Ka mua, ka muri: Looking back, moving forward

50th NZFSS

Ka mua, ka muri

Annual Conference

Nelson, 10-14th December 2018

Conference Handbook

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WELCOME

Welcome from the NZFSS President

The New Zealand Freshwater Sciences Society was founded as the New Zealand Limnological Society in 1968 by a small group of freshwater scientists who were interested in developing and maintaining a network of people interested in freshwater science. So this year marks the 50th anniversary of the Society, which has grown and strengthened with the passing of time. To mark this auspicious year and the achievement of this milestone, the conference organisers have planned some special events and are ramping up the fun. I hope you enjoy our 50th Anniversary Conference in sunny Nelson and I hope that you'll also be inspired to help make this conference one to remember!

Marc Schallenberg
President NZFSS

Conference Committee

- **Joanne Clapcott - Chair**
  Cawthron Institute
- **Roger Young**
  Cawthron Institute
- **Hugh Robertson**
  Depa=rtment of Conservation
- **Andrew Fenemor**
  Manaaki Whenua \| Landcare Research
- **Paul Fisher**
  Nelson City Council
- **Trevor James**
  Tasman District Council
- **Monique Day**
  Nelson Marlborough Institute of Technology
- **Aneika Young**
  Cawthron Institute
- **Robin Holmes**
  Cawthron Institute
- **Kati Doehring**
  Cawthron Institute

Welcome from the NZFSS Conference Committee

Nau mai, haere mai, ki Whakatū!
Welcome to Nelson for this year's Freshwater Sciences Society Conference.
This year we celebrate the 50th year of the New Zealand Freshwater Sciences Society with the conference theme "Ka mua, ka muri: Looking back, moving forward". We chose this theme because it reminds us that we are where we are because of all those that have come before us. We have 50 years of freshwater science, and a much longer history of cultural knowledge, to celebrate and to guide us with tomorrow's freshwater challenges. This week-long conference is jam-packed with plenary speaker presentations, workshops, special and contributed sessions, poster displays, a diverse array of exhibits, networking functions, and field trips that show case Nelson's unique freshwater environments and attractions. We are grateful to our generous sponsors who have helped make this week possible. We have adopted some new formats and supporting services to make this conference relevant to today. We hope you embrace the new and help us celebrate the old. Most of all, we hope you have fun!
Kia pai tō koutou wiki!

Joanne Clapcott
On behalf of the conference organising team

NIWA
Taihoro Nukurangi

NIWA FRESHWATER AND ESTUARIES CENTRE

Our goal is to bridge the gap between science and the community in the field of freshwater resources, by providing science, technology and resource management services to New Zealand.

Our freshwater research work is organised into six research programmes:

Aquatic rehabilitation and protection
Science and solutions to protect, enhance and rehabilitate freshwater values and indigenous biodiversity.
Contact: fleur.matheson@niwa.co.nz

Catchments to estuaries
Understanding and predicting connections between catchments and estuaries to improve the management of diffuse-source contaminants and reduce adverse effects in estuaries.
Contact: andrew.swales@niwa.co.nz

Causes and effects of water quality degradation
Understanding and predicting sources, control and effects of freshwater contaminants, for use in land management decisions.
Contact: sandy.elliott@niwa.co.nz

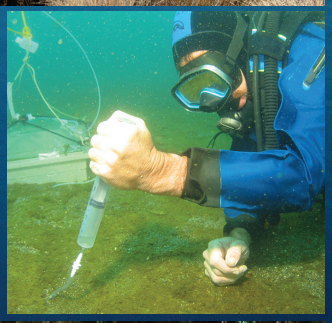
Freshwater biosecurity
Science to support the protection of New Zealand's freshwaters and estuaries from adverse impacts of non-native invasive species.
Contact: paul.champion@niwa.co.nz

Sustainable water allocation
Understanding and predicting the effects of human use and modication of rivers and groundwater systems for sustainable water allocation.
Contact: doug.booker@niwa.co.nz

Water resources
Understanding and predicting the state of water resources in rivers and aquifers – where the water comes from, how much there is and how it is used – to improve its sustainable management.
Contact: christian.zammit@niwa.co.nz

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

Scott Larned
Manager – Freshwater Research
+64-3 343 7834
scott.larned@niwa.co.nz



CELEBRATE 50 YEARS OF NZFSS

In 1968, a few enthusiastic freshwater scientists got together and founded the New Zealand Limnological Society, nowadays known as the New Zealand Freshwater Sciences Society. What started off as a small group 50 years ago, has grown to a 430 members strong society, leading freshwater science in New Zealand as well as worldwide.

At this year's NZFSS conference we will celebrate the Society's past, present and future. We start with the past – portraying previous presidents and other interesting snippets from newsletters, press-releases, etc.

Delve into the past of New Zealand's Freshwater Science Society, some 50 years back where you could become a member of the NZ Limnological Society for 50 cents per annum…

Vida Mary Stout

First President 1968-1973 and founder

Vida was a member of a highly distinguished family. Her father was a surgeon and vice chancellor of Victoria University of Wellington and her grandfather was the 13th premier of New Zealand and later chief justice. Vida was dux at Woodford House before going to Victoria University where she did her BSc and MSc in Zoology. Her thesis was on the two large red water mites found in ponds. She wrote two long papers on mites from her thesis and another on the rhabdocoel flatworm Mesostoma – all were published in the Proceedings of the Royal Society of New Zealand. She then went to Bedford College, University of London where she did her PhD on Daphnia. This was followed by post-doctoral work in Sweden before returning to New Zealand. Vida was appointed to the Zoology Department at the University of Canterbury in 1958, where she remained until her retirement in 1996
In 1968 she and Ann Chapman founded the New Zealand Limnological Society (now the NZ Freshwater Sciences Society) as a forum where freshwater workers could meet at an annual conference and contribute to a newsletter. Vida was the first president of the Society and Ann was the first newsletter editor. After retiring in 1996, she continued to go to her office almost every day until the university forbid her access, citing fears for her safety. Vida died in 2012 aged 82.

Right: Exhausted members of the Lake Blackwater expedition, Cass (1979). From left, John Stark, Richard Rowe, Lynley Pearce, John Hayes, Brian Timms, Vida, Malcolm Forster, Mike Winterbourn.

Vida instructing students at a tarn in Arthur's Pass about 1995.

CELEBRATE 50 YEARS OF NZFSS

New Zealand Limnological Society Conference – Taupo, 1982

Back row: J. Gibb, M. Timperley, B. Coffey, S. Wood, A. Viner, C. Mitchell, R. Wells, E. White, R. McColl, T. Stephens, W. Vant, D. Jellyman, M. Gibbs, R. Edwards, J. Boubee

Third row: C. Richmond, M. Downes, M. James, P. Gillespie, V. Wilkinson, J. Stark, P. Claman, V. Stout, B. Biggs, P. Henriques, P. Mylechreest, J. Quinn, J. Davies, E. Cudby, W. Donovan, I. Vidal

Second row: L. Whiteside, Y. Stark, S. Davis, A. Chapman, M. Fransen, S. Porter, C. Burns, R. Vigor-Brown, L. Harper, A-M. Schwarz, M. Butler, F. Eccles, M. Harper, K. Law, J. Edwards, L. Ryan

Front row: S. Pickmere, P. Lawless, G. Payne, P. Todd, R. McLay, P. Tortell, D. Forsyth

50th Anniversary Photo Display in Catering Area

"Ka mua: Ka muri" – 50 years have passed since the New Zealand Freshwater Sciences Society has been established and the Society would not be where it is today if it wasn't for its people. To celebrate this special milestone and the people behind the Society, explore past and present members and see how they have changed, reminisce about their humour and lets remind ourselves about their science. You will see that some of our key members are missing– so make sure they are not forgotten about and fill in their names and draw their portrait on the blank spaces!

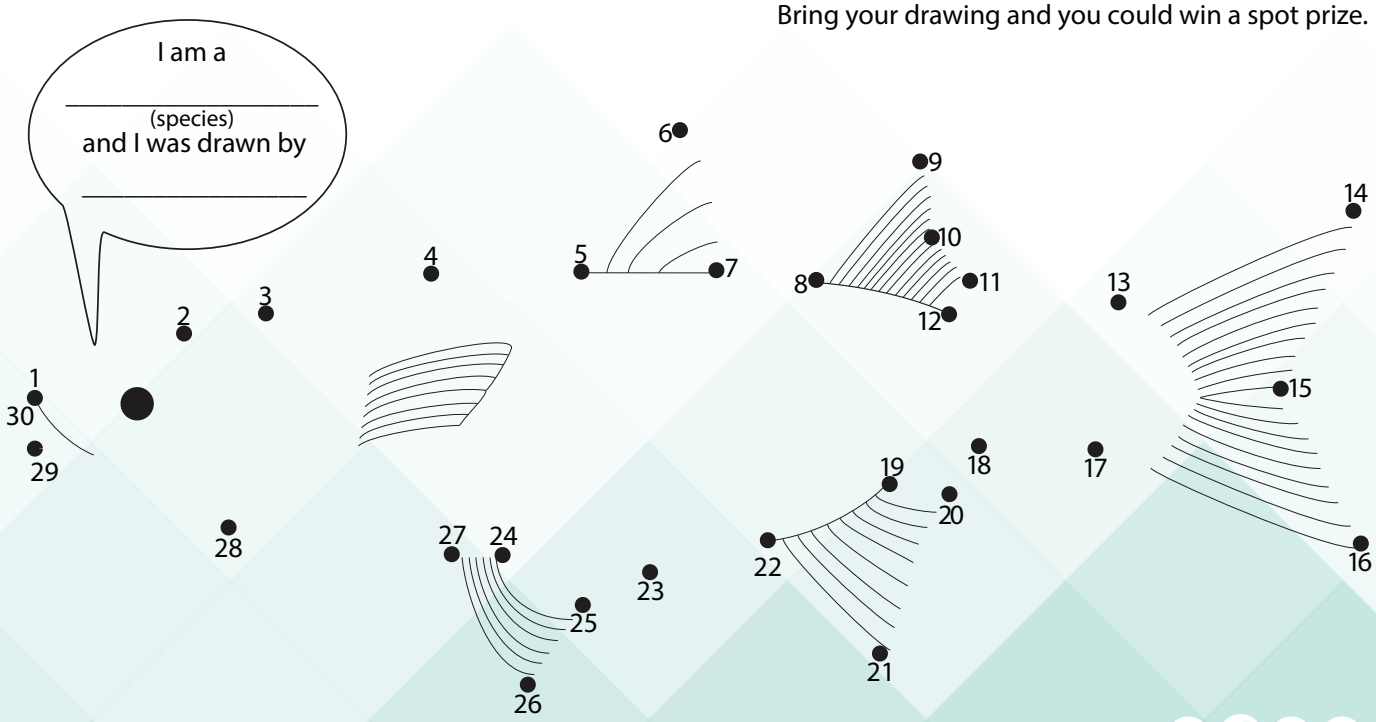
Photo Silent Auction

You are welcome to view and purchase the photos on display in the Registration area, these have been provided to the society by members working in freshwater science and management within New Zealand.

Ministry for the Environment
Manatū Mō Te Taiao

Connecting the dots between science and policy

Come along to our Freshwater Policy Update.
Bring your drawing and you could win a spot prize.



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Te Waiora
Joint Institute for Freshwater Management

Working to support

- the rehabilitation, restoration and protection of freshwaters
- the quality of freshwater decision-making and management strategies
- the next generation of scientists and water managers

Get in touch to find out how we can work together
www.TeWaioraFreshwater.co.nz

GENERAL INFORMATION

Registration Desk
If you require any assistance throughout the conference please see the conference organisers at the Registration Desk.
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 blue NMIT 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.
Wifi Password: NZFSS2018

Parking
Compliemntary all-day car parking is available for conference guests. Please note that parking is subject to availability.

Contact Numbers
For assistance please call Shelley Haring from On-Cue Conferences on **021 403 316**

Conference Catering
All catering breaks will be split across two areas; Riwaka Foyer (Exhibition Trade area) and Maitai Foyer (Registration area)
If you have advised us of your special dietary requirements, these have been forwarded to the caterers 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 Wednesday 12th, lunch will be served as a 'boxed lunch' please collect this from the catering areas and you are welcome to either stay at the venue or wander outside with this. We suggest a visit to the lovely gardens across the road at the Nelson Cathedral, plenty of places to sit, relax and enjoy your lunch.
If you are attending a Field Trip on Friday 14th, a take-away lunch is provided and will be placed on the bus for you

Loading Talks
Please load your talk at the speaker preperation area beside the registration desk in the Maitai Foyer

Poster Presenters
The poster boards are located in rooms Maitai 1 & 2, please put your poster on your allocated board. Posters must be put up before 3pm on Monday 10th. Velcro dots will be supplied.

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.

GENERAL INFORMATION

Medical

- **Nelson Hospital**
  Tipahi Street, Nelson South
  ☎ (03) 546 1800 | www.nmdhb.govt.nz

- **Life Pharmacy**
  296 Hardy Street, Nelson

- **After Hours Medical Centre**
  98 Waimea Road, Nelson South
  ☎ (03) 546 8881 | www.micn.org.nz

Student Awards

This year the following students awards will be presented:

- Best Published Paper Award
- Best Student Oral Presentation
- Best Masters or Honours Oral Presentation*
- Best Student Poster
- Best Freshwater Management Poster
- Best Freshwater Management Paper

**this prize will not be awarded if the Best Student Oral Presentation is won by a Masters or Honours student*

Can judges please meet in the Waimea room at Thursday lunchtime to determine award recipients.

Getting Around

TAXIS

Nelson City Taxis 03 548 8225 or 0800 10 88 55
Sun City Taxis 03 548 2222
The Airport is an 11 minute drive from the conference venue.

Media

There will be media present at the conference. We also have a social media policy.

Social Media Policy #NZFSS2018

We have prepared the following guidelines for using social media during the NZFSS conference.

- First and foremost, think before you tweet! We want all attendees and non-attendees to have a positive experience of the conference. Don't write anything that you wouldn't say kanohi ki kanohi (face-to-face).
- Be generous with compliments. New to tweeting? Here's an example of how you might reference a presentation at the conference: #NZFSS2018 @scientist of @Uni: shows Maitai stream restoration success!
- Be kind and question/comment about the research and ideas, not about the person or mode of presentation.
- Direct quotes get "quotation marks". Other people's words belong to other people.
- Be respectful of presenters' requests for no social media coverage.
- Always ask permission before posting images of people, figures or tables with data.
- Have fun! And help build a positive community within the Society.

Code of Conduct

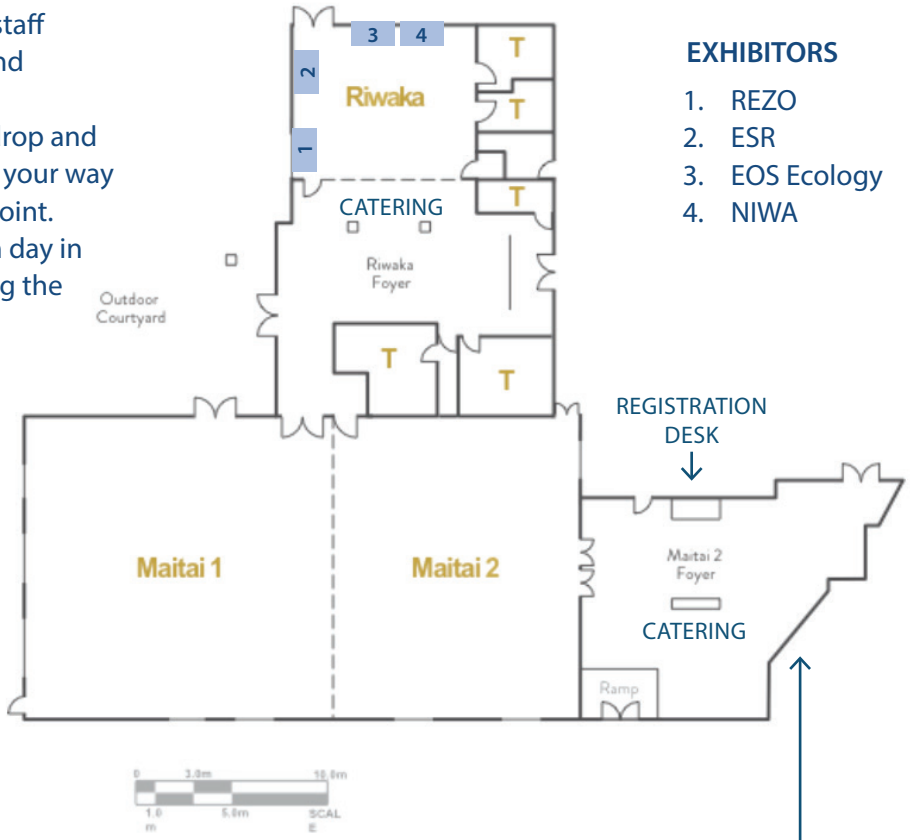
It is our experience that the NZ Freshwater Science Society meetings are a supportive and kind environment for sharing knowledge and fostering the future of freshwater research and management in Aotearoa. We invite delegates to acknowledge this by adopting a Code of Conduct. You can read more here: kindnessinscience.wordpress.com
We invite delegates to be kind and enjoy the 50th annual conference of the New Zealand Freshwater Sciences Society.

VENUE FLOOR PLAN

EMERGENCY INFORMATION

In the event of an emergency you will hear an alarm at the venue, please follow staff instructions, evacuate the building and assemble in the car park.
In the event of an earthquake, stop, drop and cover. When the shaking stops make your way out of the building to the assembly point.
This information will be covered each day in conference housekeeping, preceeding the Keynote presentation.

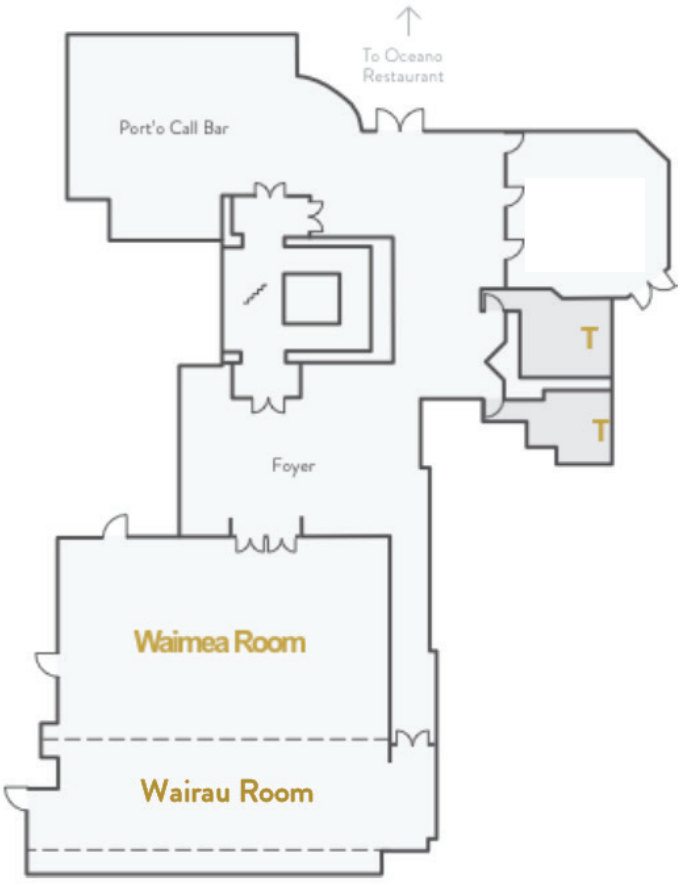
GROUND FLOOR



EXHIBITORS

1. REZO
2. ESR
3. EOS Ecology
4. NIWA

SECOND FLOOR



ART INSTALLATION - *BREATHE*

Located in the Maitai Foyer

Breathe tells the story of water temperature, in Te Wairepo/York Stream, via a series of internet connected fish replicas. The work was realised through the collaboration of ecologists, artists, technologists and students from schools along the waterway. It was part of a wider community engagement project supported by Nelson City Council.

NELSON MAP

1. **Conference Venue - Rutherford Hotel Nelson**
   Address: 27 Nile Street, Nelson
   Phone: 03 548 2299

2. **Gala Dinner - Trafalgar Centre**
   Address: Paru Paru Road, Nelson

3. **Welcome Function - Top of Trafalgar Street**
   Address: Top of Trafalgar Street

4. **Student Function - Deville's Café**
   Address: 22 New Street, Nelson

5. **Pōwhiri - Conference Opening - Whakatū Marae**
   Address: 99 Atawhai Drive, Nelson

WELCOME & SOCIAL FUNCTIONS

Pōwhiri and Conference Opening at Whakatū Marae

Monday 10 December 2018
10:30 - 11:10am
Venue: Whakatū Marae
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 Whakatū Marae. Please be sure to be in attendance at the pre-conference gathering on time. Buses will depart The Rutherford Hotel 10:15am and return back to The Rutherford at 12:50pm. Light refreshments will be served following the pōwhiri.

Welcome Function

Monday 10 December 2018
6:00 - 7:30pm
Venue: Top of Trafalgar Street
Tickets: If you have registered to attend the welcome function, you will find 2 x drinks tickets with your conference lanyard
Renew old friendships and make new acquaintances as we welcome you to Nelson. Join us for the 'Top of Trafalgar Street party' where you can use your drinks tickets at any of the participating restaurants and enjoy complimentary nibbles as well. Keep an eye on the street for some pop-up street performances! We encourage you to stay on and enjoy dinner at one of the many great Nelson restaurants in this area. Don't forget to book.

Fun Run

Tuesday 11 December 2018
7:00 - 8:00am
Venue: Nelson Cathedral Steps - Top of Trafalgar Street
For all those wanting to start the day with a bit of exercise, there will be two options to jog along with fellow delegates on local Nelson walking tracks. One option will invole hills and the other, not so many hills. Seize the day!

Early Career Mixer

Tuesday 11 December 2018
5:30pm - 7:30pm
Venue: Deville's Café, 22 New Street
Students and early career researchers are invited to attend the NZFSS Student Mixer event. Nibbles and a free drink provided.

SWIM Meeting

Tuesday 11 December 2018
5:30pm - 7:30pm
Venue: Rutherford Hotel - Waimea Room
The regional council Surface Water Integrated Management group meet Tuesday evening in the Waimea Room by invite only.

Rōpū Māori hui

Wednesday 12 December 2018
12:00pm - Lunchtime
Venue: Rutherford Hotel - Waimea Room
The Māori group will meet at Wednesday lunchtime in the Waimea room. Agenda items include update on progress of the rōpū, terms of reference, and election of representatives. New members welcome!

NZFSS Annual General Meeting

Wednesday 12 December 2018
5:00pm - 6:30pm
Venue: Rutherford Hotel - Maitai Room 1
The Annual General Meeting for NZ Freshwater Sciences Society will be held on Wednesday. All delegates are welcome to join, however only members are eligible to vote if required.

Public Seminar - Future-Focused Freshwater Research

Wednesday 12 December 2018
From 7:00 - 8:30pm
Venue: Rutherford Hotel
There is some great research going on in our freshwaters around the country. We would like to share some of this with you and invite you to attend this free public event, timed to coincide with the 50th anniversary conference of the New Zealand Freshwater Sciences Society being hosted in Nelson. The seminar will include presentations by three emerging freshwater scientists and be chaired by Emeritus Professor Carolyn Burns (University of Otago). We hope you can join us!

NZFSS 50th Anniversary Gala Ball

Kindly sponsored by Nelson Forests Ltd.

Nelson Forests Ltd.

Thursday 13 December 2018
6:30pm - 11:30pm
Venue : Trafalgar Centre, Paru Paru Road, Nelson
Tickets : $95 + gst per ticket
Dress : Dress to walk the red carpet
This is the night everyone remembers! Includes a 3-course meal, beverages and entertainment.

National SCIENCE Challenges

We are working towards a future in which catchments contain mosaics of land uses that are more resilient, healthy and prosperous than they are today;
a future where all New Zealanders can be proud of the state of our land and water.

Come along to the **Land and Freshwater Special Session at 1.30pm on Wednesday 12 December** to learn more about Our Land and Water's transformational, collaborative, mission-led research.

FIELD TRIPS

Each trip leaves at the specified time on Friday 14 December from the Rutherford Hotel, please be ready 10 mins prior to departure. Each field trip includes a packed lunch and bottle of water.
If you haven't booked a field trip and wish to do so, please see the registration desk by close of conference on Tuesday. Numbers are limited.

Maitai River Mountain Bike

Time : 9:00am - 3:00pm
Price : $35 Excluding Bike Hire
After four days of sitting, this field trip offers a chance to stretch some muscles, suck in some fresh air, and see some of Nelson's precious and beautiful streams, rivers and mountains.
Total distance 38 km, ca. 1,000 m climbing, est. ride time 4-5 hours. You need to have some mountain biking experience and be reasonably fit. The climb is gentle, but the decent requires an intermediate/advanced skill level. Starting from town, we will cruise up the historic Dun Mountain walkway - New Zealand's first railway. We will pause when we reach the mineral belt, a zone free of tress due to its unique geology, where we will drink from a cool and refreshing stream, and prepare for one of New Zealand's longest mountain bike downhills.
We stop at the Maitai dam for lunch where we will discuss the impacts of the dam on the Maitai River water quality, flow and fish passage. We'll explore measures underway to reduce some of the impacts. Next up is a for a leisurely ride back to town – stopping at the new Groom Creek wetland

Freshwaters of Abel Tasman

Time : 8:15am - 4:00pm
Price : $85.00
A unique field trip into Abel Tasman National Park to see some of the regions more intact lowland freshwater streams, wetlands, and lagoons. It will include a charter boat trip into the national park and visits to relatively intact freshwater systems that support strong fish populations, as well as impacted sites currently under restoration. We'll hear from a range of speakers about migratory fish populations, impacts of Cyclone Gita, stream and wetland restoration, tourism pressures, freshwater education (youth ambassadors) and from manawhenua iwi on their kaitiaki responsibilities and cultural health projects. We'll also make sure there is time for a swim during lunch.
Sites visited will include:
- Abel Tasman National Park – charter boat trip to coastal Anchorage within the national park
- Coastal streams and coastal lagoon – key sites for migratory fish
- Otuwhero stream and wetland restoration, near Marahau

Greening Our Urban Stream Stormwater Networks

Time : 9:30am - 4:00pm
Price : $50.00
The field trip will be an opportunity to learn about the challenges of Nelson City and Tasman District Councils modifying urban streams to meet engineering standards for maintaining flood capacity that potentially conflicts with the National Objective Framework ecosystem health, natural character and Tangata Whenua values and attributes. The trip will visit a range of projects with different challenges, including streams confined by existing infrastructure and urban development and culminate with the major restoration of a coastal creek.
Sites visited will include:
- Brook stream fish passage remediation and channel baffle trials
- York stream high flow channel and fish ramp
- Saxton creek staged development of an urban stream with sediment and flood detention ponds and inanga spawning area
- Reservoir Creek fish passage restoration with in-culvert baffling and fish ladder
- Borck Creek stream restoration project, a re-creation of a meandering lowland coastal stream channel

Waimea and Mid-Motueka River Catchments

Time : 9:00am - 4:00pm
Price : $50.00

The Waimea and Motueka Rivers are geologically diverse freshwater systems that flow into Tasman Bay. They are a focus of catchment management and river restoration for Tasman District Council and many other partners and stakeholders, including iwi, Fish & Game.

This field trip will visit river, stream and estuary sites from mid-reaches of the Waimea and Motueka Rivers to the Waimea Inlet and see progress in river restoration, fish passage, sediment removal and habitat creation. We'll discuss ICM research and future strategies for large-scale catchment management as well as enjoying the scenic landscapes of the Waimea and Motueka.

Sites visited will include:

- Waimea Inlet - including Neimann Creek sediment removal project
- Waimea River catchment - including water augmentation, fish passage improvement at Wai-iti River, and water quality monitoring
- Upper Motueka River – ICM research, habitat creation and river engineering

A Fish Eye View Of The Motueka River

Time : 7:30am - 6:00pm
Price : $85.00

Learn about the environmental and socio-economic issues impacting on the Motueka River trout fishery and ecosystem through the lens of trout and trout fishing—by being out there doing it, fishing with local expert anglers and Cawthron's own scientist-anglers.

Owing to the small pool of expert angler and scientist guides available this excursion will be limited to a small number (6–12) of participants. So if you are a keen, or aspiring, angler and would like to mix trout fishing with science and socialising, book early. Bring your own fishing gear (fly fishing and / or spin-fishing), including waders, hat, polaroid sunglasses and sun cream—and a fishing license. Guides will be able to provide some rods, reels & flies for any participants without their own. You'll spend the morning to mid-afternoon fishing with a buddy and a 'guide', learning the ways of trout and fishing in the Motueka River, and how these are affected by environmental and social pressures operating at catchment, regional and national scales. We'll then all get together at a pleasant picnic spot to share experiences and hear perspectives on the fishery and pressures on it from Nelson-Marlborough Fish and Game staff.

Sites visited will include:

- Motueka River – fishing access areas

KEYNOTE SPEAKERS

Barney Thomas

Talk time: Monday 10 December 11:30am - Whakatū Marae
Topic: Kaitiaki roles and responsibilities
Chair: Aneika Young

Ko Tokomaru, ko Tahumatā rātou ko Piripiri ngā maunga
Ko Wairau, ko Okana rātou ko Waitohi ngā awa
Ko Tainui, ko Tokomaru rātou ko Takitimu ngā waka
Ko Barney Thomas tāku ingoa

Barney was born and educated in Picton and moved to Nelson in 1979; encouraged by his mother who was a shareholder in Wakatu incorporation. Through Barney's mother, his iwi connections are Ngāti Rārua, Ngāti Tama, Ngāti Toa, Te Ātiawa, and through his father, Ngāi Tahu. Barney has been a Trustee of Ngāti Rārua Ātiawa Iwi Trust since its inception and Vice Chair since 1998. He is also a Director for Wakatū Incorporation. He is currently Chairman of both Tiakina te Taiao and Manawhenua ki Mohua which are the RMA structures for Nelson/Motueka and Golden Bay respectively. Barney is currently the Pou Tairangahau (all-encompassing cultural adviser) for the Department of Conservation in the Nelson/Marlborough area and has worked for the Department since 1996. He was formerly with the Inland Revenue Department and the Department of Labour. Barney is married to Shona who is a very patient and supportive wife, has three children (Renee, Fraser and Jackson), and a granddaughter, Sophia.

Abstract

The roles and responsibilities of kaitiaki (guardian) can be complex. Barney will share his experience as mana whenua (authority over land or territory) in the context of defining and protecting the Cultural Values of Wai. He will also discuss issues related to Te Waikoropupū as a wāhi tapu (sacred site) and the processes that whanau, hapū and iwi had to consider when protecting this taonga (treasure). He will also reflect on the water take application of Kahurangi Virgin Waters, from his experience when he was the Chairman of Ngāti Rārua Iwi Trust.

KEYNOTE SPEAKERS

Tina Porou

Talk time: Monday 10 December 12:10pm - Whakatū Marae
Topic: Te Mana o te Wai and the experiences of implementing the kaupapa through current planning tools
Chair: Aneika Young

Tina is of Ngāti Porou, Ngāti Tūwharetoa, Ngāti Kahungunu and Ngāi Tāmanuhiri. She has been an environmental planner for the last 20 years working with local authorities, iwi and hapū, central government and the private sector on a range of natural resource matters. Her expertise is in connecting mātauranga Maori with technical skills in the planning field to build win-win outcomes for the environment and our sustainable businesses. Tina was the Head of Sustainability and Environment at Contact Energy before deciding to follow her calling to establish Poipoia. She has a 17-year-old daughter Te Rina, five nieces and one nephew making for a very full life. Tina was the recipient of a Sir Peter Blake Leadership Award in 2015 for her work with the environment and was honoured as a member of the NZ Order of Merit in 2016.

Abstract

The Pou Taiao Iwi Leaders Group was instrumental in introducing a range of changes to the National Policy Statement for Freshwater Management and the Resource Management Act. These changes were a reflection of a wider framework, Te Mana o te Wai. I will discuss the development of these tools, why they were developed and how we can see these being implemented across the country in different iwi and councils. I will focus on the challenges that are facing many iwi in this space and the diverse ways in which these challenges are being addressed in both post and pre-settlement Iwi. I will also discuss the next space of allocation and giving effect to rights and interests in freshwater and some views from my experience across multiple Iwi experiences.

KEYNOTE SPEAKERS

Professor Russell Death

Talk Time: Tuesday 11 December 8:55am
Topic: Is Good Science Good Enough?
Chair: Marc Schallenberg

Russell Death is a Professor in Freshwater Ecology in the School for Agriculture and Environment at Massey University. With nearly 30 years' experience in ecological research and teaching, Russell's main area of expertise is the ecology of stream invertebrates and fish. He has over 100 peer-reviewed publications in international scientific journals and books and has given around 60 conference presentations and supervised 38 post-graduate research students. Russell has been a Quinney Visiting Fellow at Utah State University and an International Distinguished Visitor to the University of Birmingham. He is also on the editorial board of the international journal Freshwater Science. Although Russell's primary interest is ecological research he has also been involved in applying that science in planning arenas such as the One Plan, Canterbury Regional Plan and Ruataniwha irrigation scheme. Russell is the recipient of the 2017 New Zealand Freshwater Science Medal.

Abstract

As a relatively affluent, prosperous, and educated country, New Zealand likes to pride itself on making policy, environmental, and economic decisions based on well-developed and rigorous scientific facts. Although, the recent debacle on "methamphetamine contaminated" houses clearly illustrates that this does not always occur. Members of the New Zealand Freshwater Science Society have made sustained significant intellectual contributions to the advancement of science, both in New Zealand, and on an international stage over the last fifty years. However, despite this, freshwater biodiversity and water quality continue to decline in many New Zealand rivers and lakes. It seems that in some cases there is a fatal disconnect between the scientific facts and how those facts are used for New Zealand. Despite the NPS-FM having the explicit intention of safeguarding life supporting capacity of aquatic environments nutrient limits for lakes were included in the policy but not for rivers. Irrespective of the science – that elevated nutrients degrade water quality and life supporting capacity, the stated values of the New Zealand government and those espoused by the public there remain barriers to integrating scientific knowledge successfully into policy to achieve good environmental outcomes. The challenge for NZFSS as a society, moving into the next fifty years, is to ensure that rigorous freshwater science plays a critical and effective role in making New Zealand the place we want. To that end, we compiled readily available data and used a weight-of-evidence approach to objectively determine thresholds for nutrient attributes in rivers. In the case of nutrients it clearly seems lack of science is not the reason riverine nutrient thresholds are absent from the NPSFM. If we truly want to manage ecosystem health, we must surely consider the most important determinants of its condition so that informed, objective decisions can be made on the implications of particular actions.

KEYNOTE SPEAKERS

Dr Jonathan Tonkin

Talk time: Tuesday 11 December 9:35am
Topic: Equipping river ecosystem management for a highly uncertain future
Chair: Marc Schallenberg

Jonathan is a Postdoctoral Fellow and soon-to-be Rutherford Discovery Fellow at the University of Canterbury, having just returned to New Zealand after six years abroad. Following his PhD at Massey University, Jonathan conducted research as a Lecturer at Xi'an Jiaotong-Liverpool University in China, and as a Postdoctoral Researcher at Senckenberg Research Institute and Natural History Museum, Germany, and Oregon State University, USA. He has published 50 peer-reviewed papers and is on the editorial boards of Freshwater Biology and PeerJ. Jonathan's research couples basic ecological theory with quantitative modelling to address major global issues in freshwater ecology and management, including metacommunity dynamics in dendritic networks, flow management under hydroclimatic non-stationarity, river restoration, ecological interaction networks in dynamic systems, and developing community-wide mechanistic models. These scientific interests combine with a love of rivers that see him in backcountry whenever he gets the chance.

Abstract

Human exploitation of rivers has imparted a severe ecological cost, threatening many essential services that river ecosystems provide to humanity. Principles of ecosystem management are widely employed to actively restore and sustain river function and services. But it is increasingly recognised that contemporary patterns of hydrologic variability are shifting beyond their historical ranges, thereby violating assumptions of water resources management and directly challenging many prevailing principles of river ecosystem management. New approaches to sustainable river management in a nonstationary world are urgently needed. I argue that the reliance of management on historical benchmarks and the current practice of extrapolating future river ecosystem states from contemporary trends is destined to fail. Process-based models that explicitly link critical biological processes with hydrologic dynamism provide an alternative solution that are robust to highly uncertain futures. To demonstrate the utility of these approaches for river ecosystem management, I will use several case studies focused on the management of river flow regimes for populations, communities, ecosystems and ecological networks of invertebrates, fish and riparian plants. In particular, I will share recent work using process-based approaches that demonstrate the ecosystem-wide trade-offs associated with designing river flow regimes for particular ecological targets.

KEYNOTE SPEAKERS

Professor Emily Bernhardt

Talk time: Wednesday 12 December 8:55am
Topic: Surfing the Data Wave at the Frontiers of Freshwater Science
Chair: Angus McIntosh

Dr Emily Bernhardt is a Professor of Biology at Duke University, North Carolina, USA. Emily's research focusses on the effects of global environmental change on the biogeochemistry of rivers, wetlands and watersheds. She grew up in a small town in western North Carolina, gaining a love of nature from frequent hikes in the Appalachian Mountains. During her undergraduate and graduate years, she spent time at the University of Michigan, and in Venezuela and Chile before obtaining her PhD from Cornell University in 2001. Her dissertation research at Hubbard Brook Ecosystem Study explored the impacts of forest age, ice storms and carbon supply on stream nitrogen cycling. Following postdoctoral placements, at Duke and University of Maryland, she joined the faculty at Duke University where she has established a dynamic research lab, which has supported dozens of scientists to grow their potential and to love ecological science. Emily was the President for the Society for Freshwater Science from 2016-2017, serves as an associate editor on three journals, and is the recipient of numerous awards and honours including being named a Fellow of the Ecological Society of America earlier this year. Emily has two daughters and a K9 who keep her heading up those mountains.

Abstract

We are living in a very exciting time in freshwater science, in which the advent of new technologies and high computing capacity is changing the temporal and spatial scales at which we study our ecosystems. One part of this wave is due to the reduced cost and reliability of aquatic sensors and corresponding advances in the modelling frameworks for estimating river metabolism and river loads. Until very recently we had only a few published records of continuous productivity and respiration from stream ecosystems. By the end of 2018, the StreamPULSE project will be hosting continuous annual metabolism records for more than 500 rivers. We expect that number to double by 2020. Over the same period, new remote sensing technologies and strategies are providing high-resolution data on river colour from satellite imagery, and converting that to turbidity, chlorophyll a and dissolved organic matter concentrations and loads. This data revolution is allowing us to ask new sorts of questions about rivers and to reexamine many of our ideas about rivers that have largely been based at the reach scale. Answering these new frontier questions effectively will also require a new scientific culture that facilitates the rapid exchange of BigData through Open Science platforms. I will talk about several of the frontier questions I believe Freshwater Scientists are best poised to attack in the next decade and discuss the opportunities for our discipline to use this opportunity to simultaneously become more collaborative, less hierarchical and more diverse.

KEYNOTE SPEAKERS

Professor Yvonne Vadeboncoeur

Talk time: Wednesday 12 December 9:35am
Topic: Clearing a way back: illuminating the littoral in lakes and limnology
Chair: Angus McIntosh

Dr Yvonne Vadeboncoeur is a Professor of Biological Sciences at Wright State University, Ohio, USA. Yvonne's research focuses on the importance of energy linkages among habitats in freshwater ecosystems. She is especially interested in the function of benthic, or bottom, habitats in both lakes and rivers. She has shown that attached algae are critical, but often cryptic, resource in aquatic food webs. Yvonne's passion for exploring aquatic habitats (especially while SCUBA diving) has taken her to Canada, Denmark, Greenland and East Africa. Yvonne looks forward to seeing more of New Zealand during her 2019 sabbatical as a Fulbright Scholar at Cawthron Institute.

Abstract

Aquatic ecosystems worldwide experience widespread degradation owing to multiple, diffuse, anthropogenic stresses. In lakes, a persistent focus on planktonic algal biomass (water column chlorophyll) and nutrient concentration have left scientists, and the public, unaware of other forms of degradation. Human activity is concentrated at lake edges, but there is no corresponding scientific emphasis on the structurally and biologically complex littoral habitats. Using data from lakes around the world, I illustrate that littoral zones are hotspots of biodiversity and an integral component of lake food webs. Attached algae are a cryptic, high-quality resource that forms the base of strongly inverted pyramids of trophic level biomass. Littoral and open water fish populations are energetically dependent on attached algae. Complex feedbacks between grazers and attached algae promote low-nutrient, high productivity clear-water ecosystems that provide high value to human society. Humans are eroding these consumer-resource feedbacks, and we must overcome a severe knowledge gap to restore littoral zone function in lakes.

KEYNOTE SPEAKERS

Neil Deans

Talk time: Thursday 13 December 8:55am
Topic: NZFSS 50 years young
Chair: Roger Young

Neil Deans is a Principal Advisor at the Department of Conservation—Te Papa Atawhai. He has been involved in freshwater science and management throughout New Zealand for over 30 years. Neil has been a member of the Freshwater Sciences Society for most of that time and was President in the early 2000s. He has worked for and with many groups with interests in freshwater, including the former Wildlife Service, Fish and Game, the Land and Water Forum, the Minister for the Environment's office and has just rejoined the Department of Conservation. Much of his career has been at the interface between science, environment and policy and between the practical and the theoretical. Neil brings a wealth of experience to share, from field work to writing peer-reviewed publications, expert witness to wildlife ranger, advising Ministers to working with tangata whenua for improved water management.

Abstract

The Society for our country's freshwater scientists is celebrating 50 years. This presentation reflects on the Society, what and who preceded it and its context and contribution to science and to and from the wider society. Given freshwater issues have never been at a higher level in public discourse, it is timely to consider what it is about our past that can help inform the future of the science and its contribution to policy and the community. This personal view is based partly on interviews undertaken with senior Society members for the Society's 40th anniversary and more recent narratives. Times have changed, but the need for rigour and vigour in, and good communication of, our science is undiminished if it is to make a sound contribution to policy and to wider society.

KEYNOTE SPEAKERS

Hon David Parker

Talk time: Thursday 13 December 9:35am
Topic: Making polluted rivers clean again
Chair: Roger Young

David Parker is a Member of Parliament appointed as Attorney-General, Minister for Economic Development, Environment, and Trade and Export Growth, and Associate Minister of Finance. Born in Roxburgh, David grew up in Dunedin and has a BCom and LLB from the University of Otago. He was a litigation and managing partner in law firm Anderson Lloyd and was a co-founder of the Dunedin Community Law Centre. David is an experienced CEO and company director in a range of industries and has experienced both success and failure. He held various portfolios in the last Labour-led Government and in opposition. In 2008 he was named by the Listener magazine as Environmentalist of the Year for his work as Minister of Energy and Climate. He pioneered New Zealand's emission trading scheme, then described by many as the most significant environmental reform for decades. He maintains strong interests in the protection of civil liberties, as well as economic and environmental policy. David pursues policies which both enhance economic growth and address the growing extremes between rich and poor in New Zealand, while protecting the environment. Passionate about the outdoors, David is a keen tramper and skier.

Abstract

As Minister for the Environment, Hon David Parker will be speaking about the Government's commitment to deliver a noticeable improvement in freshwater quality in five years.
Following last year's election, the Minister says the Government has a mandate and duty to improve the quality of our waterways and he welcomes the contribution of anyone who is willing to share that duty.
As a long-time advocate for our waterways, the Minister will speak about his experience and his personal commitment to turning around water quality in New Zealand. He will talk about where he sees positive signs of progress and where challenging issues remain to be resolved. He will discuss the Essential Freshwater work programme and its focus on ecosystem health. To support this programme, the Government is engaging with an advisory network including a science and technical advisory group, and the Minister will provide an update on progress.

Special Session: SETAC-Sponsored session on ANZECC water quality guidelines

Monday 10 December 2018
2:00 - 5:15pm
Room : Matai 2
Chair : Jenni Gadd

This special session is sponsored by the Society of Environmental Toxicology and Chemistry Australasia (SETAC-Au) and will focus on the updated ANZECC guidelines which are due for release in 2018. The ANZECC water quality guidelines cover freshwater, estuarine and marine water and sediment quality, for physical and chemical stressors (e.g., clarity, conductivity), sedimentation and toxicants. The session will cover the process of developing the guidelines, the guideline website, and key guidelines that are expected to be of most interest to the NZFSS community. A keynote presentation in this session will be delivered by Rick van Dam who is the Director of the Environmental Research Institute of the Supervising Scientist (ERISS), Australia.

Special Session: RSNZ-Sponsored session on Mātauranga Māori shaping freshwater futures

Monday 10 December 2018
2:00 - 5:15pm
Room : Maitai 1
Chair : Joanne Clapcott

Māori have distinct cultural knowledge, values, and perspectives that establish their identity, responsibilities, and rights to manage and use aquatic resources. There is an enormous potential for the use of mātauranga Māori to enhance our understanding of aquatic ecosystems, underpin culturally appropriate restoration approaches, and provide a more holistic and integrated perspective for research, monitoring, planning, and policy and resource development. The Royal Society of New Zealand are pleased to sponsor this session which shares the stories brought together in a special issue of the New Zealand Journal of Marine and Freshwater Research focused on mātauranga Māori and how it is informing current and future research and decision-making in aquatic environments of Aotearoa.

Special Session: Resistance, Resilience, and Restoration

Monday 10 December 2018
2:00 - 3:45pm
Room : Waimea
Chair : Elizabeth Graham

Resistance and resilience are terms used to describe the capacity of an ecosystem to withstand and recover from a perturbation. Thus, community resistance and resilience are often desired goals and are commonly associated with healthy communities (positive resistance and resilience). However, degraded ecosystems can also be resistant and resilient to perturbations (negative resistance and resilience) making them resistant to restoration. In this session, we invite approaches and ideas incorporating biotic mechanisms and aspects of resistance and resilience in restoration. One talk slot will be set aside for group discussion at the end of the session.

Special Session: Lake snow: past and future perspectives on an emerging nuisance slime

Monday 10 December 2018
2:00 - 3:45pm
Room : Wairau
Chair : Marc Shallenberg

Lake snow in New Zealand is a globally unprecedented phenomenon. Although lake snow has been occasionally reported overseas, it has not previously been attributable to a single species, nor occupied numerous lakes over a wide area. From apparent isolation in Lake Wanaka in the mid-2000s, the causative organism Lindavia intermedia has spread far and wide through clean lakes (and some not-so-clean) in the South and North Islands of New Zealand, with lake snow appearing in many. We will describe how the causative species was identified; reconstructions of its colonisation of New Zealand lakes from sediment cores, molecular genetics, and historical samples; the response from authorities; new ways of analysing the polysaccharides that make up the slime; and "where to from here".

Special Session: Swimmability

Tuesday 11 December 2018
1:30 - 3:15pm
Room : Maitai 1
Chairs : Elaine Moriarty, Juliet Milne

In 1998-2000 a freshwater microbial survey was carried out at river and lake sites across New Zealand that formed the basis of a quantitative microbial risk assessment (QMRA) to determine the relationship between microbial indicators and pathogens. The research findings underpinned the current freshwater component of the national recreational water quality guidelines and also informed the development of the E. coli human health for recreation attribute in the National Policy Statement for Freshwater Management 2014. Nearly 20 years on, our land use and land management practices have changed as may potentially the carriage of pathogens. We also have more knowledge about faecal sources, greater awareness of naturalised sources of faecal indicator bacteria, and improved laboratory methods for detection and characterisation of pathogens. In this special session, we outline a proposed updated microbial survey and revised QMRA to underpin a review of our 2003 national recreational water quality guidelines. We will also hear from researchers and practitioners investigating different freshwater microbial contamination issues.

Panel Discussion: Art for freshwater's sake

Tuesday 11 December 2018
1:30 - 3:15pm
Room : Maitai 2
Chairs : Charlotte Šunde. Bruce Foster

If our waterways are akin to the nation's lifeblood, then art signifies the pulse of our national heartbeat. Artists play a critical role as change-makers who, in bringing attention to the demise of waterways, spark opportunities for political discourse and collective action. The conference theme is timely and reflexive: what does the condition of our rivers and lakes say about us? The true value of art for New Zealand's freshwater sciences goes well beyond entertainment or public outreach. 'Art for freshwater's sake' involves the art of questioning that prompts, provokes and pushes us to think, feel and behave as if our future depends on it. Invited artists who will share their work include Bruce Foster, Gregory O'Brien, Jenna Packer, Vicki Smith and Nic Moon.

Panel Discussion: OLW-Sponsored session on Freshwater Collaboration Inside and Out

Tuesday 11 December 2018
1:30 - 3:15pm
Room : Waimea
Chair : Jim Sinner

Collaborative planning approaches have been utilised by several regional councils to implement the National Policy Statement for Freshwater Management. The nature of representation and participation in these processes has varied, with stakeholders on the 'inside' of some and 'outside' of others. This session will examine how various groups and interests have been represented in collaborative planning processes and how this affected the outcomes in terms of ecosystem health and community support for the resulting freshwater plan. What are the broader implications for the future of freshwater planning? Our panellists have been on the inside or outside of collaborative freshwater planning processes. Each will comment on the main topics, with plenty of time for questions and general discussion.

Workshop: Freshwater management in urban catchments

Tuesday 11 December 2018
1:30 - 3:15pm
Room : Wairau
Chair : Jonathan Moores

While NPS-FM implementation to date has tended to focus on rural catchments, a number of regions are now involved in urban implementation projects as well as associated plan reviews and managing the next generation of stormwater and/or wastewater discharge consents. Urban catchments bring a specific range of challenges, from flashy hydrology to metal toxicants, wastewater overflows and concreted channels. The purpose of this workshop is to provide for a discussion of approaches to NPS-FM implementation and freshwater planning and consenting in urban catchments. It will involve learning from the experience of practitioners working on a range of urban freshwater management projects to explore successes, challenges, information needs, knowledge gaps and opportunities for cross-sectoral collaboration.

Special Session: Characterising lake communities: challenges and solutions

Wednesday 12 December 2018
1:30 - 5:00pm
Room : Maitai 1
Chair : Susie Wood

Lakes make up 1% of the world surface area, yet are estimated to contain 10% of its biodiversity. In New Zealand knowledge on contemporary and historic lake biodiversity is limited, and data on species interactions and food-webs is constrained to a few systems. This session will explore new methods for characterising lake communities (the future), and highlight how these techniques can be used to reconstruct past communities (learning from the past to enhance our lakes future). It will bring together emerging and established researchers, and scientists and stakeholders. It will embrace a diverse range of topics from microscopic organisms (picocyanobacteria/diatoms), to entire trophic interactions (food-webs) and will include studies that have focused on single lakes and those which are applying new techniques at regional or national scales.

Special Session: Citizen science and water monitoring in NZ: where it's come from, where it's going

Wednesday 12 December 2018
1:30 - 5:00pm
Room : Maitai 2
Chair : Richard Storey

Resources and programmes for volunteer water monitoring in NZ have been around since the late 1990s. But in the last few years, public interest in water monitoring has increased rapidly at the same time that new technologies have made it easier for volunteers to collect and share their data. We will profile recent and future developments in resourcing and co-ordinating citizen science water monitoring across NZ, hear about new applications, discuss how we are addressing current challenges, hear different perspectives on the values of volunteer monitoring and explore opportunities to expand monitoring from rivers to lakes and estuaries.

Special Session: Joining up land use and freshwater – tools for scientists and managers from the Our Land and Water National Science Challenge

Wednesday 12 December 2018
1:30 - 5:00pm
Room : Waimea
Chair : Scott Larned

Land and water management in New Zealand must meet multiple objectives: preventing ecological degradation, protecting cultural and social values, and ensuring a viable primary sector. Achieving these objectives requires a transformation in our perspective of land-water systems, a diverse set of tools for managers, and innovative science to underpin those tools. The overarching aims of the Our Land and Water Challenge are to deliver the perspective, tools and science. In this session, we report on research in all three areas: new perspectives that link land use to freshwater, tools for data analysis and mapping, and integrated land-water science.

Special Session: Native Freshwater Mussels as Freshwater Sentinels

Wednesday 13 December 2018
3:15 - 5:00pm
Room : Wairau
Chair : Sue Clearwater

Individual freshwater mussels can live more than 50 years making them probably the oldest invertebrate inhabitants of our waterways. Successful completion of their life cycle depends on the presence of fish hosts for their parasitic larvae, and excellent water and sediment quality for their juveniles. Mussel presence/absence, and population health can therefore reveal much about past and present river or lake health and connectivity. Freshwater mussels' status as culturally important taonga species and their influence on biodiversity means they can be characterised as Cultural Keystone Species. Considering the whakataukī "Kia whakatōmuri te haere whakamua" (My past is my present is my future, I walk backwards into the future with my eyes fixed on my past) we will examine how understanding the past impact of human activities on our waterways through freshwater mussels can improve future freshwater management.

