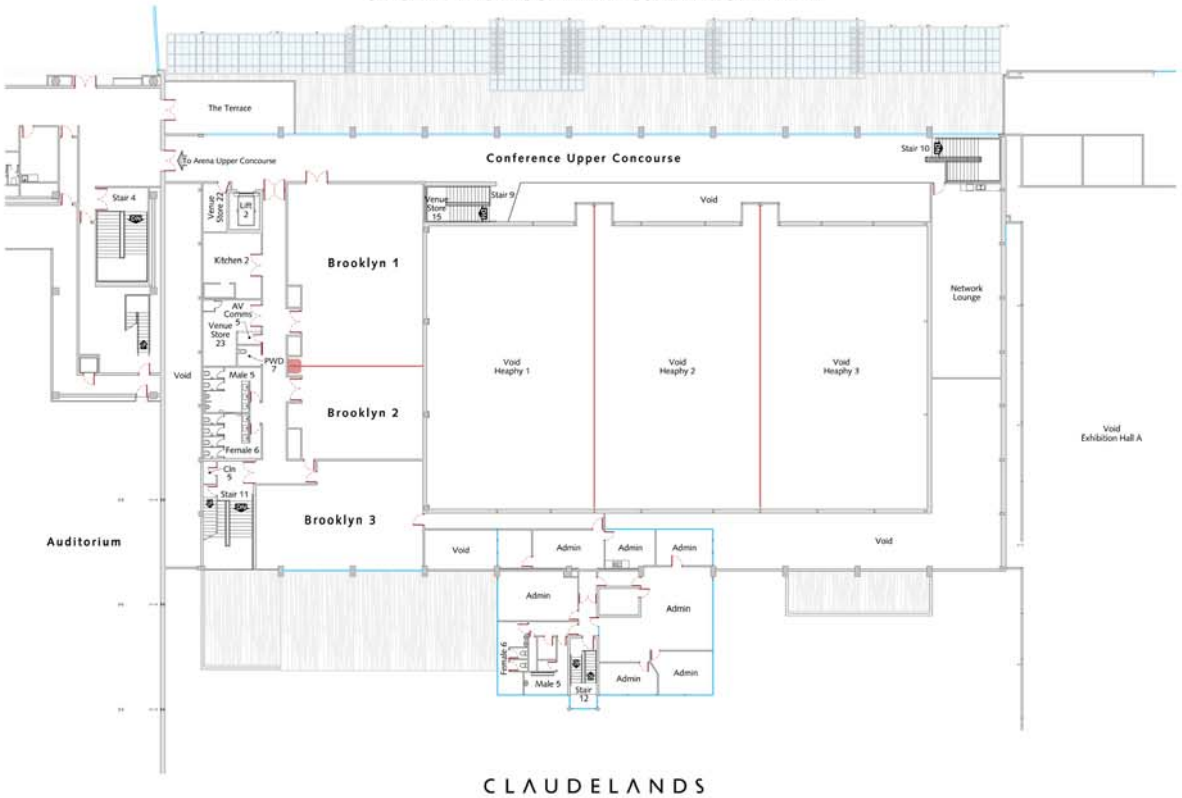
CLAUDELANDS

CONFERENCE FLOOR PLAN

CLAUDELANDS FLOOR PLAN - CONFERENCE LEVEL G



CLAUDELANDS FLOOR PLAN - CONFERENCE LEVEL 1



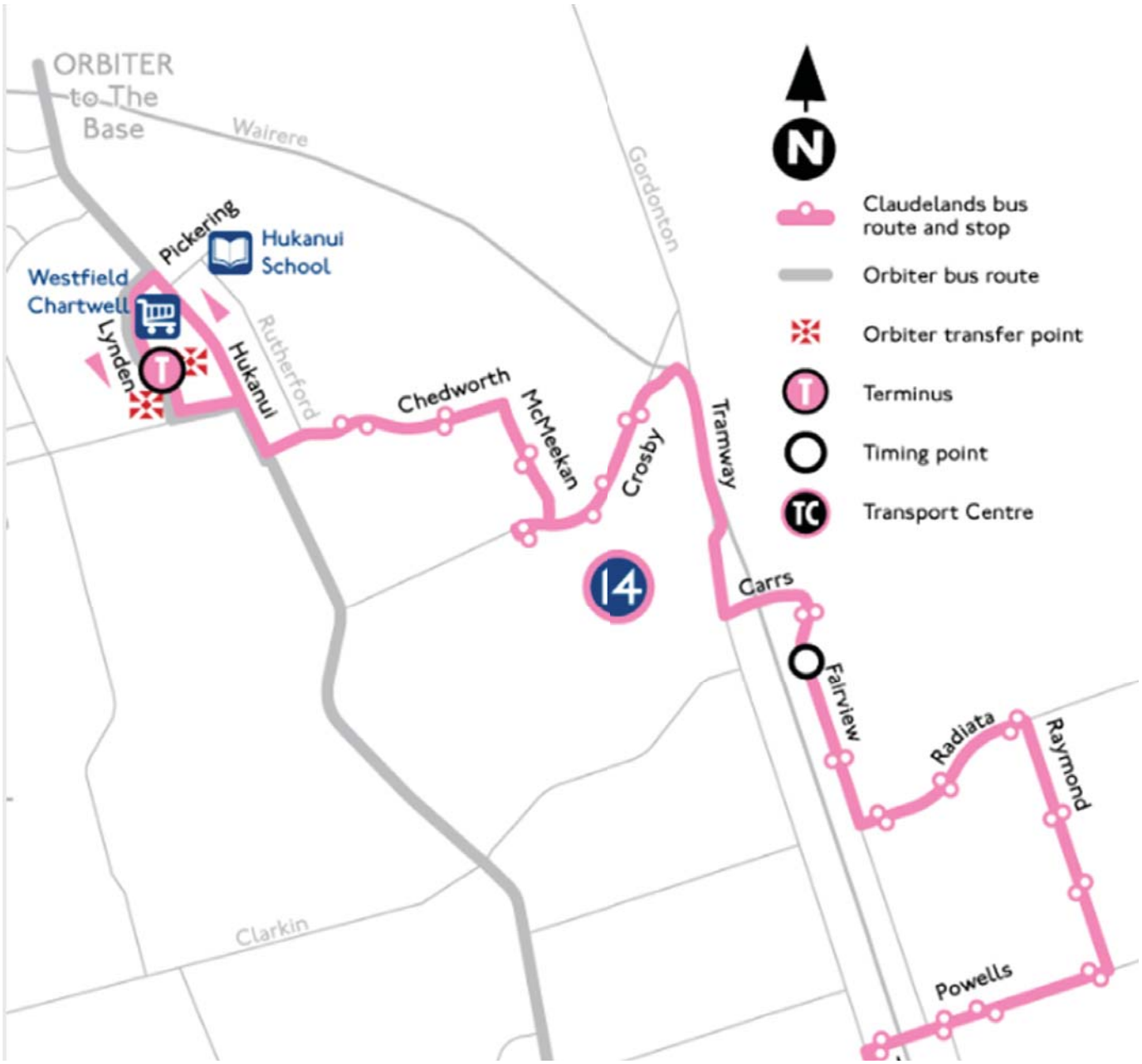
CLAUDELANDS

GETTING AROUND

Getting to Claudelands

- Claudelands is a 10–15-minute walk from the CBD, with pedestrian access via the Arena Plaza on Heaphy Terrace. Bicycle racks are also available on site.
- Taxi stands are located on Heaphy Terrace.
- Bus stops are situated on Brooklyn Road and Heaphy Terrace. For details please see below or go to www.busit.co.nz

Bus Route



Bus Timetable

Monday to Friday

14	Transport Centre	Claude St	Fairview St	Westfield Chartwell
	TC			1
Estimated journey time	7 min	6 min	15 min	
	Depart	Arrive	Arrive	Arrive
AM	Platform L			
	7.20	7.27	7.33	7.48
	7.50	7.57	8.03	8.18
	8.20	8.27	8.33	8.48
	8.50	8.57	9.03	9.18
	9.15	9.22	9.28	9.43
	9.45	9.52	9.58	10.13
	10.15	10.22	10.28	10.43
	10.45	10.52	10.58	11.13
	11.15	11.22	11.28	11.43
PM	12.15	12.22	12.28	12.43
	12.45	12.52	12.58	1.13
	1.15	1.22	1.28	1.43
	1.45	1.52	1.58	2.13
	2.15	2.22	2.28	2.43
	2.45	2.52	2.58	3.13
	3.15	3.22	3.30	3.45
	3.45	3.52	4.00	4.15
	4.15	4.22	4.30	4.45
	4.45	4.52	5.00	5.15
	5.15	5.22	5.30	5.45
	5.45	5.52	5.59	6.13
	6.15	6.22	6.29	6.43
	7.15	7.22	7.29	7.43

Claudelands

Westfield Chartwell	Fairview St	Claude St	Transport Centre
1			TC
8 min	7 min	17 min	
Depart	Arrive	Arrive	Arrive
6.45	6.53	6.59	7.13
7.15	7.25	7.34	7.49
7.40	7.50	7.59	8.16
8.10	8.20	8.29	8.46
8.40	8.50	8.57	9.14
9.10	9.18	9.25	9.42
9.40	9.48	9.55	10.12
10.10	10.18	10.25	10.42
10.40	10.48	10.55	11.12
11.10	11.18	11.25	11.42
11.40	11.48	11.55	12.12
12.40	12.48	12.55	1.12
1.10	1.18	1.25	1.42
1.40	1.48	1.55	2.12
2.10	2.18	2.25	2.42
2.40	2.48	2.55	3.12
3.10	3.18	3.25	3.42
3.40	3.48	3.55	4.12
4.10	4.18	4.25	4.42
4.40	4.48	4.55	5.12
5.10	5.18	5.25	5.38
5.40	5.48	5.55	6.08
6.10	6.18	6.23	6.36
6.40	6.48	6.55	7.08

Times in **BOLD** are scheduled, all other times are approximate.

5 Chartwell and 14 Claudelands are a through-route. This means the 5 Chartwell bus will become the 14 Claudelands bus at Westfield Chartwell, allowing for new journey options. For example, you can travel from Fairview Downs to Waikato Diocesan without having to change buses.

The Wairere Drive extension part of the new ring road is now open (through to Fifth Ave). There are no effects to the 14 Claudelands route. The route heading from the Transport Centre is unchanged. When heading into the Transport Centre the bus will travel down Powells Road, turn left onto Tramway Road, then go around the new roundabout and back onto Fifth Ave.

Accessible Buses

Buses on this service are wheelchair friendly. Wheelchairs must be under 250kg in weight and 80cm in width to travel on the bus. The operator always aims to operate accessible buses; however, there may be times when this is not possible due to operational reasons.

Taxis

When booking a taxi to pick you up from Claudelands, please advise the taxi company that the collection point is Entrance 1 on Heaphy Terrace.

Hamilton Taxis

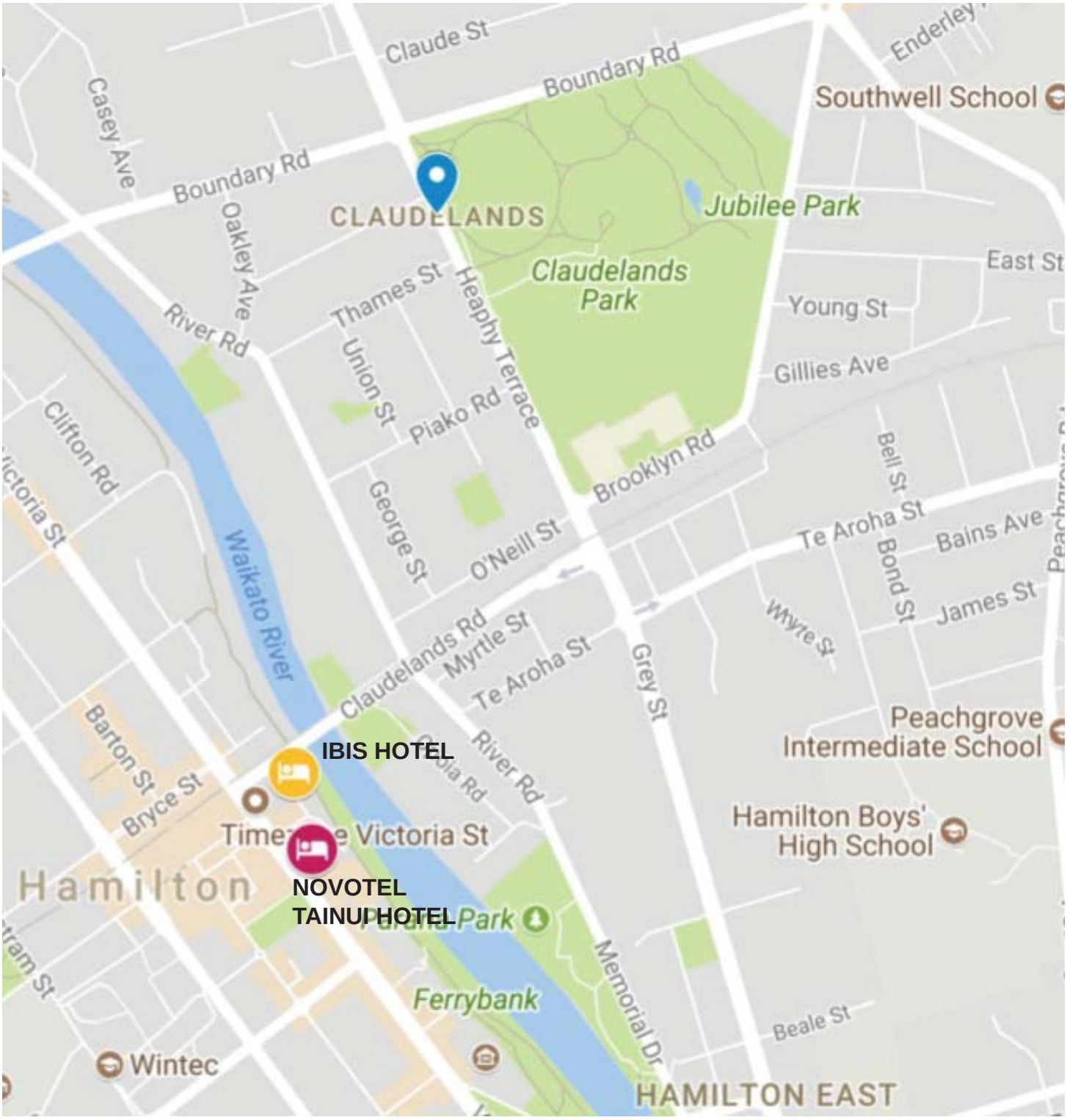
Phone: 07 8-477-477 or **Freephone** 0800 477 477
Website: www.hamiltontaxis.co.nz

Super Shuttle

Phone: +64 9 522 5100

The Hamilton Airport is approx. 20–30 minutes' drive from Claudelands Events Centre; the cost is approx. $50–$60 NZD.

MAP FROM CLAUDELANDS TO NOVOTEL & IBIS HOTELS



SCIENCE, RESEARCH AND INNOVATION

Science, research and innovation play an important role in keeping our region healthy.
Celebrating science in the Waikato is important to us and that's why we're proud to be a Gold Sponsor of the New Zealand Ecological Society and the Society for Ecological Restoration Australasia joint conference.

MONITORING PROGRESS VITAL TO REGIONAL HEALTH

As part of their work, Waikato Regional Council staff use leading edge science to monitor and identify opportunities to improve the environmental, social and economic health of the region.

Scientists from the council do this by tracking trends against a number of indicators in order to get a picture of the region's 'health'. This then helps them to understand how quality of life can be improved for those living in the region and how native flora and fauna and natural landscapes can be protected.

Indicators cover aspects such as coastal habitats, air quality, income, public transport, employment and life expectancy among many others.

Find out more about the health of our region, call 0800 800 401 or visit **waikatoregion.govt.nz**/indicators and **waikatoregion.govt.nz**/wpi.

Waikato Regional Council staff member, John Vosper works with local farmer to asses soil quality.

Waikato Regional Council coastal scientist Hannah Jones tests water quality in Whaingaroa (Raglan) Harbour.

Waikato Regional Council biosecurity officer, Hamish Hodgson, releases lace bugs to help control the environmental pest plant, privet.

HE TAIAO MAURIORA HEALTHY ENVIRONMENT
HE ŌHANGA PAKARI STRONG ECONOMY
HE HAPORI HIHIRI VIBRANT COMMUNITIES

For more information call Waikato Regional Council on 0800 800 401 or visit waikatoregion.govt.nz.

Waikato
REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

HAMILTON INFORMATION

Restaurants

Top 7 TripAdvisor Hamilton Restaurants

- **Victoria Street Bistro Restaurant**
  Type: European, New Zealand, Contemporary, Gluten Free Options
  153 Victoria Street, Hamilton
  ☎ (07) 839 4444

- **Palate Restaurant**
  Type: European, New Zealand
  20 Alma Street, Hamilton
  ☎ (07) 834 2921

- **Gothenburg Restaurant**
  Type: European, Spanish, Fusion, New Zealand, Vegetarian Friendly
  21 Grantham Street, Hamilton
  ☎ (07) 834 3562

- **Mexico Food and Liquor Restaurant**
  Type: Mexican, Gluten Free Options
  254 Victoria Street, Hamilton
  ☎ (09) 280 1487

- **Good George Brewery and Dining Hall Restaurant**
  Type: Bar, New Zealand, Pub
  32A Somerset Street, Frankton, Hamilton
  ☎ (07) 847 3223

- **Madam Woo Restaurant**
  Type: Asian, Malaysian, Vegetarian Friendly
  6 Sapper Moore-Jones Place, Level 1, Hamilton
  ☎ (07) 839 5605

- **Caffe Centrale Restaurant**
  Type: Italian
  10 Alma Street, Hamilton
  ☎ (07) 838 1013

Medical

- **Waikato Hospital**
  Pembroke Street, Hamilton West
  ☎ (07) 839 8899 | www.waikatodhb.govt.nz

- **Life Pharmacy**
  501 Victoria Street, Hamilton 3204

- **After Hours Medical Centre**
  Anglesea St and Thackeray St, Hamilton 3420
  ☎ (07) 858 0800 | angleseamedical.co.nz

WELCOME & SOCIAL FUNCTIONS

The pōwhiri (welcome ceremony)

An invitation is extended to all delegates to attend the pōwhiri. The pōwhiri is a welcome ceremony by the tangata whenua that draws everyone together in the opening of the conference. This will be held at Tūrangawaewae Marae. Please be sure to be in attendance at the pre-conference gathering on time in order to be seated for the cultural performance. Buses will depart Claudelands Events Centre at 3.00pm and return to the Novotel Hotel and Claudelands at approx. 6:00pm. Light refreshments will be served following the pōwhiri.

Sunday 19 November 2016
3.00pm – 6.00pm

Venue : Tūrangawaewae Marae
Additional Tickets : $25.00
Dress : To show respect to the people of the marae, the dress guidelines are provided on the website.

Pre-Conference Mixer

The pre-conference Mixer will take place after the pōwhiri

Sunday 19 November
6.00pm – 7.00pm

Venue : Novotel Hotel, Union Room
Transport : Buses will depart at 6.00pm from Tūrangawaewae Marae for Claudelands
Additional Tickets : $25.00
Includes : 1 drink and canapes, cash bar available:
Dress : Casual

Monday Mixer (kindly sponsored by Morphum Environmental Ltd)

The Monday Mixer will be a great opportunity to mingle with fellow attendees of the IMAV Conference, you will be able to share ideas and discuss the week ahead.

Monday 20 November
4.15pm – 6.30pm

Venue : Claudelands Upper Concourse Arena
Additional Tickets : $25.00
Includes : 2 drinks and canapes, cash bar available:
Dress : Casual

Conference Dinner

This is the night everyone remembers! This dinner is an additional cost from your Conference registration. If you haven't booked for the dinner and wish to attend, visit the registration desk to book your space.

Thursday 23 November
6.30pm - late

Venue : Hamilton Gardens
Transport : Buses will depart at 5.30pm, 5.45pm and 6.00pm from the Novotel Hotel, feel free to wander around the gardens if you arrive on an early bus. Pre-dinner drinks start at 6.30pm.
Tickets : $115.00
Includes : 3 course meal, drinks, entertainment and transport
Dress : Flower Power

Optional Event - NZFSS Public Forum "Pathways to swimmable rivers"

For many kiwis swimming in rivers is a summer tradition associated with whanau, fun and rejuvenation - it's often how we have our deepest relationship with freshwater. But the suitability of rivers for swimming has come into doubt due to factors including reduced flow, nuisance plant growth and illness risk from pathogens. This forum, hosted by the NZ Freshwater Sciences Society, will explore the pathways to swimmable rivers by short presentations and a panel discussion on (i) what we mean by swimmable rivers, (ii) how Waikato rivers measure up in the "swimmable" stakes, and (iii) what can be done and is being done and to improve swimmability.

Monday 20 November
7.30pm - 8.30pm

Venue : Claudelands, Heaphy 1 Room

Tickets : No charge to attend

Optional Event - Special Screening of the Lost Rivers Film, organised by Morphum Environmental

Lost Rivers is a thought provoking documentary about daylighting which presented a global vision to resurrect "hidden" rivers to revive urban areas and provide solutions to flooding and pollution issues. The film takes you on an adventure into the underground world of piped waterways across the globe, meeting visionary urban thinkers, artists and explorers from around the world, all passionate about reconnecting rivers with their natural and urban environments.

Wednesday 22 November
6.00pm - 8.00pm

Venue : Lido Cinema, 501 Victoria Street, Hamilton

Tickets : No charge to attend

Includes : Drinks and Nibbles will be provided by Morphum Environmental, in the foyer, from 6.00pm

Spaces are limited so if you would like to book your spot, please email info@morphum.com to book a seat.

BOOKS FOR SALE

New Zealand's Rivers: An Environmental History

Author: Catherine Knight Publisher:Canterbury University Press

'New Zealand's Rivers: An environmental history'explores the relationship between New Zealanders and our rivers, explaining how we have arrived at a crisis point, where fresh water has become our most contested resource and many rivers are too polluted to swim in. Environmental historian Catherine Knight reveals that the tension between exploitation and enjoyment of rivers is not new. Rivers were treasured by Māori as food baskets and revered as the dwelling places of supernatural creatures. But following European settlement, they became drains for mining, industrial waste and sewage, and were harnessed to generate power and to irrigate farmland. Over time, the utilitarian view of rivers has been increasingly questioned by those who value rivers for recreation as well as for ecological, spiritual and cultural reasons. Today, the sustainable use of rivers is the subject of intense debate. Thoroughly
researched and richly illustrated, 'New Zealand's Rivers'is an accessible and compelling read for all New Zealanders, including anglers, kayakers, farmers, environmental practitioners, policy-makers, students and anyone with an interest in our environment and history.

Price: NZD$49.99

The Waters of the Waikato - Ecology of New Zealand's Longest River.

Editors: Kevin Collier, David Hamilton, Bill Vant and Clive Howard-Williams

The Waters of the Waikato: Ecology of New Zealand's Longest River is a case study of an iconic New Zealand river. It is of great cultural and spiritual significance, has considerable economic and recreational value, and provides a place to live for a wide variety of plants and animals. This book tells a story of this river's physical and chemical environment and the life it supports, from the turbulent blue waters at the outlet of New Zealand's largest lake down to the tidal waters of the river delta. It is a contemporary synthesis of current scientific knowledge of the river, and will provide a reference for river managers, policy makers, students and the interested public.

Price: $25 Numbers are limited.

Advances in New Zealand Freshwater Science

Editors: Phillip G Jellyman, Tim JA Davie, Charles P Pearson, Jon S Harding

In 2004 the New Zealand Freshwater Science and New Zealand Hydrological Societies published a joint book Freshwaters of New Zealand. This book was the first comprehensive summary of hydrological and ecological research in New Zealand fresh waters and included contributions from a wide range of scientists and managers. Advances in New Zealand Freshwater Science summarizes new hydrological and ecological research in streams, rivers, wetlands, ponds, lakes and groundwater over the last 12 years. This book comprises 34 chapters with over 100 contributing authors. Some research themes have been the focus of much new research since 2004, while freshwater management in New Zealand has undergone some profound changes. In particular there have been major advances in catchment and environmental modelling, invasive species (such as didymo), and new pond and wetland research with greater emphasis on restoration and rehabilitation. This book also recognises the greater engagement with Māori in freshwater management and the changing policies invoked by the National Policy Statement for Freshwater Management. Advances in New Zealand Freshwater Science will be of interest to scientists, practitioners, managers, students and lay people and is particularly timely given the increasing public interest in the state of New Zealand's fresh waters.

Price: $90 (plus $10 for postage and handling within NZ)

Ensuring the benefits flow on

NIWA's National Centre for Freshwater and Estuaries provides the research, tools and expertise needed to support effective management of New Zealand's freshwater resources and estuarine environments.

Science supporting sustainable water use

Our work focuses on the water cycle, the consequences of water use and allocation, water quality, the impacts of catchment land use, pollutant mitigation, invading weeds and pest fish and the restoration of ecosystem health.

Smart solutions

We provide purpose-built tools and models such as CHES (Cumulative Hydrological Effects Simulator) and EFSAP (Environmental Flows Strategic Allocation Platform) which support planning, ecosystem management, environmental assessment and consent applications.

To discuss the ways our science can support your commercial and resource management goals contact:

Dr John Quinn – Chief Scientist, Freshwater and Estuaries

Email: john.quinn@niwa.co.nz Phone: +64-7-859 1735

NIWA
Taihoro Nukurangi

Partnerships

Te Kūwaha o Taihoro Nukurangi – NIWA's National Centre for Māori Environmental Research – is working with Māori communities and business throughout Aotearoa to realise their environmental and economic research aspirations.

Collaborative approaches

Developing fit-for-purpose approaches driven by Māori aspirations and opportunities, utilising Māori knowledge and methodologies where appropriate.

Knowledge systems

Undertaking the fundamental research required by Māori to inform their unique responsibilities as kaitiaki and managers of freshwater resources.

Co-management and restoration

Developing research methods and tools with iwi, hapū and whānau that increase capability and inform innovative approaches for the restoration and economic development of freshwater taonga species and their ecosystems.

To discuss how Te Kūwaha can support your environmental management goals contact:

Marino Tahi – Manager Māori Engagement and Strategy

Email: marino.tahi@niwa.co.nz Phone: +64-7-856 1793

NIWA
Taihoro Nukurangi

PLENARY SPEAKERS

Gerald Kaufmann

Talk time: Monday 20 November, 9:30am - 10:15am
Topic: Catchments, Watersheds, and Basins: The Global Governance and Policy of International River Science

Gerald is the Waikato River Authority plenary speaker for the 2017 conference. He holds the position of Director, University of Delaware-Water Resources Center, one of the 54 National Institutes for Water Resources (NIWR) supported by the United States Geological Survey, along with joint faculty appointments in the Department of Civil and Environmental Engineering, School of Public Policy, and Geography Department. He is also Delaware's first "Water Master" appointed by the Water Supply Coordinating Council Act of 2000 and co-chairs the Christina Basin Clean Water Partnership, an interstate effort between the U.S. Environmental Protection Agency, Delaware River Basin Commission, State of Delaware, and Commonwealth of Pennsylvania to restore the watershed that provides 60 percent of the First State's drinking water supply. Jerry conducted a review of restoration activities on the Waikato River co-ordinated by the Waikato River Authority. He lives in Newark, Delaware with his family in the White Clay Creek National Wild and Scenic River watershed.

Abstract

You call it a catchment and I call it a watershed and they call it a basin but across the globe water resources are best protected by the common themes of international river basin governance and management. I will discuss the governance, economics, and policies of investing in watersheds, a topic that Delaware as a small peninsular state and New Zealand as a small island country, have much in common. In the continents throughout the world, river basin management is practiced with various degrees of sophistication, from the user payers approach of the European Union and South America to the privatised systems of the United Kingdom and the autocratic ministries of Russia and Central Asia. We'll discuss the revenue and governance structures of the Agencies de L'eau, Genossenschaften, and Dutch Polders of Europe, the RBOs of Morocco and Brazil, and the water ministries of China, Vietnam, and the Far East. It's been said that the nations on Earth are divided by borders but the people on the Planet are united by a common river.

PLENARY SPEAKERS CONTINUED

Linda Te Aho

Talk time: Monday 20 November, 3:30pm - 4:15pm

Topic: Te Mana o te Wai. A Māori perspective on rivers and the place of indigenous values in river management.

Linda Te Aho is of Waikato-Tainui, Ngāti Korokī Kahukura descent and is an Associate Professor in Law at Te Piringa - Faculty of Law, University of Waikato, Hamilton. Linda was appointed by her iwi of Waikato-Tainui as a guardian mandated under the 2010 settlement for the co-management of the Waikato River ecosystem to develop the long term vision for its holistic restoration. Linda serves as a Ministerial adviser on Māori land reforms. She has provided expert advice to the government and to iwi leaders on reforms to the Resource Management Act and freshwater issues. Linda served as a lead negotiator for Ngāti Koroki Kahukura Treaty Claims and continues to provide specialist advice on Treaty of Waitangi claims and Post-Settlement Governance issues to iwi and hapū organisations.

Abstract

Water resources are becoming scarce and valuable. We are witnesses to the importance for all communities when the health of our waterways is at risk. Governance and management systems have not been able to cope with legacy issues, nor can they cope with the complex problems of diffuse pollution from intensive farming, climate change, pest species and population growth. The Government's recent policy proposal, "Next Steps for Freshwater", proposes new criteria for efficient and sustainable use, supporting economic development, and encouraging good management practice. In recognising that the indigenous Māori of New Zealand 'have rights and interests in freshwater', the Government proposes ways to improve their involvement in freshwater decisions. But do the government proposals go far enough? There are increasing calls to include traditional Māori knowledge into decision-making frameworks, and terms such as 'kaitiakitanga' (the responsibility to take of natural resources) and 'Te Mana o Te Wai' (the integrity of water) have gained traction. This presentation explain these core concepts and provide a Māori perspective on rivers and the place of indigenous values in river management with reference to case studies involving two major North Island Rivers, the Waikato and Whanganui.

PLENARY SPEAKERS CONTINUED

Catherine Knight

Talk time: Tuesday 21 November, 9:00am - 10:00am
Topic: How have we valued New Zealand's rivers? A historical perspective.

Dr Catherine Knight is an environmental historian and policy specialist who has published extensively on the environmental history of both New Zealand and Japan. Her most recent book, New Zealand's Rivers: An Environmental History (Canterbury University Press, 2016), was longlisted for the Ockham New Zealand Book Awards 2017 and was selected as one of the Listener's Best Books for 2016. Her previous book, Ravaged Beauty: An environmental history of the Manawatu (Dunmore Press, 2014), won the J.M. Sherrard major award for excellence in regional and local history, and Palmerston North Heritage Trust's inaugural award for the best work of history relating to the Manawatu. Catherine is a policy and communications consultant and lives on a small farmlet in the Manawatu, where she and her family are working to restore the totara forest indigenous to that area.

Abstract

How have we valued New Zealand's rivers? In this presentation, environmental historian Dr Catherine Knight will answer this question by tracing the history of people's interactions with rivers since they first arrived in this South Pacific archipelago centuries ago. Her conclusions may surprise you, but will without doubt provide valuable context to the debate about our rivers and the collision of values we face in relation to fresh water today.

PLENARY SPEAKERS CONTINUED

Sonja Jähnig (kindly sponsored by Waikato Regional Council)

Talk time: Tuesday 21 November, 3:30pm - 4:15pm

Topic: Modelling riverine biodiversity and ecosystems service delivery - simple, integrated, or complex?

Sonja is a research group leader at the Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB, Berlin). She has an interest in global change effects in river ecosystems and focuses on the influence of abiotic factors on aquatic organisms and communities, integrating different spatial and temporal scales. She has applied species distribution models to predict climate change impacts on riverine invertebrate communities and has developed an integrated modelling approach that focuses on flow and on global change induced flow alterations. She has recently started to include ecosystem services provisioning into forecasting.

Abstract

Freshwater biodiversity is highly threatened worldwide and we are witnessing a rapid decrease of biodiversity in freshwater ecosystems, which is exceeding their terrestrial or marine counterparts. Rivers are particularly affected due to their small relative proportion in area, high degree of habitat fragmentation, distinct internal connectivity within the network, and their close links to surrounding terrestrial areas which may result in severe anthropogenic impact given by land use in the respective watershed. Today, freshwater management for rivers is increasingly supported by models to foster decision-making, e.g. to predict ecological consequences of different management alternatives or to account for potential future changes in the ecosystem, independently of environmental management. Various modelling approaches exist for aquatic ecosystems with different levels of sophistication and advancement when comparing modelling methods for hydrological regimes, riverine habitats, species, or ecosystem aspects such ecosystems functions or service provision. Most approaches so far have in common that they focused on one aspect only, neglecting the integrated nature of rivers. I will present different modelling approaches ranging from 1) global change projections by species distribution models, 2) integrated modelling approaches with a more comprehensive view on riverine habitats, towards a 3) projection and optimisation framework which assesses the status of biodiversity and evaluates simultaneously ecosystem services. Thus I will present a framework which considers multiple policy and stakeholder objectives for biodiversity and ecosystem services, their deficits, management alternatives and cost-effectiveness of management solutions.

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PLENARY SPEAKERS CONTINUED

Gary Brierley

Talk time: Wednesday 22 November, 9:00am - 10:00am

Topic: A new dawn is upon us: The use of emerging technologies in river science and management

Gary Brierley was educated at Durham University, UK and Simon Fraser University in Vancouver, Canada. He completed his post-doctoral work at the Australian National University, working on the impacts of environmental change in Australasia and the Pacific region, prior to working at Macquarie University in Sydney. He is presently Chair of Physical Geography in the School of Environment at the University of Auckland. Gary is a landscape scientist. His research promotes the use of integrative scientific understandings to inform river management practices. He has published over 150 fully reviewed publications, on topics ranging from geomorphology, geo-ecology and sedimentology to concerns for rehabilitation practices, environmental justice, ethnogeomorphology (understandings of biophysical-and-cultural landscapes) and environmental governance. He is co-developer of the River Styles framework, an approach to the use of landscape science to inform river management applications. This work has been applied in various parts of the world. In 2004 this framework was shortlisted for the inaugural International River Prize. This work was awarded the research innovation prize by Macquarie University; it is one of the 50 research exemplars selected to celebrate the 50th anniversary of the university.

Abstract

Place-based knowledges underpin effective approaches to river science and management. Emerging technologies present remarkable capacity to 'know' each river system. But, how are we 'knowing'? Which scientific frameworks and approaches to classification do we choose to use? How integrative are these understandings (i.e. do they convey a conceptual model showing how a given river system 'works'?). Who writes the algorithms for automated monitoring procedures? How are these understandings used alongside local knowledges to generate 'owned' approaches to management practice? As we move beyond inappropriate use of coarse-resolution, remotely-sensed data and overly-generalised understandings/framings, what lessons have we learnt that can support effective use of more precise (higher resolution), more recurrently derived, catchment-specific datasets? Putting aside concerns for data overload, for which we always seem to find answers one way or another, this presentation examines how we construct data gathering procedures and associated approaches to learning in efforts to inform proactive river management in better ways. A future focus has always been important in management endeavours, but in the rapidly-changing world of complexity, contingency, emergence and no-analogue states, where greater levels of uncertainty are inevitable, these deliberations have become even more significant, fashioning the ways we live with our rivers (increasingly, the choices that are available to us). We cannot control uncertainties – we have to learn to live with them. The perspective outlined in this talk will endeavour to speak for the river itself, in efforts to find, and live with, 'the voice of the river'.

PLENARY SPEAKERS CONTINUED

Melissa Parsons

Talk time: Thursday 23 November, 9:00am - 10:00am
Topic: Extreme floods and river resilience: a social-ecological perspective

Melissa Parsons is a river scientist with broad-ranging and interdisciplinary research interests in river and floodplain resilience, natural hazards, resilience assessment, water resource policy and management, river monitoring and assessment, large flood disturbances and river ecology. Melissa works at the interface between theoretical and applied science, examining the ways that concepts such as resilience can be applied to deliver management and policy outcomes. Melissa's current research is focused on natural hazards and she leads a project within the Bushfire and Natural Hazards CRC to develop an Australian Natural Disaster Resilience Index. Other projects examine attitudes towards natural hazards, the psychology of flood driving behaviour, the role of social capital in natural disaster recovery and the use of citizen's juries to develop community-based strategies of flood risk management and preparedness.

Abstract

It has been almost 20 years since one of the first issues of the journal Ecosystems introduced the concept of large infrequent disturbance. Since then many studies have demonstrated the geomorphological and ecological effects of extreme floods, often accompanied by warnings about the ways in which climate-related increases in the magnitude and frequency of extreme floods may affect river ecosystems. Yet rivers are also social-ecological systems in which social and ecological elements are linked through feedback mechanisms. This invokes a relativist view in which knowledge and understanding of extreme flood disturbance exists in relation to society, culture and experience, rather than solely as the domain of realist science. Resilience - the ability of a system to absorb disturbance, maintain the same state and respond and adapt to change - is a concept applied in both river science and social science, and may be a useful umbrella for aligning knowledge about the social and ecological effects of extreme flood disturbances. In this talk I will explore the effects of extreme floods from social and ecological perspectives and attempt to reconcile them under a resilience framework.

PLENARY SPEAKERS CONTINUED

Julian Olden

Talk time: Thursday 23 November, 3:15pm - 4:00pm
Topic: New vision, new life, new hope, for dammed rivers

Julian is a Professor in the School of Aquatic and Fishery Sciences and co-director of the Center for Creative Conservation, both at the University of Washington. Broadly motivated by a future where people recognise and respect the diverse values provided by functioning freshwater ecosystems, Julian seeks to integrate science-based approaches with on-the-ground management and conservation decisions. His research focuses the challenges associated with water resource management, dams, invasive species and climate change. Julian actively engages in generating and communicating science, and believes that uncensored discussions are essential to meet the environmental challenges of the future and to strengthen the modern conservation movement.

Abstract

Harnessed, managed, and exploited for human benefit, the damming of rivers supported the birth of ancient civilizations and modern societies. Over the millennia, dams have tamed streamflow for myriad reasons that include delivering water for drinking, irrigating crops, supporting recreation, and providing flood control and hydropower. Despite these well recognised benefits, river regulation by dams has also caused considerable ecological damage and the loss of important ecosystem services valued by society. But our time together will not be spent lamenting these dam(n) problems. Instead, we explore many of the new, exciting, and at times controversial, ways in which rivers are being re-born, restored, and ultimately re-envisioned for the future. From daylighting streams to dismantling dams to designing flows, our journey together will be filled with a little sorrow and a ton of hope.

NEW ZEALAND FRESHWATER SCIENCES SOCIETY MEDAL OF EXCELLENCE SPEAKER

John Hayes

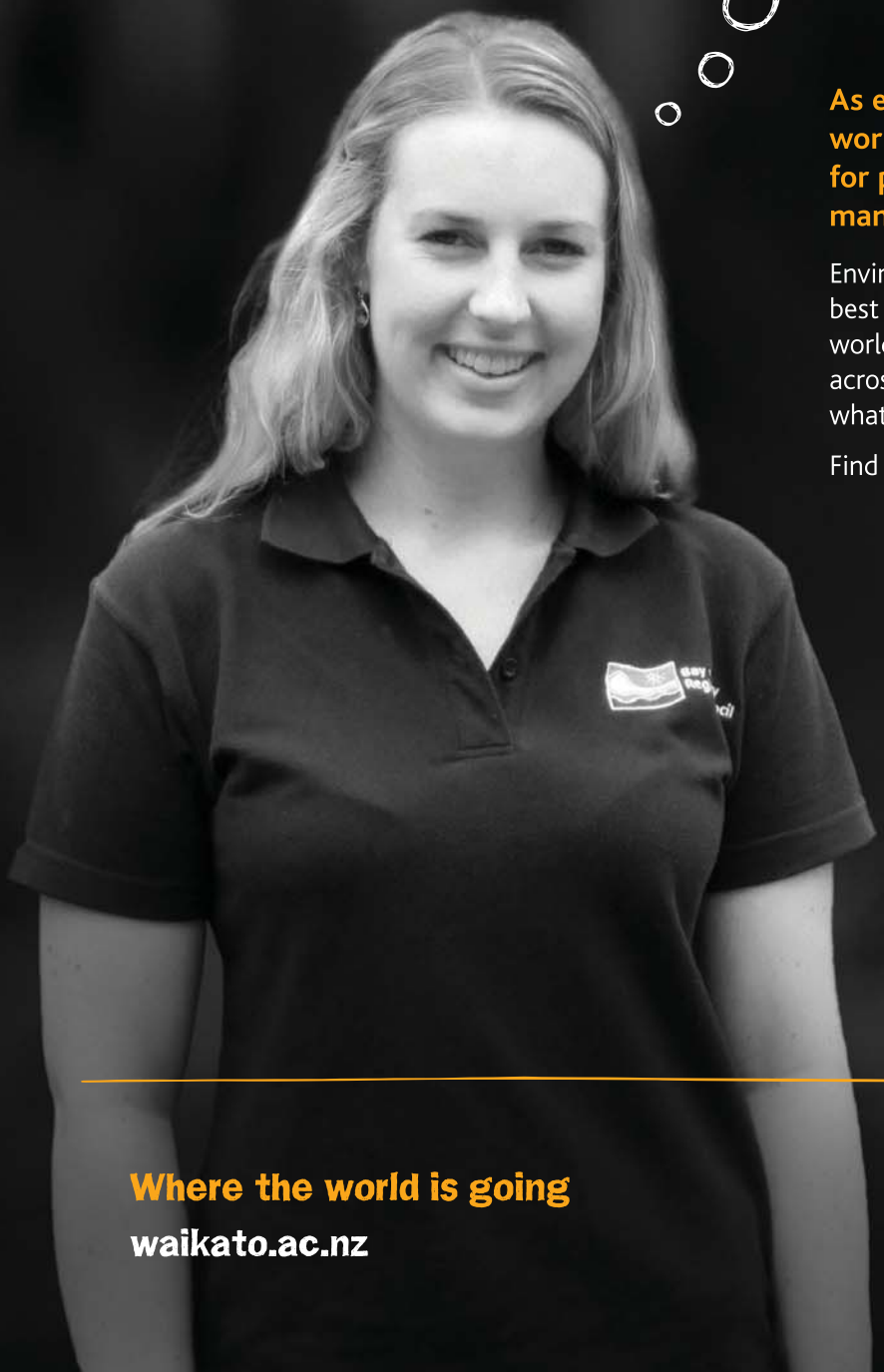
Talk time: Wednesday 22 November, 5:00pm - 5:30pm

Topic: The paradox of integrating immigrants: how salmonids have influenced freshwater values, environmental law and policy, water wars and research in New Zealand

Abstract

The paradox of integrating introduced salmonids in the management of multiple aquatic values is that on the one hand they provide New Zealand's most valuable freshwater fisheries while on the other hand invasive trout have adversely affected indigenous aquatic fauna. The paradox runs deeper in that salmonid fisheries are among the freshwater values that have most constrained exploitative use of water in New Zealand, and environmental legislation and policy implemented to protect salmonids and their habitat has benefitted native fauna. Moreover, environmental campaigns mounted to fight water wars against unsustainable land and water management have in large part been bankrolled by trout and salmon anglers, through Fish and Game councils and Acclimatisation Societies. Yet the emergence of indigenous conservation ideology, most recently expressed in the vision for "predator free New Zealand", and associated anti-trout sentiment, threatens to alienate trout anglers and thereby divide a united stance against unsustainable natural resource management. In addition to contributing to New Zealand's outdoor cultural heritage, salmonid fisheries, because of their value, have been the catalyst for much of New Zealand's freshwater fisheries research, some of which is internationally renowned. The challenges of modern natural resource management require multi-disciplinary, predictive science. Of all our freshwater fish fauna, salmonids are the most amenable to this kind of science because of the extensive international knowledge base on them. I illustrate such research from my career in fisheries research and ecohydraulics and suggest that insights learnt from process-based research on trout also apply in principle to native fish. A paradigm change in understanding of the potential effects of flow change on drift feeding trout arising from this research sets these inconvenient fish on a new collision course with intensified agriculture and hydro-power lobbyists and like-minded politicians.

Conserve resources for FUTURE generations



As environmental pressures increase, the world needs more people who have a passion for protecting the earth's ecosystems and managing our resources in a sustainable way.

Environmental Science students at Waikato have the best of both worlds – classroom learning from world-leading researchers, and numerous field trips across the North Island where they can directly apply what they're learning to help solve real life problems.

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THE UNIVERSITY OF WAIKATO

Te Whare Wānanga o Waikato

SPECIAL SESSIONS

Balancing Human and Ecological Objectives in River Restoration Across a Range of Settings and Catchment Scales

Date : Monday 20 November
Time : 10.30am - 3.00pm
Room : Heaphy 1

Convenor: Gardner Johnston, Inter-Fluve Inc.

The session objective is to present riverine restoration and management programmes that integrate human utility with ecological services, from highly urbanised at one extreme and wilderness rivers at the other. Talks will highlight how practitioners achieved the balance between human and ecological objectives and how the balance point changes depending on the setting.

Land-use Effects on In-stream Cycling and Retention of Nitrogen and Phosphorus

Date : Monday 20 November
Time : 10.45am - 3.00pm
Room : Heaphy 2

Convenor: Bill Richardson, USGS Upper Midwest Environmental Science Center

As the earth surface is transformed by anthropogenic forces, lotic systems draining these landscapes are altered in potentially irreversible ways that likely change the retention and cycling of nutrients. The causal mechanisms and outcomes of these changes along with the ability of mitigating management practices to protect or reverse altered biogeochemistry may be key to better land-use management and improved water quality. The goal of this special session is to explore how land-use alters the cycling and retention of nitrogen and phosphorus in lotic

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Fish Passage Management

Date : Tuesday 21 November // Wednesday 22 November
Time : 10.30am - 3.00pm // 10.45am - 12.00pm
Room : Heaphy 1 // Heaphy 1

Convenor: Sjaan Bowie, Department of Conservation

This special session will cover designing and management of structures/culverts for upstream and downstream fish passage, including good practice and tools for management, remediation tools, fish swimming speeds and other important design aspects for passage, effects of water allocation on passage requirements, and pump station design. Fish passage provides connectivity between all habitats necessary to complete freshwater fish and other instream organisms' life cycles, for example aquatic invertebrates and shrimp.

SPECIAL SESSIONS CONTINUED

Insights from Long-term Temporal and Large-scale Spatial Datasets

Date : Tuesday 21 November
Time : 1.30pm - 3.00pm
Room : Heaphy 2

Convenor: Andrew Casper, Illinois Natural History Survey

Fundamental concepts and theories are the framework for our expanding understanding of river systems. However, the significance of shorter-term research projects or events such as floods, disturbance or droughts is difficult to understand without some historical context. Studies with either long-term or spatially extensive data sets can provide context for testing and exploring concepts and theories. This session is meant to present an overview of insights gained into the mechanisms, patterns, and expectations concerning many current projects around the globe.

Integrative Methods for Environmental Design of Hydropower

Date : Tuesday 21 November
Time : 10.30am - 12.00pm
Room : Heaphy 2

Convenors: Ana Adeva Bustos, Norwegian University of Science and Technology, Roser Casas Mulet, University of Melbourne & Martin Wilkes, Coventry University

In the context of growing global power demand, there is an opportunity for hydropower to expand given its role as a flexible generator and potential for storage of energy. However, developing hydropower in a socially equitable and environmentally acceptable manner is one of the current greatest challenges. This session will focus on international examples of sustainable approaches to hydropower management.

Spatial Patterns and Processes of Biota in River Networks

Date : Wednesday 22 November
Time : 1.30pm - 4.45pm
Room : Heaphy 1

Convenors: Johannes Radinger, Leibniz-Institute of Freshwater Ecology and Inland Fisheries, & Daniel Teschlade, University of Duisburg-Essen

The spatial organisation of rivers as branching networks makes rivers unique ecosystems and fundamentally different from other aquatic and terrestrial ecosystems. The network perspective provides an essential spatial template that affects many ecological patterns and processes of rivers at large scales . This session aims to highlight current approaches in analysing, modelling, simulating and assessing spatial patterns and processes of biota in river networks ranging from aquatic macroinvertebrates to river fish.

SPECIAL SESSIONS CONTINUED

Making Room For Rivers

Date : Wednesday 22 November
Time : 10.45am - 12.00pm
Room : Heaphy 2

Convenor: Kyle Christensen, NZ Rivers Group

The philosophy of making room for rivers is gaining widespread international support as a way of reducing flood and erosion risks and allowing rivers to exhibit their more natural morphological behaviour. The purpose of this session will be explore the issues that could arise from making room for rivers.

Balancing Environmental Flow Objectives: Designing and Implementing Flow Regimes that Achieve Instream Functions while Supporting Water Resource Needs.

Date : Thursday 23 November
Time : 1.30pm - 2.30pm
Room : Heaphy 1

Convenor: Paul Franklin, National Institute of Water & Atmospheric Research, Angus Webb, University of Melbourne, and Sarah Yarnell , Centre for Watershed Sciences

Environmental flow design and management in rivers with high resource demands remains challenging; however, recent examples show that with creative thought, ecological and other instream needs can be met while accommodating water resource demands. This special session includes presentations that address methods for balancing multiple flow objectives, provide examples of flow regimes negotiated by stakeholders to achieve multiple flow objectives, and discuss ideas for integrating instream flow needs with human demands.

Estuaries – Environments in Transition

Date : Thursday 23 November
Time : 10.30am - 12.00pm
Room : Heaphy 2

Coordinator – Eleanor Gee, National Institute of Water & Atmospheric Research

Estuaries are some of the most valued and most impacted parts of rivers, and they are some of the most challenging freshwater-influenced environments to understand and manage. This session will highlight new research into estuarine processes and ecology, with a particular focus on managing freshwater inputs into estuaries to support the ecological and human-use values of these environments.

Science Media Lunch Session - Freshwater in the media: who speaks for science?

Date : Monday 20 November
Time : 12.30pm - 1.30pm
Room : Arena Lounge

Speaker: Dacia Herbulock, Science Media Centre (NZ)

Freshwater issues have captured an unprecedented level of public interest in Aotearoa New Zealand in recent years. Science and environmental impacts feature strongly in many public debates, but end up mired in confusing technical detail and conflicting viewpoints. Meanwhile the health of our freshwater continues to decline. This interactive session will explore how freshwater issues have been covered in the media, the role of experts in influencing this and ways for researchers to participate more effectively in the ongoing public conversation. Throughout, we will offer practical advice for busy scientists and suggest strategies to make the most of opportunities to communicate with the wider public.

Dacia Herbulock is Senior Media Advisor at the Science Media Centre (New Zealand), an independent resource centre promoting evidence-based media coverage of emerging issues where science meets society. She joined the SMC at its launch in 2008, bringing experience in radio, film, documentary, television news and science writing in the US, China and NZ.

She designs and delivers the Science Media Centre's national series of media training and science communication workshops for researchers. She also regularly facilitates "expert encounters" inside newsrooms that pair journalists with scientists to discuss issues like balance in media reporting of scientific evidence, conflicts of interest and emerging technologies.

CONFERENCE FIELD TRIPS: FRIDAY 24 NOVEMBER

All field trips depart and return to Claudelands Events Centre

Haerenga ki te kei o te Waka o Tainui – Lower Waikato River Field Trip

The lower Waikato River inherits the consequences of the upper Waikato river activities. It is a genuine indicator of the health and well being of the Waikato and Waipa Rivers. Take this haerenga (journey) from Kirikiriroa (Hamilton) past te huinga o ngā wai (the meeting of the Waipā and Waikato waters) to the lower Waikato Lakes, reflecting the impacts of confiscation and cultural history in the restoration projects of the lower Waikato. We will also hear the history of Waikato-Tainui, the impacts of confiscation and visit key historic areas adjacent to pest fish eradication, eel and habitat restoration projects.

8:00am	Depart Kirikiriroa (Hamilton)
8:30am	Te Huinga o ngaa wai - The confluence of the Waikato and Waipa Rivers Understanding the influence of the Waipa River on the Lower Waikato catchment focussing on the impacts of soil erosion, sedimentation and deposition.
9:15am	Taupiri Maunga (Taupiri Mountain) – Mangawara Stream Acknowledging the Maunga and the resting place of our tribal ancestors. Discussing the erosion and water management issues of Taupiri Maunga and the impacts of the Mangawara River that flow in the Waikato River.
10:00am	Morning Tea at Te Ahurei - Huntly Power Station Kanae Kakariki to discuss their 3 year restoration project along the Waikato River between Huntly and Rangiriri.
10:45am	Tuna Restoration Project – Lake Okowhao Site visit to see the eel restoration project. Collaborative project between Waahi Whaanui Trust, Genesis Energy and Waikato-Tainui.
11:30am	Eel Processing Factory – Te Kauwhata Site visit to the processing factory to see first hand the production of eel and its marketing and demands.
12:15pm	Lunch – Rangiriri Battle Site Hear the history of the Battle of Rangiriri and the invasion into central Waikato region. Discuss the restoration of the wetlands and restoring the link between the Waikato River and adjacent Lakes.
1:15pm	Lake Waikare and Lake Kopuera Site visit to the Koi Digester Project, a collaboration between Ngaa Muka Development Trust (not Ngati Naho) and should include Waikato District Council. Discuss the impacts of the Whangamarino Wetland, the flood protection scheme, Koi populations and cultural values associated with the Lakes and Wetland.
2:15pm	Return to Hamilton via Hakarimata Road to Ngaruawahia and then to Hamilton.
3:00pm	Arrive in Hamilton.

Price: $60.00 per person

Kaituna River Field Trip (kindly sponsored by DHI)

The Kaituna River is Rotorua Raftings playground, with an all kiwi crew and home to not just one but three awesome waterfalls, including the highest rafted waterfall in the world, Tutea Falls at 7m there is no denying that there is something amazing about this trip!
Whether you are a first time rafter or a white water legend, let Rotorua Rafting guide you through one of the most beautiful rivers that New Zealand has to offer. The extra bonus is that the Kaituna River is also the one of the warmest rivers in New Zealand.
The Kaituna River has long been the source of life for the local iwi (tribe). It supplied Kai (food) and wai (water) needed for survival. However it has not always been a peaceful place, for centuries the local warriors of Ngati Hinerangi battled to keep their Taonga (treasure) that is the Kaituna.
Now 200 years on with Rotorua Rafting you are the warrior, battling Papatuanuku (Earth Mother) against one of it's most powerful elements and the 7 metre waterfall.
Dressed in the highest standard equipment and being guided by world champion guides, you are sure to be victorious in your battle

Departs from and returns to: Claudelands Events Centre
Departure time: 8.00am
Return time: 5.00pm

10:00am - 12:00pm - Rafting Kaituna River with Rotorua Rafting
12:00pm - 1:00pm - BBQ Lunch next to the Kaituna River
1:00pm - 1:30pm - Travel to Mouth of Kaituna River
1:30pm - 3:00pm - Site visit to Kaituna RE-Diversion Project which will be in the early stages of construction

Price: $65.00 per person (Price includes BBQ lunch)

Waikato Peat Lakes

Peat lakes are distinctive features in the Waikato Region, having formed alongside the once large areas of peat bogs. Now they are mostly found in pastoral landscapes and subject to water level change, nutrient enrichments and peat shrinkage. Efforts to restore these lakes include the Living Water partnership between Fonterra and the Department of Conservation who are working together to improve biodiversity and water quality across three peat lakes. This trip will highlight some of the projects being undertaken at Lakes Areare, Rotomānuka and Ruatuna.

A visit to the National Wetland Centre will also be included depending on timing and number who register for this field trip.

Departs from and returns to: Claudelands Events Centre
Departure time: 8.30am
Return time: 2.30pm

Price: $55.00 per person

Urban stream restoration in Hamilton

Hamilton's urban gully systems are a unique ecological feature of the city and are a central focus of a city-wide restoration programme for indigenous ecosystems. This trip will showcase some of the restoration projects and research being undertaken around the city, focusing on Bankwood and Mangakotukutuku Streams.

Work has included fish passage enhancements, installation of artificial instream habitats, riparian enhancement and wetland creation. We will also get the chance to meet some of New Zealand's unique native fish.

