fresh

NOVEMBER 2023

New Zealand
Freshwater Sciences Society

Cover image: Darien Kissick (Greater Wellington Regional Council) and a koura.

This page: The Tasman river flows into Lake Pukaki.

FROM THE EDITOR

Kia ora koutou,

Welcome to the 2023 issue of the Fresh newsletter, your update on everything freshwater sciences in Aotearoa New Zealand. It's landing in your inbox a bit later than anticipated due to a few factors, but I trust you'll find some interesting reading here, ahead of our regional hui events in December.

It's been a huge year. You'll find award and conference **updates from our society president**, Jenny Webster-Brown, in the next few pages. This is followed by an introduction to our **new student representatives**, Holly Harris and MM Maran, on page 7. Flick through to page 8 for an update from **the Rōpū Māori**, including new representatives and to read about the current scholarship recipient.

I'd like to thank **Anya Kardailsky (page 13) and Rory Lennox (page 16)** for agreeing to write feature articles about their Master of Science research; both completed earlier this year. These articles are followed by an update from the current **NZFSS Scholarship in Freshwater Science recipient**, Caitlin Wheeler, on page 20. Ignacio (Nacho) R. Sainz has written a great and entertaining piece on **everything you need to know about the toe biter** on page 22.

A topic of conversation within the executive committee this year has been how we, as a society, can better support the growth and retention of skilled freshwater scientists in Aotearoa New Zealand. A starting point for this discourse is a snapshot of the **current tertiary freshwater sciences landscape**, by Jenny Webster-Brown and Holly Harris, on page 24.

Lastly, we have all the wonderful **updates from public and private organisations in freshwater sciences** around Aotearoa New Zealand, starting on page 28. Thank you very much to everyone who takes the time to put these contributions together.

After a bit of a summer break (having just completed my own MSc, I need it!) I'll be thinking a bit more about how to improve and streamline these communications. Feel free to contact me if you have any thoughts on what you like, don't like, or if you have something special you'd like to contribute.

Cheers, and
ngā mihi

Christina McCabe

President's address

Tēnā koutou katoa,

It has certainly been an exciting year for the Society so far, and a steep learning curve for our relatively new Executive Committee. After being elected at the AGM in November last year, we had only 6 months to come up to speed with NZFSS systems and processes before the international Freshwater Science conference in Brisbane in June. It was a very busy start to 2023, spent finalising conference organisation and support for NZFSS members to attend. Te Wai Māori Rōpū worked particularly hard to support the Society's mātauranga Māori researchers and practitioners. Indigenous freshwater science and culture from both Aotearoa and Australia was a major feature of the Brisbane conference.

Members of the new Executive Committee and the Te Wai Māori Rōpū, and their responsibilities, are listed on the NZFSS website together with many other useful contacts, communications and resources. We encourage you to check the website regularly to stay aware of developments, as the Executive Committee is planning to refresh and raise the profile of the society, after the recent COVID-disrupted years, and to improve the experience of being a member. Our new secretary, Issie Barrett, has already started fortnightly e-news updates to the members, and we are currently seeking ideas for redesigning the logo. Please don't hesitate to feedback to us on items shared in the e-news or on the website, or on any of the initiatives of the Executive Committee. Your thoughts are welcome and appreciated.

We have changed the timing of the newsletter this year, to mid-year instead of end-of-year after the annual conference. This is to break up the long 12 months (usually!) between conferences with a significant communication from the Society to its membership. We hope you find this to be an improvement, perhaps providing some good reading material for the long winter months. Again, feedback is welcome. I would like to acknowledge the dedication of the NZFSS newsletter editor, Christina McCabe, in getting this communication out while also in the process of submitting her thesis at Otago University.

As this is the first newsletter since the end of 2021, there are quite a few events and awards to report in the President's Piece this time:

NZFSS MEDAL

The NZFSS Awards Committee awarded the 2022 NZFSS Medal to Ton Snelder for his outstanding contributions to freshwater management. Ton gave his Medal plenary at the Brisbane conference, where he spoke about the benefits and challenges of setting limits in freshwater systems. He was also very understanding when his "medal" was awarded on stage, and turned out to be a set of (very nicely wrapped) aboriginal art coasters. The early timing of the conference meant that his medal had not yet been engraved. He has since received the actual medal and our sincere apologies. Congratulations Ton.

HONORARY MEMBERSHIP

The Executive Committee's nomination of Philippe Gerbeaux as an honorary NZFSS member, for his services to wetland science and conservation and his contributions to the Society, was wholeheartedly supported by the membership at the 2022 AGM. As a past NZFSS Executive Committee member, and organiser of both the memorable Shantytown 2002 and international INTECOL 2021 conferences, Philippe is well known and fondly regarded by all. Congratulations Philippe.