Workshop: NZ Fish Passage Guidelines and Fish Passage Assessment Tool

Thursday 13 December 2018
1:30 - 3:15pm
Room : Maitai 1
Chair : Eleanor Gee

This workshop will introduce participants to the 1) NZ Fish Passage Guidelines and the new 2) NZ Fish Passage Assessment Tool. The NZ Fish Passage Guidelines were launched in April 2018 and set out recommended practice for the design of culverts, fords, weirs, flood and tide gates to provide for fish passage. We expect the guidelines to set the foundation for the improvement of fish passage management in New Zealand and we consider it crucial that as many NZFSS members as possible are familiar with New Zealand's first fish passage guidelines. The NZ Fish Passage Assessment tool implements a new standardised protocol for identifying instream structures and assessing the likely impact on fish movements in the form of a freely available mobile app. The app can be used to collect information including the location of the structure, photos of the structure, and information about the type of structure and its characteristics. That information is automatically uploaded to a national database and can be viewed and downloaded from the Fish Passage Assessment Tool website.

Special Session: Freshwater Policy Update from Ministry for the Environment

Thursday 13 December 2018
1:30 - 3:15pm
Room : Maitai 2
Chair : Alison Collins

As 2019 approaches, the state of our freshwater continues to be a key priority for science and policy across New Zealand. The Ministry for the Environment works with other government departments and stakeholders on the policy response for tackling the many interrelated problems that put pressure on our waterways. This Special Session will cover the key aspects of the current policy response, highlighting the Ministry's recent thinking and work programme. There will also be time for reflections on the future direction of freshwater policy, specifically focussing on the interaction of policy with science. The format will be five short, connected presentations with time for Q&A at the end.

Workshop: Multi-Criteria Decision Analysis

Thursday 13 December 2018
1:30 - 3:15pm
Room : Waimea
Chair : Simone Langhans

In this workshop, we introduce a well-known participatory decision support framework based on multi-criteria decision analysis (MCDA) that can be used to support community-inclusive decision-making in freshwater management. The NPS-FM mandates Regional Councils to account for community values in managing freshwaters. However, it gives no guidance on how this complex process should be undertaken. While some councils have already undergone consultation processes, others are currently considering options. Freshwater collaborative processes require the input of scientists, managers, iwi, locals and industry stakeholders. Many of the NZFSS members will have been involved in such processes and it will be interesting to critically compare the MCDA process with other approaches. Furthermore, many NZFSS members are likely to be involved in such processes in the future and this workshop will give them a deeper understanding of how MCDA operates including its strengths and weaknesses.

SPECIAL SESSIONS / WORKSHOPS / PANEL SESSIONS

Special Session: Constructed wetlands for treatment of diffuse pollution from intensive agricultural landscapes in New Zealand: What have we learnt and where are we going?

Thursday 13 December 2018
1:30 - 3:15pm
Room : Wairau
Chair : Rebecca Eivers

Constructed treatment wetlands (CTWs) are being used increasingly throughout New Zealand as mitigation tools to improve the water quality of streams, lakes and rivers within intensive agricultural catchments. Early CTWs primarily targeted nitrate and were created to treat effluent from tile drains, implementing subsurface filtration wetland design principles. Other CTWs were focused on capturing sediment and associated phosphorus, loosely following free surface flow wetland design concepts. Research and monitoring of the efficacy of agricultural CTWs in New Zealand has revealed both positive and negative outcomes. To instil confidence in CTWs as valuable mitigation tools, and facilitate continued implementation throughout the agricultural sector, it is imperative we look back at what we have learnt. As water quality scientists providing technical CTW advice, our collective inertia moving forward is best fuelled by our shared knowledge and experiences.

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PROGRAMME

NZFSS Conference Abstract Programme - 10-14th December 2018 - Nelson

All Concurrent Sessions are based on 15-minute talks (talk 12 min, 3 min Q&A)

* = eligible for Student Prizes

MONDAY 10 DECEMBER					
8.30am		**Registration Desk Open**			
10.00 - 10.15am		**Bus departs Rutherford Hotel for Whakatū marae**			
10.30 - 11.00am	**POWHIRI**	Pōwhiri and Conference Welcome at Whakatū Marae 99 Atawhai Dr, Nelson			
11.00 - 11.25am		**MORNING TEA**			
11.25 - 12.50pm	**KEYNOTE 1/2**	Official opening and housekeeping (10 mins) **Keynote Speaker 1: Barney Thomas** Kaitiaki roles and responsibilities **Keynote Speaker 2: Tina Porou** Te Mana o te Wai and the experiences of implementing the kaupapa through current planning tools **Session Chair: Aneika Young**			
12.50pm		**Bus returns to Rutherford Hotel**			
1.00 – 2.00pm		**LUNCH**			
	CONCURRENT SESSION 1	**Special session: Mātauranga Māori shaping freshwater futures** **Room: Maitai 2** **Chair: Joanne Clapcott**	**Special session: SETAC ANZECC** **Room: Maitai 1** **Chair: Jennifer Gadd**	**Special session: Resistance, resilience, restoration** **Room: Waimea** **Chair: Elizabeth Graham**	**Special session: Lake snow** **Room: Wairau** **Chair: Marc Schallenberg**
2.00 - 2.15pm		Mātauranga Māori shaping marine and freshwater futures. ***Joanne Clapcott***, *Cawthron Institute*	Key features of the revised Australian and New Zealand Guidelines for Fresh and Marine Water Quality. ***Rick van Dam***, *Environmental Research Institute of The Supervising Scientist*	Delayed biological recovery after restoration – negative resistance & resilience. ***Kristy Hogsden & Helen Warburton*** *University of Canterbury*	"Lake snow": mucilaginous planktonic macroaggregates and their effects on lake ecology. ***Marc Schallenberg***, *University of Otago*
2.15 - 2.30pm		*Whakamanahia te mātauranga o te Māori: empowering Māori knowledge to support Aotearoa's aquatic biological heritage.* ***Gary Garner***, *Te Tira Whakamātaki*		Does the past matter? The influence of disturbance history on community resistance to future disturbance. ***Roland Eveleens***, *University of Canterbury*	The value of archived diatom collections: understanding the spread of Lindavia intermedia in New Zealand. ***Cathy Kilroy***, *NIWA*
2.30 - 2.45pm		Māori oral tradition and indigenous freshwater knowledge: What do whakataukī tell us? ***Hēmi Whaanga***, *University of Waikato*	Developing guidance for including Indigenous cultural and spiritual values in water quality management in Australia and New Zealand. ***Brad Moggridge***, *University of Canberra*	Boosting biological recovery in degraded streams: disturbing degraded communities to reverse the effects of environmental filtering. ***Issie Barrett***, *University of Canterbury **	Local Authorities response to Lindavia incursion in New Zealand. ***Stephanie Dwyer***, *Lincoln University*
2.45 - 3.00pm		Evaluating a traditional Maori harvesting method for sampling stream populations of koura and toi toi. ***Ian Kusabs***, *Ian Kusabs and Associates Ltd*	Estimation and application of nationwide reference conditions of water quality indicators. ***Doug Booker***, *NIWA*	Helping plants find their feet – restoring macrophytes in lakes. ***Deborah Hofstra***, *NIWA*	Taxonomy, provenance, abundance, and activity of Lindavia intermedia as revealed by molecular (and other) methods. ***Phil Novis***, *Manaaki Whenua-Landcare Research*
3.00 - 3.15pm		Murihiku Cultural Water Classification System: Enduring partnerships between people, disciplines and knowledge systems. ***Jane Kitson***, *Kitson Consulting Ltd,* ***Ailsa Cain***, *Kauati Ltd*	Challenges in updating copper and zinc water quality guidelines for Australia and New Zealand. ***Jennifer Gadd***, *NIWA*	Stream community recovery trajectories following progressive forest harvesting vary by disturbance frequency and magnitude. ***Elizabeth Graham***, *NIWA*	Vibrational Spectroscopic and Multivariate Analysis of New Zealand 'Lake Snow'. ***Ruth Sales***, *University of Otago*

		Special session: Mātauranga Māori shaping freshwater futures **Room: Maitai 2** **Chair: Joanne Clapcott**	**Special session: SETAC ANZECC** **Room: Maitai 1** **Chair: Jennifer Gadd**	**Special session: Resistance, resilience, restoration** **Room: Waimea** **Chair: Elizabeth Graham**	**Special session: Lake snow** **Room: Wairau** **Chair: Marc Schallenberg**
3.15 - 3.30pm		He Tohu o te wā – Hangarau pūtaiao. ***Yvonne Taura,*** *Manaaki Whenua*	Considerations for water quality guidelines for emerging contaminants. ***Louis Tremblay,*** *Cawthron Institute*	Is resistance futile? Managing and restoring ecological systems for multiple benefits. ***Ross Thompson,*** *University of Canberra*	Determining the Polysaccharide Composition of the New Zealand Freshwater Biofouler Lake Snow. ***Cara Luiten,*** *Victoria University of Wellington **
3.30 - 3.45pm		Bicultural lake models to support tāngata whenua in freshwater management. ***Mereana Wilson-Rooy,*** *QEII Trust **	The challenge of deriving default ecosystem protection guideline values for PFOS in freshwater. ***Rick van Dam,*** *Environmental Research Institute of The Supervising Scientist*		Discussion
3.45 - 4.15pm		**AFTERNOON TEA**			
	CONCURRENT SESSION 2	**Session: Mātauranga Māori shaping freshwater futures** **Room: Maitai 1** **Chair: Jane Kitson**	**Special session: SETAC ANZECC continued** **Room: Maitai 1** **Chair: Jennifer Gadd**	**Session: Restoration methods** **Room: Waimea** **Chair: Deborah Hofstra**	**Session: Natural history of freshwater biota** **Room: Wairau** **Chair: Brian Sorrell**
4.15 - 4.30pm		Collaborating with mana whenua. ***Kathryn Gale,*** *Aukaha*	New guidelines and existing freshwater policy: using the best tool for the job. ***Jennifer Price,*** *Ministry for the Environment*	Sediment traps as mechanisms for reducing E. coli concentrations in dairy farm streams. ***Megan Devane,*** *ESR*	Elucidating climate change effects on longfin and shortfin eels using multi-decadal (1960-2012) otolith growth reconstructions. ***Eimer Egan,*** *NIWA*
4.30 - 4.45pm		Tieki wai in the Waiapu. ***Pia Pohatu,*** *Hīkurangi Takiwā Trust* **Joanne Clapcott,** *Cawthron Institute*	Issues with using water quality guidelines in management: developing decision-support frameworks. ***Chris Hickey,*** *NIWA*	Trialling stream rehabilitation tools to attenuate high nitrate loads in agricultural headwaters. ***Brandon Goeller,*** *NIWA **	Bergmann's rule and whitebait: differences in size, age and growth of whitebait across New Zealand. ***Mike Hickford,*** *University of Canterbury*
4.45 - 5.00pm		Me pēhea te whakarauora i ngā repo o Maniapoto - how do we go about restoring the wetlands of Maniapoto? ***Kelly Ratana,*** *NIWA* **Ngahuia Herangi** *Maniapoto Māori Trust Board*	EPA use of Australian and New Zealand guidelines for fresh and marine water quality. ***Richard Mohan,*** *EPA*	Stream shade effects on instream plants and comparison of shade measurement methods ***Fleur Matheson,*** *NIWA*	Ninjas in NZ: Red-eared slider turtles are breeding in New Zealand. ***Nicholas Ling,*** *Waikato University*
5.00 - 5.15pm		Discussion	Ngā Pou Mataara: A Māori framework to monitor mauri in the Tukituki Awa. ***Kate McArthur,*** *Catalyst Group*	Stream shade restoration: are canopy shape or channel orientation important? ***Kit Rutherford,*** *NIWA*	Environmental factors affecting the Irrawaddy dolphin (Orcaella brevirostris) distribution in the Mahakam River, East Kalimantan. ***Februanty Suyatiningsi**h,* *University of Waikato **
CLOSE OF DAY ONE					
5.15 - 5.45pm		**Tribute to John Quinn (Maitai 1)**			
6.00 - 7.30pm		**WELCOME FUNCTION // Trafalgar Street Party**			

TUESDAY 11 DECEMBER					
7.30am		**Registration Desk Open**			
8.45 - 10.15am	**PLENARY 3/4**	Housekeeping: (10 mins) Plenary Speaker 3: Russell Death Talk Title: Is Good Science Good Enough? Plenary Speaker 4: Jonathan Tonkin Talk Title: Equipping river ecosystem management for a highly uncertain future Session Chair: Marc Schallenberg			
10.15 - 10.45am		**MORNING TEA**			
	CONCURRENT SESSION 3	**Session: Population ecology and climate** **Room: Maitai 1** **Chair: Travis Ingram**	**Session: Community ecology** **Room: Maitai 2** **Chair: Robin Holmes**	**Session: Freshwater science, management and policy** **Room: Waimea** **Chair: Trevor James**	**Session: Nutrient modelling** **Room: Wairau** **Chair: Hans Eikaas**
10.45 - 11.00am		Rapid genetic adaptation offsets plastic increases in body growth rate under warming. ***David Fryxell,*** *University of Auckland*	Spatial abundance and diversity of picocyanobacteria in two lakes with contrasting geomorphology and trophic status. ***Lena Schallenberg,*** *University of Otago **	Land, Air, Water Aotearoa (LAWA) – Behind the Scenes. ***Kati Doehring,*** *Cawthron Institute* **Abi Loughnan** *LAWA Environmental Monitoring and Reporting Project*	Development of the LUCI model for supporting nature-based water resources management in the Vietnam Mekong Delta ***Anh Nguyet Dang,*** *Victoria University of Wellington **
11.00 - 11.15am		Altering the flow and thermal regimes of river basins changes the growth dynamics of long-lived fishes. ***Rick Stoffels,*** *NIWA*	Effects of intraguild predation on individual specialisation in the Common Bully. ***Marine Richarson,*** *University of Otago **	Combating in-stream ecological health – from bad to good by picking the low hanging fruit. ***Duncan Law,*** *Tonkin + Taylor Ltd*	Advective transport modelling of Orari Plains water quality. ***Patrick Durney,*** *Dhi Water and Environment Ltd*
11.15 - 11.30am		Thermal adaptation alters the ecological role of consumers. ***Emma Moffett,*** *University of Auckland **	Are rare macroinvertebrate assemblages driven by distinct environmental factors? ***Dimitrios Rados,*** *Massey University **	Ecological health monitoring of large river systems: Establishing a Waikato region network. ***Alicia Catlin,*** *Waikato Regional Council*	Dynamic catchment modelling of a New Zealand dairy farming catchment. ***Linh Hoang,*** *NIWA*
11.30 - 11.45am		Can we find a climate-change fingerprint? Detecting recent range shifts among Japan's freshwater-associated species. ***Kylie Park,***	Invertebrates associated with macrophytes bought from aquarium stores in Canada and New Zealand. **Ian Duggan**, *Waikato University*	Freshwater trends for the Asia-Pacific Region and the importance of training early-career scholars in science-policy ***Catherine Febria,*** *University of Canterbury*	Dairy Typologies: A means to Quantifying the N and P Footprint across Spatial Scales. From Farm to Nation. ***Hans Eikaas,*** *DairyNZ*
11.45 - 12.00pm		Trophic interactions of kōwaro (Canterbury mudfish) across a gradient of drying intensity ***Christopher Meijer,*** *University of Canterbury **	**SESSION THEME CHANGE: Environmental flows** Advancing the assessment of environmental flows for estuaries. ***Eleanor Gee,*** *NIWA*	Eight research areas that could foster ecosystem-based management in fresh waters, if combined. ***Simone Langhans,*** *University of Otago*	A Catchment Accounting Framework for tracing contaminants and calculating loads throughout New Zealand's surface waters. ***Christophe Thiange,*** *DairyNZ*
12.00 - 12.15pm		Carryover effects of larval environment on individual niche variation of adult common bullies. ***Travis Ingram,*** *University of Otago*	A new substrate mapping approach for high resolution habitat suitability assessments when designing environmental flows. ***Jo Hoyle,*** *NIWA*	Can the Integration and Implementation Science framework support better research for land and water policy? ***Melissa Robson-Williams,*** *Manaaki Whenua Landcare*	Can I Trust that Model? eSource Catchment Model Validation, a learning process. ***Rochelle Carter,*** *Bay of Plenty Regional Council*
12.15 - 12.30pm		A toxic puzzle – unravelling the relationship between anatoxin production & strain dominance in Microcoleus autumnalis (Phormidium autumnale). ***Laura Kelly,*** *Victoria University of Wellington **	Drift transport capacity: what do we know and what does it mean for flow management? ***Karen Shearer,*** *Cawthron Institute* ***John Hayes,*** *Cawthron Institute*		On the need for more rigorous adoption of best practices in environmental modelling. ***Deniz Özkundakci,*** *Waikato Regional Council*

12.30 - 1.30pm		**LUNCH**			
	CONCURRENT SESSION 4	**Special session: Swimmability** **Room: Maitai 1** **Chair: Elaine Moriarty**	**Panel Discussion: Art for freshwater's sake** **Room: Maitai 2** **Chair: Bruce Foster and Charlotte Sunde**	**Panel Discussion: Freshwater collaboration** **Room: Waimea** **Chair: Jim Sinner**	**Workshop: Freshwater management in urban catchments** **Room: Wairau** **Chair: Jonathan Moores**
1.30 - 1.45pm		Revisiting New Zealand's recreational water quality guidelines: the freshwater microbiological sciences review project. ***Elaine Moriarty,*** *ESR*			
1.45 - 2.00pm		Public Health Recreational Freshwater Quality Guidelines: What's the story overseas? ***Beverly Horn,*** *ESR*			
2.00 - 2.15pm		Recreational water quality investigation: sources of faecal contaminants. ***Eloise Ryan,*** *Waikato Regional Council*			
2.15 - 2.30pm		Casting a net over the river: Bayesian networks as a real-time prediction tool for swimability. ***Sarah Pirikahu,*** *ESR*			
2.30 - 2.45pm		Near real-time monitoring of microbial water quality in contrasting New Zealand rivers using ColiMinder. ***Rebecca Stott,*** *NIWA*			
2.45 - 3.00pm		Suitability of Brazilian freshwaters for contact recreation. Assessment by a water quality index. *Universidade Federal de Minas Gerais Brazil*			
3.00 - 3.15pm		Discussion			
3.15 - 3.45pm		**AFTERNOON TEA**			
3.45 - 5.15pm	**POSTERS**	**POSTER SESSION (Matai 1 and Maitai 2)** Kindly Sponsored by DOC Arawai Kākāriki Wetland Restoration Programme			
		CLOSE OF DAY TWO			
5.30 - 7.00pm		**EARLY CAREER MIXER // Deville's Café, New Street, Nelson** **SWIM MEETING // Waimea Room**			

WEDNESDAY 12 DECEMBER					
7.30am		**Registration Desk Open**			
8.45 - 10.15am	**PLENARY 5/6**	Housekeeping (10 mins) **Plenary Speaker 5: Emily Bernhardt** Surfing the Data Wave at the Frontiers of Freshwater Science **Plenary Speaker 6: Yvonne Vadeboncouer** Clearing a way back: illuminating the littoral in lakes and limnology **Chair: Angus McIntosh**			
10.15 - 10.45am		**MORNING TEA**			
	CONCURRENT SESSION 5	**Session: Aquatic plants and water quality** **Room: Maitai 1** **Chair: Fleur Matheson**	**Session: Community ecology and biological interactions** **Room: Maitai 2** **Chair: Catherine Febria**	**Session: Environmental indicators** **Room: Waimea** **Chair: Richard McDowell**	**Session: Waterscapes** **Room: Wairau** **Chair: Sarah Pirikahu**
10.45 - 11.00am		Nutrient attenuation in gravel bed rivers: ecosystem service or eutrophication symptom? Ngā tohu o te Tukituki. ***Kit Rutherford on behalf of John Quinn,*** *NIWA*	Intriguing trophic structures associated with mudfish pools in South-Westland: not extreme, just size-structured. ***Angus McIntosh,*** *University of Canterbury*	The influence of macroscale and microscale habitat factors on invertebrate communities: implications for SoE monitoring. ***Alastair Suren,*** *Bay of Plenty Regional Council*	Tracking groundwater contamination using DNA tracers. ***Liping Pang,*** *ESR*
11.00 - 11.15am		Stimulation of river periphyton growth by ammoniacal-N vs. nitrate-N: is there a difference? ***Logan Brown,*** *Horizons Regional Council*	Modelling network structure and temporal connectivity in freshwater metacommunities. ***Finnbar Lee,*** *University of Auckland **	Improving the cost-effectiveness of macroinvertebrate state of the environment monitoring. ***John Stark,*** *Stark Environmental Limited*	Predicting groundwater contamination using next generation sequencing. ***Judith Webber,*** *ESR*
11.15 - 11.30am		Water we to do - Periphyton and relationships to water quality in the Horizons region. ***Tom Stephens,*** *Auckland Council*	Spatial heterogeneity in flow-disturbance influences abundance and temporal stability in native–invasive species co-occurrence in riverscapes. ***Nixie Boddy,*** *University of Canterbury **	Using stationary and aerial red-green-blue and multispectral camera imagery for stream periphyton monitoring. ***Anika Kuczynski,*** *NIWA*	What do we know about groundwater ecosystem functions, values and threats? ***Michelle Greenwood,*** *NIWA*
11.30 - 11.45am		Improving our understanding of Southern slime. ***Roger Hodson,*** *Environment Southland*	Invasive macrophyte presence and growth form influence plankton communities. ***Heremerose Matutes,*** *Visayas State University-Alangalang*	Using sediment fingerprinting to determine the contribution of bank erosion to stream sediment yields. ***Manawa Huirama,*** *Waikato University **	Water balance and groundwater capture zone assessment of Pukepuke Lagoon. ***Catherine Sturgeon,*** *Jacobs New Zealand Limited*
11.45 - 12.00pm		Water quality and periphyton modelling of point source discharge effects. ***Olivier Ausseil,*** *Aquanet Consulting Ltd*	Consumption of kōura in Lake Rotoiti by brown bullhead catfish: a risk assessment. ***Laura Francis,*** *Waikato University **	Efficacy of a phycocyanin sensor as a surrogate measure of cyanobacterial bloom. ***Ngaire Phillips,*** *Streamlined Environmental Ltd*	Water source and contaminant pathways in the Waiokura catchment, Taranaki, New Zealand. ***Rob van der Raaij,*** *GNS Science*
12.00 - 12.15pm		Eutrophication Risk Assessment: Linking Across Freshwater Environments. ***Sandy Elliot,*** *NIWA*	Macrophytes in an ICOLL: an open and shut case? ***Mary de Winton,*** *NIWA*	Natural Dispersion of Mercury from Puhipuhi, Northland – Revisited. ***Andrew Rumsby,*** *Pattle Delamore Partners Ltd*	Update on the New Zealand water model-hydrology project. ***Christian Zammit,*** *NIWA*

12.15 - 1.30pm		**LUNCH (boxed lunch)** **Rōpū Māori Meeting (Waimea Room)**			
		Special session: Characterising lake communities **Room: Maitai 1** **Chair: Susie Wood**	**Special session: Freshwater citizen science** **Room: Maitai 2** **Chair: Richard Storey**	**Special session: Land use and freshwater** **Room: Waimea** **Chair: Scott Larned**	**Session: Contaminants and nuisance plants** **Room: Wairau** **Chair: Cathry Kilroy**
1.30 - 1.45pm		Understanding toxin production in bloom-forming cyanobacteria from New Zealand lakes. ***Jonathan Puddick,*** *Cawthron Institute*	Resourcing and coordinating freshwater citizen science across New Zealand. ***Richard Storey,*** *NIWA*	Worldviews and dogma: Embracing diversity in the science challenge discourse ***Ken Taylor,*** *Our Land and Water NSC*	Preventing the spread of freshwater pests – what's working and what's not. ***Tracey Burton,*** *NIWA*
1.45 - 2.00pm		Shifts in the bacterial communities associated with the formation and breakdown of a toxic cyanobacterial scum. ***Konstanze Steiner,*** *Cawthron Institute*	Engage, advise, support – helping communities own their research. ***Sheryl Miller,*** *Greater Wellington Regional Council*	Science to policy and back again: compliant land use practices still cause P leaching. ***Richard McDowell,*** *Our Land and Water NSC*	Pesticides in New Zealand's running waters: a survey of agricultural streams. ***Christoph Matthaei,*** *University of Otago*
2.00 - 2.15pm	**CONCURRENT SESSION 6**	Development and implementation of a robust, regionally representative water quality monitoring network for lakes. ***Mark Hamer,*** *Waikato Regional Council*	Citizen Science and Freshwater Monitoring in Aotearoa from an NGO Perspective. ***Liz Gibson,*** *Mountains to Sea Wellington, The Whitebait Connection.* **Kim Jones** *Mountains to Sea Conservation Trust, The Whitebait Connection*	The land use suitability concept: A Southland case study. ***Amy Whitehead,*** *NIWA*	Towards more realistic ecotoxicology: evaluating chronic effects of neonicotinoids using a ubiquitous New Zealand mayfly. ***Sam Macaulay,*** *University of Otago **
2.15 - 2.30pm		Are non-indigenous fishes exploiting empty niches in lacustrine environments? ***Alton Perrie,*** *Greater Wellington Regional Council **	Empowering the community; volunteers monitor hutt River 'swimmability'. ***Juliet Milne,*** *NIWA*	Sediment delivery from erosion source to catchment outlet – where should erosion-management be focussed? ***Arman Haddadchi,*** *NIWA*	Deconstructing individual chemical stressors in two contrasting catchments. ***Michael Stewart,*** *Streamlined Environmental Ltd*
2.30 - 2.45pm		Improving lake marginal habitat for native fish using structure. ***David Kelly,*** *Cawthron Institute*	Florida LAKEWATCH: Citizen Scientists protecting Florida's aquatic systems. ***Mark Hoyer,*** *University of Florida*	Land-use effects on aquatic ecosystems: strengthening the evidence-base. ***Scott Larned,*** *NIWA*	Stressor dominance and sensitivity-dependent antagonism: Disentangling freshwater insecticide and agricultural stressor effects. ***Jon Bray,*** *University of Canberra*
2.45 - 3.00pm		Changes at the edge: food web impacts of degradation of littoral habitats. ***Simon Stewart,*** *Cawthron Institute*	What were we swimming in? Citizen study of the water quality in Lake Wanaka, NZ. ***Chris Arbuckle,*** *Aspiring Environmental*	Recent advances in reporting and interpreting water quality trends. ***Ton Snelder,*** *LWP Ltd*	Environmental drivers of Microcoleus (Phormidium) blooms in the Maitai River, Nelson and development of a predictive model. ***Georgia Thomson-Laing,*** *Cawthron Institute*
3.00 - 3.15pm		Learning from the past to identify lake resilience and enhance restoration. ***Marcus Vandergoes,*** *GNS Science*	Nature Agents – Participatory Science for Environmental Improvement. ***Kirsty Brennan,*** *EOS Ecology*	Investigation of Methods to Predict Groundwater Redox Status Using Limited Sample Data. ***Scott Wilson,*** *Lincoln Agritech*	PFAS in New Zealand Fish: Is this the next threat to our aquatic ecosystems? ***Nerena Rhodes,*** *Pattle Delamore Partners Ltd*
3.15 - 3.45pm		**AFTERNOON TEA**			

		Special session: Characterising lake communities continues **Room: Maitai 1** **Chair: Susie Wood**	**Special session: Freshwater citizen science continues** **Room: Maitai 2** **Chair: Richard Storey**	**Special session: Land use and freshwater continues** **Room: Waimea** **Chair: Scott Larned**	**Special session: Freshwater mussels** **Room: Wairau** **Chair: Sue Clearwater**
3.45 - 4.00pm		Ecosystem services at Lake Wairarapa: insights into its past, present, and future. ***Sky Halford,*** *Victoria University of Wellington **	Citizen science invertebrate monitoring provides similar assessments of ecological health as professional monitoring. ***Martin Neale,*** *Puhoi Stour Ltd*	CLUES calibration – can we use CLUES to estimate attenuation? ***Annette Semadeni-Davies,*** *NIWA*	Characterising the fish fauna associated with freshwater mussels in Waikato streams. ***Nicole Hanrahan,*** *NIWA **
4.00 - 4.15pm	**CONCURRENT SESSION 7**	Tracking historical cyanobacterial communities in five contrasting shallow New Zealand lakes. ***Maïlys Picard,*** *Cawthron Institute **	Assuring quality of community-based water monitoring data. ***Rob Davies-Colley,*** *NIWA*	A regional council application of tools – taking the road less travelled. ***Elaine Moriarty,*** *Environment Southland*	Temporal partitioning of reproductive resources in two sympatric Echyridella freshwater mussel species in Waikato streams. ***Michele Melchior,*** *Waikato University **
4.15 - 4.30pm		One shakey lake: Impacts from 1000 years of natural tectonic disturbance on in-lake communities. ***Katie Brasell,*** *Cawthron Institute **	Project Baseline Lake Pupuke Initiative, a case study for effective citizen science. ***Ebrahim Hussein,*** *Auckland Council*	Measuring actual denitrification to understand nitrogen attenuation. ***Heather Martindale,*** *GNS Science*	Glochidial development of the New Zealand freshwater mussel (Echyridella menziesii) on non-indigenous fish. ***Tom Moore,*** *Waikato University **
4.30 - 4.45pm		Reconstructing lake diatom community change: comparing novel DNA metabarcoding with traditional morphological techniques. ***Rose Gregersen,*** *University of Auckland **	Discussion	Variability of *E.coli* in rivers: implications for interpretation of grab samples. ***Richard Muirhead,*** *AgResearch*	Can kākahi (Bivalvia: Hyriidae) prey on non-indigenous Daphnia? ***Anita Pearson,*** *Waikato University **
4.45 - 5.00pm		Lake sediment as sentinels of historical food web dynamics: A case study of two eutrophic lakes in Central Otago, New Zealand. ***Samiullah Khan,*** *University of Otago **	Discussion	The Illinois River Watershed, USA – The Convergence of Science and Policy. ***Brian Haggard,*** *University of Arkansas*	The biology of kĀkahi a taonga species, insights into restoration across waterways in Canterbury. ***Channell Thoms,*** *University of Canterbury **
CLOSE OF DAY THREE					
5.00 – 6.30pm		**NZFSS AGM // Maitai 1**			
7.00 – 8.30pm		**Public Seminar // Maitai 1**			

THURSDAY 13 DECEMBER					
7.30am		**Registration Desk Open**			
8.45 - 10.15am	**PLENARY 7/8**	Housekeeping (10 mins) **Plenary Speaker 7: Neil Deans** NZFSS – 50yrs young **Plenary Speaker 8: Hon David Parker** Making Polluted Rivers Clean again **Chair: Roger Young**			
10.15 - 10.45am		**MORNING TEA**			
	CONCURRENT SESSION 8	**Session: Fish and fisheries** **Room: Maitai 1** **Chair: Kati Doehring**	**Session: Wetlands, lakes and estuaries** **Room: Maitai 2** **Chair: David Kelly**	**Session: Urban streams** **Room: Waimea** **Chair: Timothy Hopley**	**Session: Water quality** **Room: Wairau** **Chair: Olivier Ausseil**
10.45 - 11.00am		The New Zealand Whitebait Fishery - current knowledge and research gaps. ***Jane Goodman,*** *Department of Conservation*	Wetlands Must Be Wet: Paludiculture for the Climate and the Future. ***Brian Sorrell,*** *Aarhus University*	Environmental Education for Auckland's Industry - Industrial Pollution Prevention Programme. ***Rhianna Drury,*** *Auckland Council*	Fire Water: The effect of the 2017 wildfires on the streams of the Port Hills, Canterbury. ***Jenny Webster-Brown,*** *Waterways Centre for Freshwater Management*
11.00 - 11.15am		Trapping methods: evaluating soak time, fish density, predator presence, and baiting for īnanga population assessments. ***Andrew Watson,*** *University of Canterbury **	Nutrient load limit setting for estuaries - the New Zealand Estuary Trophic Index approach. ***David Plew,*** *NIWA*	Assessing flow and nutrient contributions from rheocrene springs and groundwater seepage in two urban waterways. ***Belinda Margetts,*** *Christchurch City Council* ***Peter Callander*** *PDP Ltd*	Stream and sediment chemistry interact to control dissolved reactive phosphorus concentrations at baseflow. ***Zach Simpson,*** *Lincoln University **
11.15 - 11.30am		Whitebait wizardry: modelling the composition of a mixed species fishery. ***Bridget Armstrong,*** *University of Canterbury **	Nutrient thresholds for protecting wetland ecological integrity. ***Hugh Robertson,*** *Department of Conservation*	Understanding what's left: assessing the ecological health of Wellington's urban streams to inform Whaitua Te Whanganui-a-Tara. ***Evan Harrison,*** *Greater Wellington Regional Council*	Changes in the water chemistry of Cannel Creek following remedial works at Bellvue Mine. ***Marlese Fairgray,*** *University of Canterbury **
11.30 - 11.45am		New Zealand Whitebait – Assessment of Ecosystem Services. ***Hannah Mueller,*** *Tonkin + Taylor Ltd*	Denitrification and burial of N and P in lakes explain seasonality of algal growth limitation. ***Piet Verburg,*** *NIWA*	Lifting the lid on piped streams. ***Alex James,*** *EOS Ecology*	Land-use and Waterway Quality at Mt. Grand Station, New Zealand. ***Shyam Provost,*** *Lincoln University **
11.45 - 12.00pm		Behavioural response of Taupo anglers to new liberal fishing regulations. ***Michel Dedual,*** *Department of Conservation*	Waiwiri: Trembling waters, beauty of the South...plans to restore a Manawatu lake catchment. ***Phillipe Gerbeaux,*** *Department of Conservation*	Heavy metal contamination from storm water in an industrial catchment and the relationship with antecedent dry periods. ***Timothy Hopley,*** *University of Auckland/Auckland Council*	Comparison of traditional and emerging methods of trend analysis and load calculation in Lake Rotorua streams. ***James Dare,*** *Bay of Plenty Regional Council*
12.00 - 12.15pm		Brown trout natal homing in the Taieri River estimated by otolith microchemistry. ***Pavel Mikheev,*** *University of Otago **	A case study: linking catchment land use management to lake water quality. ***Keryn Roberts,*** *Environment Southland*	Monitoring and salvage of kākahi (Echyridella menziesii) in a non-wadeable lowland river subject to dredging. ***Greg Burrell,*** *Instream*	What's to blame for low oxygen in streams – effluent, stream flow, macrophytes or groundwater? ***Thomas Wilding,*** *Hawkes Bay Regional Council*
12.15 - 12.30pm		DOC's freshwater fish monitoring – what, why, when, where and how? ***Natasha Petrove,*** *Department of Conservation*	Valuing rural riparian zones and wetland areas. ***Carla Muller,*** *NIWA*		Long-term trends in water quality of Canterbury's high-country lakes. ***Tina Bayer,*** *Environment Canterbury*

12.30 - 1.30pm	**LUNCH**				
	CONCURRENT SESSION 9	**Workshop: Fish passage guidelines** **Room: Matai 1** **Chair: Eleanor Gee**	**Special session: MfE policy update** **Room: Maitai 2** **Chair: Alison Collins**	**Workshop: Multi-Criteria Decision Analysis** **Room: Waimea** **Chair: Simone Langhans**	**Special session: Constructed wetlands** **Room: Wairau** **Chair: Rebecca Eivers**
1.30 - 1.45pm			Key policy priorities in Water and Climate Change. ***Cheryl Barnes,*** *Ministry for the Environment*		Constructed wetlands for dairy run-off: are they working? ***Suzanne Lambie,*** *Manaaki Whenua - Landcare*
1.45 - 2.00pm			The Water policy work programme ***Martin Workman,*** *Ministry for the Environment*		Accelerating uptake of constructed wetlands through recognition of performance in the limit-setting process. ***Aslan Wright-stow,*** *DairyNZ*
2.00 - 2.15pm			Science in contested places: principles and roles. ***Alison Collins,*** *Ministry for the Environment*		Constructed wetlands to reduce contaminant losses from agriculture: what don't we know? ***Chris Tanner,*** *NIWA*
2.15 - 2.30pm			The science and policy interface 'on the front lines'. ***James King*** *Ministry for the Environment*		Design considerations for constructed treatment wetlands mitigating diffuse pollution from intensive agricultural catchments. ***Rebecca Eivers,*** *Streamlined Environmental Ltd **
2.30 - 2.45pm			Ecosystem Health – a new framework to focus our water science and policy. ***Carl Howath,*** *Ministry for the Environment*		Constructed wetlands – the good, the bad and the ugly. ***James Sukias,*** *NIWA*
2.45 - 3.00pm			Discussion		A GIS model to assess the landscape suitability for installation of storm water detainment bunds. ***John Paterson*** *Phosphorus Mitigation Project*
3.00 - 3.15pm					Discussion
3.15 - 3.45pm	**AFTERNOON TEA**				
3.45 - 4.45pm	**PLENARY 9**	**PECHA KUCHA** Stream rehabilitation in NZ: unscrambling eggs or turning ecological lemons into lemonade? A PhD in 7mins. ***Robin Holmes****, Cawthron Institute*. Conservation status of New Zealand freshwater invertebrates – 2018 update. ***Tom Drinan****, Department of Conservation* Faecal Indicator Bacteria in New Zealand Freshwater Fish: A Pilot Study. ***Sarah Coxon****, ESR* Were the New Zealand and Australian graylings (Prototroctes spp.) distinct species? ***Gerry Closs****, University Of Otago* Drain impacts to wetland hydrology, and restoration planning. ***James Blyth****, Jacobs NZ* Kaikōura Earthquake - the many crossings along the road to recovery. ***Tanya Blakely****, Boffa Miskell Ltd* The Final Frontier: Using enterprise modelling to implement freshwater accounting. ***Mark Heath****, GWRC* DOC's Freshwater Stretch Goal "50 freshwater ecosystems restored - from mountains to the sea" ***Tracie Dean-Speirs****, Department Of Conservation*			
4.45 - 5.00pm	**CLOSE**	**Official Conference Close**			
6.30 - 11.30pm	**CONFERENCE DINNER // Trafalgar Centre, Paru Paru Rd, Nelson** Kindly Sponsored by Nelson Forests Ltd				

FRIDAY 14 DECEMBER	
Various Times, please check the conference handbook	**FIELD TRIPS // All departing from Rutherford Hotel**

POSTER LIST

*= eligible for Student Prizes

Presenting Author		Organisation	Poster #	Paper Title
First Name	Last Name			
Frederico	Azevedo Lopes	Universidade Federal de Minas Gerais	1	Should we swim here? An indexing approach for contact recreation on the Hutt River, Wellington.
*Vanessa	Barbosa	University of Waikato	2	Dispersal patterns and connectivity of aquatic insect populations in fragmented landscapes: an integrated study
*Alexandra	Barclay	University of Canterbury	3	Establishing a baseline: understanding the effect of global climate change on Canterbury-Westland alpine tarn communities
*Issie	Barrett	University of Canterbury	4	Resilience isn't always healthy: using stressors to overcome negative resistance and resilience in stream restoration
*Javiera	Benavente	University of Auckland	5	Ecosystem consequences of warming and reduction of predator body size
Manas	Chakraborty	Cardno (NZ) Ltd.	6	Urban stormwater drains in Kapiti Coast (lower North Island, New Zealand) provide potential fish habitats to several native species
Sue	Clearwater	NIWA	7	Managing predation to increase the survival of juvenile freshwater crayfish (Paranephrops planifrons) – laboratory studies.
Kevin	Collier	University of Waikato	8	Estimating departure from Trophic Level Index reference state for New Zealand lakes
*Katie	Collins	University of Canterbury	9	Rethinking riparian buffer design to control macrophyte growth in small agricultural streams
Tanya	Cook	Northtec	10	Effect of cattle exclusion on black mudfish (Neochanna diversus) and Gambusia affinis in Wairua River Wildlife Management Reserve, Northland, New Zealand
Siobhán	Culhane	EOS Ecology	11	"LIFE ON THE INSIDE Aquatic fauna utilise habitat inside a damaged culvert"
Rob	Davies-Colley	NIWA	12	Channel widening of small streams following riparian planting – when will it happen?
*Markus	Dengg	University of Otago	13	Trace Metal Limitation of Phytoplankton Growth in Lakes of the Taupo Volcanic Zone
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Paul	Fisher	Nelson City Council	16	Site fidelity of koaro (Galaxias brevipinnis) spawning in a Nelson stream
*Lucian	Funnell	Universtiy of Otago	17	Restoring a lowland stream in Southland: do the physical restoration works affect the invertebrate community?
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Andrew	Hughes	NIWA	19	Stream water quality and hydrology response to conversion from pasture to plantation forest
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*= eligible for Student Prizes

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*Riki	Parata	NIWA, University of Waikato	31	Quantifying relationships between juvenile wai-kōura (Paranephrops planifrons) abundance and micro-habitat features in Waikato hill-country streams.
*Anita	Pearson	University of Waikato	32	"A global review of zooplankton species in aquaculture ponds: what are the risks for invasion?"
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Poster Session Kindly Sponsored by DOC Arawai Kārāriki Wetland Restoration Programme

ORAL ABSTRACTS

IN ORDER OF PRESENTERS LAST NAME

What were we swimming in? Citizen study of the water quality in Lake Wanaka, NZ

Chris Arbuckle[1,2], Eddie Spearing[2], **Marjorie Cook**[2], Sharyn Gingell-Kent[3], Kevin Gingell-Kent[3]
[1]*Aspiring Environmental,* [2]*Touchstone,* [3]*Wanaka Lake Swimmers*

In 2017 the Wanaka Lake Swimmers club representatives embarked on a Citizen Science study, the aim being to better understand the water quality in their Lake and how it affects their recreational values. Water quality and environmental sampling methods included classical sampling methods (grab sampling), and some not so classical methods (baby wipes) to examine what's affecting the lakes water quality. As a result, swimmers have gained a deeper understanding of the quality of water in their lake, can educate their swimming community about water quality and increase community awareness about the threats to their highly valued swimmers' environment. The project has raised awareness about the influence of stormwater on the lakes water quality and is advancing community understanding about the changes in the ecology of Lake Wanaka caused by the recent invasion of *Lindavia intermedia* (Lake Snow). All these issues previously affected their perception of the future recreational value of the lake, but now community-based understanding puts all these issues into perspective. This in turn can more positively influence community awareness about the lake's future. What are we swimming in? is contributing to a bottom up understanding about how the Lake can be better valued by its community. This is funded by Curious Minds Participatory Science, and the project is part of a broader community-based initiative looking at water issues around Lake Wanaka; called The Touchstone Project.

Whitebait wizardry: modelling the composition of a mixed species fishery

Bridget Armstrong[1], Mark Yungnickel[1], Mike Hickford[1], Elena Moltchanova[1], David Schiel[1]
[1]*University Of Canterbury*

Five species of fishes of the genus Galaxias make up whitebait catches in New Zealand, although one species (*G. maculatus*) makes up around 90% of the catch. The adults of most of these whitebait species are either in decline or at risk of extinction. Whitebait are immature post-larval fish that have yet to develop the distinctive colouration and morphological traits of adults. In their tiny translucent stages as whitebait, the five species are difficult to tell apart. There are also distinct spatial (rivers) and temporal (different months in the whitebait fishing season) differences in abundance among the species and even within a species. To better manage the fishery it is necessary to identify regional differences in the species composition of the whitebait catch. Finding species compositions is difficult because of the time and effort required to sample catches and identify species morphologically or genetically. In my study I have used a recently compiled database comprising 13,000 entries of whitebait samples, species composition, and morphological variability to develop statistical models that predict the species-to-species composition of catches throughout New Zealand. Probabilistic models could be powerful tools in the fishery and conservation of whitebait species.

Water quality and periphyton modelling of point source discharge effects

Olivier Ausseil[1], Michael Greer[1], Lovisa Ekelund[1], Fiona Death[1]
[1]*Aquanet Consulting Ltd*

Towns, cities and industries generate wastewater, which, in New Zealand, is typically discharged to land and/or water after treatment. New Zealand legislation requires the consideration of alternatives and options as part of the resource consenting process. Options considered typically involve various levels of wastewater treatment and discharges to waterbodies or to land, or to dual systems, where wastewater is discharged to land at certain times of the year and to water at other times. The development, assessment and optimisation of discharge system options involves multiple and complex scenarios, which require detailed modelling, interpretation and communication.

Aquanet developed a daily time-step model to assess the potential effects of discharge scenarios on river water quality and periphyton growth.

Over the last four years, the model has been successfully applied to several municipal and industrial systems and has been found to provide robust and useful support to system development, decision making and assessment of future compliance with specific water quality targets or limits. The water quality and periphyton modules are being calibrated to additional sites and further developed to incorporate recently acquired periphyton growth data. Real-life examples of model application and latest developments will be presented.

Suitability of Brazilian freshwaters for contact recreation. Assessment by a water quality index

Frederico Azevedo Lopes[1,2], Julia Piazi[1], Juliana Souza Silveira[1], Andrea Coelho Leite[1], Natalia Isabel Azevedo Lopes[1], Rob Davies-Colley[2]
[1]*Universidade Federal de Minas Gerais - UFMG - Brazil,*
[2]*National Institute of Water and Atmospheric Research - NIWA*

Water-based recreational activities are important for mental health and contributions to the local economy. In developing countries like Brazil, where climatic conditions are favourable, swimming is one of the few free leisure options for poor people. However, in Brazil there is a dearth of studies and governmental support for contact recreation in freshwaters, in contrast to marine waters. In the landlocked state of Minas Gerais, freshwater recreation is important in reservoirs and rivers, particularly near waterfalls. Nevertheless, the official water quality network does not have a specific surveillance or grading program for recreational suitability. One of the main challenges facing environmental managers is the conversion of complex environmental data into information that is understandable and accessible to non-technical audiences. Water quality indices attempt to convey information about suitability of waters for intended uses. We applied the Index of Conditions for Bathing – ICB (Lopes et al. 2016) for Brazilian freshwaters to available data from 369 monitoring sites in Minas Gerais between 2007 to 2017. This index considers *E. coli* (indicating fecal pollution and microbial hazards), cyanobacterial density (health risks and aesthetic quality), turbidity (aesthetics and safety associated with visual clarity), and pH (safety and eye-comfort). Our gradings (long-term assessment) show that recreational water quality is “Unsuitable” (ICB score <50) at 71% of the monitoring sites, while 29% were classified as “Very bad” (ICB score <25). Despite environmental policy advances, and investments in pollution control, swimming suitability did not improve in 2007-2017. We advocate a specific monitoring network for Minas Gerais to inform users about swimming suitability.

Key policy priorities in Water and Climate Change

Cheryl Barnes[1], James King
[1]*Ministry for the Environment*

Leading two of the most pressing environmental policy areas, Cheryl will give an overview of policy priorities in Water and Climate Change at the Ministry for the Environment. She will outline the work programme for both areas, and outline in more depth where the climate and water policy areas intersect. Cheryl will also discuss the role of public servants in providing analysis and advice to Ministers, including how the value of 'free, frank and fearless advice' is applied in practice with Ministers when advising on policy decisions.

Boosting biological recovery in degraded streams: disturbing degraded communities to reverse environmental filtering

Isabelle Barrett[1], Catherine Febria[1], Angus McIntosh[1], Kristy Hogsden[1], Elizabeth Graham[2], Jon Harding[1], Helen Warburton[1]
[1]*University of Canterbury,* [2]*NIWA*

The environment imposes filters on communities through which only species with particular traits are able to pass. This filtering process shapes communities into distinguishable community types, associated with particular environmental conditions. For example, a braided river invertebrate community shaped by frequent flooding will be dominated by mobile species that can withstand disturbances (e.g. mayflies and stoneflies), whereas an agricultural stream community shaped by nutrient and sediment input will be dominated by sedentary, pollution-tolerant invertebrates (e.g. worms and snails). These community types will each likely respond differently to additional stress: if more of the same stress is applied to a system, community composition will remain relatively stable; however if conditions change and novel environmental filters are applied, community composition will likely change. To test this, stream mesocosm experiments were conducted to investigate the impacts of different stressors (flooding, sedimentation, and nutrients) on three community types sourced from braided rivers, stable springs and agriculturally impacted streams. Invertebrates were placed in channels and stressors applied for 24 hours. Both invertebrates drifting out of the channels and those remaining in the channels at the end were collected and identified. Results suggest that how individual taxa respond to stress depends on disturbance history and resulting pre-stress community composition. We propose that whilst using stressors to further disturb degraded ecosystems seems counter-intuitive, it could be used to trigger positive community change as a valuable restoration tool.

Long-term trends in water quality of Canterbury's high country lakes

Tina Bayer[1]
[1]*Environment Canterbury*

Long-term monitoring data from high country lakes in New Zealand is limited, mostly due to logical challenges in data collection. Environment Canterbury has now collected nearly 15 years of seasonal monitoring data (December to May) for more than 30 lakes in Canterbury's high country, ranging from small eutrophic to large oligotrophic systems. Regular LakeSPI monitoring was also carried out. This dataset provides valuable insights into the state and trends in water quality of these lakes, as well as information on ecosystem functioning.

Key findings:

1. More than half of the surveyed lakes are in high or excellent ecological condition.
2. Lindavia intermedia is now widespread, but still likely absent from a number of lakes.
3. There is substantial inter-annual variation in Trophic Level Index (TLI) for many smaller lakes.
4. Most of Canterbury's high country lakes are more likely to be P than N limited.
5. Several deep lakes support autumn rather than summer peaks of phytoplankton.
6. Turbidity is increasing in more than 50% of the monitored lakes.
7. Turbidity, Total Nitrogen and Total Phosphorus are decreasing in several large Southern lakes.
8. Several lakes show clear impact of land use changes, but there are also strong regional climate signals.
9. Individual lakes (such as Lake Pearson) displayed step-changes in water quality, possibly in response to changes in water clarity.

Data from this monitoring programme has informed our Land and Water Regional Plan and helped assess policy and plan effectiveness. Our data highlights a large natural variability and the strong influence of climate, but has enabled us to identify 'vulnerable' lakes and triggered more detailed follow up investigations in several lakes.

Kaikōura Earthquake - the many crossings along the road to recovery

Tanya Blakely[1]
[1]*Boffa Miskell Ltd*

On 14 November 2016, a 7.8 magnitude earthquake shook the Kaikōura coast. Resultant slips and damage destroyed roads and river crossings. While many roads were cleared and re-opened within 24 hours, major parts of State Highway 1, the Main North Line railway, and the Inland Kaikōura Road remained closed, with no road or rail to or from Kaikoura.

The North Canterbury Transport Infrastructure Recovery (NCTIR) alliance was formed and charged with repairing damage to the road and rail infrastructure along that eastern coastline.
The NCTIR project area extends from the Waiau River near Cheviot, to Wairau River in Blenheim, and includes a substantial number of waterways, from braided rivers and forested streams, to spring-fed streams, creeks and channels that drain farmland. The earthquake left the freshwater systems highly disturbed, some cut-off from the sea due to coastal uplift, others impacted by landslides and sedimentation. But importantly, the waterways were intersected by the state highway and rail, where infrastructure repair works was urgently required. Records in the New Zealand Freshwater Fish Database indicated at least 20 species of indigenous fishes, as well as kēwai, occurred in the affected waterways, including Threatened, At Risk, and taonga species.

The NCTIR Ecology team was tasked with working closely with design and construction teams to reopen the road and rail, while avoiding or minimising impacts on freshwater habitats and fauna. This presentation is an overview of some of the main challenges and methods used at the interface with freshwater habitats and the road and rail recovery works.

Drain impacts to wetland hydrology, and restoration planning

James Blyth[1], Hugh Robertson[1]
[1]Jacobs New Zealand Ltd, [2]Department of Conservation

In 2017, the Department of Conservation (DOC) and Jacobs completed hydrological monitoring installations at three wetlands around New Zealand, which was driven by the Department's Freshwater Stretch Goal: 50 freshwater ecosystems are restored from mountains to the sea.

The three focus sites were Kaimaumau-Motutangi (Northland), Moawhitu (D'Urville Island) and Awarua (Southland), all of which have been extensively impacted by drainage schemes. The hydrological effects of drainage on wetland ecosystem functioning has been captured through pressure transducers arranged in transects perpendicular to drains to determine changes in water level gradients. In total 32 pressure and three barometric transducers were deployed in the wetlands for the last year, and have been surveyed to datums relevant to their locality.

These annual hydrological results will be presented and used to describe the potential drainage impacts in different wetland systems, and the subsequent reasons for the variations exhibited in drained water levels between sites. The data will be used to help guide restoration activities in the wetlands, including assessments of wetland inundation area and engineering options for resolving drainage effects whilst also supporting fish passage.