Departs from and returns to: Claudelands Events Centre
Departure time: 8.30am
Return time: 1.00pm

Price: $55.00 per person

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Monday 20 November					
7:30am	Registration Desk Opens				
8:45am	Welcome, Housekeeping and Opening Location: Heaphy 1&2				
9:30am – 10:15am	Keynote Speaker – **Gerald Kaufmann** *Catchments, Watersheds, and Basins: The Global Governance and Policy of International River Science* Chair – Bob Penter Location: Heaphy 1&2				
10:15 – 10:45am	Morning Tea - kindly sponsored by Kessels Ecology				
Session	**Special Session: Balancing Human and Ecological Objectives in River Restoration**	**Special Session: Land-use Effects on In-stream Cycling and Retention of Nitrogen and Phosphorus**	**Climate Change**	**Connectivity**	**Aquatic Resource Monitoring**
Chair	**Gardner Johnston**	**Lynn Bartsch**	**Alexander Milner**	**Eimear Egan**	**Alton Perrie**
Location	**Heaphy 1**	**Heaphy 2**	**Heaphy 3**	**Brooklyn 1**	**Brooklyn 2**
10:45am – 11:00am	Balancing human and ecological objectives in river restoration design **Gardner Johnston** *Inter-Fluve, USA*	Land use effects on nutrient cycling and loss from headwaters to Great Lakes in the Fox River Basin, Wisconsin, USA: project overview **Rebecca Kreiling** *United States Geological Survey, United States*	Glacier shrinkage driving global changes in downstream ecosystems **Alexander Milner** *University of Birmingham, United Kingdom*	Growth of adult inanga is related to when they hatch and when they migrate to freshwater **Eimear Egan *** *University of Canterbury, New Zealand*	Patterns and drivers of spatio-temporal variability of turbidity in lakes at the regional scale **Deniz Özkundakci** *Waikato Regional Council, New Zealand*
11:00am – 11:15am	Ecogeomorphology and partnerships: strategies employed in building a watershed restoration programme in rural Washington State, USA **Will Conley *** *Massey University, New Zealand*	Phosphorus retention across land cover types in the Fox River Basin, Wisconsin, USA **Rebecca Kreiling *** *United States Geological Survey, USA*	Climate reconstruction using the New Zealand freshwater bivalve *Echyridella menziesii* from Lake Rotorua **Dilmi Herath *** *Macquarie University, Australia*	Genetic and ecological population structuring among and between landlocked and diadromous populations of a facultatively amphidromous fish **Jason Augspurger** *University of Otago, New Zealand*	Temporal trends in the relative abundance of New Zealand freshwater fishes **Shannan Crow** *NIWA, New Zealand*
11:15am – 11:30am	Stream restoration in the Hawaiian Islands: how mālama ka `aina is restoring traditional farming practices and improving stream conditions for native `o`opu **Gordon Smith** *United States Fish and Wildlife Service, USA*	Instream nitrogen cycling and loss from headwaters to Great Lakes in the Fox River Basin, Wisconsin, USA **Lynn Bartsch** *United States Geological Survey, USA*	Does riparian management influence greenhouse gas emissions from soils and streams? **Nikki Burrows *** *University of Auckland, New Zealand*	Is salmonid migration initiated by juvenile intra-specific competition? **Pavel Mikheev *** *University of Otago, New Zealand*	Ecology and the six values approach to managing Christchurch City's waterways **Greg Burrell** *Instream Consulting, New Zealand*

Location	Heaphy 1	Heaphy 2	Heaphy 3	Brooklyn 1	Brooklyn 2
11:30am - 11:45am	Waikato and Waipa River Restoration Strategy - an action plan for the restoration of New Zealand's longest river **Keri Neilson** *Waikato River Authority, New Zealand*	Land use change alters nutrient processing in streams along Brazil's agricultural frontier **Kathi Jo Jankowski** *United States Geological Survey, USA*	Bottom-up quantification of mega inter-basin water transfer vulnerability to climate change **Enze Zhang *** *Beijing Normal University, China*	Transportation of spawners is more effective than multiple fish passage facilities in the river Klaralven, Sweden **Marco Blixt** *Fortum Sverige AB, Sweden*	Critical water quality assessment in Lamtaklong River, Thailand **Nares Chuersuwan** *Suranaree University Of Technology, Thailand*
11:45am – 12:00pm	Creating habitat for endangered fish in a managed river system - how created ecosystems are becoming the new focus of stream restoration: Dry Creek, Sonoma County, California, USA **Greg Koonce** *Inter-Fluve, USA*	Starting at the top: attenuation of agricultural nitrogen loads by a headwater wetland **Chris Tanner** *NIWA, New Zealand*	Non-linear effects of hydrological variability on fish population dynamics in extremely stochastic freshwater ecosystems. **Richard White** *University of Canterbury, New Zealand*	Fish community response to the fragmentation of river networks **Leah McIntosh *** *University of New England, Australia*	Implementing a real river and stream State of the Environment monitoring programme **Alton Perrie** *Greater Wellington Regional Council, New Zealand*
12:00 – 1:30pm	Lunch			12:30pm – 1:30pm "Freshwater in the media: who speaks for science?" Presenter: Dacia Herbulock, Science Media Centre Arena Lounge Room (all welcome)	
Session	**Special Session: Balancing Human and Ecological Objectives in River Restoration**	**Special Session: Land-use Effects on In-stream Cycling and Retention of Nitrogen and Phosphorus**	**Invertebrate Ecology**	**Connectivity**	**Managing Within Limits**
Chair	**Keri Nielsen**	**John Quinn**	**Richard Storey**	**Konrad Górski**	**Scott Larned**
1:30pm – 1:45pm	Using beaver dam analogues to reduce downstream sediment loads: a pilot project in California Creek, Spokane, Washington State, USA **Sue Niezgoda** *Gonzaga University, USA*	Bioavailability of phosphorus emissions and loadings in surface waters of Germany **Markus Venohr** *Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Germany*	Relationships between large wood in rivers, benthic macroinvertebrates, and hyporheic invertebrates **Chiara Magliozzi *** *Cranfield University, United Kingdom*	He not busy being born is busy dying **Clifford Ochs** *University of Mississippi, USA*	The land use suitability concept: a system to inform land-use and catchment planning and assessment **Rich McDowell** *Our Land And Water National Science Challenge, New Zealand*
1:45pm – 2:00pm	A servant of many masters - when restoration has to meet many expectations: management and monitoring in a floodplain restoration project along a Danube stretch in Bavaria (Germany) **Bernd Cyffka** *University of Eichstaett-Ingolstadt, Germany*	Nitrogen and phosphorus filters: performance of tile drain nutrient filters at Waituna – year one **Neale Hudson** NIWA*, New Zealand*	Applying a combination of geomorphological and ecological techniques to understand the relationships between macroinverterbrate communities and river morphology in New Zealand **Kelly Clinton *** *Massey University, New Zealand*	Present state and future trends in the hydrologic connectivity of central Chilean rivers: Effects on native fish diversity **Gustavo Díaz *** *University of Concepción, Chile*	Contaminant load limits and the "critical point" **Malcolm Green** *Streamlined Environmental, New Zealand*

Location	Heaphy 1	Heaphy 2	Heaphy 3	Brooklyn 1	Brooklyn 2
2:00pm - 2:15pm	Manuka-dominated ecosystems to improve water quality and provide economic and social return in the Lake Waikare catchment **Maria Jesus Gutierrez Gines** *Environmental Science and Research Institute, New Zealand*	Geospatial data and Overseer for nutrient management on dairy farms **Hans Eikaas** *DairyNZ, New Zealand*	Are rare, macroinvertebrate taxa important for freshwater community ecology? **Dimitrios Rados *** *Massey University, New Zealand*	Can local-scale longitudinal variability of low-flow width be a proxy of mesohabitat diversity? **Marie Spitoni *** *French National Centre for Scientific Research, France*	Incorporating resilience and resistance in assessments of land-use suitability **Scott Larned** NIWA, *New Zealand*
2:15pm – 2:30pm	Artificial fish shelters developed by a statistical approach on natural fish habitats **Sebastien Den Doncker** *Stream and River Consult, Belgium*	Characterising the scales and sources of nitrate export in agricultural waterways in Canterbury, New Zealand **Brandon Goeller *** *University of Canterbury, New Zealand*	Oxidative stress response of caddisfly larvae *Stenopsyche marmorata* to combined effects of turbid water and temperature **Jumpei Suzuki *** *Central Research Institute of Electric Power Industry, Japan*	Effects of connectivity on benthic macroinvertebrate community structure of secondary channels in the Mississippi River, USA **Audrey Harrison *** *University of Mississippi, USA*	The Land Use Suitability Spatial Explorer (LUSSE) **Ton Snelder** *Land Water People, New Zealand*
2:30pm – 2:45pm	Incorporating broader environmental objectives into Lower Waikato flood control infrastructure and drainage services **Peter Roberts** *Waikato Regional Council, New Zealand*	Drivers of periphyton biomass and community type along the gravel bed Tukituki River during summer. **John Quinn** *NIWA, New Zealand*	Zooplankton influence on algal dynamics in rivers **Anna Freeman *** *University of Reading, United Kingdom*	The impact of historical mining activity on aquatic macroinvertebrates at Puhipuhi, Northland **Marlese Fairgray *** *University of Canterbury, New Zealand*	Freshwater tipping points: What? When? Where? How? Why? **Marc Schallenberg** *University of Otago, New Zealand*
2:45pm – 3:00pm			Effects of contrasting extreme flooding on biotic communities in Glacier Bay, Alaska **Alexander Milner** *University of Birmingham, United Kingdom*	Changes in hydrologic connectivity of the largest river basin in Chile: effects on native fish with different dispersal abilities **Konrad Górski** *Universidad Católica de la Santísima Concepción, Chile*	Exploration of implications of capacity for land use intensification under water quality constraints at national scale **Sandy Elliott** *NIWA, New Zealand*
3:00pm – 3:30pm	Afternoon Tea				
3:30pm – 4:15pm	Keynote Speaker – **Linda Te Aho** *Te Mana o te Wai. A Māori perspective on rivers and the place of indigenous values in river management.* Chair – Julian Williams Location: Heaphy 1&2				
4:15pm – 6:30pm	Mix & Mingle - kindly sponsored by Morphum Environmental Claudelands Upper Concourse Arena				
7:30pm	NZFSS Public Forum: Pathways to swimmable rivers Claudelands Heaphy 1				

Tuesday 21 November						
8:00am	Registration Desk Opens					
8:50am	Welcome and Housekeeping Location: Heaphy 1&2					
9:00am - 10:00am	Keynote Speaker – **Catherine Knight** *How have we valued New Zealand's rivers? A historical perspective.* Chair: Laddie Kuta Location: Heaphy 1&2					
10:00am - 10:30am	Morning Tea					
Session	**Special Session: Fish Passage Management**	**Special Session: Integrative Methods for Environmental Design of Hydropower**	**River Water Quality**	**Connectivity**	**Human Health**	**Indicators and Frameworks**
Chair	**Sjaan Bowie**	**Ana Adeva Bustos**	**Jenny Webster-Brown**	**Josh Smith**	**Gillian Lewis**	**Juliet Milne**
Location	**Heaphy 1**	**Heaphy 2**	**Heaphy 3**	**Brooklyn 1**	**Brooklyn 2**	**Brooklyn 3**
10:30am - 10:45am	The New Zealand Fish Passage Advisory Group – improved coordination and management of a key pressure facing our waterways **Sjaan Bowie** *Department of Conservation, New Zealand*	Importance of integrating physical and biological processes along with societal needs for sustainable energy and protecting a river's goods and services **Allen Curry** *Canadian Rivers Institute, Canada*	Before and after integrated catchment management: changes in water quality **Andrew Hughes** *NIWA, New Zealand*	Assembly and disassembly of aquatic invertebrate communities in a dynamic floodplain ecosystem **Stefano Larsen** *Trento University, Italy*	Moving to real-time measurement of microbial health risks in rivers **Rebecca Stott** *NIWA, New Zealand*	Riverine ecosystem services: Pledges and pitfalls of their integrative assessment **Martin Pusch** *Leibniz Institute of Freshwater Ecology and Inland Fisheries, Germany*
10:45am - 11:00am	Evaluating the likelihood of fish passage success at culverts in New Zealand using expert knowledge **Paul Franklin** *NIWA, New Zealand*	Using LiDAR to suggest an integrative environmental flow in a Swedish river **Ana Adeva Bustos *** *Norwegian University of Science and Technology, Norway*	Nitrogen budgets in rivers: proteins can make an important, but varied contribution to dissolved organic nitrogen. **Gavin Rees** *La Trobe University, Australia*	Spatial variability of invertebrate drift in coarse-bed streams: hydraulic and morphodynamic controls **Piotr Cienciala** *University of Illinois at Urbana-Champaign, USA*	*E.coli* standards and risks to human health in New Zealand waterways: what more? **Ayokunle Christopher Dada** *Streamlined Environmental, New Zealand*	Development of linked frameworks to represent and manage catchment-scale contaminant transport for improved water quality outcomes **Richard Muirhead** *AgResearch, New Zealand*
11:00am - 11:15am	Floating fish ramps: a new tool in the fish passage toolbox **Dan Fake *** *Hawkes Bay Regional Council, New Zealand; The University of Waikato, New Zealand*	Assessing the limits of eco-sustainable hydropower development **Carina Seliger** *University of Natural Resources and Life Sciences, Austria*	Understanding the linkage between hydrological and chemical signatures at catchment outlets and dominant contaminant transfer pathways **Roland Stenger** *Lincoln Agritech, New Zealand*	The influence of site connectivity on zooplankton assemblage dynamics within the Lower Mississippi River Floodplain **Jarrod Sackreiter** *University of Mississippi, USA*	The world's largest waterborne campylobacteriosis outbreak: Havelock North August 2016 **Brent Gilpin** *Environmental Science and Research, New Zealand*	Evaluating Greater Wellington Regional Council's Natural Resources Plan **Lucy Baker** *Greater Wellington Regional Council, New Zealand*

Location	Heaphy 1	Heaphy 2	Heaphy 3	Brooklyn 1	Brooklyn 2	Brooklyn 3
11:15am - 11:30am	How effective are spat ropes at providing for fish passage in culverts five years after installation? **Dean Miller** *Tonkin & Taylor, New Zealand*	FISH-Net: A model to support sustainable hydropower planning, design and monitoring for fish passage in the temperate Southern Hemisphere **Martin Wilkes** *Coventry University, United Kingdom*	Nutrient limitation in the Waikato River catchment, from Lake Taupo to the estuary **Piet Verburg** *NIWA, New Zealand*	Waikato Regional Council freshwater fish monitoring programme – overview and preliminary results with a focus on connectivity **Josh Smith** *Waikato Regional Council, New Zealand*	Using a metagenomic sequencing approach for faecal source tracking **Megan Devane** *Environmental Science and Research, New Zealand*	Managing freshwater ecosystems: how do we measure success? **Carl Howarth** *Ministry for the Environment, New Zealand*
11:30am - 11:45am	Refinement of fish friendly criteria for hydropower and irrigation diversions **Craig Boys** *Charles Sturt University, Australia*	Strategies to implement cost-efficiency mitigation measures in hydropeaking rivers: a focus on early life stages of salmonids **Svein Jakob Saltveit** *University of Oslo, Norway*	Temporal and spatial pollution dynamics in the river-style Three Gorges Reservoir on the Yangtze River, China **Andreas Holbach** *Karlsruhe Institute of Technology, Germany*	How old is your streambed? **Michael Stewardson** *The University of Melbourne, Australia*	Not all faecal pollution is equal: targeted management relies on knowledge of the source **Justine Quinn** *Tonkin + Taylor, New Zealand*	'Maintain or Improve': how do we judge that? **Graham McBride** *NIWA, New Zealand*
11:45am – 12:00 pm	Downstream migrant eel movements in the lower Waikato River and passage past Huntly power station **Cindy Baker** *NIWA, New Zealand*	Fish Hazard Index: a tool for assessing hydropower impacts on fish **Christian Wolter** *Berlin, Germany*	The effects of the 2017 wildfires in the Port Hills on stream water quality **Jenny Webster-Brown** *Waterways Centre for Freshwater Management, New Zealand*		Viral beach balls and bacterial backstroke: pathogen ecology in freshwater **Gillian Lewis** *University of Auckland, New Zealand*	
12:00 - 1:30pm	Lunch					
Session	**Special Session: Fish Passage Management**	**Special Session: Insights from Long-term Temporal and Large-scale Spatial Datasets**	**Citizen Science and Ecosystem Services**	**Food Webs**	**Human Health**	**Mussel Biology and Conservation**
Chair	**Bryn Quilter**	**Martin Thoms**	**Roger Young**	**Karen Shearer**	**Rebecca Stott**	**Susan Clearwater**
1:30pm - 1:45pm	Fish passage solutions: a bit of theory, give it a go, monitor, and learn from our mistakes. **Logan Brown** *Horizons Regional Council, New Zealand*	Use of long-term data in river science: recent successes and future challenges and opportunities **Andrew Casper** *University of Illinois, USA*	Volunteer water monitoring as a focus for community engagement in New Zealand **Robert Davies-Colley** *NIWA, New Zealand*	Quantifying basal trophic resources for shallow lake food webs **Kevin Collier** *University of Waikato, New Zealand*	Modelling differing human health risk from recreational water contact with different faecal sources **David Wood** *Environmental Science and Research, New Zealand*	Mass propagation of native freshwater mussels *Echyridella menziesii* **Susan Clearwater** *NIWA, New Zealand*

Location	Heaphy 1	Heaphy 2	Heaphy 3	Brooklyn 1	Brooklyn 2	Brooklyn 3
1:45pm - 2:00pm	Engineering design for fish passage **Bryn Quilter** *Tonkin & Taylor, New Zealand*	Effects of climatic and trophic processes on freshwater invertebrate communities: recent insights from long-term studies on French streams and rivers **Mathieu Floury** *Irstea, France*	Community monitoring of water quality – do the *E. coli* numbers stack up? **Paul Fisher** *Nelson City Council, New Zealand*	Quantifying trophic interactions in shallow lake food webs using stable isotopes of carbon and nitrogen **Michael Pingram** *Waikato Regional Council, New Zealand*	Use of QMRA to assess the human health risk of the Mataura River, Southland **Peter Cressey *** *Environmental Science and Research, New Zealand*	Effects of water temperature on the release and viability of glochidia of the freshwater mussel, *Echyridella menziesii* **Michele Melchior *** *University of Waikato, New Zealand*
2:00pm - 2:15pm	Assessment of public road-river intersections for provision of fish passage in Southland, New Zealand: methods, interim results, and proposed management actions **James Dare** *Environment Southland, New Zealand*	Taxonomic and functional diversity in four large and intensively-monitored Midwestern United States rivers **Jerrod Parker** *Illinois Natural History Survey, USA*	Just because I'm young, don't count me out **Kirsty Brennan** *EOS Ecology, New Zealand*	The influence of nutrient enrichment on riverine food webs: are the defences compromised? **Adam Canning *** *Massey University, New Zealand*	Do cyanobacteria blooms develop inshore or in the middle of the lake? **Max Gibbs** *NIWA, New Zealand*	Assessing habitat preference and in-stream distribution of New Zealand freshwater mussels using mark-recapture techniques **Alicia Catlin** *Waikato Regional Council, New Zealand*
2:15pm - 2:30pm	Managing the effects of land drainage and flood control infrastructure on fish passage in the Waikato **Mike Lake** *Waikato Regional Council, New Zealand*	Macroecological analysis of rivers in temperate steppes of the USA and Mongolia: from hydrogeomorphology to food webs **James Thorp** *University of Kansas, USA*	Contributing science to collaborative group decision making: reflections on working with the Takaka Freshwater Land Advisory Group **Roger Young** *Cawthron Institute, New Zealand*	Seasonal variations in consumer nitrogen recycling in an oligotrophic lake: a stable isotope study **Simon Stewart *** *University of Waikato, New Zealand*	Simple *E. coli* testing methods – how do they stack up for community volunteer monitoring? **Rebecca Stott** *NIWA, New Zealand*	Can the bio-deposition and physical structure of hyriid freshwater mussels alter benthic algae and invertebrate assemblages in floodplain rivers? **Nicole McCasker** *Charles Sturt University, Australia*
2:30pm - 2:45pm	Use of passive integrated transponder tags and acoustic hydrophones to document eel movement and mortality through a non-gravity fed axial pumping station **Bruno David** *Waikato Regional Council, New Zealand*	Naughty rivers: conforming or deviating ecosystem responses to anthropogenic drivers **Jason DeBoer *** *Illinois River Biological Station, USA*	Riverine ecosystem services: exploring stakeholders' views **Gebriela Costea** *Leibniz Institute of Freshwater Ecology and Inland Fisheries, Germany*	Composition of Kōwaro populations in different climatic conditions **Christopher Meijer *** *University of Canterbury, New Zealand*	Little Oneroa Stream – Great for ducks, not for people **Brett Stansfield** *Environmental Impact Assessments Ltd, New Zealand*	Freshwater mussel research and conservation Aotearoa **Susan Clearwater** *NIWA, New Zealand*
2:45pm – 3:00pm	Weir removal made easy **Matthew Bloxham** *Auckland City Council, New Zealand*	The non-effect of restoring a large river: the Darling River, Australia **Martin Thoms** *University of New England, Australia*		Energy density of common New Zealand macroinvertebrates for freshwater invertebrate-fish relationships, models and indices **Karen Shearer** *Cawthron Institute, New Zealand*		Mussel conservation discussion

3:00pm – 3:30pm	Afternoon Tea
3:30pm - 4:15pm	Keynote Speaker - **Sonja Jähnig** *Modelling riverine biodiversity and ecosystems service delivery - simple, integrated, or complex?* Chair – Deniz Özkundaci Location: Heaphy 1&2
4:15 - 6:00pm	Poster Session, Claudelands Upper Concourse Arena
6:00pm – 8:00pm	ISRS Boat Trip, Buses depart outside Claudelands – Heaphy Terrace
6:30pm	Student Function, Roaming Giant
6:30pm	SWIM Meeting, Claudelands Arena Lounge

Wednesday 22 November						
8:00am	Registration Desk Opens					
8:50am	Welcome and Housekeeping					
9:00am - 10:00am	Keynote Speaker – **Gary Brierley** *A new dawn is upon us: The use of emerging technologies in river science and management* Chair – Brendan Hicks					
10:00am - 10:45am	Morning Tea					
Session	**Special Session: Fish Passage Management**	**Special Session: Making Room For Rivers**	**Ecohydraulics**	**Wetlands**	**Resilience**	**Algae and Macrophytes**
Chair	**Kati Doehring**	**Kyle Christensen**	**John Hayes**	**Yvonne Taura**	**Elizabeth Graham**	**Cathy Kilroy**
Location	**Heaphy 1**	**Heaphy 2**	**Heaphy 3**	**Brooklyn 1**	**Brooklyn 2**	**Brooklyn 3**
10:45am - 11:00am	What has been the contribution of fish passages for migratory fish conservation in tropical systems? **Luiz Silva** *UFSJ, Brazil*	The evolution of river width design for gravel bed rivers in New Zealand. **Kyle Christensen** *Independent Consultant, New Zealand*	Invertebrate drift transport modelling: it's been a wild ride! **John Hayes** *Cawthron Institute, New Zealand*	Managing wetlands for carbon storage in an agricultural landscape I: threats and management options **Susanne Watkins** *Murray Local Land Services, Australia*	Vulnerability of freshwater ecosystems to state shifts associated with tipping points **Angus McIntosh** *University of Canterbury, New Zealand*	Within mat nutrient cycling in *Phormidium* – alkaline phosphatase activity and regulation **Laura Kelly *** *Victoria University of Wellington, New Zealand*
11:00am - 11:15am	Na ika i Viti - freshwater issues in the tropical islands of Fiji **Kati Doehring** *Cawthron Institute, New Zealand*	Defining braided river margins **Jo Hoyle** *NIWA, New Zealand*	Predicting the effects on mussels of decreased minimum flows **James Layzer** *Tennessee Tech University, USA*	Managing wetlands for carbon storage in an agricultural landscape II: project approach and achievements **Sarah Ning** *Murray Darling Wetlands Working Group, Australia*	Community structure and food web pathways in macro-algal dominated lakes: is this another stable state? **David Kelly** *Cawthron Institute, New Zealand*	*Phormidium* growth responses along hydrological gradients in three south Canterbury rivers **Tara McAllister *** *Waterways Centre for Freshwater Management, New Zealand*
11:15am - 11:30am	Case study at River Orkla in Central Norway: numerical modelling of hydraulic conditions at a river section combined with fish telemetry data in 3D **Marcell Szabo-Meszaros *** *Norwegian University of Science and Technology, Norway*	One small river and one road - so why two large bridges? **Iain Smith** *Beca, New Zealand*	Analysis of bedload transport processes during flood events based on numerical simulations **Kurt Glock *** *University of Natural Resources and Life Sciences, Austria*	Te Reo o Te Repo – The voice of the wetland, a cultural wetland handbook **Yvonne Taura** *Manaaki Whenua, New Zealand*	Sediment geochemistry indicators of lake resilience **Sean Waters** *Cawthron Institute, New Zealand*	When and why do *Phormidium* blooms occur, and when are toxins produced and released? **Soozie Wood** *Cawthron Institute, New Zealand*
11:30am - 11:45am	Impacts of weirs on downstream passage of native fish in the Murray-Darling Basin **Craig Boys** *Charles Sturt University, Australia*	Vulnerability zone identification and river channel change sensitivity in the Ruamahanga catchment **Will Conley *** *Massey University, New Zealand*	A physical objectives approach to achieving desired periphyton removal using environmental flows **Andrew Neverman *** *Massey University, New Zealand*	Loss of freshwater wetlands since 1990 in Southland, New Zealand: causes and consequences **Hugh Robertson** *Department of Conservation, New Zealand*	Does nutrient enrichment affect the response of stream communities to large floods? **Yen Dinh *** *Massey University, New Zealand*	Redefining "accrual period" improves ability to predict annual maximum chlorophyll a in rivers **Cathy Kilroy** *NIWA, New Zealand*

Location	Heaphy 1	Heaphy 2	Heaphy 3	Brooklyn 1	Brooklyn 2	Brooklyn 3
11:45am – 12:00 pm	Fish passage research needs to diversify its concepts and methods to work on a global scale **Martin Wilkes** *Coventry University, United Kingdom*	"Big" rivers, big pressures **Dave West** *Department of Conservation, New Zealand*	Flow-vegetation interactions at the patch scale **Hamish Biggs** *NIWA, New Zealand*	An introduction to wetland delineation protocols in the USA **Daniel Gerber** *University of Wisconsin, USA*	Resilience is not always good! A framework for overcoming negative resistance and resilience in stream restoration **Helen Warburton** *University of Canterbury, New Zealand*	Understanding factors that affect macrophytes in agricultural waterways **Katie Collins *** *University of Canterbury, New Zealand*
12:00 - 1:30pm	Lunch					
Session	**Special Session: Spatial Patterns and Processes of Biota in River Networks**	**Traditional Knowledge**	**Lake Water Quality**	**Macroinvertebrate Indicators**	**Hydrogeomorphology**	
Chair	**Johannes Radinger**	**Julian Williams**	**David Hamilton**	**Joanne Clapcott**	**Ian Fuller**	
1:30pm - 1:45pm	The interacting effects of connectivity and global change on fishes in river networks **Johannes Radinger** *Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Germany; Universitat de Girona, Spain*	Development of a strategic and enduring approach to managing and improving Mahinga Kai within the Ngati Tahu-Ngati Whaoa rohe – Te Awa o Waikato **Johlene Kelly / Evelyn Forrest** *Ngati Tahu-Ngati Whaoa Runanga Trust, New Zealand*	Modelling of trophic state of New Zealand lakes and visualisation with the geospatial platform Takiwa **David Hamilton** *Griffith University, Australia*	Macroinvertebrate indicators: presence or absence in national policy? **Joanne Clapcott** *Cawthron Institute, New Zealand*	Integrating geomorphology and ecology for resilient river engineering **Ian Fuller** *Massey University, New Zealand*	
1:45pm - 2:00pm	Interactive effects of hydrogeomorphic characteristics on fish community structure in a floodplain river **Michael Delong** *Winona State University, USA*	The application of a maatauranga whakapapa framework by Ngaati Tahu Ngaati Whaoa towards mahinga kai attributes within the National Objectives Framework **Evelyn Forrest / Sue Clearwater** *Ngati Tahu-Ngati Whaoa Runanga Trust, New Zealand; NIWA, New Zealand*	The relationship between watercolor, CDOM absorption and remotely-sensed reflectance spectra of New Zealand lakes **Uyen Nguyen** *University of Waikato, New Zealand*	Predicting the invertebrate community reference condition for New Zealand rivers **Martin Neale** *MartinJenkins, New Zealand*	Direct and indirect effects of multiple stressors on stream fauna across watershed, reach and site scale: a path modelling analysis revealing the role of hydromorphology **Jeremy Piffady** *Irstea, France*	
2:00pm - 2:15pm	Does genetic introgression between stocked and wild populations affect patterns of dispersal? A case study in a brown trout (*Salmo trutta*) population. **Keoni Saint-Pé** *Station d'Ecologie Theorique et Expérimentale du CNRS, France*	Wai Ora Wai Māori – a kaupapa Māori assessment tool for freshwater management **Yvonne Taura / Kiri Reihana** *Manaaki Whenua, New Zealand*	Water colour trends over 18 years in all New Zealand lakes from Landsat observations **Moritz Lehmann** *University of Waikato, New Zealand*	Development of stressor-specific invertebrate metrics – does it work and what for? **Annika Wagenhoff** *Cawthron Institute, New Zealand*	**A technique to assess river habitat change – the missing dimension for water resource management.** **Meredith Davis** *Massey University, New Zealand*	

Location	Heaphy 1	Heaphy 2	Heaphy 3	Brooklyn 1	Brooklyn 2	Brooklyn 3
2:15pm - 2:30pm	Network connectivity and complexity drive population persistence and stability in connected landscapes **Angus Webb** *University of Melbourne, Australia*	Lake Waahi hauanga kai co-science project **Mathew Allan / Norm Hill** *University of Waikato, New Zealand; Boffa Miskell, New Zealand*	Within-lake measurement of phosphorous bioavailability: a multimethod approach **Huma Saeed *** *University of Waikato, New Zealand*	Incorporating biological traits in New Zealand freshwater biomonitoring and assessment **Brian Smith** *NIWA, New Zealand*	Influence of bank habitat type on fish and invertebrate communities in the Waikato River **Toni Shell** *Tonkin & Taylor, New Zealand*	
2:30pm - 2:45pm	Confluence configuration controls spatial patterns in fish assemblages **Nixie Boddy *** *University of Canterbury, New Zealand*	The continuing journey towards kaitiaki monitoring. **Brett Cockeram** *Greater Wellington Regional Council, New Zealand*	Lakes as organic matter upgraders – seasonal variation in biochemical compositions of in- and outflowing particles in pre-alpine Lake Lunz, Austria **Samiullah Khan** *University of Otago, New Zealand*	The role of macroinvertebrates in nutrient processing in the Tukituki River **Elizabeth Graham** *NIWA, New Zealand*	Characteristics of the very rare Whakatāne flood of 6 April 2017 and implications for design **Peter Blackwood** *Bay of Plenty Regional Council, New Zealand*	
2:45pm – 3:00pm	Targeting connectivity restoration in inland waters: a spatial network analysis approach **Pedro Segurado** *University of Lisbon, Portugal*	Kaitiaki layers: visualising mātauranga Māori and science **Maui Hudson** *The University of Waikato, New Zealand*	Contribution of organic phosphorus to phytoplankton phosphorus demand in a phosphate-depauperate lake **Matthew Prentice** *Griffith University, Australia*		Morphological effects of altered flow and sediment regime and vegetation encroachment in dam-impacted braided rivers: a numerical modelling study **Guglielmo Stecca** *DICAM University of Trento, Italy*	
3:00pm - 3.30pm	Afternoon Tea					
Session	**Special Session: Spatial Patterns and Processes of Biota in River Networks**	**Traditional Knowledge**	**Monitoring and Assessment Methods**	**Fish Ecology**	**Urban/Stormwater**	**Modelling/Hydrology**
Chair	**Johannes Radinger**	**Julian Williams**	**Eloise Ryan**	**Phil Jellyman**	**Damian Young**	**Christian Zammit**
3:30pm - 3:45pm	River Network Toolkit – easing freshwater network data management **Pedro Segurado** *University of Lisbon, Portugal*	Kia Mahitahi – working together: a cultural perspective for freshwater management in Te Tau Ihu o te Waka a Māui. **Aneika Young** *Cawthron Institute, New Zealand*	Monitoring river use with camera traps **Adam Daniel** *Auckland/Waikato Fish & Game, New Zealand*	Large longfin eels in an unfished Taranaki landslide-dammed lake **Dylan Smith** *University of Waikato, New Zealand*	Watercourse assessment and catchment management in Hamilton City **Damian Young** *Morphum Environmental, New Zealand*	Hydrodynamic catchment to sea modelling **Graeme Smart** *NIWA, New Zealand*
3:45pm - 4:00pm	Species distribution and species dispersal models, instruments for tomorrow's river basin management? **Daniel Teschlade** *University of Duisburg-Essen, Germany*	Te Wai Koiora – stream restoration and cultural stream health monitoring **Katie Blakemore** *Taranaki Regional Council, New Zealand*	Centrifugal Macrophyte Elutriation (CME): a novel method to separate macroinvertebrates from organic matter in streams with high macrophyte biomass **Michael Greer** *Greater Wellington Regional Council, New Zealand*	Predicting the biodiversity consequences of altered thermal regimes in rivers: the need to understand fundamental thermal niches **Rick Stoffels** *Murray-Darling Freshwater Research Centre, Australia*	Integrating ecological and stormwater mitigation and offsetting **Mark Lowe** *Morphum Environmental, New Zealand*	Estimating water residence time distribution in river networks by boosted regression trees (BRT) model **Meili Feng** *University of Nottingham Ningbo China, China*

Location	Heaphy 1	Heaphy 2	Heaphy 3	Brooklyn 1	Brooklyn 2	Brooklyn 3
4:00pm - 4:15pm	Gene flow simulations demonstrate resistance of long-lived species to genetic erosion of habitat fragmentation **Matthew Fuller** *Duke University, USA*	Protecting ancient Māori rock art in a changing freshwater management environment **Mandy Home** *NIWA, New Zealand*	A global approach for assessing environmental flow requirements: considering organic matter budget and energy transportation **Yui Shinozaki *** *University of Tsukuba, Japan*	Wet and dry season flows influence juvenile fish abundance in a tropical river **Alison King** *Charles Darwin University, Australia*	Watercourse assessment reports: a framework for integrated stream management **Michael Lindgreen** *4sight Consulting, New Zealand*	Cumulative Hydrological Effects Simulator: a tool for characterising the consequences of water use on multiple values **Jan Diettrich** *NIWA, New Zealand*
4:15pm - 4:30pm	A conceptual synthesis of flow-recruitment relationships for riverine fishes **Nicole McCasker** *Charles Darwin University, Australia*	Incorporating cultural values and perspectives of First Peoples' (Aboriginal People) into water planning and environmental water management **Bradley Moggridge *** *University of Canberra, Australia*	The value of high-frequency water quality monitoring before, during and after high flow events for describing temporal and spatial dynamics in an intensively farmed lowland floodplain **Eloise Ryan** *Waikato Regional Council, New Zealand*	The impact of didymo on adult trout abundance – has there really been an effect? **Phil Jellyman** *NIWA, New Zealand*	Drainage geometric networks and catchment management to support freshwater outcomes **Emily Reeves** *Morphum Environmental, New Zealand*	Improving instream habitat and mitigation studies with spatially extensive groundwater – surface water interaction models **Christian Zammit** *NIWA, New Zealand*
4:30pm - 4:45pm	The importance of network discontinuity in the ecology and conservation biology of African headwater stream minnows **Darragh Woodford** *University of the Witwatersrand, South Africa*		A new multi-scale approach to predict potential hyporheic exchange flow in rivers **Chiara Magliozzi *** *Cranfield University, United Kingdom*	Turning 'nice to know' into 'need to know': a decision support system to diagnose factors limiting stream fisheries **Robin Holmes** *Cawthron Institute, New Zealand*	Colourful urban streams: microplastic pollution of the freshwater systems in the Auckland region. **Nadia Dikareva *** *University of Auckland, New Zealand*	Tidal flood modelling at Dargaville **Hugh MacMurray** *Barnett & MacMurray, New Zealand*
5:00pm – 5:30pm	NZFSS Medal Award Plenary - **Dr John Hayes** - *The paradox of integrating immigrants: how salmonids have influenced freshwater values, environmental law and policy, water wars and research in New Zealand*					
5:30pm - 6:15pm	NZFSS AGM, Claudelands Arena Lounge					
5:30pm – 6:00pm	NZRG AGM, Claudelands Brooklyn 1					
From 6:00pm	Special screening of the Lost Rivers Film, organised by Morphum Environmental at Lido Hamilton			Optional Informal Social Function Meet other delegates across the road, at the Roaming Giant (own expense)		

Thursday 23 November						
8:00am	Registration Desk Opens					
8:50am	Welcome and Housekeeping					
9:00am - 10:00am	Keynote Speaker – **Melissa Parsons** *Extreme floods and river resilience: a social-ecological perspective* Chair – Martin Thoms					
10:00am - 10:30am	Morning Tea					
Session	**Special Session: Balancing Environmental Flow Objectives**	**Special Session: Estuaries – Environments in Transition**	**River Restoration**	**Lake and Wetland Restoration**	**Water Quality**	**Sediment**
Chair	**Paul Franklin**	**Eleanor Gee**	**Fleur Matheson**	**Soozie Wood**	**Chris Hickey**	**Murray Hicks**
Location	**Heaphy 1**	**Heaphy 2**	**Heaphy 3**	**Brooklyn 1**	**Brooklyn 2**	**Brooklyn 3**
10:30am - 10:45am	Water quantity limits to support multiple values in New Zealand rivers: are minimum flows enough? **Paul Franklin** *NIWA, New Zealand*	Minimum flow considerations in estuaries **Eleanor Gee** *NIWA, New Zealand*	Big data on New Zealand riparian restoration: who, what, where, why, how much, and is it working? **Richard Storey** *NIWA, New Zealand*	Can proven geo-engineering products increase water clarity and decrease sediment phosphorus fluxes in a Waikato peat lake? **Ben Woodward** *NIWA, New Zealand*	Light regime in a large river using flow-path, snap-shot, and fixed-site measurement approaches **John Gardner *** *Duke University, USA*	Ecological aspects of sediment management and monitoring at alpine rivers **Rolf Rindler *** *University of Natural Resources and Life Sciences, Austria*
10:45am - 11:00am	Mapping water quantity allocation across New Zealand **Doug Booker** *NIWA, New Zealand*	The New Zealand Estuary Trophic Index (ETI) Tools **John Zeldis** *NIWA, New Zealand*	Stream enhancement – what actually happens? **Alex James** *EOS Ecology, New Zealand*	Responses of the fish community and biomass in Lake Ohinewai to fish removal and a carp exclusion barrier **Brendan Hicks** *University of Waikato, New Zealand*	Diurnal variations in nutrient uptake and recycling in the Tukituki River **Kit Rutherford** *NIWA, New Zealand*	Effects of change in catchment sediment load on sediment rating curves and particle size **Murray Hicks** *NIWA, New Zealand*
11:00am - 11:15am	Enabling an Indigenous community to inform environmental flow setting processes: examples from the results of Cultural Flow Preference Studies undertaken in New Zealand. **Gail Tipa** *Tipa and Associates, New Zealand*	Demonstrating the New Zealand Estuary Trophic Index (ETI) Tools **Amy Whitehead** *NIWA, New Zealand*	Relating with rivers as part of best river management practice **Simon Mould *** *Macquarie University, Australia*	Nutrient cycling in Lake Horowhenua and restoration options **Piet Verburg** *NIWA, New Zealand*	The search for the source of phosphorus in the Tukituki River: the role of diurnal fluctuations in water column pH from periphyton photosynthesis **Craig Depree** *NIWA, New Zealand*	Effects of different size sediment deposition on the riparian forestation **Takashi Asaeda** *Saitama University, Japan*

Location	Heaphy 1	Heaphy 2	Heaphy 3	Brooklyn 1	Brooklyn 2	Brooklyn 3
11:15am - 11:30am	Environmental flows for ecosystem function: plausible reality or impossible dream? **Fiona Dyer** *University of Canberra, Australia*	Fish composition of permanently open and intermittently closed estuaries in east coast of Otago, New Zealand **Fasil Taddese *** *University of Otago, New Zealand*	Effectiveness of whole ecosystem and in-stream lime applications to restore acid-stressed Adirondack Mountain stream communities: leaf decomposition and nutrient uptake responses **Randy Fuller** *Colgate University, USA*	Using environmental DNA to characterise contemporary and historic lake communities **Soozie Wood** *Cawthron Institute, New Zealand*	'NZ inc.' takes a step towards national consistency in river and lake water quality monitoring – a new National Environmental Monitoring Standard (NEMS) **Juliet Milne** *NIWA, New Zealand*	Measurement and estimation of fine suspended sediment-related attributes in NZ waters **Robert Davies-Colley** *NIWA, New Zealand*
11:30am - 11:45am	Characterising diverse river landscapes using hydro-geomorphic classification and dimensionless hydrographs **Belize Lane** *University of California, USA*	Specialist estuarine fishes: not just diadromous transients **Nicholas Ling** *University of Waikato, New Zealand*	Reintroduction of invertebrate communities – a field experiment in a German lowland stream **Armin Lorenz** *University of Duisburg-Essen, Germany*	The temporal coherence of lake phytoplankton community composition across a regional set of lakes **Bingqin Xu *** *The University of Auckland, New Zealand*	Updating the ANZECC water quality guidelines for copper and zinc **Chris Hickey** *NIWA, New Zealand*	Using fluorimetry to better assess the effects of suspended sediment on phytoplankton: an agricultural bayou case study **Richard Lizotte** *United States Department of Agriculture, USA*
11:45am – 12:00pm	Habitat assessment in an irrigation system conjoint with a spring-fed stream **Shinji Fukuda** *Tokyo University of Agriculture and Technology, Japan*	Spatio-temporal analysis of geomorphological changes in the Nadi coastal and delta areas **Preetika Singh *** *University of New England, Australia*	Riparian shading as a tool to manage nuisance instream plants: testing the concept in Hawkes Bay and Waikato streams and rivers **Fleur Matheson** *NIWA, New Zealand*	Investigation of drainage impacts on wetland hydrology, and restoration planning **James Blyth** *Jacobs New Zealand Limited, New Zealand*	Isotopes in nitrate and organisms can target opportunities for improved agricultural management to reduce eutrophication. **Troy Baisden** *GNS Science, New Zealand*	
12:00 – 1:30pm	LUNCH			12:30 – 1:30pm "Draft NEMS Water Quality – drop-in discussion" Brookly 2 Room		
Session	**Special Session: Balancing Environmental Flow Objectives** **Chair: Paul Franklin**	**Aquatic Ecosystem Restoration** **Chair: Jürgen Geist**	**Threatened Species and Ecosystems** **Chair: James Shelley**	**Contaminants** **Chair: Brenda Baillie**	**Environmental relationships** **Chair: Gerry Closs**	
1:30pm - 1:45pm	Developing tiered environmental flow targets using a functional flows approach for California streams **Rob Lusardi** *University of California, USA*	Aquatic ecosystem restoration: priority setting and indicators of success **Jürgen Geist** *Technical University of Munich, Germany*	Sitting on the fence: testing the stock exclusion paradigm on a threatened high country galaxiid **Jarred Arthur** *Environment Canterbury, New Zealand*	Mechanism elucidation and performance evaluation of Pb(II) and Cd(II) removal by low-cost *Citrullus lanatus* rind in batch and continuous systems **Qian Wang** *The Hong Kong Polytechnic University, Hong Kong*	Does size matter? The ecological consequences of decreased body size with temperature rise **Emma Moffett *** *The University of Auckland, New Zealand*	

Location	Heaphy 1	Heaphy 2	Heaphy 3	Brooklyn 1	Brooklyn 2	Brooklyn 3
1:45pm - 2:00pm	When to "piggyback" an environmental water release: balancing flood risks and environmental outcomes **Mike Stewardson** *The University of Melbourne, Australia*	Dispersal and fate of augmented gravel in a boulder-bed channel: early implications for restoring salmonid habitat **David Gilvear** *Plymouth University, United Kingdom*	Ecosystem productivity dynamics in a rare chain of ponds system: Mulwaree Ponds, Southern Highlands, New South Wales, Australia **Lorraine Hardwick** *Macquarie University, Australia*	Emerging organic contaminants in a predominantly rural aquatic environment – what do we know and should we be worried? **Michael Stewart** *Streamlined Environmental, New Zealand*	Anthropogenic effects on ecological networks: Understanding how acid mine drainage impacts freshwater food webs **Justin Pomeranz *** *University of Canterbury, New Zealand*	
2:00pm - 2:15pm	Adaptive management of environmental water through Australia's Long-Term Intervention Monitoring project **Angus Webb** *University of Melbourne, Australia*	Is riparian vegetation helpful in better management of the riverine corridor? Some tricks to take advantage of a cheap and natural fluvial component **Andrew Neverman *** *Massey University, New Zealand*	Assessing Canterbury mudfish (*Neochanna burrowsius*) translocation viability using a graphical metapopulation model **Simon Coats *** *University of Canterbury, New Zealand*	Use of pesticides and fertilisers in New Zealand's planted forests – implications for water quality **Brenda Baillie** *Scion Research, New Zealand*	Influence of species, hydrological disturbance, and habitat size on the trophic position - body mass relationship of freshwater fishes **Kevin Fraley *** *University of Canterbury, New Zealand*	
2:15pm - 2:30pm	Mapping environmental flow objectives to spatial and temporal scales of response **Rick Stoffels** *CSIRO Land and Water, Australia*	Multidimensional evaluation of freshwater restoration efficacy in coastal wetlands: conceptual model from molecules to functional groups of the macrobenthos **Xiaoxiao Li *** *Beijing Normal University, China*	Is the Kimberley in remote north-western Australia a cradle of freshwater fish biodiversity or a museum? **James Shelley** *NIWA, New Zealand*	Accelerating uptake of constructed wetlands and riparian buffers by quantifying contaminant attenuation performance: a proposed national investigation **Aslan Wright-stow** *DairyNZ, New Zealand*	The breeding of a passerine bird, the white-throated dipper *Cinclus cinclus*, and the potential influence of Atlantic salmon *Salmo salar* and brown trout *Salmo trutta* **Svein Jakob Saltveit** *University of Oslo, Norway*	
2:30pm - 3:00pm	Afternoon Tea					
3:00pm - 3:45pm	Keynote Speaker – **Julian Olden** *New vision, new life, new hope, for dammed rivers* Chair – Angus McIntosh Location: Heaphy 1&2					
3:45pm - 4:15pm	Conference Close Location: Heaphy 1&2					
From 6:30pm	**Conference Dinner, Hamilton Gardens** Buses depart the Novotel Tainui Hotel at 5:30pm / 5:45pm / 6:00pm Pre-Dinner drinks begin at 6:30pm and guests are to be seated at 7:00pm					

POSTER LIST

Barclay	Alex	University of Canterbury	
Title: Macroinvertebrate community composition in South Island alpine ponds – what's up there?			**Poster Board #: 1**
Benavente	Javiera	University of Auckland	
Title: Origin and genetic structure of introduced Rainbow Trout *Oncorhynchus mykiss* (Salmoniformes: Salmonidae) in Chile			**Poster Board #: 2**
Brown	Bob	Landcare Research	
Title: Comparison of host fish suitability for larvae (glochidia) of the native fresh-water mussel, *Echyridella menziesii*			**Poster Board #: 3**
Colin	Nicole	Center for Research on Biodiversity and Sustainable Environments (CIBAS)	
Title: Trends in biomarkers and bioindicators reveal contrasting long-term effects of pollution on native fish populations in a Mediterranean river			**Poster Board #: 4**
Collins	Katie	University of Canterbury	
Title: Persistence and ecological consequences of glyphosate to control aquatic macrophytes in Canterbury lowland streams			**Poster Board #: 5**
Cooper	James	The University of Waikato	
Title: Effects of emergent structure on recruitment of Hydrobiosidae (Trichoptera) in spring-fed streams.			**Poster Board #: 6**
Croker	Glenys	NIWA	
Title: Do introduced mitigation practices enhance water quality and macroinverte-brate communities in five studied dairy catchment streams?			**Poster Board #: 7**
Demchick	Emily	EOS Ecology	
Title: Walnut Creek CSI: How to assess the composition/impacts of a chemical spill.			**Poster Board #: 8**
Fierro	Pablo	Universidad de Concepcion	
Title: Development of a benthic macroinvertebrate multimetric index (MMI) for streams in Mediterranean Chile			**Poster Board #: 9**
Greenwood	Michelle	NIWA	
Title: What lies beneath? Groundwater biodiversity is more than a curiosity			**Poster Board #: 10**
Gregersen	Rose	The University of Auckland	
Title: A paleolimnological meta-analysis to assess the effects of agriculture on lakes ecosystems			**Poster Board #: 11**
Itsukushima	Rei	Kyushu University	
Title: Relation between molluscan fauna and river course characteristics in river estuaries to establish river improvement technology for environmental consideration			**Poster Board #: 12**

James Trevor Tasman District Council

Title: Managing faecal contamination to improve 'Swimmability' in Tukurua Stream, Golden Bay **Poster Board #: 13**

Juvigny-Khenafou Noel Xi'an Jiaotong-Liverpool University

Title: Integrate multiple stressors analysis into water system restoration and management strategies: a conceptual framework **Poster Board #: 14**

Kilroy Cathy NIWA

Title: Comparing space-for-time with time-deep approaches for predicting peak chlorophyll a in rivers **Poster Board #: 15**

Lakhanpal Garima The University of Melbourne

Title: How bioturbation activity by macroinvertebrates affect the physical structure of sub surface sediments in river systems **Poster Board #: 16**

Lee Finnbar University of Auckland

Title: The influence of local and regional mechanisms shaping metacommunities in dendritic networks: a meta-analysis **Poster Board #: 17**

Mcclintock Georgia University of Canterbury

Title: A different kettle of fish: early life history variations in whitebait species **Poster Board #: 18**

Mcewan Amber Riverscapes Freshwater Ecology Ltd

Title: Exotic fish eradication in a large, deep, stratified reservoir above an urban area – is it feasible? **Poster Board #: 19**

Mcintosh Leah University of New England

Title: Fish community response to the fragmentation of river networks **Poster Board #: 20**

Moore Tom The University of Waikato

Title: Interactions between freshwater mussels and non-indigenous species in New Zealand. **Poster Board #: 21**

Murchie Ani Te Kūwaha, NIWA

Title: Social-cultural and ecological indicators within freshwater-receiving environments **Poster Board #: 22**

Neverman Andrew Massey University

Title: A standardised approach to quantifying amour layer compaction using a penetrometer **Poster Board #: 23**

Özkundakci Deniz Waikato Regional Council

Title: Response thresholds for macroinvertebrates communities to land-use stressors at the regional scale - Implications for resource management **Poster Board #: 24**

Parmar	Kiran	University of Auckland

Title: Stream geometry and meta-community theory: what is the influence of stream network structure on the composition of benthic invertebrate communities within urban and agricultural systems? **Poster Board #: 25**

Richard	Gigi	Colorado Mesa University

Title: Invasive riparian vegetation removal and channel mobility on the Colorado River **Poster Board #: 26**

Shi	Fang	Institute of Hydroecolgy

Title: Studies on food web structure and trophic dynamics of Three Gorges Reservoir **Poster Board #: 27**

Thompson	Karen	NIWA

Title: Why use fish, when you can use a dish? In vitro larvae transformation of native freshwater mussel *Echyridella menziesii* **Poster Board #: 28**

Valois	Amanda	NIWA

Title: Smartphones as a "key" to freshwater biomonitoring: the SHMAK identifica-tion app **Poster Board #: 29**

Wang	Qian	The Hong Kong Polytechnic University

Title: Biosorption of Pb(II) and Cd(II) in aqueous solution by *Mangifera indica* seed: equilibrium, kinetics and mechanism **Poster Board #: 30**

ORAL ABSTRACTS

(In order of **presenters last name**)

Using LiDAR to suggest an integrative environmental flow in a Swedish river

Ana Adeva Bustos[1], Knut Alfredsen[1], Richard Hedger[2], Morten Stickler[3]
[1]NTNU (Norwegian University of Science and Technology), Trondheim, Norway, [2]NINA, Trondheim, Norway, [3]Statkraft, Oslo, Norway

Designing optimal environmental flows in Swedish regulated rivers is a challenge that needs to be addressed. The effects produced by river regulation in the ecosystem have been broadly studied. Consequently, their ecosystem services are also affected. Energy production plays an important role in Swedish rivers. However, this production has started to be affected by the application of Environmental Law measures. The present case study shows the suggestion for an optimal environmental flow in Ljungan, a regulated salmon river in Sweden. Ljungan is defined as having a poor ecological status under the Water Framework Directive (WFD). It is regulated by 14 power plants where the lowest one (Viforsen) marks the end of the anadromous part, 19 Km inland. Aiming to reach a Good Ecological Status for the WFD Ljungan River brings the challenge to implement adequate management. The present case study shows the process carried out to suggest an optimal environmental flow. The methodology applied was the "integrative method" developed previously in Mandalselva that combines three main components of assessment: the hydrological, the hydraulic, and the biological. An innovative technique was included; the inputs for the hydraulic modelling are a combination of LiDAR and Acoustic Doppler Profiler data. The outputs are used for the biological model (IB-salmon) where different scenarios are carried out to identify the bottleneck for the Baltic salmon production. In addition, power production under different scenarios is considered in order to find the most cost-effective situation. Preliminary results shows that discharge under 30 m^3/s is critical for the spawning grounds and the effects on the total smolt production will be determined. Stakeholders' opinions are considered during the process and the final results will be a combination of an adaptive management where an optimal environmental flow in terms of users' interests will be suggested.

Lake Waahi hauanga kai co-science project

Mathew Allan[1], Norman Hill[2]
[1]The University of Waikato, New Zealand, [2]Boffa Miskell, Hamilton, New Zealand

The Lake Waahi hauanga kai collaborative modelling project aims to recognise and develop synergies between quantitative and qualitative methodologies to assess water quality including both traditional science (numerical modelling and remote sensing) and Maatauranga Maaori. We hope the tools are used to support shared learning and decisionmaking in order to envisage future scenarios in response to different management options and environmental pressures. Lake Waahi is a relatively shallow super-eutrophic lake with high turbidity and high algal biomass since the macrophyte collapse in the late 1970s. "Waikato-Tainui aspires to have waters that are drinkable, swimmable, and fishable with the water quality at least at the level it was when Kiingi Taawhiao composed his maimai aroha" (*Tai tumu tai pari tai ao*, 2013). Keeping this in mind, we present potential "lake futures" in an intuitive, easily interpretable visually based style that we hope can be meaningful to iwi/hapuu groups and the general public.

Sitting on the fence: testing the stock exclusion paradigm on a threatened high country galaxiid

Jarred Arthur[1], Duncan Gray[1], Michael Greer[2]
[1]*Environment Canterbury, Christchurch, New Zealand,* [2]*Greater Wellington Regional Council, Wellington, New Zealand*

Land use intensification places pressure on the viability of many freshwater fish populations. It is assumed that stock damage in and around the margins of streams is one key driver affecting aquatic habitat decline, particularly in stable spring-fed streams. Fencing and stock exclusion have been suggested as a mitigation panacea to this issue. However, with the occurrence of invasive macrophytes, and restriction of some fauna to small and potentially sub-optimal habitats by exotic piscivorous fish, we ask: "is this blanket approach to stream management appropriate?" The bignose galaxiid (*Galaxias macronasus*) is endemic to the Mackenzie Basin and classified as 'nationally vulnerable'. Little is known about its distribution, life history, or behaviour other than its propensity to inhabit small spring-fed streams. Initially, we undertook extensive habitat-specific fishing surveys to investigate the broad scale distribution of the species. We found many new sites and expanded the known range. Within an extensive population we trialled fish capturing techniques and individually tagged fish in order to estimate population size. We also observed the tendency for fish to occur in greater abundances in clear, macrophyte-free reaches of streams. As part of a long-term study, seven springs have been newly fenced and we are monitoring the responses of aquatic habitat and fish over time.

Effects of different-sized sediment deposition on the riparian forestation

Takashi Asaeda[1], Bhagya Madusankha[1], Harun Rashid[2]
[1]*Saitama University, Saitama, Japan,* [2]*Bangradesh Agricultural University, Mymensingh, Bangladesh*

Vegetation encroachment in riparian zones has been reported in many rivers lately. Vegetation coverage differs greatly between fine and coarse sediment reaches. It is highly affected by the sediment deposition. Gravel deposition at floods removes existing vegetation and discourages plant colonisation by creating low moisture and nutrient conditions. Deposited fine sediments, on the other hand, contain high moisture and nutrients which promote the growth of herbs and trees. The analyses of aerial photos provided that, at deposited areas, the recolonisation of herbs was delayed three years and one year, and that of trees was delayed seven years and two years for gravelly channel and sandy sediment river reaches, respectively. The dynamic riparian vegetation model (DRIPVEM) is used to obtain the general trend of vegetation colonisation delay depending on the sediment nature of river channels. The observed results of the age-specific tree numbers and herb biomass distribution are reproduced fairly well by the model. The vegetation coverage, as the functions of the fraction of deposition area at floods and the grain size, was obtained by a long-run simulation. The fine sediment channels are highly covered by vegetation regardless of the deposition area fraction. However, in larger grain size reaches, the vegetation coverage decreases more distinctively with the increasing deposition area fraction. In gravel channel reaches, the deposition area fraction depends on the sediment inflow rate and the existing amount of sediment in the channel. Hence it is said that the reduction of sediments by sediment mining and the termination of inflow by dams increased vegetation coverage in the original gravel channels. While, in fine sediment channels, the enhanced fine sediment and nutrient inflows, which spread during floods, enhanced vegetation in the riparian area.

Genetic and ecological population structuring among and between landlocked and diadromous populations of a facultatively amphidromous fish

Jason Augspurger[1], Matthew Jarvis[1], Travis Ingram[1], Graham Wallis[1], Gerry Closs[1]
[1]*University of Otago, Dunedin, New Zealand*

Factors influencing dispersal of larval amphidromous fish have long been a mystery and the subject of debate. While long-distance offshore larval dispersal undoubtedly occurs, recent studies suggest larvae often resist widespread dispersal. However, factors determining when and why larvae retain are relatively unknown. Here we employ a hierarchical approach using genetic and otolith trace-element analyses in landlocked and diadromous populations of an amphidromous fish (*Galaxias brevipinnis*) to investigate population dynamics. We hypothesise short timescale otolith results will show distinct catchment level meta-populations within lake and coast. These patterns will not persist on longer timescales as genetic results will show relatively panmictic populations within lake and coast. But, landlocked populations will show relatively high levels of divergence when compared to coastal populations. Our results suggest local retention is the dominant process but forms a leaky mechanism which may not result in genetic divergence of nearby populations in both diadromous and landlocked populations of *G. brevipinnis*. However, while within-system populations remain connected, landlocked and diadromous populations are disconnected and genetically diverging even when in close proximity with no barrier preventing exchange. Thus, landlocked populations may represent evolutionarily significant units and require management separate from diadromous populations.

Use of pesticides and fertilisers in New Zealand's planted forests – implications for water quality

Daniel Neary[2], Carol Rolando[1], **Brenda Baillie**[1]
[1]*Scion, Rotorua, New Zealand,* [2]*USDA Forest Service, Flagstaff, United States*

Currently, the standard use of agrichemicals and fertilisers in New Zealand's planted forests focuses on the early part of an approximately 28-year rotation, primarily to ensure the successful establishment and early growth of planted tree seedlings, primarily *Pinus radiata*. Beyond this initial establishment period, agrichemical use changes from herbicides to a focus on insecticides or fungicides used for the control and treatment of pests and diseases that have the potential to harm the economic viability of the tree crop. Fertiliser use, at the mid-rotation stage of the forest rotation has, to date, been minimal. As the expansion of planted forests on to new land has become increasing cost prohibitive, research efforts are looking at potential opportunities to increase the productivity and profitability of the existing planted forest estate. However, any intensification will need to be within the sustainable limits of New Zealand's freshwater sources and regulatory requirements. Research to date on the effects of agrichemicals and fertiliser use on water quality identified the day of application and rainfall events in the immediate post-application period as the time frames when highest concentrations were measured in stream water. We assess these results against water quality and ecological benchmarks and discuss identified research gaps.

Isotopes in nitrate and organisms can target opportunities for improved agricultural management to reduce eutrophication

Troy Baisden[1]
[1]*National Isotope Centre – GNS Science, Lower Hutt, New Zealand*

Reducing inflows of nitrate to aquatic ecosystems remains widely considered to require reductions in agricultural productivity, yet nitrate leaching occurs mainly as a result of insufficient plant and microbial demand to retain soil nitrogen. Thus, improved management should be able keep nitrogen on farms and enhance productivity, while mitigating hot spots and hot moments of nitrate leaching. An indicator framework has now been developed that allows high concentration breakthroughs of nitrate linked to urine, urea, other fertilisers, or effluent to be identified and targeted for improved management. The indicator framework utilises nitrogen and oxygen isotopes in nitrate, as well as nitrate concentrations, to define a "signature" for sources associated with unwanted "breakthrough" sources. The breakthrough source signatures can be distinguished relative to a frequently observed pattern of "normal nitrogen retention". The framework can be applied to both surface water and groundwater, and can potentially avert the need to understand groundwater flow and processes. Progress with this tool also suggests that 2–5% shifts in nitrogen isotopes, algal particulate matter, periphyton, macrophytes or wider food webs can directly link aquatic impacts to manageable sources of excess nitrogen. The next steps in identifying management opportunities to reduce nitrate loads now requires application of these techniques in small streams, estuaries, or lakes, where inflows from groundwater and other sources require identification.

Downstream migrant eel movements in the lower Waikato River and passage past Huntly Power Station

Cindy Baker[1], Brenda Bartels[1], Joshua Smith[1]
[1]*NIWA, Hamilton, New Zealand*

In the Waikato River, longfin *(Anguilla dieffenbachii)* and shortfin *(Anguilla australis)* eels are two of the most common native fish species and form important traditional and commercial fisheries. As both species are catadromous, the Waikato River represents an important migration corridor for sexually mature eels to reach their marine breeding grounds. As downstream migrant eels must pass the Huntly Thermal Power Station (HPS) en route to the sea, the intake and outfall infrastructure could affect the survival and therefore breeding success of these fish. As such, Genesis Energy commissioned a telemetry study to examine the migration patterns of downstream migrant eels in the Waikato River and the proportion of the population whose movements were influenced by the HPS. In 2009, 81 longfin and shortfin eels were tagged with acoustic and Passive Integrated Transponder (PIT) tags, and 798 were tagged solely with PIT tags. Following tagging, the eels were released at six sites upstream of the HPS. Examination of movements past the HPS suggested that the majority of eels followed the deep river channel and the HPS Iowa Vanes and outfall had little influence on their migration. Results suggested that around 3% of the migrant eels passing the HPS may impinge upon the intake screens. To ensure maximum survival rates of impinged fish, in 2010/11 Genesis Energy upgraded the fish collection and return system on the intake screens to safely return eels and other biota back to the Waikato River. Subsequently, survival rates >99% for shortfin and longfin eels have been recorded, which are in line with international best practice. Overall, the results of this study expands our understanding of the downstream migration patterns of eels in the Waikato River and confirms that the HPS has a negligible effect on downstream eel passage.

Evaluating Greater Wellington Regional Council's Natural Resources Plan

Lucy Baker[1], **Lian Butcher**[1]
[1]*Greater Wellington Regional Council, Wellington, New Zealand*

Evaluating natural resources plans is not only a legislative requirement but also provides an opportunity for councils to show that their activities are meeting the outcomes desired by communities and iwi. Greater Wellington Regional Council is using a collaborative process to produce a community-driven plan effectiveness programme. We aim to include environmental science, narratives, social science, economics, citizen science, cultural monitoring and mātauranga Māori in our measures. As part of this process, we are prioritising what we evaluate. One of the challenges we and other Councils face is to develop meaningful measures of whether our activities have efficiently achieved their intended purpose – not only have we done what we said we'd do, but have these activities led to the desired outcomes? Our collaborators include a range of internal departments and groups, iwi partners and external organisations. We have gained a huge diversity of ideas and viewpoints on what meaningful plan evaluation should look like, and learnt a lot about others through the process. Taking a collaborative approach means taking time early on in the process to develop relationships and listen to other viewpoints, but we believe that it ultimately provides many wide-ranging benefits and more sustainable solutions in the long term.

Instream nitrogen cycling and loss from headwaters to Great Lakes in the Fox River Basin, Wisconsin, USA

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Land-use patterns and in-river processes affect nutrient concentrations and delivery to the Great Lakes. Land-use patterns reflect loading rates of phosphorus and nitrogen from rivers to the Great Lakes. Patterns in nutrient loading have been linked to hypoxic zone development and harmful algal blooms and have become a recurring feature of near-shore areas adjacent to tributary inputs in many of the Great Lakes. While loading rates are reasonably well documented, land-use patterns and in-river conditions that create biogeochemical hot spots for nitrogen processing and loss are less well understood. We evaluated nitrogen loss through measures of in-channel ambient and potential denitrification rates at 110 sites distributed throughout the Fox River basin (16,400-km^2 watershed) in 2016. We will relate sediment and water-column characteristics (e.g., elemental compositions) along with prominent land-use features to discern patterns in nitrogen loss rates (i.e., denitrification) within the Fox River System.

Flow-vegetation interactions at the patch scale

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Aquatic plants occur in most river systems around the world and tend to reach their greatest abundance in nutrient-rich, lowland rivers with morphologically stable channels. Determining the size of aquatic plants and how they interact with flow is critical to understand their effects on river ecosystems and habitat. To address this knowledge gap 1,099 *Ranunculus penicillatus* patches were surveyed in the River Urie (North East Scotland), with distributions of parameters such as planform area, length and aspect ratio being evaluated. This survey revealed that natural *R. penicillatus* patches at the end of summer have mean planform area of 1.32 m^2, mean length of 2.95 m, mean aspect ratio of 5.63, over 1,000 m of total stem length and over 15,000 leaves. These average natural patches are 2-3 orders of magnitude larger than laboratory replicas by biomass, with this new data enabling improved scaling of future laboratory experiments to more accurately represent field conditions. Field studies at the plant scale were also undertaken to better understand flow interactions with single patches of the macrophyte *R. penicillatus* and the bryophyte *Fontinalis antipyretica*. These studies comprised high-resolution measurements of fluid velocities, which were performed using stereoscopic particle image velocimetry (PIV) and acoustic Doppler velocimetry (ADV) systems. Both plant species caused substantial changes to mean velocities and turbulence in their wake, with the bryophyte causing a redistribution of energy to higher frequency turbulence above the canopy. Flow fields downstream of the plants showed high spatial and temporal heterogeneity and the log-law was not found to apply. This illustrates the complexity of flow interactions with aquatic vegetation and shows that estimating discharge in vegetation patch mosaics from point velocity measurements at 0.6 of depth would yield highly inaccurate discharge estimates. In these cases, regularly spaced point measurements throughout the water column are recommended.

Characteristics of the very rare Whakatāne flood of 6 April 2017 and implications for design

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On 6 April 2017 the Whakatāne River experienced a flood well beyond the size of those in recorded history. At the Valley Road gauge, the peak flood level was 0.63m higher than the 1% Annual Exceedance Probabiity – AEP -- (1-in-100 year) flood of 2004. The peak flood flow upstream was even greater, as three stopbanks built to the 100-year standard with 500mm freeboard were significantly overtopped. A key contributor to the extraordinary flood flows was an intense band of rain at the tail of the storm producing almost the "perfect flood". This is yet another in a series of large floods relating to the negative phase of the Interdecadal Pacific Oscillation. Conversely for the 25-year period preceding 1998, no floods exceeded 20% AEP (1-in-5 year). The probability of that non-occurrence is remote at 0.8^{25}. This paper describes the challenges in estimating the flood size and corroborating that size; and secondly, reassessing frequency distributions. A further feature of this flood was the performance of the "spit-fuse" alongside the Whakatāne Western Training Wall. This operated far better than in the 2004 flood, but still provides a challenge. The final point traversed is the detailed project investigating means of mitigating climate change for the Whakatāne and other major rivers in the Bay of Plenty.

Transportation of spawners is more effective than multiple fish passage facilities in the river Klaralven, Sweden

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Salmon populations in Lake Vanern represent some of the last remaining large-bodied, landlocked salmon stocks worldwide. The historical large catch levels declined considerably by the late 1800s, and even more during the 1900s. However, through focused actions based on the upstream transport of adult spawners ('trap-and-transport'), returns of wild salmon to the river Klaralven have rebounded during the last 20 years. The regional Authority recently undertook a project with the goal to guarantee free migration routes for the salmon all the way from Lake Vanern to the upper Norwegian part of the river. The project encouraged measures to reduce migration delay and mortality using approaches such as increasing spill, construction of multiple fish passage facilities at each dam and, in extreme cases, dam breaching. If the project should be realised, it is likely that it will be at great expense to both biodiversity and sustainable energy production. According to best available technology for Atlantic salmon migration in run-of-river hydropower systems, it is still not possible to construct fishways that are efficient enough to pass fish both upstream and downstream of eight to eleven hydropower plants (in the main stem, additional dams in tributaries) in numbers that will sustain the population growth seen during the last decades in the river. The cumulative losses and delays for salmon passing this many hydropower plants will result in such great losses of spawners not reaching their spawning areas, that it will jeopardise the wild salmon population. Thus, based on current ecological and technical knowledge, a change from today's trap-and-transport operations to migration through the present state-of-the-art fish passages in this specific case can be seen as a high-risk gamble that threatens the future existence of the remaining Klaralven salmon population.

Weir removal made easy

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Fish passage into around twenty kilometres of stream habitat was recently restored for the first time in three decades with the removal of an old NIWA gauging weir on Great Barrier Island. The weir was removed as permitted activity. Along with the rigorous rules governing working in and around water that PA rules bring, the bipartisan group grappled with remoteness and uncertainty. So how did we do? Report card reads: "got the job done, but could do better".

Investigation of drainage impacts on wetland hydrology and restoration planning

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A new hydrological restoration initiative across three significant wetlands is being undertaken as part of the New Zealand Department of Conservation's Freshwater Stretch Goal: 50 freshwater ecosystems are restored from mountains to the sea. The focus sites are Kaimaumau-Motutangi (Northland), Moawhitu (D'Urville Island) and Awarua (Southland), all of which have been extensively impacted by drainage schemes. The initial phase of the project involves eco-hydrological research to quantify the impacts of drainage on wetland ecosystem functioning, and then to develop permanent restoration options through modelling. Wetland hydrological monitoring installations were recently completed at all sites, with pressure transducers arranged in transects perpendicular to drains to determine changes in water level gradients. These transects were coupled with a number of inlet and outlet transducers that provide options for future flow gauging and characterisation of wetland inflows and outflows. In total 32 pressure and three barometric transducers were deployed in the wetlands. Preliminary results from the hydrological network will detail how water levels vary at short (daily) and longer-term (monthly) time intervals, with corresponding effects on the natural functioning of the gumland (Kaimaumau), swamp (Moawhitu) and bog (Awarua) systems. We will also present an overview of potential hydrological restoration options that include drainage plugs, low-water level controls (weirs) and drain diversions. Progressing wetland restoration requires increased research on the impacts of historical drains and this study will help to determine the scale of drainage impacts in different wetland systems across New Zealand.

Confluence configuration controls spatial patterns in fish assemblages

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Habitat complexity can result in higher fish diversity and abundance at the reach scale. However, the importance of large-scale variability in environmental complexity and riverscape configuration is not well understood, especially in the context of invaded riverscapes. Using twelve replicate mainstem and tributary combinations, creating a gradient of riverscape complexity in flow and temperature characteristics in Canterbury, New Zealand, we evaluated how the juxtaposition of stream tributaries with similar (e.g., stable –> stable) versus different (e.g., stable-> disturbed) characteristics influenced spatial patterns in fish diversity and abundance. Spatially explicit hierarchical models incorporating: confluences, flow direction, stream size, and both reach- and network-scale physical attributes revealed that fish population responses were both species- and size-specific, and likely driven at least partially by negative competitive and predatory interactions between non-native trout and galaxiids. For example, trout abundances increased with proximity to stable (i.e, low bed instability and temperature variability) reaches, whereas galaxiid abundance decreased with proximity to stable reaches. Trout abundances remained high in stable streams regardless of confluence configuration, while galaxiid abundances were higher in disturbed branches of stable-disturbed confluences than in confluences between two disturbed streams. This suggests trout were selecting habitat based on preference for stable locations, whereas galaxiid abundance was more likely a reflection of a resource-predation trade-off. Thus confluences with different stream characteristics spatially juxtaposed could create opportunities for both galaxiids and trout to occupy the same riverscape. As a result, complex riverscapes may support higher fish diversity and abundance by facilitating coexistence between galaxiids and trout. Therefore the amount and configuration of flow and temperature complexity within riverscapes is likely an important contributor to both local and large-scale spatial patterns in fish diversity and abundance and should be considered in stream management, particularly when invaders are present.