SCHOLARSHIP AWARDS

The recipients of 2022 NZFSS and He Manawā-ā-Whenua freshwater research post-graduate scholarships, worth $7,500 each, were Alyssa Thomas (HMAW) and Caitlin Wheeler (NZFSS). Congratulations to you both and we trust your thesis research is going well.

BEST STUDENT PAPER 2022

The Best Student Paper for 2022 was awarded to Andrew Watson for his paper entitled "Interacting effects of density and temperature on fish growth rates in protected freshwater populations". The judging was again very close and the standard of research undertaken was impressive. Congratulations Andrew for your excellent contribution to freshwater science research.

ANNUAL NZFSS CONFERENCE 2022

The 2022 annual conference was held jointly with the NZ Marine Sciences Society from 21- 24 November at AUT's campus in the Auckland CBD. The theme was "Waitī Waitā", stars associated with freshwater and the ocean in the Matariki constellation. The event provided a great opportunity for members to reconnect with each other, and with our more saline colleagues. However, it is probably most memorable for being a very impressive COVID super-spreader event, which seriously disrupted the rest of 2022 for many attendees.

The calibre of the student presentations was again very high, as we have come to expect, and judging the presentations was therefore rather difficult. However, the hard decisions were made and the following students were recognised for their outstanding oral presentations: Rachel Crawford for best presentation, Inge Martens for best presentation by a Masters or Honours student, Chris Meijer for best applied science presentation and Georgia Thomson-Laing for best presentation by a PhD student. Channell Thoms received the NZFSS Rōpū Māori award for best presentation including Mātauranga Māori and Ben Crichton received the Department of Conservation's award for contributions to conservation. Student awards were made at the appropriately themed "stellar" conference dinner. Congratulations to you all.

BRISBANE JOINT NZFSS-AFSS-SFS CONFERENCE 2023

The "Freshwater Science" conference in Brisbane was jointly organised by NZFSS, Australian Freshwater Science Society (AFSS) and the USA Society for Freshwater Science (SFS). Finally held from 3-7 July, this conference had been a long time in the planning after being postponed in 2022 due to COVID-19.

With over 750 registrants from over 30 countries, this was a very successful conference and a credit to the various organising committees and to the host organisation, AFSS. NZFSS's immediate past president Kate McArthur and current vice president Joanne Clapcott worked particularly hard throughout the planning phase and at the conference to ensure that NZFSS had a strong and genuinely bicultural presence at this large international event. I would also like acknowledge the efforts of the new Executive Committee in early 2023, working to a very tight timeframe to organise support for students and members to attend the conference.

The standard of student presentations was universally very high, although nerves were understandably often in evidence in front of international experts and large audiences. K'lee Begbie was awarded best presentation including Mātauranga Māori, Chris Meijer received the best oral presentation and Christina McCabe received best oral presentation by a Masters or Honours student. For poster presentations, Siobhan Nuri and Christina McCabe were respectively awarded best poster and the Department of Conservation's poster award for contributions to conservation. Showing great consistency in performance, Ben Crichton's oral presentation received the Department of Conservation's award for contributions to conservation for the second year in a row. Well done everyone!

Joanne Clapcott recounts the origins of the AFSS Apple Prize, at the NZFSS-AFSS-SFS conference in Brisbane.

Sergio Sabat-Bonilla (Virginia Tech, US) received the Golden Gumboot award, at the NZFSS-AFSS-SFS conference in Brisbane.

FUTURE CONFERENCES

2023: The Brisbane conference was NZFSS's official 2023 conference. However, regional hui are planned to coincide with the 2023 virtual AGM in November/December. The format of these hui can be designed to meet the expectations of members in each region, but may range from an informal gathering to collectively "attend" the AGM to a more organised seminar with refreshments or similar. NZFSS will fund regional gatherings and organise the AGM.

The recipients of 2023 scholarships and awards such as the NZFSS Medal, Best Student Paper and Early Career Researcher will be announced at the next AGM. As I write, nominations are still open for both the NZFSS Medal and the Early Career Research Award (see website). Please don't miss this chance to nominate someone you think has made, or is making, a valuable contribution to freshwater science in Aotearoa.

2024: We are currently planning to hold a NZFSS conference in the central North Island towards the end of 2024. Details are not yet confirmed, but the venues could perhaps be Hamilton or Rotorua.

2025: The AFSS Executive Committee have suggested that we hold another joint AFSS-NZFSS conference in 2025, this time in Aotearoa. The NZFSS Executive Committee are enthusiastic and currently looking at a venue in Christchurch, possibly the new convention centre, Te Pae.