Spatial heterogeneity in flow-disturbance influences abundance and temporal stability in native–invasive species co-occurrence in riverscapes

Nixie Boddy[1], Angus McIntosh[1]
[1]University of Canterbury

Given the importance of spatial heterogeneity in altering dispersal, interspecific interactions, and population persistence, high rates of habitat homogenisation across the globe are a concern. In river networks, confluences likely produce discontinuities in physical conditions, potentially creating hotspots of heterogeneity that influence fish assemblages, including interactions between native and invasive fish. However, mechanisms driving fish assemblage responses to such spatial heterogeneity are not well understood. We investigated how heterogeneity in flow disturbance conditions around confluences in the South Island high country of New Zealand influenced the density and relative abundance of native and invasive fish. Electrofishing in mainstem and tributary branches of replicate confluences revealed highly context-dependent distributions, contingent upon the combination of flood disturbance history in branches. Heterogeneity-related dynamics in fish assemblages meant confluences with homogenous flow conditions had lower fish abundance and higher temporal variability in the relative abundance of native and invasive species than confluences with heterogeneous flow conditions. These results demonstrate how flow regime influences are spatially transferred at confluences, creating areas of influential riverscape heterogeneity. This link between assemblage stability and riverscape heterogeneity supports the use of measures of temporal variability in community composition to provide important insights into the effects of landscape processes on communities. Overall, our research indicates understanding the role of heterogeneity will assist in identifying locations of ecological significance in river networks and improve the strategic management of fish, especially in invaded riverscapes.

Estimation and application of nationwide reference conditions of water quality indicators

Doug Booker[1], Paul Franklin[1], Ton Snelder[2], Rich McDowell[3]
[1]NIWA, [2]LWP, [3]AgResearch

The setting of environmental objectives for streams and rivers can be aided by knowledge of reference conditions. In the first half of this talk we demonstrate how monitoring data have been used to estimate reference conditions for all streams and rivers across New Zealand with respect to chemical, physical and microbiological variables (e.g., water clarity, Escherichia coli, total nitrogen and areal cover of deposited fine sediment). We used mixed-effects models to quantify the relationship between each variable and the proportion of the catchment occupied by intensive agriculture. The method incorporates the River Environment Classification (REC) to account for natural variation in each variable associated with climate, topography and geology. Accounting for natural variability in climate, topography and geology helps to identify realistic and justifiable water quality objectives. The method is designed to avoid setting water quality limits or targets that are either impossible to meet (e.g. below reference conditions), or too high, such that they have little ecological benefit. In the second half of this talk we demonstrate how estimated reference conditions of deposited fine sediment can be used to demonstrate ecological impacts at the national scale. We applied mixed-effects models to predict the relationship between deposited fine sediment and probability of capture of various fish species. The River Environment Classification (REC) was again used to account for natural variation in fish communities associated with climate, topography and distance inland. We then combined estimates of deposited fine sediment under reference conditions with fish probability of capture models to provide national-scale quantification of change in fish community associated with changes in physical conditions. We therefore demonstrate how estimated reference conditions can aid setting of objectives for deposited fine sediment by expressing objectives in terms of expected deviation away from reference fish community.

One shakey lake: Impacts from 1000 years of natural tectonic disturbance on in-lake communities

Katie Brasell[1,2], Jamie Howarth[3], Xavier Pochon[1,2], Anastasija Zaiko[1,2], Marcus Vandergoes[4], Kevin Simon[2], Susie Wood[1]
[1]Cawthron Institute, [2]University of Auckland, [3]Victoria University of Wellington, [4]GNS Science

Many of New Zealand's lakes have been impacted on a large scale by human activity that can cause pronounced shifts in lake health and community composition. But how do lake communities respond to large-scale natural disturbance events? Do lake regime shifts occur, or do continued disturbance events cause cumulative change? Lake Paringa, near Haast, sits directly adjacent to the Alpine Fault, which ruptures regularly every 300 years resulting in magnitude 8 earthquakes, and large sediment deposition into the lake. In this study, DNA preserved in lake sediment layers was extracted from a sediment core and 16S rRNA metabarcoding used to assess the lake bacterial community over the past 1000 years – a period which included four major tectonic events. Bacteria were selected as they have proven to be a useful proxy for changes in water quality and the wider lake community. The metabarcoding data is used to demonstrate changes that occur immediately following tectonic events and explore if they return to the same stable state or shift to a new normal.

Stressor dominance and sensitivity-dependent antagonism: Disentangling freshwater insecticide and agricultural stressor effects

Jon Bray[1], Sue Nichols[1], Ross Thompson[1], Alexandra Keely-Smith[1], Saurav Bhattachryya, Susmita Gupta[2], Abhik Gupta, Jack Gao, Kristie Thompson[4], Sarit Kaiserton[3], Jochen Mueller[3], Audrey Chou, Ben Kefford[1]
[1]Institute for Applied Ecology, University of Canberra, [2]Assam University, [3]QAEHS, University of Queensland, [4]Brigham Young University,

Pesticide concentrations are correlated with regional declines in stream invertebrate diversity. However, pesticide effects on stream invertebrate assemblages are complicated by interactions with other stressors and natural environmental gradients. We experimentally examined the effects of a pesticide among other agricultural stressors on stream invertebrate structure. We used 24 independent 1000L re-circulating outdoor mesocosms in a semi-orthogonal design. Two pulses of the pesticide malathion were delivered at low and high concentrations (Pulse 1: low at 0.1 and high at 1µgL^{-1}¬; Pulse 2: at 2.5 and 25 µgL^{-1}), crossed with nitrogen, phosphorus and clay (kaolin) sediment additions as a single treatment (hereafter agricultural stressors). Malathion degradation was rapid in all treatments likely because of photolysis, hydrolysis, pH, and the effects of biofilms and sorptive processes (<24hr half-life). There were considerable differences in invertebrate assemblages between treatments, where malathion contributed to 48% and 87% of deviance during Pulse 1 and 2 respectively. Malathion had strong negative effects during Pulse 2, decreasing Ephemeroptera, Plecoptera and Trichoptera abundance ($P<0.05$), invertebrate richness ($P<0.01$) and total invertebrate abundance ($P<0.01$). Despite the dominant effects of malathion, agricultural stressors inhibited rates of leaf litter breakdown ($P<0.05$), stimulated invertebrate densities and weakly mitigated malathion toxicity in mesocosms (PERMANOVA, $P\approx0.1$). Experimental toxicity assays of select sensitive taxa and malathion rates of breakdown identified kaoline sediment ameliorated malathion effects through alkaline hydrolysis and sorption. Sensitivity-dependent effects were observed where both direct and interactions among stressors were dependent on taxonomic sensitivities. Findings support that within real ecosystems pesticide effects may be difficult to quantify, difficulties in capturing pulsed exposure, rapid pesticide breakdown and pesticide-environment interactions. Among co-occurring stressors however, pesticide effects may be underestimated where environmentally relevant concentrations can have dominant negative consequences on ecosystems, causing rapid community shifts and homogenising biota.

Nature Agents - Participatory science for environmental improvement

Kirsty Brennan[1], Bronwyn Gay[1], Shelley McMurtrie[1], Alex James[1]
[1]EOS Ecology

In our fast-paced society we're increasingly disconnected from local natural environments, often to the detriment of ecosystem health. To move towards environmental improvement public participatory science must be encouraged, including genuine working partnerships between community, scientists, and authorities. Even highly motivated communities cannot go it alone – but given appropriate tools, goals and ongoing support, they're capable of driving positive change. Collecting the right data builds participants' awareness and knowledge of local issues – helping inform plans for improving the current situation.

With this in mind, EOS Ecology developed 'Nature Agents' – a true participatory science programme, currently implemented in schools across Canterbury. 'Nature Agents' uses long-term dataset collection to provide students with an understanding of their local waterway. Appropriate monitoring sites, parameters and methods were chosen to fit students' capabilities and safety protocols. Schools use the Programme to collect, interpret, compare and communicate results.

Programme incorporates:

- Teacher planning session – framework that guides teachers through curriculum-appropriate science learning.
- Printed/digital resources and data sheets – comprehensive instructions for Programme implementation, using equipment/data sheets, and further learning suggestions.
- Equipment kit – easy-to-use, long-lasting monitoring equipment (schools keep the kit forever, allowing ongoing monitoring).
- Field training – scientist-run training for schools at their monitoring site to develop their skills, cover how to collect site, water quality, invertebrate, and habitat data.
- Data file – for entering collected data, includes built-in analysis providing meaningful/comparable outputs.
- Ongoing support – additional scientist input for data collation/analysis/communication...whatever schools need.

Empowered with knowledge and skills, communities are more inclined to challenge the status quo and encourage improvement in local environmental management practices – especially when they have the data to back them up. With budgets tight, true participatory science (communities supported by scientists) will be a vital mechanism helping drive environmental improvement.

Stimulation of river periphyton growth by ammoniacal-N vs. nitrate-N: is there a difference?

Logan Brown[1], Cathy Kilroy[2]
[1]*Horizons Regional Council,* [2]*NIWA*

In the Manawatū–Whanganui region, significant investments into upgrades of wastewater treatment plants (WWTPs) to reduce concentrations of dissolved reactive phosphorus (DRP) in discharges to rivers have not always had the desired effect of reducing nuisance periphyton growth. One explanation is that particulate organic phosphorus in WWTP discharges continues to supply phosphorus that can be taken up by periphyton. A second possibility is that high concentrations or proportions of ammoniacal nitrogen (NH4-N) in the discharges could also lead to higher than expected periphyton biomass. NH4-N is the most energy-efficient source of N for algae and is taken up preferentially over nitrate nitrogen (NO3-N). To address the second possibility, Horizons Regional Council coordinated a study to compare the effects on periphyton biomass of dissolved inorganic nitrogen (DIN) enrichment as NH4-N versus NO3-N. A literature review identified few published studies on responses by stream periphyton biomass to changes in NH4-N concentrations or proportions, and responses were inconsistent. To contribute to filling this knowledge gap, an experiment was carried out in stream-side channels. We compared periphyton biomass and community composition developed over three weeks in late summer under DRP >20 mg m-3 and DIN ~500 mg m-3, with DIN comprising 77%, 30% or <1% NH4-N. Under 77% NH4-N, periphyton biomass as chlorophyll a developed faster and peaked at 50% higher than under <1% NH4-N. Biomass as ash-free dry mass did not differ with proportion of NH4-N, but community composition did. We concluded that DIN made up of high proportions of NH4-N can potentially stimulate periphyton chlorophyll a to a greater extent than DIN primarily comprising NO3-N. Our observations applied to the conditions of the experiment. We discuss the implications of the results for management of WWTP discharges.

Monitoring and salvage of kākahi (*Echyridella menziesii*) in a non-wadeable lowland river subject to dredging

Greg Burrell[1], Winsome Marshall[2]
[1]*Instream,* [2]*Aquatic Ecology Ltd*

The native kākahi, or freshwater mussel (*Echyridella menziesii*) has an At Risk conservation status and is uncommon in urban waterways. A rapid snorkel assessment in 2017 revealed kākahi were widespread in non-wadeable reaches of the Styx River in Christchurch city. A proposal to dredge the Styx River therefore prompted a kākahi salvage and monitoring operation. Divers were used to estimate kākahi densities at two "impact" locations to be dredged and two "control" locations upstream and downstream of the dredge area. Kākahi salvage was undertaken by divers prior to dredging, and also by examining dredged sediment spoil piles after dredging, with salvaged kākahi moved upstream of the dredge area. A total of 17,810 kākahi were salvaged from a 475 m length of the river. The dive team spent a combined total of 49 person hours over 3 days removing a total 17,164 kākahi prior to dredging, while the dredge spoil team spent a total of 48 hours over 10 days searching, with a total of 646 kākahi recovered. Thus, diver salvage was far more efficient than spoil pile searching, with an average of 352 kākahi per hour collected by divers, compared to between 3 and 20 per hour for the spoil pile team, depending on the methods used. Mean kākahi density prior to salvage and dredging ranged from 32 to 64 kākahi per m² across the four sites. Kākahi abundance was similar to pre-dredge densities six months later at control sites, but was 90% lower than pre-salvage densities at the impact sites. This study has confirmed the presence of a large population of kākahi in a lowland waterway and shown that diving is an efficient method of salvaging and monitoring kākahi in non-wadeable rivers. Further monitoring would provide an improved understanding of the recovery time of kākahi following dredging.

Preventing the spread of freshwater pests – what's working and what's not

Tracey Burton[1]
[1]*NIWA*

Effective decontamination of equipment by responsible lake users and agencies alike, is critical for preventing the spread of invasive freshwater species. The number and type of invasive freshwater species present in New Zealand is a moving target, emphasizing the need to use the most effective and up to date decontamination techniques available.

The Check, Clean, Dry social marketing campaign introduced by Biosecurity New Zealand (now MPI) in 2005 followed the discovery of the invasive freshwater diatom *Didymosphenia geminata* (didymo) in the South Island. The Check, Clean, Dry mantra has since become a long-term incursion response management program for the prevention of all freshwater pests in New Zealand.

While the Check, Clean and Dry protocols had been extensively tested for didymo, little experimental testing has been carried out to validate the existing methods for use on other freshwater pests. This presentation presents the results of a study carried out to validate the Check, Clean and Dry methods, with a focus on the effective treatments for three of New Zealand's worst aquatic weed species. *Ceratophyllum demersum* (hornwort), *Lagarosiphon major* and *Egeria densa* are all actively spreading around the country by boat traffic (E.g., trailers, jet intakes, anchor wells) and/or other recreation activities (E.g., fishing equipment, water ski gear). In addition to these weed species, the current Check, Clean and Dry protocols were also tested for use against two other freshwater invasive species causing concern over potential future impacts: *Cyclotella bodanica* (Lake Snow) and the Ear Pond snail (*Lymnaea* (Radix) *auricularia*).

Can I Trust that Model? eSource Catchment Model Validation, a learning process.

Rochelle Carter[1]
[1]*Bay Of Plenty Regional Council*

Being neither modellers or statisticians, this is a brief story of the "learn as you go" journey undertaken by council water quality scientists trying to navigate the complex waters of model validity.

Using models to test the state of our freshwater resource and the measures that might be used to preserve them, can be a hugely complex and daunting task. Where many see a black box that provides the definitive answers, others will challenge every nook and cranny. Satisfying community to environment court requires a robust validation process to test model limitations. Such a process is fundamental to creation of a robust tool that might underpin setting of freshwater limits or for testing mitigation strategies to meet those limits.

Faced with limited observed data, we trialled a range of statistical and graphical measures to test model outputs. While much of the model validation is traditionally performed by the modeller(s), by having council staff embedded in integrated catchment resource management to undertake a model validation process results in a better informed model, and staff. This has the dual benefit of a more robust model and the ability to better deliver model outputs in the context of how they were derived. The downside is the amount of time it takes.

This paper will give a measure of tools used and some of the pros and cons of the approach we took.

Ecological health monitoring of large river systems: Establishing a Waikato region network

Alicia Catlin[1], Michael Pingram[1], Mark Hamer[1]
[1]*Waikato Regional Council*

Large river systems are functionally diverse, and are complex at both spatial and temporal scales. Assessing ecological health in large rivers can prove difficult because the majority of methodologies available for key indicators are centred on sampling wadeable streams and rivers. In order to assess the ecological health of these large systems, new approaches are needed that can be consistent and repeatable amongst differing systems. Previously, methods for assessing large river systems have been trialled within the Waikato Region in collaboration with Cawthron, with results suggesting optimal times for sampling and indicating the effects of land use type, and spatial variability on functional indicators. Of these indicators, cotton strip assays can be applied as an indicator of organic matter decomposition– a key function of river systems. Waikato Regional Council are in the initial phases of establishing a regional large river monitoring program, which includes further refinement and exploration of ecological indicators of river health. These sites are largely aligned with established water quality and flow sites to maximise the availability and quality of supporting data. The network consists of up to 40 sites across Hauraki, West coast, Coromandel, Waipa and Waikato catchments including 8 sites on the main stem of the Waikato River. Here I present the methodology used and the preliminary findings of our first round of sampling, at 19 sites. This monitoring has the potential to be applied at both a regional and national scale, allowing these once unmonitored systems to become a part of a larger network of monitored and reviewed sites. Giving effect to the key policy documents aimed at improving ecosystem health of our waterways.

Mātauranga Māori shaping marine and freshwater futures

Joanne Clapcott[1], Jamie Ataria[1, 2], Chris Hepburn[3], Dan Hikuroa[4], Anne-Marie Jackson[5], Rauru Kirikiri[7], Erica Williams[6]
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Māori have distinct cultural knowledge, values, and perspectives that establish their identity, responsibilities, and rights to manage and use aquatic resources. There is an enormous potential for the use of mātauranga Māori to enhance our understanding of aquatic ecosystems, underpin culturally appropriate restoration approaches, and provide a more holistic and integrated perspective for research, monitoring, planning, and policy and resource development. This special session brings together rich and diverse experiences and opinions on how mātauranga Māori is informing current and future research and decision-making in aquatic environments of Aotearoa New Zealand. In this introductory talk, we describe the unique process of creating a special issue for the New Zealand Journal of Marine and Freshwater Research on 'Mātauranga Māori shaping marine and freshwater futures' (Volume 52, Issue 4). We provide an overview of contributing topics which include: an historical setting and kaumatua view of challenges of revitalising and applying mātauranga Māori for protecting and enhancing aquatic bio-heritage; a reflection on what whakataukī contribute to freshwater knowledge; examples of partnerships which shape research and decision making in aquatic management; examples of mātauranga-informed revitalisation of fisheries; the development of mātauranga-informed tools for assessing the mauri of awa and river flows; and, a view of the future and how urban tamariki (youth) are combining mātauranga with science through a process of reconnecting with local waterways. Finally, we discuss the guiding principles and emerging ideas from mātauranga Māori in relation to marine and freshwater kaitiakitanga (guardianship).

Were the New Zealand and Australian graylings (Prototroctes spp.) distinct species?

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The Southern Hemisphere graylings (Prototroctidae) comprise two modern species; the extinct New Zealand grayling (*Prototroctes oxyrhynchus*) and the extant Australian Grayling (*P. maraena*). The New Zealand grayling was formerly described as one of the most common New Zealand freshwater fish, but has not been recorded since the 1920s. Approximately 20 preserved specimens are held in museums. The Australian grayling, native to south eastern Australian coastal catchments, has declined since European settlement, and is listed as vulnerable. The two species are morphologically very similar, and presumably had a similar biology, however the genetic relationship between the two species is unstudied. We sampled Australian Grayling from Tasmania and extinct grayling from New Zealand, encompassing the geographic distribution of the species. Using genetic techniques specific to formalin preserved specimens, we obtained partial mitochondrial cytochrome b sequence from the New Zealand grayling. Phylogenetic analysis indicates a strongly supported sister relationship between the Australian and New Zealand grayling. The level of divergence (~8%) supports separate species status and indicates a divergence time during the Pliocene around 4 million years ago, and the possibility of multiple colonisation events of New Zealand when fossil taxa are taken into consideration (e.g. 16-19 Mya Saint Bathans Grayling taxa). Given that Prototroctes spp. have colonized New Zealand more than once, a case for restoring the genus to New Zealand by introducing Australian grayling could be made. However, such a step must be considered cautiously given that the species are distinct, and there is a remote possibility that New Zealand grayling may still persist somewhere. Other risks, including the translocation of disease, must also be considered.

Science in contested places: principles and roles

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For most science endeavours, advances build on previous advances, and major breakthroughs or irrefutable certainty is rare. Much of the scientific method is about prodding, testing, articulating and constraining the bounds of uncertainty. But this brings challenge in the use of science as part of evidence-based policy making and reporting, particularly in areas such as freshwater that have importance, value and connection in our lives, and where 'trusted' evidence is demanded.

We will explore some of the principles for managing science in contested places, and in particular freshwater, where there is inherent complexity and increasing public interest. The talk will include some of the roles and capability needed for responsible use of science, and how science can support, not confuse the debate as policy is developed. Examples of how we are applying some of these principles at Ministry for the Environment will be provided, and in particular, within our freshwater and environmental reporting programmes.

Faecal Indicator Bacteria in New Zealand Freshwater Fish: A Pilot Study

Sarah Coxon[1], Brent Gilpin[1]
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Water contaminated by faecal materials may contain pathogenic microorganisms that present a health risk to water users. Microbial water quality assessment is based on the presence of faecal indicator bacteria (FIB), including *E. coli* and enterococci that are present in high concentrations in the gut of endothermic ('warm-blooded') animals. Recent studies have suggested that poikilothermic animals (whose body temperature varies with environmental temperature) may represent an overlooked source of these bacteria in the environment.

A pilot study was undertaken to investigate the presence of FIB in the faeces of New Zealand freshwater fish (trout, eel, inanga, bully). Fish were obtained from a large river, small roadside creeks and a hatchery. FIB were recovered from fish of each species and location, with *E. coli* and enterococci present in 71% and 75% of faecal samples, respectively. Where present, FIB concentrations were highly variable, with maximum concentrations of 2.1×10^4 *E. coli* and 1.3×10^6 enterococci per gram of faeces. FIB were also recovered from aquaria in which fish were held. These findings suggest that FIB are not indigenous members of the fish microbiome, but are acquired from the environment; once ingested, they appear capable of replication within the gut and are subsequently shed to the environment. It remains unclear whether FIB become established in the gut or replicate within the intestinal contents during gut passage.

The presence of high FIB concentrations in fish faeces may hold implications for accurate water quality assessment, by acting as a continuous source of FIB after an original contamination source is removed. Further studies to determine whether FIB colonise the gut, and identify environmental factors that might influence the importance of fish as an FIB source (e.g. hydrology, temperature), are warranted. The potential for fish to act as sources of faecal pathogens such as Salmonella should also be investigated.

Development of the LUCI model for supporting nature-based water resources management in the Vietnam Mekong Delta

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Unsustainable water resources management in the Vietnam Mekong Delta (VMD) has gradually degraded the delta's ecological functions and services. Local flood prevention systems play a role in flood protection by diverting floodwater to the sea to facilitate year-round cultivation however they also decrease the capacity of the delta's floodplains to store and slow floodwaters. In addition, the ecosystem services provided by natural floods to the floodplains of the VMD have been reduced i.e. sediment trapping, water purification and provision etc. As a result, the VMD has become more vulnerable to environmental and climate changes. "Nature-based" or "living-with-flood" alternatives have emerged as a sustainable approach for water resource management which are increasingly being applied in developed deltas. However, they have not been successfully implemented in developing deltas like the VMD to date due to many challenges and obstacles. Besides social and financial obstacles, there is a lack of scientific evidence about multiple benefits of nature-based alternatives and their spatial distribution in the VMD. Hence, it is difficult for policy makers to persuade local farmers and stakeholders to implement win-win nature-based alternatives which are suitable for the VMD's biophysical condition and can support the synergies of multiple ecosystem services in the region. In response to this, the research aims to develop the Land Utilisation & Capacity Indicator (LUCI) model to map multiple ecosystem services in the VMD and identify where synergies and co-benefits exists. Further, we will also assess how different land-water use scenarios, focusing on nature-based alternatives, affect ecosystem services in the region. The result is expected to support the establishment of effective nature-based alternatives that ultimately contribute to sustainability of the VMD and local farmers' well-beings.

Comparison of traditional and emerging methods of trend analysis and load calculation in Lake Rotorua streams

James Dare[1]
[1]*Bay of Plenty Regional Council*

Lake Rotorua has been vigorously studied since the 1960's, with results showing a steady decline in water quality coinciding with urban and agricultural development. As a consequence, cyanobacteria blooms have become more common over time, affecting the values of residents and tourists alike. The recently notified Plan Change 10 (PC10) is intended to help address these issues by providing a statutory framework to meet the proposed, total sustainable load target of 435 T of nitrogen per annum by 2032. The current study is part of a wider suite of scientific modules supporting the PC10 process, and the second to calculate nutrient trends and loads for the nine major inflows to Lake Rotorua.

Two methods of trend analysis were employed. The first used traditional seasonal Kendall or Mann-Kendall methods, while the second explored the use of the USGS' R package 'Exploration and Graphics for River Trends' (EGRET), based on the 'Weighted Regressions on Time Discharge and Season' (WRTDS) model. Load estimation was carried out using three different techniques: numeric integration; and two regression variants, USGS' Load Estimator (LOADEST), and WRTDS. Traditional trend analysis results were varied and dependant on site and period. In general, NNN and NH4-N concentrations improved across the entire dataset, although NH4-N degraded at a number of sites after 2009. Furthermore, TP and DRP were found to be degrading at most sites after 2009, while TN was highly variable. Inflow load estimates were comparable between methods, equating to an average of 412t TN and 35t TP in 2016, while DRP to TP load ratios highlighted an increasing contribution of particulate P in many catchments. Finally, EGRET analysis helped elucidate trends with regard to discharge, revealing increasing concentrations over time at higher flows, for a number of sites, while also showing significant potential for future council reporting applications.

Assuring quality of community-based water monitoring data

Robert Davies-Colley[1], Amanda Valois[1], Juliet Milne[1], Richard Storey[1], Rebecca Stott[1]
[1]NIWA

Water monitoring data must be of good quality (e.g., accurate, relevant) to assess state-of-environment and inform water resource management. Perhaps not surprisingly, therefore, water management agencies, while recognizing a valuable role for volunteer monitoring in education and awareness-raising on water issues ('citizen water science'), are often sceptical about quality of data collected by community volunteers. The term "quality assurance" covers a wide range of activities including: training, certification, standard protocols, auditing, and 'social' factors, but arguably replication of measurements by another agency (demonstrating reproducibility) comes closest to actually assuring quality. Recently, Storey et al. (2016) published comparisons of paired volunteer versus professional measurements and demonstrated satisfactory agreement for a wide range of state-of-environment reporting variables. We re-worked the paired data from this, and more recent, studies to assess both numerical agreement and correlation. Our results suggest that volunteers can produce useful data of good quality when professionally supported. Assessing agreement of volunteer versus professional measurements would seem to be a valuable part of wider professional support to confer confidence about reliability of volunteer data and diagnose any discrepancies. Indeed, parallel measurements by co-operating agencies, typically on joint sampling runs or 'regatta'-type activities, is recommended for demonstrating reproducibility of professional measurements in the recently-finalised NEMS-water quality standard. We outline a near future in which community engagement in water monitoring is more widely valued, and professional agencies, particularly regional authorities, replicate some volunteer measurements as part of a broad platform of on-going support for volunteer monitors.

Macrophytes in an ICOLL: an open and shut case?

Theo Mouton[1], **Mary de Winton**[1], Hugh Robertson[2], Emily Funnell[2], Jane Bowen[2], Sarah Crump[2]
[1]NIWA, [2]Department of Conservation

Coastal New Zealand waterbodies contain unusual macrophyte communities known for their tolerance to fluctuating salinity as these systems open to, or shut-off from the sea. Waituna Lagoon is an ICOLL in Southland that still retains native, Ruppia-dominated vegetation. Eutrophication risks to this vegetation are partially managed via lagoon openings to flush nutrients, but openings also need to maintain an appropriate ecological niche for Ruppia. Understanding the spatio-temporal responses of Ruppia to managed lagoon openings and habitat conditions is important to inform conservation strategies.

We examined variations in macrophyte and macroalgae distribution in relation to habitat conditions in Waituna Lagoon. Surveys in summer covered most of the Lagoon's possible habitat gradients and were undertaken between 2011 and 2018. Additional seasonal surveys were made between 2014 and 2017. We tested the hypotheses that physico-chemical variations with lagoon openings and with season interacted to significantly affect the composition of lagoon vegetation.

Results from multivariate ordination statistics and species distribution models confirmed that seasonal and physico-chemical conditions significantly interacted and explained most of the spatio-temporal distribution for vegetation assemblages. Specifically, a multivariate correspondence analysis indicated greater abundances of macroalgae during warmer periods. Analyses of individual ecological niches using Boosted Regression Tree analyses also showed clear differences in the ecological preferences of Ruppia species as opposed to macroalgae. Ruppia species had strong requirements for deeper, cooler habitat and clear waters, while macroalgae favoured warmer habitat, with other, contrasting responses to physico-chemical conditions between the vegetation groups.

Showing that macrophytes respond strongly to conditions associated with the open or shut status of Waituna Lagoon, as well as seasonal influences, confirms there is scope to optimise an opening regime that favours Ruppia vegetation.

DOC's Freshwater Stretch Goal "50 freshwater ecosystems restored - from mountains to the sea"

Tracie Dean-Speirs[1], David West[1]
[1]*Department of Conservation*

In 2015, DOC's executive established a series of new mid-term goals (known as "stretch goals"), to identify areas of focus for the department over the next 10 years. These included a Freshwater Stretch Goal "50 freshwater ecosystems restored – from mountains to the sea".

This paper provides an overview of DOC's progress on its Freshwater Stretch Goal, and the systems that have been developed to support it. Projects at the current stretch goal sites will also be discussed.

Conservation planning tools have been refined and further developed to support the identification of a national network of freshwater ecosystems for restoration under this goal. This has been necessary to identify potential catchments that best meet the 'mountains to sea', catchment-based aspirations of the goal, and maximise connectivity with freshwater ecosystems (or parts thereof) that occur within protected areas. An overview of this analysis, and the results of recent discussions with local staff to apply and test these national rankings will be given.

The relationship between this programme and other regional and national freshwater restoration initiatives will also be explored.

Behavioural response of Taupo anglers to new liberal fishing regulations.

Michel Dedual[1]
[1]*Department of Conservation, Taupo Fishery*

The overall goal of managing any recreational fishery is to find a balance between fish harvest and fish production that can maintain angler's satisfaction. Production is controlled by environmental factors and harvest by fishing pressure. Fishing pressure needs to be reduced or sometimes increased but always relies on fishing regulations. As anglers are the only tool that managers can use to maintain angler's satisfaction, the success of any regulation depends on how the angler are responding. In the Taupo fishery the decline in fish harvest due to the overall decline in license sales combined with increased practice of catch-and-release has resulted in reduced fish harvest that in turn leads to a decline in fish condition and consequently to angler's satisfaction. Regulations on daily bag limits and minimum size were relaxed in 2017 to encourage harvest. More than 700 creel anglers survey reveal that lake anglers responded by increasing their harvest by 20%. However, rivers anglers did not harvest more fish and didn't change their attitude toward catch-and-release.

Sediment traps as mechanisms for reducing *E. coli* concentrations in dairy farm streams

Megan Devane[1], Louise Weaver[1], Beth Robson[1], Erin McGill[1], Margaret MacKenzie[1], Catherine Febria[2], Angus McIntosh[2], Jon Harding[2]
[1]*Institute of Environmental Science and Research Ltd (ESR),* [2]*Canterbury Waterways Rehabilitation Experiment (CAREX), University of Canterbury*

In 2016, the Canterbury Waterways Rehabilitation Experiment team (CAREX) at the University of Canterbury installed two sequential sediment traps in the Silverstream catchment of the Selywn District. Financial support for the sediment traps was provided by the Department of Conservation and Fonterra through the Living Water Partnership. We hypothesized that sediment traps by design would reduce flow velocities sufficiently to settle out fine particles which would include particle-bound microorganisms.

In collaboration with CAREX, ESR began monitoring concentrations of the faecal indicator bacterium Escherichia coli in the inputs and outputs of the sediment traps over six seasonally aligned sampling events during 2016-2018. Average *E. coli* levels in Silverstream water and its tributaries ranged between 53 and 1950 *E. coli* /100 ml with the spring period recording the highest concentrations.

Consistent reductions of flow-weighted *E. coli* concentrations were observed as the stream flowed over sediment trap #2. Sediment trap #1 showed reductions but they were not as consistent. Other mechanisms of *E. coli* removal such as sunlight inactivation are likely to be contributing to lower *E. coli* concentrations as control sites also recorded reductions (albeit smaller) in *E. coli* loads. Importantly, monitoring showed that there was no accumulation of *E. coli* in stream sediments, which supported findings that sediment traps are not creating an environmental reservoir of *E. coli*.

Additional monitoring is ongoing to better quantify the magnitude of *E. coli* reductions during stream flow over sediment traps, the impacts of sediment clearance on trap functioning and the potential impact of multiple, sequential sediment traps. The talk will cover lessons learnt about sediment trap and stream channel design and how our learnings can improve best practice on farm and broaden our thinking on the effectiveness of in-stream and riparian management tools to address multiple indicators of water quality and ecosystem health.

Land, Air, Water Aotearoa (LAWA) – Behind The Scenes

Kati Doehring[1], **Abi Loughnan**[2]
[1]*Cawthron Institute,* [2]*LAWA Environmental Monitoring and Reporting Project*

Demand is increasing for readily available, high quality environmental information. In response to this, a partnership has been set up between central government, regional and unitary authorities and the Cawthron Institute, which focuses on improving the quality and consistency in collection, availability, and presentation of environmental data. LAWA (www.lawa.org.nz) was launched in 2014 and was a world first in presenting environmental freshwater data from an entire country – and is now reporting freshwater data to the public from approximately 1400 monitoring sites.

If you wanted to know: what exactly goes on behind the scenes? How does LAWA quality assure its freshwater data? What other environmental topics will be added to the platform in the near future? What initiatives are underway to make environmental data more accessible? - Come along to our session to get the answers.

Conservation status of New Zealand freshwater invertebrates – 2018 update

Tom Drinan[1], Kevin Collier[2], Russell Death[3], Natasha Grainger[1], Jon Harding[4], Troy Makan[5], Jeremy Rolfe[5], Brian Smith[6]

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The conservation status of 677 freshwater invertebrate taxa was assessed in 2018 using the New Zealand Threat Classification System criteria. This is the second freshwater invertebrate list to be prepared under the Townsend et al. (2008) system – the first occurred in 2013. The 2018 listing is the most comprehensive to date, with a number of additional taxonomic groups being assessed for the first time – Hemiptera: Heteroptera; and Nematomorpha: Gordiida.

The New Zealand Threat Classification System is administered by the Department of Conservation; however, the conservation status assessments are undertaken by panels of subject-matter experts. An overview of the New Zealand Threat Classification System and listing process will be presented, as well a brief description of the data and information used to inform the expert panel's decisions. An analysis of the change in conservation status of taxa from previous lists, along with some brief notes of the most notable changes, will also be presented.

A brief overview of the sampling requirements needed to collect rare and threatened freshwater invertebrates will also be discussed, using examples from a number of different taxonomic groups.

Townsend AJ, de Lange PJ, Duffy CAJ, Miskelly CM, Molloy J, Norton DA 2008. New Zealand Threat Classification System manual. Department of Conservation, Wellington. 35 p.

Environmental Education for Auckland's Industry - Industrial Pollution Prevention Programme

Rhianna Drury[1]

[1]Auckland Council

Auckland is New Zealand's largest city. Surrounded by water it has complex interconnections between natural aquatic environments, stormwater and wastewater. It has large industrial areas, some of which directly border sensitive habitats such as rivers and estuaries. It is widely accepts that stormwater is known to negatively impact the water quality and ecological health of streams, this impact is positively correlated to the density of development. Stormwater from heavily industrialised zones contributes to chronic and acute toxicity of aquatic organisms. Pollution from industrial areas is more likely to cause serious ecological damage as they handle larger volumes of potentially harmful liquids and substances, stormwater infrastructure accelerates pathway to natural water environments. Often spills in these areas go undetected or the source is difficult to trace. Poor understanding of stormwater connections to streams may explain why sites within industrial areas often do not have suitable pollution preventative measures and are ill-equipped to deal with a spill if it does occur.

Auckland Council introduced the Industrial Pollution Prevention Programme to educate businesses and industry about pollution hazards and best management practice to prevent incidents. Since 2014 the programme has visited over 3200 businesses and covered the much of Auckland's industrial areas. Over 95% of businesses approached accepted the voluntary advisory visit. More than half of the sites where risks were identified through the programme adopted recommendations soon after the visit, with 70% of recommendations adopted within 12 months. This presentation will outline the project approach, successes and limitations and its potential to attain behaviour change.

Invertebrates associated with macrophytes bought from aquarium stores in Canada and New Zealand

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[1]University of Waikato, [2]NIWA, [3]Great Lakes Institute for Environmental Research, The University of Windsor

Invertebrates hitchhiking with macrophytes being moved by the aquarium trade have gained increasing attention in recent years, but factors affecting the movement of species from stores to homes are poorly understood. We determined how macrophytes bought from stores act as vectors for transport of non-indigenous invertebrate species. We tested whether incidental invertebrates carried on macrophytes vary internationally by comparing the New Zealand and Canadian trades, and if macrophyte species with different morphologies carry different risks. We recorded a large variety of invertebrate species associated with Vallisneria spp., Sword plants and Elodea bought from stores, including species non-indigenous to both countries. Invertebrate community composition differed significantly between New Zealand (primarily domestically cultivated) and Canadian (primarily imported) bought macrophytes. Differences in composition between different macrophyte species were only statistically significant between wild-collected Elodea and the cultured species in New Zealand. Behaviours observed in stores, such as the amount of time macrophytes were removed from water before being placed in plastic bags for transport, did not affect the abundances or richness of incidental invertebrates transported, and thus did not appear to be effective in reducing invasion risk. We recommend management to reduce the probability of introduction of hitchhikers to home aquaria, from which risk of release to natural waters is greatest.

Advective transport modelling of Orari Plains water quality

Patrick Durney[1], Jen Dodson[2]
[1]DHI Water And Environment Ltd, [2]Environment Canterbury

To support ongoing regional planning work for South Canterbury, New Zealand, we developed a water quality model of the Orari Plains. The model simulated nitrate transport in the surface and groundwaters of the study area. We aimed to create a tool that lets decision makers test land use scenarios in a relative change framework.

The water quality (transport) model was built upon a previously calibrated MIKE SHE flow model of the study area. We used the advection-dispersion solver of MIKE SHE to model water quality. Our input data was in the form of a GIS shapefile of loads of Nitrate-Nitrogen (NO_3-N) that represented the NO_3-N loss from farming activities in the catchment. We applied this load approximately 600 mm below the surface of the model (in the unsaturated zone), allowing the model to calculate recharge concentrations from water infiltration following a recharge event or from discharge concentrations because of groundwater upwelling. We specified sources of river water quality at the model inflow boundaries.

Model calibration was limited to transport parameters and primarily involved adjustment of saturated zone porosities and advection parameters. Although the water quality transport model was reliant on modelled inputs for sources of NO_3, the model performs well against measurements taken across the study area. The model performance provides confidence that both the inputs and the model setup and functions are reasonable and hence can be used for catchment-scale water quality assessments in the relative change framework. The modelling suggests that unless land-use changes take place to reduce the nutrient loads coming into the study area long-term the water quality will decline slightly from the current state. Despite overall declines in water quality, immediately adjacent to Orari River, groundwater quality will be maintained because of rapid recharge from the river.

Local Authories response to Lindavia incursion in New Zealand

Stephanie Dwyer[2]
[1]*Otago Regional Council,* [2]*Lincoln University*

New Zealand's economy, unique environment and the community is constantly threated by the introduction of invasive pests entering the country through imported goods, mail and travellers. In New Zealand, the Biosecurity Act (BSA) 1993 is an Act to restate the law relating to the exclusion, eradication, and effective management of pests and unwanted organisms. Currently, Otago Regional Council (ORC) is operating under the BSA to address an invasive gelatinous alga called "Lake Snow". Lake Snow were originally discovered in Lake Wanaka in early 2000's and has now become widespread throughout North and South Island. The media are asking the question "Why did Otago Regional Council take so long to address lake snow?" The main aim of this research was to analyse the challenges that arise within institutional body's ability to form frames and framing, due to risk and uncertainty that invasive species pose. Otago Regional Council's approach to identifying and managing lake snow under the BSA was analysed using a single case study.
This research found that how a biosecurity threat such as lake snow is framed can strongly influence regional council's ability to respond and approach invasive pests. A biological risk can be framed in a variety of ways due to different scientific, community knowledge, social institutions, and challenges incorporated in understanding the phenomenon. Non-government organisations and freshwater scientists have framed lake snow as a biological risk at the earlier stages of detection, whereas Otago Regional Council was reluctant to frame lake snow as a biological incursion due to the lack of scientific evidence. The high uncertainty surrounding invasive pests in New Zealand can make it more difficult to detect invasive pests, and determine and manage the effects that pests may pose to the overall health of water users and water quality.

Elucidating climate change effects on longfin and shortfin eels using multi-decadal (1960 – 2012) otolith growth reconstructions

Mike Beentjes[1], Don Jellyman[1], **Eimear Egan**[1], Shannan Crow[1]
[1]*NIWA*

The effects of environmental variability associated with climate change on New Zealand's longfin (*Anguilla dieffenbachii*) and shortfin (*Anguilla australis*) eels are unknown. It is increasingly shown that climate change is affecting the marine larval dispersal routes of eel species worldwide. However, the effects of climate change during juvenile and adult freshwater residence is poorly understood. In New Zealand, the longevity and slow growth rates of eels suggests they may be particularly susceptible to climate change effects during their freshwater life phase.

Here, we reconstruct otolith-derived growth histories of shortfin eels from lakes and rivers in New Zealand to investigate climate effects on growth rates. Archived and contemporary otolith collections from 1970 to 2014 were used to generate growth chronologies spanning up to 50 years. Mixed effects modelling was used to partition annual growth rates into intrinsic (e.g. sex, ontogeny) and extrinsic (e.g. temperature, precipitation, Southern Oscillation Index) components, to better understand drivers of annual and multi-decadal growth rate variation. We discuss the application of this bio-chronological approach to understand multi-decadal patterns in eel growth rates and implications for their life histories.

Dairy Typologies: A means to Quantifying the N and P Footprint across Spatial Scales. From Farm to Nation.

Hans S. Eikaas[1], Ross Monaghan[2], David Burger[1]
[1]*DairyNZ,* [2]*AgResearch*

A growing number of NZ dairy farmers are required to report on nitrogen and phosphorous losses from farms to water. This is facilitated by a computer model (OVERSEER) that calculates the flow of nutrients on a farm and produces nutrient budgets and estimates of greenhouse gas emissions. OVERSEER also provides estimates of N and P losses to water for a particular farm through a series of sub-models that mimic known bio-physical processes and incorporate some important effects of farm management. However, calculation of losses across larger spatial scales, such as a catchment, require significant effort and access to farm-specific information.

To enable broad scale analysis, we have established a framework of dairy farm typologies. Based on case-study farm attributes and key dairy agro-ecosystem (AE) types, and encompassing the broad range of landscape features and management systems typical of NZ dairy farming, we have defined a set of 62 dairy typologies. This approach, which uses freely available spatial datasets, allowed us to define risk zones for farm-scale losses of N and P based on landscape features that influence N and P loss within each AE region. Wetness, soil drainage status, slope, soil anion storage capacity and temperature were key attributes used in this approach.

When the N and P budgets for each typology (in kg/ha/yr) are applied to a farm boundary coverage, we can estimate the nutrient losses for dairy farms across the country. In this way we can extrapolate the estimated nutrient footprint from dairy farms, to sub-catchments, catchments, constituency, districts, and the whole country.

A next step in this approach is to consider establishing typologies for other land-uses, and then ultimately couple the typologies and their annual loads with stream flows. The outcome could be a model that would allow us to target mitigation incentives where one would get the best return for the efforts, both in terms of cost and improvement in water quality.

Design considerations for constructed treatment wetlands mitigating diffuse pollution from intensive agricultural catchments

Rebecca Eivers[1]
[1]*Streamlined Environmental*

Constructed treatment wetlands (CTWs) have been implemented as mitigation tools to manage diffuse pollution from intensive agricultural catchments. This study investigated CTW efficacy and evaluated different predictors of performance in shallow Waikato (New Zealand) peat lake catchments, exploring morphological and environmental variables which influence treatment efficiency. The CTWs were comprised of a sedimentation pond 'module', with around half including shallow wetland-modules planted with native species, and three with additional sedimentation pond-modules. The inflows were surface-flow watercourses diverted from modified or artificial drainage networks, and the outflows were either surface-flow (through drainage channels or culverts), or filtration (through vegetated riparian margins). Morphological predictors of CTW performance included area (range 7 – 1950 m^2), depth (0.2 – 2.1 m), volume (12 – 2030 m^3), Wetland to Catchment Area Ratio (0.01 – 1.18), hydraulic retention time (0.2 – 37.2 h), and hydraulic loading rate (0.4 – 130 m/d). The presence/absence of macrophytes as well as outlet type and the number of CTW modules were included as categorical variables. Reductions in nitrogen (N), phosphorus (P) and suspended solids (SS) differed considerably across CTWs, driven by varying influent concentrations and dominant forms of N, P, and SS, as well as CTW morphologies. Generally, CTWs with larger areas and volumes improved removal performance of nitrate, total N and coarse sediments, while deeper CTWs more effectively reduced particulate N and volatile SS. Macrophytes improved removal of nitrate and P, whereas filtration outlets frequently increased ammonium. Greater accumulated sediment depths significantly reduced P removal efficiency, signifying the importance of CTW maintenance. Increasing the number of CTW modules largely improved performance, thus implementing individualised treatment-train concepts is recommended.

Eutrophication Risk Assessment: Linking Across Freshwater Environments

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Nuisance primary production and dissolved oxygen depletion associated with nutrient enrichment remain of high interest to land and water managers. There is a need to quantify relationships between nutrients and primary production responses, and to link responses across environments (tributaries, lakes, rivers, estuaries) in a spatial context, so that critical response locations and types can be identified, leading to targeted nutrient reductions or other controls. In this paper we provide an overview of recent and current laboratory and field investigations of eutrophication responses across nutrient gradients in multiple environments in the NIWA Eutrophication Risk Assessment programme, and introduce a preliminary integrative decision support framework and modelling approach.

Does the past matter? The influence of disturbance history on community resistance to future disturbance

Roland Eveleens[1], Angus McIntosh[1], Helen Warburton[1]
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Widespread changes in disturbance regimes are either already occurring or are predicted within freshwater ecosystems due to human development and global climate change, which may drive shifts in community composition. Both disturbance history and type are likely to structure communities through filtering processes selecting for particular species traits. For example, the history of flooding likely leads to communities resistant to floods. However, these communities could be susceptible to other types of disturbance. Consequently, knowledge of the separate and interactive influences of disturbance history and type on community composition is needed to understand community resistance to future disturbances. We used an in-stream channel experiment to test how the disturbance resistance of aquatic macroinvertebrate communities were affected by changes in disturbance. Channels placed in five stable spring-fed streams and five highly disturbed streams (disturbance history) were used to manipulate disturbance type including rock-rolling to simulate flooding, low-flow and undisturbed controls. We found that the effect of disturbance type (rock-rolling vs low flow) on the composition of aquatic macroinvertebrate communities was dependant on disturbance history. In stable streams, low-flow conditions had a greater effect on the composition of macroinvertebrate communities than rock-rolling, while low-flow and rock-rolling had similar effects in disturbed streams and there was no significant difference in the effect of rock-rolling across disturbance histories. In addition, our results also suggested that species traits influenced responses to disturbance because species groups displayed contrasting responses to disturbance with sedentary species much more affected by disturbance. Therefore, antecedent disturbances likely affect community responses to further disturbances with disturbance type and history both influencing how resistant communities are to disturbance. Overall, less frequently disturbed communities are more vulnerable to changes in disturbance regimes, and so the influence of disturbance history should be considered when managing the impacts of changes in disturbance regimes.

Changes in the water chemistry of Cannel Creek following remedial works at Bellvue Mine

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Acid mine drainage (AMD) is an environmental phenomenon where the dissolution of metal sulfides from an ore body results in an acidic solution containing high concentrations of sulfate and heavy metals. When this solution enters a stream environment the receiving environment becomes degraded and the aquatic ecosystem impacted. Remediation of AMD waters aims to raise the pH to near-neutral conditions and remove heavy metals from solution so that their concentration is no longer at a toxic level. One way to treat AMD is through the use of Sulfate reducing bioreactors (SRBRs).

At Bellvue mine, West Coast NZ, untreated AMD was discharged into a nearby stream, Cannel Creek. This resulted in the stream becoming degraded and the aquatic ecosystem impacted. SRBR's have been installed at Bellvue mine to treat the AMD water before it enters Cannel Creek so that the stream ecosystem can recover.

Monitoring of water chemistry in Cannel Creek prior to and following the installation of the SRBRs has shown that immediately downstream of where the AMD enters the stream, pH has increased from 3.2 to >6.5. Dissolved Fe, Al and Ni concentrations have been reduced by >80%. Dissolved Zn and Co concentrations have been reduced by >60%. This section of the stream now meets water quality guidelines for aquatic ecosystem protection for all metals, except Al which is naturally high in the streams in this area, when AMD flow is <1.5L/s (88% of time).

Freshwater trends for the Asia-Pacific Region and the importance of training early-career scholars in science-policy

Catherine Febria[1]
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The Asia-Pacific region (APR) is home to more than 4.5 billion people across 60 countries. Nearly half of the world's biodiversity hotspots are found here and it is also a region with the greatest linguistic, socioeconomic and cultural diversity. APR is facing unprecedented threats from a growing population, extreme weather events, agricultural intensification and pollution. If aspirations for global sustainability are to be achieved and losses in biodiversity and ecosystem services can be reversed or slowed, a global community of scientists and decision-makers must work together on multiple fronts. Here I present an overview of the UN Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and in particular a summary of freshwater data synthesised in the inaugural APR assessment. For this assessment, more than 120 experts from 27 countries conducted a scientific review of biodiversity and ecosystem services over a three year period (2015-2018). One of the major headlines was that Asian commercial fish stocks could be depleted by 2048 and freshwater ecosystems are among the most vulnerable to climate change. And yet considerable data gaps exist particularly for freshwater ecosystems in the Pacific Islands, and coverage of data on ecosystem types and taxa are patchy. By nation, spatial coverage of freshwater data is consistent with the Global North and South divide. IPBES was modelled after the Intergovernmental Panel on Climate Change (IPCC) now in its' 5th iteration since its launch in 1998. A distinct difference between the two platforms is a capacity building function in IPBES including a Fellows program for early- and emerging scholars at the science-policy interface. I discuss the role of IPBES Fellows and expand on the critical role of training new experts to bridge disciplinary, generational, and science-policy divides.

Consumption of kōura in Lake Rotoiti by brown bullhead catfish: a risk assessment

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We investigated the impact that predation by brown bullhead catfish (Ameiurus nebulosus) may be having on freshwater crayfish (kōura; *Paranephrops planifrons*) in Lake Rotoiti through (i) stable isotopes and stomach contents analyses, and (ii) comparisons of kōura sizes and numbers in areas with different densities of catfish. Our hypothesis is that catfish, which have undergone a recent range expansion in Lake Rotoiti (Bay of Plenty), pose a significant risk to kōura. Globally, catfish introductions have been associated with reductions in native biodiversity through direct consumption, and by degrading habitat and water quality, largely through the bioturbation of sediments. In Lake Taupo, kōura were found in 85% of stomachs from large catfish found in rocky habitats. Preliminary results from Lake Rotoiti catfish indicate that <5% of stomachs analysed (n = 185) contained kōura.

We collected kōura with baited fyke nets and whakaweku (bracken fern bundles). Whakaweku caught smaller kōura (size range: 11 – 31 mm OCL, n = 17) compared to baited fyke nets (size range: 13.4 – 53.5 mm OCL, n: 976). Our study will help further the limited understanding of the direct effects that catfish have on kōura, and provide a basis for informing future management decisions involving catfish in Lake Rotoiti.

Rapid genetic adaptation offsets plastic increases in body growth rate under warming

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Trait responses can mediate the ecological outcomes of anthropogenic change. These trait responses are the product of within-generation (plastic) changes and among-generation genetic (evolutionary) changes. Much attention has focused on plastic changes because they are obviously rapid, but an abundance of evidence now suggests that evolutionary changes can also be rapid and can be ecologically-meaningful. Thus, predicting trait and ecological responses to anthropogenic changes like warming may require understanding whether evolutionary responses offset or exacerbate plastic responses. To decouple short-term evolutionary responses from plastic responses to warming, we second-generation common-reared populations of a globally invasive fish (*Gambusia affinis*) which were recently established along a substantial geothermal gradient. All populations grew substantially faster at higher rearing temperatures via plasticity. However, recent evolution at warmer temperatures significantly offset this plastic increase such that the actual temperature dependence of growth (i.e. populations reared at their “home” temperatures) was less than half that produced purely by plasticity. Our preliminary ecological experiments suggest this rapidly evolved “countergradient variation” may have consequences for population dynamics and trophic interactions under a warming scenario. If the rapid evolution of countergradient variation in growth is common in nature, we must significantly alter our predictions for ecological responses to climate change.