Mapping water quantity allocation across New Zealand

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Water is abstracted from rivers and aquifers for agricultural, industrial, domestic and power generation purposes. These activities have the potential to drastically alter river flow regimes, thereby influencing both ecological and human values. River managers need to balance the economic and social benefits of abstraction against its potentially deleterious consequences for ecological functioning, ecosystem services, cultural values and recreation. Limit setting represents one planning mechanism to regulate this balance, and to clarify water availability to abstractors. Such legislative requirements are in place in several countries. In New Zealand, recent legislation states that limits for the use of water resources should be set for all water bodies to manage the potential cumulative impacts of abstraction and reduce allocation of water in over-allocated catchments. These limits must comprise at least a minimum flow (the flow at which all abstraction must cease) and a total allocation rate (the maximum rate of abstraction summed across all abstractions). Application and enforcement of such water-quantity limits is complicated by practical difficulties, temporal variability and spatial scaling issues. This presentation outlines such issues and presents a method for calculating allocation status within and between catchments using data on consumptive water consents. Total allocation for each catchment is expressed by calculating Weighted Allocation Impact (WAI); an index that integrates magnitude and spread of water resource allocation across an entire catchment. Maps of WAI across New Zealand show that existing consents to abstract water, which have legal protection, have resulted in over-allocation in several catchments.

The New Zealand Fish Passage Advisory Group – improved coordination and management of a key pressure facing our waterways

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Many of New Zealand's iconic freshwater fish species (e.g. whitebait and trout) are migratory, and require open access to and from the sea, and within waterways to complete their life-cycles. However, instream structures such as culverts, weirs, dams and tide gates, which are commonly found in streams and rivers, can obstruct fish movements if they are not well designed and maintained. These barriers can delay or prevent fish from reaching critical habitats, impacting and ultimately reducing the distribution and abundance of native and sports fish in New Zealand. The problem of instream barriers to fish migrations needs better coordinated management to ensure restoration and protection of our freshwater fish and fisheries into the future. To help promote and achieve this, DOC & NIWA agreed to work together and the New Zealand Fish Passage Advisory Group (NZFPAG) was formed. NZFPAG is a group of ecologists, engineers and environmental advisors representing various groups involved in fish passage management in New Zealand that are using the multi-disciplinary team to develop, communicate, promote, and advocate for improved technical guidance and policy to support fish passage and connectivity of our waterways. Key progress in improved coordination, better management, lessons learnt and future plans will be presented.

Refinement of fish-friendly criteria for hydropower and irrigation diversions

Lee Baumgartner[2], **Craig Boys**[1]
[1]*Charles Sturt University, Thurgoona, Australia*

Hydropower and irrigation weirs can disrupt downstream migrations of all species. It is important to ensure that passage through regulators or mini hydro systems is not harmful or fatal. Many new infrastructure projects (<6 m head) are proposed for freshwater systems worldwide, and it is important that designs incorporate the best-available science to protect downstream migrants. Most work on the effects of river development on fish has been based on North American salmonids at high head installations. Salmonid research as focused on both upstream and downstream effects. Many measures to mitigate environmental impacts have been subsequently developed. But there is mounting evidence to suggest that salmonid-focused techniques cannot be readily applied to other species which have different biological and physiological requirements. Furthermore, design criteria for high head dams may not be applicable at low head sites. Recent advances in technology have provided new techniques which could be applied to other freshwater species to obtain design criteria that can facilitate safe passage. Obtaining and applying this knowledge to new infrastructure projects is essential in order to produce outcomes that are more favourable to local ecosystems and fisheries.

Impacts of weirs on downstream passage of native fish in the Murray-Darling Basin

Lee Baumgartner[2], **Craig Boys**[1]
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Determining factors responsible for increases in the mortality of freshwater fish larvae is important for the conservation of recruitment processes and for the long-term sustainability of freshwater fish populations. There are an estimated 10,000 dams and weirs installed in the Murray-Darling Basin (MDB). Two major weir designs, undershot and overshot, are constructed on MDB waterways, both delivering water downstream in a different way. Overshot weirs deliver water in a water-fall effect, and undershot weirs release water from under a sluice gate. A controlled field study aimed to determine the impacts of both weir designs on downstream fish passage of common MDB fish species at a range of flows to determine fish welfare impacts. Passage through overshot weirs was associated with substantially greater survival in all species compared to undershot weirs. Few fish died, and the main welfare issues arose when water from overshot weirs fell into shallow water, causing fish to become physically injured when impacting the downstream weir apron. These results indicate that the construction of overshot weirs with deep plunge pools would provide safe conditions for many fish species and sizes moving downstream. In contrast, most Golden perch (*Maquaria ambigua*) and Silver perch (*Bidyanus bidyanus*) larvae, and more than half of Murray cod (*Maccullochella peelii*) larvae died during undershot weir passage, regardless of tailwater depth. Small-bodied native fish such as Australian smelt (*Retropinna semoni*) and Unspecked hardyhead (*Craterocephalus stercusmuscarum*) displayed extremely high mortality when passing through undershot weirs. Adult life stages of large-bodied species were also affected by undershot weirs but to a much lesser degree. Analysis determined that undershot weirs were characterised by higher values of shear, turbulence and pressure changes. The relatively large number of undershot weirs within the known distribution of these species could impact upon recruitment over a large scale.

Te Wai Koiora – stream restoration and cultural stream-health monitoring

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Ngaa Rauru Kiitahi, the southernmost iwi in Taranaki, have commenced working on a stream restoration and monitoring project within their rohe. The project, Te Wai Koiora, was funded by the Te Mana o Te Wai fund, and with support from Taranaki Regional Council for the application (and Horizons in the southern aspect) plus Department of Conservation support. Initially funded for two years, the project involves riparian fencing and planting along stream and river margins, with long-term monitoring of this planting using the Stream Health Monitoring and Assessment Kit (SHMAK). The Te Wai Koiora project has a waterway monitoring framework, which links to freshwater goals in the Ngaa Rauru Kiitahi's Puutaiao (Environmental) Management Plan. The outcomes sought through Te Wai Koiora traverse the environmental, social, cultural, and economic. As an iwi, Ngaa Rauru Kiitahi expects that improving the water quality will help restore their customary relationship and practices like gathering kai and rongoaa (medicinal species), and fishing. Their traditional role as kaitiaki will be enhanced through increasing their capacity to monitor the health of the awa, particularly during the annual hikoi down the Waitootara River. There are eco-tourism opportunities present in the Waitootara River valley, which will benefit from an enhanced environment, and habitat for native fish including tuna (eels) and whitebait will improve with the clearing of willows and riparian planting. Ngaa Rauru Kiitahi recognises that these waterways carry the spirit of their being – from the mountains to the sea. They are seen as their source of life to be cherished, respected and protected. Key outcomes of this project are relationship building and provision of scientifically robust and culturally meaningful data to Council, plus growing the kaitiaki role of Ngaa Rauru Kiitahi uri (people) and the council's understanding of and engagement with kaitiakitanga and Ngaa Raurutanga.

Just because I'm young, don't count me out

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There is strong evidence of a lack of science learning opportunities for school students in New Zealand, especially in the early years. In 2016, with the Mountains to Sea Conservation Trust, we developed Environment Investigators, a Whitebait Connection programme. Through programmes like this, young New Zealanders have opportunities to connect with their environment and increase their knowledge and understanding of key concepts and capabilities in the science field. This provides individual benefits and can be effective in influencing community behaviour change and even management practices. With a focus on inanga, over 1,000 young students aged 3-15 years in Christchurch became Environment Investigators. Through hands-on and authentic experiences and support from scientists, benefits were gained for the students, teachers, and the wider community. Young students expanded their understanding of their natural environment through a real-world connection and local context. They used their knowledge to share with others and took action within their communities, with benefits to all kids of all learning abilities, and insights of what it's like to be a scientist. Benefits to the science community include greater understanding and passion in the community about key science concepts that creates a greater drive for change - based on knowledge. It's amazing to see the impact a few kids can have on decision-making Councillors! There's a need for science and education to come together in more meaningful and open ways so that the younger people of New Zealand have a deeper understanding and connection with science and our environment. Breaking down the barriers between science in the textbooks and science in the field can seem challenging but is, in fact, extremely rewarding.

A new dawn is upon us: The use of emerging technologies in river science and management

Gary Brierley[1]
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Place-based knowledges underpin effective approaches to river science and management. Emerging technologies present remarkable capacity to 'know' each river system. But, how are we 'knowing'? Which scientific frameworks and approaches to classification do we choose to use? How integrative are these understandings (i.e. do they convey a conceptual model showing how a given river system 'works'? Who writes the algorithms for automated monitoring procedures? How are these understandings used alongside local knowledges to generate 'owned' approaches to management practice? As we move beyond inappropriate use of coarse-resolution, remotely-sensed data and overly-generalised understandings/framings, what lessons have we learnt that can support effective use of more precise (higher resolution), more recurrently derived, catchment-specific datasets? Putting aside concerns for data overload, for which we always seem to find answers one way or another, this presentation examines how we construct data-gathering procedures and associated approaches to learning in efforts to inform proactive river management in better ways. A future focus has always been important in management endeavours, but in the rapidly changing world of complexity, contingency, emergence and no-analogue states, where greater levels of uncertainty are inevitable, these deliberations have become even more significant, fashioning the ways we live with our rivers (increasingly, the choices that are available to us). We cannot control uncertainties – we have to learn to live with them. The perspective outlined in this talk will endeavour to speak for the river itself, in efforts to find, and live with, 'the voice of the river'.

Fish passage solutions: a bit of theory, give it a go, monitor, and learn from our mistakes

Logan Brown[1]
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Horizons Regional Council has been on a journey of undertaking survey work to discover fish passage barriers, and prioritising these barriers for remediation. Recently effort has moved into developing solutions and undertaking remediation work for those that were deemed to be highest priority. This has meant working closely with our river management team, external fish experts, structure owners, contractors, funding partners, and other stakeholders as we developed solutions to prevent the structure being an on-going barrier to fish passage. Throughout this journey it has been important to recommend fixes that have the strongest possibility of being successful. Therefore, the monitoring of selected fixes has been vital to help inform future actions and also to convince external funders that any dollars being spent are a wise investment. In this presentation I intend to cover off some of the work that Horizons Regional Council has undertaken to date, using examples to look at some of the successes we have had, some failures, and where to from here as the fish barrier programme within the council ramps up.

Ecology and the six values approach to managing Christchurch City's waterways

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In the 1990s the Christchurch City Council signalled a departure from its land drainage origins by adopting a multi-value approach to managing waterways. This new "six values" approach included consideration of ecology, landscape, recreation, culture, heritage, and drainage when managing waterways. The council's 2003 Waterways, Wetlands, and Drainage Guide introduced the philosophy of "working with, rather than against, nature", and the guide continues to be a core design text for council staff, contractors, and land developers. From an ecological perspective, design features in this guide extend from riparian planting, to the incorporation of instream habitat features, and fish passage considerations. The mid-to-late 2000s saw an increasing commitment to best-practice stormwater treatment for new developments and restoring ecological function when repairing ageing infrastructure. Despite this, city waterways are still affected by legacy issues, particularly the historic stormwater network that lacks any form of treatment, and fine sediment deposited in the predominantly spring-fed city rivers. The 2010 and 2011 Christchurch earthquakes further impacted city waterways, particularly through deposition of liquefaction-derived fine sediment. However, the earthquakes also precipitated major waterway repairs and the six-values approach has seen habitat enhancements along many kilometres of streams and drains. The public is now very aware of water quality issues, and the council has made considerable investment in improving water quality. Looking into the future, ongoing challenges include educating the public, engineers, and planners about the importance of other important ecosystem components, particularly improving riparian and instream habitat, and fish barrier identification and prioritisation for remedial works. However, the primary limiting factor to improving ecological value will always be the allocation of money within tight budgets.

Does riparian management influence greenhouse gas emissions from soils and streams?

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Agricultural practices are intensifying to provide for a growing human population, but this process degrades stream health and increases greenhouse gas (GHG) emissions. These two issues are not commonly considered together; most GHG work has been done on paddock soils and most stream research focuses on stream response to changes in the terrestrial environment, usually riparian zones. We merged these perspectives by examining how changes in riparian management influences GHG emissions and concentrations in soils and streams. We measured soil efflux and stream concentrations of three GHG's (CO_2, CH_4 and N_2O) in an array of streams that included riparian treatments in the Canterbury region, developed through the Canterbury Waterway Rehabilitation Experiment (CAREX) project. Riparian treatments included bank rebattering, *Carex* plantings, two-stage ditch installation, mature vegetation and fencing alone. Soil efflux was determined using chambers and the efflux of streams using headspace equilibrium. Gas concentrations were analysed using cavity down ring spectrophotometry. Soil samples were taken and a vegetation assessment conducted at each of the chamber locations to investigate environmental drivers of gas flux. Results show that gas emissions are mostly lower in riparian zones than paddocks; however, results are variable over the treatments. Both CO_2 and CH_4 emissions were correlated to soil temperature, ground cover and the number of plant species using a general linear model. Treatments with bank modification showed higher CH_4 emissions due to higher ground water tables. Soil N_2O flux was quite variable and poorly explained by environmental parameters, but N_2O concentration in streams rose with increasing nitrate concentration.

The influence of nutrient enrichment on riverine food webs: are the defences compromised?

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Nutrient enrichment in rivers has been rapidly increasing over the past few decades, primarily because of agricultural intensification. Despite it being well established that nutrient enrichment can cause excessive periphyton growth and changes in community composition, how the resulting emergent properties change is poorly understood. We used ecological network analysis (ENA) to examine the emergent properties of twelve riverine food webs across a nutrient enrichment gradient throughout the Manawatu, New Zealand. Nutrient enrichment drove communities to be composed of energy-inefficient species with high community (excluding microbes) respiration. Community respiration was several times greater in enriched communities and this may drive hypoxic conditions even without changes in microbial respiration. Enriched communities also had weaker trophic cascades, which may result in greater robustness to energy-flow loss, yet species that were flow-disturbance-sensitive species dominated more keystone positions, making the communities more vulnerable to floods.

Use of long-term data in river science: recent successes and future challenges and opportunities

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Rivers are diverse and dynamic systems that are subject to an array of influences, especially anthropogenic ones, over longer time-scales. Attempts to manage and mitigate these have been diverse, ranging from policy and regulation-of-use approaches to hydrologic and geomorphic restoration. Despite these diverse approaches, there are often relatively short time-horizons for producing results in order to maintain institutional and societal support. In the case of the Midwestern floodplain rivers of North America, more than 50 years of ecological degradation was caused by the succession of commercial resource extraction to floodplain isolation, combined with water pollution. However, the widespread negative results of these decisions spurred a subsequent period in which improvements in theory (e.g., the Flood Pulse Concept, tipping points and alternate stable states) as well as policy and management (e.g., the Clean Water Act, extensive physical restoration) led to measurable socio-ecological improvement such as increased biodiversity. Despite early years of success, the remaining challenges have become cumulative and complex, eluding simple stand-alone solutions. One example is the potentially generation(s)-long time lags in a population's response to pollutants like estrogenic and endocrine disrupters that suppress fish reproduction. In these cases, once society identifies and controls the stressor, we still have to wait for years to see the benefit. All river scientists know that without clear improvements after a mitigation action, it can be difficult to justify and sustain the policies and patience needed to understand and manage complex river systems. Long-term data sets, especially those whose period of record is at least as long as ecological time lags of the components they are measuring, can provide society with the evidence that we can effect positive change in river systems provided we know how long the change will need to take to be measurable.

Assessing habitat preference and in-stream distribution of New Zealand freshwater mussels using mark-recapture techniques

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Kākahi or the New Zealand freshwater mussel plays many pivotal roles in freshwater ecosystems as they possess high filtering abilities, can bioturbate sediments and further are culturally important taonga species to Maori. Little is known about the distribution and abundance of Kākahi within New Zealand streams as they are not routinely monitored by councils. Freshwater mussels are under threat within New Zealand with *Echyridella aucklandica* being currently recognised as "Nationally vulnerable" while *Echyridella menziesii* is "declining". This decline has been linked to multiple factors such as eutrophication, predation, habitat loss and sedimentation. Within New Zealand little research has been undertaken on investigating key factors influencing the presence and distribution of freshwater mussels in streams. Therefore, to understand the habitat preferences and distribution of freshwater mussels, Waikato Regional Council developed a mark-recapture study on the Ohautira Stream. This stream has been surveyed since 2013 where both populations of *E. aucklandica* and *E. menziesii* are present in large numbers. Results of the study indicate that there is preference towards certain types of habitat, such as bank foot areas that are dominated by silt substratum and areas within a stream with a constant flow, such as run habitat. In-stream distribution of Kākahi and mark-recapture rates will be analysed post monitoring of this year's survey. Results of this ongoing study can help to gain a better understanding of freshwater mussel habitat requirements and how freshwater mussel monitoring can influence management of the fishery.

The evolution of river-width design for gravel-bed rivers in New Zealand.

Kyle Christensen[1]
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Determining the design width for a river channel has been one of the fundamental questions that has challenged river engineers in New Zealand throughout the past century. One of the most prevalent theories was based on the work of Gerald Lacey and a regime width that could be calculated through Lacey's (1929) equation: $B = 4.84Qd^{0.5}$, where B = channel width; and Qd = dominant discharge. This equation was specifically recommended for use in New Zealand in the influential work of Grant (1948) and Nevins (1969). The major limitation of the use of this equation was the fact that it was an empirically based equation which was derived from low-gradient, silt-phase, irrigation canals constructed in cohesive sediment. It is difficult to imagine any river system that could be more different from the steep, braided, gravel-bed rivers that the New Zealand engineers of the time were trying to "train" into this regime width. Notwithstanding the above, there was wide application of this equation with varying degrees of success in rivers across the country. In the 1980s there was further consideration of regime equations developed from gravel-bed rivers in Canada, USA, UK and Russia which produced widths with a factor of four between the minimum and maximum widths calculated. The concept of a stability index, specific for a particular river was also introduced by Griffiths in 1982 but never gained widespread acceptance or use. The widths that we currently manage our rivers to is partly a legacy of the application of empirical equations over the past 75 years as well as the current expectations and affordability of different river-bank maintenance options. Understanding the legacy of this historical development is important for informing the current debate on the width we should design and manage our rivers to.

Critical water quality assessment in Lamtaklong River, Thailand

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This research aims to evaluate the present and future water quality in Lamtaklong River, influenced by the fifth largest municipality in Thailand, using a Water Assessment Simulating Program (WASP) with river specific input parameters. The river is used as the source of raw water supply for communities, agricultural irrigation, and in industries. Year-round water quality data clearly classified the river into two sections, upstream and downstream. The upstream locations and downstream locations indicated serious deterioration, dissolved oxygen (DO) approached 0 mg/L and biochemical oxygen demand (BOD_5) was more than 4 mg/L, especially during the low-flow season, and ammonia nitrogen (NH_3-N) exceeded 0.5 mg/L. The critical sections were within the municipality and further downstream. The in-situ sediment oxygen demand (SOD) was determined monthly at 14 locations, representing the hydrological segments, along the river over one year. The data provides the first insight into the spatial and temporal representation of such data in Thailand. Monthly SOD ranged from 0.09 to 12.23 $g/m^2/d$. Point sources and non-point sources as the inputs were identified from the geographic information system (GIS) database within a 1 km buffer zone from the river. With the local inputs in the WASP model, the simulated results showed an improved prediction of DO concentrations with the lower value of the root mean square error (RMSE) and relative error (RE), 0.81 and 35.0%, respectively. Scenarios were simulated and showed very critical results. Business-as-usual will further degrade the water quality during the low-flow season. The simulations also showed that a loading reduction as high as 50-80% was not sufficient, at some downstream locations, to satisfy the legal limit of DO and BOD_5, 2 mg/L and 4 mg/L, respectively. More local inputs were required for a better NH_3-N prediction. All stakeholders must understand the urgent need to restore the river now.

Spatial variability of invertebrate drift in coarse-bed streams: hydraulic and morphodynamic controls

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Invertebrate drift is a phenomenon of fundamental importance for riverine ecosystems, yet current understanding of how hydraulic conditions and morphodynamic processes may influence spatial variability in its characteristics is limited. This results in uncertainty in predictions generated by mechanistic drift models, often used as a component of bioenergetic models for drift-feeding fish. In this research, we used field data from a small, coarse-bed stream in British Columbia to examine: (1) associations between drift attributes (concentration and mean body size) and morphodynamic and hydraulic variables; and (2) differences in drift concentration and body size between three study reaches, morphological unit types, and vertical layers of water column (surface, mid-depth, near-bed). Our results indicate that the strongest associations existed between drift characteristics and channel morphodynamics. Specifically, bed scour was positively correlated with drift concentration; bed fill, on the other hand, was negatively correlated with mean body size of drifting invertebrates. In contrast, hydraulic variables showed no compelling relationship with invertebrate drift characteristics. In the analysis of spatial patterns in drift, few statistically significant differences were detected between the morphological units and vertical layers of water column and we did not find any statistically significant differences in drift characteristics among the morphologically distinct study reaches. Overall, our findings are largely inconsistent with a set of hypotheses developed under the assumption of passive drift, driven predominantly by the direct effects of hydraulic conditions. These findings also suggest that spatial variability in drift body size as well as the connections between invertebrate drift and sediment dynamics deserve more study and should not be disregarded in drift models.

Macroinvertebrate indicators: presence or absence in national policy?

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Benthic macroinvertebrates are important organisms in streams and used worldwide as indicators of stream ecosystem health as they respond to human pressures, are taxonomically diverse and are easy to sample. In New Zealand, macroinvertebrate metrics have a long history of application in state of the environment reporting and resource-consent monitoring. As such their absence from the National Objectives Framework within the National Policy Statement for Freshwater Management (NPS-FM) has raised concern amongst freshwater managers, scientists and the public. We provide an overview of a recent project funded by the Ministry for the Environment. The project aimed to develop stressor-specific macroinvertebrate metrics and a framework for inclusion of new and existing macroinvertebrate metrics in the NPS-FM to contribute to the assessment of ecosystem health. We addressed the following knowledge gaps: (1) Can stressor-specific metrics be developed using existing data? (2) Can a multivariate reference condition approach be applied at the national scale? (3) How can macroinvertebrate traits contribute to an assessment of ecosystem health? (4) Are any of the new and existing macroinvertebrate metrics quantitatively linked to stressors and hence suitable to act as attributes? In this talk we present key outcomes of the project and our recommendations for implementing macroinvertebrate metrics into a NPS-FM framework aiming to maintain and improve ecosystem health.

Freshwater mussel research and conservation Aotearoa

Susan J Clearwater[1], Kevin J Collier[2], Robert Brown[3], Mark Hamer[4], Channell Thoms[5]
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We present a brief overview of the New Zealand Freshwater Mussel Conservation Strategy 2015 and current research and management activities on freshwater mussels. In particular, we focus on Item 2 of the strategy which aims to "Increase knowledge of mussel population status & trends" by: (1) developing basic monitoring protocols (e.g., for community groups); (2) developing detailed monitoring protocols for use nationally; (3) including traditional and local knowledge; and (4) providing a website to document presence/absence records, data collected according to national protocols, biological information and key contacts. Current activities include a research programme ("Cultural Keystone Species: Co-management and restoration") examining freshwater mussel propagation, host requirements and juvenile mussel habitat requirements. Additionally, ongoing research and monitoring includes non-indigenous species impacts on mussels through the Biological Heritage National Science Challenge, ongoing detailed freshwater mussel surveys and tagging experiments in the Waikato, and the second community survey of mussels in Lake Wairarapa. Some of this work will be the subject of other presentations at the conference, so the linkages among studies and information gaps that need addressing will be examined in this forum. This presentation will be followed by an open discussion where questions and comments can be directed at the presenters and other researchers in the audience.

Mass propagation of native freshwater mussels *Echyridella menziesii*

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There are three species of native freshwater mussels in New Zealand and their official conservation status ranges from "declining" to "nationally vulnerable". Freshwater mussels are considered keystone species that have positive impacts on water quality, biodiversity and nutrient cycling, so their suboptimal conservation status is of concern. They are also considered candidates for use in bioremediation of environments like shallow lakes and are valued by Māori as taonga species. We are therefore pursuing efforts to propagate and "grow-out" juvenile freshwater mussels in order to provide mussels for: (1) restocking of restored environments; (2) for bioremediation studies; (3) to enhance the less common species of mussels; and (4) for ecophysiological studies to understand their habitat requirements and contaminant tolerances to guide restoration initiatives. Our native mussel *Echyridella menziesii* produces a larvae (glochidia) that is an obligate fish parasite for approximately two weeks while it transforms into a juvenile. By adapting methods used in North America, Asia and Europe we have been able to make progress on mass production of juvenile mussels either by artificially infesting fish with larvae or by substitution of the fish host with in vitro culture of the larvae. After transformation into the juvenile stage we have been able to grow juveniles for 3.5 months with good survival and growth rates using an intermittent flow-through system with automated feed delivery and weekly maintenance. We will present information on our efforts to produce juvenile mussels with a focus on using fish hosts en masse and juvenile grow-out techniques. A separate presentation will provide detailed information about the in-vitro larval transformation method.

Applying a combination of geomorphological and ecological techniques to understand the relationships between macroinvertebrate communities and river morphology in New Zealand.

Ian Fuller[1], **Kelly Clinton**[1], Russell Death[1]
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Freshwater research within New Zealand, whilst extensive, lacks in the quantification of aquatic biodiversity through ecogeomorphological variables, such as macroinverterbate community variability under changing microhabitat conditions at multiple scales. To aid in conservation and the management of these river systems, considering the link between geomorphology and biota and identifying the interlinking processes which help create distinct ecological communities is thus of vital importance. This oral presentation will present initial findings comparing Surber-sampled macroinvertebrate communities between pools, riffles and runs to add to multiscale mesohabitat analysis. The general consensus for previous work involving pool/riffle comparisons has indicated that taxa such as Chironomidae are more dominant in pools due to enhanced nutrient levels within the fine sediment often found in those environments. Conducting similar research in New Zealand lotic networks will help to establish whether community composition patterns reflect those found elsewhere. We also introduce a plan to apply methods from geomorphology, including Lidar and drone imagery of river beds, to investigate gaps in the influences of river networks, catchment scales, substrate stability and typologies on New Zealand macroinvertebrate communities.

Assessing Canterbury Mudfish (*Neochanna burrowsius*) translocation viability using a graphical metapopulation model

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The Canterbury mudfish (*Neochanna burrowsius*) is an endemic freshwater fish species that has been reduced to small fragmented populations due to decades of agricultural expansion across the Canterbury Plains, South Island, New Zealand. Translocations have been frequently attempted to reverse the decline of this critically endangered species; however, these efforts have produced few persistent populations. This has highlighted the need for improvements in the identification of translocation sites. Geographic Information System (GIS) modelling represents a valuable tool for providing these improvements, due to its processing power and effective integration of ecological theory. Using existing fish survey data, spatial information, and multiple regression, we have assessed the relationship between *N. burrowsius* presence and environmental characteristics. From this information we have created a habitat suitability index, which has been used to map potential translocation sites across the historical range of the species. Additionally, we have used the upper Waianiwaniwa Valley as a case study, where graphical models were used to assess the translocation potential of identified sites within a meta-population context. Translocation sites that were close to existing populations were found to provide the most conservation and habitat connectivity benefits. The model will help to identify potential translocation sites and assess their conservation value in relation to habitat connectivity, further colonisation of habitats, and support provided to existing habitats. This will provide a valuable tool for informing future *N. burrowsius* translocations, and demonstrate the capability of GIS to use existing data to solve issues in freshwater species conservation.

The continuing journey towards kaitiaki monitoring

Brett Cockeram[1]
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Cultural monitoring was first mentioned in Greater Wellington Regional Council's plan in 2001, and although progress was initially slow, some real progress has been made of late. Ara Tahi (Iwi advisory committee) made a commitment to work with iwi and in 2015, after five years' work, Te Upoko Taiao (the Natural resources committee) released the Proposed Natural Resources Plan (PNRP). The plan contained more iwi input than any of its predecessors. The PNRP heralded a new age of resource management in the region. Iwi values are imbedded throughout the plan and the objective for council to manage all fresh and coastal water for mahinga kai and Māori customary use poses a significant wero (challenge) for how the regional council approaches monitoring and reporting. In order to build a regional approach to cultural monitoring Wellington Regional Council is building and strengthening partnerships with individual mana whenua through the development of monitoring strategies. The strategic approach has enabled all partners to get a better understanding of the needs and complexities of working in this space. This is the continuing story of the journey towards kaitiaki monitoring in the Wellington region.

Quantifying basal trophic resources for shallow lake food webs

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We characterised basal food resources gravimetrically and chemically in five eutrophic Waikato peat and riverine lakes along a Trophic Lake Index gradient (4.7-6.3) to understand relative amounts and quality of material available to lake food webs. Suspended seston was split into five size fractions representing a continuum from samples dominated by Cladocera (>250 µm) to samples containing only fine organic particles (<40 µm). Coarse particulate organic matter (CPOM; 0.5-4 mm) and macroinvertebrates were obtained using grab sampling from benthic habitats. Total seston dry mass ranged from 3.5 – 29.6 g/m^3 and was heavily dominated (>88%) by material <40 µm, with total seston mass lowest in the two least-eutrophic peat lakes. CPOM dry mass, which varied by an order of magnitude among lakes (0.13-1.11 kg/m^2), was also lowest in samples from two least-eutrophic peat lakes and highest in a heavily nutrient-enriched riverine lake. Carbon:nitrogen (C:N) ratios, an indication of food quality, were highest in these peat lakes for seston (13.3-14.1) and CPOM (27.2-28.3), while the range for phytomicrobenthos was 8.6-11.4 across all lakes. Benthic macroinvertebrate communities were dominated by Oligochaeta and Chironomidae, with the latter group most abundant in the two least-eutrophic peat lakes. Our results suggest a link between lake water quality, food quality and benthic macroinvertebrate abundance in these shallow Waikato lakes, underscoring the cascading influence that nutrient enrichment can potentially have on lake food webs.

Understanding factors that affect macrophytes in agricultural waterways

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As part of the Canterbury Waterway Rehabilitation Experiment (CAREX), we conducted a large spatial scale survey to identify environmental factors that influence macrophyte growth. Aquatic macrophytes provide important functions in stream ecosystems. However, excessive macrophyte growth in agricultural landscapes can have negative impacts including accumulating sediment and causing flooding. When agricultural waterways become choked during summer, management typically involves mechanical clearance using a bank-side digger. This practice can over-steepen banks, damage in-stream habitat and hinder aquatic ecosystem function. We surveyed 28 small waterways (<5 m wetted width) across the Canterbury region, measuring reach and small-scale site factors that might influence macrophyte species present and percentage macrophyte cover. Understanding the different factors influencing macrophyte distribution and growth and the scale at which they operate will be useful in terms of developing management strategies for addressing excessive macrophyte growth in Canterbury.

Ecogeomorphology and partnerships: strategies employed in building a watershed restoration programme in rural Washington State, USA

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A catchment-scale restoration program was developed for the Klickitat River sub-basin in the early 2000s in Washington State's longest undammed watershed to assist Chinook salmon and steelhead population recovery. Individual projects were implemented from headwaters to mouth and founded on geomorphic and ecological suitability. The catchment's largely rural landscape mosaic afforded opportunities to restore ecogeomorphic processes that would be prohibitive in more densely settled areas. Project outcomes included restoration of shallow aquifer storage, culturally significant plants, fish passage, sediment continuity, and salmon habitat-forming processes. Initiated by the Yakama Nation Fisheries Program, projects mixed an array of funding mechanisms, partnerships, and a balance of cultural and regulatory considerations. Recently, emerging climate science and increased human pressures on groundwater resources have reinforced some priorities while giving cause to reassess others. This talk will provide a retrospective of initial strategic decision-making and emphasise project implementation and effectiveness examples.

Vulnerability zone identification and river channel change sensitivity in the Ruamahanga catchment

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Recent land-use shifts to intensive-agriculture and rural-lifestyle in New Zealand's Wairarapa Region involve significant economic investment in flood-prone areas, which elevates potential consequences for human life and property in the event of flooding. Analysis of high-resolution terrain models indicates relic channel geometries tend to differ from modern forms, possibly indicative of changes in climate, upstream source-area characteristics, and/or local boundary conditions associated with land cover. Multiple contemporary river paths differ from prevailing prehistoric alignments with signs that changes may have been abrupt (e.g. avulsion). Forced channel, floodplain, and terrace forms and proximity to tectonic landforms suggest modern channel locations and patterns are under the ongoing influence of the southern North Island Fault System. Four valley segments have been identified for detailed investigation, based on anticipated sensitivities to bed-elevation changes and adverse consequences for the Wairarapa's major population centres from avulsion and/or break-out flooding. A morphological sediment budgeting approach using repeat high-resolution topographic data sets is being employed to quantify current coarse sediment flux. Combined with catchment-based models, several sediment scenarios will be hydraulically modelled to evaluate reach-scale sensitivity to bed-elevation changes and establish magnitude-frequency relationships for break-out flooding and/or avulsion.

Riverine ecosystem services: exploring stakeholders' views

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Rivers and floodplains are offering ecosystem services for various sectors of society. Compiling such a wide range of ecosystem services may be based on several kinds of data sources. For the evaluation of many ecosystem services, the importance of those services for various stakeholders needs to be explored. As part of a collaborative research project, we've developed a stakeholder involvement strategy in order to involve different categories of stakeholders and to combine several participatory methods for an integrated ecosystem services assessment. As part of this methodology we've created and distributed a comprehensive questionnaire focusing on the ecosystem services provided by rivers and floodplains in Germany, which may be applied on paper or in an online version. The questionnaire firstly provides basic information on the purpose and formal framework of the questionnaire, and then asks abot the previous knowledge of the interviewee. Responses to subsequent questions asking for an opinion on the added value of the ecosystem services concept provide valuable information on the acceptance of the approach by stakeholders. The main part of the questionnaire asks interviewees to assess the relevance of individual ecosystem services in their area, and for their opinion about monetisation of those ecosystem services. We have administered the questionnaire to several groups of stakeholders and present a summary of the results, which provides insight about how different stakeholders perceive and value riverine ecosystem services.

Use of QMRA to assess the human health risk of the Mataura River, Southland, South Island, New Zealand

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Under the current freshwater guidelines the suitability of a river for recreational use is based upon the concentration of *E. coli* present. *E. coli* is used as an indicator organism for the risk to human health from swimming in the river. Risk is based upon the relationship between *E. coli* and the bacterial pathogen *Campylobacter* spp. When a pollution source is fresh, such as the defecation of an animal, the relationship between *E. coli* and *Campylobacter* is quite consistent. However, when the pollution source is aged or treated in some manner, such as through wastewater treatment plants, the relationship is disrupted and *E. coli* may not be a suitable predictor of the risk to human health. The Mataura River in Southland currently exceeds the bottom line for Secondary Contact Recreation (*E. coli*) as set out in the National Policy Statement 2014. There are numerous point and diffuse inputs to the Mataura River. These inputs have undergone a number of treatments and are of various ages, which affect the *E. coli*/*Campylobacter* spp. health risk relationship. To overcome these issues and to provide a representative risk assessment, a quantitative microbial risk assessment (QMRA) model has been developed for the Mataura River in Southland. A number of direct inputs were monitored over a 24-hour period and the concentration of both indicator and pathogenic bacteria enumerated. The bacterial quality of the receiving water was monitored and any data relating to historical water quality analysed. Using these data along with the hydrological data for the river a QMRA was developed. This will be compared with the standard NPS state and may provide a case for QMRA to be utilised in the place of indicator bacteria where high levels of indicator bacteria are occurring within the receiving environment of a treated wastewater discharge.

Temporal trends in the relative abundance of New Zealand freshwater fishes

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The New Zealand Freshwater Fish Database (NZFFD) contains the longest time-series of fish information in the country, but without accounting for confounding factors in the data there is too much noise to accurately describe trends in abundance. The objective of this study was to calculate and assess standardised trends in fish abundance from the NZFFD, which will improve the reliability of using this dataset to examine temporal trends. We used stepwise generalised linear models (GLM) to estimate the characteristic probability of capture attributable to each year of the record (probability of capture hereafter) for a selected group of species. A Sen Slope Estimator (SSE) was used to simplify the complex temporal variability in probability of capture into straight lines for each of three time periods: 1977–2015, 1977–1994 and 1995–2015. From the 78 Sen slopes, 35% (n = 27) corresponded to decreasing trends, 28% corresponded to increasing trends, and the remainder were indeterminate. The average (±95% CI) magnitude of the decreasing trends was 0.38 (± 0.12) %/year. The average (±95% CI) magnitude of the increasing trends was 0.27 (± 0.05) %/year. Brown trout and Canterbury galaxias displayed decreasing trends in each time period; for shortfin eels, increasing trends occurred in each time period. The present study provides information on the direction and magnitude of trends in the relative abundance of freshwater fish species, but it does not consider the ecological or management implications of the trends. Future assessments of the causes and management implications of trends in freshwater fishes are likely to become more pressing in New Zealand given that the high proportion of native freshwater fishes classified as 'Threatened' or 'At Risk' has recently increased under the current New Zealand Threat Classification System.

Importance of integrating physical and biological processes along with societal needs for sustainable energy and protecting a river's goods and services

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Humans have been prolific dam builders. Dams provide various socioeconomic services and, of these, hydropower dominates worldwide. The combination of evolving values, aging physical structures, and new energy alternatives has forced a rethinking of dam building for hydropower, including sustaining the many facilities that are coming to their end of service life. The pressures to both use and protect the services provided by river ecosystems is driving the development of improved tools for understanding and detecting meaningful ecological changes. The Mactaquac Aquatic Ecosystem Study (MAES) arose from a need for renewal of a 675 MW hydropower facility in New Brunswick, Canada. MAES was designed to prepare the utility to make a decision regarding the rebuilding or removal of the facility, along with the science to support the future of the selected option. MAES is an ecosystem-scale study that integrates across physical, chemical, and biological components of the environment. It builds physical templates for the reservoir and river using models - Delft3D-FLOW (river flow, sediment, and temperature) and CEQUEAU (streams flow and temperature across the watershed) – which then provide the foundations for modelling faunal and floral habitats and trophic structure using meso-CASiMiR and DELWAQ. The spatio-temporal characteristics of the river's biological structure and function are interwoven into the modelling templates. The biophysical knowledge are then merged with societal priorities regarding the river's goods and services and including indigenous foods through the development of an environmental flow regime (an ELOHA approach), i.e., a hydrologic foundation to determine flow-ecology relationships followed by policy to achieve river condition goals. We will present the current state of MAES and its links to and support of the ongoing debate and decisions regarding energy economics and societal values.

A servant of many masters - when restoration has to meet many expectations: management and monitoring in a floodplain restoration project along a Danube stretch in Bavaria (Germany)

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The Danube floodplain is disconnected from its river and natural water dynamic is inhibited by hydropower generation. Despite the hydropower dams, this restoration project aims to bring back water dynamics to the floodplain by a new floodplain stream, by ecological flooding and by temporary groundwater drawdown during the summer months. Connected with these measures are expectations of the different stakeholders. For the Water Management Authority longitudinal connectivity for migrating species has first priority (requirement of the European Water Framework Directive). So, fish and flowing waters are in focus and therefore, more or less stable conditions are required. Nature Conservation Authorities are aiming at dynamics in hydrology, ranging from no water to high water to imitate the conditions on a natural floodplain. Phases of ecological flooding and groundwater drawdown in high/low extremes and of long duration are welcome. The groundwater drawdown can serve as an example. It aims to enhance the abiotic conditions for pioneer species of muddy streambanks. But due to the new floodplain stream, former fluctuating water zones which are habitats for target species, e.g. *Oenanthe aquatica* (water dropwort), have changed to aquatic habitats which are required for fish. The monitoring compares the situation before restoration with the effects of three different types of groundwater drawdown. For these types, the hydrological situation was investigated and the effects on the occurrence of *Oenanthe aquatica* were mapped. The outcome is that one type can enhance germination of *O. aquatica*, but is detrimental to fish. The other type is able to provide the same suitable conditions for *O. aquatica,* without severely harming the aquatic habitats. The third type cannot reach the required low water levels and is therefore not a comparable option. The results show that an interdisciplinary monitoring is able to develop a measure suitable for both competing habitat types.

E. coli standards and risks to human health in New Zealand waterways: what more?

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Recently, the New Zealand government announced a target of 90 per cent of the country's lakes and rivers meeting swimmable water quality standards by 2040. This announcement was accompanied by the release of a new policy document featuring changes to the National Policy Statement for Freshwater Management, information maps on current water quality for swimming that identify where improvements are needed, and the commissioning of a new $100M Freshwater Improvement Fund. The policy document (NZ Clean Water) also itemised the government's action plan needed to achieve the 2040 target. There are, however, concerns that 'NZ Clean Water' fails to consider several critical issues including assertions that the new rules lower the bacteriological standard of freshwater quality, thus potentially failing to capture risks to human health in New Zealand waterways. With a view to identifying policy gaps and potential areas for improvements, the current study compared 'NZ Clean Water' with other international policy documents and research publications that seek to support formal blueprints for protecting human health in recreational waters. Going beyond the 'politics of numbers' built on counts of *E. coli* or other faecal indicator bacteria (FIB) in culture-based assays, the need for intensive quantitative microbial risk-assessment research to support the policy drive for robust recreational water quality management in New Zealand was identified. This may include studies that estimate risk associated with waters impacted by human versus non-human faecal sources, considering that the risks from mixed sources are driven predominantly by the proportion of the contamination source with the greatest ability to cause human infection (potency), not necessarily the greatest source(s) of FIB count. Other issues with potential implications for the management of bacteriological quality in New Zealand recreational waters are also discussed.

Monitoring river use with camera traps

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In response to concerns about increased angling pressure caused by mountain bike and ATV tracks, Auckland/Waikato Fish & Game staff conducted an extensive angler-monitoring program on the Whakapapa and upper Whanganui Rivers from October 2014 to October 2016. Camera traps were placed at 25 locations on randomly selected river reaches and successfully recorded for a total of 8441 monitoring days. Of the 485 river users recorded 85% were fishing and 88% of the anglers recorded were male fly fishermen. The vast majority of the non-anglers recorded were Department of Conservation staff and only 3% of river users (hunters, rafters and hikers) were not carrying fishing equipment. Angler-use was compared between sites based on distance and estimated travel time to the nearest maintained road. Fishing pressure generally declined as total travel time increased but usage was highly variable. The Whakapapa and upper Whanganui Rivers are important strongholds for the endangered blue duck (*Hymenolaimus malacorhynchos*) and excessive human traffic is seen as a potential threat to blue duck breeding success. Overall fishing pressure was extremely low with a pooled average of only two anglers per month and is unlikely to pose a significant threat to blue ducks. However numerous native and invasive predators were recorded during the study that would pose a significant threat to blue duck breeding success.

Assessment of public road-river intersections for provision of fish passage, in Southland, New Zealand: methods, interim results, and proposed management actions.

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Southland has significant cultural, recreational, and biodiversity values associated with its freshwater fishery resources. Yet until recently, there has been little understanding of the number of in-stream barriers that may negatively affect these values. In response to this issue, Environment Southland established an on-going fish-passage monitoring and remediation project that aims to assess in-stream structures, and develop a priority list for remediation of confirmed barriers. The project underwent pilot testing in 2016, and full-scale assessments commenced during the summer of 2016-2017. Each survey day, field staff drove pre-planned routes around the region, stopping at every waterway crossing they encountered to assess the in-stream structure. Each structure was spatially identified using a handheld GPS unit, and broadly assessed for provision of fish passage. A full assessment was carried out on structures that either impeded fish passage at the time of survey, or could potentially impede fish passage under different flow conditions. Data were later transcribed and stored within ArcMap for future analysis. To date, 745 road-waterway intersections, approximately 15% of the region's public road-waterway intersections, have been assessed, of which 219 (29%) were either confirmed barriers, or predicted to be a barrier under different flow conditions. Culverts produced the greatest number of confirmed in-stream barriers (92%), followed by bridges (6%), and all other structures combined (2%). The vast majority of culvert barriers were perched (87%), including several examples installed within the past five years. Interim results have been presented to relevant council teams, and a cross-divisional response has been engaged. Initial actions include: contacting consent holders of confirmed barriers, development of factsheets for best-practice culvert installations, education of road contractors, and development of a prioritisation matrix for barrier remediation. This project aims to continue until every public road-waterway intersection within the region has been assessed.

Use of passive integrated transponder tags and acoustic hydrophones to document eel movement and mortality through a non-gravity fed axial pumping station

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The effects of agricultural drainage on aquatic ecosystems have been well documented. One of the primary impacts in floodplain habitats is loss of river connectivity and fish passage. In the Lower Waikato River Basin in New Zealand wide-scale catchment development for intensive agriculture and its associated drainage activities, has resulted in dramatic subsidence of former peat substrates and loss of diverse structural habitat through channelisation of watercourses and removal of riparian and wetland vegetation. The loss of natural gravity-fed flows caused by land subsidence has necessitated the installation of 'one way' flood pumps in many catchments to keep these now-lower elevation areas free from flooding. Although fish mortality through pump-stations was known to occur, few studies have documented the degree of mortality and/or trauma that occurs during typical operating scenarios. For the first time in New Zealand, we assessed the survivability of tagged (PIT) and non-tagged migrant shortfin eels through a non-fish friendly axial pump station during a natural autumn flood event. A large fyke net attached to the pump outlet enabled capture of downstream migrants that had passed through pumps to assess survival. It was noted that at times the pumps made a particular sound when eels passed through suggesting an opportunity to use a hydrophone as a potential remote monitoring tool to assess mortality and timing of migrations at these pumping stations. Replacing the existing axial (propeller) pumps at the study site with "fish friendly" Bedford pumps (U.K manufacturer) is proposed, representing the first pump of this type to be installed in New Zealand. The pre-replacement data documenting survival/mortality through the existing non-fish friendly axial pump station will be used to evaluate and compare the effectiveness of the new pump design for promoting safe downstream passage of migrant eels in a New Zealand context.

Measurement and estimation of fine suspended sediment-related attributes in New Zealand waters

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Fine suspended sediment (0.1 to 63 µm equivalent diameter) has multiple effects on aquatic ecosystems and water values. These effects include: direct damages to respiratory or filter-feeding structures of aquatic animals, reduced visual range through water for animals (and humans), and reduced light availability to aquatic plants. A range of further effects ensue once fine sediment is deposited, but are beyond scope here. Suspended sediment mass concentration (e.g., Total Suspended Solids (TSS), Suspended Sediment Concentration(SSC)) is probably most relevant to loads in downstream waters and direct biotic damages, e.g. to fish gills. Visual range (and reactive distance) are controlled by visual clarity which is most usefully measured (usually in situ) as black disc sighting range. And light availability is controlled by water depth and light penetration which is quantified by the irradiance attenuation coefficient (or, equivalently, the euphotic depth), measured with a submersible radiometer. Turbidity, a commonly measured index of water cloudiness (light scattering) by suspended particles, is most useful when locally calibrated to more directly environmentally relevant quantities. For example, sediment mass load estimation is often greatly assisted by continuous turbidity records locally calibrated to TSS. Visual clarity is quite strongly, inversely, related to turbidity, and can be estimated, roughly using 'global' relationships, or accurately using local calibrations, from discrete or continuous turbidity measurements. Where visual clarity is difficult to measure on occasion, such as when the sighting path is limited in small clear streams, locally calibrated turbidity can be conveniently used to estimate visual clarity. Light penetration is related in a more complicated way to the concentration and properties of suspended sediment, and is usually non-linearly related to other sediment-related metrics, while also depending on other optical properties notably coloured dissolved organic matter. We survey some practical approaches to measurement of fine suspended sediment-related metrics, or estimation from turbidity, with applications in operational sediment management.

Volunteer water-monitoring as a focus for community engagement in New Zealand

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Recent reform of freshwater management in New Zealand envisages increasing involvement of the community in water management. Meanwhile there is considerable action on riparian management (fencing to exclude livestock and planting trees), much of it by community groups, and often with the stated aim of improving water quality and stream ecosystem health. But there is very little monitoring to confirm the expected recovery in response to this riparian action. The main professional water management agencies in New Zealand, the 16 regional councils and territorial local authorities ("regional authorities", RAs), have the resources to monitor only a small fraction of the stream rehabilitation effort. Recently, we compared community volunteer monitoring with professional measurements by RAs, and found encouragingly close agreement for a comprehensive range of water attributes, including important state-of-environment (SoE) reporting variables: visual clarity, *E. coli* and macro-invertebrates. Therefore, we think that the same community groups who are doing much of the riparian rehabilitation work could gainfully monitor their streams to demonstrate the benefits of riparian action. However, it is clear from 'social' research as a follow-up to our paired monitoring study, that community volunteers need and want on-going professional support and encouragement. Fortunately, there are also important benefits of such community engagement to RAs. Support of volunteer monitoring by RAs in New Zealand could include: development of a community strategy, providing professional advice and encouragement, training on measurement methods, quality assurance (QA), web resources for uploading and interpreting data, analyses of water samples collected by volunteers, and use of volunteer data in SoE reporting. This presentation will overview the potential of community volunteer monitoring as a focus for wider community involvement to improve water outcomes in New Zealand. Our on-going research aims to improve resources and systems for volunteer monitoring, and engage volunteers to document benefits of riparian rehabilitation.

A technique to assess river habitat change – the missing dimension for water resource management

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Conservation of healthy and stable native fish populations depends on ensuring there is an adequate quantity and quality of habitat for all species present in a river or stream. River engineering and management activities have the potential to have significant adverse effects on habitat quantity and quality. The 'event Habitat Quality Index' (eHQI) provides a simple way to record the change in habitat characteristics relevant for specific native fish at any river reach. We identify the key geomorphological variables that have been determined to assess habitat for each of 10 native species of fish. All variables for each species of fish predicted to be present at a site according to the River Environment Classification should be measured before and after any management activity. Each of these variables should be expressed as a ratio of 'measure after' / 'measure before' such that a ratio of 1 would represent no change. The median of all component eHQI's yields the eHQI. A decline of more than 15% in this index, or a decline of more than 40% in any single component, would indicate cause for concern and the need for potential mitigation activity.

Naughty rivers: conforming or deviating ecosystem responses to anthropogenic drivers

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Large rivers are amongst the most regulated and highly modified ecosystems, globally. More than 65% of the world's large rivers are fragmented by dams, experience hydrological regulation, and are controlled for navigation purposes. Large rivers are increasingly modified by multiple drivers that cumulatively influence these ecosystems. However, few studies explicitly explore the effects of, or responses to, multiple drivers. Furthermore, our understanding of how system-wide drivers overlap in space or time and interact with each other is lacking. The question remains: do highly modified, large river systems maintain the ability to respond to additional cumulative anthropogenic drivers in a significant and substantial way, and if so, how are these responses manifested? To expand our knowledge of the influence of anthropogenic drivers in large rivers, we need to investigate ecosystem response at broad spatial and temporal scales, whereas most studies focus on single drivers and small scales. This study utilises a 60-year, river-wide dataset to determine if fish community diversity in the Illinois River (Illinois, USA) changed in response to two major, system-wide anthropogenic drivers: the Clean Water Act (1972) and the Asian carp invasion (2000). We analysed diversity changes for the entire river system, among functional process zones, and also for functional feeding guilds to represent groups of species that have similar roles in the same community.

Interactive effects of hydrogeomorphic characteristics on fish community structure in a floodplain river

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Hydrogeomorphic characteristics are key determinants of the abundance and richness of fish communities within habitats of floodplain rivers. Research examining the combined influence of geomorphological and hydrological attributes on composition of fish communities, however, is limited. This study examined how hydrogeomorphic attributes of slackwater habitats of a floodplain river act to determine composition of fish communities in lateral habitats. Fish were collected from 27 lateral habitats in the Upper Mississippi River between Alma, WI and Brownsville, MN, using a boat-mounted electrofisher, fyke, and mini-fyke nets. Fish data were standardised by conversion to catch-per-unit-effort followed by determination of relative abundance. A suite of 22 hydrological and geomorphological variables was generated with data from a 50-yr record of stage height, remote sensing images, and field measurements. Cluster analysis of hydrogeomorphic data identified three groups: floodplain lakes (Lakes); a mixed group of floodplain lakes and backwaters that disconnected periodically (Mixed); and backwaters that remained fully connected (Backwaters). Similarity Percentage (SIMPER) analysis revealed that similarity among sites within each hydro-geomorphic group was predominantly accounted for by: hydrological variables for the Lakes group; a combination of hydrological and geomorphic variables for the Mixed group; geomorphic variables for Backwaters. Analysis of similarity (ANOSIM), of the fish data, grouped a priori on the three hydrogeomorphic groupings, revealed significant differences in fish community composition between the groups and a multivariate dispersion index found differences in heterogeneity of community composition within each group. This study demonstrated that lateral habitats of this section of the Upper Mississippi River exhibit distinct hydrogeomorphic characteristics; and, that their distinctive attributes shape organisation and abundance of fish communities within this riverine landscape. This study illustrates the need to apply appropriate measures of both hydrology and geomorphology jointly to address the complex dynamics of slackwaters for both river research and management.

Artificial fish shelters developed by a statistical approach to natural fish habitats

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Fish shelters have been studied as a key habitat for fish population management, especially in urban areas where well-known techniques that provide good refuge against flooding and predators are not possible because of specific constraints of channelised urban rivers. Artificial fish shelters provide a seductive alternative to protect the fish population and to assure longitudinal connectivity. Added to that, some workers have tested artificial fish shelters to provide a basic fish refuge in rivers impacted by hydropeaking. This talk describes how we designed artificial structures based on monitoring fish habitats in wild New Zealand rivers. We analysed more than 100 natural fish shelters and described their characteristics, and also built and monitored artificial fish shelters. We tried to highlight the efficiency of artificial shelters and compared the fish density for each category of natural shelters. Fish density in shelters seems to be linked to some measurable characteristics.

The search for the source of phosphorus in the Tukituki River: the role of diurnal fluctuations in water column pH from periphyton photosynthesis

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Prior to October 2015, the Tukituki River received high concentrations of Dissolved Reactive Phosphorus (DRP) from Waipukurau and Waipawa sewage treatment plants (STPs), which combined with high upstream nitrate concentrations, often resulted in nuisance growths of periphyton during summer. A common feature in surveys was the complete removal of nitrate from the water column (within 50-60 km downstream of STPs), indicating the system was not P-limited. Since October 2015, DRP discharged by the STPs has reduced by around 95%, which was expected to 'reinstate' some P-limitation downstream of the STPs. However, the results from 2016 and 2017 surveys showed the same 'pre-upgrade' pattern of complete nitrate removal. Calculations show that post-STP upgrade the downstream river system is supplying around 85% of the phosphorus theoretically required for complete nitrate removal (via periphyton uptake). In previous surveys, high water column pH values of >9.5 were typical, and we hypothesised that the magnitude of diurnal pH fluctuations may be an important source of DRP via dissolution of iron/aluminium-phosphate in sediments. pH and DRP were continuously monitored for 2-3 days at three locations. Despite typical pH fluctuations between 7.6 and 9.6 (pH >9 for up to 10 hours per day), no increase in water column DRP concentrations were detected. Analysis of sediments showed that only 3-4% of the total sediment phosphorus pool was potentially extractable under alkaline conditions (i.e, Fe/Al-phosphates). Laboratory extractions (at pH 7-8 vs 9-10 for 12h) showed, on average, 3-4-fold higher DRP concentrations at higher pH. The difference between field and laboratory results most likely reflects either: (1) unrealistic reproduction of field pH conditions; and/or (2) that the armoured nature of bed means P-containing fine sediments do not 'see' the high water column pH values. The implications of these findings with respect to instream phosphorus sources and P-limitation will be discussed.

Using a metagenomic sequencing approach for faecal source tracking

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The ability to use next-generation sequencing tools to identify the individual genera/species of microorganisms present in the microbial community of a single environmental sample such as faeces, water and soil has been termed metagenomics. Metagenomic approaches provide information on thousands of microorganisms in a sample simultaneously, thereby multiplying the power of a single assay to generate useful information. Nationwide and internationally, researchers are building up databases of the microorganisms present in the environment to understand the changes in microbial communities between different environmental matrices. Applying a metagenomic method to identifying the sources of faecal pollution in waterways could lead to a revolution in our approach to faecal source apportionment. Identifying signatures that indicate natural microbial communities associated with groundwater and surface waters, and comparing them with microbial communities from polluted waterways, could allow researchers to identify microbial responses to polluted aquatic environments subjected to faecal contamination and/or high nutrient runoff. For example, the presence of high levels of nitrates can significantly increase the concentrations of microbial populations capable of denitrification. Furthermore, when mitigations are put in place to reduce/eliminate contamination sources, determining the consortium of the microorganisms present will help us to evaluate the community response to reducing pollutants and what constitutes a healthy stream microbial fingerprint. This dynamic research focus for faecal source tracking will be discussed in relation to the bacterial community signatures identified in fresh and aged cow pat runoff, and in dairy farm streams fed by groundwater aquifers and impacted by animal faecal runoff. Metagenomic data will be discussed in relation to the identification of conventional faecal source tracking markers (such as faecal sterols and polymerase chain reaction (PCR) markers) in water and faecal runoff samples.

Present state and future trends in the hydrologic connectivity of central Chilean rivers: effects on native fish diversity

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The Andean river basins in central Chile have experienced significant changes in hydrologic connectivity due to anthropogenic activities (mainly construction of dams). These changes and their effect on river biota, however, have not been quantified up to date. This study aimed at detailed quantification of the current fragmentation state in these basins, their projected future changes (2050) and assessment of the effects of these changes on native fish communities. We analysed six river basins between Rapel River (33°S) and Imperial River (38°S). To assess the fragmentation status of each basin presently and in the near future, we developed a fragmentation index (IF). Subsequently, this fragmentation index was used to assess the effects of fragmentation on the diversity of native fish. We recorded 61 barriers in total in all analysed basins of which 42 were hydroelectric dams. The most fragmented basin was the Rapel River (93% of river length upstream of at least one barrier), whereas the Imperial River was the least fragmented basin. The basin with the most increase in fragmentation (2016-2050) was the Itata River (24.3% increase of river length upstream of at least one barrier), whereas the highest number of new barriers (43) is projected for the Biobío River. We found a positive correlation between the IF and both α-diversity and β-diversity. However, only correlation with β-diversity was statistically significant. Environmental variables such as water temperature, conductivity and substrate type explained most of the variation in fish diversity patterns. The effects of barriers on fish communities were expressed mainly through reduced dispersal rates and species sorting into metacommunities. We conclude that the increase of fragmentation and resulting reduction of available habitats in near future will pose a severe threat to the diversity of native freshwater fish and is expected to cause local extinctions of Chilean native fish species.

Cumulative Hydrological Effects Simulator: a tool for characterising the consequences of water use on multiple values

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CHES (Cumulative Hydrological Effects Simulator) is an ArcGIS add-in tool for characterising the consequences of water use on multiple in-stream and out-of-stream values. It is targeted at river managers and others involved in allocation of water resources. It simulates the consequences of surface and ground water abstraction scenarios for in-stream (e.g. physical fish habitat) and out-of-stream attributes (e.g. reliability of supply). CHES uses estimated natural flows and consented abstractions under given abstraction rules as the inputs, and then estimates the modified mean daily surface water flows. CHES then uses the modified mean daily flows to model the consequences of water use for in-stream and out-of-stream attributes. CHES has been applied to the Grey River Catchment (New Zealand) under a Community Engagement Fund project with the West Coast Regional Council. Hind-cast flow simulations for the last 40 years were generated in CHES to drive simulations of different water abstraction management scenarios. These scenarios help to inform the researchers of the interplay between the water volume abstracted and changes in fish habitat. Results will be presented for different scenarios, ranging from current consented abstractions, to alternative limits, additional storage/allocation scenarios, and climate change scenarios. Seventy-eight abstractors were included in the different simulations, with high reliability of supply for the current consented abstraction scenario. Brown trout and longfin eel habitats were simulated for each reach downstream of any abstraction, and physical habitat loss was quantified. Under a climate change scenario, average reliability of supply improved, and physical habitat showed only a small decrease compared with the baseline scenario describing current allocation. A scenario simulating a new off-line storage abstraction was also investigated, for a hypothetical farm supporting 500 cows. CHES showed that this could be achieved with a dam size of 86,400 m^3, giving ample drinking/cleaning water and an irrigation reliability of >95%.

Colourful urban streams: microplastic pollution of the freshwater systems in the Auckland region.

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Microplastic pollution of aquatic systems is a global environmental concern. Most research has focused on marine systems, but streams are the main pathways for land-based plastic debris to be delivered into the oceans. Streams located in highly populated areas are particularly vulnerable because all plastic use and disposal is solely associated with human activities. To determine the level of contamination and potential drivers of variations in the amount of microplastics in urban streams in New Zealand we tested 18 streams along the population density gradient in the Auckland region. Microplastic abundance, size and type were determined for the water column and sediments at 21 sites spanning gradients in urban development and storm water infrastructure (e.g. sanitary vs combined storm water overflow sewers). Laboratory analyses included elutriation of sediments, density separation with Sodium Iodide (NaI), digestion of organic material with peroxide and sulphuric acid, microscopic and spectroscopic analyses. Maximum amount of microplastics were found in streams with high population densities in surrounding areas and accounted for 303 particles/m^3 in the water column and 80 particles/kg dry sediment. However, microplastic was found even in streams draining catchments with minimal human land use. The most abundant were particles of the smallest size range (63-500 µm). Fragments were the most common type found in sediments while films were the most common particles found in the water column. Poly(hexadecyl) methacrylate, polyethylene, polypropylene and ethylene/vinyl acetate were the most common polymers found in Auckland streams.

Does nutrient enrichment affect the response of stream communities to large floods?

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An increase in the frequency of extreme flood events is now emerging as a threat to aquatic ecosystems. Many watersheds have been also adversely affected by nutrient pollution; however, it is still unclear how nutrient enrichment may alter the effects of extreme floods on stream invertebrate communities. We studied a 1-in-50 year flood in Wellington, New Zealand at five stream sites. PCA of six nutrient measures divided the five sites into three groups: low (two sites), medium (one site) and high nutrient levels (two sites). The flood significantly reduced periphyton biomass at sites in the high-nutrient group and increased at sites post-flood in the low-nutrient group. The flood reduced diversity indices (Simpson index, and Species richness) at sites in the low-nutrient group; however, community structure was affected only at sites in the high-nutrient group. Nutrient enrichment seems to result in communities more sensitive to floods.

Na ika i Viti - freshwater issues in the tropical islands of Fiji

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Fiji's freshwater fish are highly migratory – an estimated 98% of species make contact with saltwater at some stage during their life cycle. This makes them extremely vulnerable to migration barriers. Apart from infrastructure development such as dams, weirs and culverts, reduction of suitable habitat due to deforestation and high levels of fine sediment also affect fish migrations throughout Fiji. Freshwater fish are an important food source and have cultural totemic importance, so their conservation and barrier-free migration should be high priority. Fiji also has the second highest known freshwater fish diversity and the third highest level of endemism in the Pacific. However, lack of funding and awareness mean that threat classifications of Fiji's fish fauna are almost absent - as are any other national legislative resource plans. Come and join me for a short tropical splash into the world of a developing country's freshwater systems and the challenges they face.

Environmental flows for ecosystem function: plausible reality or impossible dream?

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The prevailing approach to delivering environmental flows across the Murray Darling Basin (MDB), Australia is one that focuses on delivering water to support particular environmental assets, i.e. structural elements of the aquatic ecosystem such as fish or water birds. This is based on the premise that delivering water to support key biota will concomitantly ensure that a range of ecosystem processes and other biota also benefit. The risk with an asset-based approach is that environmental flow design becomes compartmentalised, focussing on delivering individual events for individual outcomes (e.g, spawning events for fish species) rather than a more holistic regime-based approach. As a consequence, calls to incorporate ecosystem function and ecosystem processes into environmental flow planning are becoming more frequent. A review of environmental flow programs from across the MDB reveals that translating objectives for "biodiversity" and "ecosystem function" into river-scale watering plans generally results in a focus on events (sometimes sequences of events) and species outcomes. The need to establish specific objectives for water use, and the requirement to monitor and report outcomes promotes such an approach, particularly as we often lack the knowledge to develop meaningful objectives for ecosystem processes or whole of ecosystem outcomes. In contrast, within the Australian Capital Territory (ACT), flow regimes (as opposed to flow events) are designed to produce outcomes for ecosystem health as well as a target species. This approach is made possible because well-accepted measures of ecosystem health are used for monitoring and reporting. Learning from the ACT suggests that it is possible to adopt an ecosystem focus, provided clear objectives are established and the tools are available to report on outcomes. This confirms the need to continue to develop integrative measures of river health that enable the evaluation of flow regimes rather than flow events.