That is plenty from me I suspect. Again, please don't hesitate to get in touch with your feedback on these, or any other ideas and initiatives NZFSS has in mind. I wish you all the best in this season of renewal, as the Society seeks to look to the future, while keeping in touch with our past.

Mānawatia a Matariki

Jenny Webster-Brown
NZFSS President

Photos from the NZFSS-AFS-SFS conference, Brisbane (clockwise from top-left): Presenters from the Indigenous knowledge session including Wardaman Rangers, Jane Kitson, Joe Greet, Nikorima Nuttal and Bradley Moggridge; Ton Snelder is presented with the NZFSS Society Medal by president Jenny Webster-Brown; Ben Crichton and Christina McCabe receive DOC Best Conribution to Conservation awards for their oral and poster presentations, respectively; Ian Kusabs delivers a plenary on using a traditional Māori harvesting method, the tau kōura, for monitoring freshwater crayfish (kōura).

STUDENT REPRESENTATIVES

Tēnā koutou students of NZFSS,

We'd like to introduce ourselves as the new student reps for the NZFSS, and say a huge thank you to the outgoing student rep- Chris Meijer. Chris has done an awesome job and we're sorry to see him off.

So you now have two people to represent yourselves! Maran is from the University of Auckland, and I'm at the University of Canterbury - feel free to drop either of us an email.

Don't forget the society also has a mentoring programme going and this might be something neat and beneficial to be a part of- you could get advice on hard skills like CV writing or paper publishing, or life skills like navigating through tricky systems or work-life balance. Plus, you get to be connected to people outside of your institution.

Please get in touch if you have anything you'd like to see from the society, need some advice, or just want to say hi! If we don't hear from you, you can picture us as mudfish without water: we'll still be here but not doing all we can do!

Noho ora mai,

Holly Harris

The Cass river, Canterbury

RŌPŪ MĀORI UPDATE

Ngā Mahi o NZFSS Rōpū Māori

Nā mātou Dr Ian Kusabs, ko Siobhan Nuri, ko Kathryn Gale, ko Tredegar Rangiātea Hall

Mō wai, mōu māori mā – Water for all

Tēnā koutou katoa,

Kei te rere tonu ngā mihi ki a tātou Ngāi Māori, otirā te rōpū kairangahau Māori, me ngā tauira, huri noa o te motu, e whakapeto nei i ō tātou ngoi ki te whaitakenga o ēnei o ā tātou mahi whakahirahira. Kua mauria mai e tēnei tau he momo tumatumatanga ki te nuinga o mātou i ēnei wa ngākaurua, e arotahi ana mātou ki o mātou whānau, ki ngā hāpori a ka mahi tonu tātou i ngā mahi rangatira ki te wai māori.

We continue to acknowledge you, as Māori, in particular as Māori scientists, researchers and students throughout New Zealand, with all our efforts in and for this important work. This year has brought a variety of challenges to most of us, in these unprecedented times, we focus on our whānau and local communities, while continuing our important work in freshwater.

He ai ki ngā kōrero o mua:

He pātua wai mairingi, he tangata moumou taonga

As water flows into a crevice, so possessions are wasted by man

NZFSS EXECUTIVE COMMITTEE SUPPORT FOR TE WAI MĀORI

The NZFSS Executive Committee continue to recognise and value the contribution that Te Wai Māori – NZFSS Rōpū Māori make to the overall Society aim to 'establish effective liaison between all persons interested in any aspect of fresh and brackish water research in New Zealand'. In particular, the Executive appreciate rōpū input into shaping annual conferences, engaging with mana whenua and facilitating kaitiaki attendance. The rōpū representatives have liaised with the Executive about the best ways to support the rōpū in this capacity.

The annual update of the Rōpū Māori Terms of Reference (ToR) that clearly defines the purpose and structures of the rōpū. Our tikanga approaches are guided and supported by our kaiārahi representative Tredegar Rangiātea Hall (Ngāti Tūwharetoa, Te Arawa). The vision of the NZFSS Rōpū Māori is the successful participation of Māori in freshwater sciences, management and research where Māori principles, values and interests are identified and valued within the New Zealand Freshwater Sciences Society (NZFSS). The full ToR can be viewed here: https://freshwater.science.org.nz/te-wai-maori-nzfss-ropu-maori