Challenges in updating copper and zinc water quality guidelines for Australia and New Zealand

Jennifer Gadd[1], Chris Hickey[1]
[1]*NIWA*

The update of the Australia and New Zealand water quality guidelines includes updating the copper and zinc toxicity guidelines values for freshwater and marine waters. The previous guidelines were derived in the late 1990s and our understanding of toxicology and environmental chemistry has progressed considerably over that time. There has also been more data published showing toxicity at low concentrations to some sensitive species, such as the glochidial stage of freshwater mussels. Metal toxicity is influenced by the water quality, including the pH, hardness and the presence of dissolved organic matter (measured as DOC). These aspects need to be incorporated into water quality guidelines to ensure that while they are fully protective of sensitive species, they are not overly stringent where modifying conditions exist. There are diverse ways that modifiers have been incorporated into water quality guidelines internationally; each with different advantages.

This talk will cover the effects of these water quality modifiers on toxicity of copper and zinc as shown internationally and in NZ species. It will also cover the way that modifiers have been incorporated into the ANZ water quality guidelines; the effects of these on the default guideline values; and a comparison of modified and non-modified guidelines to measured in-stream copper and zinc concentrations.

Collaborating with mana whenua

Kathryn Gale[1]
[1]*Aukaha*

There is an abundance of western scientific monitoring of natural environments undertaken across Aotearoa, but only recently has attention been given to measuring cultural health. Cultural health information is important because of the significance of natural environments to Māori identity and wellbeing. However there appears to be little weight given to these cultural values, or cultural values are compromised in favour of other values in land use and freshwater decision making. Increasingly scientists, resource managers and stakeholders can see the benefits of more inclusive water management that is responsive to cultural beliefs, values and uses.

Aukaha (an environmental consultancy working for Ngāi Tahu in Otago) and Lincoln Agritech (a research and development company based in Canterbury and Waikato) recently collaborated on a research project examining how land use change affects water and mahinga kai in Otago.

This research was funded through the Vision Mātauranga Capability Fund, and was designed to meet requirements regarding the inclusion of mātauranga Māori and mana whenua in the research. This was the first collaboration between Aukaha and a research and development organisation, and many lessons were learned about how to enable meaningful collaboration between Māori and research and development organisations. This presentation will discuss how to best engage with mana whenua based on experience of the collaboration.

Whakamanahia te mātauranga o te Māori: empowering Māori knowledge to support Aotearoa's aquatic biological heritage

Tohe Ashby (Ngāti Hine, Ngā Puhi)[9], James Ataria (Rongomaiwahine, Ngāti Kahungunu, Ngāti Raukawa)[1,2,11], Jim Doherty (Ngāti Manawa)[6,7], Simon Lambert (Ngāi Tūhoe, Ngāti Ruapani)[10,11], Melanie Mark-Shadbolt (Ngāti Kahungunu, Ngāti Porou, Te Arawa, Te Ati Awa, Ngāti Raukawa)[1,3,11], **Gary Owen Garner (Ngāti Ranginui)[11]**, Kevin Prime (Ngāti Hine, Ngāti Whātua, Tainui)[3,5,11], Aroha Te Pareake Mead (Ngāti Awa, Ngāti Porou)[4], James Waiwai (Ngāi Tūhoe, Ngāti Ruapani, Ngāti Awa, Ngāti Kahungunu, Tūhourangi)[8]

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As Aotearoa New Zealand grapples with developing solutions to complex issues surrounding its unique freshwater and marine biological heritage, there is a growing recognition that mātauranga Māori can be 'unlocked' and used with great effect alongside western science. Examples where appropriate consideration and development of robust methodologies for the application of mātauranga Māori coexisting alongside western science are increasing. Unfortunately, despite the benefits that can be derived from this collaboration, the quality of engagement is not always satisfactory often due to poor interpersonal relationships and misidentification of the knowledge holders. By providing an appropriately historical context, we consider the critical issues now facing mātauranga and the Māori knowledge holders today, and fundamental requirements that will empower application of this knowledge within bio-heritage management. We contemplate how the development of a methodology between mātauranga Māori holders and potential end-users might contribute to improved outcomes for Aotearoa's biological heritage.

Advancing the assessment of environmental flows for estuaries

Eleanor M Gee[1]

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Estuaries, similarly to riverine systems, are impacted by flow alteration. New Zealand's National Policy Statement for Freshwater Management requires the establishment of minimum flow limits for rivers and streams and that regard be given to connections between freshwater bodies and coastal water. To achieve this, water resources managers need to assess the environmental flow needs of the estuaries they manage. However, the application of environmental flows science to estuaries has lagged behind riverine applications, partly due to the complexity of flow-response relationships in estuaries due to the added influence of the sea. Environmental flows for estuaries are still assessed largely on an ad hoc basis for individual systems, and managers often therefore struggle to identify a starting point or approach to environmental flows assessments. To address this, a conceptual framework is presented that sets out an approach to characterising the environmental flow requirements for estuaries. The framework includes consideration of estuary geomorphology, the relative influence of sea and riverine forcing, and the valued services the estuary provides. A review of the evidence for the impact of freshwater flow alteration on various types of New Zealand's estuarine ecosystems, categorised based on their geomorphology and hydrodynamic influences, is also presented.

Waiwiri: Trembling waters, beauty of the South...plans to restore a Manawatu lake catchment

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Waiwiri is a small coastal area that includes a spring-fed perched dune lake; Lake Waiwiri (Papaitonga) in the Papaitonga Scenic Reserve. The Waiwiri stream flows west from the lake to the Tasman Sea. The lake is very shallow and is the only remaining lake bordered by an undisturbed sequence of wetland to native forest in the Horowhenua/Wellington region. It is an important taonga to local iwi and the area contains rare plants and wildlife, including endangered land snails. However, over the last two decades, the lake's water quality has been quickly degrading.

All those characteristics made the Waiwiri catchment an ideal candidate as a stretch goal site (see Tracie Dean-Speirs's presentation). This presentation will discuss scientific (with a focus on water balance and water quality data), cultural and management challenges associated with the site. A proposed approach will be presented that aims to restore and sustain the ecological functioning and biodiversity of the Waiwiri freshwater and coastal ecosystems, from its headwaters to the sea, by working with local Iwi, councils and the community.

Citizen Science and Freshwater Monitoring in Aotearoa from an NGO Perspective

Liz Gibson[1,3], **Kim Jones**[2,3]
[1]Mountains To Sea Wellington, [2]Mountains To Sea Conservation Trust, [3]The Whitebait Connection

The Whitebait Connection (WBC) programme is a national freshwater education, restoration and citizen science project aimed at empowering and supporting communities in conservation for freshwater. Through a model of collaboration between schools, community groups, restoration project partners, and science organisations we have established many restoration and scientific monitoring projects for streams, rivers and wetlands throughout Aotearoa. This process begins with experiential education and engagement, followed by restoration planning and action, underpinned by community led freshwater monitoring. WBC use a wide range of current protocols and tools for assessing impact and informing restoration, as well as partnering with science institutions to develop and support new freshwater monitoring tools. In our community science we focus on training groups in ecological health monitoring, freshwater fish surveys, and inanga spawning habitat assessments. Working with schools and community groups, training them to independence in freshwater monitoring, boasts an interesting array of challenges, opportunities and rewards for the environment and the partners involved. This is told through stories and experiences of WBC from case studies of restoration and community science partnerships from across the country.

Trialling stream rehabilitation tools to attenuate high nitrate loads in agricultural headwaters

Brandon Goeller[2], Catherine Febria[1], Jon Harding[1], Angus McIntosh[1]
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Small agricultural waterways and the groundwater, tile drains, and riparian seeps they intercept can contribute disproportionately to downstream nutrient loads. Thus, treating nitrate loss using a multiple tool, multiple-scale approach in small waterways could offer improved management of these sources. We trialled stream rehabilitation tools as part of the Canterbury Waterway Rehabilitation project in spring-fed, lowland agricultural headwaters with high nitrate-N >10 mg L-1 (CAREX; www.carex.org.nz). We tested the suitability of three small (< 30 m3) denitrifying woodchip bioreactors implemented along a waterway with stream bank re-shaping and native riparian planting in place along a 1000-m reach and compared this to a control waterway with no rehabilitation. In a three-and-a-half-year trial, riparian rehabilitation enhanced reach nitrate flux attenuation compared to pre-rehabilitation attenuation, but only under relatively low flow conditions. In both the control and treatment waterways at all times, N fluxes increased when reaches gained water downstream, likely due to groundwater N inputs. To address the N loads not removed along the riparian corridor, we experimentally added in-stream wood in four waterways. Sampling longitudinally in paired 400 m reaches (upstream control, downstream treatment) over six-months revealed enhanced nitrate removal averaging between 2.5 to 3.5 mg L-1 NO3-N (90 % CI for mean reductions across waterways). These substantial nitrate depletions were manifested sporadically at different locations downstream of the wood and at different times.
The nitrate removal associated with organic matter amendments was surprising, given the overwhelming inputs of high nitrate from groundwater. Overall, a multiple-tool, multiple-scale application of rehabilitation tools can reduce downstream N fluxes. However, these will not replace catchment-scale nutrient plans to address losses from land and legacy groundwater N pollution, and local rehabilitation tools like those trialed here will need to be scaled appropriately if they are to significantly attenuate nutrient losses from small agricultural waterways.

The New Zealand Whitebait Fishery - current knowledge and research gaps

Jane Goodman[1]
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The whitebait species and the fishery are managed by the Department of Conservation (DOC) under several pieces of legislation. Regional Councils also play a role in the conservation of these species through managing the adverse effects of resource use on habitat and water quality.

Critical to the conservation and management of these species and the fishery is collating existing information and identifying gaps, so that decision making about future management can be better informed.

This presentation summaries current knowledge about migratory galaxiids and the whitebait fishery; and outlines the process being undertaken to look into future options for management.

Key conclusions of this collation of research and identification of information gaps are:

- Habitat and distribution of all five species are well researched and experts can largely describe their 'preferred' adult habitat.
- Excluding īnanga, the spawning habitats of the four other species – kōaro, banded kōkopu, giant kōkopu and shortjaw kōkopu are poorly documented.
- Little conclusive research about the effect of harvest on the five species. Some attempts have been made to collect catch data, but these have largely been unsuccessful and/or inaccurate.
- Recent studies have increased knowledge about the catch composition of species nationally, the spawning habitats of two galaxias species and the ecology and biology of īnanga whitebait migrations.
- Limited understanding of the stock structure and life history of the species, with recent studies suggesting these may vary greatly between species and regions.
- Little information is available on the larval phase of the migratory galaxiids – where they develop (freshwater or marine environments), their swimming ability, diet and the threats and pressures these tiny fish are subject to.
- Pressures on and threats to these species are relatively well known however the magnitude of each impact on each species is not well understood.

Stream community recovery trajectories following progressive forest harvesting vary by disturbance frequency and magnitude

Elizabeth Graham[1], John Quinn[1], Aslan Wright-Stow[2], Brian Smith[1]
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Resistance and resilience describe the capacity of an ecosystem to withstand and recover from a disturbance or stress. Resistance and resilience are determined by the interactions of species and their environments across temporal and spatial scales. Diverse communities are predicted to have greater resistance and/or resilience because they are more likely to contain species which will respond differently to the disturbance, thereby maintaining structure and function (i.e. positive resistance and resilience). On the other hand, multiple disturbances over time have been shown to result in a reduced but stable community (i.e. potentially negative resistance and resilience).

We investigated the relationships between disturbance frequency and magnitude and community resistance and resilience in fifteen Coromandel forest streams over a 20-year time series of progressive catchment harvesting. Forest harvest is associated with a range of specific disturbances, such as changes to hydrology, sediment, nutrient, and organic matter inputs, temperature, water quality, and habitat structure. Streams varied in both catchment size and harvest intensity. Community recovery trajectories were characterized using distance-based metrics in ordination space. Streams with smaller catchments in which a large proportion of the catchment was harvested at a single time showed faster recovery than streams in larger catchments where a smaller proportion of the catchment was harvested repeatedly over several years. Streams with multiple harvests also had greater variation in community composition over time. A beta diversity partitioning analysis showed that community dissimilarity due to nestedness increased in streams subject to multiple harvests, indicating a subset of resistant fauna, while community dissimilarity due to turnover increased more in streams where the majority of the catchment was harvested at once, suggesting greater community resilience. Understanding patterns and drivers of positive and negative community resistance and resilience will not only aid in predicting community recovery trajectories post-disturbance, but potentially post-restoration as well.

What do we know about groundwater ecosystem functions, values and threats?

Michelle Greenwood[1], Graham Fenwick[1], Juliet Milne[1], Erica Williams[1], Erina Watene-Rawiri[1]
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New Zealand's groundwaters are important sources of drinking water for people and livestock, support diverse agricultural and industrial activities, and culturally are highly significant. The ecological communities within groundwater ecosystems (GEs) likely function to support many of ecosystems services GEs provide. For example, processing by microbes and invertebrates may bioremediate some contaminants and invertebrate grazing and bioturbation likely helps maintain hydrological connectivity within and between groundwater and surface water bodies. However, we know very little about what lives in GEs, and even less about how they function, how they support ecosystem services and how they may respond to pressures such as groundwater contamination or water abstraction.

Recognition of the importance of GEs and the services they provide is increasing in New Zealand, as has already occurred in countries such as Australia and the United States. The National Policy Statement for Freshwater Management (NPS-FM 2014) and proposed National Environmental Standard on Ecological Flows and Water Levels both explicitly reference groundwater or aquifers in an ecosystem health context. At a regional scale, objectives to safeguard the ecosystem health values of both GEs and connected surface water ecosystems are starting to be included in regional plans. However, the lack of knowledge surrounding GEs and the fact that they function differently from surface water ecosystems presents a challenge for the sustainable management of these systems. A greater understanding of how GEs function and respond to different threats will assist with setting water quality and water quantity limits that adequately protect GE health.

In this talk we provide a synthesis of current knowledge of the organisms present in GEs, how GEs function, and the ecosystem services and values supported by GEs. We identify known threats to GEs and priority research needed to help sustainably manage GEs.

Reconstructing lake diatom community change: comparing novel DNA metabarcoding with traditional morphological techniques

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In New Zealand 37% of monitored lakes have eutrophic to supertrophic productivity status largely due to intensive agricultural land-use. While environmental information is available for some lakes, long-term monitoring data are generally lacking, limiting knowledge on lake natural state and evidence for the causes of decline. Sedimentary diatom community composition is a commonly used proxy for reconstructing paleolimnological environments. Whilst well-established and effective, traditional morphological techniques are time consuming and restrict the temporal resolution and spatial scope of paleo-reconstructions. New DNA barcoding methods show potential for more efficient reconstruction of paleo-communities. However, development of these methods for diatoms remains limited, and there are few examples where they have been compared against traditional identification techniques. We compared the use of DNA metabarcoding with microscopic identification, for reconstructing the sediment diatom community profile of Lake Johnson, a eutrophic lake in the South Island. Extracted DNA was analysed using metabarcoding of the V4 region of the 18S rRNA gene. Results differed substantially among the two methods. DNA metabarcoding yielded significantly lower species richness, and increasingly poor performance with sediment age. Some taxa were identified to higher taxonomic resolution by DNA metabarcoding than was possible by morphological identification. Limited regulation and extent of DNA reference database, DNA degradation, and taxonomic resolution of the 18s gene could explain limited performance of metabarcoding. We suggest future studies explore the use of shorter gene sequences, larger volumes of sediment for DNA extraction, and construction of a regulated reference database. This study highlights some of the challenges associated with using DNA metabarcoding on ancient sediments, as well as its potential to overcome some of the limitations associated with paleolimnology. With further research and method development, DNA metabarcoding of diatom community composition has potential to complement traditional paleo-reconstructions and provide novel insights into lake ecosystem response to long-term agricultural impacts.

Sediment delivery from erosion source to catchment outlet – where should erosion-management be focussed?

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Fine sediment is a major contaminant of many New Zealand rivers and downstream receiving environments (e.g. lakes and estuaries). There is a growing requirement in regional and national policy to reduce sediment delivered into water bodies by immobilising the sediment at its source. The challenge we face is to accurately map sediment sources to direct effective erosion mitigation expenditure. This is complicated because sediment transfer downstream is rarely a direct process but involves exchanges between the river and riparian storage (e.g. bank deposition and erosion).

Various tracing techniques have been used individually to apportion long-term average sediment load to sources in terms of either land-cover, rock-type, or erosion-process. However, application of those techniques provides little information about recycling through storage, delivery efficiency between source and sea, exact primary source locations, and source variation within flood hydrographs. They therefore provide diffuse information of where erosion management should be located.
In this presentation, we explain how an integrated sediment tracing approach coupled with sediment load sampling at high temporal resolution can help us to identify the sources of each constituent of the suspended load at any stage of the river hydrograph. This, in turn, will pin-point those sources having the greatest time-weighted impact on sediment-related environmental variables (e.g. water clarity, sediment deposition).

We also describe a development of the grid-based tracing technique to: i) better represent tracer properties within source types and thus improve the accuracy of the sediment tracing results, ii) increase the granularity of the sediment source maps and characterise sediment source hotspots at a spatial resolution exceeding that of the source type areas. This high-resolution erosion data can be related to catchment characteristics including soil-type, slope position, and proximity of sources from waterways. These approaches will provide basic science advances that have profound implications for erosion control and mitigation.

The Illinois River Watershed, USA – The Convergence of Science and Policy

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Elevated phosphorus concentrations in the Illinois River Watershed (IRW) have long been an environmental issue between the states of Arkansas and Oklahoma, USA. These issues were addressed in a statement of joint principles and actions in 2002, where landscape and effluent management changes were defined. The phosphorus concentrations then decreased from ~0.4 mg L-1 in base flow during summertime to less than 0.1 mg L-1, which is still greater than the water quality standard (0.037 mg TP L-1) in downstream Oklahoma. However, the US Environmental Protection Agency developed (and recently released) watershed and lake models to be used in total maximum daily load (TMDL) evaluation of the phosphorus sources. In 2013, a second statement of joint principles and actions was developed to address where the water quality standard was applicable to protect aesthetic water quality conditions – specifically the point at which a statistically significant shift occurred in algal biomass and composition. The 'joint phosphorus study' was conducted by an independent third party under the supervision of a committee representing both states, showing changes in various algal metrics at phosphorus concentrations as low as 0.010 mg L-1 to over 0.070 mg L-1. Thus, the 'joint committee' recommended an average phosphorus concentrations of 0.035 mg L-1 over a six month period during critical flow conditions was sufficient to protect from nuisance conditions (based on the results from the 'joint phosphorus study'). The phosphorus concentrations in the IRW near the Arkansas and Oklahoma border have been relatively stable since 2010, but there might be recent shifts downward following additional watershed management changes. The missing piece for the IRW would be understanding legacy phosphorus and landscape management changes, and how this influences source apportionment and changes over time.

Ecosystem services at Lake Wairarapa: insights into its past, present, and future

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Ecosystem services encompass the wide range of intrinsic and extrinsic benefits that humans derive from ecosystems and how such services contribute to community wellbeing. The provision of effective and efficient ecosystem services at Lake Wairarapa (a shallow, super-trophic, coastal lake in the lower North Island) has been heavily impacted through anthropogenic use since human arrival in the area.

In order to address the degradation of ecosystem services, this study aimed to take a holistic approach exploring the past, present, and future of Lake Wairarapa through three distinct, yet complementary studies.

The first involved a paleolimnological study using a sediment core taken from the centre of the lake. A range of variables were analysed including: charcoal, grainsize, geochemistry, and environmental DNA. Results highlight that successive periods of settlement by early Māori and European communities converted the surrounding landscape through fire clearance to enhance food provision, subsequently impacting regulation of catchment erosion and increasing cyanobacterial presence.

The current catchment is now dominated by agriculture. The second study focussed on utilising the antimicrobial properties of mānuka to reduce nitrogen leaching and *E. coli* contamination through riparian management. A field trial of 5000 mānuka and a greenhouse trial comparing mānuka, rātā, horopito, and pasture suggests that mānuka provides a potential mitigation strategy to reduce pervasive agricultural pollution and enhance provisioning and regulating ecosystem services.

Acceptance and implementation of future lake and catchment management strategies are contingent on the values and visions that communities hold. The third study used qualitative interviews to investigate cultural ecosystem services and the values that people derive from the lake ecosystem. It also explored their visions for the future regarding community wellbeing, management, and ecosystem health at Lake Wairarapa.

Multi-disciplinary and holistic approaches provide a framework for developing a positive and inclusive future for Lake Wairarapa and its communities.

Development and implementation of a robust, regionally representative water quality monitoring network for lakes

Deniz Ozkundakci[1], **Mark Hamer[1]**, Edmund Brown[1], Asaeli Tulagi[1], Matt Barson[1]
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Understanding both, the current condition of an environmental resource and how it is changing over time is crucial for sustainable resource management. Carefully designed and implemented monitoring programs will likely produce accurate information of the status of the measured resource for the time period of interest, which ultimately provides the base line information needed to detect temporal changes. This accuracy depends on the design of the survey, the measurement procedure and method, and components of natural variation; i.e. if the extent of the natural variation (i.e. variability) within a given ecosystem is large, many samples must be taken and analysed to obtain a high level of certainty, for example, in an annual mean value. Here, we present the development, design and implementation of a representative monitoring network for a regional set of lakes. Power analyses were carried out for calculating minimum annual sample size for the five attributes total nitrogen, total phosphorus, chlorophyll a, suspended sediment concentrations and Secchi depth. Additionally, we carried out an assessment of the number of lakes required at the regional scale to detect a trend through time for a range of carefully selected effect sizes (i.e. the trend one can expect to observe in the data as a measure of policy and management effectiveness). Results show that a minimum of 12 samples per year (i.e. monthly) would be required for all attributes and lakes, albeit it is noted that monthly sampling may be inadequate in some Waikato lakes with high variability. A representative assessment of the state of the environment at the regional scale would require monitoring of 38 lakes. This number of lakes ensures that an annual assessment of state has appropriate accuracy for 75% of the time. There is generally a trade-off between sufficient sample sizes to achieve adequate power and oversampling.

Characterising the fish fauna associated with freshwater mussels in Waikato streams

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Associations between potential fish hosts and kākahi/freshwater mussels (Unionidae) in eleven wadeable streams of the Waikato region were explored through comparisons of fish communities associated with (i) mixed populations of Echyridella aucklandica and E. menziesii compared to monospecific populations of E. menziesii, and (ii) populations of E. menziesii showing recruitment versus those with geriatric populations. Mussel and fish surveys were undertaken during the peak glochidia release season to identify potential fish hosts. In total, eight native fish species, brown trout (*Salmo trutta*) and kōura (*Paranephrops planifrons*) were found associated with mussel beds. The most commonly-occurring native species were longfin eel (*Anguilla dieffenbachii*), shortfin eel (*Anguilla australis*), and common bully (*Gobiomorphus cotidianus*). A comparison of physicochemical characteristics between mixed and monospecific populations found no significant differences in the parameters measured, suggesting that neither E. menziesii nor E. aucklandica have specialised physicochemical requirements. Four of five sites with *E. aucklandica* had higher fish diversities and similar fish community compositions, compared to sites without *E. aucklandica*. Evidence of recruitment in E. menziesii populations varied across sites; only three streams showed clear signs of recruitment (>45% of mussels ≤50 mm length), compared to five sites supporting predominantly geriatric populations (<15%). Recruitment appeared unrelated to stream physicochemistry or fish community structure and species abundance. This preliminary study paves the way for ongoing research a) confirming which fish species enable the metamorphosis of glochidia into juvenile mussels in the field and; b) comparing the services fish provide as potential vectors of dispersal.

Understanding what's left: assessing the ecological health of Wellington's urban streams to inform Whaitua Te Whanganui-a-Tara

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Implementing the National Policy Statement for Freshwater Management (NPS-FM) across the Wellington Region has seen the establishment of five Whaitua (super-catchments). Under this policy, freshwater management objectives and limits have been set for the Ruamahanga Whaitua, are being finalised for Te Awarua o Porirua, and now we're looking to set objectives and limits for Whaitua Te Whanganui-a-Tara (Wellington/ Hutt Valley). This Whaitua spans three city councils, and includes pristine upper catchment headwaters, agricultural areas, rugged coastlines and New Zealand's capital city, Wellington.

Within Whaitua Te Whanganui-a-Tara there are several streams which are within the urban footprint of Wellington City. Many of these streams have been piped and historically there has been minimal information on their ecological health (habitat condition, macroinvertebrate community health and fish populations). To address this knowledge gap prior to the commencement of the Whaitua, Greater Wellington Regional Council has worked with Wellington City Council over the last two years to better understand the ecological health of Wellington's piped and free flowing urban streams. This presentation will focus on the surface streams component of this work. The results of the free flowing streams survey will provide baseline information on the ecological health of urban streams within Wellington City and inform the design of a long-term monitoring network. This monitoring network will inform the adaptive management of these streams and assist in protecting them into the future

Drift transport capacity: what do we know and what does it mean for flow management?

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A defining function of rivers is that they transport material downstream, including particulate organic matter. The fine fraction of particulate organic matter (seston) provides the food supply for filter-feeding invertebrates and coarse fractions, macroinvertebrates, provide food for drift-feeding fish. The flow-dependency of drift, and its relevance to environmental flow assessment, has only recently been recognised. It can for instance be more sensitive to flow reduction than flow-related habitat for fish and benthic invertebrates. We present insights from recent research on the flow-dependencies of drift and the consequences for drift feeding fish (and filter-feeding invertebrates), and for setting environmental flow limits that safeguard this important ecosystem process and related life-supporting capacity of rivers.

The Final Frontier: Using enterprise modelling to implement freshwater accounting

Mark Heath[1], Kiri Brown[1], Kat Banyard[1]
[1]*GWRC*

The National Policy Statement for Freshwater Management (NPS-FM) requires regional councils to establish accounting systems for both water quantity and quality. A fully functional accounting system should improve information on freshwater takes and sources of freshwater contaminants, estimate catchment loads, identify resource availability, and provide the public with timely feedback regarding the progress being made towards meeting limits and, ultimately, towards achieving freshwater objectives. Under the NPS-FM regional councils were required to have implemented their respective freshwater accounting (FWA) systems by 1-August-2016. Two years later, limited progress has been made particularly in relation to accounting for freshwater contaminants.

In September 2018, Greater Wellington Regional Council (GWRC) embarked on an intensive twelve week project to kick-start FWA in the region, and to identify where barriers and opportunities to implementation exist. The project is ICT led, but the development and testing team will consist of policy, science, regulation and land management staff, and external stakeholders. The key objective of this intensive twelve week project is to provide a single high level understanding of what a FWA-system is, as well as an understanding of potential high value starting points and establishing a working partnership with both internal and external FWA stakeholders.

The intended output is a FWA-system enterprise model, which will be used by the wider business and ICT team to highlight any barriers within GWRC currently hindering the implementation of a FWA-system. To assist in the development of the enterprise model and to help understand what FWA is, a proof-of-concept sediment accounting tool is being developed.

The success of the intensive twelve week project in delivering a FWA-framework will be discussed in this presentation. Moreover, the learnings from applying an ICT led systems thinking framework to FWA, will be explored as this framework has the potential to be applied/tested in other regions.

Issues with using water quality guidelines in management: developing decision-support frameworks

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The application of generic water quality guidelines for ecosystem protection requires consideration of environmental factors which affect the toxicity to aquatic life. These include: the nature of the exposure (i.e., whether acute (short-term) or chronic (long-term)); toxicity modifying factors (TMFs, e.g., pH, temperature, dissolved organic carbon (DOC)); mixing and cumulative effects for point source discharges; fate of contaminants – such as downstream accumulation in sensitive lake or estuarine environments and freshwater/saline conditions; and food-chain bioaccumulation effects. More critical investigations may involve site-specific consideration of the nature and adequacy of species present in the toxicity database, the application of chemical speciation modelling approaches – including the biotic ligand models (BLMs) for bioavailable metals, and addressing complex mixtures of chemical contaminants.

The Australian and New Zealand Guidelines for Freshwater and Marine Water Quality (ANZECC 2000) are currently in the process of updating guideline values (GVs). New approaches are being incorporated into the GV derivation and application process – including incorporating bioavailability-based approaches. For example, metal guidelines are incorporating parameters such as hardness, pH and DOC, whereas only hardness normalisation was incorporated into the ANZECC guidelines for appropriate metals. Additionally, the updated freshwater ammonia guidelines will incorporate both temperature and pH adjustments – compared with only pH in the earlier guidelines. These ANZ guidelines only provide long-term (chronic) protection values for freshwater or marine species – requiring guidelines from other jurisdictions to be used for acute exposure risk assessments.

The increasing complexity of guidelines requires additional guidance, including decision-support frameworks – which include TMF monitoring requirements or suitable default conditions – to provide standardised approaches and improve environmental management. This presentation will review the updated ANZ guidelines and their application for freshwater and marine management.

Bergmann's rule and whitebait: differences in size, age and growth of whitebait across New Zealand

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Whitebait is the collective term used around the world for small, juvenile fish that are caught and consumed in large numbers. In New Zealand, 'whitebaiting' describes a recreational and commercial fishery where large shoals of post-larval galaxiids are caught as they migrate from coastal waters into freshwater catchments. The whitebait catch consists mainly of īnanga (88%), with much lower proportions of banded kōkopu (7%), kōaro (5%), giant kōkopu (0.03%) and shortjaw kōkopu (0.01%). Previous studies, with limited spatial coverage and small sample sizes, have indicated regional differences in the size and age of īnanga whitebait, but no studies have compared characteristics of the less common whitebait species across a broad geographic range. Here we present the findings of a large-scale whitebait sampling program (>95,000 fish from 92 rivers) over six months in 2015. Over 20,000 whitebait were measured and 1500 fish were aged using otoliths. For all species, whitebait entering southern rivers were larger. Whitebait entering northern rivers were on average younger with higher average daily pelagic growth. Whitebait on the east coast of the South Island were older, with lower growth rates, than those at similar latitudes on the West Coast. This study is the first to make broad-scale spatial comparisons of the size, age and growth of the five whitebait species. From our findings it is apparent that the New Zealand whitebait fishery is not comprised of a single meta-population and that spatial differences in oceanic conditions drive local adaptation and variability in early life history traits.

Dynamic catchment modelling of a New Zealand dairy farming catchment

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Dynamic catchment models are able to represent the dynamic behaviour of complex processes and provide insights into catchment systems where direct measurement may not be feasible at large scale. The Soil and Water Assessment Tool (SWAT) is a dynamic catchment model that has been applied across a wide range of catchment scales and conditions to assess hydrological and environmental issues. SWAT was developed specifically for agricultural catchments, and is potentially a modelling tool applicable to intensively farmed regions such as New Zealand. In this study we test the ability of the SWAT model to simulate water quantity and water quality in a typical dairy farming catchment in New Zealand. We chose the Toenepi catchment that was one of the Dairy Best Practice catchments, as a case study. Extensive long-term monitoring data, information about farm practices and knowledge about biophysical characteristics exist from previous studies. Preliminary results indicate that the SWAT model predicts discharge very well, with daily Nash Sutcliffe Efficiencies (NSE) of 0.76 and 0.77 in the calibration and validation periods, respectively. The model performance was better at the monthly time step with NSE of 0.91 and 0.92 in the two periods. Although flow variation was very well captured, high flows experienced during storm events were underestimated. Subsurface drainage is the main contribution to streamflow, as expected in a pastoral catchment with an extensive tile drain network. The water quantity predictions imply that SWAT adequately represents hydrological processes in the study catchment and is likely to provide a sound basis for water quality modelling, which will be undertaken during the next phase of this assessment.

Improving our understanding of Southern slime

Roger Hodson[1], Nuwan De Silva[1]
[1]*Environment Southland*

Environment Southland has been collecting data on benthic periphyton as chl-a, AFDW and percentage cover as part of our long-term environmental monitoring programme. Specifically we have collected periphyton chl-a, and AFDW data annually since 2001 at up to 103 sites from 55 different streams and rivers (74 sites retained for analysis, n≥6), and on a monthly basis from 30 sites located on 27 different streams and rivers since 2015. In addition the monthly monitoring has included estimates of percentage cover.

Analysis of monthly data illustrated a better state of ecosystem health with respect to periphyton than previous assessments from annual data only.Analysis of monthly benthic chl–a showed that 100% of the 30 sampling sites were likely to be within the National Objectives Framework (NOF) band range of A – C, above the national bottom line. While none of the sites were in the band D category (below the national bottom line), seven sites had an upper 95% CI value in the D band.

In contrast, assessment of annual chl–a showed 88% of the sampling sites were within the NOF band range of A – C. However, 12% of sites from eight different streams and rivers, were in the band D category and failed to meet the national bottom line.

Comparison of estimates of biomass from annual data vs monthly data showed that estimates based on annual data were on average 1.6 times greater than those from monthly data.

Analysis of the AFDW and percentage cover of periphyton data from monthly monitoring sites demonstrated that 68% and 21 % of sites were compliant with respective standards defined in the proposed Southland Regional Water and Land Plan (2018).

Helping plants find their feet – restoring macrophytes in lakes

Deborah Hofstra[1], Mary de Winton[1], Ben Woodward[1], Denise Rendle[1]
[1]*Niwa*

Thirty-six percent of lakes in New Zealand are in poor or very poor condition according to recent state of environment reporting. Amongst New Zealanders there is a growing desire to improve or restore freshwater systems, and there is recognition in government policies of the importance of controlling contaminants that enter lakes. However, in many cases such external controls alone will not restore shallow lake ecosystems because there remains a myriad of in-lake challenges. These include internal nutrient cycling, poor water clarity, compromised substrates, invasive species and depauperate native seedbanks. Moreover, widespread failure by restoration interventions has led to a suggested critical role for submerged macrophytes in stabilising restored lakes long-term.

This presentation considers how we can restore submerged macrophytes to lakes. The focus is on approaches for native plant restoration and examples of removing barriers to their restoration; invasive weeds, insufficient light environments, poor anchorage, biotic disturbance and lack of propagules.

Stream rehabilitation in NZ: unscrambling eggs or turning ecological lemons into lemonade? A PhD in 7mins.

Robin Holmes[1,2], Christoph Matthaei[2], Gerry Closs[2], John Hayes[1]
[1]*Cawthron Institute,* [2]*University of Otago*

A lot has happened to rivers over New Zealand's recent history. The intensified riverscape is now deeply engraved into our environmental story. Yet from growing awareness of the environmental cost of intensive landuse two new stories are emerging. In the first story, society gets to have its ecological cake and eat it too—with the right science and policy we can have thriving freshwater ecosystems within productive intensified landscapes. I argue that science will struggle to realise this audacious vision, unless we can resolve the discrepancy between the modest scale of experimental inquiry and the vast landscapes across which rivers are degraded. The second story is one of community and institutional pragmatism—people and organisations getting stuck-in, making rivers as healthy as they can but within land-use constraints. In this case, science is playing catch-up because critical evaluations of grass-roots river rehabilitation projects are sparse.

In this talk I describe the success of a historical community-led stream rehabilitation effort and outline a Bayesian Belief Network-based tool to guide stream fishery rehabilitation. I also detail the response of a native fish community to a catchment-scale channel engineering event. Finally, I present a new conceptual model that aims to provide a predictive framework for incorporating spatiotemporal scale into future stream rehabilitation science and practice. This work was undertaken as part of my PhD candidacy which is now in its final stages.

Heavy metal contamination from storm water in an industrial catchment and the relationship with antecedent dry periods.

Timothy Hopley[1]
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Elevated levels of heavy metals, particularly copper, zinc and lead, into receiving environments is a concerning issue for community and environmental health. A study was undertaken at 2 mixed - industrial catchments in Auckland investigating heavy metals and other parameters in storm water over a 12 month period. Flow weighted composite samples; first flush and bulk were collected using autosamplers along with field parameters from probes. The antecedent dry period before each rain event was analysed to help understand and fill gaps in contaminate build-up relationships, an area that is scanty on robust data and conclusions, especially in the Auckland region. The data collected in this study will help with the development of contaminant load models and be useful to improve land management practices to ensure effects are mitigated going forward into the future.

Public Health Recreational Freshwater Quality Guidelines: What's the story overseas?

Beverley Horn[1], Sarah Coxon[1]
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New Zealand and a number of countries overseas have produced Recreational Water Quality Guidelines. One aspect of the guidelines is to help reduce the risk of illness or infection due to exposure to microorganisms while participating in activities such as swimming and boating at freshwater sites.

This talk will introduce and compare the guidelines from Australia, Canada, United States of America, the European Union and the World Health Organisation. Areas of comparison will include; the factors influencing the guideline development, the choice of risk metric, how water is graded, the levels of risk associated with different bathing water grades, the choice of monitoring micro-organisms, sampling requirements and required responses to monitoring results.

Ecosystem Health – a new framework to focus our water science and policy

Carl Howarth[1], James King
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Ecosystem health is a compulsory value in the National Policy Statement for Freshwater Management, but has not previously had the specific policy focus or methodological detail required to guide improvements in our waterways. Historically in New Zealand, we have focussed more on measuring chemical and physical aspects of water quality. While these aspects are important components of ecosystem health, they don't tell the whole story. Adding to this, there is no consistent approach for evaluating ecosystem health.

To address these issues MfE has put together a team of ecosystem health experts who have created an ecosystem health framework with guidance on applying it to rivers and streams. The approach can be adapted to other water bodies such as lakes and wetlands. The framework will be useful for helping resource managers and communities collect adequate information for decision making and future planning, as well as for reporting on ecosystem condition. The five core components of the framework are aquatic life, water quality, water quantity, physical habitat and ecosystem processes. In this presentation, we will unpack recently commissioned work on ecosystem health to help focus current and future policy work, monitoring and assessment.

Florida LAKEWATCH: Citizen Scientists protecting Florida's aquatic systems

Mark Hoyer[1]
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Florida LAKEWATCH is a successful example of a long-term volunteer water quality monitoring program that started in 1986. Working with thousands of volunteers, these dedicated citizen scientists have collected reliable long-term water quality data for over 1100 lakes, 175 coastal sites, 120 rivers, and 5 springs. These data encompass water resources in 57 Florida counties. This manuscript describes the start and evolution of LAKEWATCH, including discussions of the following two major hurdles to the continued success of the program: 1) demonstrating to professional groups that trained volunteers are capable of collecting credible (research and regulatory quality) data, and 2) maintaining consistent long-term funding. Funding is especially critical because trained and committed core staff are needed to work along with volunteers. Quality staff members are also important to provide direction, ensuring consistent data are collected and enough sites are monitored to answer statewide questions such as how geology impacts water chemistry in Florida. Examples are also provided on how LAKEWATCH data have been used to address lake management issues in the State of Florida. We hope the Florida LAKEWATCH experience assists other groups who have a vast army of citizen scientists waiting to get involved and then to best develop a successful monitoring program.

A new substrate mapping approach for high resolution habitat suitability assessments when designing environmental flows

Jo Hoyle[1], Arman Haddadchi[1], Jochen Bind[1]
[1]*NIWA*

Environmental flows are often designed based on predictions of the physical habitat provided by a given flow for key species, with habitat suitability assessed based on depth, velocity and substrate composition (by areal proportion). With advances in modelling capability, velocity and depth for a given flow are now commonly predicted using high resolution 2 dimensional hydraulic models. This creates a need for substrate composition to be mapped at an equivalent resolution. Mapping substrate across large study reaches (e.g., 1-2 m grid resolution over 1-2 km long reaches) presents a significant challenge and pushes the boundaries of what has been previously attempted.

Our aim was to develop a workflow which enables underwater and sub-aerial mapping of substrate over large reaches from imagery for ready integration with 2d hydraulic models.

Our workflow includes six key steps:

1. Substrate image collection - using aerial photographs collected by UAV or underwater video.
2. Preparation of images for automated substrate classification – extracting image tiles over a regular grid, or extracting video frames, and discarding blurry/noisy images or those where substrate is obscured by vegetation, bubbles, algae etc.
3. Automatically classifying the proportion of substrate in each image that is sand, fine gravel, gravel, small cobble, coarse cobble, and boulder (Wentworth 1922) using batch-processing of the Morlett Wavelet approach (Buscombe 2013).
4. Non-automated classification (for locations where automated classification could not be run) - using either manual (visual) classification or synthetic classification based on facies mapping and the allocation of surrogate classifications.
5. Combining and checking substrate classification approaches for consistency.
6. Interpolating substrate grids for integration with hydraulic model grids.

This approach has substantial advantages over the commonly used approach of visually estimating grainsize proportions on site: it is more objective, more consistently reliable, and it can be applied over large areas.

Using sediment fingerprinting to determine the contribution of bank erosion to stream sediment yields

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Suspended fine sediment is an important diffuse pollutant. Increased delivery of fine sediment to streams can adversely affect in-stream and marine ecology, amenity values and recreational uses by degrading water quality (primarily by light attenuation) or by direct smothering of organisms and their habitats. In New Zealand catchments bank erosion is often anecdotally identified as an important source of sediment in catchments. However, studies that quantify the contribution of bank erosion to the sediment yields of New Zealand streams are rare. More quantitative studies are required to improve our understanding of the role of different sources of catchment sediment. Data from such studies will inform restoration projects and will ensure that limited catchment restoration funds are targeted most efficiently.

The aim of this research is to quantify the contribution of streambanks and hillslopes as sources of sediment in streams. The study site is located in two adjacent headwater catchments with contrasting land uses (pasture and native forest) in the western Waikato Region. The water quality at these sites has been monitored for over two decades by NIWA and was previously used as a research site for AgResearch. The methods utilised in this research were radionuclide fingerprinting, catchment surveys and the analysis of two decades worth of suspended sediment data. The initial radionuclide results indicate that there is a significant difference between the caesium-137 concentration within the streambanks and hillslopes, clearly distinguishing both sources of sediment. Further, radionuclide analysis will be undertaken on in-stream suspended sediment samples to identify the main erosion sources within both catchments.

Project Baseline Lake Pupuke Initiative, a case study for effective citizen science

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Lake Pupuke is a volcanic crater lake located in Auckland's North Shore. It is a high use recreational water body and a premier park with a fully urban catchment. Concerns regarding water quality have been raised by the local community over the years and reduced water clarity had been noted by a variety of recreational users. Large scale algal blooms have recently developed and current State of the Environment (SoE) monitoring did not provide any definitive explanations for these blooms. There was a significant lack of understanding associated with bloom development, key drivers & the fluctuating state of the lake.
Seasonal surface based water quality sampling was not sufficient to understand what was happening in the lake and regular subsurface observations were needed. These types of assessments are very costly and resource heavy so the Auckland Council partnered with the Project Baseline Initiative (international citizen science NGO) to facilitate high frequency data capture. Doing this has enabled the use of both council funded and citizen science driven data acquisition to support and inform a more holistic management/monitoring strategy for Lake Pupuke.

A year after the project started the Auckland Council, Project Baseline and Crown Research Institutes discussed several options for improving water quality with the goal of identifying management & monitoring solutions to address the decline in lake health. The resulting strategy relies on council funding and volunteer support from Project Baseline for subsurface sampling & monitoring.

Project Baseline has proved to be a useful tool to facilitate the collaboration between citizen science and local government by formalising community driven data collection. The Project Baseline Lake Pupuke Initiative is a proven example of how citizen science can be used to address critical knowledge gaps, compliment SoE monitoring and directly feed into environmental management strategies.

Carryover effects of larval environment on individual niche variation of adult common bullies

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Populations are often composed of heterogeneous individuals that vary in behaviour and trophic interactions. A possible driver of non-genetic variation between individuals is early life experience, which can affect adult phenotypes through carryover effects. Several widespread New Zealand fish species exhibit flexible life histories, including facultative diadromy, which can involve contrasting larval rearing environments. We tested for carryover effects of common bully (*Gobiomorphus cotidianus*) larval habitat on adult traits including size, diet, parasite load, and behaviour. Otolith microchemistry did not reveal discrete clusters indicating freshwater and marine-reared individuals, but we instead found a continuum of microchemistry signatures (Sr/Ca) that we cautiously interpret as individual position along a salinity gradient through Lake Waipori to the Taieri Mouth estuary. Larval Sr/Ca and adult Sr/Ca interactively predicted both trophic position inferred with nitrogen stable isotopes and parasite load, but did not significantly influence diet composition or behavioural traits. These results are broadly consistent with carryover effects and indicate possible trade-offs associated with shifts in habitat through ontogeny. Early life experience has the potential to shape many aspects of individuality within populations, and otolith microchemistry offers a route to detect these associations in wild populations.

Lifting the lid on piped streams

Alex James[1]
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Worldwide, urban land use often results in the extensive piping of small streams. Wellington is no exception, and in many urban catchments open streams now only exist as isolated sections linked by a network of pipes. While making up the bulk of stream length in these catchments, the piped sections remain unstudied from an ecological perspective. As a consequence, EOS Ecology and Greater Wellington Regional Council have begun a pilot project to investigate urban piped stream ecology.

The first stage involved a manhole lid lifting exercise to identify suitable sites for detailed survey. During this exercise we took the opportunity to trial the collection of piped stream macroinvertebrates using a long handled net. Macroinvertebrate samples were collected from 16 manholes in the Island Bay, Miramar, and Waitangi Stream catchments. A total of 21 taxa were found with oligochaete worms and Potamopyrgus snails accounting for 50% and 20% of all invertebrates captured respectively. Diptera larvae accounted for 12% of the catch leading to the possibility they complete their lifecycle, including the adult flying phase, underground in near total darkness. Spider webs were also obvious around some manholes implying there are flying insects to catch. Eels were observed down two manholes, including a large shortfin in a catchment that would appear to have no surface water habitat suitable for a fish of that size.

The next phase of the project involves a detailed ecological survey of six sites in four catchments. This will involve developing sampling methodologies adapted for permanently dark confined spaces where strict health and safety procedures must be followed. This work has implications for the management of piped streams, which are generally considered part of the stormwater pipe network rather than as highly modified streams with measurable ecological values.

Improving lake marginal habitat for native fish using structure

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New Zealand's lake fish communities are highly associated with littoral zones of lakes. Within these marginal habitats, fish utilise structure provided by substrata, aquatic plants and large-wood for key life history functions including refugia, foraging, and reproduction. However, many lowland lakes have become enriched with nutrients and lost their riparian connections, depleting the availability of structural habitat for fish. We tested the use of large woody-structures of varying scales to enhance the usage of littoral habitats by fish at two sites, Lakes Moawhitu and Wairarapa. Fish habitat usage was monitored through a combination of overnight set-netting and video footage using a Didson acoustic camera. Fish abundance data from net catches and video footage suggests nearly double the number of fish inhabiting structurally enhanced areas, with fish usage proportional to the amount of added structure. Some challenges were needed to be overcome around anchoring habitats in areas prone to wave exposure. We suggest that structural habitat enhancement could be a useful community-based restoration tool to improve habitat in lakes where macrophyte re-establishment or riparian reinstatement are difficult to achieve.

A toxic puzzle – unravelling the relationship between anatoxin production & strain dominance in *Microcoleus autumnalis* (*Phormidium autumnale*)

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Microcoleus (previously known as Phormidium) is a benthic, filamentous cyanobacteria genus, which under certain environmental conditions can form thick, cohesive mats that spread across large areas of the benthos. Some Microcoleus species can produce anatoxins; potent neurotoxins, which are harmful to both humans and animals. In New Zealand Microcoleus autumnalis is an anatoxin producer and proliferations are being reported in an increasing number of streams nationwide. Anatoxin content in M. autumnalis-dominated mats varies spatially and temporally, making understanding and managing proliferations difficult. In this study a *M. autumnalis*-specific Taq-man probe quantitative PCR (qPCR) assay targeting the anaC gene was developed to quantify the number of copies of the anatoxin gene cluster in a sample. The anaC assay and a cyanobacterial 16S rRNA qPCR were then applied to 122 environmental samples collected from 19 sites on 10 streams in New Zealand. The percentage of toxic cells in the environmental samples ranged from 0 to 30.3%, with significant differences between streams. The anatoxin content in mats had a significant relationship with the percentage of toxic cells. The development of the assay and the verification of its use on environmental M. autumnalis-dominated mats will enable new insights into anatoxin variability, and enhanced knowledge on how biotic and abiotic parameters influence anatoxin production and the relative abundance of toxic and nontoxic genotypes.

Lake sediment as sentinels of historical food web dynamics: A case study of two eutrophic lakes in Central Otago, New Zealand

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Paleolimnological studies are increasingly recognized as a means to re-construct historical food web structure and ecosystem dynamics. Daphnia plays a central role in many pelagic food webs, and has the potential to be used as an indicator of health and resilience of lakes. We studied two eutrophic lakes, Lake Hayes and Lake Johnson in Central Otago, NZ and investigated several paleolimnological parameters with special emphasis on Daphnia dynamics. We assessed the historical dynamics of two Daphnia species and compared with known historical changes to the lake food web and progress of eutrophication. Daphnia post-abdominal claw and resting eggs (ephippia) in sequential slices were examined. Fossils were counted and taxonomically identified to infer historical relative abundance. This information was used to construct a timeline of Daphnia species invasion, co-existence and possible exclusion. To improve taxonomic resolution and verify fossil-based taxonomy, molecular analysis (DNA) was conducted on embryos from viable ephippia. A 210Pb chronology was conducted to determine approximate time of sediments deposition. Stable nitrogen (δ15N) and carbon (δ13C) isotopes were analyzed to assess historical changes in trophic composition and relative contribution of different sources of organic matter. Results reveal that D.'pulex' from North America became established in Lake Hayes during the 1960s, four decades earlier than first reported, while in Lake Johnson it became established during the 1980s. Results suggest that indigenous D.thomsoni and non-indigenous D.'pulex' co-exist in both lakes and demonstrate a consistent increase in D.'pulex' abundance since this species first became established. Ephippia counts suggest that few years after D.'pulex' became established, the number of ephippia produced by D.thomsoni doubled followed by 80-fold increase in ephippia of D.'pulex'. The co-existence is an affirmation of a previous study that suggests these two species prefer different temperature regimes and therefore their realized-niches for planktonic existence within a fundamental-niche are temporally divided.

The value of archived diatom collections: understanding the spread of Lindavia intermedia in New Zealand

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The silica cell walls (frustules) of diatoms resist degradation. Thus, algal samples can be analysed for diatoms long after the samples were collected, and without special preservation. Samples organised into searchable collections can then become invaluable in unexpected ways. We examined samples selected from two archived diatom collections to estimate a timeline for the arrival and spread of *Lindavia intermedia* (the freshwater diatom that causes nuisance lake snow) in New Zealand. Our study followed paleolimnological and molecular research indicating that *L. intermedia* was a recent arrival. No *L. intermedia* was detected in 40 lake diatom samples from the Vivienne Cassie collection (Landcare Herbarium), collected between 1970 and 1991. A further 144 samples from lakes or lake outlet rivers were selected from the NIWA diatom collection (NIWA, Christchurch). No *L. intermedia* was detected in 67 samples collected between 1998 and 2004. However, L. intermedia was detected in 20 of 66 samples collected in 2005, suggesting presence in at least nine lakes throughout New Zealand, from Lake Moawhango (North Island), to Lake Tennyson (Canterbury) and Lake Gunn (Fiordland). The finding was surprising because, in 2005, lake snow had recently been reported as a problem in Lake Wanaka, but nowhere else. Samples collected after 2005 confirmed presence in further lakes, including Lake Waikaremoana. We concluded that the earliest records of *L. intermedia* in New Zealand lakes remained from samples collected in 2002 from Lakes Hayes and Aviemore, reported in an earlier study. The results highlighted that potentially problematic freshwater microorganisms can spread rapidly. Furthermore, the wide distribution in 2005 suggested human vectors. The main defence against spread by people is to apply Check, Clean, Dry measures (developed in 2005 for didymo). These measures are as important as ever, to prevent the spread of as-yet-unrecognised nuisance species, as well as didymo and *L. intermedia*.

The science and policy interface 'on the front lines'

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Leading on from previous presentations on how policy advice works we will delve further into how science and policy interact. We will bring the perspective as analysts 'on the front lines' of policy development at the Ministry for the Environment. We will use recent examples from their work to focus on issues such as dealing with uncertainty in data and models in policy development and implementation. We will also discuss the role of science in different phases of the policy cycle – particularly the problem definition, policy formation and options development phases. We will conclude with reflections from public policy research about why some policy proposals seem to go ahead easily, while others do not.

Murihiku Cultural Water Classification System: Enduring partnerships between people, disciplines and knowledge systems

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Mātauranga Māori is increasingly being used to improve freshwater management outcomes, driven by contemporary legislative and policy requirements. However, there is a need to develop enduring mechanisms that enable different knowledge systems and disciplines to work in co-production, while ensuring the integrity of the respective systems is upheld. National and international law is deficient in its protection of cultural intellectual property and indigenous knowledge systems and there is reliance on voluntary protection mechanisms to establish collaborative partnerships.