Growth of adult inanga is related to when they hatch and when they migrate to freshwater

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Inanga are an amphidromous galaxiid that spend their larval life in a pelagic environment and adult life in freshwater. The early life histories of inward-migrating post-larvae are highly variable throughout the pelagic phase. Previous work has shown that autumn-hatched fish are slower growing and migrate inward during early spring while winter-hatched are faster growing, and migrate in late spring at younger ages. Because of these staggered migrations and associated early life-history differences, inanga may grow at different rates in freshwater dependent on migration timing, but with consequences for their demographics. To investigate these relationships, otolith microstructure methods were used to reconstruct the growth histories of adult inanga, to estimate ages and derive hatch-dates. Generalised additive mixed-effects models were used to model otolith-derived growth from multiple populations in Golden Bay. Growth histories were compared among hatching times as proxies for migration timing and early life history variation. Results showed that autumn-hatched inanga had higher age-dependent growth rates in rivers compared to winter- or spring-hatched fish despite being significantly slower growing in their pelagic phase. For later migrating winter- and spring-hatched fish, although pelagic larval growth rates were faster, growth in the river was slower compared to autumn-hatched fish. These results shed light on the relationships between growth attained in pelagic and freshwater environments and suggest inanga may be able to maximise growth in either the pelagic or freshwater environments.

Geospatial data and OVERSEER for nutrient management on dairy farms

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Across the dairy industry in New Zealand, a growing number of farmers are required to report on their nitrogen (N) and phosphorous (P) losses to regional councils. This is facilitated by a computer model (OVERSEER) that models the flow of nutrients on a farm to produce nutrient budgets and greenhouse gas (GHG) footprints. This is achieved by entering information about how a farm is run (inputs), then modelling through a series of complex sub-models that mimic known bio-physical processes operating across a farm system. The majority of this data is entered by a farm consultant or the farmer. We focus on defining case-study farm attributes and key dairy agro-ecosystem (AE) types that encompass the broad range of landscape features and management systems typical of New Zealand dairy farming nutrient loss targets, through geospatial processing of freely available spatial datasets. Further sub-categorisation was undertaken to define different risk zones for farm contaminant losses based on landscape features that influence the inherent loss risk of different farm types within each AE region, such as rainfall, topography, soil type, drainage class and soil anion storage capacity. We then seek to define benchmarks of N, P or GHG losses that consider the "inherent loss risk" producing these features, assuming that all model farm scenarios were operating under "Best Practice". Finally, we assess Good Management Practice (GMP) mitigation effectiveness measures that reduce losses of N, P, and sediment to water, using actual farm files representing typical farms in each study region. Assessments are undertaken at a whole-farm scale. This scale of analysis will help to reduce confusion created by earlier reports that document mitigation effectiveness at paddock- and block-scales. Using a Geographical Information System (GIS) approach will ensure consistency across the nation for data entry into OVERSEER.

Exploration of implications of capacity for land-use intensification under water quality constraints at national scale

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The National Policy Statement for Freshwater Management in New Zealand (NPS-FM) has introduced a system of national water quality objectives. We developed a national modelling approach to identify the implications of this policy for the capacity for new agricultural development. The analysis addresses questions of whether contaminant loads need to be reduced to meet the desired water quality state, or whether there is capacity to increase loading while remaining within water quality objectives (nitrate toxicity, *E. coli,* periphyton, lake nutrients), including consideration of whether new mitigation measures can create capacity for further development. Heuristic methods were used to determine the implications of water quality constraints spatially, using a combination of the CLUES catchment model, measured and modelled current state, relationships between periphyton and nutrients, and catchment tracing algorithms which propagate information about constraining locations through the drainage network. The study found that current *E. coli* guidelines for primary contact severely constrains capacity for development; current loads need to be reduced to meet the primary contact objectives, even after applying mitigation. At the other extreme, nitrate toxicity bottom lines provided were limiting in only small areas; consequently, the capacity for development was limited by the requirements for maintaining or improving water quality, and capacity essentially matched the amount of mitigation. Applying constraints to maintain water quality only at the stream outlets rather than at all nodes did not appreciably change the estimated capacity for further development. Overall, the results were consistent with our intuition. However, we found that often people did not appreciate how failing to meet a bottom line at a location constrains development in the entire upstream catchment. The model did not address how contaminant loads could be redistributed while maintaining current loads and increasing land intensification by, for example, locating intensive land use on areas that are less prone to contaminant losses through cap and trade approaches. Alternative methods such as land use optimisation at national scale could be used in the future to enhance the analysis.

The impact of historical mining activity on aquatic macroinvertebrates at Puhipuhi, Northland

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The Puhipuhi catchment is an area in Northland where the aquatic environment has been affected by historic mining activities, in particular the mining of mercury. In summer 2016 benthic macroinvertebrate sampling was carried out in the catchment at the same time as water and sediment sampling in order to assess the impact of mine-drainage waters on macroinvertebrate communities. Sites in the upper part of the catchment where metal contamination from mining was more severe showed reduced taxa richness, %EPT and a low AMDI score relative to those in the lower part of the catchment or at control sites in a nearby catchment unaffected by mining. Macroinvertebrate indices showed strong correlations with dissolved iron, manganese, nickel and mercury concentrations as well as with sediment iron and mercury concentrations in that higher concentrations of metals corresponded to lower macroinvertebrate community indices. Control sites and sites in the lower catchment had macroinvertebrate communities dominated by mayflies and freshwater snails which have a high AMDI tolerance score, as well as a large number of beetles. In contrast, metal-impacted sites had macroinvertebrate communities comprised of worms, caddisflies and chironomids, which have a low AMDI tolerance score. Given that this area is being investigated for future mining opportunities, this research highlights the importance of adequately treating mine wastes such that nearby aquatic ecosystems are not severely impacted as has been observed for sites downstream of past mining activities.

Floating fish ramps: a new tool in the fish passage toolbox

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Many of New Zealand's indigenous freshwater fish species require connectivity between the sea and freshwater, yet small scale anthropogenic barriers such as weirs and culverts have been found to disrupt these migrations and restrict fish from key inland habitat. The enormity of the problem for managers comes both from the quantity of barriers needed regionally, and the price tag associated with remediating them. This highlights the need for low-cost, robust solutions that can be applied in streams to enable migrating fish to overcome these barriers. A series of three laboratory trials were conducted with floating ramps, testing the passage response of Inanga *(Galaxias maculatus)* and redfin bullies *(Gobiomorphus huttoni)* on an array of ramp surfaces. The trials served both to build on existing knowledge of the ramp-swimming capabilities of these fish, and to inform a design process with an end-goal to produce a fish ramp that is commercially available for managers. Results showed that the plastic ground-drainage product Mirradrain® had the highest passage success and that the addition of spat rope longitudinally down the centre and wetted margin of the ramps improved passage for both species. Rotomoulded ramps, designed and funded through a collaboration of regional councils, were produced with textured plastic panels attached, which resembled Mirradrain®. Four Hawke's Bay streams (two treated, two control) were selected for in situ trialling, and fished with fyke nets both pre- and post-ramp installation. Initial results indicate that some inanga were able to pass the ramps, although numbers caught were low above and below ramps. The robustness of the ramp and its attachment design were proven to withstand a 1-in-5 year flood event during the testing phase. This study has shown that Mirradrain-style ramps should provide an effective and robust tool for mitigating migration barriers in small streams for under $500.

Estimating water residence time distribution in river networks by boosted regression trees (BRT) model

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In-stream water residence time (WRT) in river networks is a crucial driver for physical and biogeochemical processes that contribute to the functioning of river ecosystems. WRT has been mostly considered in the context of run-off dynamics and wave propagation during flood events. WRT during normal flow condition is rarely observed and time-intensive to model, in particular at river basin scales. This study illustrates the potential of integrating spatial landscape analysis with machine learning statistics to understand the impact of hydrogeomorphology on the WRT in river networks, especially at large scales. We applied the Boosted Regression Trees (BRT) model for water residence time estimation, a promising multi-regression spatial distribution model with a consistent cross-validation procedure, and identified crucial factors of influence. Reach-average WRTs were estimated for the annual mean hydrologic conditions, as well as the flood and drought month. Results showed that the three most contributing factors in shaping the WRT distribution are river discharge (57%), longitudinal slope (21%), and the drainage area (15%). This study enables the identification of key controlling factors of the reach-average WRT, and estimation of WRT with rapid application under specific hydrological conditions. The resulting distribution model of WRT at the national level may serve to improve water quality modelling and water management practices that aim to estimate or maximise nutrient retention in river systems.

Community monitoring of water quality – do the *E. coli* numbers stack up?

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Monitoring water quality *E. coli* counts for Ecosystem Health and Human Health Recreation is undertaken by regional councils and laboratories and is of great public interest. Community participation in the Freshwater Management Unit consultation process and public interest in water quality has cultured the need for growth and upskilling in citizen science monitoring of local rivers and streams. The Parallel monitoring project illustrated that community monitoring of water quality can provide meaningful data that is comparable with regional council State of Environment programmes for some key water-quality attributes. The Friends of Maitai River Monitoring Group monitored *E. coli* counts over a range of flows, using different *E. coli* kits that are widely available. Replicate *E. coli* analysis was undertaken by two independent accredited laboratories and a parallel study of the *E. coli* kits was undertaken. The *E. coli* kits are evaluated by the community group using a range of criteria, including a stock *E. coli* sample, the variance of total *E. coli* counts with laboratories, user-ability of test kits, repeatability of methods and cost. This study further demonstrates that community river monitoring can contribute meaningful *E. coli* water quality data that provides an opportunity for community groups and educators to be more informed about local water quality issues and participate in the wider debate on clean water.

The application of a maatauranga whakapapa framework by Ngaati Tahu Ngaati Whaoa towards mahinga kai attributes within the National Objectives Framework

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In partnership with Waikato-Tainui, and with the support of NIWA, Ngaati Tahu Ngaati Whaoa (NTNW) have explored the application of processes and frameworks for structuring and organising maatauranga Maaori and Maaori aspirations within their rohe pertaining to freshwater mahinga kai. The processes and frameworks were developed by Waikato-Tainui as a part of the 'Ngaa Tohu o Te Taiao' project, a multi-institute collaborative effort that aims to develop knowledge tools and processes for setting freshwater limits for mahinga kai within the National Objectives Framework (NOF). Information was obtained from existing available knowledge of NTNW mahinga kai and follow-up interviews with iwi representatives as a step towards formulating locally relevant mahinga kai attributes for application in the NOF process. We will outline the application and exploration of the process and frameworks by NTNW, and provide a co-produced maatauranga whakapapa framework as an example and possible pathway for other iwi and hapuu to utilise when working with their own maatauranga Maaori.

Effects of climatic and trophic processes on freshwater invertebrate communities: recent insights from long-term studies of French streams and rivers

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In the field of macroecology, climate- and productivity-related factors are frequently identified as the strongest correlates of species-diversity patterns. These variables describe the action of climate on species, either directly by influencing physiological processes, or indirectly by controlling resource productivity or biomass. Being among the most vulnerable ecosystems to climate change, streams and rivers can experience both types of climate-induced effects and their consequences on communities. Here, we gather recent insights from multi-decadal studies investigating long-term responses of invertebrate communities to climatic and trophic changes in France. On the one hand, stream communities have been directly influenced by long-term hydroclimatic changes with a gradual increase in taxa exhibiting resistance and resilience strategies (e.g, small-sized organisms) at the expense of climate-sensitive taxa (e.g, typical from fast-running, cold waters). This general trend followed a latitudinal gradient supporting the predicted northwards colonisation/migration by Mediterranean species. On the other hand, additional long-term variations in invertebrate communities have been induced by trophic resource changes, either corresponding to a climate-induced trophic amplification, especially in headwaters, or related to water quality improvement. In both cases, trophic processes have promoted specialists of different resource types following either a productivity enhancement or a primary production transfer. As a result, these climatic and trophic changes have concomitantly contributed to the overall long-term increase in functional diversity of invertebrate communities throughout France. Nonetheless, beyond these present trends, invertebrate communities are threaten by the expected future warming due to distribution range contractions of the remaining sensitive taxa and/or competitive exclusions by the colonising tolerant taxa. These insights illustrate whether combining long-term and trait-based approaches can help to disentangle direct, indirect and confounding merged effects of environmental drivers on biological communities, with functional relevance for understanding and predicting community dynamics over broad spatial scales.

Influence of species, hydrological disturbance, and habitat size on the trophic position-body mass relationship of freshwater fishes

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Body mass and corresponding stable isotope-derived trophic position of fishes have been found to be correlated in marine and tropical freshwater taxa. This relationship supports the ecological theory that trophic position of omnivorous or predatory fishes increases as they grow larger and are able to prey upon items higher in the food chain through increased gape size and mobility. However, this relationship has not been explored in temperate freshwater fishes. Because trophic position is a heavily-used metric in freshwater ecological studies, it is advantageous to quantify the trophic position-body mass relationship of fishes to understand what modulates it. Additionally, if trophic position and body mass are closely linked, predictive regressions can be calculated that will eliminate the need for lethal stable isotope sampling, and body mass data can be collected instead. We investigated this by measuring body size and collecting stable isotope samples from ten fish species in 59 stream reaches in Canterbury. We found that the relationships between trophic position and log of body mass were poor when pooled over all taxa (R^2 = 0.16), but species-specific relationships were more robust in many instances (R^2 >0.4). Despite low predictive power, fish mass significantly affected trophic position in all cases (P <0.03). Some species with distinct body shapes and life histories exhibited unique relationships (e.g., longfin eels and juvenile Chinook salmon). Finally, we found that hydrological disturbance significantly affected the trophic position-body mass relationship for some taxa. Our results illustrate that body mass and habitat variables significantly affect the trophic position of freshwater fishes, but body mass is not correlated well enough with trophic position to substitute for stable isotope-derived measures.

Evaluating the likelihood of fish passage success at culverts in New Zealand using expert knowledge

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Migratory fish species are dependent on connected habitats to complete their life cycles. Instream structures such as culverts, weirs and dams can impede the movement of migratory species. Disruptions to migratory pathways impact ecosystem health by reducing the abundance and diversity of species present. A number of metrics are available for quantifying habitat fragmentation within river networks, but they are dependent on sufficient information being available on the location and severity of migration barriers. Characterising the likelihood of fish passage success at instream structures requires information on the characteristics of the structure and the capabilities of fishes. Biotelemetry and mark-recapture studies are the most effective approaches for quantifying passage success, but are impractical for broad-scale evaluation of multiple instream structures. Bayesian networks offer a flexible approach for deriving probabilistic models suitable for broad-scale rapid assessment of instream structures for barrier severity. We present a Bayesian network derived for evaluating the probability of fish passage success at culverts in New Zealand. A formal expert elicitation process was utilised to populate the prior probability distributions in the model. We present the results from 300 culverts in the Waikato region where the model has been applied. By taking advantage of expert knowledge, the model offers a practical and objective approach for rapidly quantifying the likelihood of fish passage success at multiple instream structures without the need for resource-intensive biotelemetry studies. The results are also consistent with requirements for developing environmental reporting metrics for stream connectivity and the model has been used as the basis of a new fish passage assessment protocol for New Zealand.

Water quantity limits to support multiple values in New Zealand rivers: are minimum flows enough?

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The New Zealand National Policy Statement for Freshwater Management (NPS-FM) sets out a framework for protecting freshwater values. Integral to this is a requirement to set environmental flow limits for all streams and rivers. The NPS-FM states that environmental flows must include an allocation limit and a minimum flow limit. Allocation limits define the total availability of water for out-of-stream use. Minimum flow limits define the flow at which all water takes must cease. This approach is consistent with long-standing practice in New Zealand of using minimum flow limits as the basis for protecting instream values. As demand for water resources has increased in New Zealand and elsewhere, the suitability of minimum flow limits for providing adequate protection to instream values has been questioned. For example, minimum flows alone do not provide protection for flow variability which is known to have important ecological and geomorphic functions. Furthermore, while there is an expectation that multiple values should be accounted for in determining appropriate environmental flow limits, the often-used assumption that minimum flow limits set to protect instream physical habitat for fish are sufficient to also protect both ecosystem health and other freshwater values, e.g. cultural and recreational, has been challenged. Moreover, resource managers have expressed concern over the availability of suitable tools and decision support systems for defining justifiable and transparent limits that support the competing demands of multiple freshwater values. In this presentation we summarise these challenges faced by resource managers in New Zealand and ask the question: are minimum flow limits enough to provide adequate protection for multiple values of streams and rivers?

Zooplankton influence on algal dynamics in rivers.

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Algal blooms in rivers are often associated with foul smell, high concentrations of toxins and fish kills. They affect river amenity value and may damage water supplies. Harmful algal blooms can be prevented when all processes of their development and termination are fully understood. It has been established that factors such as residence time, water temperature, nutrient chemistry and light alone do not completely explain phytoplankton fluctuation in rivers. This study is focused on biological control of algal dynamics, mainly on zooplankton 'grazing' effects. It was conducted on the River Thames, UK. Zooplankton were surveyed weekly, between March-October 2015. Organisms were enumerated and identified to genus and possibly species levels from nine sites along the catchment, including three tributaries. The zooplankton were dominated by rotifers, with a maximum of approximately 9,000 ind./L recorded in summer in the lower-Thames. Every rapid increase in rotifer numbers occurred following centric diatom blooms, typically with a two-week delay. Micro-crustaceans were found mostly in larval stages and did not develop significant densities (maximum of 125 ind./L in spring in the middle-Thames), possibly due to short residence time. The significance of grazing impact on algal dynamics was experimentally tested at multiple sites across the Thames. A series of mesocosm experiments was undertaken in the growing season of 2016. In all experiments, phytoplankton and zooplankton diversity and densities were maintained close to their natural conditions. Temperature, light and nutrient concentrations were monitored. Experimental data revealed a moderate to non-significant grazing effect throughout the spring-summer period, with indications of small numbers of zooplankton actually promoting algal growth. Microscopic examination of fresh samples highlighted a rise in algal mortality due to algicidal bacteria and fungal parasites. Further work is being planned to explore this potential cause of high algal mortality.

Habitat assessment in an irrigation system conjoint with a spring-fed stream

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While water flows in an irrigation system are regulated, based on seasonal water requirements for agriculture, paddy environment is known as a biodiversity hotspot in Japan. For instance, many fish species migrate into agricultural canals right after the beginning of irrigation and use these temporary canals for spawning and nursery purposes. However, such a good habitat can turn into a poor habitat after irrigation is stopped. It is therefore important to understand the seasonality of flow patterns and habitat conditions for an improved management strategy of such an environment. This study provides a report of monthly habitat surveys at 14 reaches each in the Fuchu Yosui Irrigation System and Yagawa (i.e., a spring-fed urban stream) flows into the irrigation system. Results clearly indicate the differences in fish composition between two study sites and the seasonal changes specifically in the irrigation system. It may be necessary to analyse habitat conditions considering permanent and temporal water flows as observed in the two study sites.

Integrating geomorphology and ecology for resilient river engineering

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Flood protection schemes typically involve channel straightening and a reduction in geomorphic complexity. Engineered rivers are also usually fixed in place to reduce channel migration. These engineered rivers are expensive to maintain. Disconnection with adjacent floodplains limits replenishment of bedload calibre sediment leading to bed degradation, which undermines costly hard-rock bank protection. These rivers are highly vulnerable to catastrophic failure when floods occur that exceed their design limits. Furthermore, in a narrowed, deepened, simplified form, these rivers lack the diversity of habitat to sustain healthy river ecosystems. This paper reports on an approach that integrates geomorphology and ecology to encourage river engineering that is more resilient to catastrophic failure, and provides a diversity of habitat for aquatic life. We achieve this objective at a number of levels. Firstly, by using archive material to assess pre-engineered channels, we identify natural equilibrium river forms. This state of the river is then compared with the current river condition, and a river habitat quality index (HQI) quantified to identify the scale of change from pre- to post-engineered channel assemblage. The HQI can then be used to recommend changes for future river engineering to improve resilience and habitat quality. Secondly, a similar pre-and post-engineering assessment can then be executed to establish the nature and extent of changes effected by engineering intervention. We illustrate the integration of geomorphology and ecology to derive a habitat quality index at different temporal and spatial scales using case studies from New Zealand, including the Hutt, Otaki, Waikanae and Motueka rivers.

Gene flow simulations demonstrate resistance of long-lived species to genetic erosion of habitat fragmentation

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Habitat fragmentation restricts the movement of individuals across a landscape. In both terrestrial and aquatic systems, barriers to organism movement can modify population and community dynamics—demographic change of a species and community assembly—at local or regional scales. This goal of this study was to contrast the life history trait of longevity with habitat fragmentation to determine the impacts on species population genetic structure. This contrast was made by simulating gene flow among populations in a river network and tracking the genetics of individuals and populations for 200 years. The modelled scenarios represent a full cross between five life history strategies—longevities—and four riverscapes representing varying degrees of fragmentation. The five life history strategies include species with average lifespans ranging from 10 to 50 years. The movement landscapes ranged from fully fragmented to panmictic with a stepping-stone landscape allowing movement to only neighbouring populations for each dispersal event and a fragmented landscape divided by the dams currently standing in the network. It was expected that scenarios with more restricted movement would exhibit greater population genetic structure, lower observed heterozygosity, and lower allelic richness at the end of the 200-year simulation. Furthermore, scenarios simulating species with short average lifespans should have greater population genetic structure than species with long lifespans.

Effectiveness of whole ecosystem and in-stream lime applications to restore acid-stressed Adirondack Mountain stream communities: leaf decomposition and nutrient uptake responses

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The Adirondack Mountain region is particularly susceptible to the effects of acid deposition, and a potential restoration strategy is to add pelletised limestone directly to stream channels or across entire drainage basins to neutralise incoming acid. We studied the impact of lime amendments in five streams. Two episodically acidic had lime applied annually directly to stream channels, and in 2013, we aerially applied lime to the whole drainage basin of one chronically acidic stream. We compared rates of leaf decomposition and microbial respiration as well as macroinvertebrate community composition in all streams for both summer and autumn in 2012, 2014 and 2015. Leaf decomposition and microbial respiration rates were lower in chronically acidic than episodically acidic streams, and overall, decomposition rates were highest in summer. In-stream lime applications that increased stream pH did not result in an increase in leaf decomposition or microbial respiration rates nor was there any shift in macroinvertebrate community composition. However, the chronically acid stream within the catchment that was aerially limed did show an increase in pH and leaf decomposition and microbial respiration rates were higher in 2015 compared to the chronically acid reference stream in an adjacent catchment. While it took more than a year to observe this shift, it does suggest that whole ecosystem aerial applications may be a more successful mitigation strategy. Ammonium and phosphorus uptake dynamics showed no differences that related to levels of acidity despite lower microbial respiration rates in the chronically acid stream. We did observe shorter uptake lengths for ammonium in summer and phosphorus in autumn suggesting that with leaf abscission in autumn, nitrogen may be less limiting than phosphorus. Our results suggest that ecosystem functional metrics are slow to respond to improved chemistry from in-stream lime amendments whereas aerial lime applications may be more successful.

Juvenile trout mortality in a river subject to persistent and extreme water abstraction - how frequently are we underestimating the flow needs of fish populations in New Zealand?

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To assess the impacts of water abstraction on fish populations, we studied juvenile trout movement and mortality during summer low flows in the Lindis River, Central Otago, New Zealand. Water abstraction for agriculture in this river has historically resulted in a residual summer flow ≤ 25% of the MALF for 75–100 days each year. The movements of >1,000 juvenile brown and rainbow trout (age 0+ and 1+) were tracked over two summer low-flow periods using passive integrated transponder (PIT) tags. PIT tagging occurred at the onset of extreme low-flow conditions, which resulted in 20–35% of the study reach drying up during the study period each season. Our mark recapture analysis shows that annual low-flow events, exacerbated by water abstraction, result in the death of > 60% of the trout population within six weeks. We also found evidence that increased predation pressure, due to reduced habitat cover and loss of connectivity, was the primary cause for the unusually high mortality rates. These results show that predictions of trout population responses to water abstraction based on physical habitat modelling alone can be overly simplistic, by failing to account for ecosystem effects such as increased vulnerability to avian predation at low flows. Moreover, this study highlights the importance of evaluating the influence of habitat suitability curves on predicting flow requirements of fish populations.

Light regime in a large river using flow-path, snap-shot, and fixed-site measurement approaches

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Rivers are complex systems. However, our understanding of rivers, as well as many other ecosystems, is largely derived from measuring or modelling one or more fixed locations over time. Alternative measurement approaches include: (1) a synoptic approach, taking a snap-shot across space at one point in time (e.g, remote sensing); or (2) a flow-path approach, tracking objects through space and time (e.g, drifting sampling, animal tagging). We applied all three of these approaches to understand the underwater light regime in large US rivers. We measured vertical light profiles over time with fixed-site sensors, over space with synoptic profiles from a boat, and over space and time with a neutrally buoyant autonomous sensor platform that moves with the river currents. Light extinction coefficients were comparable between the three measurement approaches. However, the flow-path approach revealed there is high variability in the light exposure of a neutrally buoyant particle as it moves throughout the water column. On average, a particle was in the euphotic zone 50% of the time, and less in deeper and/or more turbid rivers. Light is a fundamental control of metabolic processes in aquatic systems, and in large rivers the high variability in light intensity derived from planktonic particles movement through the water column may be an important control.

Minimum flow considerations in estuaries

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Around the world, estuaries are some of the most impacted aquatic ecosystems, often located where the tension between human and ecosystem needs is most acute. The provision for environmental flows in river systems has been increasing for the past decade, and in New Zealand, the National Policy Statement for Freshwater Management stipulates the setting of minimum flow limits. The established methods for this include hydrological, hydraulic and habitat-based assessments. However, the application of these methods may not be appropriate in estuaries because of high-frequency water-level fluctuations, and the influence of seawater which alters the relationship between water level and circulation patterns, and affects other physicochemical variables such as dissolved oxygen levels and salinity. Additionally, static or minimum water levels may not be critical compared to the impact of changes in the dynamics of the movement of the tidal prism, which is influenced by changes in upstream flows. We discuss some considerations for setting minimum flows limits in estuaries and suggest a three-stage approach for minimum flow setting in estuarine reaches. The staged approach we propose involves: (1) Identifying values, issues and drivers along the estuarine reach; (2) Characterising spatial and temporal relationships; and (3) Investigating the details of the relationship between flow and drivers of ecological change. As a case study, we consider the Manawatu River estuary, and discuss a monitoring program to characterise spatial and temporal relationships between flow and drivers of ecological change. We identify how the data collected during the monitoring program can assist with subsequent investigation of the details of flow-ecology relationships.

Aquatic ecosystem restoration: priority setting and indicators of success

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Streams and rivers are among the most heavily degraded ecosystems worldwide. There is a pressing societal need to reverse the decline in biodiversity and replace lost ecosystem functioning and services by enabling natural recovery or by active restoration. Substantial effort has been invested to improve and restore aquatic habitats in Europe, including aspects of water quality, structural diversity, and connectivity. Still, indicators of restoration success are not clearly defined and management decisions are often based on gut feeling rather than on scientific evidence. Many of the realised restoration projects have not yet resulted in the expected recovery of target species and communities, or have failed to properly record and assess changes following restoration. This contribution thus investigates the factors which are crucial for the success of stream rehabilitation using concrete examples of restoring stream beds, restoring connectivity, and introducing fish habitat structures. It also differentiates how the openness of a system affects the degree to which active restoration versus passive recovery can be most effective. Seven steps of successful restoration planning based on ecological, technical and socioeconomic criteria are proposed. Restoration schemes need clearly defined target states. They should generally take an evidence-based, process-oriented and step-wise management approach, judging success against reference or control sites. In addition to the ecological-biological targets and technical requirements, societal and political expectations need to be managed. Especially within urban settings, restoration schemes should not promise too much. The current approach of prioritisation in restoration which often targets a "good ecological status" or "good ecological potential" in highly degraded systems is questioned as it was only found to support generalist species. An alternative prioritisation is suggested in which the least degraded systems are selected for a process-based restoration which aims at providing key habitats for keystone species.

An introduction to wetland delineation protocols in the USA

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Wetlands often have important water connections to adjacent lakes, streams and rivers. Wetland boundary determination therefore is critical for the protection and regulation of this important resource and to their adjacent water bodies. In the United States, discharges of dredged and fill materials in waters and wetlands are regulated under the Clean Water Act (Section 404). Accurate determination of the wetland boundary, termed wetland delineation, follows a standardised protocol in the US Army Corps 1987 Wetland Delineation Manual which has been updated in recent regional supplement additions. The wetland delineation process identifies where a wetland legally starts and stops. Many people however do not fully understand the process of wetland boundary determination. This presentation will focus on the history of US wetland boundary determination, the wetland delineation process, types of wetlands found in the Upper Midwest, and their protection.

Do cyanobacteria blooms develop inshore or in the middle of the lake?

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Contact with toxic cyanobacteria can cause illness in humans and death to dogs. Skin irritation is one common effect but inhalation of the vapour or spray from a cyanobacteria bloom while swimming or boating can cause headaches and respiratory distress, and ingestion of cyanobacteria-contaminated water can result in liver damage and kidney failure. Human contact with cyanobacteria often occurs around the shores of a lake where the proliferation of cyanobacteria may be seen as a surface scum in the edge waters. These scums are attributed to the accumulation of wind drift cells from cyanobacteria growing in the middle of the lake and, in some lakes, can reach bloom proportions. While this is a well-accepted interpretation, it raises the question of where the bloom began – in the middle of the lake or in the edge waters? Observations, from some North Island, New Zealand, lakes suggest that the bloom may actually develop in the edge-water and move out into the lake before being blown back in-shore to form the surface scum. This paper looks at the mechanisms that could stimulate the development of a cyanobacteria bloom in the shallow edge-water of some lakes. Determining where the bloom first develops could be fundamental to understanding how cyanobacteria blooms grow and their subsequent management in lakes.

The world's largest waterborne campylobacteriosis outbreak: Havelock North, August 2016

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In August 2016, over 5,000 people become ill with campylobacteriosis following consumption of reticulated water in Havelock North, New Zealand. Campylobacter have been isolated and genotyped from over 200 clinical isolates, reticulated water samples, groundwater samples, surface water samples and animal faecal samples. In the initial stages of the outbreak investigation, Multiplex Binary Typing (MBiT) analysis confirmed a linkage between cases and the water one day after receipt of primary isolation plates, while whole genome sequencing (WGS) was completed another three days later. Source attribution suggested that isolates were likely to be from ruminants. Five main genotypes of campylobacter were found in clinical cases, with three of these also found in reticulated water, two in the bores, and three in sheep faeces. Both wgSNP and wgMLST were used to confirm linkages. A number of pathways for sheep faeces to contaminate the bore have been investigated. In common with most waterborne outbreaks, this event is the result of the combination of a very heavy rainfall event, close contaminant source, and inadequate treatment of the water (in this case, no treatment).

Dispersal and fate of augmented gravel in a boulder-bed channel: early implications for restoring salmonid habitat

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Gravel augmentation is a method for partially offsetting the adverse impacts of dams on downstream salmonid spawning habitats. Here, over 400 tons of gravel over a three-year period was introduced at a number of locations of the regulated River Avon (Devon, UK). The dam is 33-m high with the river downstream for the most part being boulder-bed with intervening gorge-like sections and varying in width from five to 15 meters. Unlike augmentation in alluvial reaches where gravel dispersion is generally understood to intersect with riffle-tail spawning habitats, the benefits of gravel dispersing through a high-energy hydraulically rough channel is far from certain. Monitoring using seismic impact plates, RFID-tagged particles and fluvial audit is aimed at establishing particle mobility rates, dispersal distances and depositional settings to assist in determining appropriate volumes, frequencies and locations for future augmentation. Over 500 "tagged" particles have been introduced into the river over the last three years and tracked within two 500-metre reaches. Impact plates downstream of the lower most-gravelled augmentation site have received over 300,000 impacts. In addition, a fluvial audit was undertaken over a 5 km reach downstream of the dam. 234 individual gravel accumulations have been mapped, and coded according to size, and depositional setting. A comparable dataset also been undertaken on a nearby un-dammed river to act as a reference condition. Analyses indicate that augmented particles have been transported downstream with a number of "tagged" particles found in excess of 400 metres below augmentation locations. The augmented gravels are creating a variety of gravel habitat predominantly at channel margins, in the lee of boulders and in lower stream power reaches. The biological significance of the accumulations has yet to be quantified.

Analysis of bedload transport processes during flood events based on numerical simulations

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In Austria recent floods demonstrated the vulnerability of mankind against such events and highlighted the central importance of knowledge about bedload transport and yields for an enhanced sustainable flood risk management. Therefore a national network of gauges, including an integrative bedload monitoring system at the Drau River, has been developed over several years for collecting bedload transport information. Although the integrative bedload monitoring system consists of geophones, basket samplers and slot samplers, collected data are still limited to a certain spatial as well as temporal extent. Therefore the application of numerical models provides the opportunity to broaden the spatial and temporal perspective. The presented study aims to use the existing data set for setting up and calibrating a numerical sediment transport model of around 600 m length at the Drau River. Objectives of the modelling tasks were given by: (1) improving the understanding of sediment transport processes in general, such as intermittent transport by gravel sheets, and (2) in particular expanding knowledge about transport processes taking place during floods when the river bed becomes fully mobile. The simulations were performed using the sediment transport model iSed, which is coupled with external hydrodynamic codes providing flow fields and bed shear stress patterns. Bedload was treated by solving a non-uniform variant of the transport equation by Meyer-Peter and Müller, while the bed evolution was determined from solving the sediment continuity equation (Exner equation). The existing measurement data set enabled a successful calibration of the sediment transport model. The simulation results show natural phenomena occurring during flood events including variations of bedload yields and grain size distributions. In future the sediment transport model will be used to improve calculations of bedload transport yields, i.e. by filling gaps in observed time series, and facilitate a better understanding of the processes occurring at the river bed.

Characterising the scales and sources of nitrate export in agricultural waterways in Canterbury, New Zealand

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A vast network of surface- and subsurface drains supports agricultural production on the Canterbury Plains, South Island, New Zealand. However, these drains can transport significant amounts of leached soil nitrate and nitrate from shallow groundwater/springs downstream, circumventing riparian protection networks. Within the Canterbury Waterway Rehabilitation Experiment (CAREX), we quantified nitrate export in 9 one-kilometre long lowland agricultural headwaters <2 m wide to characterise local vs. regional influences on leaky plumbing. We measured nitrate concentrations and discharge at least monthly for 4 years. These data were used to estimate seasonal mass loads (tonnes 90 d^{-1}) and fluxes (kg d^{-1}) to characterize the seasonal and spatial scales of downstream nitrate export. Across-site differences in upstream/spring-source water nitrate concentrations generally predicted differences in annual nitrate loads downstream (<1 to >50 tonnes NO_3-N 365 d^{-1}). Nitrate loads were higher in wet seasons (autumn and winter) and wet years, reflecting strong groundwater influences. Within sites, longitudinal increases in nitrate export likely reflected the relative contributions of groundwater to base-flow nitrate loads downstream; however, nitrate export from tile drains was more variable and sometimes substantial within waterways. Fluctuations in nitrate export from tile drains were more strongly tied to changes in tile drain discharge, while these relationships were much weaker at the downstream end of the 1-km sampling reaches. Characterising the timing and contributions of regional groundwater/springs versus leached soil nitrates from tile drains will help identify the scales and locations for nitrate mitigation tools to reduce downstream nitrate export in small Canterbury agricultural waterways.

Changes in hydrologic connectivity of the largest river basin in Chile: effects on native fish with different dispersal abilities

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Alterations to longitudinal and lateral riverine connectivity have strong implications for the population processes and structure of native fish communities. These connectivity alterations are expected to have differential effects, dependent on a fish species' dispersal abilities. The Biobío River, located in central Chile, is the largest river basin in the country and accommodates the highest fish diversity among Chilean rivers (18 native and four introduced species). The Biobío River has experienced significant changes in hydrologic connectivity in recent decades due to anthropogenic activities e.g., construction of dams and land use intensification. We quantified the present state of connectivity alterations in the basin and assessed future fragmentation (in the year 2050) based on proposed and ongoing projects. Subsequently, we assessed the effects of hydrological connectivity changes on fish, based on historical catch records (2006-2016). We found that fragmentation of the basin caused by hydropower dams and road culverts significantly altered fish communities in the basin. Species with high dispersal abilities, migratory life-stages and broad home-ranges (e.g. silverside *Basilichthys microlepidotus* and lamprey *Geotria australis*) were affected most severely and experienced local extinctions upstream of the barriers. Furthermore, several rare native species. e.g., *Nematonegys inermis, Brachygalaxias bullocki, Diplomystes nahuelbutaensis* and *Trichomycterus chiltoni,* have experienced severe population fragmentation over the last decades. According to our results the Biobío River will experience a rapid increase in fragmentation in upcoming decades (42% and 43 new dams until 2050) due to new hydropower projects. Our analyses underscore the urgent need for conservation measures to preserve and enhance populations of rare species, and for the implementation of measures such as fish-passes allowing mitigation of future fragmentation in planned projects.

The role of macroinvertebrates in nutrient processing in the Tukituki River

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The Tukituki River is a nutrient-enriched, highly productive system which supports incredible densities of macroinvertebrates - up to 30,000 per square metre! Such a large number of invertebrates is likely to have a strong influence on periphyton growth and nutrient dynamics. Macroinvertebrates affect nutrient processing via: (1) grazing on periphyton, which controls biomass accumulation and enhances active growth; (2) recycling nutrients directly through excretion; (3) transferring nutrients up the in-river food chain to fish; and (4) removing nutrients from the river as emergent insects which are incorporated into terrestrial food chains. We estimated the N and P flux at nine sites along the Tukituki River between 2012 and 2017. In-stream standing stock of nutrients was calculated using periphyton and larval invertebrate biomass, in-stream export was measured as downstream drift of sloughing algae and larval invertebrates, and nutrient removal was estimated as uptake by periphyton and emergence of adult insects. Multiple methods of estimating adult emergence were compared, including collection of adults in emergence traps, counting the number of pupal exuviae in the stream surface drift, and assuming 1% emergence of larval biomass. The amounts of nutrient removal estimated by each method were highly variable, indicating that more accurate techniques of determining adult emergence are still required. We found that insect emergence can export up to an additional 1/3 of the total reach nutrient removal, and is therefore an important nutrient removal mechanism which needs to be included in investigations of N and P dynamics at the stream-network scale.

Contaminant load limits and the "critical point"

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Collaborative planning processes under the National Policy Statement for Freshwater Management (NPSFM) are required to limit resource use to achieve agreed values, which may require setting contaminant load limits to achieve objectives. Values are typically translated into numerous objectives. We explore the concept of the "critical point", which arises when confronted with the challenge of setting load limits to achieve multiple, spatially distributed objectives in receiving environments throughout a catchment. The critical point is a location along a contaminant-transport pathway that requires overachievement of objectives at one or more upstream locations to achieve the local objective. This may result in a perception of inequity, with upstream landowners having to work hard to achieve distant objectives, while overachieving local objectives. There is nothing "intrinsic" about the critical point; they depend on objectives, which are decided in the planning process, and on the spatial arrangement of contaminant sinks, which is a physical property of the system. When there is a critical point, we need to consider the whole system at once to set "balanced" load limits; but, when there is no critical point, we can set load limits at different locations in isolation of each other. To achieve the objective at a critical point, assimilative capacity must be transferred down from upstream. A simple contaminant accounting scheme can readily calculate the transfers of assimilative capacity that are needed to ensure all objectives are achieved. The accounting scheme should be applied to the set of receiving environments that are connected to each other by the flow of contaminants along transport pathways. This might be different for different contaminants, for instance, contaminants that are conveyed primarily by surface water compared to those with groundwater paths. Being significantly affected by contaminants transported in freshwater runoff, estuaries clearly should be considered together with freshwater receiving environments for the purposes of limit setting.

Centrifugal Macrophyte Elutriation (CME): a novel method to separate macroinvertebrates from organic matter in streams with high macrophyte biomass

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True quantitative macroinvertebrate sampling of macrophytes can be highly resource- and labour-intensive due to the volume of samples collected and time spent separating macrophytes from macroinvertebrates. Accordingly, we designed and trialled a novel Centrifugal Macrophyte Elutriation (CME) apparatus to separate macroinvertebrates from macrophytes on the stream bank. The apparatus is a heavily modified, manually driven 20-litre salad spinner that is capable of spinning large macrophyte samples at 555 rpm. The unit has lateral and vertical water jets installed on the lid and outer wall, which provide a continuous water supply to flush macroinvertebrates from the spinning plant material and out through a sample collection port. Five macrophyte samples were harvested with a traditional Hess sampler to test the performance of the CME apparatus. Each sample was spun for eight 30-second, "wash cycles" to produce nine macroinvertebrate sub-samples including the residual macrophyte material. Maximum likelihood models for calculating density from depletion sampling techniques were then used to estimate total macroinvertebrate abundance in each macrophyte sample at each consecutive wash cycle. Estimated abundances were then compared to total measured abundance, to determine if standard depletion methods can be used to calculate macroinvertebrate densities from CME sampling. Analysis of CME sampling results using maximum likelihood models proved an accurate method of estimating total macroinvertebrate abundance, and initial results suggest that five 30-second wash cycles may be sufficient to estimate density to within ± 5%. Although further trials are required to confirm the efficacy of CME sampling, our results suggest that this methodology may significantly reduce the resources required to quantitatively sample macroinvertebrates in macrophyte beds by eliminating the need to sort through plant material in the laboratory.

Manuka-dominated ecosystems to improve water quality and provide economic and social return to the Lake Waikare catchment

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The strategic importance of Lake Waikare and the Whangamarino wetland as the lungs and kidneys for the lower Waikato are recognised by local iwi. These areas have multiple cultural, ecological, recreational and economic values. The health and wellbeing of the lake and surrounding catchment is degraded by high inputs of nutrients, sediment, algae and bacteria from farm run-off and removal of the vegetation filtering potential around lake margins. This in turns impacts on the spiritual and social connections of the mana whenua of the lake. Laboratory, lysimeter and small field trials conducted by the Centre for Integrated Biowaste Research (CIBR) have shown that bioactive/antimicrobial compounds produced by myrtaceaeous plants, especially mānuka *(Leptospermum scoparium)*, may inhibit the conversion of ammonia into nitrate and nitrous oxide, and also enhance the die-off of pathogenic organisms in the wastes that pass through their root systems. We hypothesise that incorporating such plants into biodiverse riparian planting schemes has the potential to both filter and inactivate pollutants from intensive agriculture leading to improvements in water quality. A collaborative project between CIBR, Ngā Muka Development Trust, Te Riu o Waikato Ltd, Matahuru Marae/Nikau Whanau Farm Trust and Waikato Regional Council, funded by Waikato Rivers Authority, is the first working example of mānuka-dominated riparian zone planting (four hectares) along the margins of Lake Waikare. The objective of this project is not only to demonstrate active reduction of the amount of nitrate and *Escherichia coli* leaching into the lake, but to restore the natural ecosystem that was lost, according to the expectations of the mana whenua of the lake. Initial learnings from the project and environmental and social linkages identified, will be discussed.

Modelling of trophic state of New Zealand lakes and visualisation with the geospatial platform Takiwa

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Takiwa is a geospatial platform for visualising New Zealand lake data. Over the past two years its capabilities have been progressively increased to provide a comprehensive repository for lake morphology, high-frequency sensor, satellite and routine monitoring data, stream typology and soil information for lake catchments, hydrology, meteorology and literature. Information to support the visualisation is sourced at scales from national databases to individual lake-monitoring points. We have used national-scale information on water, total nitrogen (TN) and total phosphorus (TP) yields from lake catchments, obtained from the CLUES model, as input data for in-lake TN and TP mass budget models from which it is then possible to empirically derive annual mean chlorophyll a (chl α) concentrations. This information has been used to calculate TN, TP and chl α concentrations for >800 lakes of area >2 ha. Multiple mass-budget and nutrient–chl α models are used to generate a range of output concentrations and convey to the Takiwa user a probabilistic element to the predictions. Further work is being carried out to compare model outputs with measured data. The model outputs have been contextualised by visualisation in Takiwa relative to the bands (A, B, C and D) in the National Objectives Framework of the National Policy Statement for Freshwater Management. An interactive component has been added to the Takiwa platform so that users may adjust nutrient loads in order to meet objective criteria (i.e., to maintain or improve water quality based on TN, TP and chl α outputs). Takiwa provides a valuable tool to be able to visualise water quality at scales ranging from an individual lake to the whole of New Zealand.

Ecosystem productivity dynamics in a rare chain of ponds system: Mulwaree Ponds, Southern Highlands, New South Wales, Australia

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Mulwaree Chain of Ponds is a geomorphically rare aquatic system in eastern Australia. Apparently stable and in a highly altered agricultural setting, these ponds are uncharacteristic of local river systems. The deep, large ponds are connected by shallow, vegetated and discontinuous preferential flow paths. Margins of the ponds are vegetated by aquatic, mostly rhizomatous or stoloniferous plants, including *Triglochin procera, Vallisneria gigantea, Phragmites australis* and *Eleocharis sphacelata*. Once flow is disconnected during summer, these ponds become strongly stratified, related to dissolved oxygen, temperature and electrical conductivity; and with a euphotic depth (z1%) of up to six metres. This unusual ecosystem provided an opportunity to investigate some of the functional processes driving production, respiration and decomposition during connected and disconnected flow periods. Use of light and dark bottles, combined with phytoplankton methods and *Triglochin* procera leaf decomposition, has enabled initial understanding of the ecology of this rare system. Light and dark bottles were incubated in-situ at depths mid-pond and at three points in the vegetated margins for 24 hours to investigate community production, with chlorophyll A, nutrients and water quality also measured. Leaf litter bags with mesh size 9 mm and 150 micron and cotton strips were used to measure total, microbial and standardised decomposition respectively over 21-28 days, mid-pond and within the vegetated margins. Maximum mean gross production at the pond surface (562 mg/m^3/d), during mid-summer, significantly declined below the oxycline (30 mg/m^3/d) during disconnection. These patterns were not reliably matched by chlorophyll a levels at the same sample points. Total to microbial leaf litter decomposition varied with each sampling, with microbial significantly less than total carbon loss (89 cf. 68%, n=32, $p<0.05$ mean carbon loss on ignition), indicating impacts by invertebrates and fish. Additionally, small individual pond effects such as cattle grazing and recreational activities altered pond dynamics.

Effects of connectivity on benthic macroinvertebrate community structure of secondary channels in the Mississippi River, USA

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In the free-flowing lower Mississippi River, secondary channels are numerous and provide a substantial amount of riverine habitat, comprising roughly one third the total length of this 1500 km reach. Availability of this habitat for use by riverine organisms is critical in their life cycles, because unlike the main channel, which is heavily engineered for navigation and flood control, secondary channels retain natural habitat features including natural steep banks and a higher proportional riparian interface. In this system, however, most secondary channels are periodically disconnected from the main channel by the implementation of dikes at their upstream opening that serve to maintain a self-scouring navigation channel. When channels become disconnected at low river stages, lotic habitats instantly transform into lentic environments comprised of pools and in some cases become completely dry. By sampling the benthos of a series of secondary channels spanning a gradient of hydrological connectivity to the main channel, we investigated the biotic response of macroinvertebrate communities, as well as potential impacts on resource availability for both macroinvertebrates and fish. Our results indicate a lasting negative impact of seasonal disconnection on riverine communities, particularly for maintenance of a permanent species-rich macroinvertebrate assemblage. Additionally, we found that recent efforts to increase connectivity by notching dikes positively impact secondary channel benthic communities, and argue that more efforts be taken to increase secondary connectivity. Restoration efforts like these, along with efforts to diversify habitat by increasing structural complexity and substrate heterogeneity, are the next steps in maximising the restoration potential of these invaluable riverine habitats.

Invertebrate drift transport modelling: it's been a wild ride!

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Understanding and predicting the flow dependency of passive invertebrate drift is important for assessing effects of flow regime change on aquatic invertebrate dispersal and drift feeding fish. We borrowed concepts from sediment transport theory to provide the process-based foundation for constructing a drift transport model for predicting relationships between flow and invertebrate drift concentration and drift flux. These concepts include: entrainment, settling, advection, diffusion, and dilution. The model is calibrated against observed drift concentration by tuning an entrainment function that operates on bed shear stress, which, along with other hydraulic data, is provided by a 1d or 2d hydraulic model. Perfecting the calibration procedure has been a challenging task. We tested the model against observed drift concentration x flow data from two rivers (Mataura and Oreti). Daytime invertebrate drift concentration varied spatially and with discharge over natural flow recession largely consistent with passive entrainment. Total community drift concentration decreased with decreasing flow, but we found considerable variation in the pattern of flow response among taxa. The drift model performed reasonably well in predicting drift concentration x flow relationships for total community drift and the most drift-prone taxa. It also demonstrated that in unconfined, gravel-bed channels the positive relationship between drift concentration and flow arises from entrainment dominating over dilution. Our empirical and modelling results demonstrate that flow reduction diminishes the capacity of rivers to entrain and transport invertebrate drift, which has adverse consequences for drift-feeding fish and invertebrate dispersal/colonisation.

The paradox of integrating immigrants: How salmonids have shaped freshwater values, water wars, environmental policy, and research in New Zealand

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The paradox of integrating introduced salmonids in the management of multiple aquatic values is that, on the one hand, they provide New Zealand's most valuable freshwater fisheries while on the other hand, invasive trout have adversely affected indigenous aquatic fauna. The paradox runs deeper in that salmonid fisheries are among the freshwater values that have most constrained exploitative use of water in New Zealand, and environmental legislation and policy implemented to protect salmonids and their habitat has benefited native fauna. Moreover, environmental campaigns mounted to fight water wars against unsustainable land and water management have in large part been bankrolled by trout and salmon anglers, through Fish and Game councils and Acclimatisation Societies. Yet the emergence of indigenous conservation ideology, most recently expressed in the vision for "predator-free New Zealand", and associated anti-trout sentiment, threatens to alienate trout anglers and thereby divide a united stance against unsustainable natural resource management. In addition to contributing to New Zealand's outdoor cultural heritage, salmonid fisheries, because of their value, have been the catalyst for much of New Zealand's freshwater fisheries research, some of which is internationally renowned. The challenges of modern natural resource management require multi-disciplinary, predictive science. Of all our freshwater fish fauna, salmonids are the most amenable to this kind of science because of the extensive international knowledge based on them. I illustrate such research from my career in fisheries research and ecohydraulics and suggest that insights learnt from process-based research on trout also apply in principle to native fish. A paradigm change in understanding of the potential effects of flow change on drift-feeding trout arising from this research sets these inconvenient fish on a new collision course with intensified agriculture and hydro-power lobbyists and like-minded politicians.

Climate reconstruction using the New Zealand freshwater bivalve *Echyridella menziesii* from Lake Rotorua

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Geochemical information stored in bivalve shells has been successfully used in climate reconstructions in the Northern hemisphere, but such studies are scarce in the Southern hemisphere. Here we explore the potential of shells of the freshwater bivalve *Echyridella menziesii* from Lake Rotorua to be used as a proxy local climate archive. Bivalves were collected live from Lake Rotorua each month for 13 months from May 2016. Water parameters (trace element concentrations, stable isotope content, chlorophyll a, dissolved organic carbon, temperature and pH) were monitored over the same period close to the bivalve bed in Lake Rotorua. The bivalve shells have an aragonitic nacro-prismatic microstructure, covered by a thick organic periostracum. Polished thick sections of the shells show dark coloured lines that appear to develop during low growth periods. The formation of these lines is currently under examination to determine whether they can provide accurate age and growth rate estimates for *E. menziesii* in Lake Rotorua. High-resolution oxygen isotope ratios in shells measured by secondary ion mass spectrometry indicate a seasonal pattern with high δ18O values in winter and low values in summer. We have converted these ratios into reconstructed temperatures that agree well with measured lake water temperatures. Sr, Ba and Mn concentrations in bivalve shells were measured in situ by high-resolution laser ablation inductively coupled mass spectrometry (LA-ICPMS). Sr/Ca, Ba/Ca and Mn/Ca ratios in the shells show cyclic patterns responding to changes in the ambient environment. Relationships between these element/Ca ratios with various climate parameters will be presented and discussed.

Updating the ANZECC water quality guidelines for copper and zinc

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The Australian and New Zealand Environment and Conservation Council (ANZECC 2000) water quality guidelines are currently being updated. In New Zealand, the metals copper and zinc are of considerable interest, mainly due to their concentrations in stormwater and downstream receiving environments, and there is much interest in the update of guidelines for these. The process for this update is the same as for pesticides and emerging contaminants that are also being updated currently, with two key differences that will be discussed. Firstly, in contrast to other contaminants, there is no shortage of toxicity data for these metals. For example, an initial search of toxicity databases for copper in marine waters yielded over 3,000 lines of data. This required considerable data filtering to include only data from chronic tests, which measured metal concentrations, and reported important water quality characteristics. Secondly, the metals are also highly influenced by water quality factors, such as hardness, pH and dissolved organic carbon (DOC). In freshwater, increases in hardness reduce the aquatic toxicity of zinc, and increases in pH increase the toxicity. In fresh and marine waters, the presence of DOC reduces the aquatic toxicity of copper, as copper binds to DOC, decreasing bioavailable free copper. As part of the guideline derivation, we developed new algorithms for adjusting the conservative default guidelines based on these water quality factors. The freshwater zinc guidelines have adjustments for both hardness and pH. The copper guidelines for freshwater and marine waters have an adjustment for DOC. These adjustments result in substantial changes to the guideline value, implying that site-specific measurements of water quality factors will be required in the future to avoid applying excessively stringent default guidelines. The marine zinc guidelines have no adjustments for water quality characteristics. Guideline values were derived from information based on at least 19 different species from at least five taxonomic groups, incorporating multiple native or resident species.

Responses of the fish community and biomass in Lake Ohinewai to fish removal and a carp exclusion barrier

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The objective of this research was to evaluate responses of water quality and fish biomass in the 16.8-ha Lake Ohinewai to removal of invasive fish species. Lake Ohinewai is a shallow (maximum depth 4.5 m), hypertrophic, riverine lake in pastureland in the Waikato Region, New Zealand. We hypothesised that reduction of invasive fish to below 100 kg/ha would improve water quality, so we removed koi carp *(Cyprinus carpio),* brown bullhead catfish *(Ameirus nebulosus),* goldfish *(Carassius auratus)* and rudd *(Scardinius erythrophthalmus)* during the recapture phases of four capture-recapture population estimations. We also installed a one-way barrier that allowed adult fish to leave but prevented re-entry of adult koi carp. In 2011, before fish removal, koi carp comprised 97% (308 kg/ha, 95% CL 211–466) of the total biomass of invasive fish (334 kg/ha). We reduced the biomass of koi carp to 39 kg/ha (95% CL 24–67) in 2012 and to 14 kg/ha (95% CL 7–27) in 2014 by a combination of fish removal and the one-way gate. Total invasive fish biomass in 2014 was estimated as 28 kg/ha, well below our target of 100 kg/ha. In 2016, after two years without fishing but with the one-way barrier still in place, koi carp biomass had increased to 94 kg/ha (95% CL 49–197) and total invasive fish biomass was 157 kg/ha, partly because of a strong biomass response by catfish (12 kg/ha in 2011, 36 kg/ha in 2016). The native shortfin eel *(Anguilla australis)* also showed a strong biomass response (14 kg/ha in 2012, 41 kg/ha in 2016). Water quality (Secchi depth, suspended solids, and concentrations of chlorophyll a, total nitrogen and total phosphorus) was evaluated before and after fish removal. None of these variables showed changes that were coincident with invasive fish removal except for chlorophyll a concentration, and the lake remained hypertrophic.

Effects of change in catchment sediment load on sediment rating curves and particle size

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Relationships between suspended sediment concentration (SSC) and water discharge (Q) and between SSC and visual clarity (VC, or other similar water optical properties) can be coupled algebraically with flow duration curves to predict how the frequency distributions of SSC and VC should change in response to change in catchment sediment load. Such a coupling offers a framework for managing catchment sediment exports in order to meet environmental targets set around SSC and/or VC for discharges into downstream water bodies such as estuaries (e.g., VC greater than 1 m for 90% of the time). In the New Zealand context, this has potential application to implementing the National Policy Statement for Freshwater Management around sediment issues. Two underpinning assumptions, however, are that when catchment sediment supply changes: (1) the SSC vs Q relationship (sediment rating curve) on a log-log plot simply offsets vertically, with no change in gradient; and (2) the particle size distribution (PSD) of the suspended sediment load does not change, and thus the relationships between SSC and water optical properties do not change. This paper explores the validity of these assumptions using datasets that capture changes in catchment sediment load associated with extreme hydrological events or land-use change. The results show that the assumption of a simple vertical offset of sediment rating curves is invalid where sediment load changes are not uniform within a catchment and/or load change is accompanied by a change in runoff. Using specific turbidity (the ratio of turbidity to SSC) as a PSD proxy, it was observed that changes in sediment load can cause changes in the PSD and so changes in the relationships between SSC and optical properties, but the significance will depend on sediment supply heterogeneity and PSD across the catchment.

Temporal and spatial pollution dynamics in the river-style Three Gorges Reservoir on the Yangtze River, China

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The Three Gorges Reservoir (TGR) on the Yangtze River in China is amongst the largest and most controversially discussed reservoirs in the world. It is globally unique due to its size, annual water level fluctuation, eutrophic state, and very low mean water residence time. Due to its hydrological features, it can neither be fully considered a lake nor a river. The impounded water body is of distinct dendritic shape with many tributary backwaters reaching up to 60 km into the impounded former valleys of tributaries. These features cause highly interesting patterns of water mass interaction and pollutant transport between the Yangtze River mainstream and its tributaries that have markedly changed after the impoundment of the TGR in 2003. In this study, we investigate water quality and element concentration data from monitoring and sampling campaigns in the TGR carried out in the frame of the Sino-German Yangtze-Hydro Project between 2011 and 2014. Water chemistry in the TGR shows distinct seasonal variation that is also related to concentrations of several pollutants in the water. We differentiated pollutant loads between the dissolved (<0.45 µm) and particulate (>0.45 µm) phases. Loads of heavy metals in the water (Cr, Ni, Cu, Zn, Cd, Pb) show a highly variable fraction related to suspended particles (9-95%) whilst phosphorus mainly occurs as dissolved species (63-98%). Seasonality of these pollutant loads points towards different types of sources. Based on dense samplings across the Yangtze River mainstream and two of its tributary backwaters, we can estimate temporal loads of transported pollutants in the TGR and question the results of studies based on surface water samples only. Our study will help to understand pollutant sources and transport processes in the TGR and to derive mitigation measures, e.g. by means of the Three Gorges Dam management.

Turning 'nice to know' into 'need to know': a decision support system to diagnose factors limiting stream fisheries

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Maintaining productive freshwater fisheries is a key challenge for catchment groups across New Zealand. However, the inherent uncertainty and complexity of managing fisheries, based on scant environmental data, makes it difficult for collaborative groups to reach consensus on management actions. To deal with this issue we created a literature-based decision support system to diagnose limiting factors for stream fisheries. Once limiting factors are determined then appropriate management actions can be tailored to address them. Our Bayesian Belief Network-based framework (BBN) serves two functions: (1) it directs users to assemble (or collect) a parsimonious environmental data set to inform stream fishery management; and (2) it integrates and interrogates these data to generate standardised, repeatable and testable hypotheses about which environment factors are most likely to limit fish productivity in a stream. The BBN has been trained on brown trout because among freshwater fish this species has the richest literature base and is highly valued. However, the framework could be easily adapted for mahinga kai species such as longfin eels. We tested our BBN on the Horokiri stream, a data-rich catchment in Wellington, New Zealand. The BBN probability outputs were comparable with the conclusions of a panel of leading fishery biologists - following their detailed investigation into the factors that led to the loss of the Horokiri trout fishery between 1960 and 1990.

Protecting ancient Māori rock art in a changing freshwater management environment

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Rock art refers to the drawings and carvings of Māori people on both large and small, rock surfaces. Tuhituhi neherā (rock art) sites are found on limestone rock formations, sandstone and Schlitz formations all over the South Island of New Zealand; and some places in the North Island. Many of these sites have been damaged or destroyed due to natural processes such as rock weathering, oceanic influences, and human activities. Human impacts have ranged from direct interference with sites through acts of vandalism or misguided attempts at preservation; to indirect effects from changes in land use and freshwater management practices. Rock art sites are intimately associated with freshwater ecosystems; as these sites were based around providing mahinga kai and transport, in addition to cultural and spiritual uses. All rock art sites are near streams, rivers, and/or swamps. The preservation and management of rock art sites, including the freshwater ecosystem within which it is intimately situated, requires a robust understanding of the sensitivity and vulnerability of each site to modifications and disturbances within the local hydrological and hydrogeological environment (e.g., irrigation practices, diversion of waterways, groundwater abstraction and sub-surface contaminant flows). The Ngā Kete o Te Wānanga project team and the Ngāi Tahu Rock Art Trust have developed a freshwater-focussed sensitivity mapping approach that will contribute to the preservation of sites and their associated ecosystems (springs, wetlands, streams). Conceptual diagrams have enabled the sensitivities of rock art to water to be illustrated. This research is providing a valuable and unique opportunity to engage with an established specialist Māori team of experts (i.e., Rock Art Trust), to draw upon mātauranga Māori and complement the project team's scientific expertise, particularly around hydrogeology (groundwater-surface water interaction).

Managing freshwater ecosystems: how do we measure success?

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Freshwater ecosystems underpin economic, social, and cultural wellbeing in New Zealand. In recognition of this, the National Policy Statement for Freshwater Management 2014 (NPS-FM 2014) makes ecosystem health a compulsory value that Councils must manage. A healthy ecosystem is described as one where ecological processes are maintained, there is a range and diversity of indigenous flora and fauna, and there is resilience to change. Councils face a number of barriers to effective management of ecosystem health, including how to evaluate the extent that this critical value is being provided for. These stem from gaps in our knowledge of ecosystem health outcomes (for example the state of fish species), and the lack of a consistent and robust approach to assessing ecosystem health. This project aims to inform the management of ecosystem health in New Zealand. It includes a review of approaches within New Zealand and overseas, the role of outcome indicators compared to diagnostic metrics, and the types of barriers that exist for their implementation and management outcomes. If successful, the project will develop a tool such as a multi-metric indicator, which Councils (and their communities) can use to measure and describe ecosystem health, and help identify the actions necessary to improve it.

Defining braided river margins

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New Zealand's braided rivers support high biodiversity, provide vital habitat to threatened birds (e.g., wrybill, banded dotterel), and are sources of aggregate for construction and roading, and water for irrigation and hydropower. In order to protect our braided rivers, regional councils have policies in place which outline permitted activities within the river bed. However, the definitions of 'river bed' under the Resource Management Act, and typically referred to under current regional council policies, do not adequately incorporate the area required for protection of braided rivers. Current legal definitions of river boundaries assume stable, single-thread channels with well-defined banks. In contrast, the active channel of a braided river moves around within a 'braidplain'. This dynamic behaviour is what generates the mosaic of terrestrial and aquatic habitats. Braid migration also poses erosion and flooding risks, and many braided rivers have been confined between stop-banks and willow-belts. Another pressure on river width is agricultural encroachment, when landowners farm braidplain margins in the absence of active channels. Introduction, definition and spatial delineation of the term 'braidplain' to planning terminology would remove uncertainty for land owners and resource managers. However, this change would require clear definition of the parcel of land classified as 'braidplain' for each braided river. Definition of the braidplain of a braided river presents a number of challenges. For example, parts of the braidplain of a given braided river may not have been occupied by active channels for some time. This may be due to natural river migration, and may be temporary, or may be the result of longer-term river adjustment in response to geomorphic controls such as changes in sea level. This paper will outline a methodology and rules for defining the 'natural braidplain' of braided rivers, using examples from the Canterbury region.

Nitrogen and phosphorus filters: performance of tile drain nutrient filters at Waituna Lagoon, Southland, New Zealand – year one

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Tile drains are a key pathway for nutrients mobilised on the landscape to enter surface water that eventually drains into Waituna Lagoon. Field trials of nitrogen (N) and phosphorus (P) filters have been under way on dairy farms in the Waituna catchment, for approximately 16 and 10 months, respectively. The N filter is a 100 m^3 lined woodchip bioreactor which receives subsurface drainage under gravity from an approximately 9 ha sloping, cropped catchment. The P filter is a small-scale, above-ground bin (1 m^3) containing Aqual-P™. Drainage is pumped up to the P filter from a subsurface tile drain derived from approximately 1,000 m^2 of pasture. Flows were continuously measured at the inlet and outlet of both filters, and discrete water-quality samples were collected at the same locations under baseflow and stormflow conditions. The P filter received a variable proportion of the intermittent total drainage at rates up to 226 L/h (median 165 L/h). The N filter flowed continuously measured inflows ranged from 0.107 L/s to 10.164 L/s; seasonal median inflows ranged from 0.14 L/s (April) to 0.93 L/s (July). Under baseflow conditions the N filter reduces nitrate-N concentrations (inflow median concentration approximately 2,200 µg/L) by more than 95%. Although storm event performance is more variable (dependent on flow rates and season), the median removal rate during high-flow events was 45%. The inflow to the P filter was intermittent. At the variable loading rates applied, it can reduce inlet TP concentrations (inflow median approximately 195 µg/L) by 78%, and DRP concentrations (inflow median 88 µg/L) by more than 95%. The impact on removal efficacy of several factors were explored, including: inflow rate (and therefore bed residence times), temperature, turbidity and season. The dominant factor under all season/ temperature conditions is flow rate (residence time). N removal efficacy improves as temperatures increase. Information derived from the trial may be used to indicate the size of treatment unit necessary to mitigate nitrogen discharges to surface water. Additional trials will be required to provide this level of information for the P filter.

Kaitiaki layers: visualising mātauranga Māori and science

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Visualisation of environmental data is becoming an increasingly important way to connect science with citizens and policy makers, and to support decision-making. Within Aotearoa New Zealand, Iwi participation within co-governance models for environmental resources and advocacy for the inclusion of mātauranga Māori (indigenous knowledge) has led to the development of the kaitiaki layers within the Takiwa Geospatial Platform. This presentation will outline the logic framework for the organisation of cultural and scientific indicators as well as the key challenges to balance the competing interests in terms of protecting and creating value through the use of mātauranga Māori.

Before and after integrated catchment management: changes in water quality

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Few studies have comprehensively measured the effect of catchment rehabilitation measures in comparison with baseline conditions. Here, we present the changes in water quality for a 22-year period in a headwater catchment within the western Waikato Region, New Zealand. For the first six years, all of the land in the catchment was used for hill-country cattle and sheep grazing. An integrated catchment management plan was implemented whereby cattle were excluded from riparian areas, the most degraded land was planted in Pinus radiata, channel banks were planted with poplar trees and the beef cattle enterprise was modified. The removal of cattle from riparian areas without additional riparian planting had a positive and rapid effect on stream water clarity. In contrast, the water clarity decreased in those sub-catchments where livestock was excluded but riparian areas were planted with trees and shrubs. We attribute the decrease in water clarity to a reduction in groundcover vegetation that armours stream banks against preparatory erosion processes. Increases in concentrations of forms of phosphorus (P) and nitrogen (N) were recorded. These increases were attributed to: (1) the reduction of instream nutrient uptake by macrophytes and periphyton due to increased riparian shading; (2) uncontrolled growth of a nitrogen-fixing weed (gorse) in some parts of the catchment, and (3) the reduction in the nutrient attenuation capacity of seepage wetlands due to the decrease in their areal coverage in response to afforestation. Our findings highlight the complex nature of the water-quality response to catchment rehabilitation measures.

Modelling riverine biodiversity and ecosystems service delivery - simple, integrated, or complex?

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Freshwater biodiversity is highly threatened worldwide and we are witnessing a rapid decrease of biodiversity in freshwater ecosystems, which is exceeding their terrestrial or marine counterparts. Rivers are particularly affected due to their small relative proportion in area, high degree of habitat fragmentation, distinct internal connectivity within the network, and their close links to surrounding terrestrial areas which may result in severe anthropogenic impact given by land use in the respective watershed. Today, freshwater management for rivers is increasingly supported by models to foster decision-making, e.g. to predict ecological consequences of different management alternatives or to account for potential future changes in the ecosystem, independently of environmental management. Various modelling approaches exist for aquatic ecosystems with different levels of sophistication and advancement when comparing modelling methods for hydrological regimes, riverine habitats, species, or ecosystem aspects such ecosystems functions or service provision. Most approaches so far have in common that they focused on one aspect only, neglecting the integrated nature of rivers. I will present different modelling approaches ranging from: (1) global change projections by species distribution models; (2) integrated modelling approaches with a more comprehensive view on riverine habitats; towards a (3) projection and optimisation framework which assesses the status of biodiversity and evaluates simultaneously ecosystem services. Thus I will present a framework which considers multiple policy and stakeholder objectives for biodiversity and ecosystem services, their deficits, management alternatives and cost-effectiveness of management solutions.

Stream enhancement – what actually happens?

Alex James[1]

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Stream enhancement activities are now commonplace in New Zealand. Such efforts are often included in the resource consent conditions of construction projects although in some instances they may be a component of wider stream corridor ecological restoration schemes. Enhancement efforts typically involve "improving" habitat via increasing physical habitat complexity. There are numerous methodologies employed, including designing the channel to have riffle-run-pool sequences, increasing sinuosity, installing habitat features (i.e., logs, boulders, pipes), adding coarse substrate, and riparian planting. Individual enhancement projects generally involve very short lengths of stream when considered in the context of total catchment channel length. Monitoring of stream enhancement projects is sporadic and short-term with results often buried in the grey literature of consent monitoring reports. In this presentation I investigate the effect on fish and macroinvertebrates of enhancement projects in two heavily modified peri-urban streams in Christchurch. Both have fish faunas dominated by bullies (common and upland) and shortfin eel and macroinvertebrate communities dominated by taxa common in modified systems (i.e., *Potamopyrgus antipodarum* snails, Ostracoda seed-shrimps, chironomid midge larvae, and *Paracalliope fluviatilis* amphipods). I will consider if there are predictable successional trajectories for any taxa or taxa groups following enhancement in these two degraded lowland streams, whether the enhancements increased taxa richness, and whether the physical habitat enhancement of discrete sections of degraded streams is worthwhile from an ecological perspective.

Land use change alters nutrient processing in streams along Brazil's agricultural frontier

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Rising global populations and income levels are anticipated to double the global demand for crops by 2050. Currently, the greatest potential for meeting these demands lies in expanding and intensifying agriculture in tropical areas, such as the Brazilian Amazon basin. Brazil has greatly expanded intensive agriculture in the south-eastern Amazon and large-scale soybean-maize double cropping is now widespread through the region. This requires substantial addition of N and P fertilisers to watersheds, which have caused well-known environmental consequences in other agricultural regions of the world and greatly threaten the integrity of freshwater ecosystems. However, little information on the implications of extensive N and P fertilisation for stream nutrient dynamics and the efficacy of riparian forest buffers in preventing nutrient export to streams is available in this region of recent agricultural expansion. Using stream and groundwater monitoring and pulse additions of NO_3, NH_4, and PO_4 to nine watersheds draining forest, soybean, and soybean-maize agriculture in the Xingu Basin in Brazil, we asked: (1) Has nutrient export increased? (2) What is the fate of nutrients that reach headwater streams? (3) Do uptake rates of N and P differ by land use? and (4) What in-stream and watershed-scale factors control the rate of uptake of N and P? Pulse nutrient additions demonstrated that N had the potential to travel long distances downstream, but P was taken up rapidly across all streams, supporting the general pattern of P limitation of tropical ecosystems. Furthermore, our data show that P is taken up even more rapidly in cropped watersheds suggesting that land use change has increased the demand for P by stream biota. This talk will explore the patterns, potential mechanisms, and implications of these shifts in stream ecosystem function in response to widespread watershed land use change in this region.

The impact of didymo on adult trout abundance – has there really been an effect?

Phil Jellyman[1]
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The non-indigenous freshwater diatom *Didymosphenia geminata* (didymo) is capable of forming large blooms in rivers that contain significant trout fisheries. Since the first discovery of blooms in New Zealand in 2004, there have been major concerns about the potential impacts of didymo on angling values and whether it would result in a decline in trout abundance. Despite its arrival being more than 10 years ago, river management agencies including Fish & Game New Zealand and the Department of Conservation remain concerned about the long-term implications of didymo blooms for river ecosystems. The focus of this particular work was to investigate the perceived detrimental impact of didymo blooms on the trout fishery in rivers around the South Island. To address this question, drift-diving data supplied by Fish & Game regions around the South Island were used to examine changes in trout by comparing populations in rivers pre- and post-didymo arrival. In addition, staff scored rivers from 1 to 5, based on the extent of didymo biomass/coverage at sites during their drift dives, so that the severity (or absence) of didymo blooms in these rivers could also be factored into analyses. At the time of writing this abstract, some regions were still in the process of supplying data so the results of this work cannot yet be reported. However, when these results are presented in November, they will be of relevance to a wide-range of scientists, stakeholders and decision-makers who are tasked with research or managing didymo blooms in freshwater ecosystems.

Balancing human and ecological objectives in river restoration design

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Strategies for balancing human and ecological objectives in river restoration vary depending on location, scale, and the amount of human intervention. Case studies from a range of settings, spanning from urban to wilderness, are used to illustrate the degree of alteration found in our natural systems and how river restoration efforts can integrate human and ecological objectives to optimise benefits. On one end of the spectrum, we'll highlight urban restoration projects where human objectives related to flood control, stormwater treatment, and greenspaces are integrated with ecological objectives related to natural aquatic habitat, riparian forests, and stream geomorphic functions. In these heavily impacted "novel" ecosystems, the processes that govern ecological function have been fundamentally altered, so a return to a historical or natural condition is no longer possible. Restoration focuses on creation of new habitats for desired species and this requires working with a wide array of constituents and incorporating principles of Landscape Architecture, where human integration with the landscape is explicitly considered in design. On the other end of the spectrum, we highlight restoration of relatively intact montane rivers, where a legacy of forestry and mining practices has impaired aquatic habitat. In these cases, it is possible to restore some of the underlying natural processes governing habitat, but these are often long-term commitments and must therefore be combined with short-term measures to address areas with critically depressed species. Human-related objectives in these settings primarily include outdoor recreation, river safety, and traditional uses by indigenous communities; and although there are fewer human uses compared to urban streams, they nevertheless impact project design. This presentation will serve as an introduction to the session "Balancing Human and Ecological Objectives in River Restoration Across a Range of Settings and Catchment Scales" and will provide context for the presentations that follow.

Catchments, watersheds and basins: the global governance and policy of international river science

Gerald Kaufmann[1]
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You call it a catchment and I call it a watershed and they call it a basin but across the globe water resources are best protected by the common themes of international river basin governance and management. We will discuss the governance, economics, and policies of investing in watersheds, a topic that Delaware as a small peninsular state and New Zealand as a small island country, have much in common. In the continents throughout the world, river basin management is practiced with various degrees of sophistication, from the user payers approach of the European Union and South America to the privatised systems of the United Kingdom and the autocratic ministries of Russia and Central Asia. We'll discuss the revenue and governance structures of the Agencies de L'eau, Genossenschaften, and Dutch Polders of Europe, the RBOs of Morocco and Brazil, and the water ministries of China, Vietnam, and the Far East. It's been said that the nations on Earth are divided by borders but the people on the Planet are united by a common river.

Community structure and food-web pathways in macro-algal dominated lakes: is this another stable state?

David Kelly[1], Susie Wood[1], Sean Waters[1], Lena Schallenberg[2]
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Shallow lakes can undergo rapid changes in their community structure and food-web pathways related to regime shifts between macrophyte-dominated and phytoplankton-dominated states. However in some instances, nutrient enrichment of lakes can result in an alternative state, dominated by benthic macro-algal production. The food web of these lakes is poorly understood, and it is uncertain if the macro-algal state is stable or a merely a transitionary state prior to the lake shifting to a phytoplankton-dominated state. In this study we examine the food-web structure of two Ashburton Basin lakes, one of which in has recently transitioned from being macrophyte-dominated to macro-algal dominated, the other remaining macrophyte-dominated. Measures of community structure, diets (eDNA), and food-web structure (stable isotopes) demonstrate significant differences in lake community structure of food-web pathways. Transition to a macro-algal state appears not to reflect conditions normally associated with lakes flipping to phytoplankton domination. We perceive this state to have low resilience, with a high probability of flipping to phytoplankton domination or back to a macrophyte-dominated state.

Development of a strategic and enduring approach to managing and improving mahinga kai within the Ngati Tahu-Ngati Whaoa rohe – Te Awa o Waikato

Evelyn Forrest[1], **Johlene Kelly**[1]
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Ngati Tahu-Ngati Whaoa (NTNW) wish to be instrumental in our role as kaitiaki of the cultural and natural resources within our rohe. To enable us to practice kaitiakitanga and what it means to us, we believe we need to achieve a good understanding of our resources, their historic cultural values, current cultural values, current state and the issues facing their management and wellbeing. NTNW Runanga Trust has had a particular focus in the last two years on collating this information for Mahinga Kai within our rohe (within Te Awa o Waikato). We aim to use this information to enable us to practise active kaitiakitanga and to work with others to create opportunities to achieve our aspirations. We will outline the steps we have taken to develop our framework and our key findings and challenges during this process. We will discuss how we have applied both science and Ngati Tahu-Ngati Whaoa matauranga to achieve a direction to support the aspirations of the NTNW people and to play our role in achieving the Te Ture Whaimana o Waikato (The Vision and Strategy for the Waikato River). Our future steps and challenges will be woven into our korero.

Within mat nutrient cycling in *Phormidium* – alkaline phosphatase activity and regulation

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Phormidium spp. grows in relatively low-nutrient waters often with particularly low levels of dissolved reactive phosphorus. However, phosphate levels within *Phormidium* mats are frequently considerably higher than in the overlying water column. Two mechanisms may be acting to create and maintain this high within-mat phosphate concentration. First, biochemical conditions within mats may act to desorb sediment-bound phosphate during high alkalinity periods, through high photosynthetic rates and high respiration, which in turn results in low dissolved oxygen. Second, within-mat nutrient cycling may be occurring, as organic phosphorus from senescing cells (both bacterial and cyanobacterial), along with organic material caught in the mat matrix, is converted to inorganic phosphorus via the alkaline phosphatase (AP) enzyme. The inorganic phosphorus produced by this process may then be available for *Phormidium* growth. This study examined the second mechanism. Alkaline phosphatase is likely to be most useful in later mat development, when a matrix is formed and any converted phosphate due to alkaline phosphatase activity is retained and usable by *Phormidium*. Alkaline phosphatase activity is up- and down-regulated in *Phormidium* and controlled by either phosphate availability (high phosphate leads to low alkaline phosphatase), or the availability of organic phosphorus to act as a substrate for the alkaline phosphatase enzyme (high organic phosphorus upregulates alkaline phosphatase). Differences in the regulation of alkaline phosphatase activity between toxic and non-toxic strains, may influence the dominance of toxic or non-toxic strains.

Lakes as organic matter upgraders – seasonal variation in biochemical compositions of in- and out-flowing particles in pre-alpine Lake Lunz, Austria

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In this field study, we investigated how particulate organic matter (POM) quantity and its biochemical quality changed between lake inflow and outflow as well as within the oligotrophic, pre-alpine Lake Lunz, Austria, from 2013 to 2015. We tested the hypothesis that irrespective of seasons, stream water recharging the lake contains predominantly recalcitrant POM (>1.2 µm particle size), whereas outflowing lake water is mostly composed of more labile, algae-derived organic matter. Samples were collected on a monthly basis from the lake layers, inflowing and outflowing streams, and analysed for fatty acids as biochemical indicators of POM quality. Results showed that increasing precipitation and runoff predicted significantly increasing inflowing concentrations of POM ($r = 0.72$, $R2 = 0.52$, $P < 0.001$). The lake retained ~58% of total imported POM, but exported ~3X, ~8X, and ~6X more bacterial fatty acids (BAFA), and algae-derived omega-3 PUFA and omega-6 PUFA, respectively, than the inflow. Long-chain saturated fatty acids (used as proxy for terrestrial organic matter) constituted ~9% in inflow and ~6% of total SAFA in the outflow. In general, Lake Lunz exports on average 8X more labile POM (algae-derived) than the inflow. These results suggest that the oligotrophic, pre-alpine Lake Lunz is a biochemical upgrader within the fluvial network of this drainage basin and supplies highly labile and nutritional POM to consumers further downstream, irrespective of the season.

Redefining "accrual period" improves ability to predict annual maximum chlorophyll a in rivers

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Periphyton biomass (as chlorophyll a) has been recognised as an important indicator of river health in New Zealand through inclusion in the National Policy Statement for Freshwater Management. Ability to predict responses by periphyton to alterations in nutrients and flows is therefore a priority to prevent the damaging effects of excessive periphyton and to assess consequences of flow and nutrient management. Empirical regression models for predicting maximum annual chlorophyll a across rivers have been available since 2000. These models use mean annual dissolved nitrogen and phosphorus, and accrual period, as predictor variables. Here, "accrual period" refers to the time available for periphyton development between events exceeding 3 x median flow. Use of 3 x median flow as the threshold above which periphyton starts to be removed originated from a 1997 study in which FRE3 (mean annual frequency of flows > 3 x median) was the hydrological metric most closely related to biological indices. Recently, periphyton datasets collected by regional councils have provided opportunities to refine the 2000 models. In a dataset from Canterbury, observed maximum annual chlorophyll a was not correlated with chlorophyll a predicted from the 2000 models. However, when we replaced accrual period based on 3 x median flow with accrual period based on the flow that actually removed periphyton (1.5 – 10 times median flow) the predictions explained up to 70% of the variance in maximum chlorophyll a. Predictions were usually overestimates; therefore we developed new regression relationships that included additional variables that may influence periphyton biomass (e.g., conductivity and percentage of fine material on the stream bed). These new models were applied to independent data and produced predictions that were reasonably close (± 30%) to the observed values in most cases. The method is being applied to datasets from other regions to determine its wider applicability.

Wet and dry season flows influence juvenile fish abundance in a tropical river

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The rivers of northern Australia contain a high diversity and abundance of freshwater fishes, and are relatively undisturbed compared to similar systems throughout the world. There is, however, increasing pressure to use the region's water resources to support agricultural and mining development. It is imperative that we understand the ecological water requirements of key biota before any such development occurs. This study assesses the importance of both wet and dry season hydrological flow components on juvenile abundance of key fish species. We utilised a standardised electrofishing dataset spanning ten years that has sampled the freshwater fish assemblage at a number of sites in the Daly River, Northern Territory. Results suggest whilst juvenile abundance in the early dry season of many wet-season breeding species was related to the magnitude and timing of wet season flows, their subsequent survival to the end of the dry season was also highly related to dry season discharge and duration. Interestingly, the abundance of species which breed in the dry season was also related to both the previous wet and dry season flow conditions. This study emphasises the importance of both wet and dry season flows on freshwater fish recruitment patterns, and also the need to place species-specific flow responses in the context of their life history. Our work will assist in environmental flow management decisions throughout Australian tropical rivers.

How have we valued New Zealand's rivers? A historical perspective.

Catherine Knight[1]
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In this presentation, environmental historian Dr Catherine Knight will answer this question by tracing the history of people's interactions with rivers since they first arrived in this South Pacific archipelago centuries ago. Her conclusions may surprise you, but will without doubt provide valuable context to the debate about our rivers and the collision of values we face in relation to fresh water today. Catherine is the author of New Zealand's Rivers: An Environmental History (Canterbury University Press, 2016).

Creating habitat for endangered fish in a managed river system - how created ecosystems are becoming the new focus of stream restoration: Dry Creek, Sonoma County, California, USA

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Dry Creek at the turn of the 19th century was an intermittent stream providing seasonal (winter) habitats for salmonids in the Russian River Drainage of Northern California. As the area populated and water needs grew for the Northern San Francisco Bay region and the Sonoma county wine industry, a large reservoir (Lake Sonoma) was constructed. Today, Dry Creek below Lake Sonoma flows year round as a delivery mechanism for human water consumption and tens of million of dollars are being spent to transform this former dry stream into a haven for endangered fish. The year-round release of stream flows into Dry Creek presents an opportunity to provide essential habitat for juvenile salmonids within a system that historically did not provide such habitats. The creation of habitat in systems that have been heavily modified by man is an area of emerging design that creates a new "novel" ecosystem defined as "A system of abiotic, biotic, and social components (and their interactions) that, by virtue of human influence, differ from those that prevailed historically…" (Hobbs et al. 2013). Created ecosystems that combine elements of important wildlife and fishery habitat in areas heavily managed for human interests is a growing need in restoration design simply due to the ever-prevailing human use of the land and the subsequent loss of former habitats. We present one such created environment as an example where humans are providing for new habitat complexity in the overall ecosystem despite heavy human utilisation.

Land use effects on nutrient cycling and loss from headwaters to Great Lakes in the Fox River Basin, Wisconsin, USA: project overview.

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The Fox River courses 322 km from northern and central Wisconsin, USA, into the Laurentian Great Lake Michigan at Green Bay (average discharge 117 m^3/s). The catchment is complex, encompassing three distinct sub-catchments. From the north, the Wolf River catchment is nearly devoid of agriculture, has high water quality, is heavily forested, and overlays sandy soils; from the east, the Upper Fox catchment is dominated by relatively small farms and wetlands and has slightly degraded water quality; to the west, the Lower Fox catchment is heavily urbanised and with intense agriculture, dominated by large dairy farms including confined animal feeding operations. These operations overlay clayey soils and the water quality is poor. In a series of papers, we report on our efforts to measure and understand the effect of land use and land management on metrics of nitrogen (e.g., denitrification) and phosphorus (equilibrium phosphorus concentration) cycling and local (sediment particle size, redox potential) and regional (best management practices, land-use patterns) physical characteristics influencing these cycling metrics. We attempt to link land use to alterations of cycling and retention of nitrogen and phosphorus in the Fox River system over a gradient from nearly pristine and forested to heavily degraded land use. This set of papers is from a large, multi-year project in the Fox River Basin, funded by the Great Lakes Restoration Initiative (US Environmental Protection Agency). Our project is explicitly linked to several others, also focussing on the Fox River and its confluence with and effect on nearshore water quality of Green Bay, Lake Michigan.

Phosphorus retention across land cover types in the Fox River Basin, Wisconsin, USA

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Land cover type and land use are important drivers of nutrient concentrations in rivers. Rivers draining agricultural landscapes typically have elevated concentrations of phosphorus (P) and other nutrients, which leads to eutrophication, production of harmful algal blooms, and hypoxic zones. Best management practices are implemented in agricultural landscapes to reduce P loads but little is done to remove or manage P once it enters river networks. Rivers have the capability of retaining some of the P by binding P to sediment cations and through biotic uptake. Understanding the distribution of these areas of increased P retention would be beneficial to resource managers. During the summer of 2016 we measured sediment and water column P dynamics at 110 river sites in the Fox River Basin in Wisconsin, USA. The sites spanned forested to agricultural land cover ranges and were located in all stream sizes from headwater streams to the river mouth. We measured sediment equilibrium phosphorus concentration (EPC0), sediment phosphorus saturation ratio (PSR), sediment and water column P concentrations, and physical sediment characteristics typically associated with P (e.g., particle size, sediment porosity, and cation concentration). Water column and sediment P concentrations increased with row crop and pasture increases, and maximum water column P concentrations were at those sites associated with the highest area of pasture. Meanwhile, PSR declined as the area in forest increased in the catchment; EPC0 decreased as the sediment porosity increased, indicating that sediments with a higher organic and silt and clay content were able to retain more P. Thus these areas could potentially be managed for increased P retention.

Managing the effects of land drainage and flood control infrastructure on fish passage in the Waikato

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Land drainage and flood control schemes in the Waikato Region are recognised as impediments to both upstream and downstream fish passage. Amongst adverse effects upon native fish are direct mortality on downstream migrants as they attempt to pass through flood pumps. To date there have been limited efforts made by scheme managers to address these effects within New Zealand. To begin to deal with the issue the Waikato Regional Council commissioned a report to define the problem, explore the legislative and policy context and review a range of potential remedial measures that exist internationally. The report found limited conclusive information regarding the effectiveness of many of the remedial measures reviewed, particularly within the New Zealand setting and that the implementation of many of these measures will present significant additional costs to the operation of schemes. However, the adverse effects of these activities upon native fish cannot be overlooked and a strategy to systematically reduce the adverse effects within the Waikato Region is currently being developed. The first stage of the strategy has been to prioritise the 539 catchments that are controlled by scheme infrastructure within the Waikato Region to begin to address the existing fish passage impacts in the highest-risk catchments. The prioritisation is based on the relative impact of different infrastructure types and size of the affected catchment. Progression of the strategy will rely on the identification of proven remedial measures and development of novel measures where needed. This, in turn, will require the implementation of field trials and robust monitoring. Trials currently under way include the installation of a hydrostal "fish-friendly" pump and the electrification of debris screens. A collaborative approach between scheme managers, regulators, stakeholders and industry is recommended to ensure sharing of information so that effective fish passage outcomes are optimised.

Characterising diverse river landscapes using hydro-geomorphic classification and dimensionless hydrographs

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Defining environmental flow targets for Mediterranean rivers is complicated by extreme hydrologic variability and intensive water- and land-management legacies. Improved understanding of the diversity and spatial arrangement of natural streamflow patterns is needed to support the future development of effective environmental flow targets at appropriate scales for management applications with minimal resource and data requirements. This research study describes the development of a spatially explicit reach-scale stream classification for the State of California based on unimpaired streamflow time-series and geospatial information related to climate, topography, geology, and soils. The resulting classification identifies nine natural flow classes representing distinct flow sources, hydrologic characteristics, and catchment controls over rainfall-runoff response in California. Dimensionless reference hydrographs were generated to characterise the distinct seasonal patterns and daily within-class variability of each natural flow class. This final integrated stream classification and associated dimensionless hydrographs provide a broad-scale hydrologic framework upon which flow-ecology relationships can be established for the region.

Incorporating resilience and resistance in assessments of land-use suitability

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Land and water management in New Zealand is transitioning from an effects-based approach that relies on consents for individual activities to a limits-based approach that relies on catchment, regional and national policies and plans. The limits-based approach is formalised in the National Policy Statement for Freshwater Management, which requires resource-use limits in order to achieve objectives in freshwater and estuarine receiving environments. In turn, the objectives are set to support the intrinsic ecological, social, economic and cultural values present in receiving environments. There are multiple strategies for reducing or preventing adverse effects of land use on these values, including appropriate land-use choices, best management practices within each land-use sector, mitigation systems at contaminant sources, intervention systems in receiving environments, and combinations of these. We are developing the land use suitability (LUS) concept as a procedure for systematically assessing the effectiveness and costs of these strategies, and to assist in limit-setting. LUS assessments need to predict the responses of different values in different types of receiving environments to different land-use pressures. These predictions are based on pressure-response relationships, which can be characterised in terms of resistance (absorbing pressure with minimal degradation), resilience (recovery from degradation following the reduction of pressure), and tipping points (threshold behaviour in pressure-response relationships). In this presentation, we show how resistance, resilience and tipping points can contribute to LUS assessments and limit-setting. We also show how mitigations and interventions increase resistance and resilience in the LUS framework, thereby affecting sustainable resource use limits.

Assembly and disassembly of aquatic invertebrate communities in a dynamic floodplain ecosystem

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Braided river floodplains are highly dynamic ecosystems, where aquatic communities are shaped strongly by hydrological regimes. So far, however, detailed understanding of how flow variation influences assembly mechanisms is limited. We collected benthic chironomids and oligochaetes over a year across a lateral connectivity gradient in the semi-natural Tagliamento River (Italy). Three bankfull floods occurred during the study allowing the assessment of how hydrologic connectivity and disturbance mediate the balance between stochastic and deterministic community assembly. While invertebrate density was positively correlated to connectivity, and species turnover through time was higher in disconnected water bodies, richness and diversity patterns were unrelated to hydrologic connectivity. Invertebrate composition was weakly related to connectivity, but changed predictably in response to floods. Multivariate ordinations showed that composition across the water bodies diverged during stable periods, reflecting differential species sorting across the lateral gradient, but converged after floods. Contrary to expectation, hydrologic connectivity did not influence the response of community metrics to floods. Stable hydrological periods allowed communities to assemble deterministically with the prevalence of non-random structures and a large proportion of variation explained by local abiotic features. These signals of deterministic processes clearly declined after flooding events. This occurred despite no sign of flood-induced homogenisation of habitat character. This study is among the first to examine the annual dynamic of aquatic assemblages across a connectivity gradient in natural floodplains. Results highlight how community metrics can show variable relation with hydrologic connectivity, which also did not influence the response of communities to floods. Conversely, appraisal of the assembly mechanisms through time indicated how flooding shifted the balance from deterministic species sorting across floodplain habitats, towards stochastic processes related to organisms redistribution and the likely resetting of assembly to earlier stages.

Predicting the effects on mussels of decreased minimum flows

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Mussel populations in streams throughout the south-eastern United States are faced with an impending threat – a conflict over water. Urban and industrial growth is placing ever greater demands for off-stream use of water. However, the effects of reduced flows on mussels are poorly understood. The most obvious effect of extreme low-flow conditions (i.e., 99% exceedance flows) is the dewatering of habitat, and the associated stranding and desiccation of mussels, but the effects on mussels of less-severe flow reductions are unknown. On each of two mussel beds, we used a systematic sampling design to determine the density and spatial distribution of mussels. Water velocities, surface elevations and bottom profiles were measured using standard instream flow incremental methodology (IFIM) techniques. Results of a concurrent mesocosm study were used with the physical habitat simulation system (PHABSIM) to identify the percentage of each mussel bed where lethal and nonlethal affects would occur at various discharges. Effective and scientifically defensible environmental water allocations require this type of specific information. To evaluate PHABSIM predictions, we also used PHABSIM to predict areas where lethal and sub-lethal affects would occur at normal base flow. Within these areas, we established 1 m^2 plots. Adult individuals of two common species were collected, tagged, translocated into these plots and monitored weekly from June to October to assess mortality and emigration. Areas predicted to affect translocated mussels at base flow did indeed do so in a manner consistent with the results of the mesocosm study.

Water colour trends over 18 years in all New Zealand lakes from Landsat observations

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The Landsat series of satellites provides continuous and coherent earth observation data from space since 1972. Multispectral scanners on board Landsat 5, Landsat 7 and Landsat 8 have taken thousands of images of New Zealand regularly since 1999 providing the potential for powerful regional and national retrospective analysis of water quality. Water clarity, chlorophyll a concentrations, suspended sediments, and coloured dissolved organic matter are potentially detectable from space, but retrieval algorithms for these constituents are not yet calibrated or validated for most of New Zealand's lakes. Alternatively, the colour of lakes provides a fundamental and intuitive metric related to water quality and its observation by satellites does not depend on retrieval algorithms, but only on atmospheric correction. Here, we quantify the trends of lake water quality over the last 18 years by analysing the time series of relative blueness (ratio of blue over red band reflectances) in all New Zealand lakes. Generally, clear and pristine water is blue while the presence of suspended sediments, algae and coloured dissolved organic matter adds colour signatures across the green and red wavelengths of visible light. Preliminary results suggest that about 40% of New Zealand's lakes show statistically significant trends towards diminishing blueness and therefore possibly degraded water quality. The regional patterns in these trends provide a wealth of opportunities to investigate environmental correlates for cause-and-effect relationships for drivers of lake water quality.

Viral beach balls and bacterial backstroke: pathogen ecology in freshwater

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Swimmability of freshwater is pitched on the occurrence of *E. coli* and, while this organism is a useful indicator, its use implies a clear understanding of the implications of its use for the likely presence of microbial pathogens in water. The ecology of *E. coli,* and the many pathogens for which it serves as surrogate, are varied and interesting and important to our interpretation of swimmability recommendations and to quality enhancement. Pathogens including the bacteria types *Campylobacter, Yersinia, Salmonella, Aeromonas, Arcobacter, Pseudomonas, Legionella, Helicobacter, Listeria,* toxigenic or invasive *E. coli* and *Mycobacterium* may be of human, animal or environmental origin, and may derive from faeces, skin or replicate in biofilms or sediments. These bacterial groups show different potentials for occurrence, growth, survival and human health implication when associated with surface waters. Protozoal pathogens including *Cryptosporidium, Giardia, Cyclospora* and *Nigleria* demonstrate similarities in source to the bacteria but a very different ecology and survival potential. A multitude of human viruses may also occur in surface water contaminated by human waste. These vary in robustness and human symptoms subsequent to infection. The *E. coli* measure focusses on those that are derived from faecal sources and was established based on gastrointestinal illness symptoms. It models a proportion of the potential risks but is recognised as failing as a model of protozoans, viruses and a number of the bacteria. This presentation will pull together the key principles of viral and bacterial pathogen ecology and the broader need for a risk-based interpretation of *E. coli* measures.

Multidimensional evaluation of freshwater restoration efficacy in coastal wetlands: conceptual model from molecules to functional groups of the macrobenthos

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Freshwater restoration, jointed tidal barrier construction and freshwater releases, are the most common measures to restore and recover the degraded coastal wetlands. Freshwater releases change the receiving wetlands' hydrology, salinity, and sediment deposition, and thereby affect the macrobenthos community which has been regarded as an important bioindicator of environmental characteristics due to their restricted habitat, long life cycle, and direct contact with sediments. Previous studies commonly evaluated the efficacy of freshwater restoration from the single responses of macrobenthos, such as genetic diversity, community composition, biomass and individual richness, as well as functional groups, while freshwater restoration efficacy should be evaluated in multidimensionality. Here, we developed a conceptual model containing four major essential components (drivers, stressors, ecological effects and attributes) to assess the macrobenthic responses in restoration projects. Further, using China's Yellow River Delta wetland as a case study, we evaluated the holistic efficacy of freshwater restoration based on the conceptual model. The degraded wetlands have been receiving freshwater since 2010 in July each year, normally for a period of 20-30 days, in combination with the Xiaolangdi water and sediment regulation projects. A positive effect has been found on the macrobenthic community. Overall, the application of the conceptual model suggests adaptive freshwater releases will be necessary to achieve sustainable management of freshwater restoration projects.

Watercourse assessment reports: a framework for integrated stream management

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Watercourse Assessment Reports (WARs) are documents developed by Auckland Council to guide watercourse and stormwater network management in the context of a holistic strategic approach for managing stormwater effects on streams. The WARs represent the most recent iteration in a series of program refinements towards developing a management methodology capable of achieving multiple objectives within realistic environmental, economic and social constraints. WARs provide baseline data on the existing stream state, and are informed by comprehensive field watercourse assessments. The field-based surveys utilise a remote data collection platform and cloud storage services to capture attribute information in real-time, with the survey scope including assessments on the ecological character of stream reaches, stream mouths, and wetlands; the presence and condition of engineering assets; the identification of erosion and fish passage issues, and enhancement opportunities. In conjunction with desktop reviews, the WAR uses the results of field assessments to identify stream state and catchment issues. Grouping and prioritisation of key issues informs management options and zones for the catchment, supporting the delivery of a targeted works programme that seeks to remedy similar issues on a prioritised basis. The approach ultimately ensures that the most meaningful benefits on a catchment-wide prioritised basis are achieved through identification of where multiple issues exist. WAR outputs offer a catchment-specific framework for watercourse and network management which can inform and support a range of stakeholder aims (i.e., local boards, community groups, developers, infrastructure providers) and related stormwater management and development processes. Within the Auckland region this holds value where the WARs will play an important role in informing the development process and delivery of watercourse and water-sensitive design outcomes. The paper will explore the refined WAR approach, and an example of the outputs that can be used by infrastructure providers to deliver prioritised catchment-wide network maintenance.

Specialist estuarine fishes: not just diadromous transients

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Estuaries, like wetlands, are transitional zones that are challenging to define and characterise. Estuaries are commonly regarded as temporary habitat for diadromous fishes transiting between fully marine and freshwater habitats. However, growing evidence for many of our amphidromous species is that estuaries may be a primary rearing habitat for juveniles. Additionally, there are several species in New Zealand that appear to live almost exclusively in estuaries or that migrate between estuaries and riverine habitat without ever venturing to sea. The dependence on the estuary may vary between catchments in accordance with the variable morphology of the estuary. Although estuaries present significant physiological challenges for fish, especially for osmoregulation, these costs may possibly be outweighed by the niche opportunities afforded by a habitat with low species diversity, relative shelter and high productivity. The ichthyofauna of New Zealand mesohaline estuaries has been relatively poorly studied by comparison with marine or freshwater habitats, especially with respect to seasonal abundance and movements of freshwater or marine amphidromous species and species that may be estuarine specialists. We are starting to unlock the life histories of some of these species using otolith microchemistry and to uncover the importance of mesohaline estuaries. These studies highlight the importance of the estuary to individual catchments and the susceptibility of the amphidromous fauna to degradation of estuarine habitats.

Using fluorimetry to better assess the effects of suspended sediment on phytoplankton: an agricultural bayou case study

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Suspended sediment (TSS, Total Suspended Solids) continues to be a globally pernicious issue in freshwater systems within agricultural watersheds. The impact of high TSS loads is most readily apparent on freshwater primary producers, algae. However, long-standing methods using chlorophyll a concentrations as a measure of phytoplankton biomass often produce only weak-to-moderate relationships with TSS. A 1.7 km^2 agricultural watershed draining into a bayou, Roundaway Lake, in Mississippi, USA, was studied to address this issue. From 2 November 2015 to 17 October 2016, surface water (0.1 m) samples were collected every 14 days in the bayou at four habitat sites: a shallow-channel upstream site; a deeper, broader channel mid-point site; a shallow channel downstream site; and a minimally impacted control tributary site. The current study utilised standard chlorophyll a measurements as a surrogate for algal biomass and in-vivo chlorophyll fluorimetric photosystem II efficiency (Chl PSII) as a surrogate for algal primary productivity. Additionally, recent advances in monitoring techniques have allowed for measurements of phycocyanin as a surrogate for cyanobacteria biomass and in-vivo phycocyanin fluorimetric photosynthetic photosystem II efficiency (PC PSII) as a surrogate for cyanobacteria primary productivity. TSS in the bayou ranged from 1 mg/L to >1,000 mg/L with highest median concentrations of 216-256 mg/L occurring at mid-point and downstream sites, respectively. Median bayou chlorophyll a and phycocyanin concentrations ranged from 15.1-49.3 µg/L and 26.9-86.2 µg/L, respectively. Median bayou Chl PSII and PC PSII ranged from 0.17-0.49 and 0.06-0.33, respectively. Non-linear regression models of TSS vs algal endpoints produced coefficients of determination (R^2) that were lowest for chlorophyll a and phycocyanin concentrations (0.015-0.661) highest for Chl PSII and PC PSII (0.245-0.865). More robust models generated with Chl PSII and PC PSII are valuable in improving water quality modelling and determining water quality criteria for TSS in freshwater systems.

Reintroduction of invertebrate communities – a field experiment in a German lowland stream

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River restoration is conducted all over the world to combat human impacts. However, morphological restructuring does not inevitably restore reference communities. Particularly, benthic invertebrates exhibit low dispersal capabilities and monitoring of restored sites often demonstrates very low recolonisation rates. Thus, a reintroduction of reference species communities would be a solution to improve restored sites. So far, reintroduction projects rarely approached aquatic invertebrate communities except for some single iconic species e.g., the noble crayfish. In a field experiment, we tested the translocation of a reference community from a near-natural stream to a restored but biologically impoverished stream. Both streams are small sand-bottom lowland streams according to the German stream typology. In a pre-test, different natural substrates i.e., gravel, leaves or dead wood, were placed in mesh bags and exposed for four different time periods in the reference stream. Colonisation rates and substrate preferences yielded the best combination for the follow-up colonisation phase. 200 mesh bags with a leave/wood mixture were then exposed in the reference stream and after six weeks transferred to the impoverished stream. The whole procedure was conducted in spring and summer 2016 and in spring 2017. A selection of mesh bags in each translocation and both streams were analysed pre- and post-reintroduction for invertebrate community composition. This presentation will sum up the field experiment and the first results.

Integrating ecological and stormwater mitigation and offsetting

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The operative Hamilton City Council plan seeks stormwater systems capable of mitigating, remedying or avoiding any adverse environmental effects attributable to stormwater discharge. The Waikato Regional Plan seeks the avoidance of significant adverse effects on aquatic ecosystems or significant adverse effects from flooding or erosion. Therefore, both the Waikato Regional Plan and the Hamilton City Plan meet the RMA intent of avoiding, remedying and mitigating environmental impacts. However, when this is not possible, or significant residual impacts remain following avoidance and mitigation, there is an option to offset these impacts. While there is a clear direction to avoid and mitigate significant adverse effects resulting from increased imperviousness and stormwater discharges, the residual impacts following typical stormwater retention, detention and treatment are not always assessed. These residual impacts can be significant, particularly where significant existing downstream erosion exists; where there is high erosion susceptibility downstream, or where altered hydrographs impact on fish passage and/or habitat availability. The Stream Ecological Valuation method can be used to assess residual stream ecological impacts and calculate an appropriate quantum of offsetting. However, the Stream Ecological Valuation method does not perform well in assessing the ecological impacts associated with altered hydrographs, particularly with respect to exacerbated erosion, sediment deposition and fish passage. This paper discusses options and difficulties of assessing residual adverse impacts following implementation of typical stormwater mitigation methods. This paper also discusses options and difficulties for quantifying an appropriate quantum of offsetting in regards to these impacts, with respect to both ecological impacts, as well as the maintenance, conveyance and infrastructure risk associated with potential exacerbated erosion. In doing so, how ecological and stormwater mitigation and offsetting can be better integrated is discussed. Specific Hamilton City examples are given.

Developing tiered environmental flow targets using a functional flows approach for California streams

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Establishing environmental flow targets to protect aquatic biological communities is a priority for numerous programs in California. Although methods vary, each effort aims to achieve similar goals of stipulating stream flow conditions necessary to protect ecological integrity in light of competing water uses, such as agricultural production, hydropower operation, urban water reuse, or consumptive uses. Methods vary based on the ecological endpoint of management concern (e.g. fish, macroinvertebrates, habitat), stream type, and preferences of the implementing agency. Building on a growing recognition that hydrogeomorphic processes are inherent in the ecological functionality and biodiversity of rivers, we propose a functional-flows approach to rapidly develop statewide environmental flow recommendations. The approach focuses on retaining specific process-based components of the hydrograph, or functional flows, rather than attempting to mimic the full natural flow regime. Key functional components include wet-season initiation flows, peak magnitude flows, seasonal transition recession flows, dry-season low flows, and interannual variability. The method defines a set of quantitative flow metrics based on the unimpaired hydrologic conditions for each of nine California stream classes. Using "dimensionless reference hydrographs", which are scalable representations of the statistical variability in unimpaired flows within a stream class, we calculate the range of values for specific flow metrics that represent components of the hydrograph associated with critical ecological or hydrogeomorphic functions. The values for each functional flow metric can then be appropriately scaled to a stream of interest and serve as initial Tier 1 flow management targets. Tier 1 flow targets can be further refined by additional site-specific analyses under Tier 2 approaches as defined in the California Environmental Flows Framework. We suggest this approach allows for the rapid development of flow regimes that encompass ecosystem processes alongside varied human needs and can be applied in an adaptive management framework allowing for changing conditions and needs.

Tidal flood modelling at Dargaville

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Hydraulic models developed for river flood simulations were used to simulate flooding due to tidal events on the Dargaville and Awakino Point floodplains, and in the Kaihu and Awakino valleys. The aim of the modelling was to assess the limitations of a simplified approach in which tidal flooding extent was estimated by a level pool model. The events simulated were of annual exceedance probabilities (AEP) 1% under present-day sea-level conditions, 2% with projected sea level rise to 2065, and 1% with projected sea level rise to 2115. The valleys are of low gradient, with for example a reversing tidal flow extending 10km up the Kaihu valley under normal conditions. The Dargaville and Awakino Point floodplains are low lying, and the level pool approach indicated widespread flooding in the design tidal events. In this study, unsteady flow simulations were undertaken with combined Mike 11 and Tuflow models to more accurately assess the extent of tidal flooding. It was found that because of the time-varying tidal boundary condition, the effect of the flood defences, and the resistance to flow in the rivers and on the floodplains, the maximum flood levels inland were generally significantly below the maximum tide level. This has implications for the assessment of coastal flood hazard. However the simulations showed that even in the absence of any associated river flood, substantial areas would be flooded. The Mike 11 and Tuflow models were linked by transfer of boundary conditions in the lower Kaihu valley.

A new multi-scale approach to predict potential hyporheic exchange flow in rivers

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The hyporheic zone (HZ) is an area of interaction between surface and ground waters found within river beds. This process of mixing, known as hyporheic exchange flows (HEF), has been shown to play significant roles in nutrient transport, organic matter and biogeochemical processing in rivers. Given the functional importance of HZs, river managers and restoration practitioners would now like to incorporate consideration of the HZ in their planning. However, research on the HZ has been conducted in a limited number of rivers and river types, and at small spatial scales (10s – 100s metres). The focus on small-scale studies has been instrumental in advancing our understanding of hyporheic zone processes, but restricts the extrapolation of findings, and prediction of HEF occurrence, to other river types and at large scale (> 100 m) using traditional statistical approaches. Hence, we present a semi-automated decision system to predict the presence of HEF using a combination of evidence from published literature and hydrological theory. The method classifies potential HEF at three spatial scales (catchment, segment, reach) based on a large set of hydroclimatic, hydrogeologic, topographic, anthropogenic and ecological factors that influence surface and ground water flows and levels. Exploratory data-mining techniques and expert knowledge are used to integrate, simplify, and identify which factors are the most related to potential HEF. The method was tested on nine rivers that have previously been the site of HEF research. The results indicate that HEF occurrence is likely to be correlated to certain characteristics across scales, showing sensible statistical agreement (> 75%) in the classification with respect to human assessment. This study demonstrates that our method has the potential to predict HEF for management and restoration planning, and may have wider uses in hydrology and ecology where empirical data is scarce and predictive models do not yet exist.

Relationships between large wood in rivers, benthic macroinvertebrates, and hyporheic invertebrates

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Large wood (10 cm diameter and 1 m long- LW) is a key element of river channels, influencing their hydrology, geomorphology, nutrient and organic carbon processing and ecology. Indeed, one of the hypothesised benefits of LW is an increase in the hydrological connectivity between the river and the shallow aquifer, primarily through hyporheic exchange. At small scales, i.e. reach to microhabitat, LW creates zones of shallow upwelling and downwelling, but, if flows are sufficient to mobilise the bed, it also induces sediment sorting and bedform development to further promote and modify hydrological exchange. This increase in hyporheic exchange flow is hypothesised to drive ecological diversity and secondary production, but this connection has not been well evidenced in empirical studies of hyporheic invertebrates. This study examined the effects of submerged, channel-spanning LW on the physical habitat and invertebrate communities of a lowland river. Invertebrates were surveyed seasonally within the benthic and hyporheic zone of two reaches in the Hammer catchment, UK. Previous studies have shown that the two reaches differ by sediment type (sand vs gravel), geomorphology and hyporheic exchange. Invertebrate samples were collected along with measurements of streamflow, sediment size, water chemistry and wood morphology. Preliminary results show that LW produces consistent patterns of habitat variability within the reaches. Such effects were more visible in the sandy reach, where wood represents the main source of in-channel structural complexity. Results of the benthic and hyporheic invertebrate community composition, biomass, and secondary production will be presented. This study is improving our scientific understanding of how wood modifies the physical environment of rivers, and its impact on biological communities, which will benefit river restoration design and planning.

Riparian shading as a tool to manage nuisance instream plants: testing the concept in Hawke's Bay and Waikato streams and rivers

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Light is essential for the growth of instream plants yet information on shading effects, particularly in New Zealand streams and rivers, is limited. The shade created by riparian vegetation, if sufficient, has the potential to moderate stream water temperatures and limit the nuisance plant growth. In soft-bottom macrophyte-clogged watercourses this could mitigate low dissolved oxygen minima and phosphorus release from sediments. Literature review suggests at least 50% shading would be required to reduce the abundance of emergent and sprawling plants and periphyton, while shading of 70% or more is likely to be effective at achieving an intermediate level of macrophyte cover. High levels of shade (i.e., >90%) may be required to reduce the abundance of some low-light-adapted submerged species. We are testing these thresholds, including evaluation by species and life-form, using field shading trials & observations, field surveys and analysis of State of Environment monitoring datasets. This presentation will outline the latest results and implications of this work.

Phormidium growth responses along hydrological gradients in three south Canterbury rivers

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Toxic benthic cyanobacterial proliferations, particularly of the genus *Phormidium*, are an escalating problem in freshwater environments worldwide. In New Zealand there has been an increase in the distribution, intensity and frequency of *Phormidium* blooms in recent decades. Blooms have been associated with numerous animal deaths and may affect the health of aquatic organisms and, in New Zealand, cover exceeding 20% triggers posting of a bankside health warning. To date, understanding what conditions favour bloom formation has been dependent on observational studies, which have associated a range of environmental factors, including nutrients and flow, as potentially important in facilitating *Phormidium* accrual. However, few of these studies are undertaken with sufficient spatial or temporal resolution to provide explicit information on relationships between *Phormidium* accrual dynamics and environmental conditions. To overcome this we have developed a method that allows us to accurately assess *Phormidium* accrual rates by seeding cobbles with a known quantity of *Phormidium*. In this study, 135 cobbles seeded with *Phormidium* were placed in pools, runs and riffles in three different rivers with varying nitrate concentrations. Biomass (biovolume, chlorophyll a, phycoerythrin) and growth rates (analysed by photographs) were measured over a four-week period. Water nutrient chemistry and macroinvertebrate communities in each habitat type were also determined. Initial analysis of results show that patches in pools were removed quickly due to high grazing pressure, and that patches expanded most rapidly at intermediate velocities. However, growth rates also varied among rivers, with highest growth rates measured in the Ōpihi River, which had intermediate nutrient concentrations. The study highlights that velocity, site-specific factors and grazers interact in complex ways in influencing *Phormidium* accrual dynamics.

'Maintain or improve': how do we judge that?

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A key requirement of national policy is that water quality should be 'maintained or improved'. We propose two steps for assessing this requirement for a water quality variable: (1) water quality trend direction assessment; (2) trend importance assessment. Item (1) addresses 'improve?' and is the simpler step. We use a new trend assessment procedure to calculate the (Bayesian) probability that the (monotonic) trend is positive or negative, or to indicate that trend direction cannot be inferred with confidence (i.e., it is indeterminate). Item (2) addresses the more challenging issue: 'maintain?' It requires the investigator to assess whether the inferred trend is environmentally important, requiring that a subjective decision is made concerning the importance of the trend magnitude over some nominated period. When a trend direction has been inferred there are three possible outcomes: (a) If a trend direction assessment indicates degradation and the trend magnitude is greater than the importance threshold, the assessment is that water quality is not being maintained; (b) If a trend direction assessment indicates improvement or degradation but its magnitude is less than the importance threshold, the assessment is that water quality is maintained; (c) If the trend direction indicates improvement the assessment is that water quality has improved. If the trend direction assessment is indeterminate there are two possible assessment outcomes: (d) If sampling effort is assessed as adequate (from rational criteria), the assessment outcome is 'maintained'. This assessment is justified on the basis that the true trend magnitude is less than the threshold of importance (because if it were greater the trend direction would not have been indeterminate); (e) If water quality monitoring has not been adequate through the assessment time period, then the assessment merely finds that data are inadequate. We will present examples of these outcomes.

A conceptual synthesis of flow-recruitment relationships for riverine fishes

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The Murray-Darling Basin Environmental Water Knowledge and Research Program aims to help inform flow management through understanding flow-ecology relationships. For the fish research theme, recruitment has been seen by both managers and scientists as a priority area. Three broad classes of theory have contributed to our understanding of riverine fish recruitment: life history theory, river ecosystem concepts and fish recruitment hypotheses. This paper will consider these, with the aim of developing an integrated model describing the recruitment of riverine fishes and its relationship with flow. Specifically, the synthesis investigates how physiological, behavioural and life-history traits are correlated, how these three components interact with the key features of river ecosystems – and flow in particular – to contribute to fish recruitment; explores the relevance of river ecosystem concepts for explaining patterns and processes in fish recruitment and population dynamics; relates current ideas and hypotheses about fish recruitment from all aquatic environments to rivers and riverine fishes; and explores how the resulting model can be used to identify knowledge gaps and future research areas, and to develop ecological guidelines for use in river management.

Can the bio-deposition and physical structure of hyriid freshwater mussels alter benthic algae and invertebrate assemblages in floodplain rivers?

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Although we know that marine mussels have large effects on ecosystem processes and movement of energy and nutrients throughout the water column and benthos, the functional roles of freshwater mussels in riverine-floodplain environments is less well understood. The aim of this research is to investigate if the bio-deposition and physical structure of the freshwater mussel *Alathyria jacksoni* (Hyriidae) can influence the distribution and abundance of associated benthic organisms. We conducted a manipulative, in-situ mesocosm experiment for four weeks in late summer 2017 in a south-eastern unregulated Australian river, examining the effect of live mussels on benthic nutrient concentrations, and diatom and invertebrates assemblages. We compared the benthos of live mussel, dead mussel and no mussel enclosures. We hypothesised that deposition of faeces and pseudo-faeces by live mussels in and on the sediment would increase local benthic nutrient concentrations, which would in turn increase abundance of periphyton and invertebrates, relative to controls. Benthic organic biomass, and total nitrogen (TN), total phosphorus (TP), chlorophyll a concentrations were quantified for treatments and controls, as well as abundance and diversity of benthic and shell periphyton and inverbertebrates. Nutrient content and organic matter of biodeposits (TN/TP) and excretion (NH^3/FRP/NOX) from mussels was also estimated during the experiment. We discuss our results in light of the role that mussels may have in riverine environment, and in the context of global declines in native freshwater mussels generally.

The land-use suitability concept: a system to inform land-use and catchment planning and assessment

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The need for simultaneous improvements in primary sector productivity and in environmental performance are driving changes in land and water policy and management in New Zealand. The intent of these changes is sustainable productivity within the limits of land and water resources. Implementing these changes will require a shift from the traditional focus on production, to a broader view that accounts for effects of land use on environmental, social, cultural and economic values at multiple spatial and temporal scales. We call this broader view 'land-use suitability' (LUS). The LUS concept is designed to link land parcels to receiving environments and provide land owners, regulators and planners with the information needed to manage the effects of land use, to reduce the degradation of values and maintain productivity. The LUS concept contains three components: (1) the potential of individual parcels of land for long-term primary production; (2) the inherent contribution of each land parcel to the delivered load to a critical point in a receiving environment; and (3) a measure of pressure on a catchment that can be ameliorated by on-farm mitigations or interventions at receiving environments. This paper will provide an overview of the concept with more detailed presentations of components to follow.

Vulnerability of freshwater ecosystems to state shifts associated with tipping points

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Tipping points are stressor (or pressure) thresholds associated with rapid changes in community structure and function (state shifts) in relation to relatively small changes in a stressor (or pressure). Such non-linearity characterises some responses to stressors in freshwater ecosystems, but more linear change is also possible. To help prioritise systems for management and to identify actions which might prevent undesirable state shifts, we have been investigating features which make freshwater ecosystems vulnerable to non-linear and linear state changes as part of New Zealand's Biological Heritage Science Challenge. Theory and empirical studies suggest vulnerability to abrupt state changes is highest in systems that have low inherent ecological resistance and resilience. Systems approaching tipping points often show a syndrome of behaviours called 'critical slowing down' characterised by reduced resistance and resilience to environmental stochasticity, temporal autocorrelation, and increased variance. Critical slowing down can apply to either tipping points associated with alternative stable states or simple non-linear threshold relationships. The main difference may be whether there are dominant 'ecosystem engineer' organisms involved (e.g., macrophytes in shallow lakes). Overall, our review suggests systems with high inherent resilience (or resistance) will be least vulnerable to tipping points. Given the above, tipping points are probably most likely to occur in naturally benign environments (e.g., springs) and least likely in freshwater environments that are naturally highly disturbed (e.g., braided rivers) for at least two reasons: (1) environmental disturbance selects for traits that improve resistance/resilience; and (2) their community assembly may be more directed towards a specific assemblage through niche rather than neutral processes (e.g., the nested communities of New Zealand ponds subjected to drying). Connectivity and dispersal should also improve resilience, so we also expect lakes and other still-water environments to be inherently more vulnerable to non-linear state shifts than flowing water environments.

Fish community response to the fragmentation of river networks

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Physical fragmentation of river networks via dams and other water control structures alters the natural flow regime and results in the loss of ecological function, and the endangerment or broad-scale extinction of many freshwater aquatic species, particularly riverine habitat specialists. Many rivers in Australia and elsewhere have been the subject of significant hydrological and physical change over the last 100 years. Monitoring of the abundance of freshwater biotic species and water quality has occurred only relatively recently, long after the initial disturbance of river networks. The ecosystem response to disturbances like fragmentation is most appropriately measured by comparing the same river and aquatic communities before and after disturbance. The existence of historical data for the Darling River in New South Wales, Australia, makes possible assessing the ecosystem response to physical fragmentation at an appropriate temporal scale. Food webs, as a functional feature of ecosystems, provide insight into the impact of human-induced disturbance on river systems. Stable isotope analysis of preserved museum fishes provides a tool for recreating an historical food web. The degree of physical fragmentation on the Darling River was quantified by comparing pre-dam river surveys with current conditions. Stable isotope analysis of tissue samples from museum specimens was used to investigate potential changes in diet source and the trophic status of fish feeding guilds before and after physical fragmentation of the river.

Erosion control treatment trials on loess soils

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During earthworks on Canterbury's Port Hills, highly erodible loess sub-soil is exposed to potential erosion. Stormwater discharged from such sites can contain large quantities of fine sediments that stay in suspension and are challenging for treatment systems to remove. The ecological impact of these fine suspended sediments on downstream receiving environments, including the Cashmere Stream, Heathcote River and Avon Heathcote Estuary, is significant. Utilising effective methods to minimise erosion of exposed soils is key to reducing the amount of leoss reaching such sensitive receiving environments. An experimental field study to test the effectiveness of erosion control treatments was commissioned by the Cashmere Working Group of the Christchurch–West Melton Zone Committee and undertaken. Five erosion control treatments applied over a leoss sub-soil were tested against an exposed leoss sub-soil control during multiple, controlled one-hour rainfall simulations. The study showed that such erosion control treatments were effective in reducing soil loss, but that proper application of the products was critical to their effectiveness. Even at the higher rates of erosion control, suspended sediment in runoff still exceeded most local consent-based limits, reiterating the importance of construction sites needing to use a treatment-train solution of erosion control and sediment control measures. The findings of the study helped inform an update of the Environment Canterbury Erosion and Sediment Control Guidelines and will be useful in resource consents to develop innovative construction-phase consent conditions, which are flexible to be applied during site development while achieving objectives, policies and water-quality outcomes in the Canterbury Land and Water Regional Plan. A collaborative approach to investigating the effectiveness of erosion control measures through field studies in a specific highly erosive area has been extremely helpful in demonstrating what is required to limit sediment loss from challenging hillside development areas.

Composition of Kōwaro populations in different climatic conditions

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Stress-tolerant species that reside in extreme conditions outside the niche of competitors and predators are likely to be particularly vulnerable to global environmental change. We studied the Canterbury mudfish (*Neochanna burrowsius*) to investigate how future changes to the drought regime were likely to affect established populations, particularly through changes to the food webs of mudfish-inhabited waterways. Sites, identified as either an isolated pool or 20-m stream reach, were selected within the Waianiwaniwa Valley and along the Hororata River and, using stable isotope analysis with support from gut content analysis, site-specific food webs were constructed. Our results indicate that micro-crustaceans dominated the aquatic community and, subsequently, were an important food resource for mudfish. Habitat drying had a strong effect on food webs by influencing energy pathways between trophic levels, but this was also affected by riparian habitat characteristics like the presence of willows. Here our results suggest that habitat drying has strong negative consequences but this may be able to be offset by managing riparian habitats which provide alternative food sources. Future directions involve comparing these food webs with those constructed for brown mudfish (*Neochanna apoda*), a closely-related species, from within native swamp forest. This will potentially provide insights into the likely historic food webs of Canterbury mudfish populations and possible restoration targets to produce resilient trophic connections.

Effects of water temperature on the release and viability of glochidia of the freshwater mussel *Echyridella menziesii*

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The New Zealand unionid mussel *Echyridella menziesii* has a current threat classification of 'Declining', in part reflecting disruption of recruitment during the sensitive larval (glochidia) and juvenile phases. Propagation of freshwater mussels has been identified as a tool to aid in the restoration of mussel populations, but more research is needed on their reproductive biology and its relationship with environmental factors, to improve management of glochidial release in the laboratory. For instance, transferring gravid mussels to low temperatures may extend the availability of mature glochidia outside the normal release season. This study, therefore, examined the influence of water temperature (8°C, 12°C and 18°C) on (i) the timing of glochidial release by gravid female *E. menziesii*, (ii) the viability of released glochidia, and (iii) the longevity of released glochidia over time at different temperatures. Preliminary results suggest that both glochidial release and viability were affected by temperature. After 42 days in the laboratory, 93% of mussels held at 18°C had released their entire glochidial load compared to 50% of those held at 12°C and 64% at 8°C. Mussels at both 12°C and 18°C extruded mature glochidia individually and as vermiform conglutinates. Conglutinates were bound together by mucus threads which were attached temporarily to the excurrent siphon. There was no significant difference in glochidial viability between 12°C and 18°C. Mussels held at 8°C expelled immature, non-viable glochidia. The longevity of viable glochidia differed between temperatures, with glochidia held at 12°C significantly outliving glochidia held at 18°C, maintaining >75% viability for 82 ± 39.5 hours and 60 ± 30.8 hours, respectively. These data suggest that temperatures 12°C or lower are required to cause gravid mussels to retain ripe glochidia. Further evaluation is required to determine the viability of glochidia from gravid mussels held for extended periods at 8°C then stimulated to release.

Is salmonid migration initiated by juvenile intra-specific competition?

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Plasticity in animal migration is a key attribute that allows for flexible responses to unstable environments and climate change. Salmonids are classic examples of migratory organisms that exhibit a variety of life histories, enabling them to exploit a wide variety of environments across mid- to high-latitude environments, and contributes to their success as invasive species. One of the most variable and invasive salmonid species is brown trout *Salmo trutta*. Brown trout exhibit a variety of life strategies, migratory tactics and may occupy lentic, lotic, estuarine and sea environments as adults. However, a common feature of all brown trout life histories is that spawning and early juvenile stages always occur in cold, well-oxygenated streams. If downstream juvenile migration occurs, then upstream migration back to spawning streams is required to complete the brown trout life cycle. Our study focused on the factors initiating juvenile downstream migration, specifically testing the hypothesis that juvenile competition for resources initiates migration. Juvenile trout density, growth, migration intensity and food supply were measured in situ in streams in which migratory or resident trout population were present. Preliminary assessments suggest that as juvenile brown trout grow, population densities will become unsustainable in streams that support migratory populations, whereas juvenile trout densities are significantly lower in streams supporting resident populations. The results of bioenergetic modelling predicting growth in relation to temperature and food supply will be presented and compared to actual juvenile brown trout densities present in migratory and non-migratory streams over summer and into autumn.

How effective are spat ropes at providing for fish passage in culverts five years after installation?

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Between 2010 and 2012, the New Zealand Transport Authority (NZTA) carried out a programme of fish passage assessment and improvement work at selected culverts along State Highway 35 (SH35) on the East Cape of the North Island. A total of 25 culverts were retrofitted with mussel spat ropes through the culvert and outlet structures. The ropes aim to enhance passage opportunities for native fish species that negotiate barriers by "climbing". The improvement work pre-dated NZTA's Fish passage guidance for state highways but informed the approach taken in those guidelines. Since the retrofitting work was undertaken, Waikato Regional Council (WRC) has published the technical document "Appropriate use of mussel spat ropes to facilitate passage for stream organisms" which sets out how to determine if spat ropes are applicable at a culvert and provides guidance on installation. In a follow-up assessment in 2017, five years after the retrofitting, work was completed to determine the status and effectiveness of the fish passage improvements. The work comprised a condition assessment of all 25 retrofitted culverts by an engineer and an ecologist and follow-up electric fishing surveys at seven of the retrofitted culverts and three reference culverts with no fish passage enhancements. Upstream and downstream reaches of 10 selected culverts were fished to assess differences in fish populations either side. This paper presents the results of the 2017 investigation. Our analysis includes an assessment of all 25 sites using the decision-tree approach set out in the NZTA and WRC guidelines to review if the correct retrofit solution was applied. We assess the longevity of the spat rope installations, maintenance issues affecting performance and whether there is a discernible difference in fish passage effectiveness of those installations that meet the guidance and those that do not.