The Murihiku Cultural Water Classification System is founded on partnerships between people, disciplines and knowledge systems. This freshwater management framework is being developed at the scale of Te Ara Koroka (a pounamu trail). Numerous barriers prevented Ngāi Tahu ki Murihiku use of the trail from around the 1880s; however, this cultural landscape and the values, beliefs and practices it supports (past, present and future) are still central to the identity of Murihiku whānau. To help reconstruct and revitalise mātauranga Māori around Te Ara Koroka, historical literature sources were used, alongside cultural value mapping, interviews and contemporary information sources. This paper explores cultural heritage methods to show how indigenous knowledge can be meaningfully and respectfully protected in research programmes. We propose that access requirements and protection mechanisms used by museums, libraries and archives could inform improved processes to better protect mātauranga Māori within the New Zealand science and research system.

Using stationary and aerial red-green-blue and multispectral camera imagery for stream periphyton monitoring

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Periphyton are part of the base of the food web in streams, but nuisance biomass levels can cause a variety of problems, especially in the case of toxin-producing species such as Phormidium. The National Policy Statement for Freshwater Management mandates monthly monitoring of chlorophyll a, the chosen metric for periphyton biomass in streams, to determine stream state relative to objectives set to protect ecosystem health. Councils also carry out monitoring of Phormidium cover at key sites in summer to assess suitability of sites for recreation. Collection of samples for subsequent chlorophyll a analysis and visually estimating cover are time- and cost-intensive monitoring methods, with low spatial and temporal resolution. Our objective is to test time- and cost-effective imagery-based monitoring. We are testing both fixed-camera monitoring, which provides a high sampling frequency (daily), and drone-based monitoring, which provides broad spatial cover. In both cases, our aim is to obtain objective results through automated rather than manual image processing. We obtained a time series of daily red-green-blue (RGB) and multispectral (VIS and NIR) imagery of a stream bed (Hawkins River) in Springfield, Canterbury and imagery covering a ~1 km reach of the Opihi River in Raincliff, Canterbury. Alongside digital imagery, we collected ground-truth data of chlorophyll a as well as visual estimates of coverage divided into different groups of periphyton (weekly at the stationary site and from four patches of the Opihi River reach). Although stream characteristics and weather conditions are limiting factors, preliminary image analysis results suggest that both RGB and multispectral imagery can be used for high resolution periphyton monitoring in shallow streams.

Evaluating a traditional Maori harvesting method for sampling stream populations of koura and toi toi

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Representative sampling of crayfish in streams is often impractical, especially in non-wadable habitats, or in areas with soft substrates. Whakaweku are artificial habitats made from bracken fern that can be used successfully in a range of habitats. We compared whakaweku, minnow traps, fyke nets and electrofishing for sampling kōura and bullies (toi toi) in two streams with differing stream characteristics and fish assemblages. Whakaweku in this study were shown to provide high capture rates of kōura and bullies, as well as a balanced sex ratio and a wide size class of kōura; comparable to that of electrofishing but with lower labour input.

A 13-week long soak trial in the Te Wairoa Stream showed that colonisation by kōura reached 90% of maximum after 2 weeks and CPUE was constant from 2 to 9 weeks. After 9 weeks, CPUE decreased due to decay of the fern fronds. Sourcing suitable bracken fern and a minimum deployment time of 2 weeks means that the whakaweku method requires more careful planning than other sampling methods. Nonetheless, whakaweku are particularly suitable for use by iwi and community groups as they are an effective sampling tool that are simple to set, and do not require expensive equipment or specialised training. On the basis of this study, we recommend that whakaweku of a similar size are deployed for at least two weeks and that a kōrapa (landing net) is used for retrieval of whakaweku, especially when sampling small-bodied benthic fish such as bullies.

Constructed wetlands for dairy run-off: are they working?

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Constructed wetlands are becoming more common in intensive agricultural landscapes as 'edge of farm' treatment systems for run-off. I retrospectively assessed two industry example CTWs to determine their performance.

The first is a 'silt trap' system adjacent to a shallow peat lake. The system exhibited large temporal and spatial variability over the two year monitoring period. The treatment efficiency of much of the system could not be determined due to persistent flooding by the Lake during wet months and stagnation in the ponds during dry months. Of the data that could be assessed, total N removal ranged between 93% and 12%, total P between -26% and 30% and suspended solids between 270% and 58%.

The second system is a small floating wetland installed in a drain which feeds into a different shallow peat lake. The floating wetland also showed considerable temporal variation with N removal ranging from 100% to 100% over the 1 year monitoring period. Suspended solids exhibited 50% removal consistently but total P removal increased over time and had not peaked 18 months after floating wetland installation.

So what have we learnt? The performance of these two industry example CTWs were underwhelming - but is this due to poor design or the inherent variability of natural treatment systems? If farmers think CTWs don't work, they won't put one in: but should they?

Moving forward, more information on the performance of floating wetlands in farm drains is needed particularly with reference to maintenance strategies as undertaken internationally. We are also moving towards testing the 'integrated constructed wetland' model developed in the UK for dairy run-off.

Eight research areas that could foster ecosystem-based management in fresh waters, if combined

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Despite the implementation of various environmental regulations, the challenges of safeguarding freshwater biodiversity while sustaining freshwater-based ecosystem services (ESS), have so far not been tackled successfully. A promising way forward is ecosystem-based management (EBM), an environmental planning and adaptive management approach that considers social and ecological needs concurrently. Being responsible for recent advances in sustainably managing marine ecosystems, a major reason for EBM's delayed uptake in freshwaters maybe its complexity, requiring planners to be familiar with the latest developments in a range of different research areas. To provide more clarity, we introduce eight research areas and their innovations, which are of core relevance for EBM. We then explain how they feed into a workflow that guides through the EBM-planning process. The workflow links species distribution modelling with ESS supply and demand modelling, SMART (specific-measurable-attainable-relevant-timely)-target planning including scenario- and cross-realm perspectives, prioritization of management alternatives, spatial prioritization of biodiversity conservation and ESS areas, and the quantification of uncertainties. The workflow is not intended to be a rigid blueprint - instead it is an adaptive procedure that can be modified to account for new information and localized changes depending on the freshwater system to be managed. Due to the documented success of EBM in the marine realm, we believe that our study will provide the means to foster on-the-ground applications of EBM in fresh waters, improve management effectiveness, and create socio-ecological benefits through buy-in from the community.

Land-use effects on aquatic ecosystems: strengthening the evidence-base

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Preventing and reversing adverse effects of land use on aquatic ecosystems are stated aims of virtually all stakeholders in land and water management in New Zealand. These stakeholders are faced with a dual challenge: management actions and compliance with environmental regulations incur substantial costs to land-users and rate-payers, and management outcomes can rarely be predicted with high certainty. The existing evidence base used to guide management actions and regulations is an ad hoc mixture of general principles, inferences from state and trend analyses, and cause-and-effect relationships from surveys and simulation models. There is a widely recognised need for stronger evidence, but practical guidance is lacking. In this talk, we set out two recommendations: 1) focus monitoring programmes and investigations on developing cause-and-effect relationships that are characterised by high reliability and feasibility rather than advancing mechanistic knowledge; and 2) shift from the current reliance on land cover as the causal variable for predicting land-use effects to land-management practices.

Combating in-stream ecological health – from bad to good by picking the low hanging fruit

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Waitangi Stream is located in the Central Plateau of the North Island near Waiouru. The stream has its headwaters in the undulating tussock grasslands of the Waiouru Military Training Area with the middle to lower reaches draining predominantly agricultural land. The stream is recognised to have multiple values including aquatic ecosystem, fishery, contact recreation and consumptive use as established and identified in Horizons One Plan (OP). The OP includes specific water quality ecological targets to protect those values, including dissolved nitrogen and phosphorus and associated periphyton biomass and coverage targets. New Zealand Defence Force (NZDF) operates the Waiouru Wastewater Treatment Plant (WWTP) which discharges treated effluent to the Waitangi Stream and in 2011 commenced a process to re-consent the WWTP discharge. Through the consent process NZDF recognised that WWTP nutrient loads were a key factor in driving excessive periphyton biomass and reduced stream ecological health in the Waitangi Stream. NZDF proposed and implemented significant WWTP upgrade work to address those issues comprising a change from secondary to tertiary treatment with nutrient stripping and ultraviolet treatment to reduce bacterial contamination.

This presentation presents the results of a comprehensive before-after-control-impact study of the effect of the WWTP discharge and upgrade work on the water quality and ecology of the Waitangi Stream. The monitoring programme includes consent compliance based monitoring of the discharge and mixing zone, but was extended to the lower stream by NZDF to provide a wider catchment context to the success of the upgrade work. The complex relationships between periphyton biomass, nutrient concentrations and loads, and stream flows are explored. We highlight the significant improvements in periphyton biomass and macroinvertebrate community health as a result of point source nutrient control from a small wastewater treatment plant.

Modelling network structure and temporal connectivity in freshwater metacommunities

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Rivers are spatially organised into hierarchic dendritic networks. This unique physical structure and the associated directionality of flow sets rivers apart from most other environments by regulating the dispersal pathways of resident biota. Additionally, structural and functional connectivity along the network can fluctuate through time due to natural and anthropogenic forces. Both the branching structure of rivers and temporal variability in connectivity can influence patterns of biodiversity via changing the relative influence of metacommunity organising processes (e.g. mass effects, species sorting etc.). Here we asked how does variability in spatial and temporal connectivity affect patterns of local diversity across a gradient of network topologies?

We used a graph-theoretic approach to stochastically model dendritic networks where nodes represent local discrete habitat patches (e.g. pools or riffles) connected by edges. We developed a discrete-time source-sink model of a competitive metacommunity to simulate community dynamics across a range of network structures (linear – bifurcating) and with a range of temporal connectivity scenarios (variance and auto-correlation levels in connectivity).

A loss of temporal connectivity was associated with a reduction in mass effects resulting in lower alpha diversity. The results associated with a loss of temporal connectivity were most pronounced in bifurcating networks and lowest in linear networks. When barriers were placed on central edges (typically those along mainstems) there was a greater loss of alpha diversity than when barriers were placed on least central edges. Our findings suggest the temporal pattern of connectivity can strongly affect local patterns of diversity. Further, diversity in bifurcating (vs linear) networks may be more vulnerable to loss of connectivity and there is a need to consider the branching structure of rivers when thinking about conservation and management.

Ninjas in NZ: Red-eared slider turtles are breeding in New Zealand

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Red-eared slider turtles (*Trachemys scripta elegans*) native to the southern USA and northern Mexico are the most commonly traded turtle species in New Zealand and worldwide. They may live for up to 30 years and are frequently released into the wild when the novelty of keeping them and their cute juvenile characteristics have passed. Sliders display temperature dependent sex determination with males produced at lower temperatures and females at higher temperatures. They have established viable populations in the wild outside their native range where soil incubation temperatures reach a critical threshold for a period spanning the mid-trimester of development. Sliders are quite commonly found in the wild in NZ as a result of aquarium releases, but until recently there were no records of wild breeding. In January 2016, a wild population of sliders at Cook's Beach, Coromandel, was found to have established a nest site and laid a clutch of eggs. The eggs developed successfully and were collected at the time of hatching. All hatched individuals were male. Subsequently the same population laid again the following summer in the same location and, following removal of the eggs, a temperature logger was deployed at the nest site to record ground temperatures throughout the projected incubation period. Nest temperature averaged 23.5 degrees until mid-March peaking at 27.5 in late February. Average temperature for 10 days in late January was 25.5. At temperatures above 28.3 degrees, females may be produced, or at lower temperatures under the influence of external natural and xenobiotic estrogenic chemicals. Environmental conditions in some areas of New Zealand are therefore likely to approach suitable incubation temperatures for viable populations of sliders in the wild as the climate warms and where sheltered microclimates provide higher average soil temperatures during the critical developmental period of a few weeks.

Determining the Polysaccharide Composition of the New Zealand Freshwater Biofouler Lake Snow

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The Lake Snow diatom *Lindavia intermedia* is responsible for biofouling in the South Island lakes of New Zealand. This species produces large amounts of extracellular polysaccharide and brown filamentous material that can very effectively blind water filters, such as those used in hydroelectric systems. The composition of this extracellular material is anticipated to be mostly complex polysaccharides. Similarly, the composition of the diatom aggregates will also contain significant amounts of polysaccharides, particularly from the diatom cell walls. Precision carbohydrate analyses on this material will be done at various locations and seasons of diatom flourishing. Our overarching goal is to complete a full carbohydrate characterisation of these materials that will inform the development of an analytical technique to quantify this material in lake waters.

Samples of Lake Snow collected and stored in lake water from Lake Wanaka were separated into (a) the polymeric material soluble in the lake water, and (b) the insoluble material associated with the diatoms. Acid hydrolysis of these two fractions followed by analysis by high performance anion exchange chromatography with pulsed amperometric detection (HPAEC-PAD), indicated a diverse range of monosaccharides present. Further collections of Lake Snow, designed to investigate the production of the extracellular polysaccharides by *L. intermedia*, indicated that the extracellular polysaccharide is not sloughed off the surface of the diatom aggregation, but is actively produced after collection. Moreover, the extracellular polysaccharide is not produced when the Lake Snow is stored in laboratory water (Type II). Further investigation into the polysaccharides of *L. intermedia* will be presented.

Towards more realistic ecotoxicology: evaluating chronic effects of neonicotinoids using a ubiquitous New Zealand mayfly

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Contamination of surface waters with neonicotinoid insecticides has become a chronic global problem. A recent survey of New Zealand streams has shown neonicotinoids are present but there are currently no published toxicity data for their effects on aquatic insects in New Zealand, and international data on chronic and multiple-stressor effects are also lacking. We aimed to address these knowledge gaps by developing a method for testing chronic toxicities of neonicotinoids and observing their sub-lethal effects on aquatic insect larvae in controlled laboratory experiments. Through a series of 4-week long experiments, the chronic toxicities of three commonly used neonicotinoids (imidacloprid, clothianidin and thiamethoxam) to nymphs of the ubiquitous New Zealand mayfly, Deleatidium, were determined and possible interactions between them investigated. In a subsequent 6-week multiple-stressor experiment with Deleatidium nymphs, we focused on possible interactions of imidacloprid exposure with simulated heatwaves and a period of food limitation. Imidacloprid, now the most widely used insecticide in the world, was the most toxic neonicotinoid to Deleatidium larvae, with a 28-day LC50 (the concentration lethal to 50% of test organisms) of less than 1 µgL-1. Clothianidin was also highly toxic, whereas thiamethoxam was the least toxic but still caused a significant reduction in mayfly survivorship and some increased sub-lethal effects during the 28-day exposure. When combined, the three neonicotinoids had a range of additive and synergistic effects were observed. In the subsequent multiple-stressor experiment, sublethal and lethal effects of exposure to 0.5 µgL-1 imidacloprid took 24-36 days to manifest and lethal effects could only be detected in the absence of heatwaves or starvation because these stressors alone already reduced mayfly survival strongly. Overall, these results highlight the importance of employing chronic experiments with sensitive test species such as Deleatidium in ecotoxicology to better understand the environmental impacts of neonicotinoids (and other contaminants) in freshwater ecosystems.

Assessing flow and nutrient contributions from rheocrene springs and groundwater seepage in two urban waterways

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Few studies have quantified the contribution of nutrients into waterways from instream spring vents (rheocrene springs) and streambed seepage. Nutrients can be toxic to biota and cause eutrophication, and levels within urban streams of Christchurch exceed guideline levels. To investigate the contribution of nutrients from springs and groundwater seepage to two urban waterways in Christchurch, we used a combination of (1) streamflow gauging and water quality sampling of surface water, and (2) discrete sampling of streambed seepage and spring vents, using seepage meters and mini-piezometers, over two time periods to determine seasonal variations. The streams showed three distinct patterns of inflow: (1) an upstream reach with many spring vents that had high inflow in September and low inflow in March (with many vents drying up), (2) a middle section with few discrete springs and low inflow rates, due to low groundwater pressures downstream of the spring vents, and (3) a downstream section with few spring vents, but high streambed seepage due to high groundwater pressures. Nitrogen concentrations were similar between spring vents, general streambed seepage and shallow groundwater bores in the area, with concentrations higher at upstream locations, which received the shallowest groundwater input to the stream. Seasonal variations were recorded, with higher concentrations in September compared to March. Dissolved reactive phosphorus inflows were more variable, with localised areas of higher concentrations. This was likely due to the release of organic matter built up in the streambed as groundwater inflows occur through areas of low streambed redox potential. The contribution of nutrients from springs and seepage recorded in this study gives a better understanding on where to focus management to improve nutrient concentrations in these spring-fed waterways. These investigation techniques could be applied easily and quickly elsewhere, to help quantify the input of any groundwater contaminant to surface water.

Measuring actual denitrification to understand nitrogen attenuation

Heather Martindale[1], Rob van der Raaij[1], Dr Uwe Morgenstern[1], John Hadfield[2]
[1]*Gns Science,* [2]*Waikato Regional Council*

Many New Zealand rivers and lakes have nitrate loadings which predominantly come through groundwater discharge rather than surface water runoff or point source contamination [3]. Denitrification, a natural process by which dissolved nitrate in groundwater is eventually reduced to nitrogen gas (N2), has potential to attenuate nitrate loads to rivers and lakes. However, the extent of denitrification occurring within New Zealand's groundwater systems is largely unknown.

Measurement of 'excess N2', the product of the denitrification reaction, is the most promising method for directly measuring denitrification that has occurred in an aquifer [4,5]. Thus the aim of this study was to validate a method for identification of denitrification in an aquifer and quantification of the extent of any denitrification that actually has taken place.

Neon samples were collected from 27 piezometers in the Waikato, Canterbury and Horizons Region following the method described in Martindale et al. (2018) [2]. Other proxies for measuring denitrification, or for measuring that there is potential for denitrification to occur, were sampled in conjunction with the Ne samples. These proxies included dissolved oxygen, δ15N, hydrochemistry, Child's tests and DNA analysis for the abundance of denitrifying genes (nirS, nirK and nosZ) [1]. Age tracers, including tritium, CFC and SF6 samples were also collected from some of the piezometers.

Of the 27 sites sampled, 19 had N2 in excess above the range of uncertainty. Twelve of these 19 sites were highly anoxic, as expected. However, 5 of the sites had dissolved oxygen between 2.5 mg L-1 and 5.8 mg L-1, indicating that complex flow pathways between the oxic and anoxic zones in the aquifer or in the well exist. Age tracers from the paired piezometers confirm this with groundwater ages differing between piezometers with depths varying by less than a metre.

[1] Bakken, L. and P. Dörsch (2007). Chapter 25 - Nitrous Oxide Emission and Global Changes: Modeling Approaches. Biology of the Nitrogen Cycle. S. J. F. ermann Bothe, William E. Newton, Elsevier: 381-395.
[2] Martindale, H.; van der Raaij, R.W.; Daughney, C.J.; Morgenstern, U. 2017 Measurement of neon in groundwaters for quantification of denitrification in aquifers. Lower Hutt, N.Z.: GNS Science. GNS Science

report 2017/51. 15 p.; doi: 10.21420/G2R65W
[3] McArthur, K. Clark, M. 2007. Nitrogen and Phosphorous Loads to Rivers in the Manawatu-Wanganui Region: An Analysis of Low Flow State. Palmerston North.
[4] Stenger R, Clague JC, Woodward S, Moorhead B, Wilson S, Shokri A, Wöhling T, Canard H. 2013. Denitrification: the key component of a groundwater system's assimilative capacity for nitrate. In: Currie LD, Christensen CL, editors. Accurate and efficient use of nutrients on farms. Palmerston North (NZ): Massey University, Fertilizer & Lime Research Centre. p. 1-11. (Occassional report; 26).
[5] Wilson GB, Andrews JN, Bath AH. 1990. Dissolved gas evidence for denitrification in the Lincolnshire Limestone groundwaters, eastern England. Journal of Hydrology. 113(1):51-60. doi:10.1016/0022-1694(90)90166-U.

Stream shade effects on instream plants and comparison of shade measurement methods

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Instream plants are an essential biotic component of river systems but prolific growth of exotic species can be problematic. Within NIWA's SMARTer Riparian and Wetland Strategies Research Project we have been working to clarify how periphyton and native and exotic macrophytes respond to different amounts of stream shade. The work is intended to better inform riparian restoration strategies. For this component of the project we surveyed nine pairs of wadeable stream reaches in the Piako River catchment over two consecutive summers. Each pair of reaches were adjacent; one was moderately to heavily shaded by riparian vegetation and the other had little or no shade. Within each reach we measured shade using a paired canopy analyser and a densiometer. All macrophyte species were recorded and the percent of water volume and water surface occupied by each species was estimated. For periphyton, we assessed cover of different life-forms and collected biomass samples. Our results showed that shade data from a densiometer tended to slightly underestimate shade compared to a canopy analyser, especially in less shaded stream reaches. Macrophyte channel clogginess and water surface cover and cover of long filamentous algae were usually much less in shaded reaches compared to their unshaded counterparts. The exotic macrophyte species, *Egeria densa*, *Elodea canadensis* and *Potamogeton crispus* were less abundant in shaded reaches. Our results show that sufficient levels of shade can limit development of nuisance primary production in streams in agricultural landscapes

Pesticides in New Zealand's running waters: a survey of agricultural streams

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Each year New Zealand uses tonnes of pesticides, many of which are mobile, relatively persistent, and can make their way into waterways. The NZ Environmental Protection Authority (EPA) has compiled a list of high-priority hazardous chemicals, which includes several pesticides, for urgent reassessment. While considerable effort goes into monitoring nutrients in agricultural streams and programs exist to monitor pesticides in groundwater, very little is known about pesticide distributions, concentrations, or potential impacts in NZ streams. We surveyed pesticide concentrations in 36 agricultural streams in Waikato, Canterbury, Otago and Southland during a period of stable streamflows in summer 2017/18. We also compared results from grab sampling and two types of passive samplers, to inform a global audience about the advantages of each approach for stream pesticide sampling. In total, seven pesticides were detected. Multiple pesticides were found at most sites; two or more were detected at 75% of sites, three or more at 67% and four or more at 42% of sites. Mean concentrations of individual pesticides in each region ranged from 0.21-243 nanograms/L and were uncorrelated with in-stream nutrient concentrations. Ecological implications of these findings will be discussed. Atrazine (detected at 81% of sites) is a triazine herbicide banned in the EU due to toxic effects on aquatic life. Chlorpyrifos (86% of sites) and diazinon (64% of sites) are organophosphate insecticides. Chlorpyrifos is controversial overseas and has been banned in five European countries due to evidence that it causes cognitive deficits and intellectual disability in humans, and because of toxicological effects on pollinators, freshwater insects and fish. Imidacloprid, clothianidin and thiamethoxam (detected at 78%, 8% and 3% of sites) are neonicotinoid insecticides known overseas for their toxicity to honey bees and to many freshwater organisms, and an increasing number of countries (e.g. EU, UK, Canada) are moving towards banning them.

Invasive macrophyte presence and growth form influence plankton communities

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There is still a considerable knowledge gap on how invasive macrophytes with varying growth forms influence plankton community structure. The influence of seven invasive macrophytes *Ludwigia grandiflora* (amphibious), *Myriophyllum aquaticum* (amphibious), *Hydrocotyle ranunculoides* (amphibious), *Elodea nuttallii* (submerged), *Pistia stratiotes* (free-floating), *Eichhornia crassipes* (free-floating) and *Salvinia molesta* (free-floating) on the community structure of phytoplankton and zooplankton were investigated through a mesocosm experiment. The main objective was to quantify the impact of the presence and growth form of invasive species on functional groups of plankton in terms of abundance, richness, diversity and composition. Results showed significant differences in total phytoplankton biovolume, phytoplankton richness, % Bacillariophyta, % Cyclopoida, and % small Cladocera among mesocosms with and without macrophytes. The mesocosms with macrophytes favored a variety of phytoplankton genera while cyanobacteria *Chroococcus spp*. were abundant in the non-macrophyte treatment. Zooplankton composition and abundance were significantly higher in the mesocosms with dense mats of macrophyte vegetation, especially for the submerged species Elodea nuttallii. The diversity of plankton communities was significantly higher in the mesocosms with macrophytes compared to the mesocosms without macrophytes. Furthermore, a principal component analysis revealed a Cyanobacteria-Chlorophyta-Bacillariophyta gradient whereby mesocosms with macrophytes harbored the Chlorophyta and Bacillariophyta groups while Cyanobacteria (*Chroococcus spp*.) dominated in the non-macrophyte mesocosms. The different macrophyte growth forms had no typical zooplankton taxa as reflected in the principal component axes. Our study provides evidence that it is important to look at growth forms when studying impacts of invasive species.

Ngā Pou Mataara: A Māori framework to monitor mauri in the Tukituki Awa

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Ngāti Kahungunu and tangata whenua submitted on cultural concerns for the Tukituki catchment and Ruataniwha Dam proposal to a Board of Inquiry (BOI) in 2013. In their decision the BOI included a policy in Plan Change 6 for the Hawkes Bay Region which required the development of a framework for monitoring the mauri of the Tukituki Awa.

This paper describes a project co-funded by Te Taiwhenua o Heretaunga and the Hawkes Bay Regional Council to develop this framework. Begining in mid-2017 stage 1 of the project was run over 18 months and was overseen by a Kāhui Kaumatua and mana whenua project team.

The project aims were to: 1) provide a hapū-based and self-determined framework that incorporates local knowledge of mauri and the Tukituki Awa, 2) to apply the maramataka (Māori calendar) using seasonal knowledge, and 3) to provide an awa-wide framework for long-term monitoring, whilst maintaining the integrity and intent of a hapū-driven process.

Four seasonal wānanga were run at marae along the Tukituki Awa. Each hapū have their own relationships, whakapapa connections and history related to the tīpuna awa a Tukituki. The project group deliberately targeted a broad range of age groups and used a kaupapa Māori approach to discuss information that was provided by tangata whenua in a way that ensured that the individual hapū relationships, whakapapa and history were reflected in project outcomes and the final framework.

Each wānanga incorporated local speakers, hapū and whānau, hīkoi (site visits) and workshops on mauri. During the workshops, participants were asked three focus questions: 1) What does mauri mean to you?, 2) How would you tell if the mauri of the awa was unhealthy or diminished?, and 3) How do you tell if the mauri of the awa is intact or healthy? Kōrero was recorded, transcribed and collated and data analysed using word cloud software. The outcomes, recordings, photographs and presentations were returned to each marae following the wānanga.

Key 'pou' identified within the kōrero were: Wairua, Whakapapa and Tino Rangatiratanga. Aligned with these pou, tohu (proxy indicators) were identified from each of the wānanga. Development of the indicators into measurable tohu that individually and collectively tell the story of the Tukituki Awa is the next stage of project development.

Science to policy and back again: compliant land use practices still cause P leaching

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Some evidence suggests that phosphorus (P) can leach to groundwater. The enrichment of groundwater P provides a legacy of P inputs into nearby streams even if P-leaching from topsoil is stopped. We analysed P in leachate from two soils from an irrigated dairy farm. One of the soils is a free-draining shallow stony soil representative of 140,000 ha under irrigated dairying in Canterbury, while the other was a deeper and moderately well-drained soil. As per industry good practice, soils were maintained at an agronomic optimum and received P as either fertiliser (40 kg P/ha/yr) or fertiliser (30 kg P/ha/yr) plus farm dairy effluent (10 kg P/ha/yr) applied according to regional rules and industry guidelines to avoid the effluent ponding on the soil surface. Filterable and particulate P concentrations in leachate from the shallow soil increased annually 4 to 7%. Mean total P load from 2001-2015 from the effluent-treated, shallow soil was 1.46 kg/ha/yr, greater than the same soil without effluent (0.25 kg/ha/yr) or the moderately well-drained soil with or without effluent applied (0.12 kg/ha/yr, for both treatments). Leaching losses were attributed to a combination of high hydraulic conductivity enhanced by the presence of macropores and the increasing P-saturation of macropore walls. An enrichment in FRP was also detected in a well intercepting groundwater at 10-m depth. However, the source of the enrichment was unclear. These data suggest that despite following industry good practice, regional rules and industry guidelines significant P losses may occur. It is unclear if applying less effluent at lower rate, would decrease P losses. Therefore, less P must be applied, made less available for loss, or P-rich effluent not applied to this freely draining shallow stony soil (or similar soils) under irrigation.

Intriguing trophic structures associated with mudfish pools in South-Westland: not extreme, just size-structured

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Food-web interactions in extreme environments provide useful insights into processes structuring communities because of the intense biotic and abiotic pressures at work. Despite the challenges, extremophile organisms often achieve very high abundance in such environments to the point where inverted Eltonian biomass pyramids form such that standing biomass at upper trophic levels is much higher than that at lower levels. Such trophic arrangement, despite being potentially unstable, could be maintained by allochthonous energy subsidies, but may also be affected by strong trophic interactions like cannibalism associated with extreme conditions. We studied these possibilities in tree tip-up pools in South Westland rainforest. These brown-water pools regularly have low pH, low dissolved oxygen, can dry for weeks at a time, and have low primary production. Despite these severe conditions, predators, including Odonata and mudfish (*Neochanna apoda),* can be super abundant (e.g., 200 mudfish/m^3). Mudfish abundance was closely related to pool surface area to volume ratio, such that pools with more surface area contained more mudfish, and all pools had very top-heavy Eltonian biomass pyramids. These findings point to allochthonous resource subsidies supplying energy to higher trophic levels. Indeed mudfish commonly feed on terrestrial invertebrates. However, size-spectra of aquatic organisms binned by body size revealed highly size-structured communities that fitted expectations from metabolic theory and were not particularly top-heavy. This is likely explained by cannibalism and reciprocal intraguild predation, including odonates feeding on mudfish fry as well as mudfish feeding on odonates. These interactions probably play an important role in regulating trophic structure, such that traditional categorization of trophic levels is misleading, and categorization by body size is more realistic. Thus, although allochthonous energy might make inverted biomass pyramids possible, extreme environmental conditions driving strong biotic interactions likely drive food webs towards a more stable structure.

Trophic interactions of kōwaro (Canterbury mudfish) across a gradient of drying intensity

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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. Kōwaro (Canterbury mudfish, *Neochanna burrowsius*) are an example of such a species. They persist only in isolated waterbodies on the Canterbury Plains which allow them to avoid predators. However, these habitats are often subject to harsh environmental conditions, such as extreme habitat drying. Sites, identified as either an isolated pool or 20 m 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 isotope biplots were constructed. Using variation in pool depth as a proxy for drought intensity and canopy cover, we investigated the likely impact of changing drought regimes on the food webs of mudfish-inhabited waterways. Whilst there was no change in overall community stable isotope biplots, the trophic position of kōwaro was significantly influenced by both drying intensity and canopy cover. Therefore, it is important that both the aquatic and riparian environments are considered and included in future kōwaro population management.

Temporal partitioning of reproductive resources in two sympatric Echyridella freshwater mussel species in Waikato streams

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Echyridella menziesii and *Echyridella aucklandica* are two ecologically-similar freshwater mussel species (Bivalvia: Hyriidae) that typically coexist as aggregated, multispecies assemblages. To continue their life-cycle, larvae (glochidia) of both species require a brief period as parasites on host fish, a potentially limited resource that the two species may compete for to successfully recruit juveniles. As part of a study into the spatial and temporal partitioning of resources among *E. aucklandica* and *E. menziesii*, we are investigating reproductive timing and glochidia release strategies, in sympatric populations within four Waikato streams. In vivo anatomical examinations of the mussel's larval brood pouches (demibranchs) over time, indicate a temporal offset in gravidity between the species, suggesting a longer brooding period for *E. aucklandica*. Brooding of early embryos by *E. aucklandica* was underway in mid-winter with 68% gravid females found in July, in contrast to *E. menziesii* females where only 19% were brooding embryos (gravid) in August. The end of the brooding period for both species was in late summer to early autumn when low proportions of brooding *E. aucklandica* (20%) and no gravid *E. menziesii* were found. Following this, a non-gravid brooding period occurred from March through to June for both species. Furthermore, differences in release strategies between species were observed, whereby *E. aucklandica* released glochidia attached to conglutinates, a unique type of mimicry thought to increase the chance of host-fish attraction and infection, while *E. menziesii* broadcast glochidia individually or attached to mucus strands. Moreover, *E. aucklandica* glochidia were found to be smaller in size (L = 103 ± 0.3 µm, n = 54) and morphometrically distinguishable from *E. menziesii* (L = 301 ± 0.8 µm, n = 50), suggesting different host attachment strategies in addition to temporally-offset infection times. These findings support temporal partitioning of reproductive strategies among these two sympatric mussel species.

Brown trout natal homing in the Taieri River estimated by otolith microchemistry

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Homing or returning to natal streams is common in the life histories of many migratory salmonids. Populations adapted to reproducing at a particular stream or river system are characterized by specific phenotypic, genetic, and behavioral traits. Conversely, the straying rate is an important adaptive feature providing the ability to colonize new habitats as environmental conditions change. Knowledge of the homing/straying ratio of the salmonids is extremely important for stock management.

We evaluated otolith microchemistry as a tool for identifying the natal origin of brown trout adults reproducing in the Taieri River catchment, which is 4th longest New Zealand river supporting populations of both anadromous and potamodromous brown trout. We used juveniles from major spawning tributaries for the compilation of baseline data and compared their otolith micro-elemental composition with otoliths of adults gathered at the Silverstream - the lowest spawning tributary at the catchment. Discriminant function classified juveniles as belonging to their natal stream with 88.4% precision. The addition of 30 post-spawners from Silverstream to the classification matrix indicated 8 fish had returned to their natal stream. Five other fish were grouped to other streams, and the origin of the other 17 could not be determined. The estimated homing was equal to 27% what was lower in comparison to the information from the native area of distribution. Previously, homing in anadromous and residential brown trout life histories, as well as Atlantic salmon and Pacific salmons, has been observed to represent 73-98% of spawning fish. The observed reduction in homing may be due to geomorphological reasons or it may be an adaptive trait developed by the species for successful survival at Southern hemisphere conditions.

Engage, advise, support – helping communities own their research

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Engagement has been a huge part of Greater Wellington Regional Council's (GWRC) process at introducing community groups to freshwater monitoring. Taking the time to understand what a group actually wants to achieve, and how to reach their goal/s increases both their ownership and success of a project. GWRC advises a 5-step approach to initiating, developing and supporting community projects. These steps will be described using our three pilot groups: Friends of Waiwhetu, Kourarau Catchment Group and Friends of Owhiro Stream. Already there have been surprising, and unexpected, results and co-benefits including discovery of previously unrecorded species, better understanding of the complexity of freshwater systems and transformation of, at times, antagonistic relationships.

Empowering the community: volunteers monitor hutt river 'swimmability'

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New Zealand's rivers are highly valued for swimming and other contact recreation activities. The most commonly recognised – and monitored – risks to human health posed by contact with rivers are faecal contamination and toxin-producing cyanobacteria. However, individuals intuitively judge a river's recreational suitability by a range of other characteristics, including visual clarity, water depth, ease of access, and the presence of rubbish and nuisance plants or periphyton.

Regional and unitary councils generally oversee monitoring of recreational water quality and have the primary responsibility for managing rivers to achieve community outcomes (e.g., 'swimmability'). However, councils have limited resources and cannot monitor everywhere people choose to recreate.

A strong community interest in water quality in the Hutt River near Wellington provided an opportunity to test the feasibility of community volunteers independently assessing the suitability of a popular swimming site for contact recreation. A suite of monitoring attributes was co-developed with the volunteers and a field session held to demonstrate and practice monitoring methods. The volunteers then assessed recreational suitability in parallel with the Greater Wellington Regional Council (GWRC) at weekly intervals from mid-December 2017 through until March 2018. Water temperature, conductivity, and (black disc) visual clarity were measured in situ, periphyton and cyanobacterial cover recorded, rubbish collected and the amounts and categories recorded, and a water sample tested for *E. coli*.

We found very good overall agreement between the community volunteer data and that collected by GWRC. Volunteer experiences will be shared along with plans to combine the various attribute measures into an overall 'suitability for recreation index'. Overall, we conclude that supporting community-based water monitoring provides an opportunity to both educate the public about water quality and empower them to assess and contribute to wider discussions on the suitability of rivers for contact recreation.

Thermal adaptation alters the ecological role of consumers

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Increasing temperature as a result of climate change is predicted to have numerous effects on species, including altered geographic distributions, shifts in phenology, and decreased body size at maturity. General theory predicts that reduced body size and rising temperature, particularly from a metabolic perspective, should lead to changes in tropic interactions and ultimately ecosystem function. However, contemporary adaptation may influence the outcome of warming and reduced body size of consumers, something not commonly considered in climate change research. We used populations of the globally invasive mosquitofish (*Gambusia affinis*) from a wide geothermal temperature gradient (19-37°C) as a model system to examine how contemporary adaptation influences individual, community, and ecosystem processes. We measured mosquitofish metabolic and excretion rates in-situ and after acclimation in a laboratory to understand how adaptation may lead to deviation from metabolic theory. We found evidence of countergradient variation in metabolic traits of wild populations that offset predicted energetic demand of warming. Our data show that, across populations allometric slopes increased predictably with temperature and the size-corrected rates of metabolism were unrelated to temperature. Aerobic scope in our laboratory acclimated populations increased with acclimation temperature and with source population temperature. We further analysed dietary variation and body elemental composition across a wide temperature range to determine if diet and nutrient acquisition varied with temperature rise. Finally, we used a mesocosm experiment to examine the ecological role of body size of thermally divergent populations. Mosquitofish diet changed strongly with temperature and this change was reflected by body C:N composition. Finally, our experimental data show that ecological responses to different body size distributions were often dependent on source population. Our data suggest considerable physiological adaptive flexibility to temperature and suggest that thermal adaptation may mediate the ecological outcome of future body size declines.

Developing guidance for including Indigenous cultural and spiritual values in water quality management in Australia and New Zealand

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Australia and New Zealand committed in 2009 to providing additional guidance on managing and assessing water quality that accounts for Indigenous cultural and spiritual values. The establishment of the Joint Steering Committee (JSC) was tasked with developing the guidance as in the 2000 National Water Quality Management Strategy (NQWMS) for Fresh and Marine Water Quality Guidelines Cultural and spiritual values were recognised as Environmental Values. The NQWMS ultimately falls under the overarching ANZECC Guidelines. The JSC appointed two Indigenous members one from Australia and the other from New Zealand representing their respective Elders and Iwi and NOTE: not representing all Indigenous people. The presentation will describe the process to produce the guidance for cultural and spiritual values including the development of principles identified at a meeting in Wellington New Zealand that bedded down the values for water quantity and quality to Indigenous people and the connectivity of the people to the land, water and sky. The Principles ultimately provided a platform to ensure cultural and spiritual values were an integral part of water quality management, with case studies and guidance produced following an extensive consultation process by the JSC and respective Australian and New Zealand governments. In 2018 the Guidance for these values were published becoming live documents on the internet for water quality managers, community groups and governments to consider implementing.

EPA use of Australian and New Zealand guidelines for fresh and marine water quality

Richard Mohan[1]
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The Environmental Protection Authority (EPA) are New Zealand's national environmental regulator. The role of the EPA includes regulating hazardous substances and new organisms, administering nationally significant proposals and the New Zealand emission trading scheme and regulating activities in New Zealand's Exclusive Economic Zone (EEZ).

The EPA use the Australian and New Zealand guidelines for fresh and marine water quality to assist with regulating activities in the EEZ. The aim of this presentation will be to give an overview of how the guideline values are used.

The water and sediment quality guideline values are used for consents regulating discharges from offshore oil and gas installations. The levels of contaminants present in production water after it is discharged are compared to the guideline values which provides an indication of the potential impacts on the environment. Conditions applied to marine discharge consents typically require environmental monitoring to compare concentrations of contaminants in the water and in sediment to the relevant guideline values.

The guideline values are also used for the regulation of sediment dumping in the EEZ. Prior to the dredging of sediment, environmental monitoring is required to demonstrate that demonstrate that any potential contaminants in sediment are below a recognised threshold. Comparison to the sediment guideline values is a key part of this process. After the sediment has been dumped in the EEZ, there will be conditions applied to monitor the impact upon the environment which may include comparison of sediment quality at the dumping location to the guideline values.

Glochidial development of the New Zealand freshwater mussel (*echyridella menziesii*) on non-indigenous fish

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Interactions between non-indigenous species and native freshwater mussels are likely to increase with the progression of global biotic homogenisation and climate change. Accordingly, with several relatively recent incursions of introduced fish species, New Zealand provides an opportunity to examine how non-indigenous fish may disrupt the obligate ectoparasitic life-stage of a native unionid mussel and host-generalist, *Echyridella menziesii*. Our objectives were to quantitatively infest non-indigenous brown bullhead catfish (*Ameiurus nebulosus*), rudd (*Scardinius erythrophthalmus*), and goldfish (*Carassius auratus*) to determine rates of glochidial attachment, loss and juvenile transformation in comparison to the native common bully (*Gobiomorphus cotidianus*). Fish were artificially infested in three separate trials each consisting of eight non-indigenous fish and four native fish held in separate tanks from which glochidia or juveniles were collected daily. The results showed glochidial attachment and subsequent loss prior to transformation standardised by fish surface area was $\bar{x}$ = 1.9 $\sigma\bar{x}$ = 0.2 glochidia per cm2 for brown bullhead catfish, $\bar{x}$ = 2.0 $\sigma\bar{x}$ = 0.4 for rudd, $\bar{x}$ = 0.7 $\sigma\bar{x}$ = 0.2 for goldfish, and, $\bar{x}$ = 3.6 $\sigma\bar{x}$ = 0.6 for native fish. This suggests that large-bodied non-indigenous species have the potential to be glochidial sinks. Additionally, although juvenile excystment rates for native fish varied within and between trials ($\bar{x}$ = 39%, range 11 - 81%), non-indigenous fish only transformed <7% of mussel juveniles from the initially attached glochidia, indicating a poor ability to be potential viable hosts in nature. These findings indicate that non-indigenous fish species may impact freshwater mussel recruitment in New Zealand, which suggests that non-indigenous fish control may be one of the actions required for freshwater mussel conservation.

A regional council application of tools – taking the road less travelled

Elaine Moriarty[1], Graham Sevicke-Jones[1], Rachael Millar[1], Karen Wilson[1]
[1]*Environment Southland*

This presentation discusses the use of application of tools developed through the Our Land and Water Challenge and a complimentary regional science programme in the Southland context and contrasts the differences with approaches taken elsewhere in New Zealand.

Over the last four years, Environment Southland has partnered with a number of research organisations and stakeholders to undertake a comprehensive new science programme for Southland. This programme compliments the work being done through the Our land and Water Challenge and sought to provide a strong conceptual understanding of the functioning of natural and socio-economic systems within the region so as to provide the spatial and temporal information context for community engagement and better resource management.

Southland is now embarking on the next steps of its journey with its People, Water and Land programme, a partnership programme between Environment Southland and Te Ao Marama Inc (the environmental arm of Ngai Tahu ki Murihiku) to inspire change to improve Southland's water and land. This is an integrated approach incorporating action on the ground and a regulatory framework to help support people, businesses and organisations to adapt their activities to reduce the adverse environmental effects. Putting people at the heart of the process is critical for a thriving Southland and ensuring our communities are resilient into the future.

This presentation will discuss the application of the tools developed through the Our Land and Water Challenge and Southland Science Programme through People, Water and Land programme, particularly the action on the ground component of this programme, and discuss how this contrasts to approaches taken elsewhere in New Zealand.

Revisiting New Zealand's recreational water quality guidelines: the freshwater microbiological sciences review project

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New Zealand's rivers and lakes are highly valued for swimming and other contact recreation activities. The most commonly recognised risk to human health posed by contact with freshwater is faecal contamination which can contain a range of pathogenic organisms, including bacteria, viruses and protozoa. The 2003 Ministry for the Environment (MfE) and Ministry of Health (MoH) national microbiological water quality guidelines for recreational areas ('the Guidelines') are the principal guidance used by regional and unitary councils to manage health risk posed by faecal pollution.

The freshwater component of the Guidelines uses the indicator organism *E. coli*, with numeric guideline values developed from findings of the 1998-2000 Freshwater Microbiology Research Programme (FMRP). The FMRP included a nationwide survey of microbial water quality across 25 sites representing different land uses and associated faecal impacts. Since Campylobacter was the pathogen most frequently detected in the water samples, a quantitative microbial risk assessment (QMRA) for campylobacteriosis was performed to estimate the risk of infection and illness. This QMRA underpins both the Guidelines and the numeric thresholds for the *E. coli* human health for recreation attribute in the National Objectives Framework of the National Policy Statement for Freshwater Management.

In the 20 years since the FMRP, there has been significant changes in land use (e.g., agricultural and urban intensification) and land and water management practices (e.g., stock exclusion from waterways, removal of point source wastewater discharges), coupled with significant advances in our understanding and quantification of the disease risk profile of different faecal contamination sources. This has led to growing calls for a new national freshwater microbiological survey to inform a review of the current Guidelines. Our presentation overviews the design of a proposed new survey and forms Phase 1 of the Freshwater Microbiological Sciences Review (FMSR) project commissioned by the MfE.

New Zealand Whitebait – Assessment of Ecosystem Services

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Whitebait catches or population figures are not monitored or otherwise quantified by central or local government, so it is virtually impossible at this point in time to determine historical population trends with any certainty. However, research and observations of fisheries indicate that whitebait numbers are in decline, and that contributing factors include pressures from human activity including habitat loss and degradation, water quality decline, waterway modifications and impacts from fish harvesting.
An assessment of the ecosystem services provided by whitebait and their habitat was conducted with a particular focus on whitebait fishery within the Waikato-Tainui rohe. The assessment was a pilot study to explore concepts and high-level findings of the state of ecosystem services provision by whitebait in New Zealand. Whitebait provide a range of ecosystem services, including food, nutrient cycling, biodiversity, reproduction, recreation and spiritual values. Substantial economic values are associated with the commercial sale of whitebait during the season. However, significant values are also associated with the recreational and spiritual functions of whitebait, which are less easy to quantify. The role of whitebait in marine and freshwater ecosystems and complex food webs is equally significant, and again has not been fully mapped. Based on the precautionary principle our study suggested stricter regulation is needed as a minimum given the uncertainty surrounding the multiple and cumulative effects of habitat degradation and fishing on whitebait species. The precautionary approach is required in Objective (F) in the Waikato River Vision and Strategy. It is also specifically mentioned in the DOC whitebait regulations regarding the management of this fishery.

Variability of *E. coli* in rivers: implications for interpretation of grab samples

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Escherichia coli (*E. coli*) concentrations in rivers are known to vary considerably, particularly during storm events. So a lot of research has been conducted on the relationship between faecal microbe concentrations and flows. However, there is still considerable variability in microbial concentrations during base-flow conditions and there has been little research conducted to understand this short-term variability. We investigated the variability of *E. coli* concentrations in base-flows at the time scales of minutes, hours and days and compared this to variability from laboratory-replication of the measurement methods. This was conducted in three different sized rivers in both summer and winter seasons. Estimates of variability were analysed using the coefficient of variation (CV). The variability at the minute time scale was 17%, compared with the laboratory replication variability of 15%. The CV then increased to approximately 32% and 60% at the hourly and daily time scales, respectively. As expected there is strong evidence that both time-scale and river significantly affect the variation in *E. coli* concentrations. *E. coli* concentrations were higher in summer than winter, with a very marked effect in the smallest stream where at one site the concentrations were >2000 *E. coli* 100 mL-1 in all summer samples. This variability of concentrations has significant implications for interpreting the results from a one-off grab sample, when used to compare against water quality standards, or for calibrating models.

Valuing rural riparian zones and wetland areas

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Understanding the total value of riparian areas and wetland zones enhances decision making. It enables more rigorous analysis of the trade-offs of costs and benefits. However, riparian zones and wetland areas are typical of many environmental assets, the majority of their costs can be valued in a market place, for example the costs of fencing and planting, while the majority of benefits are non-markets benefits, meaning they are not traded directly for money, and therefore, are often inadequately accounted for in decision making.

This paper looks at market and non-market costs and benefits for riparian zones and wetland areas. It provides estimates of costs and benefits which can be varied based on the site, including area and design, and highlights where the key gaps are in assessing these costs and benefits. The biggest gap is isolating and valuing the specific environmental benefits from these areas, such as their contribution to improving water quality. Existing studies on the willingness to pay for improved water quality provide a starting place for quantifying the non-market benefits. However, the benefits estimated in these studies generally relate to water quality as an amalgamated benefit, and there is a need to explore the willingness to pay for specific non-market benefits derived from riparian areas and wetland zones. This paper provides the foundations to investigating this research gap.

Citizen science invertebrate monitoring provides similar assessments of ecological health as professional monitoring

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We assessed the concordance between volunteer and professional data, including state and trend assessments. We compared macroinvertebrate data collected by volunteers using a simplified identification protocol to data collected by professionals following standard national protocols for collection and identification. We found that volunteer and professional macroinvertebrate data expressed as summary indices of ecological health were significantly correlated. However, the coarser level of taxonomic identification in the volunteer dataset limited the use of taxon richness as a biodiversity measure. We also demonstrated that the ability of volunteer data to detect long-term trends in ecological health is comparable to professional data. Overall, stream monitoring data collected by volunteers provided an assessment of stream health that was concordant with assessments based on data collected by professionals, indicating that volunteer data could be used to support professional monitoring programmes. The challenge for monitoring agencies now appears to be how to incorporate volunteer data into state of the environment monitoring programmes.

Taxonomy, provenance, abundance, and activity of Lindavia intermedia as revealed by molecular (and other) methods

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The centric diatom Lindavia intermedia is now widespread in New Zealand lakes, causing problematic lake snow in some cases. Recent progress has been made in understanding the taxonomy of this organism and its origin in New Zealand, and new tools developed to quantify it in samples and measure the expression of genes implicated in slime production.

Although samples from overseas were challenging to obtain, the genetic data available show a broader diversity of Lindavia intermedia in the Northern Hemisphere than in New Zealand, with samples from Youngs Lake (Seattle, USA), where lake snow also occurs, identical to New Zealand material. The ability to generate lake snow may therefore be restricted to a subset of the cryptic diversity in this species, and observations are most consistent with a recent dispersal from North America to New Zealand. Studies described by others in this session also reach the latter conclusion using complementary evidence.

Morphological confusion between this species and others, and the desirable utility of being able to enumerate cells in large numbers of samples quickly for research purposes, led to development of a qPCR quantification method based on a rapidly-evolving chloroplast genomic region (characterised earlier during the biogeographic study). The method is able to detect copies of this molecule over at least nine orders of magnitude, in theory to the level of a single cell. A combination of transcriptome sequencing and 3'RACE was then used to characterise transcripts from chitin synthase genes, which are implicated in slime production in this group of algae, and a similar qPCR method developed for quantification from total RNA. Taken together these methods have the potential to identify conditions conducive to lake snow synthesis in both field and laboratory studies, through the examination of cell abundance and activity over a range of conditions.

On the need for more rigorous adoption of best practices in environmental modelling

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Models are increasingly being relied upon to inform and support natural resource management, especially in freshwater environments. Models are incorporating an ever broader range of disciplines and now often confront people without strong quantitative or model-building backgrounds. It is easy for a non-modeller to remain unaware of the limitations, uncertainties, omissions and subjective choices in models. The risk is then that too much confidence is placed on the outputs and/or predictions of the model. There is also a danger that models may be used outside of the context they were intended for, increasing the likelihood of drawing invalid conclusions.

We have recently identified and documented challenges associated with the use of predictive modelling, including freshwater examples, in the environmental and resource management decision-making process through a systematic review of New Zealand legal decisions. All of the legal challenges to models related to the scientific components of the model (e.g. assumptions, input data, and parameters), model evaluation or application. There are numerous publications that describe best practice for modelling from a technical perspective, but it appears that these guidelines are not always being followed. If models are to be of substantial help in environmental decision-making then modellers and decision-makers will need to ensure that there is a clear understanding of the purpose of a model, the modelling process is transparent, limitations are acknowledged and considered, and that best practice guidelines are followed.

Our focus now is to develop appropriate best practice guidelines for model use and development for environmental decision makers. These guidelines will likely be based on existing best practice frameworks that focus on the technical aspects of modelling and will aim to increase transparency and scientific rigor of modelling projects undertaken for environmental decision makers.

Tracking groundwater contamination using DNA tracers

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With the expansion of human activities in New Zealand, water resources are increasingly exposed to pollution from animal and human wastes. This has resulted in an increased need for investigating the contamination sources and their pathways in groundwater using effective tracing techniques.

We have recently developed novel and environmentally friendly DNA tracers for the purposes of tracking water contamination sources and pathways. A total of 20 DNA tracers, each with a unique identifier, have been synthesised. We have tested these DNA tracers in two groundwater systems in Canterbury and Waikato, and results are promising. The groundwater systems in the Canterbury site and Waikato site have contrasting aquifer properties (coarse alluvial gravel aquifer versus fine coastal sand aquifer, respectively) and groundwater flow characteristics (fast vs slow, respectively). We have also satisfactorily evaluated these DNA tracers in lysimeters that contained undisturbed soil extracted from the Canterbury Plains. The next step is to validate these DNA tracers in surface water systems.