'NZ Inc.' takes a step towards national consistency in river and lake water quality monitoring – a new National Environmental Monitoring Standard (NEMS)

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Professor Sir Peter Gluckman's *New Zealand's fresh waters* report released in March 2017 emphasises the need for nationally consistent and integrated monitoring of freshwater quality. The National Environmental Monitoring Standards (NEMS) is one initiative that has been in place for several years to help address this. In October a draft Standard on Discrete Water Quality Sampling and Measurement was released for public comment that focuses on long-term monitoring (e.g. State of the Environment monitoring). The Standard addresses groundwater, rivers, lakes and near shore coastal waters.

The principal objective of the Standard is to ensure that long term water quality monitoring is consistent and supports robust, defensible national reporting, as sought by Central Government through the Environmental Reporting Act 2015. The Standard was prepared by an interagency team comprising experienced science and monitoring staff across regional councils, crown research institutes and analytical laboratories.

The content of the Standard was developed through a review of existing national guidance and expert panel workshops to refine and develop new material. The Standard presents protocols for: sample point selection, visit metadata, sampling equipment, on-site measurements, water sample collection and handling, laboratory testing, and data quality assurance (QA) and archiving. A matrix-style scoring system has also been developed to assign a quality code to individual water quality measurements, taking into account key aspects of sample collection, measurement and laboratory testing that have the potential to influence data quality.

This paper will highlight the key requirements of the draft Standard for river and lake monitoring, and outline some proposed additional work to investigate difference in laboratory practices identified during development of the Standard that may be affecting the quality of low-level nutrient measurements in New Zealand.

Effects of contrasting extreme flooding events on biotic communities in Glacier Bay, Alaska

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High rainfall in southeast Alaska in summer 2014 created a series of large, recurrent and atypical flood events in Glacier Bay National Park, contrasting with an earlier winter extreme flood in 2005. Understanding the effects of different flooding regimes has been hindered by absence of long-term pre-disturbance data but we have long-term records for streams, many exceeding 20 years. Findings from Wolf Point Creek, the stream with the longest record from 1978, indicated a reset of the macroinvertebrate community in the years 2006-08 following the 2005 flood. In subsequent years (2010-14) the community shifted but did not recover to pre-flood composition. After the summer flooding of 2014, the community was markedly reset again but not similar to 2006 suggesting different end-points to the two flooding regimes. Following the 2005 floods, biotic recovery appeared to be independent of geomorphic recovery and the complexity of the system appeared to play a role in the system's resilience to these events. This research has important implications for river restoration with respect to mitigation approaches to reduce the impacts of extreme and atypical floods dependent on their timing.

Glacier shrinkage driving global changes in downstream ecosystems

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Glaciers, covering ~10% of the Earth's land surface, are shrinking rapidly due to global warming in many parts of the world with the resultant hydrological changes some of the greatest projected for any ecosystem. Areas of extensive snow cover will also respond to climate change in parallel with ice loss, but glaciers impart unique footprints on river flow, sediment and nutrient regimes at times when other water sources are low. Our synthesis evaluates and contrasts the wide-ranging effects of glacier retreat on downstream biogeochemistry, and nutrient transport, community ecology and biodiversity (microbes, algae, macroinvertebrates and fish), and critical ecosystem functions and services, including hydropower and agriculture. We present new conceptual models of the major shifts envisaged this century for these important features of aquatic systems downstream from glaciers. We present tipping-point analysis for different geographical regions to predict the point at which glacier reduction increases extinction risk for specialist riverine species. Furthermore, glacier ice can represent a significant store of contaminants (e.g., mercury and POPs), which are released to downstream areas on glacial melting, decades to centuries after deposition, with associated chemical and ecological implications. Suitable management strategies are outlined to mitigate the societal impact of these profound changes in glacial runoff, with key priority research areas identified to inform these strategies.

Does size matter? The ecological consequences of decreased body size with temperature rise

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Temperature rise is one of the most significant threats to global biodiversity yet its structural and functional effects on freshwater ecosystems are largely unknown. However, rising temperature is predicted to alter species phenologies, increase metabolic rates, and decrease individual body size. Our study investigates the ecological effects of the global freshwater invader, *Gambusia affinis* (mosquitofish) adapted to different thermal environments. Previous studies have found rapid population divergence in *Gambusia* in response to predation pressure and habitat change. As such *Gambusia* make an ideal organism to understand rapid evolutionary responses (<100 years) to temperature rise. We used 40 600L mesocosms (artificial ponds) stocked with *Gambusia* from a hot population (37°C), a cool population (24°C), or with no *Gambusia*. Within each of the *Gambusia* treatments we selected for small and large body sizes where mass was equalised. Mesocosms were sampled weekly over five weeks for pelagic phytoplankton, zooplankton, inorganic nutrients, net primary production, and greenhouse gas emissions. Our final sampling included measurements of decomposition rate, pH, fish metabolic rate, fish behaviour, invertebrates, and periphyton. This study design allowed us to: (1) determine any ecological effects of *Gambusia* on community structure; (2) to determine the ecological effects of rearing temperature; and (3) to understand the ecological consequences of body size change. Both pelagic phytoplankton and greenhouse gas fluxes were highest in the small body size treatments, whereas periphyton was most abundant in the hot population treatments. Our data suggest that increasing temperatures and decreasing body sizes are likely to lead to changes in ecosystems with clear ecological effects.

Incorporating cultural values and perspectives of 'First Peoples' (Aboriginal People) into water planning and environmental water management

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Australia is the driest inhabited continent on Earth, yet it has been the traditional lands of its original inhabitants, Australia's First Peoples, for thousands of generations. Protecting water landscapes (surface and ground water) has always been a high priority for survival in a dry landscape, and protecting water remains a cultural obligation. The challenge for First Peoples is to ensure their value and relationship with water is not diminished or excluded by modern-day water planning or from environmental flow management. First Peoples acquire the right wisdom and traditional knowledge and many indicate that their worldview is seeing water as inseparable from the land and the sky, bound by traditional lore and customs for its protection. For Australia's First Peoples, occupying an ever-drying landscape, traditional knowledge of finding, re-finding and protecting water sites has been integral to their survival for so long. This paper will explore relationships between First Peoples and water planning and environmental water management in three ways. Firstly, history, challenges and institutional responses in integrating First People's cultural values into water planning and management will be discussed through a reflection on the NSW Aboriginal Water Initiative. Secondly, this paper proposes a series of on-the-ground applications of cultural water and environmental water empirically. Finally, integrating First People's perspectives into water management will be assessed through comparisons between the Australian situation through case studies looking at models and methodologies.

Relating with rivers as part of best river management practice

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Managing rivers with multiple environmental and social values presents significant challenges for all involved. One important challenge is ensuring that scientific and non-technical expert knowledges are integrated constructively so that management decisions can be environmentally and socially acceptable. However, in many cases, knowledges interact indirectly and at a later stage of the management process, which tends to situate these knowledges in opposition. We argue that a reorientation toward dialogue in river science and management can create opportunities for cross-cultural understanding further upstream of decision-making, providing a shared foundation for collaboration in river management. Drawing on a case study at Crisp's Creek in southeast Australia, the work of building, reconfiguring and maintaining relationships, between people and between people and place, is presented as a form of river rehabilitation in its own right. In this example, dialogue between researcher and members of a local Aboriginal organisation changed the way that each understood the river and opened up a potentially useful, less formal, pathway for communication in river management. This research echoes developments in geomorphology such as ethnogeomorphology and sociogeomorphology, and considers the implications for practising science and management with a 'back to basics' approach to science communication.

Development of linked frameworks to represent and manage catchment-scale contaminant transport for improved water quality outcomes

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Achieving desired water quality values – outcomes and outputs – in many catchments will require simultaneous management of multiple contaminants. However, many modelling tools are designed to manage only one or two contaminants. Furthermore, modelling tools often lump flow pathways which hinder the representation of attenuation and mitigation of contaminants as well as representing catchment travel lag times. The core of the Sources & Flows programme in Our Land & Water is a hydrology model that links together the sources, fate and transport of the four key agricultural contaminants (N, P, sediment and *E. coli*) via multiple hydrological pathways. The advantages of this approach is that it allows the estimation of the co-benefits of a mitigation or attenuation option for multiple contaminants while ensuring consistency of the fundamental input data layers. The challenge to this new approach is that there is a lack of data for specific combinations of contaminants and flow pathways. There is also a desire to be able to incorporate local and/or cultural knowledge into these frameworks. These other sources of knowledge can be important for understanding connections in the landscape and inundation zones etc. This information has the potential to provide guidance on the best locations in a catchment to build attenuation systems to enhance water quality and other values. These gaps and their implications for addressing water quality goals at the catchment scale will be discussed.

Predicting the invertebrate community reference condition for New Zealand rivers

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There has recently been more interest in the use of invertebrates as indicators of river health due to the inclusion of Ecosystem Health as a compulsory attribute in the National Policy Statement for Freshwater Management (NPSFM) and the proposal that invertebrates become a compulsory monitoring tool for this value. However, the absence of a reference condition assessment approach makes it challenging to use invertebrates as a consistent monitoring tool across the country due to natural environmental variability. The reference condition approach distinguishes natural variability from anthropogenic impacts by comparing the biological attributes from a test site with similar sites that are in reference condition. The concept is central to many bioassessment programmes, where the reference (expected (E)) value is compared to the result from a test site (observed' (O)). The ratio (O/E) of these values is commonly used globally as basis for bioassessment. Importantly, the concept of O/E can be applied to any measure or metric of the stream invertebrate community. There are two approaches commonly used for predicting the reference condition; reference sites are classified either on their biological or environmental attributes. Here we report on a comparison of the effectiveness of the two approaches in New Zealand's streams, based on the predictive accuracy of invertebrate fauna predictions using a dataset of 538 reference sites. Either approach resulted in greater predictive accuracy than a null model. However, for the metrics tested (Number of taxa and MCI), the biological model provided greater accuracy than the environmental model. The performance of the biological model was comparable with established international predictive models. This first exploration of the reference condition approach at a national scale in New Zealand indicates that a predictive model is feasible, able to produce useful invertebrate community predictions and therefore likely to be a valuable addition to the toolbox for managing rivers in New Zealand.

Waikato and Waipa River Restoration Strategy - an action plan for the restoration of New Zealand's longest river

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The Waikato River is New Zealand's longest and most intensively utilised river. River Iwi revere the Waikato as an ancestor who nourishes and sustains the generations of people and communities that she has founded. Approximately 150 years ago, tribal resources were confiscated, leading to years of intensive use of the river. Iwi sought to restore the river through settlement legislation focusing on regulatory change and restoration initiatives. Over the past six years, the co-governance and co-management approach has significantly changed the environmental and political landscape within the Waikato region. The implementation of the Vision and Strategy for the Waikato River and a $220m Clean-up Fund to restore and protect the health and well-being of the river for future generations, potentially sets a benchmark for other large river catchments. In 2014 the Waikato River Authority, Waikato Regional Council and Dairy NZ partnered with Iwi and stakeholders to prepare the Waikato and Waipa River Restoration Strategy. This was driven by a collective desire to co-ordinate restoration works and maximise the benefits of investment. The purpose is to guide tangible restoration work through the identification of specific, achievable, and prioritised activities developed in consultation with catchment stakeholders. The Restoration Strategy includes projects addressing erosion and sedimentation, water quality, biodiversity, freshwater fisheries, cultural values and recreation. Through a process involving literature review, modelling, technical and stakeholder workshops and site visits, approximately 200 projects have been identified, scoped and costed. Projects range in size from $50,000 to $21,000,000 and cover thousands of hectares of hill country, wetlands, lakes and rivers. Prioritisation of projects was carried out using the INFFER tool, developed in Australia by Natural Decisions Pty Ltd. This involved Iwi, stakeholders and landowners being directly involved in decision-making on projects that would best give effect to the Vision and Strategy for the river.

A physical objectives approach to achieving desired periphyton removal using environmental flows

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Excessive growth of periphyton is one of the major issues faced by freshwater managers in the 21st century, leading to degradation of freshwater habitats and negatively affecting freshwater characteristics valued by society. Flow regime and nutrient level changes have been directly attributed to excessive periphyton accrual, particularly from water storage and farming intensification. Managers are required to find the balance between societal values, such as swimmable rivers, and the need to use freshwater as a resource. Environmental flows have been widely implemented to limit periphyton accrual, but have had mixed success. Environmental flows are often established using a rule-of-thumb approach based on a multiple of the average flow, such as FRE3 (3 times the median flow). These rules of thumb directly relate discharge changes to ecological outcomes without consideration for the processes which occur and affect periphyton communities. For example, transport of fine or coarse sediment has been shown to remove periphyton, and threshold flows for sediment movement have been shown to correlate better with periphyton removal than FRE3, but sediment dynamics are not considered when designing flushing flow regimes. Improving environmental flows therefore requires consideration of how environmental flows will alter the physical processes of periphyton removal (i.e., scour, abrasion, or molar action). The effective process will be site-specific depending on local periphyton species and geomorphic setting. To improve the success of environmental flows, river managers need to be able to identify the process of periphyton removal operating at each site, which requires measurement of sediment processes to relate to periphyton dynamics. This paper demonstrates an ecohydraulic approach to flushing flow setting, and presents a pilot study which attempts to identify bedload entrainment thresholds using a range of hydrological and hydraulic characteristics to identify a new, physical-process-based metric for flushing flow setting for periphyton management.

Is riparian vegetation helpful in better management of the riverine corridor? Some tricks to take advantage of a cheap and natural fluvial component

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The interaction between riparian vegetation and morphological changes must be considered carefully, since their continuous and mutual interactions can greatly modify the geomorphic settings of a riverine environment. Considering the main characteristics of riparian vegetation (i.e., density, height) it is possible to detect different behaviours in the localised geomorphic changes along the active part of the fluvial corridor. The aim is to better define the induced morphological changes, considering the position and characteristics of riparian and in-channel vegetation. The analysis takes advantage of two LiDAR datasets (acquired in 2003 and 2010) of a Piedmont study area of the Piave River (north-eastern Italy) around 3 km-long. The Piave River is characterised by a long history of human intervention that generated an increase in vegetated patches around the active channel and a stabilisation of the surrounding vegetated floodplain. Taking advantage of the LiDAR data it was possible to detect six localised erosional processes connected to vegetated parts. The analysis permitted the detection of a clear distinction between the erosional processes that happened close to the area vegetated by mature plants (e.g., trees) compared with those with youngest vegetation (e.g., bush). In fact, the area covered by the biggest and mature trees were interested by lateral shifts of the channel that produced considerable bank erosional processes. On the contrary, those areas characterised by the presence of more dense and smaller vegetation were more stable and induced erosional processes in the active channel. These results may help to better define riparian vegetation management, considering the potential protection and stabilisation of banks using only a natural and cheap component of the fluvial system. On the other hand, these results may be helpful to define areas prone to erosion that must be protected from the removal of vegetation that may increase localised erosional processes, affecting critical infrastructure.

The relationship between water colour, chromophoric dissolved organic matter absorption and remotely sensed reflectance spectra of New Zealand lakes

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Absorption of light by chromophoric dissolved organic matter (CDOM) in freshwater systems can be a major determinant of water colour. Satellite observations can potentially quantify the concentration of CDOM and other water-colour determining constituents of inland waters through their signature in the spectral light field leaving these water bodies. This study provides an initial assessment of the influence of CDOM on water colour in different lake types of New Zealand using reflectance measurements from Landsat 8 OLI satellite data and hyperspectral in-situ radiometers. We measured reflectance spectra from seven deep, clear lakes, and seven shallow, turbid lakes in the Waikato and Bay of Plenty regions, and determined CDOM concentrations by absorption measurements in the laboratory. We hypothesise that the ratio of the reflectance in the red and blue parts of the reflectance spectrum can be explained by in-situ measured CDOM concentration, because CDOM absorption decreases with increasing wavelength. The ratio of reflectance at 670 and 571 nm can be correlated with C440, a linear transformation of the absorption coefficient at 440 nm wavelength (a440). This relationship can be exploited to evaluate the use of remote sensing data for the purpose of long-term lake water monitoring at multiple scales.

Using beaver dam analogues to reduce downstream sediment loads: a pilot project in California Creek, Spokane, Washington, USA

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The United States Fish and Wildlife Service (USFWS) is working with The Lands Council (TLC), local landowners, and Gonzaga University to address the loss of riparian vegetation, steep eroding banks, high sediment loads, and high summer water temperature in California Creek, a tributary drainage located in northeast Washington State, U.S.A. This project included installation of four channel-wide Beaver Dam Analogues (BDAs). The design of the BDAs was based on guidance provided in the Beaver Restoration Guidebook and the BDAs were constructed in September of 2016. To assist TLC and USFWS, Gonzaga University has developed and begun to implement a monitoring plan to test the hypotheses that BDAs will aggrade an incised reach and result in a measurable improvement in riparian and stream habitat conditions and a significant reduction in sediment loading into downstream tributaries. Monitoring efforts include, repeat cross-section surveys, sediment characterisation (pebble counts and volumetric sampling), soil probing, repeat RTK topographic surveys, and stream temperature logging. Only six months after construction, spring floods (e.g., 30-year event) acted to drastically alter channel morphology and damage the BDA structures in California Creek. Using the results from drone video footage during the floods and 1D and 2D hydraulic modelling, efforts were made to modify, repair, and design new, more-resilient, BDA structures within California Creek. Monitoring efforts are continuing on the newly designed BDA reach. This presentation will focus on the lessons learned from BDA implementation in California Creek, adaptive management of the BDA structures, and the results of one-two years of monitoring for sediment-trapping effectiveness. Preliminary recommendations for applying BDAs as innovative techniques to address watershed health by reducing sediment loads in other regions will also be presented.

Managing wetlands for carbon storage in an agricultural landscape II: project approach and achievements

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Inland freshwater wetlands in an agricultural-focused area are being rehabilitated to increase their capacity to store carbon and improve biodiversity. The Murray Wetland Carbon Storage project is working with landholders who were directly targeted and driven by economic priorities, presenting a key challenge for increasing their capacity to appreciate, understand and manage their wetlands. To meet this challenge, the project successfully implemented a program which invested staff time to build relationships with landholders rather than management payments, used contractors to deliver on-ground works to free up landholder's time, and allowed for the development of management actions that integrated their farming activities and biodiversity and carbon storage interests. To date the project has rehabilitated over 3,000 ha of wetlands in the Murray LLS (Local Land Services) region in inland New South Wales. Through the project's monitoring program, Deakin University's Blue Carbon Lab have found that rehabilitation of freshwater inland wetlands, through on-ground works such as fencing and revegetation, significantly improves soil carbon stocks, increasing further, the longer the wetlands have been restored. The project will continue to work with these landholders to further their efforts for restoring their wetlands carbon storage capacity.

He not busy being born is busy dying

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In a naturally meandering river ecosystem, oxbow lakes are regularly created, and eventually fill in with sediments. As long as the river can meander, there will be more-or-less a balance in the creation or "birth" of oxbows and their eventual elimination or "death" by sediment deposition. These are natural processes responsible for the hundreds of extant and even more abundant extinct oxbow lakes along the Lower Mississippi River, and other lowland meandering river systems. If the river is restrained by revetment and/or levees, and thereby prevented from meandering, oxbow lakes can no longer form, except by big engineering projects such as river cut-offs. However, existing oxbows can fill in, especially if they are embanked by the levees and subject to high river-borne sediment deposition. Although the sediment load of the Mississippi is significantly less than 60-70 years ago before upstream dam construction, the river still carries large amounts of suspended sediments, the "mud" of the muddy Mississippi. Some of the sediment load will fall out of solution in quiet backwater environments, including oxbow lakes. Over time, depending on deposition rates, the lakes will fill in. Depending on the lake size, this infilling process could take a while - a century or more - but where sediment deposition exceeds sediment removal, it will happen. This is a problem for the river system, because connected oxbow lakes provide habitat diversity and food for floodplain inhabitants, as well as sequester pollutants. Given these irreplaceable ecosystem services, the loss of extant oxbows of the Lower Mississippi River would be terribly detrimental. Therefore, careful management and protection of these lakes is critical in both the short and long term.

New vision, new life, new hope, for dammed rivers

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Harnessed, managed, and exploited for human benefit, the damming of rivers supported the birth of ancient civilisations and modern societies. Over the millennia, dams have tamed streamflow for myriad reasons that include delivering water for drinking, irrigating crops, supporting recreation, and providing flood control and hydropower. Despite these well-recognised benefits, river regulation by dams has also caused considerable ecological damage and the loss of important ecosystem services valued by society. But our time together will not be spent lamenting these dam(n) problems. Instead, we explore many of the new, exciting, and at times controversial, ways in which rivers are being re-born, restored, and ultimately re-envisioned for the future. From daylighting streams to dismantling dams to designing flows, our journey together will be filled with a little sorrow and a ton of hope.

Patterns and drivers of spatio-temporal variability of turbidity in lakes at the regional scale.

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Quantifying and interpreting variability in ecological systems allows us to better understand the driving forces that determine the functioning of ecosystems. Ecosystem variability also provides clues regarding the potential ecological responses to anthropogenic pressure and management decisions. However, describing characteristics of variability can be hindered by the lack of datasets at appropriate temporal and spatial scales. We utilised existing remote sensing technology and symbolic regression algorithms to determine concentrations of total suspended sediments (TSS) in lakes at a regional scale, producing a dataset of remotely sensed TSS from 235 Landsat 7 and 8 images captured from 1999 until the end of 2015 for 238 Waikato lakes larger than 1 ha. The coefficient of variation (CV) was used to quantify variability of TSS in two ways: (1) lake-specific spatial variability for every available image; and (2) lake-specific temporal variability from annual average TSS values. Mean CV-values for lake-specific spatial variability across all available images ranged from 0.0005 to 2.85 and varied substantially over time for a subset of lakes. CV-values for lake-specific temporal variability from annual average TSS values ranged from 0.002 to 1.67 and fluctuated markedly across years for some lakes. Potential relationships between ecosystem variability and likely drivers of observed patterns were explored using an inference-based generalised linear model with 10 lake morphological and broad-scale climatic and catchment characteristics. Lake area and depth were consistently the two most important variables for predicting characteristic lake variability of TSS. The extent of spatial variability in lakes indicates that regular monitoring of TSS from a single station likely introduces bias to annual mean values for larger water bodies. As spatio-temporal variability can be assumed to drive key ecosystem functions, determining characteristic lake (type) variability patterns for various attributes should be a prerequisite when setting management goals and developing ecosystem monitoring regimes.

Taxonomic and functional diversity in four large and intensively monitored Midwestern United States rivers

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Protecting and restoring biodiversity is a primary goal of many resource management practices and a focus of scientific research. The complex relationships between taxonomic and functional diversity can impact monitoring strategies, and the prioritisation of conservation and restoration efforts. In this case study, we characterised the spatial patterns of fish taxonomic and functional diversity across four large U.S. rivers. For six years (2010-2015) fish assemblage data were collected from each river using a standardised stratified random-sampling design and direct-current electrofishing. Three of the rivers (Mississippi, Ohio, and Illinois Rivers) are heavily modified and commercially navigable, while the remaining river (Wabash River) is relatively unmodified and free-flowing for 640 km following a single dam. Four to five reaches were sampled in each river and ranged from 6th to 8th Strahler stream order. We used the observed number of species to estimate taxonomic diversity. Functional diversity was estimated using the functional dispersion index, calculated using 18 fish-foraging and habitat-preference traits weighted with abundance or biomass. We tested how the biodiversity indices differed among the rivers and how they were related to one another across rivers. Moreover, we identified a subset of species and traits that best characterised each of the four large rivers. We found that the relatively unmodified Wabash River had significantly higher taxonomic diversity and functional diversity (biomass weighted). Though functional and taxonomic diversity largely agreed on which river was more diverse, there was no consistent relationship between the two measures of biodiversity. The lack of a relationship between taxonomic and functional diversity suggests that both should be considered when designing monitoring programs and assessing the success of restoration efforts.

Extreme floods and river resilience: a social-ecological perspective

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It has been almost 20 years since one of the first issues of the journal Ecosystems introduced the concept of large infrequent disturbance. Since then many studies have demonstrated the geomorphological and ecological effects of extreme floods, often accompanied by warnings about the ways in which climate-related increases in the magnitude and frequency of extreme floods may affect river ecosystems. Yet rivers are also social-ecological systems in which social and ecological elements are linked through feedback mechanisms. This invokes a relativist view in which knowledge and understanding of extreme flood disturbance exists in relation to society, culture and experience, rather than solely as the domain of realist science. Resilience - the ability of a system to absorb disturbance, maintain the same state and respond and adapt to change - is a concept applied in both river science and social science, and may be a useful umbrella for aligning knowledge about the social and ecological effects of extreme flood disturbances. In this talk I will explore the effects of extreme floods from social and ecological perspectives and attempt to reconcile them under a resilience framework.

Implementing a real river and stream State of Environment monitoring programme

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Greater Wellington Regional Council (GWRC) has been reviewing its approach to river and stream State of Environment (SoE) monitoring. The main drivers for this review have been that: (1) the existing site network is not representative of the region's rivers and streams because it is biased towards large rivers with sites located at the bottom of catchments. Additionally, it does not reflect the natural diversity of rivers and streams, or the range of anthropogenic stressors present in the Wellington Region; and (2) key indicators of ecological health, in particular fish communities, have not been monitored. Instead, monitoring and reporting effort has focused on traditional indicators such as physicochemical and microbiological water quality, periphyton and macroinvertebrates. As a result of this review process, we have been trialling an ecologically focused programme which utilises a network of sites that have been selected randomly (i.e., a probabilistic network design) across the Wellington Region. The programme focuses monitoring effort on aquatic plants (periphyton and macrophytes), macroinvertebrate and fish communities - to enable us to report against the programme objective, which is "to make estimates of ecological states and trends that are representative of rivers and streams in the Wellington Region." The aim of this trial is to assess the overall feasibility of this monitoring approach. We will present our learnings from this process so far, with a focus on ground-truthing the network of randomly selected sites, gaps in current monitoring and reporting methods that inhibit us from meeting our programme objective, resourcing requirements, and barriers which can impede the making of changes to long-term monitoring programmes.

Direct and indirect effects of multiples stressors on stream fauna across watershed, reach and site scale: a path modelling analysis revealing the role of hydromorphology.

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Taking the nested scales of stream functioning into account in analysing the links between pressures and ecological status calls for the development of hierarchical models on the monitoring datasets. We aimed at answering the following questions: Do the indirect links between pressures and ecological status modify the classically observed impact hierarchy of pressures? Do the different nested scales play a different role in the pressures-ecological status relationship? Do hydromorphological alterations play a specific role in ecological status evaluation? To achieve that goal, we used the PLS path modelling method to develop a structural model linking latent variables built on: (1) land use, and hydromorphological pressures descriptors at watershed scale; (2) hydromorphological alterations assessed at reach scale; (3) nutrients-organic matter contamination levels; and (4) substrate samples to explain the score variation in the French monitoring macroinvertebrate-based indicator I2M2. This method allows one to express the total effect of a variable as the sum of its direct and indirect effects. As a first important result, we have highlighted the importance of land use effect exerted on both hydromorphology and physicochemistry and their translation as an indirect effect on the biological condition of streams. We have also demonstrated that hydromorphological alterations had an effect on substrates structure and nutrients and organic matter concentrations. This study also reveals that hydromorphology has a major effect on the macroinvertebrates indicator, thus indirect. Comparatively, the nutrients and organic matter total effect on macroinvertebrates communities appears lower than expected since we take into account all the indirect effects of land use and hydromorphological alterations.

Quantifying trophic interactions in shallow lake food webs using stable isotopes of carbon and nitrogen

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We used stable isotope analyses of carbon and nitrogen to investigate trophic interactions in five shallow Waikato lakes, representing peat and riverine lake types with and without some form of invasive fish control. Lakes were sampled over spring and summer and representatives of each trophic level were collected, including basal resources, invertebrates and fish. The assimilation of carbon sources, the trophic structure of the species involved, and trophic metrics of food-web properties were determined using the R packages MixSIAR, SIAR and SIBER. Preliminary results suggest that the carbon fuelling secondary production in these food webs is likely to be largely autochthonous in origin across the sampled lakes. Stable isotope bi-plots have also highlighted that, in some mixing model scenarios, the use of primary consumers (invertebrates which integrate basal carbon) is essential to quantify trophic linkages and carbon flow to higher trophic levels where the signatures of basal resources are similar between groups or potentially variable between sampling occasions within groups. Food web properties which can be derived from stable isotope signatures, such as food-chain length and trophic overlap have also been estimated. Our results suggest significant trophic overlap between some native and invasive fish species, highlighting the need for an integrated approach to resolving lake management issues.

Anthropogenic effects on ecological networks: Understanding how acid mine drainage impacts freshwater food webs

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Understanding anthropogenic effects on food webs is a complex and logistically demanding task. Large sample sizes and allocations of effort are required for the accurate description of food webs, limiting their widespread use in ecological studies. However, recent methods have been offered which allow for the analysis of food web structure using proxies. Size spectra have been shown to co-vary with food web structure in response to environmental impacts. Additionally, two methods have recently been proposed to infer the structure of food webs using proxy variables. We wanted to apply these methods to a dataset of community composition across a gradient of acid mine drainage impacts. We found that the results of all three methods were in broad agreement, showing the negative impacts from acid mine drainage impacts, including a loss of the largest size organisms, removal of top predators, and a restructuring of biomass and energy flows through the networks.

Contribution of organic phosphorus to phytoplankton phosphorus demand in a phosphate-depauperate lake

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Phosphorus (P) is a key driver of phytoplankton growth in lentic systems. In lakes where dissolved inorganic P (DIP) is low and near detection limits, dissolved organic P (DOP) has become increasingly acknowledged as an important source of P for phytoplankton growth and driver of phytoplankton species composition. However, it is unclear what proportion DOP contributes to the phytoplankton P demand. In this study we examine the contribution of DOP mineralised via alkaline phosphatase, alongside phytoplankton P release (i.e., from exudation and lysis processes), in meeting phytoplankton P demand in a large warm-monomictic DIP-depauperate lake. We also examine the influence of alkaline phosphatase-mediated DOP mineralisation on phytoplankton composition. Alkaline phosphatase-mediated DOP mineralization rates were highest during low DIP conditions and up to 83.8 µg DIP/L/h which are relatively high compared to literature values measured across a wide range of systems. These rates were also considerably higher than those supplied by phytoplankton P release and equate to up to 89% of the phytoplankton P demand. Elevated alkaline phosphatase production was associated with a phytoplankton assemblage dominated by cyanobacteria, with other groups comprising a low proportion. Our findings demonstrate that DOP is an important and potentially bioavailable source of P capable of impacting directly on phytoplankton P demand and composition in DIP-depauperate lakes. They also suggest that we should re-evaluate our concepts of P limitation and its effects on phytoplankton composition, as they adjust to variations in P sources and availability.

Riverine ecosystem services: pledges and pitfalls of their integrative assessment

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The assessment of the ecosystem services provided by river corridors may represent a useful effort to obtain a transparent overview of existing multiple societal demands, benefits, uses, and impacts. Moreover, the analysis of the trade-offs among several ecosystem services may facilitate identifying optimised use profiles. Such analyses implicitly build up on a number of assumptions, as on the definition of an 'ecosystem service', on the availability of unequivocal indicator data, on a homogeneous assessment approach to ecosystem services either at the 'offer' or the 'demand' levels, on considering agreed reference conditions and degradation scaling, on the recognition of long-distance effects along river corridors etc. Some more potential pitfalls are associated with approaches to collate various ecosystem service assessments to a small number of integrative metrics. We present a number of related examples from the assessment of ecosystem services provided by rivers and floodplains in Germany. We propose that scientific minimum standards for ecosystem assessment studies will help to preserve and further develop the reliability and efficacy of this approach, especially in a political framework.

Engineering design for fish passage

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This presentation addresses engineering design issues, emerging (unpublished at April 2017) New Zealand guidance, and post-installation learning related to retro-fitting fish passage at existing barriers and the incorporation of fish passage facilities for new in-stream structures. Common and emerging fish passage design concepts for culverts in particular will be discussed with an overview of design issues and possible design solutions. Key topics covered will include; stream simulation vs. specific design approaches, long and/or steep culverts, as well as issues associated with mussel spat rope, weir baffle and spoiler baffle installations. The paper will also look at lessons learnt from various projects with particular regard to mussel spat rope installations.

Drivers of periphyton biomass and community type along the gravel bed Tukituki River during summer.

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We studied periphyton dynamics during summers of 2011-2017 in the Tukituki River along a 90 km reach prone to nuisance periphyton blooms. The reach is enriched upstream by upwelling groundwater (particularly nitrate) and sewage P-enrichment occurred until 2015 when two sewage treatment plants (STPs) greatly reduced their P inputs. Water column nutrient concentrations declined markedly downstream, due to uptake by periphyton, and between years with flow. Various measures of periphyton biomass, community composition and nutrient content were measured along this gradient. We hypothesised reduced P input from STPs in 2015 would shorten the river length with nuisance periphyton biomass. There was some evidence of lower periphyton biomass, and C/N and C/P ratios showed N and P deficiency at downstream sites with low water column nutrient levels. However the biomass response was not marked, likely due to nutrient supply from other sources (background, agriculture, riverbed sediment) and biomass establishing at downstream sites early in the accrual phase when higher flows and lower nutrient attenuation increase downstream nutrient supply. Periphyton biomass was influenced, at reach scale, by bed particle, antecedent flow and nutrients, and, at sub-reach scale, by shade and current velocity. Periphyton sloughing occurred in response to both increased velocity/drag during spates and "bubble-lift" on sunny afternoons when high photosynthesis resulted in gas bubbles caught within "mature" mats. *Phormidium* abundance was favoured by dissolved inorganic nitrogen (DIN) and warm, stable flow conditions, and locally by high velocity and substrate size. Filamentous green algal cover had contrasting relationships with velocity at nutrient-enriched upper reach sites (-) and nutrient-depleted lower sites (+), likely reflecting competition for space with *Phormidium* and nutrient mass transfer constraints, respectively. Periphyton biofilm thickness (24-h settled volume/stone surface area) was correlated with conventional quantitative measures (chlorophyll a, C, AFDM), suggesting it has utility in citizen monitoring.

Not all faecal pollution is equal: targeted management relies on knowledge of the source.

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Many of Auckland's beaches and waterways are subject to intermittent microbiological contamination, which can pose a risk to human health through recreational contact. Regular monitoring of faecal indicator bacteria (FIB) is undertaken at beaches over the summer months, consistent with national guidelines, and can result in beach closures. The presence of microbiological contamination within the urban aquatic environment is often presumed to be the result of human related sources. For instance, designed wastewater overflows, aging infrastructure, private septic systems or cross connections may contribute microbiological contaminants to the stormwater network and open waterways. However, non-human sources of contamination from domestic, wild and farmed animals and birds also enter the aquatic environment directly or via overland flow. FIB results alone are unable to determine the animal source of microbiological contamination and are therefore limited in terms of informing management interventions. Recent advancements in molecular techniques have permitted the use of genetic markers to distinguish between sources of faecal pollution. This presentation will illustrate the results of a meta-analysis from several investigations initiated by Auckland Council to investigate the sources of FIB contamination across the region. A tiered approach using FIB and genetic-based analysis ('microbial source tracking') was undertaken in a range of marine and freshwater environments in an attempt to determine the animal source of contamination (i.e., human, canine, avian or ruminant). The state of New Zealand's aquatic environment is regularly headlining the news and the public wants action. Identifying the sources of faecal contamination within a catchment is challenging and is influenced by a variety of factors in different receiving environments. The use of microbial source tracking can provide information on the sources of microbiological contamination, allowing the implementation of efficient and effective management responses to meet water quality outcomes.

The interacting effects of connectivity and global change on fishes in river networks

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Anthropogenic fragmentations have particularly strong effects in dendritic networks, like riverscapes, where the movement of fishes between two locations is restricted to the river corridor. Man-made obstacles in these systems often form absolute barriers for upstream migration, with dramatic effects on fish communities. Furthermore fragmentation of riverscapes interacts with other components of global change. For example, the effects of connectivity and suitability of habitats on river fishes depends on the interactions of physical barriers and streamflow and is further impaired by e.g. water abstraction and hydrological alterations caused by climate and land-use change. Furthermore, restoring connectivity might also cause and facilitate the spread of invasive species. In particular, the role of connectivity in the decline of native fish vs. the spread of invasive species is barely understood. We will show methodological attempts and the first results of trying to disentangle the independent and interacting effects of river connectivity, invasive species, and other anthropogenic stressors related to changes in water and habitat quality and hydrological alteration on native and non-native fish species in large European river basins (River Ebro and River Elbe). In particular, we consider land use and vegetation changes and hydrological models at catchment scale to assess distributions of riverine fishes and to project how climate change and anthropogenic barriers will affect specific species and entire fish communities.

Are rare, macroinvertebrate taxa important for freshwater community ecology?

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Freshwater ecosystems are generally diverse ecosystems whose biota, including benthic macroinvertebrates, are widely used for biomonitoring and investigating community ecology. Ecological communities, from all habitats, are characterised as having a few common taxa and many rare taxa. However, ironically it is common practice to exclude rare taxa from analyses on community data because their rarity is believed to be more likely a product of sampling inefficiencies and not necessarily truly rare taxa. They are often considered a nuisance, creating "noise" in the datasets that potentially masks true gradients in the study. However, individuals from rare taxa might constitute a significant percentage of the total number of individuals in any given sample. In the present study we investigated the environmental drivers of the community structure of the "rarer" aquatic macroinvertebrate species found in streams in pristine catchments draining Mount Ruapehu. Sixteen streams were sampled from all represented FENZ classes in Tongariro National Park in the Central North Island, New Zealand, in proportion to how common they were. As it is difficult to identify many aquatic invertebrate species using only the larval stage we also sampled the adult flying aquatic insects. Sea-Land-Air-Malaise (SLAM) traps and UV-light traps were used to collect adult insects flying in the vicinity of the streams sampled for larvae. The combination of larval and adult samples allowed for a more comprehensive species inventory. Analysis of the rare, the common taxa and the total community was performed and linkages with environmental drivers modelled.

Nitrogen budgets in rivers: proteins can make an important, but varied contribution to dissolved organic nitrogen.

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Dissolved organic nitrogen (DON) can contribute up to 80% of the dissolved nitrogen pool in rivers, but despite this, only limited information is available on how concentrations and composition vary within a river system. The Ovens River (Victoria, Australia) has well-characterised regions where upper reaches are dominated by native forest, mid-sections where agriculture is important and a lower section where extensive floodplain connection can occur. We measured dissolved nitrogen pools in the Ovens River during base flow and a high-flow event and examined the DON response, the concentration and proportion of the DON that was proteinaceous material (measured as amino acids), and whether the protein composition changed along the length of the river. Tributaries, and potentially the urban inputs from the city of Wangaratta, rather than floodplain connection had the greatest effect on the DON concentration in the Ovens River. Protein/peptide concentration were of the same order of magnitude as ammonium and base-flow nitrate, supplying a potentially important nitrogen source to in-stream microbes. Compositional analysis showed little variation between any of the upper reaches of the river, but that the inputs within the agricultural and floodplain reaches were distinct. What remains now is to demonstrate the extent to which either protein/peptides, or their decomposition products have a direct impact on the nitrogen dynamics within the river, and any subsequent effect on the biota.

Drainage geometric networks and catchment management to support freshwater outcomes

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There is currently no accurate drainage dataset for the Auckland Region. The Overland Flowpath La yer, River Environment Classification (REC) and Council channel and watercourse asset datasets are often used as surrogate watercourse datasets; however, using these layers to perform catchment analysis within an urbanised area such as Auckland requires a fundamental relationship with the piped network. A recently developed a geometric network for the city of Hamilton represents the drainage flowing through the city boundary. The learnings in Hamilton have helped to inform and guide the development of a methodology for implementation of a similar project for the Auckland Region. The Auckland network is far more complex and at a much larger scale given that there are 233 catchments draining to multiple receiving environments. A dataset that can accurately illustrate the direction and pathway of stormwater flows from the headwaters of catchments to ultimate receiving environment is pertinent to a city experiencing rapid growth such as Auckland. A geometric network is a geospatial dataset that represents the stormwater drainage of a catchment comprising of both the piped network and open watercourse network. A geometric network supports and provides a platform for catchment analysis including parameters such as connected impervious, contributing catchment area, pipe capacity analysis, habitat availability and contaminant modelling. This paper discusses the complexities of developing representative watercourse datasets in both Hamilton City and the Auckland Region and the application for nationally significant freshwater management projects and policies.

Wai Ora Wai Māori – a kaupapa Māori assessment tool for freshwater management

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One of the current challenges for freshwater planning and policy is how to include Māori values and attributes in a meaningful way, to account for iwi and hapū priorities. Use of Māori Freshwater Values Framework can assist with the identification and inclusion of iwi and hapū-specific values. We present a kaupapa Māori-based freshwater assessment and management tool "Wai Ora Wai Māori" developed between 2014 - and 2017 under a MBIE science-funded project: Ngā Tohu o te Taiao: Sustaining and Enhancing Wai Māori and Mahinga Kai. The tool was developed and tested in collaboration with Waikato-Tainui researchers, a technical advisory group (TAG) and the Ngāti Tahu-Ngāti Whaoa Rūnanga Trust employing specific attributes and measures for mahinga kai/hauanga kai (cultivated food gathering sites). Mahinga kai is the most developed of the kaupapa Māori freshwater values and is a compulsory freshwater value within the National Objectives Framework (NOF) for freshwater NPS-FM (National Policy Statement for Freshwater Management) 2014. The assessment tool comprises qualitative and quantitative measures for stated attributes consistent with the NOF bands for assessing and reporting standards and the condition of selected attributes. This kaupapa Māori approach can be used to assess and articulate resource condition and impact related to human activities and land management practices. It can also be used to measure and assess trends towards specific iwi/hapū goals and objectives, vision and aspirations. This tool helps provide a robust, holistic, and complementary data set when used alongside scientifically based quantitative attributes and measures, to inform freshwater management. This presentation focuses on the unique needs of iwi groups and tailored to meet their own values and attributes, while the methodology, measures, and process are consistent and generic.

Ecological aspects of sediment management and monitoring in alpine rivers

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Sediment dynamics and balance is an important issue for the morphodynamics and ecology of a river system. Sediments, however, are frequently held back through protection structures at the originating area of a river. In the upper reaches of the Strobler Weißenbach, an alpine river in the Northern Limestone Alps of Austria, two huge check dams are located and have been completely filled up with sediments over the last decades. To guarantee the proper function of these hazard mitigation measures, the eviction of the storage capacity is necessary. The goal of the presented study is to redotate the excavated sediments into the sediment regime considering ecological requirements and restrictions. The innovative monitoring program documents the current state of stream morphology, habitats, and sediment transport along the river. Via habitat models and the mapping of spawning grounds in combination with electrofishing, the status of the ecological conditions could be evaluated before the deposition of excavated sediments (pre-monitoring) and will be continuously updated in terms of high-flow events during the project. To determine the amount of the suspended sediments and consequent influence on aquatic organisms, continuously recording turbidity sensors in combination with water-level gauging stations were installed at selected locations. For monitoring the bedload migration, a detailed analysis of the granulometry was made which was the foundation to construct tracer stones in different grain fractions. To achieve this, natural stones of the river basin were drilled and fitted with RFID- (radio-frequency identification) pit (passive integrated transponder) tags. The tracer stones could then be detected by mobile tracing and fixed antennas. Based on these findings, an integrative novel sediment-management concept for alpine headwater rivers was developed, taking into account the effects of sediment transport on the lower reaches, the fisheries and certain aspects of flood protection.

Incorporating broader environmental objectives into Lower Waikato flood control infrastructure and drainage services

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The Waikato River and waterways were significantly modified in the 20th century through development of hydropower, installation of flood control infrastructure and land development for agriculture and other uses. In recent years, the Waikato Regional Council Integrated Catchment Management Directorate (ICM) and partner institutions have instigated a number of initiatives across the region and in the Lower Waikato to address broader environmental objectives while continuing to serve flood and drainage levels of service. These initiatives include generation of up-to-date best practice guidance, studies to identify interventions and projects that most effectively contribute to the Vision and Strategy of the Waikato River objectives, production of second-generation zone plans and catchment plans that incorporate broader environmental objectives, leading national and regional assessment of fish passage requirements, piloting fish friendly pumps at Orchard Road, retrofitting practices at Motukaraka pump station to better accommodate eel migration, continuation of annual work programmes under its global three-zone and drainage consents that incorporate works under environmental best practice, and significant increase in environmental audits / process of continuous improvement for flood and drainage projects and maintenance activities. While these initiatives are noted, it is acknowledged that they reflect commencement of effort. The magnitude of intervention and type of practice will need to substantially increase over current practices to establish a tangible trajectory to achieve the Vision and Strategy. This paper summarises the current flood and drainage service and provides an overview of the initiatives to better accommodate environmental objectives into ICM's asset management. A few of these initiatives are presented in more detail in companion papers.

Loss of freshwater wetlands since 1990 in Southland, New Zealand: causes and consequences

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Reports of wetland loss in New Zealand are typically related to the historical, pre-European coverage of wetland ecosystems. It is widely accepted that large areas of freshwater wetlands were converted to other land uses prior to 1990s before comprehensive environmental legislation was established. We sought to investigate recent (post-1990) changes in freshwater wetlands to determine if current rates of wetland loss remain a concern. Remote sensing images from 1990-2012 for three regions of Southland, New Zealand, were analysed to determine whether wetlands present at 1990 remained 'present' and relatively intact, were 'at risk' due to recent drainage or had been lost, 'not present'. Of the 32,814 ha of wetlands assessed across Southland, 452 ha were no longer present in the landscape and a further 3,943 ha were at risk. Most of the change in wetland extent occurred on the Southland Plains. The rate of wetland loss in Southland since 1990 (0.5%/yr) is equivalent to the global average (0.5%/yr). Taking into account wetlands that have been partially drained, the rate of decline increases to 1.0%/yr. The predominant cause of the loss of indigenous wetlands is conversion to other land use, typically to pasture used for agriculture. The wetland loss is associated with a decline in ecosystem services, including reduced capacity to regulate water quality, mitigate flooding, perform carbon cycling, or provide habitat for threatened species and game species. A review of policy mechanisms meant to protect freshwater wetlands at regional and national levels is urgently called for, as well as increased effort to promote sustainable wetland management in agricultural environments.

Diurnal variations in nutrient uptake and recycling in the Tukituki River

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During the summer of 2017 nutrient concentrations were found to vary diurnally in the Tukituki River, Hawke's Bay. Nitrate, ammonium and, to a lesser extent, phosphorus concentrations were higher at night and lower during the day (as a result of photosynthetic uptake). Nitrate concentrations varied by up to ±30% of daily average values, consistent with previous mesocosm results showing strong light/photosynthesis dependent of nitrate uptake. This highlights a potential issue of relying on spot samples to quantify average concentration. The relationships between diurnal variations of nutrient concentration, metabolism, dissolved oxygen (DO) and pH are described. Nutrient uptake and recycling rates are presented, and related to photosynthesis and respiration rates calculated from diurnal DO measurements. A flood event temporarily reduced biomass, nutrient concentrations and diurnal variations in nutrients and pH. The findings help refine our modelling of nutrient uptake and recycling, and periphyton growth.

The value of high-frequency water quality monitoring before, during and after high-flow events for describing temporal and spatial dynamics in an intensively farmed lowland floodplain.

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Understanding the ecological effects of contaminant and organic matter loading during floodplain inundation requires detailed monitoring at adequate spatial and temporal scales. Sensors were deployed in the Lake Waikare and Whangamarino Wetland catchment to obtain real-time measurements of a range of physicochemical water-quality parameters (dissolved oxygen, temperature, turbidity, water level). In combination with data from existing remote lake-monitoring buoys, information was interrogated to improve understanding of acute and chronic processes affecting water quality and ecology. In this presentation we discuss results from these devices before, during and after heavy rainfall generated by cyclones Debbie and Cook in March and April 2017. Back-to-back events caused major flooding in the Waikato region and loggers revealed the extent and duration of blackwater events that ultimately resulted in widespread mortality of tolerant native and invasive fish. Spatially, the data showed high rates of sediment and nutrient export throughout the floodplain catchment after the first large rainfall event. We also explore the potential use of water temperature data across monitoring stations as a surrogate for determining the rate of export of storm-borne water through upper parts of the catchment. Finally we illustrate the importance of real-time versus point-in-time monitoring for improving catchment model predictions and outputs when setting limits and/or catchment rehabilitation objectives. More specifically we highlight that disproportionately large contributions of annual nutrient and sediment loads to catchments can occur during relatively short periods of time and it is critical these contributions are recognised and incorporated into catchment planning processes. An immediate resource management implication of these data highlights a need for more sustainable and ecologically appropriate floodplain management.

The influence of site connectivity on zooplankton assemblage dynamics within the Lower Mississippi River floodplain

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Large floodplain rivers present a diversity of aquatic habitats connected by the flow of water, from an often turbulent main channel to stratified lentic backwaters. As passengers of flow, plankton may be widely dispersed among numerous potential habitat types, which vary in their quality with respect to food sources and availability, and suitability for reproduction or survival. Establishing the dynamics and drivers of zooplankton assemblage structure across a complex large river-scape is an essential step for determining their biogeographic distribution, roles in the food web and contributions to elemental cycling. We examined the degree to which hydrologic connection between the main channel of the river and backwater sites influences spatial and temporal variation in zooplankton assemblage structure, and opportunities for their nutrition. Samples were collected over two years between spring and fall from 10 sites in the Lower Mississippi River floodplain representing a gradient in hydrologic connectivity with the river main channel. Additionally, we collected samples from 19 sites in 2016 for analysis of zooplankton food sources as indicated by their stable isotope composition. Main-channel and highly connected sites were low in phytoplankton availability and the zooplankton assemblage largely restricted to loricate rotifers, copepods, and small-bodied cladocerans. Less-connected sites, in contrast, were strongly elevated in autochthonous production, and exhibited high variation in zooplankton assemblage composition throughout the sampling period. Overall abundance and richness of zooplankton were higher in less-connected sites compared to connected sites, likely due to the inability of many species to flourish in the extreme conditions of high sediment load, high discharge, and low primary productivity of the main channel.

Within-lake measurement of phosphorous bioavailability: a multimethod approach

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Phosphorous (P) plays a key role in cell energetics as ATP and is considered to be an important control on the number and composition of phytoplankton in aquatic systems. Although inorganic P is biologically mobile and is readily exchangeable with phytoplankton, the correlation between dissolved reactive phosphorous (DRP), or soluble reactive phosphorous (SRP) concentrations and chlorophyll-a as a proxy for the trophic status of a water body, can be misleading. Although, DRP and SRP are available for phytoplankton use after enzymatic hydrolysis, there is a major pool in the form of high molecular weight organic compounds and/or colloids that are operationally defined as dissolved but are not necessarily bioavailable. In this study conventional methods of P estimation in lake water were compared with ultra-filtered P size fractions, labile P (determined by diffusive gradients in thin films (DGT)) and measures of primary production (chlorophyll a). This analysis reveals the dynamic cycling of P between colloidal and dissolved forms which may well dictate whether DRP is indeed bioavailable.

Does genetic introgression between stocked and wild populations affect patterns of dispersal? A case study in a Brown trout *(Salmo trutta)* population.

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Genetic introgression caused by stocking of captive-bred individuals is a major management issue. Introgression has been demonstrated to affect many individual traits, although little is known about its potential influence on dispersal, an important trait governing the eco-evolutionary dynamics of populations. Here, we quantified and described the spatial distribution of genetic introgression in a Brown trout *(Salmo trutta)* population from a small watershed, and, then tested whether or not genetic introgression affected individual dispersal parameters. We genotyped 763 fish at 17 microsatellite loci sampled from both the mainstream and all populated tributaries, as well as from the hatchery used until 1999 to stock the study area. First, we used Bayesian clustering to infer local genetic structure and to quantify genetic introgression. We then identified dispersal events using full sibs family reconstruction and detection of first generation migrants, to test which individual features, in particular introgression, affected dispersal parameters (i.e., probability for an individual to disperse, distance of dispersal and direction of the dispersal event). We identified two main genetic clusters in the river basin, corresponding to wild fish on one hand and fish derived from the captive strain on the other hand, allowing us to define an introgression gradient. Highly introgressed individuals occurred almost exclusively in some tributaries and were more likely to disperse towards a tributary than towards a site of the mainstream. Furthermore, genetic introgression was positively correlated to dispersal probability, and moderately introgressed individuals exhibited the lowest dispersal distances. These findings show that various dispersal parameters may be introgression-biased, and that management policies should take into account the differential spread of captive-bred genotypes in wild populations.

The breeding of a passerine bird, the white-throated dipper *Cinclus cinclus*, and the potential influence of Atlantic salmon *Salmo salar* and brown trout *Salmo trutta*

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We studied the influence of Atlantic salmon *Salmo salar* and brown trout *S. trutta* on the breeding population size and the reproductive output of the white-throated dipper *Cinclus cinclus* in the River Lygna in southernmost Norway. The river was strongly influenced by acidic precipitation leading to extinction of the salmon population. Salmon recolonised the river following liming activities starting in 1991. We therefore compared the dipper population size and reproductive output before (1978-1992) and after (1993-2014) salmon recolonisation. Despite a rapid and substantial increase in juvenile salmon numbers, the breeding dipper population size and reproductive output was not influenced by juvenile density or total salmonid fecundity. The dipper population size was only affected by the density of parr, when the mean winter temperature was below zero degrees Celsius. Upstream of the salmonid migratory barrier, the dipper population was negatively influenced by the density of trout parr, indicating competitive interaction. The correlation between the size of the dipper population upstream and downstream of the salmonid migratory barrier were of the same order of magnitude before and after recolonisation, indicating that the downstream territories were not less attractive after the recolonisation of salmon. The upstream dipper-breeding success rates declined before the recolonisation event and increased after, a phenomenon not linked to the salmon recolonisation, but to the improved water quality due to liming, increasing invertebrate abundances and species composition. The dipper responds to the juvenile density of trout and not to salmon. Downstream of the migratory barrier, the trout parr was likely competing with the dipper population size when the environmental conditions were particularly severe. Interactions between fish and birds were not so severe as to affect the reproductive output of the dippers. Also, abiotic factors such as winter temperatures and acidic precipitation with subsequent liming seem to play an important role.

Strategies to implement cost-efficiency mitigation measures in hydropeaking rivers: a focus on early life stages of salmonids

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Alterations in hydrological and thermal regimes can potentially affect salmonid early life stages. The dewatering of salmon spawning redds due to hydropeaking can lead to mortality, with higher impact on the alevins as they have lower tolerance to dewatering than the eggs. We present a set of modelling tools to assess the cost-efficiency of implementing several flow-related mitigation options to minimise the risk of mortality in early life stages, in hydropeaking rivers. We first modelled long-term (2002-2016) hydrological and thermal alterations in the River Lundesokna (Norway). We then assessed the consequences for early-life stages salmon development and the risk potential for egg and alevin mortality. And finally, we evaluated the costs of implementing three different release-related mitigation options (A: minimum flows release during early stages; B and C: additional reduction of flow during spawning), vs their efficiency to minimise mortality risk. Overall, the economic cost of implementing mitigation measures was low and ranged between 0.7% and 2.6% of the annual hydropower production. Options B and C were considered more effective for egg and alevin survival, as reducing the flow during spawning would limit red creating below the mortality risk threshold. However, such options were constraint by water availability in the system for certain years, and therefore only option A was feasible all years. The set of modelling tools used in this study were satisfactory and provided expected results. The application of such modelling set can therefore be useful especially in systems where little field data is available. Targeted measures built on well-informed modelling tools can be tested on their effectiveness to mitigate dewatering effects vs. the hydropower system capacity to release or conserve water for power production. In additional, environmental flow releases targeting specific ecological objectives can provide better cost-effective options than conventional operational rules complying with general legislation.

Freshwater tipping points: What? When? Where? How? Why?

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Occasionally ecological concepts come along that appear to be so conceptually attractive that they become embedded in science and management, seemingly before rigorous testing of their applicability to field situations. The concept of tipping points has attracted much attention from scientists, managers and policy developers. The potential existence in lakes, rivers and estuaries of non-linear pressure-response relationships (as opposed to linear relationships) implies the existence of important phenomena such as ecological thresholds and resilience, alternative stable states, regime shifts and hysteresis. The material existence of such non-linear phenomena would hold great scientific interest and have major implications for freshwater management and restoration. We carried out a critical analysis of the concept of ecological tipping points, establishing appropriate parameters and indicators. The existence of tipping points can be confirmed by examining pressure-response relationships for individual systems where significant changes in ecosystem condition and community structure result. However, such data are rarely available and, furthermore, are not helpful for pre-emptive management (e.g., limit setting) to avoid freshwater systems crossing tipping points. Instead of using pressure-response relationships, non-linearities in temporal responses are often used to infer non-linear relationships and tipping points. Similarly, empirical relationships between ecological condition (e.g., periphyton density) vs the level of an inferred "driver" variable (e.g., nitrate concentration) across multiple systems have been used to infer tipping points. However, evidence from these two proxy methods must be carefully scrutinised before tipping point behaviour can be confirmed. We critically evaluated New Zealand lake, river and estuary data to test whether robust evidence of tipping points in these systems exists and to establish under which conditions tipping point behaviour in these systems occurs, or is likely to occur.

River Network Toolkit – easing freshwater network data management

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The threats forced upon freshwater environments continue to increase and consequently management and conservation actions for these systems are becoming more and more urgent and demanding. To study and manage freshwater environments, scientists and managers need to combine detailed landscape and river network data. The specificity of river systems – dendritic hierarchical system with a directionality imposed by river flow – creates a challenge for efficient data management. Additionally, the multiple dimensions and scales at which processes occur in these systems, and the ever-growing number of layers of digital information for dendritic river networks, have led to the increase of processing times and to the escalation of hardware requirements. Traditional geographical information systems have several limitations when performing summarisations or other calculations considering river network directionality and hierarchy, and are deemed unsuited for such tasks. The River Network Toolkit (RivTool) was developed to ease and accurately tackle this challenge. It is an innovative user-friendly free software of universal applicability that facilitates the use of multiple types of data for freshwater environments studies. RivTool is computationally fast, even with large datasets, and has a set of ready-to-use inbuilt data libraries. The software is able to compute all sorts of zonal statistics adapted to the dendritic nature of river networks, from metrics such as distances to river source or mouth, to more complex and demanding ones such as spatial neighbourhood statistics. This software is a very helpful tool for both scientists and managers, facilitating data acquisition and its integration, which is essential to improve knowledge of patterns and processes in freshwater networks and promote more effective management measures.

Targeting connectivity restoration in inland waters: a spatial network analysis approach

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Transversal barriers, such as dams, break up river networks into several sub-networks, disrupting life cycles of migratory fish and promoting isolation of populations which might lead to genetic bottlenecks and local extinctions. Analytical tools based on spatial network analysis are especially useful to model connectivity in riverine systems, allowing measurement of the impacts of different management scenarios on the connectivity of river networks. A potential application is the quantitative examination of cumulative effects of barriers at the scale of river networks, an issue that has seldom been addressed. We have developed a network analysis approach to identify which barriers most impacted the connectivity in the past and which connections should preferably be restored or enhanced in order to effectively improve overall connectivity for fish. We used spatial graph-based metrics that take into account habitat suitability, derived from ecological niche modelling. Further adaptation to the dendritic nature of river networks and the asymmetrical properties of its connections have also been addressed. The impact of each barrier on overall connectivity was assessed, considering its joint effect with the remaining barriers using two approaches: (1) an historical approach in which the impact of barriers is assessed sequentially following the historical succession of construction; and (2) a "backward" approach in which barriers were sequentially removed according to their impact until the effect on the overall connectivity decreased significantly. The results of this approach show that barriers severely reduce the overall connectivity of river networks for diadromous, potamodromous and resident fish species. This work also indicates that intervening in just a portion of the barriers in a river basin can be effective in restoring most of the lost connectivity. By allowing barrier removal/enhancement scenarios to be tested, the methodology paves the way to basin-wide connectivity restoration actions, and facilitates decision-making while supporting efficient management plans design.

Assessing the limits of eco-sustainable hydropower development

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The high hydropower potential in Austria is both a blessing and a curse. With the exploitation of approximately 68 % of the hydropower potential Austria can cover 66 % of its electricity demand. But while the EU Renewable Energy Directive strives for a further increase in hydropower production, almost 60 % of Austrian water bodies are at risk of failing the aims of the EU Water Framework Directive (WFD), half of them due to hydropower-related pressures (i.e., hydropeaking, water abstraction and impoundments). In order to fulfil both directives, strategic instruments guiding the way towards eco-sustainable hydropower development are required. To be recognised as sustainable, the hydropower sector needs to apply the full mitigation hierarchy starting with avoidance, minimisation and eventually compensation. Currently, almost exclusively end-of-pipe mitigation and minimisation measures are applied to focus on already-induced changes. Although the implementation of such measures (e.g., fish passes, environmental flows) is indispensable for existing and planned projects, we have to acknowledge that state-of-the-art solutions are still missing for several hydropower-related problems (e.g. dam siting, sediment transport, downstream migration). As a result, the realisation of new hydropower plants will inevitably increase pressures on aquatic ecosystems. Based on the monitoring routine established in the course of the WFD, Austria possesses a comprehensive database. To answer the question whether and to what degree hydropower exploitation is ecologically tolerable, we investigate the relationship of ecological status data and different types and intensities of hydropower-related pressures. Answers to this question are not only important for pressures with limited mitigation options (as e.g. impoundments and related alterations of former fluvial habitats), but also for other pressures and pressure combinations and will guide the way towards eco-sustainable hydropower development.

Energy density of common New Zealand macroinvertebrates for freshwater invertebrate-fish relationships, models and indices

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The accuracy of fish bioenergetics models, and future biomonitoring tools such as fish prey indices, rely on accurate estimates of energy density of fish food (i.e., aquatic invertebrates). Few published records of the energy density of New Zealand aquatic invertebrates are available, so we have had to rely on substitute values from overseas literature. To address this knowledge gap, we determined energy density using bomb calorimetry for a selection of common New Zealand freshwater invertebrates. We examined the influence of size structure on energy density for several invertebrate taxa. We also examined the influence of non-digestible insect parts on total energy density using the cased caddis *Olinga*, which constructs a case entirely from its own secretion. Finally, we examined the potential to predict energy density from invertebrate wet:dry weight ratios as an alternative to time-consuming bomb calorimetric methods.

Influence of bank habitat type on fish and invertebrate communities in the Waikato River

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Natural and vegetated bank habitats are increasingly being replaced by riprap to prevent erosion and protect infrastructure. We investigated the effects of different bank habitats (beach, willow, willow+riprap, riprap) on nearshore fish and invertebrate communities at three sites along the Waikato River as it passes through Hamilton City. Invertebrate sampling was carried out on two occasions when some bank habitats were disconnected from the river at low flow and at higher flows when all habitats were connected, while fish were sampled bimonthly to determine differences in community composition and species abundances. Spotlighting indicated that eels (*Anguilla* spp.) and smelt *(Retropinna retropinna)* were more abundant around willows, common bully *(Gobiomorphus cotidianus)* was most abundant around riprap, and crayfish *(Paranephrops planifrons)* were more commonly associated with willow+riprap. A total of 68 macroinvertebrate taxa were associated with bank habitats over the two sampling occasions, with most associated with riprap and willow+riprap and fewest with beach. Significant effects of sampling date (connectivity) and habitat type on community composition were detected for invertebrates, while habitat type affected the composition of fish communities across all dates and sites combined. Additive diversity partitioning indicated significant effects of habitat type and location on alpha and beta diversity, suggesting a range of habitat types at multiple locations along the river maximised macroinvertebrate biodiversity.

Is the Kimberley in remote north-western Australia a cradle of freshwater fish biodiversity or a museum?

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The Australian monsoonal tropics (AMT) is a globally significant hotspot of biodiversity and endemism, although the factors maintaining and generating the region's immense biodiversity are poorly understood. The Kimberley, in remote north-western Australia, is a unique bioregion within the AMT biome. The region has been of particular interest to biogeographers as it harbours the highest number of endemic species of any bioregion on the continent. A growing body of evidence from a number of terrestrial groups suggests that the topographically complex Kimberley highlands have provided long-term refuge from intense aridity experienced across Australia, beginning in the Miocene, but the mode of endemic diversification is unclear. Two prominent explanations for the disparity of endemic diversity in the Kimberley compared to the rest of the AMT have been proposed including that the rugged Kimberley refugia may act as a "museum" accumulating taxa and paleoendemics over time, or rather a "cradle" of more recent diversification and neoendemism. We adopted a total evidence phylogenetic approach to test the museum versus cradle hypotheses using an extensively sampled, region-wide phylogeny of northern Australia's most species-rich freshwater fish family, Terapontidae. Here, I will be presenting our complete findings.