Our field studies suggest that the new DNA tracers that we have developed show great promise for use as a water tracing tool. We will continue to work with end-users to further validate these new DNA tracers in the field conditions. With future up-scaling, the new DNA tracer techniques could provide a useful tool for concurrently tracking multiple pollution sources and pathways in freshwater environments. The impact of this research will be the development of better mitigation strategies for the protection of New Zealand's precious freshwater resources.

Can we find a climate-change fingerprint? Detecting recent range shifts among Japan's freshwater-associated species

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Analysis of long-term trends in species distributions provide insights into the status of regional biodiversity in the context of habitat loss, invasive species introductions and climate change. Conducting studies of multiple species at a national or global scale is difficult however, as adequate long-term datasets are rare for many regions resulting in data gaps and potential bias. For example, several studies have reported global poleward trends in species distributions (range shifts) and identify this trend as a "fingerprint of climate change". However the data from these studies are mostly from continental regions and largely absent for the Asia-Pacific. Assumptions that the changing climate may drive poleward shifts in other regions, as predicted for thermophilic pest fish species in New Zealand, are therefore based on geographically-biased analyses.

The present study compiled a 20-year dataset from Japan's National Census on River Environments (NCRE) to help address geographical gaps in such analyses. A modelling approach was then used to detect changes in species occurrence and distribution, and look for evidence of latitudinal range shifts in 343 species. The analysis included freshwater fish, macrophytes, and amphibians. While there are some known limitations to the NCRE dataset, the analysis was able to confirm trends in distribution and occurrence for some well-studied species. Poleward range shifts were detected in 3% of species, while range shifts towards the equator were detected in 2% of species. Although drivers of the observed trends were not analysed here, the low occurrence of poleward range shifts suggests assumptions that species will shift poleward due to climate change may be over-simplified. This work has shown that multi-species studies provide vital information to inform conservation and policy objectives, and highlights the value of long-term data sets in understanding regional – and global – changes to biodiversity.

Can kākahi (Bivalvia: Hyriidae) prey on non-indigenous Daphnia?

Anita Pearson[1], Dr Ian Duggan[1]
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In recent years, a number of non-indigenous zooplankton have been identified in New Zealand waters, with zooplankton making up one-third of the total number of known non-native invertebrate species established in New Zealand lakes. To date, studies on trophic interactions between zooplankton and freshwater mussels globally have primarily focused on the impact of non-indigenous bivalves on native zooplankton communities, or the diets of propagated mussel species. Little is known, however, of the interactions between native mussels and non-native zooplankton. We examined interactions between two recent invaders to New Zealand, the efficient filter feeding cladocerans *Daphnia galeata* and *D. pulex*, and filter feeding native freshwater mussels. We compared the predation rates of the common native mussel, *Echyridella menziesii* (also known as kākahi or kāeo), on non-native Daphnia relative to two common native species, the small cladoceran *Bosmina meridionalis* and rotifer *Brachionus calyciflorus*. Controlled laboratory experiments were conducted in which each zooplankton species was exposed to bivalve predation for a two-hour period. Comparing treatments to non-mussel controls, removal rates of *D. pulex* and *B. calyciflorus* were statistically significant. Nevertheless, kākahi were seemingly unable to remove ecologically significant numbers of daphnids (1.7% D. galeata and 7.4% D. pulex). However, kākahi removed 8.8% of *B. meridionalis* and 30.2% of *B. calyciflorus*. Our findings suggest that small, feeble zooplankton species, such as rotifers, are susceptible to predation, and potentially function as a key food source for New Zealand freshwater mussels. Further, the presence of non-native Daphnia in lake and pond systems could negatively impact kākahi indirectly, as Daphnia can reduce the numbers of rotifers available as a food source due to exploitative and interference competition. Nevertheless, low numbers of Daphnia consumed may compensate for a loss of easily consumed rotifers due to their much greater biomass.

Are non-indigenous fishes exploiting empty niches in lacustrine environments?

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Are non-indigenous fishes exploiting empty niches in lacustrine environments? The empty niche hypothesis suggests that there are unutilised resources available within an indigenous ecosystem and that a non-indigenous species will be more likely to establish when utilising these previously unexploited resources. We tested this hypothesis with analyses of the fish communities and their trophic resource use in a range of shallow lakes in the Wellington Region.

We firstly characterised the fish communities by using a combination of different mesh-sized gill nets, fyke nets and Gee-minnow traps to maximise the diversity and size ranges of species caught. From each lake, representative samples of the species and size classes were collected for analysis of stable carbon and nitrogen isotopes, as were samples of basal resources and primary consumers to establish an isotopic baseline for each lake. Ratios of stable carbon and nitrogen isotopes were then used to quantify trophic position, niche breadth and niche overlap for each species within each lake.

Of the seven lakes that have been surveyed so far, over 9,000 fish have been caught from twelve species; eight indigenous and four non-indigenous. Species richness across lakes ranged from four to eleven with a mean of seven species. Species abundance varied across lakes and shortfin eel, common bully, perch and rudd, were typically the most abundant indigenous and non-indigenous species. Preliminary analysis of stable isotope samples indicates that some non-indigenous species may occupy, at least in part, empty niches within these lakes. Large perch appear to occupy a higher trophic level than large indigenous shortfin eel, both of which are typically considered piscivorous. Adult rudd, unsurprisingly given they are considered herbivorous, were also utilising resources not used by other fishes. Further work is being undertaken to examine whether non-indigenous species really are occupying empty niches or whether niches of indigenous species are being modified in the presence of non-indigenous fishes.

DOC's freshwater fish monitoring – what, why, when, where and how?

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[1]*Department of Conservation*

The Department of Conservation (DOC) undertakes freshwater fish monitoring to help determine population status and trend, research species' biology and ecology, inform management, and assess management effectiveness. We have undertaken a national analysis and summary of all DOC's past and present freshwater fish monitoring projects, and identified common characteristics, shared trends, and gaps in our monitoring programmes. In total, 177 monitoring projects, for 27 species, have been conducted over the past 30 years. Species monitored included fourteen non-migratory galaxiids, three large galaxiids (whitebait), and all five mudfish species. A large number of monitoring projects were established as a result of priority actions identified in DOC's three freshwater fish recovery plans. Currently only 48 fish monitoring programmes are ongoing, with some of these now undertaken by other organisations. Objectives, locations, methods and trends will be presented and recommendations for future planning, collaboration and direction discussed.

Efficacy of a phycocyanin sensor as a surrogate measure of cyanobacterial blooms

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In recent years, water bodies in some parts of New Zealand have experienced an increase in the number of cyanobacterial blooms. These events have the potential to introduce into the water, toxins that can have acute effects and, if their concentrations are high enough, fatal consequences for the public.

Most cyanobacterial monitoring is conducted by conventional laboratory methods such as taxonomic analysis (cell count and biovolume measurements), phytoplanktonic pigment extractions and cyanotoxin analysis of water samples. These methods are costly, time consuming and are unable to monitor rapid changes in water quality or sudden increases of cyanobacterial biovolume.

The fluorescent pigment phycocyanin is found in most freshwater cyanobacteria. It can be readily differentiated from chlorophyll a due to its lower emission wavelength. Online fluorescence-based probes may therefore be able exploit this difference and provide an estimate of cyanobacterial proliferations. Furthermore, real-time fluorescence readings may provide immediate warnings of cyanobacterial blooms. However, robust and consistent relationships between phycocyanin fluorescence sensor readings and cyanobacterial water populations are necessary before sensor readings could supplement conventional laboratory measurements of algae cell count and biovolume.

We present the results of an investigation into the relationship between phycocyanin sensor data and cyanobacterial cell counts at 3 lake sites (Waikare, Whangape, and Waahi) and 2 Waikato River sites monitored by the Waikato Regional Council.

Tracking historical cyanobacterial communities in five contrasting shallow New Zealand lakes

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Multiple human-related changes in lake state contribute to an increasing frequency and intensity of cyanobacterial blooms. In this study, a novel paleolimnological approach was used to document the evolution of cyanobacterial assemblages over time in five contrasting New Zealand lakes; Pounui, Wairarapa, Paringa, Johnson and Hayes, with particular reference to bloom-forming taxa. eDNA was extracted from sediment cores dating back approximately 1,000-years, and analysed using cyanobacterial 16S rRNA metabarcoding. Cyanobacteria were detected in all lakes, with picocyanobacteria representing the highest relative abundance over time. Community compositions were lake-specific, although assemblages were closer in lakes from the same geographic locations. Marked shifts in cyanobacterial community composition were observed in all lakes in the past 1000 years. Lakes Hayes and Johnson displayed the most change in cyanobacterial community composition over time, with several obvious shifts since human arrival. The changes varied between lakes and comparison with other paleolimnological proxies suggests that likely drivers of change include land-use and the introduction of non-native fish. Sediment DNA analysis can complement traditional paleo-approaches, and provide novel information on microbial communities, and new insights into causes and consequences of cyanobacterial blooms.

Casting a net over the river: Bayesian networks as a real-time prediction tool for swimability

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Predicting bacterial levels in New Zealand waters often relies on complex mathematical models…. but do these models need to be complex? Can we get reasonable predictions about `swimability` by focusing on the interaction of simply a few environmental variables?

Bayesian networks can act as a tool for analysing the interactions between variables in a complex system, whilst providing a framework that can be easily understood by a non-specialist audience. In this talk we share our experiences of developing a Bayesian network to describe the swimability of the Aparima River at Thornbury, Southland. The Bayesian network developed was based on the interaction between rainfall, river flow, soil moisture and *E coli* concentrations at three areas upstream of Thornbury as well as local conditions. The current model correctly predicts the *E. coli* concentration band for 84% of the samples in our validation set. However, there is still much room for improvement.

When a Bayesian network is shown to have appropriate predictive power it can be easily implemented as a tool to provide real time predictions of `swimability`. Bayesian networks have the ability to automatically update the model as new data becomes available.

Nutrient load limit setting for estuaries - the New Zealand Estuary Trophic Index approach

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[1]*NIWA*

Eutrophication threatens many New Zealand estuaries. Symptoms of eutrophication due to high nutrient loads include excessive algal growth, depleted dissolved oxygen, sulphide-rich sediments, seagrass loss, and changes to animal communities. For most estuaries, nutrients loads are dominated by sources in upstream catchments rather than nutrient input from the ocean. Consequently, there is potential to control eutrophication in estuaries by restricting catchment nutrient yields to appropriate levels. Setting catchment nutrient yields that protect estuaries is a difficult task because impacts of nutrient loads are dependent on the interactive effects of freshwater discharge, tidal mixing of fresh and salt water, and estuary morphology.

Simple tools were developed for the New Zealand Estuarine Trophic Index that account for mixing between river and ocean water in estuaries and predict the resulting potential estuarine nutrient concentrations and flushing times. In this presentation, we describe how these concentrations and flushing time estimates have been linked with levels of macroalgae and phytoplankton to predict bandings of expected estuarine trophic condition. Inverting this process gives ranges of catchment nutrient yields corresponding to different expected trophic states in estuaries, guiding decisions about catchment management and implications for estuaries.

We illustrate how appropriate nutrient loads to estuaries can be estimated using case studies from two Otago estuaries: Shag River and Pounawea (Catlins). Bathymetry and salinity surveys were used to develop simple mixing models. The Shag River estuary has a single dominant freshwater inflow and is modelled with a single compartment box-model. Pounawea is more complicated with two main freshwater sources and two distinct basins. A two-compartment box-model was developed which enables the impact of nutrient loads from each river to be assessed, as well as the sensitivities of the upper and lower estuary. These models are also used to predict catchment load bands corresponding to expected trophic states.

Tieki wai in the Waiapu

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Hikurangi Takiwā Trust is a hapū collective within Ngāti Porou with strong kaitiakitanga aspirations and a desire to engage in the co-management of freshwater in the Waiapu rohe. For the last three years, we have been developing local capability in the design and implementation of a cultural monitoring framework that will facilitate successful co-management. A series of wānanga have fostered:

- Rangatahi, whanau and kaumatua reconnecting with their whenua, whakapapa, te reo me ona tikanga;
- identifying local values and collectivising with neighbouring values;
- Tieki wai – developing a broader understanding of freshwater assessment methods and 'state of the takiwā' freshwater surveys to quantify baseline state and help inform freshwater objectives; and
- the development of site and marae-based monitoring tools to track progress towards freshwater objectives.

Tieki wai (freshwater management) inherently needs to be informed by kaitieki (whanau and hapū guardians, caretakers) and supported by mātauranga (cultural knowledge). The cultural monitoring framework (in development) needs to be reflective of this, facilitate participation in hapū and iwi management initiatives, and robust and defensible in statutory and local government processes. Key challenges, including a small population with multiple responsibilities and limited resourcing and capability, are overcome by a kaitieki-informed approach that recognises the need to address economic, social and environmental responsibilities in unison.

New guidelines and existing freshwater policy: using the best tool for the job

Jennifer Price[1], Carl Howarth[1]
[1]*Ministry for the Environment*

The 2018 Australian and New Zealand Guidelines for Fresh and Marine Water Quality (the ANZ Guidelines) are a useful new tool for managing water quality. They have been designed to complement the existing National Policy Statement for Freshwater Management (NPS-FM), a key instrument directing local government management of freshwater. In addition to the NPS-FM, there are guidelines, standards and planning provisions that practitioners need to take into account when choosing how to assess water quality. What does this mean for freshwater scientists and managers working in New Zealand? This presentation will outline the relationship between the new ANZ Guidelines to existing policy, explore their purposes and give examples of situations where they apply. Key topics will include:

- Default Guideline Values for toxicants and physical and chemical stressors: purposes and applications
- Relationships between the ANZ Guidelines and attribute states in the NPS-FM
- Compulsory values, non-compulsory guidelines and other terminology
- Examples of situations where different guidelines, standards and attributes should be used
- Answers to frequently asked questions.

Land-use and Waterway Quality at Mt. Grand Station, New Zealand

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This research project focuses on the waterways of Mt. Grand, a South Island High Country sheep station. The station is 2136 ha of mostly mountainous terrain, running fine wool merino sheep and a small herd of beef cattle.

Nearby, flatter land has undergone agricultural intensification, and several higher altitude areas of the station have been converted to public conservation land through Tenure Review. Situated between these conversions, Mt. Grand faces intensified agronomic pressures to remain economically viable, which may affect the ecological quality of its waterways. The steep catchments of Mt. Grand face soil erosion issues, and are a ready source of sedimentation.

On three occasions during the year, stream waters in three differing catchments were sampled for analysis of Total Phosphorus, Total Dissolved Phosphorus, cDGT and total suspended solids concentrations, as well as other associated physicochemical parameters. Total Phosphorus concentrations in riparian soils, and in deposited stream sediment were also sampled. Benthic macroinvertebrate communities were sampled, and the results used as bioindicators of stream ecosystem health.

Overall, the ecological quality of stream water was good, but was reduced at lower altitudes of one catchment. Phosphate and total suspended solids concentrations were highest in a catchment containing no significant native vegetation, and increased agricultural intensity. This catchment also recorded the lowest levels of benthic macroinvertebrate biodiversity. The combined results from all catchments show a negative relationship between the observed percentages of sensitive macroinvertebrate taxa, and phosphate enrichment.

Understanding toxin production in bloom-forming cyanobacteria from New Zealand lakes

Jonathan Puddick[1], Susie Wood[1], Kirsty Smith[1], Ian Hawes[2], Daniel Dietrich[3], David Hamilton[4]
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Blooms of microcystin-producing cyanobacteria are problematic worldwide and contact with contaminated water has resulted in multiple human and animal fatalities. Despite 30 years of research on microcystins, the ecological function of the toxin and the mechanisms that regulate toxin production are still debated. Our research group has been investigating toxic cyanobacteria in New Zealand lakes with the aim of understanding: the conditions that occur within cyanobacterial blooms; how these influence toxin production; and how the cyanobacterial community responds. By assessing Microcystis blooms in the natural environment, we identified that toxin production was triggered when dense accumulations of form on the surface; i.e., 'scums'. However, it was not clear whether the increased toxin production was caused by increased cell density or by the 'stressful' conditions inside the scum (i.e., elevated pH and dissolved oxygen). To better understand the adverse environmental conditions that develop in Microcystis scums we simulated scum formation using mesocosms to concentrate suspensions of Microcystis. The scums were monitored using pulse amplitude modulation fluorometry and a benthic lander equipped with micro-electrodes to profile the pH and dissolved oxygen through these scums in 100-µm steps. Through the application of liquid chromatography-mass spectrometry, quantitative PCR and fine-scale vertical profiles collected using cryogenic samplers, we were able to demonstrate that the increased toxin production that occurs during scum formation is localised to the top layer of the cyanobacteria scum. This is possibly due to increased oxidative stress at the air-water interface or increased photosynthetic activity occurring at the surface. We will discuss our research results, how modern research tools were applied to understanding this specific system and how these techniques might be adapted in the future to understand other freshwater systems.

Nutrient attenuation in gravel bed rivers: ecosystem service or eutrophication symptom? Ngā tohu o te Tukituki

John Quinn[1], **Kit Rutherford[1]**, Craig Depree[1], Bob Wilcock[1], Brian Smith[1], Roger Young[2], Elizabeth Graham[1], Sherry Schiff[3], Mike English[4]
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Gravel bed rivers alter amount, form and timing of nutrients as they are transported downstream through a range of processes. Some processes, notably denitrification of nitrate to N gases and emergence of stream insects as adults, can permanently remove nutrients from the river water (true attenuation). Others involve often temporary storage (e.g., sedimentation) and transformation (by periphyton biomass) between bioactive inorganic forms and more refractory organic forms. These nutrient cycling/spiralling processes are generally seen as desirable ecosystem services of rivers, that support river food webs and protect downstream river reaches, lakes and the coast from eutrophication effects by reducing nutrient export. But high nutrient attenuation rates are often associated with nuisance/harmful periphyton blooms in gravel bed rivers and cascading eutrophication impacts downstream, i.e., ecosystem disservices.

We draw together lessons from summer surveys of nutrient attenuation and periphyton interactions along a 80 km reach of the lower Tukituki River from 2011 to 2017 to explore: (i) a broader conceptual understanding of in-river nutrient attenuation, (ii) the rates and dynamics of the contributing processes, and (iii) the thresholds of periphyton biomass and ecosystem metabolism that indicate when nutrient attenuation switches from a desirable service and an undesirable eutrophication symptom.

Are rare macroinvertebrate assemblages driven by distinct environmental factors?

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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 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 in Tongariro National Park in the Central North Island, New Zealand, in proportion to the FENZ classes that were represented in the area. 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.

Me pēhea te whakarauora i ngā repo o Maniapoto - how do we go about restoring the wetlands of Maniapoto?

Kelly Ratana[1,2], **Ngahuia Herangi**[3,4]
[1]Ngāti Tūwharetoa, Te Arawa, [2]NIWA, [3]Waikato/Maniapoto, Ngāti Raukawa ki te Tonga, [4]Maniapoto Māori Trust Board

With only 10% of wetlands remaining in the Waikato, wetland loss and the loss of Maniapoto resources and knowledge systems associated with these critical ecosystems is a distinctive issue for many across the Maniapoto rohe (territory). Maniapoto consider puna (springs) and repo (wetlands) a highly valued traditional resource and an integral component of the ancestral landscape. While restoration and/or preservation of wetland ecosystems often occurs at sites prioritised by economic or ecological drivers, iwi and hapū have little opportunity to capture, reframe and utilise their mātauranga to determine their own priorities or contribute to decision-making processes. Maniapoto identified that this requires knowledge of locations, values, uses, associations and importance of these sites.

Methodologies for capturing spatially-grounded mātauranga and a framework for prioritising wetland restoration efforts based on that mātauranga were developed in a project called “Ngā Repo o Maniapoto”. Participatory mapping methods using a combination of Geographic Information Systems (GIS), interactive mapping eBeam technology, and semi-structured interview techniques provided an effective and efficient way to build a knowledge inventory based on mātauranga ā-hapū. The novel eBeam technology brings participatory mapping a step further allowing real time digitisation of data. This inventory was then utilised with whānau to build the foundation of a decision-support framework to enable prioritisation of restoration efforts across their rohe. In this presentation we discuss how these relatively new and innovative methods were used to map, collate and assist Maniapoto whānau to reframe and prioiritise their mātauranga to support iwi and hapū-based decision-making.

PFAS in New Zealand Fish: Is this the next threat to our aquatic ecosystems?

Nerena Rhodes[1], James Conway[1]
[1]Pattle Delamore Partners

Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) are a group of emerging contaminants that are the subject of increasing scientific, regulatory and media interest because they are highly water soluble, persistent in the environment and bioaccumulative.

Investigations into PFAS contamination of the environment are relatively recent, particularly in New Zealand. PDP have been investigating this group of contaminants in the NZ environment since 2015. Initial investigations focused on sampling of soil and water. More recently, the investigations have extended to analysis of the tissue of aquatic plants, macroinvertebrates and fish. In some locations fish tissue samples have exceeded the applicable Food Standards Australia and New Zealand trigger level, however the relationship to ecotoxicology still remains unclear.

The results of our investigations thus far have confirmed bioaccumulation of PFAS in NZ fish and macroinvertebrate species (both freshwater and marine). Concentrations have varied between species, with some species appearing to have a greater propensity to accumulate PFAS. These species could be a useful indicator of PFAS contamination.

Investigation results indicate that sediment and to a lesser extent surface water is a poor indicator of ecological risk.

In this paper we will discuss the results of tissue analysis for PFAS of macroinvertebrates and fish from several locations which are adjacent to identified sources of PFAS. These results will be compared to results obtained from similar investigations in Australia. The current understanding of the ecotoxicology of PFAS will be discussed in the context of the concentrations observed.

Effects of intraguild predation on individual specialisation in the Common Bully

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Individual niche specialisation (IS) within populations is ubiquitous: individuals often are specialist users of a subset of their population's total available resources, meaning that individuals within a population can deploy a variety of ecological strategies to exploit a wide range of resources. In that regard, IS potentially affects population dynamics and ecosystem processes. Although the incidence and degree of IS can be influenced by biotic interactions, little is currently known about the specific effects of intraguild predation on individual niche variation. In this study, I explore how competition and predation risk from an intraguild predator influence individual specialisation within a population of New Zealand-native Common bully *Gobiomorphus cotidianus*. Common bullies exhibit a generalised diet at the population level with moderate levels of individual dietary specialisation. They compete with juvenile perch *Perca fluviatilis* for the same pool of pelagic and benthic resources, while being preyed upon by large, piscivorous adult perch. I used a mesocosm pond experiment to analyse the response of individual bullies to moderate levels of competition from young-of-year perch and predation risk from sub-adult perch. Over a 3-month period, I monitored individual habitat use through instant focal surveys, and used non-lethal gastric lavage to evaluate individual dietary preferences within the mesocosms populations. Significant effects of competition from YOY perch were found at the population level on bully diet and habitat use. Competition had also a significant effect individual dietary specialisation. Predation risk had a weak synergistic effect with competition on the position and size of the dietary niche. On the habitat niche, competition had a significant effect at the population level, but no significant effect on individual specialisation. Overall, this study provides novel information about the ways in which intraguild predation shapes individual variation and provides clues as to how populations might undergo niche shifts following species introduction

A case study: linking catchment land use management to lake water quality

Keryn Roberts[1], James Dare[2], Rob Williamson[1], Simon Mapp[1], Nathan Cruickshank[1], Nick Ward[1]
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Environment Southland has been monitoring three coastal lakes (Lake George, Lake Vincent and The Reservoir) since 2015, as part of a wider Lakes and Lagoons State of Environment monitoring programme. These shallow lakes are located in catchments extensively used for agriculture and have shown signs of degraded water quality. Specifically, we have seen increased incidences of algal and cyanobacterial blooms. Catchment land use practices in Southland such as stock wintering on forage crops, feed pads and silage storage, can increase nutrient and sediment loads in our coastal lakes. If these land use practices are not managed effectively they can indirectly impact lake health. The Lake Vincent catchment provides a case study that highlights the linkages between lake health, catchment land use, and lake water quality management. The water quality in Lake Vincent significantly degraded in 2016 when compared to work carried out by Schallenberg et al. 2004. The concentrations of Total Phosphorus (TP) fell within the 'C band' and Total Nitrogen (TN) was below the 'national bottom line' defined in the National Policy Statement for Freshwater Management. These changes were linked to poor land use practices within the catchment.
In late 2016, a 'Lake Vincent Catchment Management Proposal' was developed by Environment Southland to reduce nutrient leaching and improve water quality. This proposal involves an ongoing joint effort between Environment Southland's Science, Compliance and Land Sustainability teams, along with the landowners in the Lake Vincent catchment. Outcomes to date have included a step change reduction in point source discharges to the lake and improved land use management, including riparian fencing and planting, the lining of effluent ponds and capture of silage leachate. Monitoring showed lower TN and TP concentrations for 2017 compared to 2016, however given the land use changes are recent, more time is required to determine a trend.

Nutrient thresholds for protecting wetland ecological integrity

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The ecological integrity of freshwater wetlands is influenced by hydrological regime, invasive species, habitat loss and changes to sediment and nutrient contaminant loads entering from catchment sources. Research in Europe and North America, and from New Zealand, indicates that elevated nutrient concentrations in wetlands leads to a shift in wetland plant community composition and structure. The vegetation shift often corresponds to increased dominance of non-native plant species that adapt and grow more rapidly in response to altered trophic conditions. Nutrient thresholds are defined for other lentic systems (lakes) and applied in regional catchment planning. However, the variability of nutrient dynamics for wetlands, given site specific geological settings and hydrological dynamics has limited the ability to define equivalent nutrient thresholds or limits that can be applied to protect wetlands.

We investigated nutrient-plant relationships at three large-scale wetlands in New Zealand (Whangamarino wetland ~7000 ha; Ō Tū Wharekai/Ashburton basin wetlands (~5000 ha), and Awarua wetland (~12,000 ha). Soil chemistry (TN, TP, Organic C, pH, EC, bulk density, water content) and plant composition and abundance data were collected from a high number of sample sites (min. n = 36 at Whangamarino) stratified across the three dominant wetland types (swamp, fen, bog) at each site.

We found that nutrient concentrations and plant composition within wetland complexes exhibit clear gradients in TN, TP and the dominance of indigenous species. Within wetlands, species richness and the abundance of indigenous taxa correlated with nutrient concentrations, particularly TP with high TP in wetland soils associated with lower native dominance. Between wetlands (data combined) nutrient-plant thresholds were less definitive.

The study confirms the inter-relationship between nutrients and wetland vegetation and identifies the need for further targeted assessment and multivariate modelling of land use impacts on wetland ecological integrity.

Can the Integration and Implementation Science framework support better research for land and water policy?

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Regardless of whether policies are made collaboratively, there needs to be more purposeful collaboration in generating the knowledge for managing land use and water quality. Over the past eight years, there has been interest in collaborative policy-making for water management, responding to national policies requiring environmental limits to be set. However there has been relatively little focus on how knowledge for policy needs to change to be credible, salient and legitimate for this new type of policy and, when made collaboratively, this new policy-making environment. Undertaking this type of research provides particular challenges for the team: it is a live case-study, the decisions have real-world impact; each point in the process happens once and actions, both mistakes and successes, have consequences. However, the understanding about how to undertake such investigations is fragmented, and consequently what is done is largely informed by individual scientists' own experiences and training, and yet these processes impose new expectations on scientists involved with them. The Integration and Implementation Sciences (i2S) framework claims to provide a systematic way to describe and assess the processes, concepts and methods used in case-based research on complex real-world problems. In the Collaboration Lab, as part of the Our Land and Water National Science Challenge, we set out to test if using the i2S framework would lead to generating useful and fit for purpose science for policy and practice change. The research assessed case studies ex post for their degree of fit with the i2S framework and collected reflection and self-evaluation data from the research team and an evaluation of usefulness from the next users of the research. The early indications are that the research with the greatest degree of fit with the i2S framework is also deemed useful by the next users.

Natural Dispersion of Mercury from Puhipuhi, Northland – Revisited

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The historic Puhipuhi mercury mine is located near the headwaters of the Wairoa River in Northland. As part of their gold exploration program, Evolution Mining Limited engaged PDP to undertake a baseline survey of metal concentrations (including mercury) in biota, sediments and water in the Wairoa River. PDP re-sampled a number of locations that were previously investigated by Hoggins and Brooks in 1972 using modern ultra-trace sampling methods and analyzed samples at a US EPA reference laboratory. The levels of inorganic elements contaminants (arsenic, cadmium, and mercury) in aquatic organisms (freshwater crayfish, shortfin eels, and shellfish) were measured. Elevated concentrations of mercury were detected in eels over 30 km from the site. The investigation found similar levels of mercury in sediments and water at all revisited sampling locations despite the fact that over 40 years have passed since the initial investigation.

This study also showed that mercury concentrations in tissue samples from freshwater and eels were above the NZFSA guideline criteria (0.5 mg/kg) at a number of locations, even when mercury concentrations in surface water were significantly below ANZECC (2000) for 99% ecosystem protection trigger values. It is recommended that direct tissue sampling is undertaken to assess potential risks to human health from mercury emissions of geothermal, mining and industrial sites as using ANZECC 99% ecosystem protection trigger values do not necessary provide protection from the effects of mercury bioaccumulation.

Stream shade restoration: are canopy shape or channel orientation important?

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Restoring riparian shade to formerly forested streams is an important step towards improving ecological health. The ratio of tree height (h) to stream width (w) strongly influences average shade, while tree shape and canopy overhang are important near the stream banks. A simplified model for DIFN (viz., shading to diffuse radiation) has been tested experimentally, and shown to reproduce shade predicted using a physically-based model (which includes both direct and diffuse radiation). This supports the premise that DIFN is a useful index of long-term averaged light exposure. However, questions arising when planning stream restoration include: (a) how does stream orientation influence shade, (b) does the effect of orientation vary throughout the year with change in sun-path, and (c) must both banks be planted to achieve a target shade level? Using a physically-based model, we conclude that, when tree height and setback are the same on both banks, shade is higher for a north-south than an east-west flowing stream. Consequently, the width of stream that can be shaded, say 70% to avoid nuisance plants or periphyton, decreases monotonically with channel orientation between N-S and E-W. However, when tree height is higher on the 'sunny' (N) bank, plant and bank height, and tree setback, interact in a complex fashion to determine shade. For some combinations of bank height, setback and plant height, the maximum width of stream that can be shaded 70% occurs at 30°or 60°.

Recreational water quality investigation: sources of faecal contaminants

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To identify potential faecal contamination issues in popular swimming areas, an initial water quality snapshot survey of 18 coastal stream mouths was conducted. Based on the results of the snapshot, four catchments were selected for further investigation to gain a more comprehensive understanding of where in the catchment faecal contamination may have come from and whether the source was animal or human-derived. The sources of these contaminants are rarely within the coastal areas themselves; in most cases, we need to identify diffuse sources in the catchment that are flushed into estuaries via streams and rivers following rainfall or during flooding of low-lying land caused by spring tides. With the use of faecal source tracking, we carried out event-based sampling to quantify contamination levels during dry and wet weather and during spring and neap tides at the stream mouths. These types of investigations help us to build a better understanding of catchment-specific sources of contamination which can ultimately inform robust, science-driven management responses. Including appropriate catchment management practices

Vibrational Spectroscopic and Multivariate Analysis of New Zealand 'Lake Snow'

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Lake snow is a brown polysaccharide mucilage excreted by a microscopic alga called Lindavia intermedia. It has been found in at least a dozen lakes in New Zealand causing significant problems by clogging public filtration systems, fouling boat motors, sticking to skin of swimmers and clinging to fishing lines. Monitoring programs are required to better understand the presence of lake snow within a lake to help more accurately determine linkages with environmental drivers. Spectroscopy is suitable for providing real-time feedback for lake snow analysis as it is a fast, non-destructive technique with little or no sample pre-treatment, and has multivariate output. Various spectroscopic techniques were combined with multivariate analysis methods to detect natural variance between and within lakes and depths of sample collected. Preliminary analysis of New Zealand lake snow samples were done using multiple complementary spectroscopic techniques: Fourier transform Raman (FT-Raman), FT-infrared (FT-IR), low-frequency Raman and Raman microscopy. These techniques coupled with principal component analysis (PCA) highlighted spectral and hence chemical differences between lakes. In addition, differences were observed across different depths within one lake. These differences were from spectral characteristics which are caused predominantly by vibrations of polysaccharides, photosynthetic pigments and lipids. The different methods were able to distinguish and separate samples from different lakes, depths and concentration based on their bio-chemical components and spectroscopic selectivity.

"Lake snow": mucilaginous planktonic macroaggregates and their effects on lake ecology

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Lake snow is the name given to pelagic mucilaginous macroaggregates > 0.5mm in diameter and composed of polysaccharides, associated microbiota and other materials. Lake snow has only been reported from a handful of lakes globally. The first report of lake snow in New Zealand was from Lake Wanaka, a large, glacial, ultra-oligotrophic lake and was associated with the presence of the invasive centric diatom, Lindavia intermedia. Lake snow has since spread to at least nine other New Zealand lakes, is always associated with L. intermedia and is considered a nuisance biotic phenomenon because of its tendency to negatively affect recreational activities such as fishing and swimming and because it clogs domestic and industrial water filters. Analysis of diatoms in sediment cores collected from seven lakes in which lake snow occurs showed that L. intermedia is a recent invader of New Zealand lakes and its arrival in New Zealand apparently coincided with that of another invasive, nuisance diatom, Didymosphenia geminata.

Methods are described for quantitative sampling of lake snow, allowing for analysis of its temporal, horizontal and vertical distribution in lakes, which varies greatly. Marine snow, which has been extensively studied, perturbs normal ecological functioning and our studies show that lake snow has a similar potential to perturb lake ecosystems. For example, the sinking velocity of lake snow macroaggregates in turbulence-free water is positively correlated with aggregate size, and typically exceeds 400 m per day. Recent sedimentation rates measured in lakes in which lake snow occurs confirms that lake snow substantially increases the sedimentation rate of suspended matter to the lake bed, increasing the flux of energy and nutrients to the benthic environment and food web.

Spatial abundance and diversity of picocyanobacteria in two lakes with contrasting geomorphology and trophic status.

Lena Schallenberg[1], Susie Wood[2], Carolyn Burns[1]
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Picocyanobacteria are the most abundant photoautotrophs on earth and are responsible for up to up to 80% of total primary production in oligotrophic lakes worldwide. These organisms play an important role at the base of the microbial food web, yet very little is known about their abundance, diversity and function in freshwater systems, particularly eutrophic waterbodies. My aim was to determine the spatial (horizontal and vertical) distributions of picocyanobacteria in an oligotrophic lake (Lake Wanaka) and eutrophic lake (Lake Ellesmere / Te Waihora) using epifluorescence microscopy and 16S rRNA metabarcoding. All samples from each lake were collected in one day from: 13 sites at a 20m depth in Lake Wanaka including three sheltered bays, three open bays and five open-water locations, and six sites in Lake Ellesmere/Te Waihora from 0.5m deep including one bay site. A further three samples were taken in Lake Wanaka from one open-water site at three vertical depths (combined 0-45m, 60m and 150m). Enumeration by epifluorescence microscopy showed that picocyanobacteria are abundant in both Lake Wanaka and Lake Ellesmere/ Te Waihora at concentrations between $1x10^4$ and $1.1x10^7$ cells/mL. Metabarcoding results demonstrated that diverse picocyanobacteria communities are present in Lake Wanaka and Lake Ellesmere/ Te Waihora. These communities differed significantly between the lakes (only 6% shared taxa), and spatially within each lake. Picocyanobacterial communities in sheltered bays differed significantly from those in open-bay and open-water sites in Lake Wanaka. These findings suggest that picocyanobacterial abundance and diversity in lakes may not be accurately represented using single site samples. Furthermore, picocyanobacteria are unlikely to form a single functional group, as often reported, given the different communities found in these two lakes of contrasting trophic state.

CLUES calibration – can we use CLUES to estimate attenuation?

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The Catchment Landuse for Sustainability (CLUES) model estimates catchment-scale mean annual instream contaminant loads (TN, TP, *E. coli*, sediment). CLUES contains three modelling components, two of which (OVERSEER and SPASMO) have been pre-calibrated; these estimate nutrient yields from pasture, crops and horticulture. The third is the United States Geological Survey SPARROW model that estimates nutrient yields for other diffuse sources and sediment and *E. coli* yields from all diffuse sources. The SPARROW model component also routes contaminant loads downstream and includes terms for catchment delivery and instream and lake attenuation. CLUES has been widely used in New Zealand to support catchment planning and policy making by both regional and national government.

We evaluated CLUES performance by analysing the SPARROW calibration results for each of TN, TP and *E. coli* to identify any spatial or systematic biases in the model residuals due to spatial variability and uncertainty in input and calibration data. SPARROW has been calibrated against monthly water quality data from catchments with varying soils, geology, topography and hydrology across NZ. The latest calibration was undertaken for TN and TP to coincide with the incorporation of OVERSEER 6.3 into the CLUES framework. The *E. coli* calibration was undertaken in 2014. The goal was to test whether CLUES can provide reliable load and attenuation estimates for those contaminants at the catchment scale.

We found that CLUES gives reasonable catchment load estimates (Nash-Sutcliff efficiencies > 0.8) and no bias in the model results were identified. However, there is uncertainty in the model parameterisation suggesting compensating errors between the attenuation parameters and source yields.

We conclude that while CLUES can be used to estimate catchment contaminant loads, it cannot estimate current attenuation realiably. Improved representation of lower order streams in the calibration data would allow us to better estimate attenuation.

Stream and sediment chemistry interact to control dissolved reactive phosphorus concentrations at baseflow

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Many processes – both biotic and abiotic – contribute to the retention of dissolved reactive phosphorus (DRP) and its release back into the water-column at baseflow. The abiotic exchange of DRP with benthic sediments is likely dominant in many streams at baseflow, yet this process remains poorly understood. To elucidate sediment-P interactions, this research examines sediment and water-column chemistry across a gradient of streams in Canterbury, New Zealand. Particularly, we (1) partition sediment-P by metal-oxide phases (i.e., Fe vs Al) and by reactivity (amorphous vs crystalline metal-oxides), (2) model chemical equilibria in the water-column, and (3) place this information in the context of the stream characteristics and historical water-quality data.

During baseflow conditions in autumn 2018, we sampled streams varying in catchment geology, land use, topography, and hydraulic characteristics across Canterbury. Fine benthic sediments and stream water samples were collected from areas of active flow. We collected stream and sediment chemistry data, including DRP, and fractionated sediment P phases with a recently-developed scheme. Mineral P equilibria were modelled using PHREEQC. Numerous explanatory variables were collated, including, e.g., stream characteristics from the New Zealand River Environment Classification database; we also collected stream water-quality monitoring data from multiple sources (e.g., LAWA).

Sediment P fractions varied immensely depending on the site's biogeochemical characteristics. The quantity and reactivity of sediment Fe-(oxy)hydroxides influenced the sediment's ability to retain P; this pool was the most dynamic across sites and likely constrains the Fe-P-redox mechanism in streams. However, at sites where Ca-P mineral interactions are significant – as indicated through P- mineral solubilities and stream chemistry – the Fe-P-redox mechanism is less important. These results further our understanding of what P interactions are significant in streams according to the catchment's biogeochemical setting and therefore focus monitoring and mitigation strategies.

Recent advances in reporting and interpreting water quality trends

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Trends analysed for many sites are regularly summarised by water quality variable in tabular, graphical or map format as part of environmental reporting. The intention of site summaries (e.g., proportion improving and degrading, by variable) is to provide an overview of recent water quality changes over a domain of interest (e.g., the entire country, a region, an environment class). Typically these summaries also tabulate the number or proportion of site trends for which there are "insufficient data" to determine trend direction with confidence. These summaries produce two problems. First, the trends for which there are insufficient data can be misinterpreted as "no change" or "stable". This is an incorrect inference; insufficient data simply indicates a lack of confidence in the analysis at the nominated level. Second, trends with insufficient data to confidently determine direction nonetheless contain information about the likely direction of change that is effectively ignored by these tabulations. In this talk we describe an approach to quantifying the uncertainty of an assessment of the proportion of sites for which water quality was improving (or its complement, the proportion of sites that were degrading). The analysis uses the probability that the true direction of an individual site's trend indicates improvement, which is evaluated as part of the analysis of each individual site trend. The approach takes trend assessments for multiple sites that represent a domain of interest. The proportion of the individual site trends for which the probability of improvement is greater than degradation is referred to as the proportion of improving trends (PIT). The statistics for each of the individual site trends are used to construct confidence intervals about the estimate of PIT. PIT statistics for domains of interest elucidate spatial patterns in water quality changes that are difficult to perceive by examining the individual site trends.

Wetlands Must Be Wet: Paludiculture for the Climate and the Future

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Drainage of wetlands, especially those with peat soils, is one of the most climatically destructive of all human activities. Living peat is a huge carbon stock, occupying just 3% of the global land area but containing more than 500 gigatonnes of stored carbon – twice as much as the total forest biomass on earth. Drainage oxidises peat and causes large greenhouse gas emissions; peatlands drained for agriculture are responsible for 30% of all global agricultural emissions, with rates of carbon emission that rival industrial sources. Restoring peat wetlands is therefore essential in combatting climate change, but this can be difficult to achieve given the demand and pressure to retain agricultural activities in landscapes with drained wetlands. Paludiculture – wet agriculture and forestry on rewetted peatlands – allows continued biomass production with reduced emissions and other environmental benefits such as nutrient removal. We have been comparing wetland macrophytes for their suitability for paludiculture, using their photosynthesis-leaf nitrogen responses to compare preferences over the range of nutrient availability found in drained agricultural peat. For maximum nutrient removal, Typha species have superior responses to N, with a photosynthesis-N slope of 10.4 µmolCO2 g-1N s-1 in European *Typha latifolia*, vs. 6.5 µmolCO_2 g^{-1}N s^{-1} in the standard bioenergy crop Arundo donax. New Zealand raupo (*T. orientalis*) is even more responsive, with a slope of 12.1 µmolCO_2 g^{-1}N s^{-1}. These findings have coincided with increased interest in Typha as a biofuel feedstock and construction material, suggesting that raupo paludiculture could provide unique environmental and commercial benefits for wetland restoration. Harakeke (*Phormium tenax*), with a photosynthesis-N slope of 7.2 µmolCO_2 g^{-1}N s^{-1}, is also highly suitable for paludiculture that can compete with normal agriculture.

Improving the cost-effectiveness of macroinvertebrate state of the environment monitoring

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Macroinvertebrate State of the Environmental (SoE) Monitoring is a requirement of the Resource Management Act (1991). All Councils now undertake SoE monitoring with datasets ranging from three to 25 (or more) years, sampling once or twice per year. Most samples have been collected using D-nets, although Surber sampling has been employed, and sample processing methods have varied too (e.g., coded abundance, 200 fixed count with scan for rare taxa, full counts). The assembled datasets have been used for research including the development of new or improved biotic indices.

I do not believe that quantitative data are necessary for macroinvertebrate SoE programs, where the main screening tool for assessing river health is the Macroinvertebrate Community Index (MCI), which requires only presence-absence data. Other indices are used also for SoE reporting but these tend to be highly correlated with the MCI. Some councils require full counts from D-net samples, which, in my view is a waste of time and money. If the 200 fixed count with scan for rare taxa protocol provides robust biotic index estimates (which it does), what is the point spending time to count thousands of animals in each sample? It simply is not cost-effective.

A revision of the sampling and sample processing protocols manual is required. In particular, the recommended sampling effort for D-net samples should be reduced to 0.3 – 0.6 m2 (since this was the sample size that the characterisation of the MCI etc. was based on, and most samples we process are much larger than necessary for biomonitoring). The Quality Control (QC) procedures, which were included in the manual without any testing in NZ, also need revision. Top priority should be given to correct identifications, with missed taxa and counts of lesser importance.

Shifts in the bacterial communities associated with the formation and breakdown of a toxic cyanobacterial scum

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Toxic cyanobacteria-dominated blooms in freshwater can pose a serious health risk to humans and animals. –Cyanobacterial bloom dynamics including shifts in the dominating species, the duration of the bloom, and toxin content, are influenced by many factors. One of these factors is heterotrophic bacteria, which live within the bloom and play an important role in many growths promoting and decomposing processes. In the current study we investigated the microbial community and toxin content of a cyanobacterial scum in Lake Waitawa (Wellington). A surface scum had formed at the edge of the lake and showed signs of increasing cell lysis with decreasing distance from shore. This scenario provided a unique opportunity to explore the structure and activity of bacteria subjected to a steep gradient in cyanobacterial cell health at a single point in time.

We hypothesized that cyanobacterial genera, bacterial communities and microcystin quota (toxin content per cell) would be different in the degrading scums versus where the scum had freshly formed. Samples were analyzed using 16S rRNA metabarcoding (DNA and RNA), and a range of physicochemical parameters were determined. Microcystis transcripts were more abundant than Dolichospermum in the breaking-down scum, suggesting they are better suited to tolerating the harsh physicochemical conditions encountered within scums. Multivariate analysis of bacterial operational taxonomic units (excluding Cyanobacteria) showed differences in bacterial community structures across the scum. Proteobacteria was the most abundant phylum, among which Aeromonas, Caulobacter and Brevundimonas dominated. The differences in cyanobacteria and heterotrophic bacteria across the scum supports our hypothesis of community shifts. We could not find evidence to support our hypothesis, that microcystin quotas are influenced by either position in the scum or bacterial community. A greater understanding of interactions between cyanobacteria and heterotrophic bacteria will assist in understanding the causes of bloom formation and senescence, and toxin production.

Water we to do - Periphyton and relationships to water quality in the Horizons region

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Periphyton standing crop is a key measure of ecological and recreational health for waterways in New Zealand, capable of reporting on changes to hydrology, nutrient availability, riparian habitat and macroinvertebrate health. In turn, periphyton datasets are becoming increasingly available in New Zealand as regional authorities implement the National Policy Statement for Freshwater Management (NPS-FM) and manage for periphyton (Chl-a) effects on ecosystem health.

Several regional councils have historic datasets that predate the NPS-FM including, Horizons Regional Council (HRC). Ahead of the introduction of the Periphyton Attribute Note to the NPS-FM, HRC, NIWA and DairyNZ partnered to examine environmental factors that best explained regional and within-reach differences to periphyton standing crop from 2009-2016.

In the most exhaustive assessment to date within New Zealand, alternative approaches of space-for-time and within-station analysis were used to highlight the importance of hydrology and physicochemistry in explaining variance in periphyton standing crop. In addition, comparative fortnightly- and monthly-sampled datasets were examined, to also determine how those environmental relationships might differ based on analytical approach.

Here, we will take you on our analytical journey through seven-years of periphyton and water quality data, collected from the most intensively-resolved regional periphyton network in New Zealand, to reveal the importance of defining effective flow(s) alongside physicochemical characteristics (particularly dissolved nitrogen) when explaining changes in hard-bottomed periphyton standing crop.

Key findings will be explored for relevance to the revised NPS-FM periphyton note, including the ongoing work to derive dissolved nutrient criteria to manage to periphyton objectives within the regional plan, and the conversion of this to annualised nutrient loads. The interactive effects of conductivity will be highlighted as a potentially crucial part of the periphyton-management puzzle for regional authorities, particularly for “productive” waterway classes.

Changes at the edge: food web impacts of degradation of littoral habitats

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Littoral habitats, the shallow near-shore areas of lakes, are critical habitats for lake ecosystem function. Despite their importance, littoral habitats are often not considered in limnological research or freshwater management. A growing number of lakes globally are exhibiting rapid degradation of the littoral habitat while indicators of off-shore water quality remain stable. Specifically, many lakes globally have recently experienced proliferation of filamentous benthic algae which has displaced macrophyte beds. The food web impacts of these changes in littoral habitat have not yet been investigated.

Here we present research demonstrating the importance of littoral habitat for ecosystem function and food web stability. Our study focused on two contrasting lakes in the Upper Ashburton catchment, one with an abundant and diverse littoral macrophyte community (Lake Emma) and the other which has transitioned into a state dominated by filamentous green algae (Maori Lake East). Analyses of stable isotope and gut content environmental DNA from the mesopredator common bully (Gobiomorphus cotidianus) demonstrated the loss of trophic pathways and simplification of intra-population trophic structure associated with macrophyte decline. The food web in the filamentous algae dominated lake did not utilise epiphytic algae, the primary trophic channel in the macrophyte dominated lake. This loss of an important energy pathway resulted in individual common bullies having similar diets with greater niche-overlap compared to the macrophyte dominated lake where individuals showed higher diet-specialisation. These results suggest that in response to littoral habitat degradation food webs lose energy pathways and increase intra-specific competition which potentially results in reduced ecosystem resilience to further perturbations.

Deconstructing individual chemical stressors in two contrasting catchments

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Eutrophication of fresh and estuarine water bodies in New Zealand is widespread, however the chemical stressors implicated (i.e. N, P) are potentially only part of the degradative impact. Metal and organic contaminants are also having an impact on the health of aquatic ecosystems in New Zealand.

Much is known about effects of metals and legacy organic contaminants, and past and current regulatory efforts are reducing the impacts of these – think banning of DDT and removal of lead from paint and petrol. However, an even larger set of chemical stressors – coined emerging organic contaminants (EOCs) – may be significant contributors to water contamination and represent increased risk to human and ecological health. There are literally 1000s of EOCs and the recognition of their potential to produce adverse effects is gaining recognition worldwide.

EOCs arise from a variety of sources including sewage, stormwater, landfill leachate, agriculture, horticulture and aquaculture. Therefore, the profile of EOCs in waterways may vary markedly between urban and rural environments, and different types of catchment land-use.

Two significant issues with EOCs are the huge number of disparate chemicals being used and discharged to our environment, and the varying and subtle effects exhibited. So, where do you start? Simplify!

We are addressing these knowledge gaps through a multi-disciplinary 5-year MBIE funded research program. Following an effect-driven analysis methodology we will use multiple toxicological endpoints (high throughput assays) and chemical fractionation/analysis to hone in on the highest risk EOCs in water (through passive sampler deployment) and sediment. To ensure we are covering major sources and risks we are concentrating on two contrasting catchments: the highly urbanised Whau Estuary (Auckland); and largely rural New River/Oreti catchments (Southland).

This talk summarises our current progress and future goals.

Altering the flow and thermal regimes of river basins changes the growth dynamics of long-lived fishes

Nick Bond[2], Ben Broadhurst, Gavin Butler[4], R. Keller Kopf[6], Wayne Koster[5], Nicole McCasker[6], John Morrongiello[3], **Rick Stoffels**[1], Jason Thiem[4], Kyle Weatherman[2], Qifent Ye[7], Brenton Zampatti[7]
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In this study we estimated long-term growth biochronologies of Murray cod within multiple catchments of Australia's Murray-Darling Basin using a large otolith dataset. We aimed to: (a) model effects of historical flow and thermal regimes on the growth dynamics of this long-lived species, and (b) forecast how alteration of flow regimes under future climate scenarios affects growth. Generalised additive mixed modelling (GAMM) uncovered complex, age-specific effects of hydrology and temperature on growth. Rates of change in mean annual discharge across years, as well as discharge during the 'growth year' were key hydrological drivers of growth. Simulations of growth dynamics under scenarios of river regulation and climate change showed: (i) dams can dampen flow variability during dry climate spells, which in turn reduces growth, particularly of older individuals; (ii) in the longer term, over the life of individuals, such effects of regulation may vanish due to various forms of compensatory growth; (iii) little effect of climate warming under both a 1 °C and 2 °C increase in air temperature, but a strong negative effect on juvenile and young adult growth under a 4 °C increase. Although our study highlights the strong effects of flows and climate on cod at the individual level, a key challenge is to scale this work up to population-dynamic effects.

Resourcing and coordinating freshwater citizen science across New Zealand

Richard Storey[1], Amanda Valois[1], Rob Davies-Colley[1], Kate Davies[1]
[1]NIWA

Freshwater citizen science has been in New Zealand for many years, supported by some excellent organisations and resources. However, New Zealand has never had a coordinated nationwide programme of the kind seen in the USA and some other countries. Successful programmes require, clear leadership, collaboration among a variety of different agencies and an infrastructure provided by quality resources. The past two years have seen some exciting progress towards developing these foundations for New Zealand. Leadership is being provided by a National Advisory Group on Freshwater Citizen Science. This group is developing a strategic plan for "fostering well-resourced and coordinated freshwater citizen science monitoring programmes in New Zealand", and is promoting collaboration among regional councils, central government agencies, primary industry bodies, science providers, education specialists and NGOs. Resources currently being developed include an updated Stream Health Monitoring and Assessment Kit (SHMAK), a central database for uploading and sharing data, a website for sharing stories and answering questions, multi-media training materials and a learning pathway with levels of certification. To fully develop a programme that will support and inspire volunteers and gain value from their monitoring efforts, much is still to be done. Long-term commitments from key agencies are needed to support volunteers through training, advice and funding, to recognise and use volunteer data, to review data for quality assurance, and to recognise volunteers' contributions. Regional councils appear well-placed to provide much of the direct support to volunteers, but will need to make significant investments, particularly in strategic planning and staff time. Evidence suggests the investment will be well rewarded by increased community engagement and understanding of freshwater issues, and the additional monitoring data.