A global approach for assessing environmental flow requirements: considering organic matter budget and energy transportation

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Global models to estimate environmental flow requirement (EFR) provide indicators for sustainable water resource management at catchment to continental scale where water resources are exchanged across watersheds. Also, they provide general criteria of EFR in regions where it is difficult to conduct field observations. However, global EFR methods are still mainly based on simple hydrological methods, forced by a lack of global ecohydrological data to limit themselves to mean annual discharge and some flow variabilities. Thus, a method is required which enables the evaluation of factors such as instream budget of biomass, sediment and nutrient transportation at a global scale. We proposed a model which sets EFR according to the difference in structures of fluvial ecosystems described by energy and material transportation within and outside the system. Our model consists of three sub-models to estimate: fluvial organic matter budget, sediment transportation and nutrient transportation. These sub-models were established based on a global river channel network with a spatial resolution of 0.5° × 0.5°. Using the results, we set criteria in the estimation of annual and monthly global EFRs. Average EFR values were estimated at 40 % of mean annual discharge. In comparison with previous global EFR estimates based on flow regime only, our model suggests 20 %–50 % higher values in monsoonal and savanna regions with high ecological richness, and regions where primary productivity is low and ecosystems largely depend on allochothonous organic matter supply. The main advantage of our global model is the ability to highlight seasonal variabilities, as well as to set variable EFRs within a river basin based on differences in ecological characteristics driven by primary productivity and energy transportation. Taking such seasonal and longitudinal differences in EFRs into account aids in developing integrated water allocation strategies by reflecting differences in water resource availability for humans within a catchment.

What has been the contribution of fish passages for migratory fish conservation in tropical systems?

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Fish passages have been used worldwide as the main management tool at different types of barriers to maintain river connectivity for migratory fish species. Indeed, they became such a regular technical solution that similar designs were applied in temperate and tropical systems. For instance, Brazil experienced a boom in fish passage construction in the early 2000s, most of them vertical-slot fish ladders. Independently of the design, most of the fish passages have been effective to move Neotropical species upstream. However, their contribution to maintain connectivity between critical habitats has been debated recently, raising questions on how migratory fish conservation has been improved with fish passages at Neotropical systems? The ability to move fish upstream of a certain barrier does not necessarily mean they are reaching critical habitats for spawning and recruitment. Moreover, the migratory behaviour of Neotropical potamodromous species comprises upstream and downstream movements of different life stages, which will then require efficient downstream fish passages, which is more difficult to achieve. In fact, there is no downstream passage available at barriers in Brazil, for example. Therefore, the perception that fish passages are effective tools to improve migratory fish conservation in all scenarios where barriers are being planned is, perhaps, the major flaw of these systems. In order to reduce uncertainties and weaknesses and have more effective management tools, three areas have to be improved in the fish passage realm for tropical rivers: (1) policies – which have to include downstream passage schemes; (2) decision-making – has to be based on sound science; and (3) monitoring – has to be holistic and take the whole basin into consideration. Most of the fish-passage monitoring programs have focused on the passage itself and this is not enough information to evaluate management efficiency for fish conservation.

Spatio-temporal analysis of geomorphological changes in the Nadi coastal and delta areas

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Long-term data sets can provide context for studying future changes in the delta and coastal floodplain systems. Using historical satellite images, areas of erosion and accretion can be identified along coastlines and river systems to detect areas susceptible to environmental changes in the future. This study used Landsat TM images from 1978, 1990, 2000 and 2014 to examine shoreline changes over time in the delta and coastal floodplain areas of Nadi, Fiji Islands. The observed erosional and accretionary patterns along the Nadi coastline resulted from the interaction of the prevailing coastal processes, such as the wave-induced longshore currents and sediment supply from the river system. The waves approaching the coast from a dominantly western direction generate longshore currents and associated circulation that account for the observed shoreline changes. Human-induced changes upstream and in the delta from the 1960s have also influenced the shape of the coastal floodplains. The results suggest that increasing sediment availability is needed to offset wetland loss in the different parts of the Nadi shoreline and delta areas. Results from this study provide a geomorphological understanding of the characteristics of the environment changes and have implications for future developments in this area.

Hydrodynamic catchment to sea modelling

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River level and floodplain inundation forecasting typically comprises three steps: atmospheric (rainfall) modelling; hydrologic (catchment outflow) modelling; and hydrodynamic (floodplain inundation) modelling. Each type of model has been refined over the years to give higher resolution and more accurate data in order to predict high water levels. The combined run-time of the sequence of three computer models is usually too long (several days) to be useful for realistically and accurately forecasting the extent of high water conditions. Chain-linking of models makes the process of real-time assimilation of updated input data and feedback/forward of interdependent results more problematic. A new type of combined model is described which extends a conventional hydrodynamic floodplain modelling into a river's catchments, allowing river level predictions based on topography and land cover, direct rainfall inputs and downstream tidal conditions where appropriate. This innovation, allowing distributed water sources (and sinks) across the topography is termed "direct rainfall" modelling. A direct rainfall option is available in several commercial floodplain modelling packages but it is here extended to incorporate river catchments. Adaptive computational cells embrace both large hillslopes at a coarse scale and small channels at a fine scale. The distribution of rainfall may vary with time and location so that, for example, a storm could move down a catchment and across a floodplain as a growing flood moved in the same direction. The model is applied to the Waikanae floodplain and catchment. This area provides a microcosm of New Zealand with mild and steep catchments, native and introduced vegetation, urban and rural land uses and a significant river system. Scenarios are presented for a real flood event to show how the resolution of topography and the rainfall distribution influences the run-time of the model and accuracy of predicted river levels.

Incorporating biological traits in New Zealand freshwater biomonitoring and assessment

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Biological traits are measurable properties of an individual organism, such as body size, longevity, or feeding guild. Trait composition can be used alongside taxonomic composition to describe the biological community at a site of interest. The trait approach is increasingly being used internationally for freshwater biological assessment due to several advantages over taxonomic methods: in particular, it is less subject to biogeographic influences and can be used to diagnose causes of degradation. We report on recent updates to the New Zealand trait database for freshwater invertebrates and how traits are being explored in a project towards developing a macroinvertebrate indicator for potential use in the National Policy Statement for Freshwater Management and contribute to the management of ecosystem health. We show responses of particular traits to individual stressors such as deposited fine sediment, and describe the potential of the traits approach for enhancing causal diagnosis and prediction in freshwater biomonitoring and assessment.

Large longfin eels in an unfished Taranaki landslide-dammed lake

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Lake Rotokare is a 17.8-ha landslide-dammed lake >1920 years old within the Rotokare Scenic Reserve (230-ha) in eastern Taranaki, 12 km east of Eltham. In 2008, the Rotokare Scenic Reserve Trust completed construction of an 8.2-km predator-proof fence around the reserve. The fish species in Lake Rotokare are European perch *(Perca fluviatilis)*, longfin eel *(Anguilla dieffenbachii)*, and banded kokopu *(Galaxias fasciatus)*. The lake is sheltered by a steep catchment and is strongly stratified in summer, which leads to prolonged cyanobacterial blooms. We aimed to establish the abundance of eels using mark-recapture methods, to assess perch abundance with gill netting, and to enumerate banded kokopu in tributary streams by spotlighting. The aquatic food web was also investigated. We estimated the number of shortfin eels >100 mm long in the lake as 853 (95% confidence limits 424 to 1867). Mean weight was 656 g, which suggests that their whole-lake biomass was 665 kg, or 31 kg/ha (95% CL 16 to 69 kg/ha). We also estimated that there were 143 longfin eels >100 mm long (99 to 218, 95% CL), which had a mean weight of 1839 g. Longfin eel whole-lake biomass was therefore 295 kg, or 15 kg/ha (95% CL 10 to 23 kg/ha). Longfin eels comprised 13% of the total eel population numerically, but 32% of the total eel biomass. The proportion of recaptured eels as a proportion of marked fish was 4% for shortfin eels but 23% for longfin eels, suggesting a much greater vulnerability to fishing for longfin eels. A size class of 100-350 mm shortfin eels showed recent recruitment, but no longfin eels <400 mm were caught, suggesting a recruitment limitation. Perch were extremely numerous, and showed two distinct size classes in February, with large young of the year (65-115 mm fork length).

Stream restoration in the Hawaiian Islands: how mālama ka `aina is restoring traditional farming practices and improving stream conditions for native `o`opu

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Human uses and conservation practices of surface water resources in the main Hawaiian Islands are undergoing a significant change. Throughout the early 20th century, thousands of acres across the main Hawaiian Islands were used for the cultivation of sugarcane. The irrigation infrastructure developed to support the sugar plantations was extensive, and many miles of rivers and streams were severely impacted. At the height of the plantation era, over 50% of the 366 streams in Hawaii were fully or partially dewatered as result of surface water diversions. The impact of these widespread water withdrawals was two-fold: (1) reduced availability of water for native Hawaiians practicing traditional farming; and (2) reduced instream flows sufficient to support native aquatic stream life. Native Hawaiian subsistence farming is largely focused on cultivation of the staple food crop taro (kalo) grown in flooded pondfields (lo`i) that require cool, flowing water to maintain satisfactory growing conditions. All of the native stream fish (`o`opu) and shrimp (`ōpae) found in Hawaiian streams are diadromous and undergo a larval dispersal phase in seawater in order to complete their life cycle. These aquatic species are vulnerable to reduced instream flows and human-made barriers that impede passage to and from the sea. In recent decades, large-scale cultivation of sugarcane has come to an end and there is an unprecedented opportunity to restore stream flows in numerous watersheds on each of the larger islands. Support for flow restoration is particularly strong among native Hawaiians who are dependent on subsistence practices and strive to "malama kai 'aina" (care for the land). The reallocation of surface water from sugarcane to traditional agriculture, alternative commercial crops, and for support of native freshwater fish and invertebrates requires balancing multiple human needs and environmental restoration goals.

One small river and one road - so why two large bridges?

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The Waikanae River on New Zealand's Kāpiti Coast emerges from the rugged Tararua Ranges and flows across a relatively flat, open coastal floodplain passing the Waikanae township. The lower river naturally attracts people to live by it, walk its course, swim its waters and plant its banks. Under normal conditions the river has a flow of 5 m^3/s and the normal waterway is only 15 m wide, in places shallow enough to be waded wearing only gumboots. It looks benign. However, it spills out onto its flood plain at typically two- to five-year intervals, and the 100-year flood flow can peak at 400 m^3/s. With climate change this could become 600 m^3/s. Historically (before man-made attempts to confine it), flooding would have spread out over the adjacent land, finding some relief down several overland flow paths, even spilling to adjacent waterways. Decades of urban development along the river has seen the usual range of river- and flood-control measures implemented to protect people and property from the river. However, risk remains to these "protected" areas should a breach or overtopping storm occur. In 2017 the MacKays to Peka Peka Expressway was opened. It traverses the river floodplain and the river itself. The design needed to recognise the nature of the river and the potential effects on flood risk in the river channel and on the floodplain but also the potential effects of the river on the expressway. The design needed to recognise the day-to-day use of the river corridor, including aesthetics and environment. This paper describes, from concept to construction, how the design made room for the river and its floods. This resulted in not one but two large new bridges, all for a river which at first glance is only 15 m wide.

Waikato Regional Council freshwater fish monitoring programme – overview and preliminary results with a focus on connectivity

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The incorporation of State of Environment (SOE) freshwater fish monitoring into traditional reach-scale stream health assessments can provide important additional data of fish community 'metrics' to inform the integrity of river-scape connectivity and condition. The development and implementation of robust and repeatable standardised protocols for sampling fish communities in wadeable New Zealand streams has been implemented in the Waikato Region for the past eight years. This presentation will give an overview of the monitoring programme from network development to results and trends in relation to connectivity.

The Land-Use Suitability Spatial Explorer (LUSSE)

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The Our Land and Water (OL&W) National Science Challenge is concerned with improving the sustainability and productivity of New Zealand's primary production sector. Simultaneous improvements in primary sector productivity and in environmental performance will require a shift from the traditional focus on land-use capability for production, to a broader view that accounts for effects of land-use on environmental, social, cultural and economic values at whole-catchment scales. Within OL&W this broader view is conceptualised as 'land-use suitability (LUS)'. The Land-Use Suitability Spatial Explorer (LUSSE) implements the LUS concept in a spatial analysis and mapping system by incorporating three major components: (1) land parcels and their ability to produce contaminants, (2) the drainage network and its ability to attenuate contaminants as they move downstream, and (3) the impact of contaminants in receiving environments (e.g., rivers, lakes, estuaries). Effects in receiving environments are compared against environmental objectives and this assessment feeds back in the upstream direction to provide information on LUS. To adequately represent these complex processes, we must integrate many existing data layers, assumptions and decisions. We will discuss how LUSSE will implement the LUS concept and describe the modular design that allows for the inclusion of more realistic (and complicated) representations of real-world processes as they become available. LUS and, therefore, LUSSE attempts to represent suitability as objectively as possible. However, it is impossible to describe suitability in completely objective terms. We will discuss our current approaches to characterising suitability and describe how these characterisations can be used in making management decisions.

Can local-scale longitudinal variability of low-flow width be a proxy of mesohabitat diversity?

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Mesohabitat characterisation (e.g., pools, riffles or other in-channel habitats) is a challenging issue for evaluating river physical status. Riffle-pool sequences are key habitats for in-channel life species (e.g., fish and invertebrates). According to the literature, the riffle-pool spacing is 5 to 7 times the wetted width for gravel-bed rivers at equilibrium. Such habitats are often determined in a river from bathymetric analysis (i.e., depth structure). Nowadays, the longitudinal channel depth pattern can be extracted from aerial images, if the water column is transparent (e.g., few suspended sediments) or fairly shallow (<2 m usually), which is far from being always the case. As stated by previous authors, longitudinal structure of flow width is a proxy of depth structure through the riffle-pool longitudinal organisation. Width structure can be extracted by remote sensing techniques much more easily and widely along the channel network than channel depth. This is why we aim at exploring how the channel width longitudinal pattern can be a proxy of the longitudinal depth pattern, in order to detect mesohabitats from the depth signal and build an index of the morphological status of rivers. We first extracted from aerial images the channel longitudinal radiometry, as a proxy of depth and the channel width along a river continuum of two gravel-bed rivers of the Rhône basin in Eastern France, from which we removed high frequencies (i.e., noise) with signal processing methods. Then, we analysed both river depth and width structure potentials to detect mesohabitats. We found around 80 to 90% accuracy to detect mesohabitats from river depth structure and around 70% from river width structure, which is consistent with previous literature. Width and depth signals depict correlated variation in some parts of the two signals, but some parts are behaving independently. The cause of such different behaviour is discussed.

Little Oneroa Stream – Great For Ducks, Not For People

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The Oneroa Stream is a 3rd order stream that discharges to the sea at Little Oneroa Beach on Waiheke Island, Auckland, New Zealand. This is a popular recreation area for people to gather, picnic, swim at the beach, play at the playground and build sand castles.The Oneroa Stream has shown bacteriological contamination issues since monitoring commenced in 2002 and it is likely to have been a major source of contamination of the coastal area prior to this time. The loading of contaminants from the stream to the sea has resulted in regular bathing beach closures, often requiring a few days of clear weather for the coastal area to be safe for swimming. This study was initiated by the Waiheke Resource Trust who through funding from the Waiheke Community Board funded this bacteriological water-quality study. Unlike previous studies, this study focused more on the area where the greatest increase in *E.coli* concentrations have occurred and where the greatest degree of bathing risk is likely owing to the easy access to the lagoon from public land. This study includes stream flow analysis not undertaken before that quantifies the *E.coli* loadings within the stream and from stormwater inputs. Faecal sterol testing and fluroescent whitening agent tests were conducted for two sites. These results showed evidence of human and avian contamination. Enumerative PCR marker analysis has been recommended to further understand the source and types of contaminant inputs to this stream.

Morphological effects of altered flow and sediment regime and vegetation encroachment in dam-impacted braided rivers: a numerical modelling study

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River planform results from the interaction between flow, sediment transport and vegetation. Construction and operation of dams can alter the balance of these controls, directly by reducing the frequency and magnitude of floods, and indirectly by favouring vegetation spread due to the reduced vegetation-clearance capacity of dam-altered floods. In braided rivers, such changes promote a shift towards reduced braiding intensity and ultimately a single-thread morphology. These modifications have been observed in New Zealand's Lower Waitaki River, which is not only affected by hydropower dams but also by the spread of exotic vegetation that is more efficient in planform colonisation than is the native vegetation. We are currently studying the evolution of braided rivers such as the Waitaki under different management scenarios through two-dimensional numerical modelling. The construction of a suitable model is a task in itself, since a modelling framework coupling all the relevant processes is not yet readily available. Our starting point is the physics-based GIAMT2D numerical model for free-surface flows and fluvial transport, which we recently improved by including a rule-based bank erosion module and a vegetation module. We first tested the numerical model in applications to reproduce the morphodynamic evolution of a braided channel in a set of flume experiments that used alfalfa as vegetation. The experiments began with a braided morphology that spontaneously formed at constant high flow over a bed of bare uniform sand with an initially straight single channel. The planform transitioned to single thread when this discharge was repeatedly cycled with periods of low flow and vegetation growth. Ongoing applications focus on the Waitaki River. We use the numerical model to simulate the decadal-scale evolution of one river reach, considering different scenarios: (1) a non-dam-impacted regime; (2) the actual flow regime, determining vegetation encroachment and loss of braiding complexity; and (3) alternative dam-impacted regimes.

Understanding the linkage between hydrological and chemical signatures at catchment outlets and dominant contaminant transfer pathways

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New Zealand has experienced in recent decades one of the highest rates of agricultural land-use intensification on the globe. Accordingly, there is a great potential for contaminants to impact on our waterways. However, the relationships between land use and water quality are complex due to the variability in source loads, attenuation processes, and the resilience of receiving environments. While phosphorus, sediment and faecal microbes are typically transferred via near-surface pathways (surface runoff, interflow, artificial drainage), nitrogen is predominantly transferred via (shallow and deep) groundwater. Understanding these pathway differences is crucial, as they determine the lag time between a land management activity and the impact on the receiving waterway, the degree of natural attenuation processes, and the type of mitigation measures that can be applied. Due to the temporal and spatial variability of the processes concerned, in-depth studies unambiguously linking land use to water quality are restricted to a small number of research catchments. The required level of investment cannot be afforded across the entire country. In order to achieve the required understanding, the Our Land and Water Sources & Flows programme is reviewing 'indirect' methods to glean vital contaminant transfer information from surface water monitoring data. The objective of this study is to review the state-of-the-science that links hydrological and/or chemical signatures at the catchment outlet to the dominant sources or transfer pathways. These indirect methods will help to quantify the pathway contributions within a catchment and have the advantage that they provide an integrative measure of the processes upstream. Of the available methods, those that are applicable in New Zealand for certain circumstances and purposes will be recommended for application.

How old is your streambed?

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The recirculation of streamflow through streambed sediments contributes to a variety of ecosystem functions including retention of nutrient and contaminants and the provision of permanent or temporary aquatic habitats. Whilst these functions have received a lot of attention in the literature and river management practice, the bio-physical nature of the sediment matrix, including both its spatial variability and its evolution with time is often neglected. This paper makes the case that river managers should pay attention to the evolving condition of the river sediments. A conceptual model is presented for the evolution of streambed sediment including: resetting with bed mobilisation; subsequent physical and biological clogging; and interactions with bioturbation by animals and plants. The conceptual model is tested in an empirical analysis of streambed surveys in over 100 river reaches. The conceptual model has important implications for management of flow regimes and river channels.

When to "piggyback" an environmental water release: balancing flood risks and environmental outcomes

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Flow events (or spells, pulses or freshes) play a crucial role in maintaining the ecological health of a river system. Increased river regulation and extraction to meet human water demands has significantly altered the magnitude and frequency of flow events in many river systems, often deteriorating their ecological health. One strategy to reintroduce these events is to time releases of environmental water to “piggyback” (i.e., top-up) unregulated catchment inflow due to a rainfall event. The decision on whether to make an environmental water release is made in the presence of uncertainty of how the unregulated flow events will unfold. This uncertainty poses risk of either not achieving the intended benefit of the environmental flow release (as the event is smaller than anticipated) or of causing flood damage (as the event is larger than anticipated). To date, assessment of risks associated with piggybacking environmental flows have focused solely on the flooding risks. We consider the trade-offs between environmental risks and flooding risks when assessing whether to make a piggybacking release. We present a framework that allows for the assessment of both flooding and environmental risks when piggybacking events occur; and use optimisation to test the robustness of environmental outcomes and flooding risks when releasing piggybacking flows under forecast uncertainty. The Yarra River in Australia is used as case study.

Emerging organic contaminants in a predominantly rural aquatic environment – what do we know and should we be worried?

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As humans we are very adept at improving our living conditions, including developing a multitude of different chemicals to assist in this goal. Many of these chemicals are coined emerging organic contaminants (EOCs), a term which reflects the lack of information available to accurately assess risks to human and ecological health. Despite the dearth of knowledge, there is global concern that the presence of EOCs in the environment may lead to adverse effects on human and ecological health. EOCs enter the aquatic environment from a variety of sources including sewage, stormwater, landfill leachate, agriculture, horticulture and aquaculture. Although there may be considerable overlap of EOC constituents between these sources, there are likely to be significant differences between urban and rural environments. Within New Zealand, the majority of research has focussed on EOCs in urban environments. The Waikato region is typified by more rural landuse, with agriculture and marine aquaculture potentially contributing a different profile of EOCs to the freshwater and, ultimately, marine receiving environment, when compared with more urbanised settings. Using the Waikato region as an example, this presentation will discuss what we know and don't know about EOCs, and how they rank in relation to other contaminants of concern in aquatic environments.

Seasonal variations in consumer nitrogen recycling in an oligotrophic lake: a stable isotope study

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Consumer nutrient recycling (CNR) is an important component of lake nutrient cycles but remains poorly understood. The importance of CNR for sustaining primary production is expected to vary in space and time. For warm monomictic lakes such as Lake Taupō, CNR likely becomes an important source of nutrients for pelagic phytoplankton during summer stratification when nutrients are depleted to severely limiting levels in the surface mixed layer. Quantifying CNR by traditional methods such as nutrient pool assessments has limitations as CNR demonstrates "high flux–small pool" dynamics with extended periods of stratification. Measuring the $\delta^{15}N$ stable isotope values of nitrogen pools within a lake is a promising method to investigate the significance of CNR. Recent stable isotope analytical advances now allow $\delta^{15}N$ determination from low-concentration ammonium and nitrate pools. In this study we performed a comprehensive stable isotope survey of nitrogen constituents in Lake Taupō over a complete annual cycle to investigate the significance of CNR as a nutrient source to phytoplankton. We tested if CNR is a ^{15}N-deplete nitrogen source by examining consumer excretion in incubations. Correlations of ammonium $\delta^{15}N$ values with zooplankton excretion $\delta^{15}N$ values suggested a significant contribution of zooplankton excretion to ammonium pools. A seasonal, whole-lake survey demonstrated that CNR contributed most to nutrient pools and phytoplankton nutrient uptake during the summer stratified period. These are discussed in the context of possible responses of Lake Taupō to changes in climate and the lake food web.

Predicting the biodiversity consequences of altered thermal regimes in rivers: the need to understand fundamental thermal niches.

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Humans are altering thermal regimes of freshwater ecosystems, creating an urgent need to understand how freshwater ectotherms will fare under different thermal futures. Two key scientific challenges are: how well do the fundamental thermal niches of ectotherms map to their realised thermal niches, and which axes of the fundamental thermal niche must be modelled to predict temperature-dependent fitness in real ecosystems? The first of these challenges is particularly great in riverine systems, where gradients in temperature along the river continuum are strongly confounded by gradients in other biotic and abiotic drivers. To address these challenges, we have been comparing the realised and fundamental thermal niches of native fish and crayfish along longitudinal gradients in Australian rivers. To characterise their realised thermal niches, we have modelled distributions in relation to environmental temperature at multiple scales. To characterise their fundamental thermal niches, we performed laboratory experiments on the thermal sensitivity of various dimensions of 'performance'. Distribution patterns along the river continuum suggest strong partitioning of realised thermal niches. In contrast, experimental examination of fundamental thermal niches presents a far more complicated story. Our studies are demonstrating that modelling the thermal niches of ectotherms distributed along the river continuum is not straightforward. If we are to effectively and efficiently forecast impacts of different thermal futures, riverine ecologists must do more to experimentally decipher the relative influence of temperature and other abiotic drivers on the fitness of riverine ectotherms.

Mapping environmental flow objectives to spatial and temporal scales of response.

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A critical step in taking a structured approach to natural resource management is explicating 'fundamental' and 'means' objectives. Fundamental objectives are those things that decision makers value highest and want to achieve, whereas means objectives define the means by which fundamental objectives will be achieved. When it comes to management of plant and animal populations, the ecological processes associated with means objectives are often fast and unfold at smaller spatial scales. By contrast, the processes associated with fundamental objectives are often slow and unfold at large spatial scales. In this talk we discuss the importance of explicitly differentiating: (1) fundamental and means objectives; and (2) the spatial and temporal scales of ecological response in the adaptive management of riverine flows. We will use fish monitoring data from Australia's Long Term Intervention Monitoring (LTIM) program within the Murray-Darling Basin as a case study. We aim to highlight the importance and value of: (1) differentiating fundamental and means objectives; and (2) the importance of explicitly linking these objectives to appropriate spatial and temporal scales of response. Failure to adequately consider these issues can cloud robust interpretation of monitoring data and create unrealistic stakeholder expectations and erosion of stakeholder support, especially in the early stages of a management program.

Big data on New Zealand riparian restoration: who, what, where, why, how much, and is it working?

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New Zealanders are investing large amounts of time, energy and money into riparian restoration. Yet we know very little about how much is being done nationally, what the total investment is, what the reasons and the goals of different restoration projects are, what they look like on the ground and whether they are successful. For example, targeted research has shown that some riparian restoration projects lead to rapid recolonisation by aquatic invertebrates while others don't. To improve the effectiveness of investments in riparian restoration, we need better information on what is being done and what factors explain the different ecological outcomes among projects. We have developed a national-scale database of riparian restoration projects, capturing data from practitioners (through a website), regional councils and others. We present key findings from the database, and outline the research programme that will follow. From the database we will select up to 50 projects differing in riparian buffer age, location, length, width and other characteristics. We will train and equip project volunteers to collect data on water quality, riparian and stream habitat and stream biota at this subset of sites. Then we will analyse the data to determine what factors most strongly influence improvements in the aquatic indicators and, with the help of other agencies, will examine the terrestrial indicators. Results will be used to recommend design and location criteria for effective riparian restoration initiatives.

Moving to real-time measurement of microbial health risks in rivers

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Managing microbial water quality for multiple recreation-based values (e.g., swimming and mahinga kai) requires an understanding of where and when the potential public-health risk associated with faecal contamination of water is or will be high. New high-frequency and rapid analysis technologies provide opportunities for improved understanding of water quality and more complete characterisation of the risk profile. ColiMinder® is a fully automated cutting-edge system that can detect and quantify *E. coli* in water within 15 minutes i.e. near real-time. This is a substantial improvement on the minimum 24-hour turnaround period required for conventional laboratory culture-based methods, providing for more timely assessment and communication of microbiological health risks. During deployment in a Waikato rural stream, the ColiMinder®s' high-frequency time series data compared favourably with laboratory assays but also revealed interesting microbial diel cycles under baseflow conditions. Current testing in collaboration with Greater Wellington Regional Council at a telemetered monitoring site in the lower reaches of the Porirua Stream is providing more detail on the microbiological quality of this urban stream before it enters Te Awarua-o-Porirua Harbour. The stream has degraded water quality and currently impacts on recreational values in the harbour, including a popular waka ama launching site. Colminder®s' automated on-site *E. coli* measurements are being validated against culture-based assessments of stream water quality at baseflow and during stormflow events. These high-frequency measurements will provide valuable information on temporal dynamics of *E. coli* contamination in the stream as well as an assessment of Colminder®s' suitability for real-time microbial monitoring. Comparing high-frequency data from the Colminder® against simultaneous laboratory tests and continuous flow and turbidity measurements will also enable us to evaluate the potential of a range of more cheaply measured proxies (e.g., turbidity) as warning systems for recreational and kai moana health risk.

Simple *E. coli* testing methods – how do they stack up for community volunteer monitoring?

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Water quality is a high-profile issue in New Zealand with faecal contamination a major cause of water degradation and health risk. Increasing public concern is leading to a growing interest in water management and public participation in monitoring. Community-based water quality monitoring provides valuable opportunities for Regional Council engagement with the public, with benefits for both parties including expanded monitoring coverage. Simple and relatively low-cost methods have been developed recently for microbial water-quality testing that determine the presence and concentration of the bacterium *E. coli* – the preferred microbial faecal indicator for freshwater in New Zealand. The reliability of these methods and ease of use by volunteers needs to be assessed. We compared the operational protocols and performance of four methods with a standard laboratory method for enumerating *E. coli* in a variety of surface waters. 3M Petrifilm™, Sunita-Kun, CHARM Peel Plates and Aquagenx CBT methods were evaluated against IDEXX Colilert with Quanti-tray/2000 (as the reference standard method) using water samples collected from river SOE monitoring sites and a pastoral stream exhibiting an historic wide range of *E. coli* concentrations. The test methods were selected based on low cost, ease of use and potential application by volunteer monitors with access only to kitchen sink 'laboratories'. Each method was assessed for processing time, ease of enumeration, precision (replicate repeatability), accuracy (versus Colilert), sensitivity and versatility for wider use to determine their suitability for volunteer testing of surface waters. We also assessed data and feedback from community groups that are also trialling these methods in parallel with council testing. The side-by-side trials and community group feedback will assist the selection of appropriate tests for community volunteer monitors. Credible community-based monitoring is expected to foster increased community involvement in freshwater decision-making.

Oxidative stress response of caddisfly larvae *Stenopsyche marmorata* to the combined effect of turbid water and temperature

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Many anthropogenic activities can elevate the levels of suspended solids (SS) in streams. In particular, sediment flushing and sluicing for the management of reservoir volume increase SS levels rapidly. SS have adverse effects on freshwater macroinvertebrates, cause reduction in population sizes, increase drift rates, and damage gills. However, a few studies reported that SS does not increase the mortality of some macroinvertebrates. In addition, some previous studies have examined the effects of short-term exposure to SS on macroinvertebrates. In the present study, we focused on biomarkers of oxidative stress for measuring direct responses to SS within the time scale of a few days in Caddisfly (*Stenopsyche marmorata*) larvae, which live from upstream to midstream in several rivers across Japan. Further, we studied the combined effect of SS and temperature. *S. marmorata* acclimated at 10° and 25°C were exposed to 0, 500, and 2,000 mg/L of SS, which were sediments of a reservoir sieved with a 75-μm mesh. Non-exposed control larvae revealed that the levels of antioxidant enzymes (catalase, and superoxide dismutase) were prone to be high with high temperature. Moreover, glycogen content tended to be low at the higher temperature, at which metabolic activity was high. In addition, high SS exposure at 25°C significantly increased superoxide dismutase activity after two days and catalase activity after four days, but not at 10°C. Combined high SS and high metabolism may require high activity of the antioxidant defence system. However, oxygen radical absorption capacity, which is the final defence against oxidative stress, and oxidative damage lipid peroxidation, had no significant differences among the temperature and the SS treatments. Therefore, combined high SS and high temperature stress affect the antioxidant enzyme system of *S.marmorata*. However, the effect might not weaken the whole defence system.

Case study at River Orkla in Central Norway: numerical modelling of hydraulic conditions at a river section combined with fish telemetry data in 3D

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River fragmentation by hydroelectric facilities is a well-known threat to migratory fish, thus, considerable work has been carried out worldwide to mitigate this. The river Orkla is located in Central Norway and is considered a national salmon river. About 37 kilometres from the ocean, the Bjørset dam regulates the flow to the Svorkmo power plant installed on the Orkla River. During their downstream migration salmon smolt and kelts can be attracted into the hydropower intake and end up entering into the turbines. In order to mitigate this problem at the entrance of the intake channel, which is located at the side of the reservoir, a concrete wall with submerged intake slots was constructed. To assess the behaviour of salmon smolt and kelts at the Bjørset dam, a coupled telemetry and hydraulic modelling experiment was undertaken. Migratory paths for the downstream wandering smolts and kelts were tracked using a 3D acoustic telemetry setup in front of the intake and 2D acoustic telemetry in the intake pond upstream of the intake and below the intake towards the dam and vicinity of the fishway (pool-type fishway at the right side of the dam). The water flow in the reservoir was modelled in 3D using the interFoam solver of the OpenFOAM coupled with a k-ε turbulence model. The model was calibrated with in-situ velocity measurements at several profiles in the reservoir and inside of the intake channel. Hydraulic information, such as velocity distributions and turbulence magnitudes, were coupled to the individual fish by mapping fish positions to the hydraulic flow field. The information obtained in this study is expected to help to a better understanding of how hydraulics affect fish behaviour upstream of the dam, around the intake and in the vicinity of the fishway. Results from this experiment will form the basis for mitigation measures at the intake.

Fish composition of permanently open and intermittently closed estuaries in east coast of Otago, New Zealand

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Spatiotemporal dynamics of fish assemblages of permanently open and intermittently closed estuaries was studied along the east coast of Otago, New Zealand. Fish communities of six permanently open and six intermittently closed estuaries were sampled by seine netting in summer and winter. In the present study we examined the effect of estuary type, season and environmental variables on abundance and composition of fish. Ten species were recorded, although the majority of the total catch was represented by one species, *Gobiomorphus cotidianus*. SIMPER analysis showed that the top six species that accounted for the significant differences between estuary types and seasons were *G. cotidianus*, *Rhombosolea retiaria*, *Retropinna retropinna*, *Galaxias maculatus*, *Forsterygion nigripenne* and *Aldrichetta forsteri*. These species accounted for 68% and 61% of the differences between estuary types and seasons, respectively. Fish species with a marine-estuarine opportunistic life history dominated permanently open systems, whereas species considered to be diadromous dominated intermittently closed estuaries. In general, our results demonstrate significant differences in fish abundance and environmental parameters between estuary types.

Starting at the top: attenuation of agricultural nitrogen loads by a headwater wetland

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Wetlands are one of the key edge-of-field options available for managing diffuse pollution from agricultural land-use. We assessed the nitrogen removal performance of a small natural headwater wetland in a pastoral agricultural catchment in Waikato, New Zealand over two-year period (2011–2013). The ~0.15 ha wetland occupies 2.8% of its surface catchment and is enclosed in a ~1.9 ha paddock rotationally grazed by dairy cows. Flow and water quality samples were collected at the top and bottom of the wetland, and in piezometers installed at strategic points inside and outside the wetland. A simple dynamic model operating on an hourly time-step was used to assess wetland nitrogen removal performance. Measurements of inflow, outflow, rainfall and Penman evapotranspiration estimates were used to calculate a dynamic water balance for the wetland. Nitrogen (N) concentrations at inflow and outflow and piezometers were used as input data for the model. Nitrate and organic forms dominated the N load entering the wetland (~50% and 45% of in-load, respectively). A dynamic nitrate-N mass balance was calculated by coupling influent concentrations to the dynamic water balance and applying a first order areal removal coefficient (k20) adjusted to the ambient temperature. The model showed that despite large episodic inputs of highly contaminated surface run-off during heavy rainfall, shallow groundwater was the dominant source of flow and N load. The concentrations of nitrate-N, Dissolved Inorganic Nitrogen and Total-N were always lower at the outlet of the wetland regardless of flow conditions or seasonality, even during winter storms. The modelled water quality measurements showed high seasonal variability of pollutant loads with wetland N removal efficiency best during low-flow and poorest during high-flow events and low temperatures. Overall we estimate the wetlands were able to reduce headwater nitrate-N loads by ~70% and TN loads by ~40%.

Te Reo o Te Repo – the voice of the wetland: a cultural wetland handbook

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Te Reo o Te Repo – the Voice of the Wetland, was released as an online resource in February 2017. As Aotearoa New Zealand has lost more than 90% of our original repo (wetlands), Māori are becoming increasingly concerned about the mauri (life force) of this culturally significant ecosystem. They also struggle to have their voices heard within wetland management. This handbook responds to specific needs identified by Māori in developing culturally focused research projects and collating best-practice restoration techniques, to increase the health and well-being of repo in their rohe (region). But, most importantly, Te Reo o Te Repo is about sharing stories with each other. The handbook includes processes to facilitate renewed and vibrant connections between whānau and their repo, understanding of cultural resources, and learnings from case studies on repo restoration, cultural indicators, and monitoring – all led by or in collaboration with tangata whenua (indigenous people). The articles are written by kairangahau Māori (researchers), by environmental managers, and by researchers who work with iwi (tribes) and hapū (subtribes) partners. Many articles discuss the personal journey taken by the kairangahau and the whānau (families) involved, to promote the connections, understandings, and learnings for the restoration of their repo. The handbook aims to enhance and protect cultural wetland values to share with tangata whenua throughout the motu (Aotearoa) and to help other members of the public understand the cultural priorities for repo restoration. The online handbook is intended to be a living document. We hope to receive additional stories from tangata whenua across the motu, so that future editions of Te Reo o te Repo can continue to be relevant and appeal to the next generation of kaitiaki (guardians), kairangahau (researchers), and environmental leaders.

Te Mana o te Wai. A Māori perspective on rivers and the place of indigenous values in river management.

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Water resources are becoming scarce and valuable. We are witnesses to the importance for all communities when the health of our waterways is at risk. Governance and management systems have not been able to cope with legacy issues, nor can they cope with the complex problems of diffuse pollution from intensive farming, climate change, pest species and population growth. The Government's recent policy proposal, "Next Steps for Freshwater", proposes new criteria for efficient and sustainable use, supporting economic development, and encouraging good management practice. In recognising that the Indigenous Māori of New Zealand 'have rights and interests in freshwater', the Government proposes ways to improve their involvement in freshwater decisions. But do the government proposals go far enough? There are increasing calls to include traditional Māori knowledge into decision-making frameworks, and terms such as 'kaitiakitanga' (the responsibility to take care of natural resources) and 'Te Mana o Te Wai' (the integrity of water) have gained traction. This paper will explain these core concepts and provide a Māori perspective on rivers and the place of indigenous values in river management with reference to case studies involving two major North Island Rivers, the Waikato and Whanganui.

Species distribution and species dispersal models: instruments for tomorrow's river basin management?

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The Water Framework Directive (WFD) is one of the most important policy directives in Europe for the improvement of water quality and ecology. Water management authorities must propose measures to improve the ecological status of water bodies and identify measures that are most effective to reach good ecological status. In this regard, physical habitat models and statistical models to predict the likely occurrence or distribution of (fish) species based on relevant variables became an important tool for river conservation planning and management. Modelling approaches in riverine ecology in general can improve our understanding by generalising and simplifying complex systems to a small set of key components. In particular, modelling (fish) species distribution and dispersal are widely used approaches by ecologists, but there is still a considerable need for action for the application and establishment of these model approaches for practical implementations in the field of tomorrow's river basin management. Within the project "NRW FutureWater" we developed an innovative modelling approach to assess the ecological continuity of a river catchment in western Germany, in the southeast of Northrhine-Westphalia. The research comprises the entire catchment of the River Ruhr (4.478 km^2). We used: (1) a maximum entropy model (MaxEnt) to model species distributions and to identify suitable habitats for multiple fish species; and (2) and the GRASS-GIS tool "FIDIMO" to model fish dispersal in the River Ruhr. The main objective was to identify the most critical barriers in terms of the accessibility of habitats, by combining both modelling approaches and to develop an automatised procedure to allow for transferability to other catchments. Furthermore, we evaluated the combined modelling approach for its strengths, weaknesses and its practical relevance for the achievement of the goals of the WFD and demonstrate potential applications for tomorrow's river basin management.

The non-effect of restoring a large river: the Darling River, Australia

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Restoring river ecosystems degraded by human activities is big business, worth billions of dollars annually. Investment in river restoration has grown rapidly over the last 40 years. Despite this increase in investment our understanding of what contributes to the 'success' or 'failure' of river restoration remains limited. We present the results of a study that investigates the hydraulic and ecological response to the reintroduction of large wood into the bankfull channel of the Barwon Darling River, Australia. Our research did not detect an effect of the reintroduction of large wood into this low-energy dryland river system in terms of the character of the hydraulic landscapes or fish communities. No significant difference in the character of hydraulic landscapes between different time periods or discharges for each reach type (reference – naturally wooded, control – unwooded, and managed – wood reintroduced) were detected. The reintroduction of large wood also had a limited influence on fish communities. No significant differences between reaches over time in the total abundance or species composition were recorded but differences in fish length were. We hypothesised that the lack of a response in hydraulic character and fish communities was because the physical character and position of the reintroduced large wood did not effectively replicate that of reference reaches and this had no influence on providing functional hydraulic habitat. These findings highlight the potential lasting effects of the removal of large wood from river systems and that this may not be easily rectified through inappropriate restoration. In addition, we stress the need for an interdisciplinary systems approach to be taken in order to resolve issues of river restoration and to promote the importance of understanding processes and linkages within large river ecosystems at a range of scales.

Macroecological analysis of rivers in temperate steppes of the USA and Mongolia: from hydrogeomorphology to food webs

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Fundamental ecological research on rivers has historically been focused at the reach scale or smaller, leaving us with limited perspectives on how rivers are structured and function at macroscales, despite the fact that many of our riverine ecosystem theories present perspectives on broad scale ecological patterns. This resulting dearth of knowledge about river macrosystems also impairs our ability to manage whole river systems. The current presentation reports some results and conclusions of an ongoing study of river macrosystems located in the temperate steppe biomes of Mongolia and North America by a team of scientists and students from four countries. This research encompasses hydrology/hydrogeomorphology, system metabolism, invertebrate diversity and traits, fish diversity and traits, and food webs (food sources and food chain length). The focus of the current presentation is on a study of forested-to-dryland rivers of the U.S. Great Basin in 2016, which was the first of six expeditions to rivers in three distinct ecoregions of the temperate steppes of the two continents. General ecological results and applications to lotic ecosystem theories will be discussed.

Enabling an indigenous community to inform environmental flow-setting processes: examples from the results of cultural flow preference studies undertaken in New Zealand.

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Effective participation of Maori in water management processes, including the setting of environmental flows, is needed to ensure that the adverse impacts experienced by Maori in the past are not repeated. A Cultural Flow Preference Study (CFPS) is a process that has been applied in a number of New Zealand rivers to enable Māori to identify their flow preferences, and highlight for resource managers the dependencies of their cultural values and uses on specific flows and aquatic conditions. In this presentation we provide a description of the methodology and briefly describe the capacity needs of Maori if they want to apply the method. We then present examples from completed case studies. To date, CFPSs has been applied in more than forty streams, by five different iwi, across four regions of New Zealand. Different whanau and hapu teams have assessed streams of different sizes, and from different sources. We present examples of the data collected before describing the range of analyses that are now available to assist Maori and resource managers with their flow-setting deliberations. We conclude the paper with examples of the outcomes whanau and hapu have achieved. We will describe how regional councils have responded, via operative regional plans, to the stated flow preferences of Maori.

Bioavailability of phosphorus emissions and loadings in surface waters of Germany

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Excess phosphorus (P) is a major threat and was shown to predominantly hinder a good ecological status for European surface waters. Phosphorus mostly originates from anthropogenic sources, such as agricultural fertiliser application or insufficiently treated domestic waste water. Differences in quality, form and bioavailability of P originating from different sources are well known. Though, there is still a gap between different research disciplines addressing bioavailability of P in emissions, in surface waters and their resulting impact on aquatic primary producers and water quality. We used the model MONERIS to calculate phosphorus emissions and loads in surface water in Germany. Based on an extensive literature review, existing approaches to derive bio-available P (BAP) and total P (TP) from MONERIS were revised. For different pathways, bio-availability of P is suggested to be higher than assumed by former studies. Further, for point sources the share of BAP decreases with decreasing effluent concentrations. From this, spatial patterns of BAP in Germany were analysed. We collected water quality information from 1550 gauging stations, which include a total of 137,319 monitoring months across the years 200 to 2010.. These data were compared to water body type as well as hydro-morphological and ecological status information. The share of BAP on TP observed in rivers followed a very distinct pattern, with low shares (<40%) in northern German low-lands and elevated shares (>60 %) in hilly and mountainous regions. This trend also correlated with chlorophyll-a concentrations, indicating that the most P is incorporated in the internal P-cycling. No clear differences could be found between seasons. Based on these analyses, different management options were evaluated for their potential to reduce BAP and TP emissions and to derive efficiency optimised patterns of management options.

Nutrient cycling in Lake Horowhenua and restoration options

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Lake Horowhenua (Horizons Region) is a shallow (±2 m maximum depth) dune lake (300 ha) with a long history of eutrophication. It is among the most eutrophic lakes in the country (TLI 6-7). Macrophytes grow rapidly during spring resulting in very high pH (10-11) and decomposition of decaying macrophyte material starting during summer results in low oxygen concentrations near the bottom. High phytoplankton biomass is driven by internal loading of phosphorus (P) from the sediment as a result of low oxygen concentrations and high pH (10-11). High P loading from the sediment results in nitrogen (N) limitation during summer which stimulates blooms of N-fixing cyanobacteria. Using (1) a nutrient budget for the lake; (2) sediment core geochemical analysis; and (3) studies of biogeochemical processes affecting P release from the sediment, we show how a P legacy in the sediment affects primary production, P cycling and lake water quality. Findings of our study will inform lake restoration strategies and will specifically evaluate the potential for weed harvesting to help restore the lake to lower nutrient status, providing improved ecosystem services and freshwater values.

Nutrient limitation in the Waikato River catchment, from Lake Taupo to the estuary

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The Waikato River is New Zealand's largest river by length (425 km). Its water quality changes dramatically from oligotrophic Lake Taupo to its estuary by inputs of nutrients downstream. Both nitrogen (N) and phosphorus (P) and phytoplankton (chlorophyll) increase more or less continuously along the length of the river. P limitation in much of the river has been inferred from chlorophyll concentrations changing as a result of changes in nutrient concentrations, but nutrient limitation in the Waikato River has not been directly studied before using established indicators of phytoplankton nutrient status and their possible interaction with flushing and light. Nitrate in excess of demand for phytoplankton growth flushes out into the estuary with unknown effects for eutrophication in the estuary. Globally phytoplankton in estuaries are often assumed to be N limited and therefore growth effects from excess nitrate loading are expected. We have examined nutrient limitation using eight different indicators, based on an assortment of seston composition ratios and several types of experimental approaches, at 17 sites from Lake Taupo to the estuary. This is the first catchment-scale study in a large river system of phytoplankton nutrient limitation using the same internationally accepted methods throughout the catchment and estuary for a whole year, not only for New Zealand, but possibly globally.

Development of stressor-specific invertebrate metrics – does it work and what for?

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Ecosystem health is often degraded in streams that drain agricultural and urban catchments. Rehabilitation would be most effective if measures are taken that address the key stressors operating at the focal river site or catchment. However, currently we are lacking the tools to diagnose which of several potential stressors from land use are limiting ecological improvement. Stressor-specific metrics could help with diagnosis and tracking improvement over time but also help with defining objectives for stressor attributes to be included in regional plans. We will present a novel approach to identifying taxa that are sensitive or tolerant to fine sediment or nutrients, defining thresholds for these taxa across these stressor gradients, and finally combining this information to develop a sediment-specific metric and a nutrient-specific metric. The approach builds on gradient forest analysis that calculates species turnover functions, taking into account effects of natural environmental gradients, including interactions. We present the performance of these metrics in discriminating between the effects of sediment and nutrients using a national macroinvertebrate dataset and compare them to more general stream health metrics currently in use, such as New Zealand's Macroinvertebrate Community Index and EPT metrics used worldwide.

Fish Hazard Index: a tool for assessing hydropower impacts on fish

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The Fish Hazard Index (FHI) has been developed in fulfillment of legal requirements for species protection as an assessment tool for fish mortality at hydropower facilities. It is a species-specific assessment tool, which consists of three pillars: the fish population sensitivity based on species' life history traits as well as their IUCN conservation value, the hydropower operation related risk based on species' ecology and behavior determining encounter probability, and the constellation specific risk based on site and facility properties, as e.g. turbine type, drop height, and potentially available fish protection facilities. Life history and ecological data have been compiled and classified for 90 lamprey and fish species occurring in German waters yielding an order of species' sensitivity against human induced mortality. This classification together with the conservation risk allowed identifying key indicator species for assessment of both high conservation value and high sensitivity against mortality. In addition, empirical data on fish mortality at turbines have been compiled to assess the species-specific mortality risk from hydropower operation. Fish mortality at turbines was found between 0% and 100% and strongly related to fish size and obligate migration behavior, but also to turbine type, rotational speed and drop height. The final assessment matrix mirrors the species-specific mortality risk to site properties accounting for low to high fish mortality, while considering potentially available fish protection facilities, as e.g. a fine (10 mm) horizontal screen with bypass to protect downstream migrating fish. This matrix allows approaching the assessment from two sites, either from a potential risk of a hydropower facility due to its location, turbines and so on, which gives a number of relevant indicator species proportional to the potential risk level, or from existing stocks of conservation relevant, highly sensitive species, which limits the hydropower operation to facilities of medium to low risk with increasing efforts on fish protection devices.

Mechanism elucidation and performance evaluation of Pb(II) and Cd(II) removal by low-cost *Citrullus lanatus* rind in batch and continuous systems

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As an increasing amount of heavy metal-bearing wastewater is produced from industrial activities, low-cost fruit waste materials have been investigated as biosorbents for heavy metal removal due to their abundant availability and effective performance. This study used *Citrullus lanatus* rind (i.e., watermelon rind, WR) to remove Pb(II) and Cd(II) from an aqueous solution at varying parameters (e.g., pH, ionic strength and co-ions) in a batch system. Equilibriums of Pb(II) and Cd(II) biosorption were well described by the Redlich-Peterson isotherm with the maximum biosorption capacity (Qm) of 231.6 mg-Pb/g-WR, and the Dubinin-Radushkevich isotherm with Qm of 98.5 mg-Cd/g-WR, respectively. Kinetic studies showed that the uptake of Pb(II) and Cd(II) by WR rapidly achieved equilibrium in 30 minutes. Characterisation of WR by Fourier transform infrared spectroscopy, X-ray photoelectron spectroscopy, the measurement of zeta potential and release of light metal ions (i.e., Na+, Mg^{2+}, K^{+} and Ca^{2+}) indicated the involvement of hydroxyl, carboxyl, amino and ether groups in Pb(II) and Cd(II) removal, probably through electrostatic attraction, complexation and ion exchange (with Ca^{2+}, Mg^{2+} and H^{+}). Given the high loading capacity of Pb(II) in a batch system, a WR-packed bed column was established for continuous Pb(II) biosorption. Applying 0.05 M HCl as an eluant, the column maintained high durability and repeatability over 10 biosorption-desorption cycles with a long breakthrough time of 8.3-13.0 h (93-144 bed volume). Increasing trends were even observed in the breakthrough time and equilibrium biosorption capacity. The Thomas model fitted best to the breakthrough curves (R^2 of 99.2-99.9%), suggesting that Pb(II) biosorption followed the Langmuir isotherm and pseudo-second-order kinetics with a plug flow in the column. Besides, about 95% of the loaded Pb(II) was rapidly eluted in 1.3-2.3 h with high-concentration factors (5.8-11.6). Findings in the present study reveal the great potential of WR for Pb(II) and Cd(II) removal/recovery, especially for Pb(II), in scaled-up applications.

Resilience is not always good! A framework for overcoming negative resistance and resilience in stream restoration

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Resistance and resilience are used to describe the capacity of an ecosystem to withstand and recover, respectively, from a perturbation. Community resistance and resilience are often desired goals for ecosystem health and are commonly associated with healthy communities being able to withstand perturbations (i.e., positive resistance and resilience). However, degraded ecosystems can also be resistant and resilient to perturbations (negative resistance and resilience) making them "restoration-resistant". In New Zealand, many aquatic ecosystems are degraded, having exceeded critical thresholds leaving them locked in restoration-resistant states. Using freshwater ecosystems as a model system we are developing a framework to test and overcome negative resistance and resilience. We hypothesise that resistance to restoration is a consequence of degraded communities becoming dominated by species with traits which enhance food web stability (e.g. trophic generalism); highly stable food webs are in turn resistant to restoration actions (negative resistance). To overcome negative resistance, restoration actions that address both the abiotic and biotic components of restoration are required. Developing and testing a conceptual framework incorporating these theories will provide the groundwork for a "biotic restoration toolbox" which will build upon the existing abiotic restoration tools that are currently used in stream restoration.

Sediment geochemistry indicators of lake resilience

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Catchment exports provide the ultimate source of nutrient enrichment in lake systems. However, success in reversing eutrophication by the management of these external loads is often very slow. This hysteresis is often due to the sequestration of nutrients, particularly phosphorus, in the lake sediments and subsequent recycling (internal loading) into the water column. The lake sediments are thus a legacy reservoir of nutrients which may buffer the relationship between catchment land-use change and lake response, providing a nutrient sink during early increases in catchment exports, and a nutrient source following control of external nutrient loads. There is now a growing realisation that not enough attention has been paid to the nutrient legacies of past land use and it is evident that the evaluation of sediment nutrient status, internal loading potential and the factors which confer resilience to such loading, are key factors in lake management. The potential for the flux of nutrients between the sediment and water column of a lake system is governed by the complex interaction of various biogeochemical cycles. Understanding these is critical for understanding nutrient cycling and for comparing the resilience of different lakes to eutrophication processes. In this study surface sediments were collected from six shallow lake systems around New Zealand representing a range of pressure gradients (upper/lower catchment, land cover/use, salinity). Comparisons of sediment geochemistry, concentrations of mobile/immobile nutrient fractions and nutrient release rates in response to key environmental drivers (e.g., dissolved oxygen, pH) were used to identify key indicators of lake resilience to internal loading. Increased knowledge of the role of sediment-bound nutrients is essential for informing monitoring and actions to manage nutrient legacies and internal loading in these systems.

Managing wetlands for carbon storage in an agricultural landscape I: threats and management options

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Global acknowledgement of climate change and its predicted environmental consequences has created a need for practical management techniques that increase a landscape's ability to capture and store atmospheric carbon (C). Wetlands sequester disproportionally more C than many other components of the landscape. However, degradation of wetlands may impact their ability to sequester C. In Inland New South Wales, Australia, rain-filled wetlands are common in agricultural areas where they are threatened by livestock grazing, vegetation clearing, cropping, pests and weeds. Rain-filled wetlands offer a challenge for the management of C sequestration and storage because the hydrology of these systems, a critical driver of C capture and storage, is almost entirely driven by rainfall. We present a conceptual model of how management options, including weed and pest control, grazing and crop management and revegetation, will affect C sequestration and storage in rain-filled wetlands.

Adaptive management of environmental water through Australia's Long-Term Intervention Monitoring project

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Legislators and water managers have identified adaptive management as a means of using learning from previous management actions to improve outcomes from environmental water, and to help balance environmental and consumptive needs. The Australian Government's 'Long-Term Intervention Monitoring' (LTIM) project is evaluating responses to Commonwealth Environmental Water (CEW) delivery in the Murray-Darling Basin. Monitoring is conducted in seven 'selected areas' that operate as separate projects, reporting at the area scale. Results are also aggregated by a 'monitoring advisor' group at the basin scale. We held a workshop on adaptive management in the LTIM project. Participants included representatives from all the selected area teams, Commonwealth, regional and state water managers, community representatives, and members of the monitoring advisor group. We discovered that adaptive management of environmental flows is occurring in all areas over short time scales, with LTIM results being used in real-time communications to inform flexible and responsive environmental water-release decisions. Learning from previous monitoring has also been used to underpin annual watering plans in most of the selected areas. However, few areas are using adaptive management principles to inform long-term environmental water planning processes. All participants identified the formation of trusting networks as key to successful adaptive management. We also identified incomplete and inconsistent documentation of adaptive management and decision-making processes as being a key barrier to better dissemination of the learnings from individual selected areas to the rest of the LTIM project and beyond. Large-scale implementation of environmental flow programs is rare, and therefore large-scale monitoring, evaluation and adaptive management of environmental flows is in its infancy. There is potential for rapid advances in adaptive management of environmental water, but documenting and disseminating the learning from individual projects remains the key to achieving this.

Network connectivity and complexity drive population persistence and stability in connected landscapes

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Networks of habitat patches define the environment within which any organism must survive and reproduce. Graph-theoretic methods have become a popular way of depicting habitat networks, and increasingly such approaches are being used in dendritic ecological networks (DENs) typical of branching river systems. However, while it has been recognised for many years that DENs are a fundamentally different class of habitat network compared to the open two-dimensional 'lattice' structures that characterise terrestrial habitat networks, there has been little detailed examination of the implications of this structural difference for resident populations. Here, we examined how network structure and complexity, including the transition from lattice to DEN, affects metapopulation persistence and stability in connected landscapes. We developed population models of dispersing organisms, and implemented these across hypothetical habitat networks of different types and complexities, from linear sections through to complex lattices. We also examined the roles of differences in connectivity between habitat patches and environmental variation (disturbance) in determining landscape-scale population responses. Main results can be summarised as: connectivity generally enhances population stability (as long suspected), but only through non-linear population interactions that current modelling approaches often ignore; environmental variation reduces population stability, and interacts with connectivity to reduce the positive effect of connectivity on stability; complex habitat networks provide refuges, increasing population persistence. The major consequence of the results is that organisms in DENs typical of river systems are at greater risk of metapopulation extinction simply as a result of the structure of the riverine landscape. Moreover, independent research also showed that DENs favour the evolution of lower dispersal rates, further increasing the vulnerability of resident metapopulations. This vulnerability demonstrates the challenges we face to conserve and restore populations in the world's rivers, especially as human developments further reduce structural complexity of riverine landscapes.

The effects of the 2017 wildfires in the Port Hills on stream water quality

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In February 2017 wildfires raged out of control through the pasture, pine and native vegetation of the Port Hills, Christchurch. Over 2,000 ha of the popular recreation areas of the north and east slopes of the Port Hills were burnt out over four days, with attendant loss of property and a fatality. The loss of vegetative cover is expected to lead to increased erosion of the soft loess soils, with consequent contamination of the streams draining the burnt areas. A monitoring programme has been put in place to detect changes in water quality in the tributaries of Cashmere Stream, and in Early Valley Stream, using Bowenvale catchment, where the fire did not reach, as a control catchment. Routine monthly and storm-event measurements of water quality (sediment, trace element, major ion, nutrient, organic carbon, hydrocarbon and volatile organic carbon concentrations) are under way, along with assessments of water flow to calculate sediment and contaminant loads. The first sampling event (March 14) captured the first surface run-off from the hills after the fire, and high suspended sediment concentrations (up to 1,300 mg/L in one of the tributaries of upper Cashmere stream) were observed. Two cyclone events have since passed through Canterbury (cyclones Debbie and Cook), generating copious runoff and high stream flows in an area which has had a relatively low rainfall over the last three years. The relationships between sediment load and the transport of other organic and inorganic contaminants are being assessed as further data is collected, to understand the effects of the fires on downstream environments and their ecology.

"Big" rivers, big pressures

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New Zealand has developed world-leading predictive tools for documenting the state of streams and rivers, including farm-scale nutrient-leaching tools to predict management outcomes. Such predictions are run through a river network, usually the original River Environment Classification (REC or REC 1) or occasionally the improved REC 2. Pressures affecting instream biodiversity were modelled in Freshwater Ecosystems of New Zealand (FENZ), primarily to indicate condition of instream biodiversity used for prioritising/ranking comparable river catchments using biologically tuned environmental variables and hypothetical pressure-response curves. Subsequent research detailing instream Ecological Integrity (EI) across gradients of pressures in waterways has largely supported the pressure curves used in FENZ. However, a limitation of FENZ is that many pressures that affect larger rivers (≥6th order) were not available and pressures modelled assumed all rivers and streams responded in the same way irrespective of size. We will assess the adequacy of the representation of larger river channels in mathematically derived networks, list the pressures large rivers are under, document available metrics for these pressures, suggest how those pressures can be combined to improve overall pressure estimates for rivers, and show how those pressures can be considered in managing within the modified landscapes now characteristic of much of lowland New Zealand. New science and some little-used old science will be used to explore synergies between improved EI and reduced impacts such as flooding from reinstating access of large rivers to their margins and selected floodplains.

Non-linear effects of hydrological variability on fish population dynamics in extremely stochastic freshwater ecosystems.

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Identifying limits of hydrological change for freshwater fish populations is becoming increasingly important as frequencies of droughts and floods rise due to global warming and human water-use. Non-linearities between fish population dynamics and hydrology may help to identify and prescribe limits of hydrological change. We used mark-recapture and matrix projection models, to quantify non-linear relationships between population dynamics (growth-rate mean and variance and minimum viable population size) and indices of hydrological variability (drought frequency and coefficient of variation in depth: CV) in 41 brown mudfish (*Neochanna apoda*) populations. Brown mudfish inhabit wetland pools with extreme hydrological variability, and dry up to 19 times a year, thus providing a large gradient to observe non-linear patterns. Overall, the effects of hydrological variability on population dynamics were logarithmic, and diminished rapidly as hydrological variability increased beyond constant conditions. Population growth rates, rapidly declined and became more variable with small initial increases in drought frequency and pool depth CV, but this effect diminished as hydrological variability increased further. The non-linear effects of hydrological variability on population dynamics led to increases in the minimum viable population sizes required for populations to persist into the foreseeable future in variable environments. Although mudfish population growth rates remained positive for all levels of hydrological variability, only minor increases in hydrological variability from constant conditions resulted in the greatest decline in population stability. Consequently, this indicates that many mudfish populations persisting in highly modified habitats are likely far from their optimal growth conditions. Moreover, the diminishing effects of hydrological variability means that optimal limits to increasing hydrological variability can be identified in fish populations, at least in this case. However, because the greatest change in population growth occurred at relatively low levels of hydrological variability, such limits may be less flexible than previously thought.

Demonstrating the New Zealand Estuary Trophic Index (ETI) Tools

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The New Zealand Estuary Trophic Index (ETI) project has developed tools to help regional councils gain a nationally consistent approach to the assessment and prediction of estuary eutrophication. Among the project outputs are three online web applications, developed using the 'R-Shiny" platform that allows users to input and interrogate estuary data. This talk will demonstrate these three web applications using a case-study estuary to illustrate how users can assess the susceptibility of an estuary to eutrophication (Tool 1), score the current trophic state of an estuary (Tool 2), and assess how the trophic state of an estuary might change under different scenarios of nutrient loading or limit-setting (Tool 3). The ability to quickly assess and predict estuarine eutrophication using a nationally consistent approach will assist with regional freshwater and coastal assessments and planning

FISH-Net: A model to support sustainable hydropower planning, design and monitoring for fish passage in the temperate Southern Hemisphere

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The world is currently experiencing a hydropower boom, further fragmenting rivers already impacted by multiple barriers associated with irrigation, transport, flood and erosion management. Given that all fish need to move for reproduction, feeding, refuge, dispersal and gene flow, this poses a serious threat to aquatic biodiversity and fisheries. A pertinent example comes from the temperate Southern Hemisphere, which encompasses parts of Chile and Argentina, southeast Australia and New Zealand. In central Chile, for instance, the sites of around 1,000 potential hydropower dams overlap with a biodiversity hotspot, home to a highly endemic and threatened fish fauna. The construction of fishways, which we define as any structures designed to facilitate connectivity for fish in upstream and/or downstream directions, has traditionally been the preferred mitigation measure. However, beyond several strongly migratory species native to the temperate Northern Hemisphere (e.g., salmonids, clupeids), few empirical data are available to guide the design of efficient fishways and 'fish-friendlier' hydropower design, especially for downstream movement. Using Bayesian Networks we provide, for the first time, a systematic framework for fishway design using available empirical data, numerical models and expert judgement. Our results suggest that upstream passage efficiency and mortality of downstream moving fish could range from near 0% to near 100% depending on input parameters. The model, Fish passage In the Southern Hemisphere Network (FISH-Net), can be used in hydropower design, planning, retrofitting and environmental impact assessment. It can also be used for spatial-ecological modelling and as a basis for fishway evaluations. The beliefs represented in the model should be constantly updated in light of new evidence.