Near real-time monitoring of microbial water quality in contrasting New Zealand rivers using ColiMinder

Rebecca Stott[1], Valerio Montemezzani[1], Stephan Heubeck[1], Kerry Costley[1], Lucy McKergow[1], Juliet Milne[1], Ryan Evison[1], Margot Cazals[2], Claire Conwell[3]
[1]NIWA, [2]Montréal Polytechnique, [3]Greater Wellington Regional Council

Rapid *E. coli* detection technology such as ColiMinder has the potential to provide near real-time information on health risks for contact recreation and drinking water supply. We have monitored microbial contamination under varying meteorological conditions in three New Zealand rivers using ColiMinder as an automated bank-side sensor. ColiMinder utilizes a rapid *E. coli* enzyme assay that measures the functional activity associated with both culturable and non-culturable *E. coli* at 20 mins intervals. Results have been compared with culture based assessments of water quality using standard laboratory methods (Colilert, membrane filtration) and potential microbial proxies such as flow and turbidity.

Concentrations of culturable *E. coli* in single grab samples taken weekly or monthly at selected freshwater recreational sites are currently used to determine potential human health risks in NZ. However, *E. coli* in surface waters can exhibit large temporal variability and thus can vary greatly and rapidly within 24-48 hrs when monitoring results and possible health risks become known using culture based methods. This presents a challenge to regulatory agencies trying to assess water quality and provide timely information tothe public on suitability for swimming. In the rural Piako river, ColiMinder revealed diurnal patterns of *E. coli* contamination missed by intermittent monitoring. In the urban Porirua stream, above a popular waka ama site, ColiMinder indicated the complexity associated with multiple sources of faecal contamination that may be slowly or rapidly mobilized depending on event characteristics. Conversely, microbial water quality of the flow-controlled Waikato river, just upstream of a popular urban swimming beach, showed minimal short-term variation despite storm events over the summer bathing season. Information from these and a range of other deployments of ColiMinder is being used to evaluate its practical utility to provide improved assessment of microbiological health risks for fresh and saline waters under New Zealand conditions.

Water balance and groundwater capture zone assessment of Pukepuke Lagoon

Catherine Sturgeon[1]
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A water balance and groundwater capture zone assessment of Pukepuke Lagoon was undertaken for Horizons Regional Council. This was driven by policy in the One Plan, specifically related to landuse within coastal lake catchments and whether groundwater resources and quality are impacted from landuse activities and intensification.

This work included delineation of a recharge area, a hydrogeological desktop assessment, and a water balance calculation for the purposes of determining the groundwater capture zone of Pukepuke Lagoon.

The surface runoff and groundwater inflow was modelled using a daily rainfall-runoff model, SIMHYD, which was built into the GoldSim modelling platform. This model also simulated Pukepuke Lagoon by using bathymetry data and stage storage curves (modelling surface area, volume, and water levels on a daily timestep). The SIMHYD parameters generating rainfall-runoff and lagoon seepage losses to the unconfined aquifer were calibrated to ensure simulated water levels were representative of the observed data. A very good calibration and validation were achieved (NSE of >0.75).

The annual water balance indicated that the dominant source of inflows into the lagoon is baseflow from shallow groundwater in the unconfined aquifer (89.1%), with the balance remaining as rapid surface runoff and rainfall. The dominant outflow from the lagoon is a weir controlled outlet channel which contributes 84.5% to the total outflows. Leakage losses were estimated to be 13.7%, with the remainder as direct evaporation.

The water balance model calculated groundwater recharge to the unconfined aquifer supplying the Pukepuke Lagoon. This flow rate, along with other aquifer parameters and piezometric contours, were used in the Uniform Flow Equation model to determine the area of the groundwater capture zone for Pukepuke Lagoon. This zone has the potential to be applied as a regulatory tool to determine whether new groundwater takes may have an effect on baseflow to the Pukepuke Lagoon.

Constructed wetlands – the good, the bad and the ugly

David Burger[2], Aslan Wright-stow[2], **James Sukias**[1], Chris Tanner[1]
[1]*NIWA,* [2]*DairyNZ*

Constructed wetlands are increasingly seen as a sustainable tool for dealing with diffuse and point source pollution for a wide variety of waste sources. Wetland practitioners tend to use or modify existing designs that, in their experience, have worked previously. But each wetland designer's experience is different, and there are a wide variety of designs in use. By pushing the boundaries of accepted practice, innovative constructed wetlands designs continue to appear. Some of these have worked well, some have not. We are taking this opportunity to share some of our experiences with wetland designs which have succeeded brilliantly (the good), have failed dismally (the bad), and those with little or no consideration of aesthetics or landscape fit (the ugly).

The influence of macroscale and microscale habitat factors on invertebrate communities: implications for SoE monitoring

Alastair Suren[1], Ton Snelder
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Like most Regional Councils, the Bay of Plenty Regional Council (BoPRC) undertakes annual SoE monitoring of stream ecological health by sampling invertebrate communities, and calculating biotic metrics calculated to describe these. Habitat conditions are also routinely collected as part of this work, encompassing both semi-quantitative assessments of habitat condition using measures such as the Rapid Habitat Assessment (RHA) Protocol, and quantitative measurements of factors describing aspects of the streambed, hydraulic conditions, and riparian conditions. Although BoPRC has routinely collected this habitat data for many years, linkages between invertebrate communities and both macro-scale factors (climate, geology and land cover) and micro-scale habitat factors have yet to be established. We analysed 5 years of SoE data to determine what macroscale and microscale factors were responsible for structuring invertebrate communities. We used standard forward and backward stepwise linear regression to fit the parsimonious models. Initial results showed strong relationships between biotic metrics (e.g., MCI, QMCI, EPT_richness and % EPT) and both macroscale and microscale factors, explaining about 60% of the variation. Important micro-scale factors included measurements of fine sediment deposition (negative effects) and bank stability, RHA scores, and the amount of overhanging vegetation (all positive effects). The latter finding in particular has important implications for BoPRC's ongoing riparian protection work, highlighting the importance of riparian shade. Finally, it may be possible to develop potential criteria for some micro-scale habitat factors so that ecological health objectives can be achieved. This would result in more focussed habitat management and surveys in the future.

Environmental factors affecting the Irrawaddy dolphin (Orcaella brevirostris) distribution in the Mahakam River, East Kalimantan.

Februanty Suyatiningsih[1], Kevin Collier[1], Moritz Lehmann[1], Danielle Kreb[2]
[1]*The University of Waikato,* [2]*RASI*

In Indonesia, the Irrawaddy dolphin (*Orcaella brevirostris*; Delphinidae), also known as Pesut, has two populations restricted to either coastal or freshwater environments. The coastal population is categorised as "endangered" whereas the freshwater population is classified as "critically endangered" by the International Union for Conservation of Nature (IUCN). The decline of the riverine population, restricted to the Mahakam River in East Kalimantan, has coincided with rapid development in rural areas caused by the massive conversion of peatland forest to palm oil plantation and an increasing number of mining activities. These developments are likely to have had both direct and indirect effects on the iconic freshwater Irrawaddy dolphin. Water quality parameters and land use type from sites in upper, middle and lower sections of the Mahakam River were used to quantify the relationship between broadscale catchment and river habitat changes. Anthropogenic factors such as fishing pressure were also assessed in relation to dolphin distribution. The objectives of this analysis were to (i) quantify changes in water quality in relation to land use, (ii) correlate this change and associated human pressure with trends in dolphin distribution, and (iii) discuss implications for dolphin conservation. From 1997 to 2017, the water quality in the middle section showed an increasing concentration on temperature, total dissolved solids (TDS), followed by nitrite (NO2-N) and sulphate (SO4). In relation to dolphin distribution, the middle section of the Mahakam River has the most dolphin sightings compared to the upper and lower section. Findings from these assessments will be integrated with other dolphin ecology information to make recommendations for conservation, and help identify appropriate management actions to reduce land-use impacts on river degradation and the dolphin population.

Constructed wetlands to reduce contaminant losses from agriculture: what don't we know?

Chris Tanner[1], James Sukias[1], Aslan Wright-Stow[2]
[1]NIWA, [2]DairyNZ

Diffuse losses of sediment, nutrient, and faecal microbes from agricultural land-uses cause degradation of waterways, lakes, estuaries and coastal areas around New Zealand, with significant impacts on ecological, social, cultural, and economic wellbeing. Better matching of land-use to the lands inherent susceptibility to contaminant loss, its natural attenuation capacity, and the resilience (or sensitivity) of downstream aquatic ecosystems (aka, land-use suitability) can reduce the risk of such losses. Soft-engineering using strategic revegetation, riparian buffers, and restored and constructed wetlands etc. can help buffer flows and increase contaminant retention and removal along transport pathways.

Challenges with designing and sizing constructed wetlands, and predicting their long-term performance for different landscapes, hydrological regimes and contaminant types will be reviewed. This will be contrasted against available quantitative performance data to identify knowledge gaps limiting development of guidelines and wider application on farms. Collaborative research underway to assess constructed wetland treatment performance in the Waikato, Wairarapa and Canterbury will be outlined.

He Tohu o te wā – Hangarau pūtaiao

Yvonne Taura[1], Kiri Reihana[2]
[1]Manaaki Whenua, [2]Manaaki Whenua

A strategic priority for wharekura (Māori immersion schools) is to encourage environmental literacy, pro-environmental behaviour, and the connectivity of tauira Māori (Māori students) to the natural environment through interactive workshops (McKinley 2011, Rofe et al. 2015, Stewart 2011). We facilitated interactive workshops with tauira to explore whether a cultural monitoring tool developed for a freshwater ecosystem (Taura et al., 2017) could be applied to and implemented in other ecosystems, such as estuarine, marine wetlands, and forests.

Although initial workshops demonstrated that it was possible to apply the cultural freshwater monitoring method across ecosystems, a significant challenge was a deficiency of basic ecological literacy supported by national research (Smith, 1995; Stewart, 2011). However, we found that by promoting and using a cultural monitoring tool with rangatahi Māori (Māori youths), the uptake and understanding of basic environmental knowledge and ecological literacy increased markedly.

This presentation will demonstrate how we explored digital platforms combined with Māori knowledge and basic ecological information across ecosystems, how this combination can support and increase active participation and the engagement of tauira Māori in these programmes. We developed an integrated approach that included: utilising short- and long-term interactive workshops; engaging with expert practitioners of Māori environmental knowledge; implementing a digital medium; ensuring flexibility in the delivery of information; and developing new tools that link to existing pūtaiao resources, e.g. Ministry of Education funded resources. The digital tool is currently being developed, it will be a bi-lingual app, appealing to both wharekura and mainstream schools. The app will be a game that teaches users: about native and pest flora and fauna species; the ecosystems these species inhabit – marine, freshwater – river and wetlands, and forests; and each level will offer the user opportunities for rewards and bonus rounds.
We believe this integrated approach and digital platform will help support increased interest in tauira Māori achievement and engagement in environmental science programmes.

Worldviews and dogma: *Embracing diversity in the science challenge discourse*

Ken Taylor[1]
[1]*Our Land and Water NSC*

Some see the eleven national science challenges as representing a completely new way of delivering the information needed to resolve "complex long-term, national issues for New Zealand". Others recognise that while challenges like Our Land and Water are leading the move to generate and share information in more impactful ways, they are also responding to a growing recognition that the science needed to improve our environmental and economic outcomes requires more than a passing nod to concepts like transdisciplinarity and co-innovation. Challenge mission statements are mandated in regulation and couched in the language of transformational change. Our Land and Water's (OLW) mission is to enhance primary sector production and productivity while maintaining and improving our land and water quality for future generations. This means that the challenges are driven by an imperative that takes research delivery models well beyond business as usual, and must develop new ways to ensure impact.

OLW has recently refreshed its science strategy, as it prepares for its second phase of operation, through to June 2024. This has involved widespread discussions with Māori, multiple stakeholders, and the research community. Those conversations have been future-focused, emphasising both information needs, and the ways the research is designed and delivered if it is to be relevant, accessible and useful. However, the knowledge horizon looks very different, depending on the lens through which you view it. The challenge must ensure that its theory of change responds to those different worldviews, developing a portfolio of research that will achieve its mission because it works closely and meaningfully with all of us who have a stake in our future productive landscapes. While our programmes will in many ways represent a progression of lines of enquiry developed over the last two and half years, the portfolio will also look very different both in terms of its narrative, and in its interactions with different knowledge systems and their processes. Nowhere will this be more evident than in the way the challenge embraces Te ao Māori.

A Catchment Accounting Framework for tracing contaminants and calculating loads throughout New Zealand's surface waters

David Burger[1], Marc Weeber[2], **Christophe Thiange**[1, 2], Hans Eikaas[1]
[1]*DairyNZ,* [2]*Deltares*

The National Policy Statement for Freshwater Management (NPS-FM) requires water quantity and water quality limits to be set for all water catchments by 2025. As part of this process regional councils will require freshwater accounting systems for water quality contaminants. We are currently developing such a framework.

The Contaminant Accounting Framework (CAF) tracks nitrogen and phosphorus losses from different land uses throughout the entire river network in New Zealand. This allows contaminant loads to be traced back to their origin, and partitioned among the various contributing sources, providing a clear picture of catchment, sub-catchment, and specific landuse footprints.

Our approach combines TopNet hydrology (NIWA), dairy nutrient losses at the farm scale derived from typologies, LCDB land cover data (Manaaki Whenua) and WFD-Explorer tracer simulations (Deltares). Attenuation of N and P loads is derived from measured concentrations at Regional Council State of the Environment monitoring stations.

Future iterations of the current framework will include the use of publicly available OVERSEER budgets, typology derived contaminant losses for land uses other than dairying, and inclusion of lag time effects. The resulting tool will help to explore, understand and quantify the distribution of contaminant loads across New Zealand's catchments to assist the limit setting process.

Is resistance futile? Managing and restoring ecological systems for multiple benefits

Ross Thompson[1]
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The majority of the world's ecosystems have been profoundly altered by human activities in ways that are essentially irreversible. Global population growth will place ever greater demands on ecosystems and the services that they provide. Critically, ecosystem management remains rooted in a dichotomy; natural systems should be preserved or restored for natural values, and production systems should be intensively managed for ecosystem services. I will argue that almost always, we are managing and re-engineering ecosystems to provide a set of values of human interest and seeking to generate systems that persist in that desired state through mechanisms of resistance and resilience.
The aim of managing and restoring for resistance and resilience is oft-cited, but poorly understood and rarely operationalised. Using data from major environmental management interventions including landscape-scale revegetation, invasive animal control and environmental flow provision I will describe the challenges in restoring, remediating and re-engineering natural ecosystems.

The biology of kÄkahi a taonga species, insights into restoration across waterways in Canterbury

Channell Thoms[1]
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Freshwater mussels or kākahi (*Echyrydella sp*.) are taonga (highly-valued by Maori) species found in lakes and waterways throughout Aotearoa New Zealand. Kākahi can be ecologically important as filter feeders, ecosystem engineers and are recognised by many iwi as a mahinga kai (food gathering) resource. Functionally, this species probbaly removes suspended algae and particulate matter including potentially harmful bacteria. They create habitats for other species and assist sediment transport through bioturbation, and their living and spent shells serve as habitat for other invertebrates. Taken together, these functions make kākahi ideal biological tools for stream restoration which ultimately support restoration of mahinga kai as a food resource and practice. Unfortunately, kākahi are now classified as "in decline" and there are grave concerns for their persistence. However, there are significant knowledge gaps about their biology and population survival. Thus my PhD research examines E. menziesi in streams and river ecosystems of Waitaha Canterbury.
I will present data from a field survey and draw upon historic knowledge of their distributions throughout Mid and South-Canterbury. I will also discuss data on feeding trials to test for patterns across size and natal stream. In this presentation I will outline hypotheses to inform future translocations of kākahi populations and restoration of their stream habitats.

Environmental drivers of *Microcoleus* (*Phormidium*) blooms in the Maitai River, Nelson and development of a predictive model

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Proliferations of the toxic, benthic mat-forming cyanobacteria, *Microcoleus* (previously known as *Phormidium*) commonly occur during the summer in the lower Maitai River, Nelson. The risk that *Microcoleus* poses in the Maitai River needs careful consideration as the stream is used year-round by the public and the ingestion of mats has resulted in dog fatalities. In other stream systems, specific environmental conditions such as water temperature, water chemistry and flow have been shown to influence and drive *Microcoleus* growth and eventual proliferation. Monitoring of *Microcoleus* and environmental conditions at six sites in the Maitai River was undertaken over consecutive summers (2013 – 2018) to investigate the relationship between specific environmental variables and Microcoleus proliferations. *Microcoleus* proliferations commonly occurred for ten weeks from November to January and correlated with stable flows, slightly elevated dissolved inorganic nitrogen and increased fine sediment deposition. Generalised additive mixed modelling identified week of the year, flow and dissolved inorganic nitrogen as strong predictor variables of Microcoleus cover in the lower Maitai River. Using these data, a model was developed using week of the year and river flow as predictors to estimate *Microcoleus* cover at one site in the lower Maitai River. The model satisfactorily predicts Microcoleus cover in real time and only requires the provision of continuous flow data. Although further validation and refinement of this model is required, it represents a cost-efficient way of estimating *Microcoleus* and shows potential to be used as an alternative to field monitoring.

Considerations for water quality guidelines for emerging contaminants

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Some evidence suggests that phosphorus (P) can leach to groundwater. The enrichment of groundwater P provides a legacy of P inputs into nearby streams even if P-leaching from topsoil is stopped. We analysed P in leachate from two soils from an irrigated dairy farm. One of the soils is a free-draining shallow stony soil representative of 140,000 ha under irrigated dairying in Canterbury, while the other was a deeper and moderately well-drained soil. As per industry good practice, soils were maintained at an agronomic optimum and received P as either fertiliser (40 kg P/ha/yr) or fertiliser (30 kg P/ha/yr) plus farm dairy effluent (10 kg P/ha/yr) applied according to regional rules and industry guidelines to avoid the effluent ponding on the soil surface. Filterable and particulate P concentrations in leachate from the shallow soil increased annually 4 to 7%. Mean total P load from 2001-2015 from the effluent-treated, shallow soil was 1.46 kg/ha/yr, greater than the same soil without effluent (0.25 kg/ha/yr) or the moderately well-drained soil with or without effluent applied (0.12 kg/ha/yr, for both treatments). Leaching losses were attributed to a combination of high hydraulic conductivity enhanced by the presence of macropores and the increasing P-saturation of macropore walls. An enrichment in FRP was also detected in a well intercepting groundwater at 10-m depth. However, the source of the enrichment was unclear. These data suggest that despite following industry good practice, regional rules and industry guidelines significant P losses may occur. It is unclear if applying less effluent at lower rate, would decrease P losses. Therefore, less P must be applied, made less available for loss, or P-rich effluent not applied to this freely draining shallow stony soil (or similar soils) under irrigation.

Key features of the revised Australian and New Zealand Guidelines for Fresh and Marine Water Quality

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The ANZECC/ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality have been an important resource used by industry, all levels of government and the research sector to help ensure the sustainable use of our water resources. After many years of review and revision, the revised 'Guidelines' were released in August 2018. Key features of the revised Guidelines include:

- The Guidelines are presented as a user-friendly, intuitive and readily updatable website, allowing for greater flexibility in presenting, connecting and integrating technical information and guidance;
- An improved Water Quality Management Framework (WQMF) that better integrates the key components of good water quality management and assessment, and presents the process as a logical sequence of actions and decision points, with associated guidance for 7 typical uses of the Guidelines;
- Greater emphasis on conceptual modelling at the outset of the water quality management or assessment process;
- Improved information and guidance on cultural and spiritual values of water, and indigenous principles for water quality;
- Formalisation of integrated chemical and biological assessments through a weight of evidence (WoE) process, encouraging the use of multiple lines of evidence to make an overall assessment of water or sediment quality;
- Improved regional water quality and ecological information, including physical and chemical stressor guideline values;
- A revised toxicant GV derivation method and the associated derivation of new or revised default guideline values for over 25 high priority toxicants; and
- Improved integration of the Guidelines with guidelines for water quality monitoring, assessment and reporting (i.e. the former NWQMS Australian Guidelines for Water Quality Monitoring and Reporting).

This presentation will delve into these key features, leaving aside some time to also showcase the new website.

The challenge of deriving default ecosystem protection guideline values for PFOS in freshwater

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As part of a review of the Australian and New Zealand guidelines for fresh and marine waters, new default guideline values (DGV)s have been derived for a range of priority chemicals. A reassessment of the scientific underpinnings of DGV derivation was also undertaken paying particular attention to the acute and chronic test definitions, and guidance on the use of species sensitivity distributions (SSDs) including the assessment of modality, determining the reliability of DGVs, preferred toxicity endpoints and the use of multigenerational tests (Batley et al., 2018; Warne et al., 2018). PFOS in freshwater was one of the chemicals having a new DGV, derived by Golder. This presentation focuses on subsequent changes to the derivation methodology for bioaccumulating toxicants with assessment of modality where mode of action is uncertain.

The preferred DGV derivation method is to use SSDs. For compounds such as PFOS which bioaccumulate and biomagnify, the 99% species protection value (PC99), rather than the PC95, is recommended for slightly to moderately disturbed ecosystems.

Eighteen chronic data from five taxonomic groups, including a sensitive multigenerational 180-d growth test on zebrafish, were used in an SSD plot that spanned an unusual seven orders of magnitude. The very low slope of the tail of the SSD resulted in the 99% protection value being extrapolated to 0.00023 µg/L. There was a separation of sensitive animal data and less sensitive plant data, implying bimodality. Applying a newly developed weight of evidence screening for modality assessment (Warne et al., 2018), it was concluded that the data were bimodal and that the proposed DGV should be based solely on animal data. Using animal data alone, the data span five orders of magnitude and the recalculated PC99 value increases by two orders of magnitude. This, and other significant considerations for the PFOS DGV derivation will be discussed.

Water source and contaminant pathways in the Waiokura catchment, Taranaki, New Zealand

Rob van der Raaij[1], Heather Martindale[1], Regan Phipps[2], Uwe Morgenstern[1]
[1]GNS Science, [2]Taranaki Regional Council

This study aimed to contribute towards an understanding of nutrient loads from groundwater reaching the spring-fed Waiokura Stream, and to help resolve flow paths and origin of water and contaminants, using a suite of hydrochemical and isotopic tracers (stable isotopes ($\delta^{18}O$ and $\delta^{2}H$ of water, $\delta^{5}N$ and $\delta^{18}O$ of NO_3), hydrochemistry (Cl, Br, Na, Ca, Mg, K, Alkalinity, DOC, SO_4, N, P, and SiO_2), radon and age tracer data (tritium, CFCs, SF_6)). Groundwater inflows to the stream were identified by a survey of radon concentrations taken at 500m intervals along the stream in a low flow period. Waiokura Stream samples, taken at locations identified as having significant groundwater inflow, had mean residence times (MRTs) between 6 and 14 years. In contrast, groundwater in nearby wells ranging from 5 to 14 m deep had MRTs between 1 and 49 years, with most having MRTs of 1 to 2 years. Differences in stable isotopes of water between groundwater and stream water reflect the influence of local versus higher altitude inputs and/or seasonal effects. $\delta^{15}N$ and $\delta^{18}O$ measurements in dissolved nitrate sit above the denitrification line typical of New Zealand samples from pasture and forest sites suggesting breakthrough of urea/urine or fertiliser N. Chemistry data for the Waiokura Stream and nearby groundwater showed relationships indicating the influence of groundwater age and water-rock interaction as well as land-surface inputs. Time series chemistry data for the Waiokura Stream display seasonal variations related to either seasonal changes in uptake of nutrients by instream biota or changes in composition of inflowing groundwater due to changes in groundwater MRT.

Learning from the past to identify lake resilience and enhance restoration

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The health of our lakes is central to New Zealand's environmental, economic and cultural wellbeing. Yet we cannot robustly assess the water quality or ecological health of our 3,800 (> 1 ha) lakes because over 95% of them are not monitored. Even for the few lakes that are monitored, datasets are short (<10 years), and assessment incomplete, because monitoring started after those lakes had deteriorated. With increasing pressure to improve national water quality, it is now vital to have informed benchmarks of natural lake state and an enhanced understanding of causes of degradation. Lake sediments are natural archives that continuously record environmental history, providing measures of current and historical aquatic communities and water quality – equivalent to many centuries of environmental monitoring. The 'Our lakes' health; past, present, future (Lakes380)' project aims to use a novel toolbox of paleo-based approaches to define natural states and reveal historic resilience mechanisms to inform restoration, as well as to quantify the risk to lake health on a national scale. In this talk we use examples from a subset of lakes which we have already analysed to demonstrate how novel proxy analyses such as eDNA can be combined with traditional approaches including pollen, diatoms and pigments to reconstruct water quality and identify the timing of changes in lake health over the past 1000 years. This approach provides a richer understanding of our lakes, and can help guide their future.

Denitrification and burial of N and P in lakes explain seasonality of algal growth limitation

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A large part of the nitrogen load to lakes is usually removed by denitrification in lakes. The proportion removed by denitrification is typically around 30%. However, rates of denitrification and loss of N and P by burial in the sediment are often not well known for individual lakes. Measuring denitrification rates directly, and estimating nutrient accumulation rates in the sediment from sediment cores, is time consuming and often involves high uncertainty. Instead, ratios of N:P in different compartments of the nutrient budgets of lakes can be used to estimate denitrification and burial rates of N and P. In Lake Taupo, loss of P far exceeds loss of N (by sequestration in the sediment and removal by denitrification), resulting in a N:P ratio that more than doubles from the inputs to the lake to what leaves the lake by the outlet. This talk links information gained from nutrient ratios to nutrient limitation of algal growth in the lake. In Lake Taupo, the seasonality of surface layer N:P ratios resulting from various in-lake processes agreed well with the seasonality of the limitation of algal growth by either nutrient.

Delayed biological recovery after restoration – negative resistance & resilience

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Resistance and resilience are terms used to describe the capacity of an ecosystem to withstand and recover 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 (positive resistance and resilience). However, degraded ecosystems can also be resistant and resilient to perturbations (negative resistance and resilience) making them restoration-resistant. We hypothesise that this resistance to restoration is a consequence of food webs becoming dominated by species with traits such as trophic generalism which enhance food-web stability. To identify traits of freshwater biota and community properties in restoration-resistant communities across multiple trophic levels, we conducted a data synthesis of the literature, focusing only on studies that reported delayed biological recovery after restoration actions. We found a paucity of studies testing or reporting biotic mechanisms that likely contribute to delayed biological recovery. Moreover, most studies focused on recovery in a single trophic level, with very few considering interactions among species or across trophic levels. Nonetheless, many authors suggested/acknowledged that communities became dominated by species with traits which would likely enhance food web stability (e.g., generalist consumers). Despite this, tools to overcome negative resistance have not been widely developed or tested. These findings suggest we should implement restoration differently or at the very least reframe our expectations for biological recovery. Management implications may involve a sequence of restoration actions that decouple generalists from their environment complemented by other tools to ensure recovery of desired species. Testing this theory in the real world will inform whether whole ecosystem recovery/restoration is likely to be improved.

Trapping methods: evaluating soak time, fish density, predator presence, and baiting for īnanga population assessments

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Of the five species of migratory galaxiids that form the whitebait fishery, īnanga Galaxias maculatus dominates the catch; therefore, from a fisheries management perspective, efforts should focus on sustaining populations of īnanga. Unfortunately, the gently-flowing, soft-bottomed, darkly tannin-stained streams that īnanga inhabit are not conducive to electrofishing which is generally the preferred method for sampling fish communities in clear, swift-flowing, high-gradient streams. Backpack electrofishing in lowland streams is often inhibited by dense, overhanging, marginal and aquatic vegetation, deep water, and soft sediments that restrict operator movement and reduce capture efficiencies. Another sampling method frequently used is spotlighting. However, for many of the same reasons as electrofishing, spotlighting is ineffective in these types of streams. This leaves the use of nets and traps as the optimal method for sampling fish communities in lowland streams. Like all sampling techniques, trade-offs exist between maximising catch and minimising effort, and knowledge of gear biases is crucial for conducting valid community assessments. We evaluated the biases in Gee Minnow Traps (GMTs) and fyke nets by investigating the individual effects of soak time (nets and traps were fished for 4, 6, 8, or 24 h), fish density (nets and traps were stocked with 0, 1, or 15 īnanga), and predators (fyke nets were stocked with 1 or 0 longfin eel Anguilla dieffenbachia) on escape probability and catch for īnanga and other fishes. Additionally, GMTs were baited with Marmite™ or a light source to investigate the effects of baiting on the number of individuals captured. Our results were consistent with catch being proportional to soak times although this relationship was highly variable for GMTs and fyke nets. This highlights the importance of standardising catch by soak time for conducting valid community assessments.

Predicting groundwater contamination using next generation sequencing

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Groundwater is a vital source of drinking water supplying over 30% of drinking water in New Zealand. Microbes protect groundwater by removing contaminants that enter the groundwater ecosystem through anthropogenic activities on the surface. Currently simple bacterial and chemical methods are used to assess groundwater quality. These methods are reactive and indicate past contamination issues. Our research is aimed at gaining a better understanding of the microbes inhabiting groundwater ecosystems and how they respond to known contaminants to develop a proactive method of assessing groundwater health.

Groundwater and insitu gravel bags (representing attached biofilm) were collected seasonally from wells in Canterbury and Southland. Genomic DNA was extracted from these samples and sequenced using the Illumina MiSeq paltform. Sequences were compared to groundwater chemistry to determine microbial differences occuring in response to nutrient graidents and differing water chemistries.

All wells in Southland showed higher nitrate levels compared with more pristine wells in Canterbury. Wells in Canterbury with anthropogenic impact showed similar nitrate levels to Southland. Groundwater across both geographic locations was similar and dominated by proteobacteria (50-70%). Biofilm samples varied between geographic regions with Southland wells showing a dominance of actinobacteria (30-85%) compared with a dominance of proteobacteria in Canterbury (35-55%). Overall, a reduction in diversity occurred with increase in contaminants but seasonal stress also appeared to play a role in this change in abundance and diversity.

Shifts in natural microbial populations present in groundwater provide a method of determining long term impacts of anthropogenic activities on groundwater ecosystems. Identifying key organisms when contaminants are present will enable us to develop a tool to identify the status of groundwater.

Fire Water: The effect of the 2017 wildfires on the streams of the Port Hills, Canterbury

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In February 2017 wildfires raged out of control through the pasture, pine and native vegetation of the Port Hills, Christchurch, burning over 2000 ha in 4 days. The loss of vegetative cover was predicted to increase erosion of local loess deposits, affecting the sediment load and water quality in the receiving water bodies; spring-fed streams and rivers in Christchurch, and the Avon-Heathcote ihutai (estuary). Immediately following the fire, a water monitoring programme was implemented to detect changes in ephemeral streams draining the burnt area (Early Valley Stream and tributaries of Cashmere Stream), using the unburnt Bowenvale catchment as a control. Monthly and storm event measurements of stream discharge and of suspended sediment (TSS), trace element (including Fe, Mn, Cu, Pb, Zn, Co, Ni, Cr, As, Cd, Sb, Ge, U and V), major ion, nutrient and organic carbon concentrations has continued for 18 months. First flow conditions in early 2018 were compared to first flow in early 2017, immediately after the fire, to more clearly identify fire-related effects on stream water quality. These include increased nutrient concentrations in the ephemeral streams; a short term increase for phosphate and ammonia (1-2 months), and a longer term change for nitrate concentrations (at least 6 months). Very high TSS concentrations (up to 1900 mg/L) were measured during storm events in two of the tributaries of Cashmere Stream, but there is little indication to date that the relationship between TSS concentration and stream discharge has been significantly changed by the fire. The trace element content of the suspended sediment is consistent with a direct derivation from local loess deposits.

Māori oral tradition and indigenous freshwater knowledge: What do whakataukī tell us?

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Whakataukī are part of a strongly developed Māori oral tradition that convey critical information about aspects of life, society and tribal memory, including ecological knowledge. Such codified knowledge depends on language use and structure as a key mechanism for cultural transmission. Additionally, many meanings may not be apparent without knowing the historical, cultural and linguistic context from which the whakataukī originated. We examined a primary dataset of c. 3,500 versions of whakataukī, drawn from collections published after European arrival c. 200 years ago, to determine how marine and freshwater principles, practices and knowledge bases have developed in response to changing environmental and societal contexts in Aotearoa. In this we present information on marine and freshwater resources contained in whakataukī and discuss the connections between humans and their environment.

The land use suitability concept: a Southland case study

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The Land Use Suitability (LUS) concept provides a framework for assessing the suitability of land for primary production that accounts for connections between land use and economic, environmental, social and cultural impacts. The framework aims to inform decision-makers with spatially-explicit information describing various consequences of land use choices. This assessment of 'Productivity within Environmental Constraints' (PEC) is one example of the LUS concept. PEC evaluates the suitability of land for sustained productivity subject to environmental constraints, as defined by water quality targets. We describe the implementation of a PEC assessment of suitability of land for sustained production with constraints associated with nitrogen fluxes across a heterogenous land-water system. A modelled representation of a land-water system is used to calculate three indicators: productive potential; relative contribution; and pressure. Several methods of combining these indicators into a single map of suitability are contrasted. This implementation of a PEC assessment highlighted that the LUS concept of suitability of land is not an intrinsic and static property of a land parcel but is dependent on the wider environment (the catchment in our PEC application) and varies with normative decisions concerning the acceptability of environmental effects, assumptions about catchment land use, and choices concerning environmental targets and trade-offs between production and the environment.

What's to blame for low oxygen in streams – effluent, stream flow, macrophytes or groundwater?

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The National Policy Statement has restricted the application of oxygen standards to downstream of point sources. But what about all those streams with low oxygen, despite the removal of effluent discharges decades ago? Should the national bottom line of 5 mg/L be put to work in tackling contemporary drivers of oxygen depletion?

Other drivers of oxygen depletion can include reduced flow, nuisance macrophytes and anoxic groundwater. Groundwater often emerges from springs with little oxygen. Despite this, springs often provide a net benefit by increasing flow, and oxygen reaeration of downstream reaches as a consequence.
Flow sustains the reaeration of oxygen overnight when oxygen supply from photosynthesis shuts down. That is why adequate flow is important for preventing anoxia, particularly in low-gradient streams. Some argue this dependence on flow to sustain oxygen supply is an artefact of excess macrophyte growth. Tackling oxygen problems caused by macrophytes through riparian shading is an appealing concept, with the added benefit of reduced water temperatures. But low-gradient streams are also depositional areas where organic matter accumulates, consuming oxygen as it decomposes. And this deposition will accrue for longer periods in dry, lowland catchments, where scouring floods are infrequent. Organic matter will continue to consume oxygen in depositional streams, as it does in estuaries and swamps, even if macrophytes are shaded out.

I propose the primary risk factor for oxygen depletion is the hydrogeomorphic setting. Specifically, oxygen depletion is more likely in low-gradient, low-disturbance, depositional streams. Flow, organic effluent, and macrophytes act as finer-scale constraints on oxygen within this setting.

A hydrogeomorphic framework is the antithesis of a national standard framework adopted in the NPS. To better manage oxygen depletion in streams, we must first understand the stream type where the risk of oxygen depletion is greatest, and the drivers of oxygen depletion within that setting.

Investigation of Methods to Predict Groundwater Redox Status Using Limited Sample Data

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The aim of this work was to develop robust regional scale models to predict groundwater redox state. The models needed to account for bias in observational data, and be applied to areas where limited groundwater quality data are available.

We tested the performance of multivariate (linear discriminant) and supervised machine learning (random forest, boosted regression tree) models on the Waikato, Wellington and Tasman regions. Groundwater redox status (the response variable) was determined from redox-sensitive solute concentrations (NO_3, Fe, Mn, SO_4 and O_2) using data sourced from the respective regional councils. Predictive attributes were sourced from a range of hydrological (flow, climate, groundwater depth) and physical (soil, land use, geology, elevation) spatial databases.

Principal components analysis was derived from a correlation matrix from which inspection was used to be reduce the data set from 22 to 14 attributes for predictive modelling. The metrics used to assess model performance were accuracy (predictive success), and kappa (comparison between observed accuracy and the agreement expected due to chance).

Two sources of model bias were identified when a null-case test was applied to the data (the relationship between observations and attributes was randomised). Bias is apparent in all model performance statistics, which show a high predictive accuracy with a corresponding low kappa value.

The first source of bias arises from preferential selection of attributes during the random forest bootstrapping process. This bias was corrected by using the “cForest” model in R, however this process decreased the model kappa values. This result indicates the presence of sample selection bias (unequal sample populations). In NZ, groundwater samples are overwhelmingly oxic (>65%), and the model accuracies reflect the proportion of oxic samples in each dataset. To overcome the problem of sample selection bias, we developed a new unsupervised machine learning method (autopoietic artificial neural network with estimation).

Bicultural lake models to support tāngata whenua in freshwater management.

Mereana Wilson-Rooy[2]
[1]QEII National Trust, [2]Ministry for the Environment, [3]Ngati Awa, Tuhoe, Te Aitanga a Hauiti

Lake models were created to identify bicultural concepts, models and measures to test the effects of lake water quality management options. These experimental models help to address research gaps for freshwater management and lake monitoring in Aotearoa-New Zealand from a cultural perspective.

This empirical freshwater research generates exploratory pathways that reflect treaty-partner values, goals and governance arrangements for Lake Rotorua.

1. The Waikōura framework is a conceptual model describing water related values from mātauranga and scientific perspectives. This framework identifies the physical, chemical and biological factors that link Te Arawa cultural values to current water quality scientific values for lake Rotorua.
2. The Eco-Cultural Systems Model (ECLS) adopts an interdisciplinary systems approach that employs ecological, health and economic methods to specify and explore the multi-dimensional impacts of water quality interventions on lake health (mauri).
3. Both models are used to develop quantifiable lake health outcome measures. These outcome measures are: Koura CPUE (catch-per-unit-effort), as a cultural indicator of mahinga kai abundance, and lake TLI (trophic level index), as an environmental indicator for mauri and lake health state.
4. ECLS modelling results show wetlands and land use change were better cultural options for water quality improvement compared to alum dosing or multi-use options.
5. Results from ECLS modelling were reconciled with the Waikōura Framework to ensure a holistic and balanced view of health for lake Rotorua.

The research provides a lake management regime that is culturally grounded, environmentally accurate and economically focused to ensure the multiple uses for Lake Rotorua are sustainably managed.

Future research on the cost-effectiveness of water quality options is needed to better understand the costs of achieving multiple lake health outcomes. This research establishes multi-value, robust and sensitive lake models that recognise and provide for tāngata whenua interests in freshwater decision-making.

The Water policy work programme

James King, **Martin Workman**[1]
[1]*Ministry for the Environment*

To address the pressures on our freshwater, the Government is undertaking a new policy and implementation work programme. This work covers a wide range of areas including: sediment; wetlands and estuaries; intensity of land use; nutrient and water allocation; recognition of Māori rights and interests; compliance, monitoring and enforcement; and science to support good decision making. A key part of this work will be to include a wide range of viewpoints, including those of scientists. In this presentation we will outline the current water policy work programme, focussing on Government priorities and timeframes for delivering this work. In addition, we will provide an overview of how these policy processes will work. He will also outline research priorities for water policy, and how best to engage with the Water Taskforce about these research priorities.

Accelerating uptake of constructed wetlands through recognition of performance in the limit-setting process

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Many landowners are in the process of identifying and implementing mitigations to reduce diffuse contaminant loss to waterbodies, under regional limit-setting processes required by New Zealand's National Policy Statement for Freshwater Management (NPS-FM). Constructed wetlands (CWs) 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 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. Here we outline a collaborative research programme aimed at developing sufficient guidance and certainty of expected contaminant reductions to enable farmers and regulatory agencies to account for constructed wetland effects within farm nutrient management plans and regional planning responses to the NPS-FM.

Update on the New Zealand water model-hydrology project

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To address current over-allocation of water and water quality degradation, the National Policy Statement for Freshwater Management requires Regional Councils, in collaboration with iwi and communities, to set limits on water use and water quality, and establish allocations to stay within these limits.

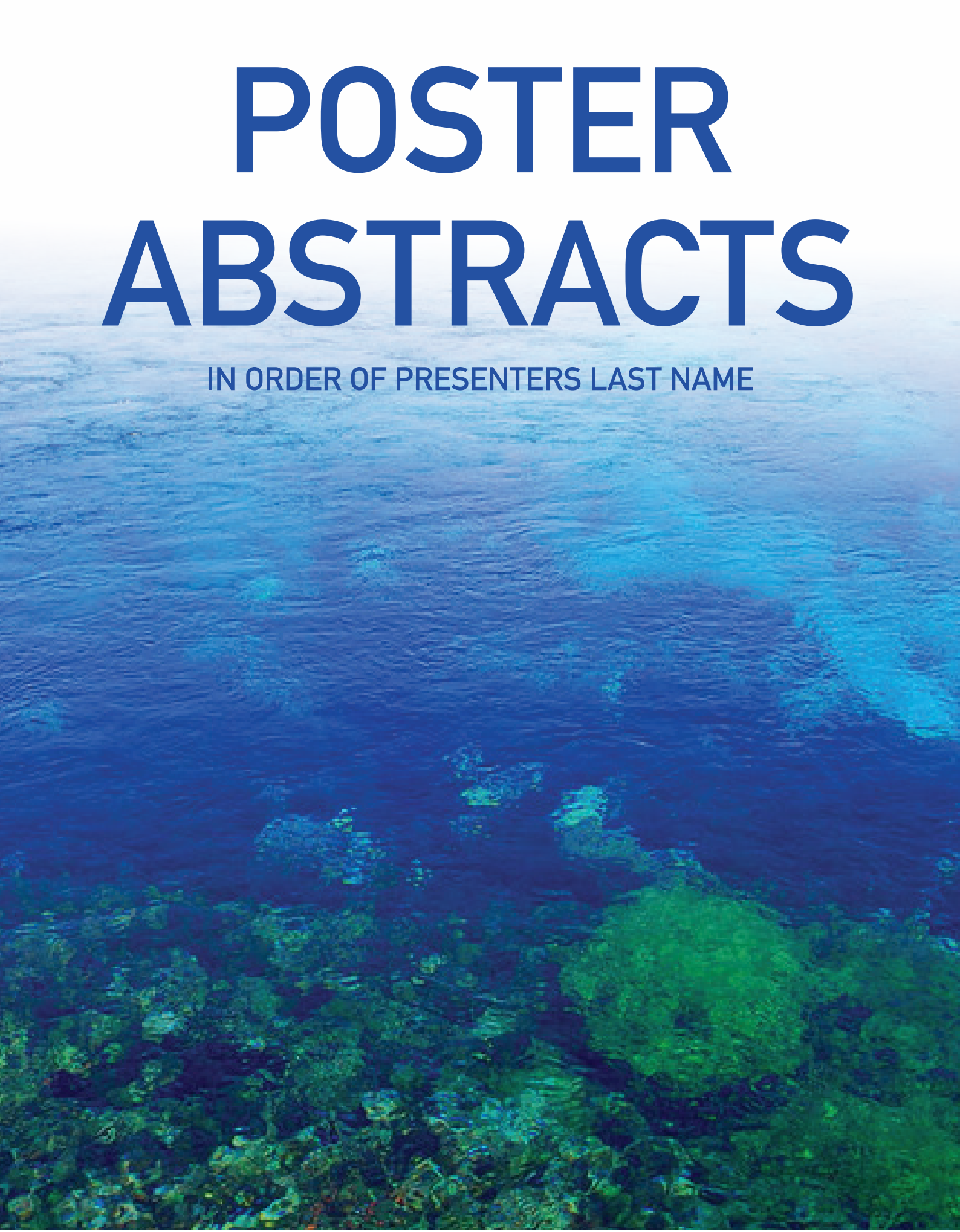
Effective and efficient limit-setting and allocation require tools that can accurately predict the transport of water and contaminants from their source areas to the receiving water bodies where their effects occur. Scarcity of direct measurements of surface and groundwater flows and contaminant concentrations at spatial/temporal scales suitable for limit setting, means simulation models are urgently needed. These models are used to make predictions and develop scenarios of the future by combining scarce measurement data, information about processes like runoff and nutrient leaching, and detailed maps of streams, aquifers, soils and other catchment properties.

Two of the main challenges for modelling flows and contaminants across NZ are : i) the complex arrangement of land and receiving waters; and ii) the time and effort needed to build models for the many places that require limit setting. The New Zealand Water Model – Hydrology (NZWaM-Hydrology) was set up by NIWA in December 2016 to answer those challenges and needs, through the development of a single, highly adaptable system focused on determining the key environmental controls of water movement across the landscape at relevant scales, that is transferable, scalable and can be simplified based on data availability. The NZWaM-Hydrology aims to provide essential information for the implementation of the NPS-FM, as well as key knowledge for the success of the National Science Challenge programmes that aim to relate pressure on New Zealand eco-systems to ecosystem responses.

The aim of this paper is to report the progress made during the second year of the project and future developments of this project.

POSTER ABSTRACTS

IN ORDER OF PRESENTERS LAST NAME



Poster Session Kindly Sponsored by DOC Arawai Kārāriki Wetland Restoration Programme

Department of Conservation
Te Papa Atawbai

Should we swim here? An indexing approach for contact recreation on the Hutt River, Wellington.

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A recent pilot study of community volunteer monitoring of the Hutt River (Milne et al. this conference) showed generally good agreement with GWRC measurements of several attributes (*E. coli*, visual clarity, periphyton – and toxic cyanobacteria, rubbish) that can strongly influence suitability-for-use for contact recreation. However, there are difficulties in interpreting this sort of monitoring data for both human health and aesthetic appeal. In principle, indexing can help. An environmental quality index attempts to aggregate data for a range of environmental attributes into one, simple, concise numerical value, understandable to the public and decision makers. Water quality indexing is complicated by the contributing attributes being measured on very different scales (e.g., *E. coli* concentration versus rubbish score). Furthermore, information can be lost during the aggregation process. We favour comparing contributing attributes on the same suitability-for-use scale, and avoiding aggregating by using a minimum operator index – which identifies the 'most limiting' attribute in terms of suitability-for-use. We illustrate the application of published minimum operator indexes to the Hutt River survey data. The resulting index values are merely indicative of the approach, but once suitability-for-use curves are developed, say based on community surveys, it should be possible to recognize the 'most limiting' attribute for swimming in the Hutt River.

Dispersal patterns and connectivity of aquatic insect populations in fragmented landscapes: an integrated study

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Increasing pastoral development has had serious effects on landscape structure and invertebrate faunas in New Zealand streams. Riparian planting has become a widespread restoration practice aimed at improving habitat, water quality and connectivity with stream networks. However, the recovery of biotic communities may fail if the role of (re)colonization and the functional connectivity among fragmented populations is not considered. Little is known on the dispersal pathways and potential barriers that may limit the connectivity of stream insect populations and consequently may affect the success of their colonisation. The goal of this study is to integrate molecular markers (e.g. SNPs/microsatellites) and landscape spatial analyses to determine the genetic structure of populations within/between streams and catchments and thereby understand dispersal pathways across fragmented landscapes. We are sampling aquatic insect populations with varied dispersal abilities in streams flowing from native forest to cleared farmland with aquatic insect populations separated by <1km to 40 km. We hypothesize that decreasing forest connectivity within/between streams leads to increased genetic differentiation due to potential barriers such as contemporary deforestation. We also predict that patterns observed will vary according to the dispersal ability of species. The study will (i) build our understanding of how landscape structure influences dispersal, connectivity, and colonisation of spatially-fragmented populations, (ii) identify the spatial scale and landscape features that influence dispersal, and (iii) enable simulation modeling to investigate riparian and landscape configurations that inhibit or facilitate dispersal and recolonisation.

Establishing a baseline: understanding the effect of global climate change on Canterbury-Westland alpine tarn communities

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Alpine tarns are likely to be sentinel ecosystems for global climate change because they are subjected to harsh conditions induced by surrounding ice and snow and are dominated by cold stenotherm communities which are often of unique conservation value. The ecology of alpine tarns in some parts of the world is reasonably well known, but other regions, including New Zealand, are data deficient. This lack of knowledge compounds threats posed by global change drivers because there is so little knowledge to underpin management actions.

To better understand New Zealand alpine tarns, and especially how communities vary with altitude, we collected invertebrate samples from tarns at four sites in the Canterbury-Westland regions of the South Island between 1160m and 1720m above sea level. Sites included the Kelly Range, Craigieburn Range, Lewis Tops and Three Tarns Pass. Tarns were intensively sampled for macroinvertebrates and physicochemical conditions measured, including: tarn area, conductivity, pH, temperature, and altitude.

Macroinvertebrate community structure changed considerably with altitude; Odonata were not present at the highest altitudes but overall species richness did not drop off with altitude and unique assemblages, especially involving Coleoptera, were found at the highest altitudes. Alpine tarns are likely to experience substantial changes in physical conditions due to climate warming, so the consequences for their inhabitants could be far-reaching. Thus, it is important for us to know as much as we can about these sensitive habitats so that we can track changes as they occur and develop strategies to mitigate the effects of climate warming on these vulnerable ecosystems. Our work demonstrates that there are unique macroinvertebrate assemblages at the highest altitudes which will be especially vulnerable.

Resilience isn't always healthy: using stressors to overcome negative resistance and resilience in stream restoration

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Resistance and resilience are terms commonly used to describe the capacity of an ecosystem to withstand and recover from a disturbance. Community resistance and resilience often underpin restoration goals, and are associated with good ecological health. However, degraded ecosystems can also be resistant and resilient to disturbance (negative resistance and resilience) making them resistant to restoration. In New Zealand, many aquatic ecosystems have become degraded and are locked in restoration-resistant states. 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), thereby increasing resistance to restoration actions (negative resistance). We predict these restoration-resistant communities must first be destabilised to facilitate recovery. 'Pushing' a degraded environment by applying a stressor may help to both alleviate poor abiotic conditions and create the instability needed to overcome negative resistance. To prevent the community from slipping back to the degraded state, actions can then be taken to aid natural colonisation; 'pulling' the community towards its desired state may be achieved by adding in missing traits through physically importing species. Using freshwater ecosystems as a model system, we present a theoretical framework to explain the mechanisms behind negative resistance and resilience, identifying potential effects of disturbance on community trait composition, because in order to use stressors as agents for community change we must first understand how they function.

Ecosystem consequences of warming and reduction of predator body size

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Climate is change is affecting all levels of biological organization. One of the ways species respond to rising temperatures is shifting their body size towards smaller sizes at age of maturity. According to metabolic theory of ecology, warming and body size reductions ought to increase metabolic rate of consumers, increasing their feeding rates in consequence. Body size reductions are more pronounce in top predators than in basal species, the combine effects of warming and body size reductions should generate strong cascading effects in freshwater ecosystems due to the increase of feeding rates of predatory fish over zooplankton. To evaluate how warming and shifts in predators body size affect ecosystem processes, we performed an outdoor mesocosm experiment. We chose *Gambusia affinis* as top predator species. We used a 2 × 3 factorial design, in which temperature (ambient temperature, warmed tank) was crossed with fish-size treatment (large fish, small fish, no fish). All treatment with fish had the same initial biomass divided in three large fish or six small fish. Experimental treatments were established in 48 outdoor mesocosm tanks. We measured as response variables fish and ecosystem metabolism, pelagic and benthic invertebrate community composition, pelagic and benthic algal abundance and nutrient concentration in water. Our preliminary results on chlorophyll concentration and stream metabolism show no effect of fish body size in pelagic algal abundance. However, we found an increase in chlorophyll and net primary productivity due to warming. Warming could not only be increasing fish feeding rate, but also be increasing invertebrate predators feeding rates over zooplankton generating an ecological cascade on phytoplankton communities.