Fish passage research needs to diversify its concepts and methods to work on a global scale

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Several important debates have recently crystallised in fish passage research. Some commentators see fishways as appropriate fisheries and aquatic biodiversity mitigation for river fragmentation. Others see them as halfway technologies at best and, at worst, as exacerbating the problem of disconnectivity in certain contexts. Even among those in agreement on the general utility of fishways, there is a difference of opinion as to how designs should be developed and evaluated. Contrast, for example, the 'ecohydraulics' perspective, which emphasises the need to incrementally build knowledge of biological criteria, with the heuristic approach using systematic review and meta-analysis. Whilst these debates remain unresolved, the current global hydropower boom is accompanied by construction of expensive fishways that are hardly suitable for native species and rarely monitored, imperilling food security, biodiversity and ecosystem function. A range of other structures associated with water resources and transport also fragment rivers, and their cumulative effects can be severe. We argue that consensus is impossible to achieve within the current, restrictive conceptual and methodological framework of fish-passage research, which often focuses solely on the percentage of fish passing upstream. This current framework is highly biased towards obligate migratory species that exhibit strong, synchronised and directed movements between clearly separated habitats, i.e. diadromous salmonids. The vast majority of freshwater fish species do not fit this definition, yet all animals must move in order to reproduce, grow, seek refuge, maintain gene flow, recolonise disturbed habitats, recover from disease and adapt to environmental change. Fishways must facilitate these processes. By integrating spatial ecological theory concerning the metapopulation and metacommunity, a new general framework is proposed within which progress can be made. This new framework applies to both migratory and resident species and is relevant to river barriers of any kind (e.g., hydropower dams, weirs, culverts).

Modelling differing human health risk from recreational water contact with different faecal sources

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Recreational water-quality guidance, including that proposed in the Clean Water package, is designed to inform users about the level of health risk posed by recreational contact with water. The Clean Water package has emphasised the importance of primary contact recreation or "swimmability" in assessing overall water quality. In New Zealand swimmability guidance uses *E. coli* concentrations in rivers as an indicator of faecal contamination, to infer the risk of human campylobacteriosis infection. Hence, the source of faecal pollution is not considered when estimating the human health risk posed by recreational contact with water. Under a "one size fits all" approach in New Zealand, the current and proposed guidelines view contamination at a level of *E. coli* derived from any non-human source to represent the same human health risk as an equivalent concentration *E. coli* from a human source. Overseas, the risk that different sources of faecal pollution pose to human health is receiving increased attention by science and regulatory agencies. Data from the United States established that the public health risks posed by different sources of faecal pollution vary. For example, two bathers consuming an amount of *E. coli*-contaminated water, one from an avian-impacted source the other from bovine-impacted, would have a higher risk of infection from the bovine-impacted water. A barrier to a source-specific risk-based approach being adopted in New Zealand is the absence of a model using New Zealand-specific data to estimate the infection risk from differing faecal sources. This project is the first step in bridging this gap by developing a Quantitative Microbial Risk Assessment (QMRA) model and applying it to New Zealand-specific data. Our presentation will include preliminary findings from revised *E. coli* source-specific modelling of primary contact recreational risk.

Using environmental DNA to characterise contemporary and historic lake communities

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Lake ecosystems and their biotic communities are facing unprecedented levels of threat from introduced species, water quality degradation and increasing water allocation demand. There is a pressing need to identify, monitor and prioritise at-risk species and lake ecosystems. Current freshwater biodiversity assessments methods are limited in scale and many sampling techniques are taxa-specific. Additionally, once collected, these samples then need identification by expert taxonomists. Emerging environmental DNA (eDNA) techniques provide the opportunity to complement traditional methodologies and allow biodiversity assessments at unparalleled spatial and temporal scales. eDNA techniques can also be applied to sediment cores enabling historic lake communities to be characterised. The method also presents an opportunity to result in significant cost savings for undertaking biodiversity inventory assessments in lakes. In this study we assessed the applicability of using eDNA-metabarcoding to characterise contemporary and historic lake biodiversity. Current-day biodiversity assessments were undertaken in lakes Emma and Maori (Canterbury, South Island, New Zealand). Lake water, filters and surface sediment samples were collected, DNA extracted and metabarcoding of the Cytochrome c oxidase I gene undertaken. The metabarcoding results are compared to data from samples collected in parallel using traditional approaches. The utility of using eDNA to characterise historic changes in lake communities is demonstrated through eDNA-metabarcoding analysis of sediment cores from Lake Pounui (Wairarapa) and Ngaroto (Waikato) dating back approximately 1,000 years. New eDNA based methods which enable rapid and cost-effective biodiversity assessments will assist in prioritising future management and mitigation efforts, and provide data that can be used in paleolimnological investigations to help elucidate lake environmental histories and establish evidence-based restoration targets.

When and why do *Phormidium* blooms occur, and when are toxins produced and released?

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Blooms of the benthic cyanobacterium *Phormidium* are increasing in prevalence in cobble-bed rivers worldwide. This is of particular concern when these rivers are used as drinking water sources or for recreation, as *Phormidium* in New Zealand frequently produce potent neurotoxins collectively referred to as anatoxins. To better understand what makes rivers susceptible to *Phormidium* blooms at a national scale, and what factors promote proliferations at regional and river scales, *Phormidium* cover data from approximately 500 nationally distributed sites were compared to data on river features, catchment and land use. A combination of approaches was used to develop a statistical model to predict the susceptibility of rivers across New Zealand to *Phormidium* blooms. To obtain a more in-depth knowledge of drivers for bloom formation we used generalised additive models and boosted regression tree analysis to investigate relationships between *Phormidium* cover, and physicochemical variables at 21 sites using data collected weekly in three regions (Manawatu, Nelson and Canterbury) and at 61 sites in the Manawatu region with monthly data. In order to determine the human health risks associated with *Phormidium* blooms in rivers we also investigated toxin production and toxin release from *Phormidium* mats in two South Island rivers over diurnal cycles. River water, mat samples and time-integrated samples were collected every two hours and toxin concentrations were assessed. Collectively these data will assist in predicting the likely locations and times of *Phormidium* bloom formation, and improve risk assessments.

The importance of network discontinuity in the ecology and conservation biology of African headwater stream minnows

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Network connectivity is considered a major component of the ecological health and conservation status of river networks, due to its impact on migratory species and the transport and cycling of nutrients across the riverscape. Some threatened headwater species, however, are not as dependent on catchment-scale connectivity to maintain their population integrity, and are in fact protected from further decline through natural and artificial breaks in network connectivity. In this paper, we review the distributions, ecology and conservation status of a group of cyprinid minnow species native to the headwaters and foothills of rivers in southern Africa. Several species, belonging to the genera *Pseudobarbus* and *Enteromius*, display extremely limited ranges today, which have often been exacerbated by habitat degradation and the invasion of predatory fish species, mostly introduced for angling. The complete exclusion of these minnows from many tributaries is often prevented by barriers to upstream invasion such as waterfalls and weirs. Genetic research nonetheless suggests very limited historical dispersal and mixing between headwater minnow populations, and observational studies indicate strong behavioural aversion to downstream dispersal, even during large flood events. Our findings suggest that the maintenance of current barriers to future invasion, together with targeted alien-fish eradication operations, offer greater potential for the conservation of southern African headwater streams than the removal of barriers to promote fish dispersal and foothill zone connectivity.

Can proven geo-engineering products increase water clarity and decrease sediment phosphorous fluxes in a Waikato peat lake?

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Shallow peat lakes are characteristic of the Waikato. However, due to excessive inputs of nutrients and sediments many of these lakes have become degraded. In a degraded state, phytoplankton production becomes dominant and submerged native macrophytes are lost. Decreased water clarity allows algae to outcompete macrophytes for light and high-nutrient concentrations favour algae that source nutrients from the water column. In lakes, nutrients can be sourced externally from the catchment and internally from lake sediments. This means that improvements in catchment management resulting in lower nutrient inputs may not be enough to rehabilitate a degraded lake. In other lakes, efforts to improve catchment management have been combined with the use of geo-engineering products that reduce the internal loading of nutrients, and have shown promise. However, the unique environment of a shallow peat lake may hinder product performance due to their polymictic nature, high organic content, low pH and alkalinity. We used laboratory-based incubations, a settling tube experiment and an in-lake mesocosm experiment to investigate how these products could increase light penetration and reduce sediment phosphorous fluxes in a Waikato peat lake. The products tested were alum, aqual P, allophane, anionic polyacrylamide and a locally modified soil (nano-bubble technology). All products partly cleared the water column but allophane and anionic polyacrylamide preformed best. The ability of these products to reduce phosphorous fluxes decreased through time. These decreases were likely caused by competition between the phosphorous released during anoxia and the humic acids (found in high concentrations in peat lakes) for binding sites on the products. These results indicate that the unique environment of shallow peat lakes makes them challenging for geo-engineering and more work is need to find suitable methods to aid in their rehabilitation.

Accelerating uptake of constructed wetlands and riparian buffers by quantifying contaminant attenuation performance: a proposed national investigation

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Many landowners are in the process of identifying and implementing mitigations to reduce diffuse contaminant loss to water bodies, under regional limit-setting processes required by New Zealand's National Policy Statement for Freshwater Management (NPS-FM). Constructed wetlands (CWs) and riparian buffers (RBs) are increasingly being considered as part of the toolbox of mitigation options available to meet limits. However, research is needed to better quantify their environmental performance and benefits, so that landowners can claim expected contaminant load reductions and regulators have confidence that specific riparian or wetland mitigations will deliver the reductions to on-farm contaminant budgets, required to meet catchment load objectives. This is expected to promote their adoption by land owners and facilitate regulatory acceptance. We outline a national approach to quantifying contaminant attenuation performance for CWs and RBs in five regions of New Zealand (e.g., nutrients, sediment, bacteria). Each regional RB experiment will be applied to ~5km head-water stream reaches, including before/after and control testing to quantify catchment-scale effectiveness. The CW trials will compare inflow and outflow loads under differing flow regimes and contaminant concentrations over periods of 2-3 years. We will develop provisional performance estimates and standardised design guidance for initial use by councils. This will be refined following long-term temporal monitoring (5+ years) to determine the regional variance in CW and RB efficacy and quantify actual attenuation performance in different landscape and climate settings. Combined, the quality and regional resolution of attenuation performance will shape use of CW and RB mitigations in regional policy, accelerate their uptake on-farm, and support robust reporting for the NPS-FM.

The temporal coherence of lake phytoplankton community composition across a regional set of lakes

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In recent years, freshwater ecology has moved away from a focus on the temporal dynamics and stability of single water bodies towards a greater understanding of multiple regional systems. Part of the reason for this shift is the recognition that many lake problems and processes are regional, or even global (e.g., eutrophication). A useful concept for understanding the dynamics of ecosystem change in a regional context is 'temporal coherence', or the degree to which change in abiotic and biotic conditions is temporally synchronous across multiple lakes. Strong temporal coherence in phytoplankton communities among lakes in a region may reflect control by drivers such as regional climate. In contrast, low coherence could occur when local-scale regulators are more important. In this study, 10 years of water quality and phytoplankton biovolume data on seven lakes in Auckland, New Zealand were used to explore temporal coherence of lake phytoplankton communities. Four groups of environmental factors spanning local to regional scales were also examined: in-lake environmental conditions (i.e., water quality); morphological features of lakes (e.g., depth); catchment land uses; geographical distances among lakes. We identified a weak temporal coherence in phytoplankton community compositions across the seven lakes, which was significantly related to the lake-specific factor of temporal variation of water quality conditions. The weak coherence in both water quality conditions and phytoplankton community composition suggest that it is not possible to use information from one lake (e.g., variations of water quality conditions or phytoplankton community compositions) to predict the dynamics of another lake in the study region.

Kia Mahitahi – Working together: a cultural perspective for freshwater management in Te Tau Ihu o te Waka a Māui.

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Freshwater quality is a significant issue for New Zealand Aotearoa. Creating more inclusive and meaningful management tools will enable greater engagement and participation towards sustainable solutions. Mātauranga Māori and ecological science are sometimes seen as competing knowledge systems. In the process of prudently managing natural resources, it is vital that we develop innovative ways to allow these knowledge systems to work together, which will result in improved environmental outcomes and decision-making. This is particularly true for freshwater bodies and associated ecological systems. In Te Tau Ihu, the top of the South Island, our research has explored the connection between knowledge systems through cross-cultural and multi-disciplinary exchange. The "Kia Mahitahi" project aimed to build a long-term connection between Tiakina te Taiao Ltd, (an iwi natural resource management entity mandated by Ngāti Rārua, Te Ātiawa, Ngāti Tama, Wakatū Incorporation and Ngāti Rārua Ātiawa Iwi Trust (NRAIT), and the Cawthron Institute (independent Nelson-based science provider). Mahitahi is the name of the local awa (river) and also translates as "working together" a metaphor for collaboration. A key researcher and Māori scientist from Tiakina te Taiao was engaged to embed this relationship using kaupapa Māori principles. The research combined local whānau and hapū values, mātauranga Māori, and Western Science knowledge to improve monitoring and research tools, while investigating these alongside the web-based platform Land Air Water Aotearoa (LAWA), aiming to deliver high-quality culturally appropriate and relevant freshwater management tools. Furthermore, the research explored two-way capability building and issues-driven collaborative research opportunities in monitoring freshwater quality. As a result of this connection there have been numerous collaborative research funding proposals – including "Te Pūnaha Hihiko Vision Mātauranga Connect Scheme – Tuia te here tāngata", that will up-skill Tiakina employees in microbial monitoring to innovate and provide a key solution to hapū and iwi freshwater management problems.

Watercourse assessment and catchment management in Hamilton City

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Integrated Catchment Management Plans (ICMPs) are being prepared by Hamilton City Council (HCC) to meet the city-wide network discharge consent which is required by Waikato Regional Council. To support the development of ICMPs, a Stormwater Master Plan (SMP) was prepared in 2015 and 2016. The SMP provides stormwater management overview at a citywide scale utilising a geospatial platform and data. This facilitates efficiencies and provides fine-grained and catchment-scale inputs to ICMPs. The SMP required the development of a GIS geometric network which represents the watercourses that flow in and out of Hamilton City boundary and the contributing piped flows to these open watercourses. This facilitated the development of a geospatial contaminant model, watercourse typing and the creation of geospatial layers to guide watercourse management in Hamilton. Much of the stream-related data including freshwater and environmental data was fragmented or non-spatial, incomplete, of variable data quality or not consistently available for across Hamilton watercourses. This acknowledged the need for a consistent data collection process and methodology for watercourse assessment. An assessment methodology was developed which is closely aligned with the Auckland Council Watercourse Assessment Methodology. The SMP supported the assessment methodology with guiding principles and management actions to enable the exploration of enhancement opportunities and prioritisation of projects within catchments. The assessment methodology and the supporting guiding principles and actions have now been successfully applied to the Mangakotukutuku catchment in Hamilton where the Peacocke growth cell and the NZTA Southern Links designation is located. This paper discusses the process of developing geospatial data layers and the supporting methodologies to achieve outcomes for freshwater management in Hamilton City.

Contributing science to collaborative group decision-making: reflections on working with the Takaka Freshwater Land Advisory Group

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The government is encouraging a move toward more collaborative decision-making on water management through the National Policy Statement for Freshwater Management. Following this lead, the Tasman District Council (TDC) has set up the Takaka Freshwater and Land Advisory Group (FLAG) to seek greater involvement from community, stakeholders and iwi in developing the water quantity and quality management provisions for the eastern part of Golden Bay. This area includes the Takaka River catchment, including the internationally renowned Te Waikoropupū Springs, ground waters and coastal streams from Wainui Bay to Tukurua, which contain high fish diversity. Ultimately, the group will prepare and recommend draft planning provisions to TDC. Over the last two years we have provided scientific advice to help the FLAG develop solutions for managing water allocation and the water quality effects of land-use activities. It has been a fascinating experience working with a diverse community group at the cutting-edge of water management. There have been a variety of challenges associated with contributing science to the group. Like any social process, time was required to build relationships and trust with the group members. Considerable effort was made to deliver concise presentations on the critical information, focus on key areas of likely contention and maintain transparency about areas of uncertainty. It was also important to provide recommendations on possible solutions, while ensuring that the group retain decision-making power. Information relating to the environmental, economic and social consequences of different scenarios proved useful for decision making. The FLAG has also faced a challenge with bringing along all their constituent communities with diverse values and interests on their decision-making journey, including some with very low tolerance for any risk. The need for strong support for collaborative group members has been highlighted through the process.

Improving instream habitat and mitigation studies with spatially extensive groundwater – surface water interaction models

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Regional fishery, hydrological and hydrochemical investigations require a detailed knowledge of the location of, and fluxes at hyporheic zones. The location of losing and gaining streams and rivers is one of the least known parts of river flow in New Zealand. Research on this topic is currently carried out under three main threads: hydrogeological models; statistical models; and hydrochemical investigations. This study describes an evaluation of: (1) A knowledge-informed statistical model; and (2) A simple hydrogeological assessment at an annual average scale, against institutional knowledge of gaining and losing streams in Southland's catchment, New Zealand. The statistical and hydrogeological method both classify reaches below 500 m a.s.l as gaining, losing, gaining and losing, or unclassified. Model results were visually assessed for effectiveness. The comparison indicates that: (1) The observed location of gaining/losing characteristics are reproduced by the statistical method, as expected from a knowledge-based hydrogeological system; and (2) Differences between the hydrogeological and statistical methods are thought to be associated with the difference in methodology and input data of the two methods. Further investigation is therefore recommended, using a fusion of both models in more advanced approaches. The results show a significant improvement in the spatial and temporal classification and understanding of losing-gaining rivers at large spatial scales. The methods offer advantages for the planning of instream mitigations, identification of spawning locations for habitat protection, and physical and hydrochemical assessments of ground- and surface water interaction.

The New Zealand Estuary Trophic Index (ETI) tools

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Although nutrient enrichment threatens many New Zealand estuaries, guidance on how to assess current and future states of estuarine trophic health is limited. Consequently, it has been difficult to determine the current state of estuaries regarding eutrophication, assess effects of land-use intensification on estuaries, and gauge consequences for estuaries of freshwater nutrient-limit settings, relative to estuary health objectives. In response, regional councils sought advice via the Ministry of Business, Innovation and Employment (MBIE) Envirolink Tools scheme, on the development of a nationally consistent approach to the assessment and prediction of estuary eutrophication. This talk describes the results: the New Zealand Estuary Trophic Index (ETI) project. The project developed knowledge on relevant estuary attributes, methods and indicators to measure estuary health and empirical relationships and nutrient models to assess estuary health under nutrient-management scenarios. This knowledge has been implemented within the web-based ETI Tools Application. Its three tools are: (1) Tool 1 – Assesses the susceptibility of estuaries to eutrophication; (2) Tool 2 – Scores the current trophic state of estuaries using measured values of trophic state indicators; and (3) Tool 3 – Uses a Bayesian Belief Network to score trophic state under scenarios of nutrient loading/limit-setting, or when values of trophic indicators are lacking.

Bottom-up quantification of mega inter-basin water transfer vulnerability to climate change

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Large numbers of inter-basin water transfer (IBWT) projects are constructed or proposed all around the world as solutions to water distribution and supply problems. Nowadays, as climate change warms the atmosphere, alters the hydrologic cycle, and threatens water availability, large scale IBWTs which are sensitive to these water-related changes may carry significant risk. Given this reality, IBWTs have elicited great controversy and assessments of vulnerability to climate change are urgently needed worldwide. In this paper, we consider the South-to-North Water Transfer Project (SNWTP) in China as a case study, and introduce a bottom-up vulnerability assessment framework. Key hazards and risks related to climate change that threaten future water availability for the SNWTP are firstly identified. Then a performance indicator is presented to quantify the vulnerability of IBWT by taking three main elements (i.e., sensitivity, adaptive capacity, and exposure degree) into account. A probabilistic Budyko model is adapted to estimate water availability responses to a wide range of possibilities for future climate conditions in each region of the study area. After bottom-up quantifying the vulnerability based on the estimated water availability, our findings confirm that SNWTP would greatly alleviate geographical imbalances in water availability under some moderate climate change scenarios but raises questions about whether it is a long-term solution because the donor basin has a high level of vulnerability due to extreme climate change.

POSTER ABSTRACTS

(In order of **presenters last name**)

Macroinvertebrate community composition in South Island alpine ponds – what's up there?

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Due to the inaccessibility of alpine ponds in New Zealand, relatively little is known about what lives in these habitats. It is essential that we understand what is present in these places so that we can assess any potential negative impacts of potential future climate change and invasive species. This is particularly important because, with increasing temperatures at altitude, it is possible that in the future invasive species once limited in altitudinal distribution by temperature may be able to invade further and further into the alpine region as the climate continues to warm. To determine what lives in alpine ponds and how communities vary with altitude we collected invertebrate samples from ponds at four sites in the Canterbury/Westland areas of the South Island between 1,160 m and 1,720 m. These included the Kelly Range, Craigieburn Range, Lewis Tops and Three Tarns Pass. Ponds were continuously sampled with a D-net until no new taxa were discovered in two consecutive samples. Samples were live-picked in the field and examples of each taxa present were preserved in ethanol and later identified in the laboratory. The coordinates and area of each pond were recorded as well as conductivity, pH, temperature, and altitude. Macroinvertebrate community structure varied between altitudes. Small subsets of the same taxa were found at all sites but there were also taxa that were unique to specific ponds. For example, *Littoria ewingii* tadpoles were found at only one site but Chironomidae larvae were found at all sites. This data is a starting point to provide more information on the species present in high alpine freshwater environments which are currently data poor and will be important for understanding and managing these systems in the future.

Origin and genetic structure of introduce Rainbow trout *Oncorhynchus mykiss* (Salmoniformes: Salmonidae) in Chile

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Rainbow trout is the most widespread invasive fish species in Chile. The ecological impacts of the species on native ecosystems are well documented, but there is little information about the origin, expansion and movement between watersheds of rainbow trout populations. The goal of this study was to evaluate the mitochondrial and nuclear genetic diversity, geographic origin and population structure of the rainbow trout populations introduced in Chile. Twenty four localities were sampled from 18ºS to 41ºS latitude. mtDNA sequences were used to determine the origin in the native range of naturalised rainbow trout and SNPs were used to estimate their genetic diversity. A certain degree of spatial structure was found according with the differences in haplotypes and the frequency of SNP alleles. Trout in the Altiplano Rivers have signs of being introduced from Peruvian fish farms from a lineage of trout originated in the North of North America, contrary to naturalised trout in Central and Southern Chile, mostly introduced from European fish farms. A high genetic diversity was observed in the localities with massive commercial fish farms, due to the admixture between escapees and naturalised trout, being the admixture of stocks of different origins, a common practice in Chilean fish farms. Central and Southern Chile present population structure without a clear geographic pattern, which could be explained by anthropic movement of individuals between watersheds. These kinds of studies can help to design effective management plans to control rainbow trout and other invasive species in Chile.

POSTER BOARD #1

POSTER BOARD #2

Comparison of host fish suitability for larvae (glochidia) of the native freshwater mussel, *Echyridella menziesii*

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The kākahi, *Echyridella menziesii*, is a widespread and ecologically important freshwater mussel. However, little is currently known about its parasitic early life stage and their fish host requirements. While it has been hypothesised that their glochidia (larvae) are host-fish generalists, it has not been tested in detail. The objective of this study was to compare host suitability for *E. menziesii* between four native fishes. We tested shortfin eel elvers, *Anguilla australis*; Canterbury galaxias, *Galaxias vulgaris*; common bullies, *Gobiomorphus cotidianus*; and banded kokopu, *Galaxias fasciatus* by artificially infecting them with glochidia. The fish were held in flow-through tanks which emptied into filter cups with fine nylon mesh that captured all glochidia and transformed juveniles. The cups were cleaned and the catch counted at 2-3 day intervals until there were two consecutive counts of zero. All four fish species were acceptable hosts and were able transform glochidia to juvenile mussels. Banded kokopu had the highest transformation rate of ~69% with an average of 195 juveniles produced per fish. The shortfin eels had the lowest transformation rate of 8.3% and were able to produce an average of 28 juveniles per fish. These rates have not, however, been corrected for fish size. An additional trial of longfin eel elvers *Anguilla dieffenbachii* was compromised by fungal infection but live juveniles were collected from this species. While the banded kokopu was the best host fish species during this test, many more native species, such as koaro *Galaxias brevipinnis* (which is a known host for juveniles), still need to be compared for their host suitability. Knowledge of host fish is an important component for any freshwater mussel conservation programme.

POSTER BOARD #3

Trends in biomarkers and bioindicators reveal contrasting long-term effects of pollution on native fish populations in a Mediterranean river

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Recycled water will play an increasing role in maintaining river flow in arid and semi-arid regions. However, its long-term effects on wildlife populations are still poorly studied. In this study we used trends in fish abundance, indices of biotic quality across taxa (diatoms, invertebrates and fish), and biomarkers (blood tests and scaled body condition index) to assess the ecological impact of treated sewage discharges in Ripoll River (NE Spain) over the period 2002-2013. To test the hypothesis that drought would increase the pollution stress, blood markers were sampled seasonally in the native fish *Barbus meridionalis* and *Squalius laietanus* in 2013. *Barbus meridionalis* consistently increased in abundance in polluted sites over the entire study period, but *S. laietanus* markedly declined in 2013. Both species had better condition under pollution but with signs of stress (neutrophilia, monocytosis, and/or release of immature cells). Further, *S. laietanus* had higher values of specific pollutant biomarkers (% abnormal cells) than *B. meridionalis* and mostly in spring, suggesting that the former was the more sensitive species and the breeding season more stressful than summer. Nonetheless, contrasting hydromorphological features and trends in fish abundance in reference sites suggests that changes in water level may shift the response of pelagic and benthopelagic species under similar pollution stress. Diatom and invertebrate indices captured better variations in water quality than the fish index. In conclusion, recycled water has genotoxic risk for fish populations and potential to cause multi-trophic impacts in Ripoll River. Better sewage management strategies are needed in Mediterranean rivers under water scarcity, and blood tests are a cheap way to monitor their consequences for fish health.

POSTER BOARD #4

Persistence and ecological consequences of glyphosate to control aquatic macrophytes in Canterbury lowland streams, South Island, New Zealand

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Public interest in the use of glyphosate to control aquatic macrophytes in the Canterbury region is high. As part of the Canterbury Waterway Rehabilitation Experiment (CAREX), we worked with the Waimakariri District Council to monitor the impact of macrophyte spraying on a sub-set of the district's lowland spring-fed drains. In five small waterways, 200 m reaches were sprayed with glyphosate in December 2016. Upstream of each treated reach a 200 m control reach was left unsprayed. Stream water and bed sediment samples were collected in both the control and treatment reaches pre-spraying, day of spraying, day after spraying, and 5-days, 3-weeks, 6-weeks and 14-weeks after spraying. Aquatic invertebrate and fish surveys were also undertaken. Initial results indicate glyphosate degrades quickly in the water column, but persists for weeks in the sediment.

Effects of emergent structure on recruitment of Hydrobiosidae (Trichoptera) in spring-fed streams.

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Restoration of degraded streams requires not only re-creation of aquatic habitat structure but also recolonisation of biota that were excluded from that site prior to restoration. Aquatic insects are key components of stream macroinvertebrate communities and provide indicators of restoration success, but often they fail to recolonise restored sites due to dispersal constraints or failure to recruit. It is hypothesised that recruitment failure for Hydrobiosidae (Trichoptera), which lay eggs on the undersides of emergent substrates, is due to a lack of suitable structure such as emergent rocks required for oviposition. We tested this hypothesis by examining the size class structure of Hydrobiosidae found at sites with suitable oviposition habitat compared to sites without suitable structure in six spring-fed streams in the Bay of Plenty region of New Zealand. We recorded nine species of Hydrobiosidae with similar mean taxonomic richness in sites with and without emergent structure. Preliminary results indicate that the presence of oviposition structure was not linked to either the abundance or size distribution of Hydrobiosidae within the sites we examined. This finding suggests Hydrobiosidae are entering streams to oviposit by different pathways, for example from stream edges or emergent macrophytes, or are drifting in from upstream reaches where emergent rocks are available.

POSTER BOARD #5

POSTER BOARD #6

Do introduced mitigation practices enhance water quality and macroinvertebrate communities in five studied dairy catchment streams?

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Dairying has increased in New Zealand over the last 20 years and there are concerns around the effect of this on water quality. Mitigation practices were introduced around five streams in catchments where the dominant land use was pastoral dairying. They included improved stream fencing and effluent disposal. The streams were degraded at the beginning of monitoring with respect to water quality and macroinvertebrate community condition. N, P, suspended solids (SS), *Esherichia coli* concentrations and macroinvertebrate metrics were typical of a catchment with intensive pastoral land use. Monitoring has been undertaken for periods of up to 13 years after mitigation practices were put in place and we present the results from catchments in the Waikato, Taranaki, South Island West Coast, Canterbury, and Southland. Results showed a decrease in SS concentrations for all streams, lower *E. coli* in two streams and generally increasing water clarity. Conversely macroinvertebrate metrics did not show consistent improvement.

Walnut Creek CSI: how to assess the composition/impacts of a chemical spill

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Construction and maintenance of structures within waterways can pose a risk to aquatic ecological health. In particular, the risk of chemical discharge during the construction process necessitates a range of targeted control measures and selection of chemicals appropriate for use within waterways. When appropriate control measures are not taken and a spill occurs, then the results can sometimes be catastrophic for the receiving environment. As evidence of the causes and immediate impacts of a spill can be short-lived, it is important to understand the investigative tools available to determine both the cause and quantify the effect of such events. In February 2014, fish deaths in a small stream in Akaroa were reported by local residents to the Environment Canterbury pollution hotline. The deaths were assumed to be a result of culvert repair works undertaken in the stream, but it was unclear as to what product or process may have been the key cause. In order to determine both the cause of the fish kills and then quantify the magnitude of the ecological effects, a multifaceted approach was implemented. This incorporated chemical testing of discarded products from the work site, water and sediment, as well as biotic surveys upstream and downstream of the site. Through use of exploratory chemical tests and assays, it was possible to link residual chemicals in the environment to products used on site, and determine the root cause of the fish kills. The spill caused significant fish mortality and changes in composition of the macroinvertebrate communities downstream of the work site, which gradually recovered over time. This thorough investigative approach was used in a restorative justice process that allowed for targeted recommendations for future construction work of this type, as well as possible environmental compensation for the discharge event.

POSTER BOARD #7

POSTER BOARD #8

Development of a benthic macroinvertebrate multimetric index (MMI) for streams in Mediterranean Chile

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Increases of anthropogenic activities have negative effects on streams worldwide. Threats to Mediterranean ecoregions have increased in recent years, resulting in declines of freshwater biodiversity. The use of aquatic macroinvertebrate assemblages is a commonly applied approach for determining freshwater ecological conditions. Considering the ongoing rise in environmental management programmes for aquatic communities, one related future goal is to develop appropriate indices, such as multimetric or biotic integrity indices, to differentiate between taxonomic groups, thereby facilitating assessments of stream health. Mediterranean climate ecosystems are priority areas of conservation efforts. However, of the five regions worldwide that present this climate, Chile is the least studied in regards to aquatic ecology. We developed a multimetric index (MMI) based on macroinvertebrate assemblages for Mediterranean Chile streams. To evaluate the relative disturbance level among sampling sites with respect to multiple anthropogenic perturbations, we used an integrated disturbance index based on catchment and local scale disturbance. We sampled five basins through 95 sites in streams and rivers across Mediterranean Chile during summer 2016. We selected 26 least-disturbed reference sites, 13 sites were classified as most-disturbed, and the remaining 56 sites were classified as intermediate. We evaluated 73 candidate metrics, representing diversity, composition, trophic structure and tolerance to pollution via a set of screening criteria. The Chilean Mediterranean MMI consisted of the total number of Diptera taxa, macroinvertebrate density, % EPT richness, EPT individuals, % Insecta, % Ephemeroptera, gatherers and predators richness. The MMI scores were significantly correlated with water quality and the integrated disturbance index. To validate MMI, we sampled streams in the winter season, and the index was able to distinguish sites on a gradient of anthropogenic impacts. MMI successfully differentiated least-disturbed from most-disturbed sites, indicating that this approach is a sufficient tool to evaluate the condition of several human perturbations at both local and catchment scales in Mediterranean Chilean streams.

What lies beneath? Groundwater biodiversity is more than a curiosity

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Groundwater is one of New Zealand's largest freshwater ecosystems, providing a source of water for domestic, industrial and agricultural use, as well as base flow to most surface waterways. Water abstraction and contaminant run-off from land-use activities threaten to alter both the quantity and quality of water within groundwater systems. Successfully managing groundwater ecosystems is challenging at present, due to a lack of knowledge regarding the biodiversity, ecology and functioning of these systems. For example, while initial research suggests that groundwater communities are likely to be diverse (invertebrate taxa; stygofauna, are estimated to exceed 500 species), few species have been formally described. Likewise, many ecosystem functions, including uptake and cycling of nutrients and maintenance of aquifer porosity, are likely performed by the ecological communities inhabiting groundwater ecosystems, yet we have limited understanding of how these processes may respond to anthropogenic pressures such as contaminant run-off or water abstraction. Successful management of groundwater ecosystems will involve defining management units at spatial scales appropriate to both the physical delineations of aquifers and to spatial patterns in faunal diversity, as well as understanding how the specific communities and biodiversity of groundwater fauna maintain groundwater quality and quantity. A research project within the Biological Heritage National Science Challenge aims to provide data that will assist in managing groundwater ecosystems. The specific goals are to investigate biodiversity differences in the stygofaunal communities within and between aquifers across New Zealand and to improve understanding of land-use impacts on stygofaunal communities. In addition, the project will improve the molecular and taxonomic database for stygofauna.

POSTER BOARD #9

POSTER BOARD #10

A paleolimnological meta-analysis to assess the effects of agriculture on lakes ecosystems

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With increasing population come the increasing demands of agriculture on freshwater resources. There has, and continues to be, vast research into the effects of agriculture on lake ecosystems. However, the majority of this research is based on modern limnological monitoring, which inherently overlooks the history of agricultural impact. The advent of paleolimnology has opened up vast possibilities for investigating the long-term effects of agricultural activities on lake ecosystems. However, most paleolimnological studies focus on individual lake-catchment systems, which limits the applicability of results to specific watersheds. Thus, there remains uncertainty surrounding the coherence of agricultural impact across lake ecosystems. Therefore, we propose to design a meta-analysis of paleolimnological studies of lake-catchment systems with histories of agricultural development. We hope to be able to reconstruct long-term changes in the ecological status of lakes across a broad spatial scale, in order to examine the coherence of agricultural impact on lake ecosystems. Diatoms have been shown to be accurate representatives of the ecological status of lakes. Therefore, we will select studies which have employed paleolimnological techniques to classify diatom community composition through time. Additionally, our selection will be limited to studies with robust chronologies, having temporal scales beginning before the onset of agricultural development in the corresponding catchment, allowing assessment of ecosystem deviation from baseline conditions. Ideally, the results of this meta-analysis will add to the growing understanding of how agriculture impacts lakes, and aid the development and instigation of management programmes.

Relation between molluscan fauna and river course characteristics in river estuaries to establish river improvement technology for environmental consideration

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Estuaries are distinctive environments which fluctuate continually by mixing fresh water and sea water due to the influence of the tide and waves. However, the disappearance of habitats is a serious problem in estuaries since river improvement technology in consideration of the environment has not been established. In this study, we investigated the relationship between molluscan fauna and the physical variables of watershed scale and river course characteristics. As a result of single correlation analysis, the sinuosity, river bed complexity, comparable height difference in the low-flow channel, depth ratio, bed slope and the number of types of habitat had a significant positive correlation to the abundance of shellfish fauna. These results suggest that the securing or creating of high-attitude areas in low-flow channels should be considered when conducting riverbed excavation, or that diversity of shellfish fauna can be secured by increasing the depth ratio when conducting river improvement.

POSTER BOARD #11

POSTER BOARD #12

Managing faecal contamination to improve 'swimmability' in Tukurua Stream, Golden Bay

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Following sustained monitoring and investigation since 2010, and cooperation from landowners, swimmable conditions in the campground swimming hole seems to be finally achieved. Discharges from stock drinking troughs and feed/stand-off pads (or races or winter cropping) were found to be major contributing sources. Many of these sources occurred intermittently over time and so can take a long time and sustained effort to identify. These sources are not part of the Dairying and Clean Streams Accord and therefore have not received much attention by farmers. It is suggested that proactive industry-led planning through farm environmental plans is needed to address these issues. Given Tukurua Stream and the reasonably high level of effort required to identify the sources of faecal contamination in this small catchment containing only one farm (that isn't even part of the dairy platform), the effort required to manage large catchments needs considerable resourcing.

Integrate multiple stressors analysis into water system restoration and management strategies: a conceptual framework

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Management of freshwater ecosystems under the impacts of multiple stressors is a rising issue, especially under the influence of climate change. Freshwater ecosystems are constantly under the influence of co-occurring stressors from anthropogenic disturbance, which has jeopardised the aquatic ecological integrity and ecosystem services. Furthermore, the world regions under severe stressors are often located in biodiversity hotspots. Whilst our knowledge about single stressor's effects on aquatic community assemblages has been well studied, the interactions between them are far less clear. The unpredictability of effects of stressor combinations on communities has been highlighted in previous studies. However, current assessment methodologies from hydrological, social-economic, environmental and biological models at different scales on river health and ecological integrity rarely have evaluated the direction and magnitude of the combined effects of multiple stressors. A managerial modelling framework is therefore needed to integrate multiple stressor analysis to ensure the long-term success of selected strategies. We first use the combination of socio-economics and hydrological SWAT models to identify priority impaired areas under multiple stressors. We then develop dirty models to set reference conditions. Finally, through a combination of model analyses: (1) local-scale stressors from previous models; and (2) riparian-and catchment- scale GIS-based climatic and land-use stressors are incorporated to identify their combinations' magnitude and amplitude effects. This workflow would help managers target restoration or managed areas to apply their efforts to generate maximum yield. The proposed workflow will be applied at the catchment scale in China and different target scenarios assessed to validate its efficiency. More than giving a general answer to river system management, this work is an attempt to generate a discussion in the scientific community of aquatic systems to improve existing techniques.

POSTER BOARD #13

POSTER BOARD #14

Comparing space-for-time with time-deep approaches for predicting peak chlorophyll a in rivers

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Periphyton standing crop is a key measure of ecological and recreational health for waterways in New Zealand, and reflects changes to hydrology, nutrient availability, riparian habitat and macroinvertebrate health. Periphyton datasets are becoming increasingly available as regional authorities implement the National Policy Statement for Freshwater Management (NPS-FM) and manage for periphyton (chlorophyll a) effects on ecosystem health. Currently, most regional datasets are too short to permit robust time-deep analyses of changes in periphyton relative to environmental changes (e.g., at individual stations over time). Instead, studies of regional or national datasets generally integrate changes in periphyton standing crop over inter-annual periods, i.e., a space-for-time approach. Such approaches form the basis of existing national guidance on periphyton management in New Zealand. The Horizons Regional Council (HRC) State of the Environment (SoE) monitoring network offers arguably the most intensively sampled and lengthy record of periphyton in New Zealand. Initial collaborative research adopted a space-for-time approach to exploring responses in chlorophyll a maxima (or 92%) to hydrology and nutrient availability. Within-site analysis was restricted to effects of hydrology on periphyton (e.g., relationships with time since freshes of varying magnitude). Here, we build on these earlier investigations using an 8-year dataset (2009-2016). Objectives included: (1) Examine space-for-time periphyton–environment relationships using various measures of periphyton standing crop including % cover by mats and filaments; (2) Examine within-station periphyton-environment relationships over time for a suite of periphyton variables; and (3) Determine whether the same hydrological and physicochemical drivers dominate in the two approaches. Output is expected to address whether important information about cause–effect relationships in periphyton responses to land-use pressure is lost in space-for-time approaches. The findings are expected to shape how regional authorities implement the NPS-FM, by determining how to examine SoE datasets for regional drivers of periphyton.

How bioturbation activity by macroinvertebrates affects the physical structure of sub-surface sediments in river systems

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Bioturbation activity by macroinvertebrates in freshwaters may influence the hyporheic exchange processes in river systems. In this study we focussed on understanding how the upward conveyor macroinvertebrate *Lumbriculus variegatus* may impact hyporheic processes through physical alterations of the sediment structure. We aim at investigating: (1) the spatial distribution of the bioturbators in sandy bedforms; (2) the effects of bioturbation on hyporheic flow path patterns; and (3) the rates and quantities of vertical transport of material by individual organisms. Objectives (1) and (2) will be addressed in a recirculating perspex flume of dimensions 2.5m (L) x 0.2m (W) x 0.3m (H) filled with triple washed sand of 0.2 mm and clogged with clay particles of 0.002 mm. Bedforms are formed manually with height of about 3 cm and length 25 cm along the length of the flume. In addition, separate perspex mesocosms with comparable grain size distribution to the flumes will be used to address objective (3). The population densities in the flume are expected to concentrate mostly in the downwelling zones/troughs of the bedforms. The hyporheic flow patterns and rates are hypothesised to expand and increase, in the presence of bioturbators in the flume. The quantities of sediment transport will be calculated from the amounts of sediment a single worm transports vertically upward through ingestion and egestion in the mesocosms. Various photogrammetry techniques will be used to observe dye preferential flow paths in the flume and to assess the vertical mixing of various layered sands by worms in the mesocosms. Galleries will be closely observed under X-ray by taking core samples along the flume. This study can help us understand the need for, and importance of, protecting the bioturbators communities for river restoration and healthy functioning of the ecosystem.

POSTER BOARD #15

POSTER BOARD #16

The influence of local and regional mechanisms shaping metacommunities in dendritic networks: a meta-analysis

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The metacommunity concept laid the groundwork for a new wave of spatial ecology, where dispersal links spatially separated communities and the interplay between local (environmental) and regional (dispersal) influences determine observed species distributions. The relative influence of spatial and environmental drivers of community structure should vary with species dispersal ability, spatial extent, and potentially network structure, as each of these variables affects a species' ability to mix among local communities and track preferred environmental conditions in time and space. We conducted a meta-analysis of studies addressing the relative importance of spatial and environmental drivers of community structure using variation partitioning techniques (i.e., canonical correspondence analysis (CCA) or redundancy analysis (RDA)). These methods attempt to disentangle the relative effects of environmental and spatial processes via partitioning the variation in species abundance and occurrence data into different components, such as unique environmental or unique spatial variation or an interaction between the two. Variation partitioning results were then related to taxonomic groups, species' dispersal ability, spatial extent of the study area and drainage network structure. Understanding the role local and regional processes play in shaping freshwater metacommunities will be beneficial for freshwater conservationists, invasive species management and restoration practitioners.

A different kettle of fish: early life history variations in whitebait species

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The early life histories of whitebait, the diadromous galaxiids, are largely unknown. Despite the wealth of information contained in otoliths, few studies of diadromous species have reconstructed larval pelagic growth to better understand their early life histories and migrations. Here, the internal features of whitebait otoliths were used to reconstruct pelagic growth profiles, estimate age and derive hatch dates. The commonest species, inanga, comprised the majority of whitebait that could be analysed for otolith microstructure. However, this is also the first widespread geographic study of the pelagic growth and age of kōaro and banded kōkopu post-larvae, and of genetically confirmed giant kōkopu and shortjaw kōkopu whitebait. Early life history variations within and among regions may play a central role for the demographics and population dynamics of adult populations. Although marine larval development facilitates dispersal in diadromous species, there may be legacy effects for adult growth, maturation and fecundity that are little understood. We will discuss these findings in the context of potential legacy effects of pelagic development for the whitebait species.

POSTER BOARD #17

POSTER BOARD #18

Exotic fish eradication in a large, deep, stratified reservoir above an urban area – is it feasible?

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The Zealandia predator-proof sanctuary in Wellington wants to eradicate the exotic Eurasian perch (*Perca fluviatilis*) population present in the lower reservoir. Very high numbers of perch are present in the reservoir and its associated stream and wetland areas, which are located in the headwaters of the densely populated Kaiwharawhara catchment. The eradication of perch will make a substantial contribution to the goals of the sanctuary, including the removal of further predatory species, the improvement of conditions for native fish species, and potentially a reduction in the cyanobacterial blooms which presently occur regularly in the reservoir. A feasibility study on the proposed eradication concluded that the only feasible means of eradication involve using the piscicide rotenone. Several factors, including the inability to lower the water level in the reservoir due to concerns about destabilising the earth dam, and the fact that the reservoir undergoes summer stratification, mean that piscicide-based eradication is more logistically complex compared to New Zealand experiences to date. The reservoir should be treated using surface application of rotenone along with subsurface injection with weighted hoses, while the stream and wetland area can be treated using a temporary coffer dam and backpack sprayers. Use of existing structures, and the retention of residual rotenone in the hypolimnion, should prevent any rotenone escaping into the Kaiwharawhara downstream. Additional factors such as the high public profile of Zealandia, and the inter-agency communications required when eradicating a sports fish also add complexity to the project. Operational planning is scheduled to begin in 2017, including multiple considerations such as consultation, monitoring, public relations, permitting requirements, and volunteer and research opportunities associated with the project.

Fish community response to the fragmentation of river networks

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Physical fragmentation of river networks via dams and other water control structures alters the natural flow regime and results in the loss of ecological function, and the endangerment or broad-scale extinction of many freshwater aquatic species, particularly riverine habitat specialists. Many rivers in Australia and elsewhere have been the subject of significant hydrological and physical change over the last 100 years. Monitoring of the abundance of freshwater biotic species and water quality has only occurred relatively recently; long after the initial disturbance of river networks. The ecosystem response to disturbances like fragmentation is most appropriately measured by comparing the same river and aquatic communities before and after disturbance. The existence of historical data for the Darling River in New South Wales, Australia makes assessing the ecosystem response to physical fragmentation at an appropriate temporal scale possible. Food webs, as a functional feature of ecosystems, provide insight into the impact of human-induced disturbance on river systems. Stable isotope analysis of preserved museum fishes provides a tool for recreating an historical food web. The degree of physical fragmentation on the Darling River was quantified by comparing pre-dam river surveys with current conditions. Stable isotopes analysis of tissue samples from museum specimens was used to investigate potential changes in diet source and the trophic status of fish feeding guilds before and after physical fragmentation of the river.

POSTER BOARD #19

POSTER BOARD #20

Interactions between freshwater mussels and non-indigenous species in New Zealand

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New Zealand populations of freshwater mussel (kākahi or kāeo) are considered threatened, and many have a geriatric population size structure (i.e., individuals >10mm are rarely found) resulting from a potential recruitment failure. We are investigating whether non-indigenous species could be a major contributor explaining this failure in the most widespread species *Echyridella menziesii*, and present a conceptual model of three possible underlying mechanisms of non-indigenous species interactions, leading to the following null hypotheses: (1) that the kākahi glochidial ectoparasitic life-stage is not host-specific and can successfully attach, encyst, and transform into viable juvenile kākahi on introduced brown bullhead catfish (*Ameiurus nebulosus*), rudd (*Scardinius erythrophthalmus*), and European (koi) carp (*Cyprinus carpio*), but that these non-indigenous fish will produce less viable juvenile kākahi than native fish hosts; (2) that population density, size, and biomass of kākahi will be inversely correlated with the biomass of non-indigenous macrophytes due to adverse physical (e.g., low water mixing, high root cover, and trapping of high fine sediments) and chemical (e.g., low dissolved oxygen, high diel pH, and elevated temperature) conditions produced at the sediment-water interface; and (3) that mammals actively preying on kākahi in bottom sediments results in significant population-level mortality. Investigation of these potential effects of non-indigenous species on kākahi will enhance understanding of threats to kākahi, and provide environmental management/ kaitiakitanga information to groups interested in protecting kākahi.

Social-cultural and ecological indicators within freshwater-receiving environments

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Estuaries rank among the most anthropogenically impacted aquatic ecosystems on earth. There is a growing consensus on the impact anthropogenic inputs have on estuarine and coastal environments, and consequently the ecological, social, and cultural values. The protection of these values is legislated for within New Zealand, and within the environmental philosophy of Ngāi Tahu, 'ki uta ki tai '. Estuarine shellfish beds are not currently managed as receivers of freshwater input. The socio-cultural component of this study, focussed on qualitative and quantitative values of site and catchment environmental condition, resource abundance and changes, and management effectiveness of these systems. Local residents and 'beach-goers', managers, scientists, and Indigenous people were interviewed. The scientific component of this study measured shellfish population indices, condition index, tissue and sediment contamination which was compared across the landscape development index, physicochemical gradient and management regimes. Overall, both the ecological and cultural findings recognised the surrounding catchment and freshwater input as a source of anthropogenic stress. The condition index of the New Zealand littleneck clam, known locally as "cockles" or "tuaki", was significantly correlated with salinity, tissue trace metal and E. coli concentration. Particular tissue contaminants had exceeded the guidance for human consumption, and particular sites of elevated contaminants shared site similarities that can further guide monitoring and restoration efforts. The top environmental indicators provided by interview participants aligned with the known global stressors within estuaries. The values of mana whenua were compromised more often than those of international visitors. The declining environmental condition impacted tribal activities and interaction with place. 'Ki uta ki tai' management systems were recommended by indigenous and non-indigenous environmental specialists.

POSTER BOARD #21

POSTER BOARD #22

A standardised approach to quantifying armour layer compaction using a penetrometer

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The success of freshwater management largely depends on the ability of scientists and managers to be able to quantify the processes occurring in a channel. This enables them to predict the future trajectory of the system, identify issues, and track the success of management works. Substrate entrainment and transport events are a critical process in riverine systems, and their frequency and magnitude determine channel stability. Channel stability is a major component of instream habit, shaping the composition of aquatic communities, and has significant implications for hazard management. Substrate stability is largely determined by the interaction of geomorphic characteristics which affect the resistance of individual clasts to entrainment, and hydraulic processes which exert force on individual clasts, resulting in clast movement if resistance thresholds are exceeded. Ecologists and geomorphologists have used a variety of approaches to quantify substrate stability for several decades, including substrate stability indices and shear stress equations. Most approaches have lacked the quantification of armour layer compaction, which is widely acknowledged as a significant factor controlling entrainment thresholds. Penetrometers are widely used in civil engineering to test the cohesive strength of soils and may offer a solution to quantifying compaction of river beds. Penetrometers have been used for this purpose in a limited number of studies, but no consistent approach was used, making it difficult to compare results. This paper presents the development of a standardised approach to measuring river bed compaction using a penetrometer, and demonstrates how this approach may be used in ecological and fluvial geomorphic research. A modified penetrometer designed for gravel-bed rivers is described. Comparison of the operation of the penetrometer in different substrate types is also presented, and suggestions for future development are made.

Response thresholds for macroinvertebrate communities to land-use stressors at the regional scale: implications for resource management

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Stream macroinvertebrates have a long history of being used as biotic indices of water quality. While such indicators are often developed using known relationships between taxa and specific environmental gradients (e.g., nutrient enrichment), they are frequently applied more broadly than originally intended. Individual taxa in community-based indicators, however, may or may not respond predictably to other environmental gradients, potentially resulting in indicator estimates which are misleading. There are clear knowledge gaps with regards to macroinvertebrate community responses at regional scales to multiple environmental gradients. Here we utilise the Threshold Indicator Taxa Analysis (TITAN) to identify community threshold responses of macroinvertebrates to 12 environmental stressor gradients using macroinvertebrate abundance data collected in wadeable streams in the Waikato region. Sites (n = 176) were selected using a rotating-panel, spatially balanced probabilistic survey design over the summers of 2013 to 2015. Data from 26 minimally disturbed sites over the same period were included in the analysis to ensure consistency with the TITAN philosophy of detecting taxon threshold responses to natural and novel (e.g., anthropogenic) environmental stressor gradients. Of the 112 taxa assessed in this study across 254 sites, 15 showed no threshold response to any stressor and six responded to all stressors (either positively or negatively). For specific environmental stressor gradients, the number of responsive taxa ranged from 20 for base-flow nitrate concentrations to 82 for silt deposition. Not all taxa responded negatively to increasing environmental stress, with a subset increasing in abundance with increasing environmental stress. Multivariate analysis of direction and magnitude of community responsiveness shows substantial differences between environmental stressor gradients, highlighting resource management implications for using aggregated community indices for multiple stressors.

POSTER BOARD #23

POSTER BOARD #24

Stream geometry and meta-community theory: what is the influence of stream network structure on the composition of benthic invertebrate communities within urban and agricultural systems?

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The metacommunity framework consists of four key models: neutral, patch-dynamics, species sorting and mass effect, which describe spatial patterns of species distribution and abundance. The key difference between each model is the relative weighting given to environmental factors and spatial processes in regulating patterns of local biodiversity. Here, the framework is used to investigate the influence of local environmental conditions and spatial variables on the total beta diversity of benthic invertebrate communities within six (two reference, two urban and two agricultural) Auckland catchments. The study also examines the influence of taxa dispersal abilities (strong vs weak dispersers) on community composition within these networks. Lastly, the study investigates how patterns observed within reference stream catchments compare with networks modified by agricultural and urban land use. Within each catchment, 20 reaches sites were sampled for benthic invertebrates using standard protocols for hard- and soft-bottomed streams. At each site, physical habitat and water-quality parameters were used to characterise local environmental conditions. Geospatial techniques were used to derive spatial variables, including the position of the site within the network, the Euclidean distance and stream-corridor distance to upstream source populations, as well as the overland distance to surrounding populations within a 5 km radius to describe the spatial characteristics of these sites. Expert knowledge and limited published data were used to categorise taxa into trait-based groups to investigate the influence of invertebrate dispersal abilities on community composition. The relative importance of these environmental and spatial variables was analysed using multivariate ordination techniques in the statistical software R. As invertebrates are routinely used in biomonitoring, understanding how these communities are assembled has important implications for how these taxa are monitored and used as biological indicators of ecosystem health.

Invasive riparian vegetation removal and channel mobility on the Colorado River

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The introduction and spread of tamarisk (*Tamarix* spp.) in the riparian zones adjacent to the Colorado River and many of its tributaries in the southwestern United States have contributed to increased stability of many of these river channels over the last century. Recent and expanding efforts to remove tamarisk from riparian zones may contribute to increased channel mobility and bank erosion, as evidenced by significant bank erosion associated with the 2011 peak flow in areas where tamarisk had been removed along the Colorado River. The purpose of this ongoing study is to assess changes in channel mobility following tamarisk removal along a 51-km reach of the Colorado River in western Colorado via GIS analysis of repeat aerial photos and field surveying of channel cross-sections at vegetation removal sites. Results from GIS analysis of aerial photos taken in 2002, 2007 and 2012 show that more erosion occurred during the 2007-2012 time period regardless of whether or not vegetation was removed, likely a result of the higher annual peak flows during that time period. Vegetation removal sites exhibited greater average annual erosion rates during the 2007-2012 time period than sites where no vegetation removal occurred ($P = 0.042$, two-tailed t-test for equal variance on log-transformed data). In addition, the erosion rates between 2007 and 2012 were higher for sites where removal was conducted prior to 2002 than those where removal was conducted more recently, which suggests that the time since vegetation removal may play a role in channel instability. Continuation of this analysis using the 2015 and 2016 aerial photos will add valuable information, as vegetation removal efforts have increased since 2007, and measuring channel change between 2012 and 2016 may shed more light on how the channel continues to respond to both the earlier and more recent vegetation removal efforts.

POSTER BOARD #25

POSTER BOARD #26

Studies on food web structure and trophic dynamics of Three Gorges Reservoir

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The substance of fisheries affected on aquatic ecosystems was changes of fish community structure and trophic cascade effects on food web structure caused by fishing or artificial stocking. To establish a sustainable fishery pattern of resource protection and utilisation in Three Gorges Reservoir, we studied the food web structure and trophic dynamics in mainstream and Xiaojiang River of Three Gorges Reservoir using stable isotope techniques. The results of stable isotope analysis showed that the relative trophic level of mainstream was higher than Xiaojiang River which reflected the relatively high fishing intensity in the tributary of the Three Gorges Reservoir. Additionally, the mass balanced models of mainstream and Xiaojiang River were constructed using Ecopath with Ecosim. Results showed that food web structure in mainstream were relatively simpler than Xiaojiang River. There were much redundant energy in both ecosystems; meanwhile, the niche overlaps of omnivorous fish species were severe. Results of mixed trophic impacts analysis showed relatively strong indirect suppressing effects of carnivorous fish species on phytoplankton. Study results would provide a scientific basis for the development of fishery conservation and utilization measures on Three Gorges Reservoir, thus would have an important significance on ecosystem service value development of Three Gorges Reservoir.

Why use fish, when you can use a dish? In vitro larvae transformation of native freshwater mussel *Echyridella menziesii*

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Freshwater mussels play an important role in the maintenance of good water quality and therefore the decrease in abundance of the three species of native New Zealand freshwater mussels is of great concern. It is our aim to be able to mass-produce juvenile mussels for use in ecotoxicity research to determine the habitat requirements and contaminant tolerances of this vulnerable early-life stage, and longer term, to support bioremediation studies, restock restored environments and increase the abundance of the more-threatened species. The mussels produce larvae (glochidia) that naturally parasitise on fish for approximately two weeks while they transform into juveniles. This process can be replicated in the laboratory but it is labour-intensive and produces juveniles that are contaminated with fish faeces, thereby compromising the grow-out phase. Although in vitro transformation of larvae into juveniles "breaks the link" between host and parasite it has the advantage of producing up to 1,000 uncontaminated juveniles in a single petri dish. We have adapted methods used in Asia and North America to successfully transform the larvae of the most widely distributed native mussel species *Echyridella menziesii* in a petri dish. This presentation will provide details of our method and the requirements for in vitro success, including the transfer of juveniles into a grow-out system. We will provide information on the different techniques trialled including the selection and collection of quality glochidia, the use of various cell culture media and antibiotics, the collection and use of fish plasma and rabbit serum, and techniques to reduce bacterial and fungal infection. A complementary presentation will provide more information about using fish hosts for mass production of juveniles, and the process of on-growing of the juveniles after transformation from the larval stage.

POSTER BOARD #27

POSTER BOARD #28

Smartphones as a "key" to freshwater biomonitoring: the SHMAK identification app

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Benthic macroinvertebrates represent the core of most professional freshwater biomonitoring programmes. However, identification issues are considered a major barrier for their widespread use with citizen scientists. Smartphones could assist in macroinvertebrate identification, both through providing an easily accessible and dynamic dichotomous key and through external optical components (e.g., macro lens) that can be attached to a smartphone to better visualise key identifying characteristics. Current identification apps for freshwater taxa include AquaInvaders for the identification and recording of invasive freshwater species in the United Kingdom, and The Waterbug App, a key for the identification of aquatic invertebrates in south-eastern Australia. Here we present a taxonomic key and online resource for freshwater macroinvertebrates in New Zealand. The SHMAK (Stream Health Monitoring and Assessment Kit) identification app includes a key designed to identify macroinvertebrates into volunteer-level taxa and can be used to calculate an invertebrate health score for your sample. It also offers a more detailed taxa list, including photos, videos, and information about each taxon's habitat and distribution to improve identification and promote learning. The app is designed to work with NatureWatch NZ, allowing users to upload photos, document species distributions, and ask for help with identifications.

Biosorption of Pb(II) and Cd(II) in aqueous solution by *Mangifera indica* seed: equilibrium, kinetics and mechanism

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Abundant fruit wastes can be converted into useful biosorbents for heavy metal removal due to their low cost and effective performance. Mangifera indica seed (i.e., mango seed, MS) was used as a biosorbent for the removal of Pb(II) and Cd(II) in this study. The batch study in a single-metal system showed that the biosorption capacities (Q, mg-metal/g-MS) of Pb(II) and Cd(II) augmented with increasing pH, with the optimal pH found at 5 and 7.5, respectively. Equilibrium studies determined that the maximum Q were 263.6 mg-Pb/g-MS at pH 5 and 93.5 mg-Cd/g-MS at pH 7.5. Non-linear simulation with various adsorption isotherm equations indicated that Freundlich isotherm provided better fitting to the equilibrium data of Pb(II) and Cd(II) biosorption than Langmuir isotherm, suggesting multilayer loadings of heavy metal ions on the heterogeneous surface of MS. Kinetic studies revealed a fairly rapid biosorption of Pb(II) and Cd(II) by MS, with the biosorption equilibrium achieved in 180 min. It is worth noting that as high as 93% of Pb(II) biosorption and 78% of Cd(II) biosorption were achieved in the first five minutes. Non-linear fitting of the kinetic data to pseudo-first-order and pseudo-second-order rate equations denoted that the former equation could well describe the Pb(II) biosorption process, whereas the latter equation fitted well to the Cd(II) case. Furthermore, the significant shifts of wavenumber detected in Fourier transform infrared spectra of MS, before and after Pb(II)/Cd(II) loadings, evidenced the participation of hydroxyl and carboxyl groups in biosorption. Ion exchange could be involved as an underlying mechanism given the release of Mg^{2+}, K^{+} and Ca^{2+} from MS during biosorption. The high biosorption capacities and rapid biosorption processes observed in this study imply the enormous potential of MS for Pb(II) and Cd(II) sequestration in aqueous solution, providing an insight into its practical application in the treatment of heavy metal-bearing (waste)water.

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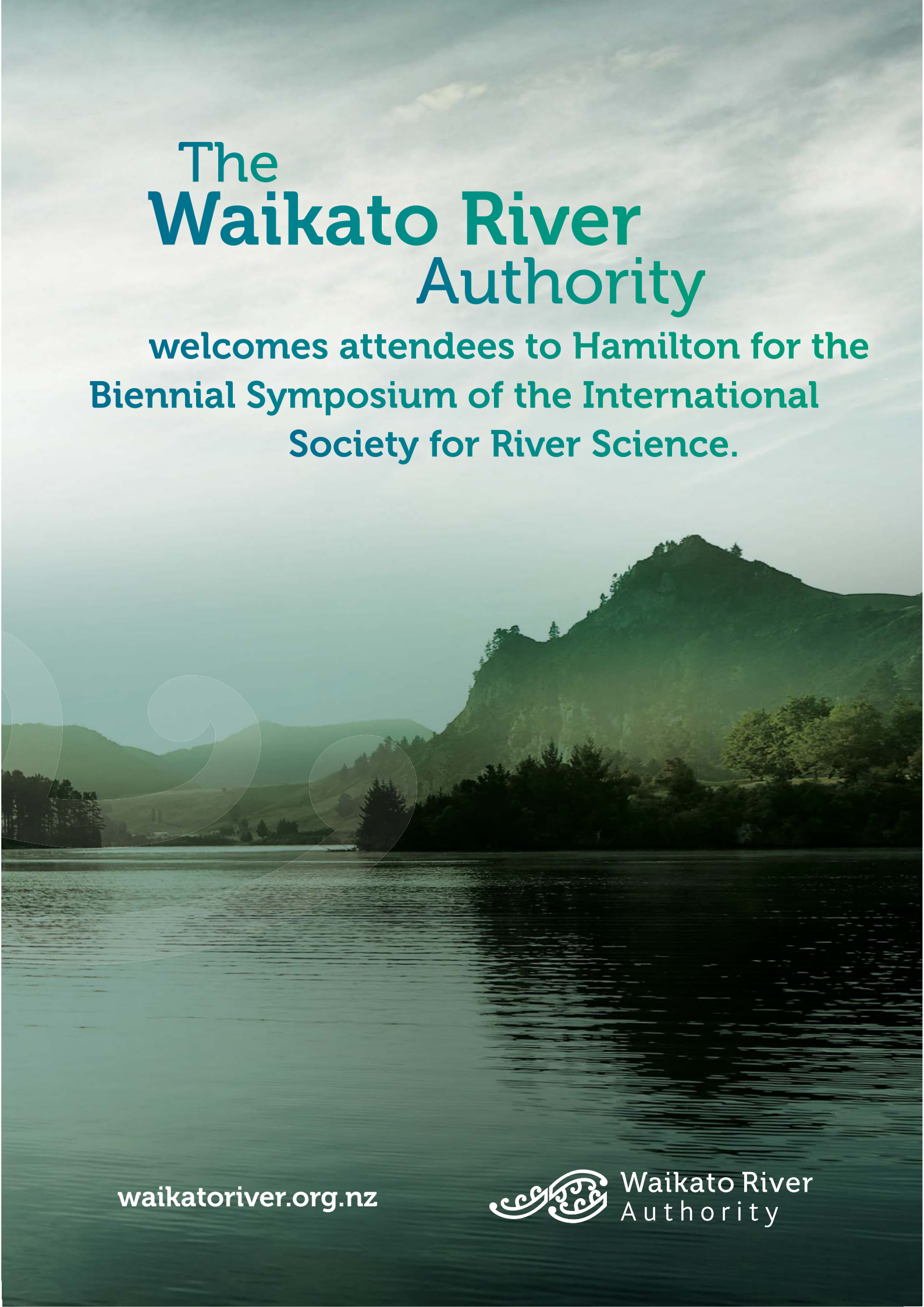
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