Urban stormwater drains in Kapiti Coast (lower North Island, New Zealand) provide potential fish habitats to several native species

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Urban streams are generally characterised by modified channels with degraded habitat conditions and low aquatic biodiversity value. These urban waterways often serve as an integral part of stormwater networks, therefore channel maintenance works such as mechanical removal of accumulated sediments from the streambed become inevitable to maintain flood conveyance capacity. Such channel maintenance works often have potential adverse ecological effects, particularly on resident fish population while removing materials from the streambed. As part of the resource consent requirements, we have undertaken fish rescue operations in few urban stormwater drains on behalf of the Kapiti Coast District Council (lower North Island, New Zealand). The rescued fish population altogether comprised six different native fish species including a few with a conservation status of nationally “declining” (DOC, 2017). Most of the rescued species were also expected to occur by FENZ freshwater fish predictive model (Leathwick et. al., 2008). In most of these waterways the REC macroinvertebrate community index or MCI prediction model (Clapcott et. al., 2013) predicted an average MCI score of 76 indicating a “Poor” water quality class (Stark and Maxted, 2007) and an average EPT taxa richness of 2 indicating their unsuitable habitat condition for pollution intolerant macroinvertebrate taxa. Our findings corresponded with Collier et. al. (2009) who found assemblages of native fish including threatened species in urban streams of Hamilton City, despite their low ecological condition. We suspect minimal distance to sea and low gradient often make these urban waterways, despite their poor water quality, as refugia for several native fish species. We think fish salvage should be mandatory before undertaking instream works in any open urban waterways irrespective of their habitat condition. Improvement of these urban waterways by riparian vegetation, better connectivity and instream diversity would provide better habitats and migration paths to many native fish species.

Managing predation to increase the survival of juvenile freshwater crayfish (*Paranephrops planifrons*) – laboratory studies.

S. J. Clearwater[1], S.E. Graham[1], A.M. Albert[1], S. Bell[1], K.J. Thompson[1], M.L. Martin[1]
[1]*NIWA*

It has been demonstrated internationally that increased habitat complexity increases freshwater crayfish survival in lakes, streams, stream mesocosms and in cultivation by a variety of mechanisms including providing shelter from predators and conspecifics (i.e., reducing intraspecies aggression and cannibalism). With a view to ongoing development of restoration methods for New Zealand streams and lakes, we examined the effects of two substrate types on juvenile crayfish (*Paranephrops planifrons*; kōura) survival in the presence of predation by the introduced catfish (*Ameiurus nebulosus*). Juvenile crayfish (occipital carapace length 3.9 ± 0.3 mm) survival was measured after two weeks in tanks (n = 40/tank) with either gravel (36 x 13 mm, mean maximum and minimum dimensions) or cobble (88 x 35 mm) substrate and either with or without four catfish predators (242 mm ± 33 mm length, gape size 30 ± 5 mm). There were three replicates of each treatment, and supplemental food was provided for both the catfish and the crayfish. We hypothesised that the larger cavity size created by cobbles would provide less effective cover for crayfish from catfish predation and intraspecies aggression. When no catfish were present crayfish survival was 92 ± 6% in tanks with cobbles, and 83 ± 12% in tanks with gravel. When catfish were present survival was 97 ± 3% with cobbles and 32 ± 47% with gravel. In this laboratory exposure, gravel provided less effective shelter from predation. Ongoing analysis is examining the effect of gape size and the average size and condition of the survivors. The findings are being used to guide field trials of substrate addition to optimize restoration techniques.

Estimating departure from Trophic Level Index reference state for New Zealand lakes

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Cost-effective allocation of resources to achieve lake management outcomes requires the ability to (i) differentiate lakes that are likely to be most responsive to restoration actions with recovery trajectories not constrained by positive feedbacks and hysteresis caused by legacies, and (ii) identify management actions for specific lake types that can be used to initiate desired ecological change. We are developing and testing a lake restoration decision support framework and tools to assist in the national-scale assessment of lakes >1ha. The aim is to identify lakes that have the potential to be maintained to prevent further loss of ecological integrity, or be restored to enhance ecological integrity, expressed as a percent of natural (reference) state. This approach acknowledges that individual lake types have different reference states that will influence assessment of restoration success. As part of this work, we are estimating reference state for Trophic Level Index components using modelling techniques that account for changes in the catchment and in-lake processes. We will present the initial results of this work in the context of a framework for identifying lakes responsive to management intervention.

Rethinking riparian buffer design to control macrophyte growth in small agricultural streams

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Riparian planting is a commonly used management strategy to restore riparian function and buffer aquatic ecosystems from their surrounding land use. We show how rethinking traditional riparian buffer design could result in additional benefits to freshwater streams by controlling nuisance aquatic macrophytes. Aquatic macrophytes are present in many rivers and streams and can provide important services; however, during summer months, excessive macrophyte growth especially of introduced species can cause significant issues in agricultural waterways. 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. The aim of this study was to evaluate the effectiveness and suitability of three control techniques intensive hand weeding; weed mat; and shading to control aquatic macrophytes at a large scale. Weed mat and polythene shading were effective tools to control macrophytes. Whilst hand weeding reduced macrophyte cover in the short term, macrophytes recovered rapidly. Where riparian planting is being undertaken and nuisance aquatic macrophytes are of concern, we suggest extending weed mat down to the water's edge to smother established seedlings and creating a barrier to prevent the establishment of bank-rooted weeds, such as monkey musk and watercress. In the long term, riparian plants will establish and grow to provide necessary shade to control macrophytes. Undertaking riparian restoration in this way will support the recovery of instream habitat, in addition to the riparian buffer, helping to restore the balance in streams and reduce the need for costly management interventions.

Effect of cattle exclusion on black mudfish (*Neochanna diversus*) and *Gambusia affinis* in Wairua River Wildlife Management Reserve, Northland, New Zealand

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The black mudfish (*Neochanna diversus*), considered 'At Risk - Declining' by Department of Conservation, is one of five endemic mudfish species. A Northland stronghold for the species is the Wairua River Wildlife Management Reserve north of Whangarei. Threats to the mudfish in this reserve include cattle damage to habitat and predation by gambusia (*Gambusia affinis*). Unbaited Gee minnow traps were deployed overnight at 49 random sites to assess mudfish and gambusia populations. Trapping was conducted on 22 occasions between April and October over a 13-year period (2006–2018) in three distinct habitats: manuka, open sedgeland and ponds. In early 2009, a fence erected around the wetland provided an opportunity to monitor mudfish and gambusia numbers before and after cattle exclusion.

Before cattle exclusion, significantly more mudfish were caught in the manuka than the open sedgeland. However, there was no significant difference in the mean number of mudfish caught between the two habitats once cattle were excluded. This is consistent with the significant increase in mudfish in the sedgeland following cattle exclusion but no significant change in the manuka-dominated habitat. Mudfish were only caught in the ponds after cattle exclusion, and in very low numbers. The highest number of gambusia were caught in the ponds, followed by sedgeland, with the least caught in the manuka habitat. This was the case both before and after cattle exclusion. However, the mean number of gambusia caught declined significantly after cattle exclusion in all habitats.

Our results show the exclusion of cattle had a positive effect by reducing gambusia numbers and allowing the mudfish numbers to increase in the sedgeland to levels similar to the manuka-dominated areas. This highlights the suitability of open sedgeland as a valuable black mudfish habitat and that appropriate wetland restoration, including cattle exclusion, is important for the conservation of this species.

Life on the inside, Aquatic fauna utilise habitat inside a damaged culvert

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A degraded, corrugated steel culvert beneath a Wellington suburb underwent repairs to prevent its future collapse. Repair works involved re-lining the 1.65 m diameter culvert with concrete as the original bottom had rusted away for much of its 220 m length, allowing the formation of cobbled pool and riffle habitat.

In order to fulfil resource consent conditions, EOS Ecology were engaged to undertake fish rescue work along this damaged stretch of culvert. A total of 57 fish/waikōura were rescued – predominately utilising a spotlighting and hand netting method. Kōaro (*Galaxias brevipinnis*), banded kōkopu (*Galaxias fasciatus*), longfin eels (*Anguilla dieffenbachii*) and waikōura (*Paranephrops planifrons*) appeared to be living in the aging culvert as well as upstream of the culvert.

The macroinvertebrate community was also investigated through sample collection within the culvert, as well as upstream. Preliminary analysis has indicated high %EPT and MCI. Mayflies were the most common taxa found both within and upstream of the culvert.

Our findings demonstrate that even relatively long culverts have the potential to house aquatic fauna similar to upstream open channels, provided appropriate instream habitat is available – for example the cobbled riffles and pools found in this instance. From an ecological perspective culvert installation or repairs usually only focus on ensuring fish passage, and not on providing permanent habitat for fish and macroinvertebrates. Theoretically, the 'stream simulation' culvert installation methodology (best practice in the NZ Fish Passage Guidelines) should provide such habitat within culverts. Where this method is not practical to implement, other ways of providing appropriate instream habitat – beyond just baffles on a concrete base – should be investigated.

Channel widening of small streams following riparian planting – when will it happen?

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Streams channels are wider in forest patches than in cleared reaches – by roughly 2-fold in low order channels. A key mechanism appears to be consolidation by pasture grasses of deposits on the inside of bends into new 'active floodplains' in cleared land, while wood in forest reaches encourages widening by lateral scour. Re-afforestation of riparian zones is widely recommended to buffer against contamination by diffuse pollutants from land including sediment, nutrients and microbes, and to improve the habitat of streams in forest biomes like NZ (notably to prevent nuisance plant and algae growth and mitigate temperature extrema with global warming). That channels are wider in forest than in pasture is worrying for such rehabilitation efforts, because it implies release of a large sediment pulse (several years' or decades' load) from the banks during the widening. This poster will describe surveys of channels in the Mangaotama Catchment, near Whatawhata west of Hamilton, at 2-year intervals following an ICM experiment (commencing in 2001) in which some steep sub-catchments were converted to pine plantations, while other sub-catchments and riparian zones were planted in native trees, while sheep-beef farming continues on 'easier' land. After nearly 20 years there is little evidence for the expected channel widening despite heavy tree shade (extinguishing pasture), but we expect this widening will occur eventually, probably in the next 2 decades. Research in the eastern USA suggests that channel widening may peak roughly 40 years after re-afforestation.

Trace Metal Limitation of Phytoplankton Growth in Lakes of the Taupo Volcanic Zone

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The soils of the Taupo Volcanic Zone (TVZ) in the North Island of New Zealand are known to be low in trace metals due to volcanic activity, which has been dominated by rhyolitic eruptions in the past. Trace metals such as iron, zinc, cobalt and molybdenum are needed by phytoplankton species to grow and by cyanobacteria to fix nitrogen.

The main aim of this study is to examine whether low availability of essential trace metals reduces phytoplankton growth and cyanobacteria nitrogen fixation in TVZ lakes. This also ties in with the practice of managing phytoplankton growth in lakes by reducing nitrogen loads. Our project will also address the question of whether nitrogen fixation by cyanobacteria can make up for the reduction of nitrogen loading to lakes, and if not, whether trace metal limitation may explain why this is the case.

We have conducted a pilot study to investigate the concentration and bioavailability of essential trace elements in eleven lakes of the TVZ region, and have used chemical pre-concentration techniques and sector-field ICP-MS to quantify trace element concentrations at low levels. The dissolved concentrations of a suite of 30 trace metals were determined for each lake, and for most trace elements, were found to be ultra-low and at the sub parts-per-trillion-level. For three of these lakes, monthly sampling of dissolved and particulate samples is currently being conducted in the surface mixed layer over a period of 12 months, to determine if there are seasonal patterns in the bioavailability and uptake of trace metals by phytoplankton and cyanobacteria. In view of seasonal turnover and stratification cycles, trace metal concentrations in the full water column will also be investigated in these three lakes to evaluate depth gradients in trace metal concentrations in summer and winter.

To have or to be, are traits or taxonomic identities more informative in freshwater ecology?

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Using biological traits has been proposed to better describe relationships between species and environment because of mechanistic linkages between trait-environment associations, which a taxonomic-based approach does not have. However, findings from trait-based studies that analyse individual trait performance have shown less sensitive responses of biological traits than species composition to changes in environmental stressors, especially flow alterations. We, therefore, investigated the responses of multiple invertebrate traits of invertebrate communities to flow disturbances in New Zealand streams and to flow regimes in UK rivers. In New Zealand, mountain streams with greater substrate disturbance increased the abundance of plastron-repsirers, but not those having two aquatic life stages or who were filter feeders. In contrast, taxonomy diversity and community structure in these mountain streams appeared to be high resilience to flow disturbances. UK rivers with predictable multiple high flows per year (RgA) supported individuals having highly synchronized life history strategy (S1); rivers with one prolonged rising climb and strong groundwater influence (RgC) were better for those having a high reproduction strategy (R3), and rivers with a steep peak flow (RgB) supported both strategies. In the three flow regime types, median values of proportions of life history strategy S1 were 37.29%, 25.05% and 18.24%; and those of life history strategy R3 were 5.59%, 21.6%, and 36.34%. In contrast, LIFE index values (Lotic-invertebrate Index for Flow Evaluation) were not different between RgB and RgC. The median values of LIFE index for the three regimes were 7.38, 6.77, and 6.97. Our findings emphasized the importance of considering responses of multiple traits to better illustrate invertebrate trait responses to environmental disturbances.

Encouraging Citizen Science to provide meaningful data

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Friends of Maitai river monitoring group are an enthusiastic group of Citizen Scientists based in Nelson. The group was established in 2014 with support from Nelson City Council and NIWA, as part of the citizen science parallel monitoring programme. The group has been building their science capacity to effectively monitor the quality of the main river catchment for its health and recreational use. Friends of the Maitai have continued to work with Council to investigate water quality issues in urban and rural catchments. The results from E.coli investigations are described. The findings were generally lower than the lab results, probably due to the sensitivity of the method. Lower concentrations were more comparable. Samples were taken in wet and dry conditions which had a significant effect on the E.coli levels and provided meaningful data where swimmablility was a concern.

Banded kokopu (*Galaxias fasciatus*) spawning in a Nelson urban stream

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Banded kokopu (*Galaxias fasciatus*) are relatively common in the Nelson-Stoke coastal streams. The species ability to climb stormwater culverts and penetrate enclosed stormwater networks has enabled small populations of kokopu to become established in urban streams where habitat is available. Banded kokopu eggs were located on 19 July 2018 in Emano stream, within the Pipers Park Reserve in Nelson City. The banded kokopu spawning record is the first for Nelson and important to highlight the species habitat requirements, which are increasingly under threat from urban development and modification of stream natural character. Fish habitat restoration work has occurred in Pipers Park Reserve over the last five years including riparian plantings, and creation of pools and securing woody material in the stream channel. The spawning site location and stream habitat restoration is described.

Site fidelity of kōaro (*Galaxias brevipinnis*) spawning in a Nelson stream

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Kōaro (*Galaxias brevipinnis*) eggs were found in late May 2017, attached under boulders submerged in riffles. Eggs were found in the same riffle section in early June 2018, and searches further upstream found additional spawning. The kōaro behaviour of spawning instream is atypical for Galaxiid species, which are considered to spawn along the margins of streams with eggs deposited in damp and shaded vegetation. The timing of kōaro spawning and habitat is described.

Restoring a lowland stream in Southland: do the physical restoration works affect the invertebrate community?

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Waituna Creek is a tributary of Waituna Lagoon in Southland, which has been greatly modified and degraded due to intensive farming activity which started in the 1950s. The Waituna Creek restoration project has focused on restoring the physical aspects of the stream by conducting large-scale instream restoration works. This restoration included installing permanent and semi-permanent structural habitat features which altered the flow dynamics of the creek. In the present study, we investigated how the invertebrate community within the restored stream reaches were affected by the physical restoration works done with diggers and other machinery. We monitored the invertebrate communities using a BACI design, by collecting samples at replicated Control and Impact sites, Before (360 days) and Shortly After (2 days) the restoration works. Two different sampling approaches, kick-net and Surber samples, were used to determine if there were any differences in results due to sampling method. Invertebrates were counted and identified using a dissecting microscope and a variety of stream invertebrate community health indexes determined. It was found that Kick-net and Surber samples often showed the same trend. Overall, there was little observed effect of the restoration works on the invertebrate community. For both sampling methods, only EPT richness showed a significant (positive) reponse to the restoration. These results indicate that the physical restoration works did not represent a short-term disturbance for the invertebrate community, possibly because the community consists mainly of pollution-tolerant, resilient species. Long-term effects of the restoration cannot be evaluated yet because there has not been enough time after restoration for the stream community to establish a new structure. Therefore, we recommend continued monitoring of the invertebrate community within Waituna Creek to determine any gradual effects of the physical habitat restoration.

Lake Koitiata Water Balance & Groundwater Capture Zone Assessment

George Hampton[1], James Blyth[1], Steven Collins[2]
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A water balance model and groundwater capture zone assessment for Lake Koitiata was developed for Horizons Regional Council (Horizons), a coastal lake of significance within Horizons' jurisdiction. The aim of this work was to understand and sustainably manage water resources that are at risk of impacts from land use intensification.

The water balance model was developed based on a conceptualisation of the hydrogeological setting and observed water level and climate data. The model simulated rainfall, runoff and lake water levels on a daily time-step in the software GoldSim. Modelling water levels on a daily time-step resulted in a good calibration and validation for two periods between 2008 and 2010, and 2015 to 2017, respectively, with the NSE greater than 0.70.

The annual average water balance derived from a simulation between 2008 and 2017 showed that ~56.6% of inflows to Lake Koitiata are from baseflow (shallow groundwater), with the remainder from surface runoff (~29.4%) and direct rainfall (~14.0%). Outflows from Lake Koitiata are primarily from leakage (~85.2%) and evaporation (~10.5%), with the remaining losses due to infrequent overflows through an outlet stream.

Outputs from the water balance model were fed into the Uniform Flow Equation, which was used to define a groundwater capture zone, with the zone area refined based on further data (such as piezometric contours and groundwater flow directions). Following this capture zone delineation, a groundwater management zone was then created which integrated both the surface water catchment with the groundwater catchment zone.

The purpose of this management zone is to delineate an area of hydrological connection to Lake Koitiata, which should be considered for planning and regulatory purposes, such as new groundwater takes or discharge consents.

A new tool to reduce flooding and nutrients farm waterways: the two-stage channel

Catherine Febria[1], Jon Harding
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Nearly two decades ago, farmers and resource managers in the mid-west USA were looking for solutions to address flooding issues on farms. One of the solutions they developed was the "two stage channel", however not only did this design solve the flooding of fields but it also provided real benefits for improving water quality in farm waterways. Two-stage channels (or ditches) are artificially-created floodplains created within existing waterway cross-section. In New Zealand agricultural waterways are commonly highly-engineered (straightened, narrowed and deepened) with frequent dredging and mechanical clearance to preserve and maintain drainage function. However, drain maintenance can be costly while also generating unwanted environmental impacts such as poor water quality, reduced biodiversity, and potentially counter-productive outcomes for farm management (e.g., nuisance weeds that require ongoing management). The two stage channel design increases the channel cross-section (therefore holding more floodwaters), lowers channel shear stress and dissipates energy across a larger cross-sectional area, thus reducing the flood power and erosion potential. Studies in the US have shown that the creation of floodplain benches within the two stage channel has some real benefits for improving water quality. Specifically, during floods the high flows inundate the floodplains. When that happens the speed of the water is reduced and sediment is deposited among the riparian plants on the floodplains. As water levels drop pools of standing water are trapped on the floodplains and nutrients such as nitrogen are lost from the water through denitrification. Published studies have shown improvements in dissolved oxygen, reduced nitrogen, phosphorus and turbidity. We present a review of two stage channel design and a synopsis of benefits for NZ farms.

Stream water quality and hydrology response to conversion from pasture to plantation forest

Andrew Hughes[1], John Quinn[1]
[1]*NIWA*

Plantation forestry is an important land use in New Zealand and is often used a way to improve economic returns, reduce erosion, improve water quality and increase carbon sequestration from degraded agricultural land. Where plantation forestry is used to improve land use sustainability, there is often the expectation that the establishment of forest cover will result in improvements in downstream water quality. However, plantation forests are subject to a range of management interventions (e.g. harvest, fertilisation, thinning and (re)planting) that have the potential to alter their capacity to attenuate the delivery of pollutants (e.g. sediment and nutrients) from catchments. Reduced stream flow caused by increased interception of rainfall by a forest canopy is also a consequence of afforestation that may have implications on wetlands, contaminant dilution, the availability of stream water for downstream uses including by humans (water abstraction) and instream biota.

Here we use over 25 years of monthly water quality monitoring data and continuous flow data to assess the impact on stream water quality and hydrology of converting a headwater pasture catchment to P. radiata forest within the Waikato region. Our results show that the most significant water quality impact of forestry is an increase in stream nitrate concentrations. Interestingly, nitrate concentrations increased steadily from the beginning of forest establishment but increase again in response to stand thinning, 8-10 years after planting. At one monitoring site the median nitrate concentration increased by a factor of four between the pre-planting period and the post-thinning period. No impact on other water quality variables (e.g. turbidity, phosphorus, ammonium and pH) was detected. Annual stream flow was estimated to have reduced by almost 50% after 8 years within a sub-catchment with 100% pine conversion. Stand thinning reduced rainfall interception by the forest but annual streamflow remained ~30% lower than the pre-planting levels.

Improving through inclusion: Using community-based initiatives to improve freshwater ecosystem health

Will Keay[1]
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The growing public scrutiny of freshwater quality issues across the country highlights their importance to New Zealanders. Recently the focus has been on rural freshwater systems, but the state of our urban freshwater systems is also of concern. With the general public's desire to improve the condition of waterways, this research aims to explore whether community-based initiatives can be part of the solution towards improving urban freshwater ecosystem health.

Through an examination of published research, a model was created that identified the key components of community participation. This model was then utilised as a sorting mechanism to analyse several case studies of participation in environmental problem solving. Drivers and barriers to participation were extracted using this method. Semi-structured interviews were then conducted in Christchurch to obtain answers on the perception of the state of local urban waterways, their management, and the ways in which community-based initiatives can be integrated into Christchurch urban freshwater management regimes. Interviewees were sought from a range of backgrounds – including freshwater science professionals, local iwi and community stream care group members. This allowed a holistic, multi-dimensional perspective of the issues to be formed.

Findings from this process will be translated and applied to the Ōpāwaho/Heathcote River catchment, an urban catchment that consistently displays poor freshwater health. This catchment has a raft of issues that impact its freshwater quality. However, a group of existing local community organisations could be engaged to help mitigate and remediate detrimental impacts. Application of these research findings to this exemplar local catchment may help provide pragmatic solutions so that community-based improvements for freshwater ecosystem health could actually become a reality.

Water quality in Canterbury rivers: state and trends across contrasting time periods

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Changes in land use intensification have been linked to water quality impacts worldwide. In Canterbury, rapid land use change has been observed over the last 20 years. Here, we use Environment Canterbury's State of the Environment data to assess water quality state between 2012 and 2017, and water quality trends over 20, 10 and 5 years prior to 2017. State was assessed for the attributes defined under the National Objectives Framework (NOF). Trend analysis was conducted using the approaches developed by Larned et al (2015) with some modifications. A relatively new trend assessment procedure was used that followed the Intergovernmental Panel on Climate Change approach and assigning categorical levels of confidence (probability) to indicate changes

Trend analysis for the 20-year period indicated increases in nitrogen concentration at more sites than decreased, but decreasing concentrations for ammonia, phosphorus, sediment and bacteria. In contrast, over the last 10-years more sites showed decreasing concentrations of nitrogen and phosphorus, but worsening turbidity and bacteria. Trends over the last 5 years, indicated decreasing concentrations across most contaminants were more common than increases. Analysis of water quality state between 2012 and 2017 indicated that more than 85% of sites fell within the NOF A-band for ammonia toxicity. Most sites had a median concentration of less than 1mg/l for nitrate-nitrogen. However, a small number of sites fell within the C-band, and a few failed the National Bottom Line for nitrate toxicity. For *E.coli*, 52% of sites had an average infection risk less than 3%.

Results indicate that the proportion of sites dominated by decreasing contaminant concentrations was highest over the most recent period, and in general, more sites were improving across most contaminants through time. This matches observations at the national scale.

Zooplankton communities in Waikato lakes and ponds: are farm dams and natural waters the same?

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Ponds on New Zealand farms are plentiful, comprising both natural and constructed dams. Despite this, little is known of the environmental conditions or ecology of these waters, here or overseas. For example, zooplankton are well known from New Zealand lakes and rivers, but little to nothing is known of their composition in smaller water bodies. We investigated zooplankton community composition in ponds on farms within the wider Waikato region. The major aims of the research are to examine the zooplankton biodiversity values of these ponds, and to determine whether differences exist in these values between natural and constructed ponds. Furthermore, this research intends to fill a gap in the Waikato Regional Council lake/pond database, as natural ponds are under-represented, while farm dams are totally unrepresented, as is the case for New Zealand in general. Particular interest was taken of the proportion of non-native species relative to native species in the ponds; an indicator of the 'health' of aquatic ecosystems. Using a random stratified selection method, 40 small lakes and ponds were chosen (20 natural and 20 farm dams). These were selected across three sections of the Waikato region (north, central, south) to encompass a wide geographical range. Zooplankton were initially sampled in August and September 2018 (winter/spring sampling), and will be sampled again in January and February 2019 (summer sampling), to take into account major seasonal variation. Water quality parameters measured included total nitrogen and phosphorus, temperature, dissolved oxygen, conductivity, chlorophyll-a and absorbance at 440 nm. We will present preliminary results of the winter/spring sampling.

Requiem for Upokororo – New Zealand's only known historic freshwater fish extinction

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In the 800 years since humans arrived in New Zealand there has been only one known freshwater fish extinction – upokororo (grayling; *Prototroctes oxyrhynchus*). At the time of European arrival upokororo occurred across New Zealand. In 1860 they were abundant, by 1870 their decline noticed, by 1900 they had disappeared from many rivers, and the last confirmed catch was made in 1923. While trout are frequently blamed for the loss of upokororo, little is known about how this extinction event unfolded in time and space.

We built a database of historical upokororo observations across New Zealand based on newspaper archives. Historical records were complemented with a meta-population model to explore how vulnerable upokororo populations were to off-take (fishing and/or predation) and altered source-sink dynamics.
We found 300 newspaper articles concerning upokororo, of which 120 were primary and gave dated locations. Sightings-based models suggest upokororo went extinct between 1924 and 1972. Thus, in just 74 to 122 years the upokororo went from abundant to extinct. At realistic meta-population growth rates, off-take rates between 0 and 30% in combination with up to 30% sink populations result in upokororo extinction in 100 years.

We have created the first systematic database of historic upokororo sightings, and shown that extinction could have occurred under relatively low levels of population pressure. Our results shed light on New Zealand's only freshwater fish extinction and highlight the fragility of our indigenous freshwater fish. Will upokororo remain New Zealand's only freshwater fish extinction, or are there more to come?

Eel/Tuna Relocations: Protecting NZ's native fish from stormwater pond dredging

Jennifer Leslie[1]
[1]*Pattle Delamore Partners*

Stormwater ponds require maintenance works to be carried out in order to keep them functioning correctly and providing water quality treatment and control of flood flows. Dredging works to remove accumulated sediment from stormwater ponds improves their ability to function, but often at the expense of native freshwater fish that have made the pond their home. Auckland International Airport Limited (AIAL) owns eight stormwater ponds/wetlands around the airport area. The close proximity of these ponds to the Manukau Harbour means they are easily accessed by young elver eels migrating inland from the ocean in search of a freshwater home to feed and grow. In order to protect these native fish from the effects of dredging operations, a number of successful relocation efforts have been made this year across three different airport ponds, prior to dredging works commencing. Due to the cultural and ecological significance of tuna to the three local iwi, their early engagement and involvement in this project was important to AIAL and contributed to the overall success of the relocation.

This poster tells the story of these relocations, explaining the methodology that was followed, the engagement and involvement of iwi who assisted with relocation efforts, and the surprising numbers of eels captured and released — over 1000, including some very large individual specimens that could have been up to 60 years old. The project has been a resounding success, with dredging operators being able to conduct their dredging works without having to consider the impact they could have had on freshwater species, and allowing the relocated eels to continue their life cycles in their new environments.

Is that really a koi carp?

Nicholas Ling, Emily Hannah, Sari Karppinen, Steve Bird

The common carp (Cyprinus carpio) is highly valued in many countries for food, and global aquaculture production exceeded 4.5 million tonnes in 2016. Consequently, it is one of the most translocated vertebrates in the world. They cause significant ecological damage, causing sediment resuspension, loss of macrophytes, mobilisation of nutrients, and can quickly dominate the fish biomass of lowland lakes and rivers. Characteristics such as large body mass, high fecundity, tolerance of environmental extremes, and non-selective benthic feeding categorise them as a super-invader and among the world's 100 most invasive species. A Japanese ornamental variety, koi carp, is also highly prized as an aquarium species. Among the world's most expensive pets, single fish can sell for more than US$250,000. Common carp became established in the wild in New Zealand by the early 1980s and were immediately referred to as koi carp because of the predominant orange colouration of these wild fish, and assumptions that the most likely importation scenario was through the aquarium trade. However, very few New Zealand wild carp show colour patterns common to Japanese koi, and koi are not the only coloured forms of common carp. The carp genome was sequenced in 2014 and a number of carp strains have been genotyped. We are investigating New Zealand common carp using a series of mitochondrial and nuclear genes to characterise the New Zealand population and determine whether our carp really does relate to Japanese koi or to some of the other Asian coloured strains such as Oujiang, Hebao, Xingguo or Heilongjiang.

Quantifying groundwater discharge into rivers using radon-222

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The aim of this study was to investigate whether quantifying groundwater (GW) discharge using the soluble, unstable isotope, radon (Rn) could provide further insight into GW-surface water (SW) interaction processes in New Zealand riverine environments.

Rn samples were collected from two study sites, the Shag River in Otago and the Te Arai River in the Poverty Bay, at a spatial resolution of 500m, under low flow conditions. Flow gauging was also undertaken during the Rn surveys. A mass-balance modelling approach for quantifying GW flux using Rn was then applied to the gaining reaches (Cartwright and Hofmann 2016). To express the uncertainty associated with the input variables in the mass balance approach, Monte Carlo sampling was applied. This allows for the uncertainty in calculated discharge rates based to be estimated. The gauged discharge rates were compared to those calculated using Monte-Carlo realisations of the mass balance equation.

In many reaches the Rn correlated well to the flow gauging data, supporting the use of this quantification method. However, there were some reaches where the flow gauging and Rn data were not in agreement. Further investigation into these reaches identified a number of different potential explanations, including;

(1) The presence of unrecorded river takes, in which case the Rn data could then be used to predict the river discharge if there were no takes;

(2) the Rn concentration of the GW varied through the study reach, and thus the Rn data indicated that there were different sources of GW entering the river; and

(3) there were contributions of Rn to the river from parafluvial flow (flow within the alluvial sediments below the river bed).

Productive riparian buffers

Stephan Heubeck[1], Electra Kalaugher[2], **Fleur Matheson[1]**, Aslan Wright-stow[2], Helen Moodie[2]
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Regional limit-setting processes are requiring farmers to reduce contaminant losses to farm waterways. Establishing riparian buffer strips is one approach to achieve this which also enhances habitat and ecological condition. However, the uptake of riparian buffers is often constrained by the cost of land taken out of production. Furthermore, there is scope to improve the functions of riparian buffers, especially in relation to stream shading, stream bank stabilisation and a shift from nutrient attenuation to nutrient removal and recycling.

Internationally, some buffers are managed to protect environmental quality and provide a sufficiently large economic return to offset the loss of productive land. These buffers often consist of a mix of trees, shrubs and herbaceous plants and provide a financial return in the form of timber, bio-fuel or as a fodder crop that is particularly valuable at times of shortage (e.g. drought). Utilizing part of the growth from a riparian buffer recycles nutrients on-farm and allows for the planting of productive species that may otherwise be considered unsuitable. We propose to test the concept of extended and productive riparian buffers in New Zealand by assessing the operational, financial and environmental performance of a mix of native and exotic trees and shrubs, with a specific focus on re-using tall willow and poplar coppice as a feed supplement for ruminants. Specifically, the project will investigate mechanical harvesting techniques, dry mass production, nutrient removal, water quality and climate change benefits and disseminate results through demonstration sites, workshops and guideline development.

Flow adjustment and regional-scale water quality trends in Tasman

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Trend analysis is useful for estimating the probability of improvement, or degradation, in water quality indicators. An important step in conducting a trend analysis is to consider any major changes to the sampling programme used to collect the raw data.

In mid-2016, Tasman District Council increased the frequency of sampling at surface water quality sites from four times per year (quarterly) to once per month. In addition, the focus on dry weather sampling (delayed sampling after rain) was shifted to all-weather sampling. As a result, the more recent surface water quality data are collected over a wider range of river flows.

When analysing these data for trends, the change in sampling frequency and the shift to sampling a wider range of flows should be accounted for. In the LAWA (lawa.org.nz) trend analysis procedure, monthly data are converted to quarterly data by taking the median value in each three-month period. However, flow adjustment is not currently part of the LAWA procedure.

To examine the impact of flow adjustment on water quality trends for the Tasman region, 10-year trends were calculated using Sen's Slope Estimator. Trend results without flow adjustment were compared to those with flow adjustment. This work is relevant for regional-scale reporting of surface water quality trends.

Comparing indigenous and western methods of kākahi translocation: implications for ecological restoration.

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Population translocation is an important tool in conservation ecology. Improper handling of organisms during translocation can negatively affect their performance, and this could ultimately undermine the translocation effort. Freshwater mussels (Family Unionidae) burrow into the substrate to reduce the risk of physical displacement and predation, and newly translocated mussels are at heightened risk of displacement and predation until they have secured a position in the substrate. Indigenous peoples have been carrying out population translocations for some time prior to the development of 'western science', thus indigenous methods likely have much to offer to the modern conservation space. In Aotearoa/New Zealand, tangata whenua traditionally used kete (woven baskets made of natural materials) to translocate aquatic animals (including mussels—locally known as kākahi) to new environments as part of ahumoana tawhito (ancient aquaculture). In this study we investigated the influence of transport method: traditional (kete stuffed with wet moss), modern (lidded plastic bucket with an aerator), and combination (bucket containing submerged kete and an aerator) on the behaviour (probing propensity) and short-term performance (burrowing rate) of kākahi, as well as the influence of probing propensity on burrowing rate directly. We also tested whether assistance (planting kākahi in the substrate) resulted in enhanced burrowing rates. We found no difference between the modern and hybrid method of transport, however kākahi that were transported using the traditional methods were slower to probe and burrow. Kākahi that were quicker to probe were also quicker to bury, and assistance resulted in faster burrowing rates. We conclude that both handling procedures and individual behavioural traits influence the short-term performance of translocated kākahi and recommend procedures for future translocation projects.

The importance of instream and riparian vegetation for kōwaro persistence in a changing world

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Stress-tolerant species that reside in habitats characterised by extreme environmental conditions are likely to be particularly susceptible to changes in climate conditions. This is especially poignant for species that have diminished dispersal ability or face dispersal barriers, which inhibit their potential to escape deteriorating conditions. Kōwaro (Canterbury mudfish, *Neochanna burrowsius*) face this situation. Their fragmented distribution of isolated populations across the Canterbury plains means that, apart from human-mediated translocations, kōwaro have severely limited capacity to escape from increasingly harsh conditions associated with extreme drought. Thus, identifying site-specific environmental conditions that benefit kōwaro and potentially mitigate the negative effects of a harsh environment being made more extreme by climate warming, would likely assist in both the long-term management of kōwaro populations and the selection of preferential translocation sites. To assess the potential value of vegetation, both aquatic and terrestrial, to the ongoing persistence of kōwaro, we compared of 26 populations in the Waianiwaniwa Valley and along the Hororata River. Both instream and riparian conditions were associated with altered abundance of kōwaro of different sizes, with these changes likely reflecting the different needs of these individuals. For example, increased cover of instream and overhanging riparian vegetation corresponded with relatively higher fry abundance, with this vegetation probably important as shelter from predators. Whereas, adult kōwaro were positively associated with canopy cover, which is potentially linked to changes in prey availability. However, the presence of willows in the riparian margins also elevated drying intensity, potentially undermining the added value of canopy cover. Therefore, it is important that both the aquatic and riparian environments are considered, particularly with respect to vegetation, for both kōwaro management and translocations because of the significant effects they could have on long-term persistence of kōwaro.

Quantifying relationships between juvenile wai-kōura (*Paranephrops planifrons*) abundance and micro-habitat features in Waikato hill-country streams.

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Wai-kōura (*Paranephrops planifrons*) is considered a taonga species by Māori and were once an abundant fishery traditionally harvested throughout New Zealand. Wai-kōura populations are under pressure in Waikato hill-country streams due to a range of factors including habitat loss and water quality degradation. The impacts on wai-kōura are under-represented, and now that stakeholders have been engaging in collaborative ecological restoration decision- making and practices to restore/enhance biodiversity and stream health within the Waikato catchment there is opportunity for wai-koura habitat enhancement. This study is examining instream habitat characteristics affecting wai-kōura abundance and size distribution across a range of scales, including between streams, within streams, and between habitat patches. A combination of electrofishing surveys, 1 m2 quadrats and kicknet sampling will be used to quantify relationships between juvenile wai-kōura abundance and habitat features within sub-reaches of contrasting native and pastoral hill-country streams in Waikato. The study will relate wai-kōura abundances with micro-habitat variables including water depth, velocity, bank undercuts, substrate size and occurrence of wood. Also, a habitat manipulation experiment is being conducted to investigate whether wai-kōura abundances, in particular young-of-the-year, are enhanced by 0.5 m2 additions of inorganic substrates (e.g., cobbles) or organic substrates (e.g., frond bundles of common riparian tree species) in stream reaches at the Whatawhata Research Station, near Hamilton. This study is being conducted in conjunction with a larger reach-scale habitat study examining koura abundances and riparian vegetation maturity. The overarching research goal is to support Iwi desires for restoration to provide adequate habitat and increased survival rates for taonga species, so there will be a focus on ensuring effective communication of the research outcomes to these audiences.

A global review of zooplankton species in aquaculture ponds: what are the risks for invasion?

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Non-native freshwater zooplankton species have been recorded from aquaculture ponds in New Zealand and Italy, while zooplankton invasions elsewhere have implicated the aquaculture industry as the vector for introduction. However, the prevalence of non-native species in international aquaculture facilities is unclear. We undertook a literature review of publications examining zooplankton assemblages in freshwater aquaculture ponds globally to determine; 1) the prevalence of non-native taxa, 2) the quality of studies undertaken, 3) how well the major freshwater aquaculture nations are represented in studies, and 4) the representation of dominant aquaculture species. Thirty-two suitable publications were found that provided data on zooplankton assemblages from aquaculture facilities. We supplemented this by sampling Huka Prawn Park, Taupō, as knowledge of zooplankton in prawn facilities was scarce. Zooplankton data were obtained for 205 outdoor ponds, from 39 aquaculture facilities, across 13 countries. Non-indigenous taxa were recorded from 17.9% of facilities globally. Over half the publications (53.1%) identified taxa to genus level, with the remaining 46.9% attempting species level identifications. The high proportion of publications not identifying to species level indicates that non-native species will not be recognised in most studies; 31.8% of facilities were invaded when considering only studies with species level identifications. In total, 234 different taxa were identified, including 184 to species level, with only 4, located in Italy and New Zealand, recognised as non-native. Few zooplankton invaders putatively originating from the aquaculture industry have been found within aquaculture facilities themselves. Our findings indicate that there is a significant lack of taxonomic resolution in most studies, and a lack of surveys in major aquaculture producing regions. Therefore, it is currently difficult to determine the prevalence of non-indigenous zooplankton species in aquaculture facilities globally, and our results suggest the risk may be far higher than is currently appreciated.

Destruction and Reconstruction: is freshwater compensation offsetting achieving the ecological goal of No Net Loss?

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Ecological offsetting is an increasingly common restoration practice worldwide to compensate for the negative environmental impacts of development where avoidance, minimisation and management of effects is not possible. This trend is prevalent in Aotearoa, where offsetting for development activities encroaching on Freshwater ecosystems is becoming commonplace. With severe and widespread anthropogenic pressures on the nations highly threatened Freshwater biota, it is essential that further development results in No Net Loss (NNL) of biodiversity and ecosystem values. This means ecological values must not be diminished due to development, and that gains in value through restoration are both additional to the current state and protected in perpetuity. NNL is the key goal underlying the majority of restoration projects, and the principle behind the development of two tools which work together to calculate compensation requirements for Freshwater offsetting. The Stream Ecological Valuation (SEV) and Ecological Compensation Ratio (ECR) are the primary methodologies used in Auckland, Wellington and increasingly by other regional authorities to direct offset site selection and restoration requirements. We examined the compliance climate in Auckland and Wellington by assessing consenting records for all ECR offset sites. We will later examine the trajectory of success in the achievement of NNL by in-situ ecological assessment of sites with completed restoration works. Trends in development and construction activity type were assessed, as well as restoration activities, monitoring conditions, duration, and covenant conditions. These factors are essential to the potential for NNL to be measured and realised. These findings were combined with site specific metadata such as stream order and the length and area of stream offset, to gain an overall picture of the state of Freshwater offsetting using SEV and ECR. Our results were then assessed against the proposed National Policy Statement for Indigenous Biodiversity, the first NPS to set principles for biodiversity offsetting.

Effects of an Eye-Dwelling Parasite on the Behaviour of Common Bully

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The trematode family Diplostomidae contains many species that inhabit the eyes of fishes as metacercariae. Of these, members of the genus Diplostomum are often studied as potential manipulators that cause their fish host to be predated at a higher rate. Recently, the first diplostomid described in New Zealand, Tylodelphys spp., was found in the eyes of a native freshwater fish, the common bully *Gobiomorphus cotidianus*. *Tylodelphys spp*., as other congeners, resides in the humors of the eyes of its fish host until it is eaten by the definitive host, a piscivorous bird. Common bullies are the most widespread of New Zealand's native fish and are important prey items for predators (e.g. birds and eels). Our study investigates how infection by *Tylodelphys spp*. affects fish behaviours that rely on vision (e.g. predator avoidance, microhabitat selection, foraging). Fish were tested in aquarium conditions for their response to predators (using a computer animation simulating a shadow moving over the fish) and their preference for microhabitats (e.g. light vs dark). Prevalence of infection in our study site, Lake Hayes (South Island), is ~98% with a mean abundance of 8.7 parasites per host. Our results show that infection has no impact on reaction to a passing visual stimulus, but that higher infection levels are associated with increased activity and time spend in the light in immature fish (gonads not well developed).

Optimising DNA metabarcoding methods to explore ecological questions: considering the challenges and limitations

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DNA metabarcoding is providing exciting new opportunities for taxonomic identification in environmental samples, however it has inherent challenges and limitations. The robust application of DNA metabarcoding techniques to ecological problems, for example the use eDNA to identify species presence, involves a number of important methodological decisions from the initial study design through to data analysis and interpretation. Many of these decisions relate to key assumptions of the methodology and have been shown to significantly influence results and interpretations of diversity metrics, yet the impacts of these assumptions and selected methodologies are rarely scrutinised. Among the methodological steps that can significantly influence the outcomes of metabarcoding studies are: (1) the choice of primers, (2) sample replication, (3) data pre-processing steps, (4) the choice of database used to attribute sequence data to taxa, and (5) the validation of results. Here we outline the typical metabarcoding protocol, highlighting the potentially influential processes and key decision steps. We emphasise that several of the potentially influential choices made in the metabarcoding workflow are subject to biases. Thus, the consequences of these decisions on the outcomes of the analyses should be rationalised and explained in each study with respect to the study aims. The need for taxonomic validation in metabarcoding studies is highlighted and we question the common assertion that high taxonomic diversity in metabarcoding studies is due to improved species detection over other methods. For example, recent studies have shown high gene copy numbers and apparent genetic diversity can exist within a single micro-organism. Finally, we call for more open discourse regarding the current challenges and limitations of metabarcoding studies so that greater confidence can be placed on ecological conclusions drawn.

Stressor-response relationships to improve lake management

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Since its first formal inception in the 1970s, lake management has advanced through four phases of increasing sophistication. The current theoretical paradigm is based on stressor-response (S-R) relationships, which encompass increasingly important ecosystem behaviours such as resistance, resilience, regime shifts and hysteresis. The S-R paradigm has the potential to facilitate the prediction of future states of lake ecosystems - a capacity that has been elusive under more simplistic management paradigms, which have tended to be mostly reactive rather than proactive. Empirical evidence supports the idea that lake responses to stressors are varied and complex, but, unfortunately, this complexity may have inhibited the uptake of S-R theory by lake managers.

We demonstrate the implicit use of S-R relationships in the management of eutrophication in three New Zealand lakes: Lake Taupo, Waituna Lagoon and Lake Hayes. In each case, empirical evidence supported the use of a different specific shape of S-R relationship to derive appropriate stressor limits to safeguard key lake values. To assist managers in selecting the most relevant S-R relationships to manage specific lake types, we developed a conceptual and empirical lake typology based on lake physico-chemical and hydrological characteristics of lakes. The proposed typology links these lake characteristics to specific relationships based on the probability that known ecological feedback processes will influence a lakes response to stressors. In addition, the presence or absence of certain invasive macrophyte and fish species in the lakes is correlated with the propensity of lakes to undergo rapid regime shifts. Together, this information can help predict the responses of lakes to certain stressor levels and should thereby provide an useful framework for predictive lake management.

Recolonisation of a re-established wetland in Southland following a period of drought – The importance of deep refuges

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At the mouth of the Waiau River in Southland a series of wetland ponds have been created by diverting water from the river. In 2017, a year of particularly low river flows culminated in a period of 80 days between November and January where river levels were not high enough to feed into the Waiau wetland system. As a result the wetland dried out entirely, with the exception of a few deep channels along old river braids. A flood in February led to the inundation of the ponds, creating an opportunity to study recolonization of the system, and understand the changes in community composition over time. The deep channels appear to provide important refuge habitat for eels during dry periods, with significantly higher numbers than sites further away. Smaller fish such as bullies and inanga took much longer to reappear in the ponds. Macroinvertebrate community differed significantly between ponds, but did not differ over time. The zooplankton community had significant differences over both space and time. The deep channels provide good habitat for eels, with high catches being common early after refilling; although they are not preferred by other fish species. Overall this study has highlighted the importance of spatial variability in a constructed wetland system, as differences allow for variation in the community, likely increasing the rate in which recolonization can occur.

Invertebrates on artificial structures in lakes; do they harbour unusual and non-native species?

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Artificial structures in marine ecosystems can provide novel habitats for invertebrate species. For example, community composition has been found to differ between artificial structures and natural habitats. Further, artificial structures been found to facilitate invasions, with non-native species found to favour some constructed substrates. Nevertheless, similar studies assessing invertebrate species composition and invasion rates on artificial structures in freshwater ecosystems are rare. The aim of this study is to examine the species diversity and composition of invertebrate species on artificial structures (e.g., wooden and concrete walls and jetties) in lakes in the Waikato and Auckland regions, relative to natural habitats (i.e., on macrophytes and sediments). Macroinvertebrates from these habitats are being examined to determine if (i) invertebrate communities on artificial structures in lakes are different from those on natural substrates; and (ii) non-native species are more prevalent on artificial structures relative to natural habitats. Twenty-two lakes have been sampled for macroinvertebrates from each substrate type (constructed, macrophytes and sediments). In addition, environmental data, including water temperature, pH, dissolved oxygen, Secchi depth, and total nitrogen and phosphorus measurements were taken for each lake, to determine if these influence species distributions among lakes. We will present our preliminary findings, indicating whether man-made structures encourage non-native invertebrate species to thrive, and whether these influence species diversity and composition in lakes.

The effect of dissolved organic carbon (DOC) on the acute toxicity of copper and zinc for different freshwater species

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Copper and zinc are essential metals for life, however, high concentrations can have adverse effects on aquatic organisms. Levels of copper and zinc in urban streams are often found to markedly exceed the current Australian and New Zealand Environment and Conservation Council (ANZECC) water quality guideline trigger values – particularly during storm events – indicating a potential contribution to the poor ecological health in such waterways.

Although ANZECC guideline values for copper and zinc are presently being revised, they only provide chronic (long-term) trigger values but no acute (short-term) values (necessary to allow ecological risk assessment of high peak concentrations in heavy metals) and include no allowance for the effect of the key water quality modifier dissolved organic carbon (DOC).

This study contributes to the development of guidelines for urban management of peak metal concentrations by determining the effect of DOC on the acute toxicity of copper and zinc for three native New Zealand freshwater species (a fish (common bully: *Gobiomorphus cotidianus*), a crustacean (amphipod: *Paracalliope fluviatilis*) and an aquatic snail (*Potamopyrgus antipodarum*)) and one international benchmark species (crustacean: *Daphnia magna*). Humic acid was used as the reference DOC material, with additional tests also undertaken with D. magna using natural DOC extracted from various common riparian plant leaves and Pōhutukawa leaves.

The experiments showed a marked reduction of metal toxicity with increasing DOC concentration for both copper and zinc – confirming the importance of DOC as a toxicity modifier. Toxicity reduction was also found to be influenced by the DOC source.

These results indicate that selective planting in riparian areas could be a useful management approach to help mitigate metal toxicity in streams. The optimisation of in-stream DOC composition and concentration resulting from leaf-litter decay or treatment systems, will contribute to improved urban management.

Trace metal limitation of phytoplankton growth

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Not only nitrogen and phosphorus can set limits to algal growth and biomass. Several trace metals are essential micronutrients for eukaryotic algae and cyanobacteria, and cyanobacteria also require trace metals to synthesise enzymes involved in nitrogen fixation. Low trace metal concentrations may prevent cyanobacteria from fixing nitrogen, and reduce cyanobacteria biomass. The soils in the Taupo Volcanic Zone, which stretches from Mount Tongariro to the Bay of Plenty, are unique, with very low concentrations of certain trace metals. It is likely that low trace metal availability limits phytoplankton growth in lakes in this region and may help maintain water quality by limiting the growth of phytoplankton. Chances of success of algal biomass reduction by nitrogen load reduction may also be enhanced by low trace metal availability preventing or reducing N fixation. Because the demand for each type of trace metal varies between phytoplankton species, this variation in demand may result in lake phytoplankton communities that closely reflect the composition and concentrations of trace metals. We use state-of-the-art techniques to measure trace metal concentrations in lakes, and perform bioassays to test whether trace metals limit growth of phytoplankton assemblages and of N fixing species of cyanobacteria. Preliminary measurements in Lake Taupo indicated very low concentrations for 15 trace metals.

Modelling Subsurface Flowpath Contributions to a Stream – The Pokaiwhenua Catchment

Scott Wilson[1]
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Determining how water and contaminants move through the subsurface enables an improved spatiotemporal understanding of the link between source (land) and receiving environment (stream). The aim of this study was to determine and model the main pathway contributions in the Pokaiwhenua catchment (432 km²) in the Upper Waikato, where substantial pine-to-pasture conversions have recently occurred.

Principal components analysis (PCA) was used to identify solute trends and identify groundwater end-members. PCA was then carried out on stream samples, and the eigenvectors for the three identified groundwater end-members were projected onto this subspace. The proportional contribution from end-members was determined from their position relative to each stream sample. End-members were then expressed as a percentage of stream flow, thereby providing a quantified conceptual model of subsurface flow in the catchment. A groundwater flow model was developed in MODFLOW to accord with this conceptualisation.

The PCA results indicate a predominance of groundwater recharge on the Mamaku Plateau, deep circulation within the Whakamaru ignimbrite, and fault-induced emergence south of Putaruru. Mamaku Plateau recharge accounts for 60% of stream flow at the catchment outlet, whereas 40% is sourced from the more widespread Whakamaru ignimbrite. The proportional contribution changes towards the catchment headwaters, with 90% of the water at the Whakauru subcatchment monitoring site being sourced from the Mamaku Plateau. The MODFLOW model simulates head, flow and stream nitrate concentrations well, but could not represent groundwater concentrations due to uncertainty of stream network elevations.

PCA-based mixing models have been invaluable for understanding subsurface flowpaths in the catchment. The study shows that the headwater streams are most vulnerable and quickly respond to local nitrate leaching since they receive less low-nitrate groundwater from the Whakamaru ignimbrite. For successful modelling of subsurface nitrate transport, an investment in accurate elevation data (e.g. through LiDAR) is essential.

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Catherine	Kilroy	NIWA
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Justin	Kitto	DairyNZ
James	Kitto	Taranaki Regional Council
Anika	Kuczynski	NIWA

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Aslan	Wright-stow	DairyNZ
Aneika	Young	Cawthron Institute
Roger	Young	Cawthron Institute
Damian	Young	Morphum Environmental
Christian	Zammit	NIWA

NOTES:

NOTES:

We know water inside out

Cawthron scientists are the water experts. We know the rivers, lakes and seas of New Zealand from microscopic detail through to the big picture of how human activity affects our aquatic resources - and what can be done to protect them.

We are specialists in:

- In-stream flow requirements
- Assessment of environmental effects
- Water quality and ecosystem health
- Habitat measurement and modelling
- Rehabilitation tools
- Molecular monitoring tools

From detailed analysis to applied science on (or in) the water, Cawthron scientists are here to help.

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