- A member of the rōpū will be invited to be part of the organising committee for all future conferences
- Conference organising committees will be responsible for ensuring sufficient sponsorship is acquired to support local kaitiaki and kaiārahi attendance at conferences
- In the event of a sponsorship shortfall, up to $5,000 of Society contingency funding will be made available to facilitate mana whenua participation and support appropriate conference tikanga
- In years when NZFSS conferences are held overseas, up to $5,000 of Society contingency funding will be made available to enable rōpū members to meet and network at a central site (note: the hui is not a replacement for the overseas conference)
- Rōpū representatives will be responsible for requesting and allocating contingency funds
- Free first-year NZFSS membership for tauira Māori
- Being invited to contribute to the Society website,

check out our activity here: https://freshwater.science.org.nz/te-wai-maori-nzfss-ropu-maori

- Produced regular newsletters and sent numerous emails to rōpū members
- Increased our social media profile via Twitter @ NZFSS Rōpū Māori (810+ followers).
- Increasing our membership annually, currently at 65 members.

CHANGE IN REPRESENTATIVES

There have been big changes to our rōpū with two long standing representatives standing down and two rōpū members becoming representatives. Dr Joanne Clapcott has stepped down from her role as a rōpū representative after four years. Joanne played a pivotal role in ensuring a consistent dialogue with the NZFSS Executive Committee and implementing new initiatives. This year, she was elected as Vice President of the Executive Committee and will continue to support the rōpū through this new role. We are grateful for her contributions to the rōpū over the past four years.

After five years of being a rōpū representative, Yvonne Taura has decided to step down to complete her PhD thesis. Yvonne's role focused on rōpū communications which ensured the members were updated with important executive decisions; annual rōpū pānui; annual Society newsletters; AGM notices; job, internship, and scholarship opportunities; and responding to member enquiries. We wish Yvonne the best of luck as she completes the last phase of her thesis.

This year, Siobhan Nuri (Ngāti Ranginui, Tūhourangi, Ngāti Pikiao, Whakatōhea), Kathryn Gale (Ngāti Pāhauwera, Ngāti Kahungunu, Ngāi Tūhoe) and Tredegar Rangiātea Hall (Tūwharetoa, Te Arawa) joined the representative team, alongside Dr Ian Kusabs (Ngāti Tūwharetoa, Te Arawa, Ngāti Maru).

Siobhan Nuri

Ngāti Ranginui, Tūhourangi, Ngāti Pikiao, Whakatōhea

Siobhan is a PhD student at the University of Waikato and part of Te Kūwaha at NIWA. Her research is looking into the early life histories of tuna and mapping their larval dispersal routes through the Pacific Ocean. She has spent many nights searching the Rangitāiki River mouth for glass eels as they return from their oceanic birthplace.

Siobhan also helps her hapū and iwi in Te Arawa with their environmental monitoring projects. Inspiring rangatahi to look after the taiao and study freshwater sciences, she works with primary school students to provide practical in field applications of science. She is looking forward to being a representative of the rōpū and increasing engagement with students.

Kathryn Gale

Ngāti Pāhauwera, Ngāti Kahungunu, Ngāi Tūhoe

Kathryn's whakapapa is mostly around Hawkes Bay and the Bay of Plenty, but she was born and raised in Dunedin. She studied Environmental Management at Otago and was fortunate to work at Aukaha (formerly Kāi Tahu ki Otago Ltd) for six years before she moved north to reconnect with her whakapapa. Now living in Napier, Kathryn works for Ngāti Pāhauwera Development Trust managing Jobs for Nature and Te Mana o Te Wai projects.

Kathryn has been a member of NZFSS since 2016 when she attended her first conference in Invercargill. She had no colleagues from her workplace and felt whakamā about being there. However, she says she was immediately embraced by the Rōpū Māori within the society who took her under their wing and invited her to sit and kōrero with them all week. "I've never forgotten how welcome and supported I felt, and that's something I hope to bring to my role as a Rōpū Māori rep." Kathryn is looking forward to encouraging whanaungatanga and tautoko between Māori scientists to support each other through the challenges that come with being Māori and working in this space.

Tredegar Rangiātea Hall

Tūwharetoa, Te Arawa

Tredegar graduated in 2012 from Te Whare Wānanga o Waikato with a Master of Social Science in Geography completing a thesis titled 'Restoring the flow: Challenging the existing management frameworks to integrate Mātauranga Māori'. He has over 10 years of experience working for iwi, previously managing Tūwharetoa's Waikato awa settlement committee and navigating the 2019 Contact Energy awa spill

via a restorative justice process centred around the application of a cultural impact assessment. He is currently working as the Pou Ārahi Māori for the British High Commission working to apply a kaupapa lens across international Māori trade and foreign policy. He is also on a number of Hapū Taiao committees still in Tūwharetoa which include a relationship group with Contact Energy (geothermal) and re-consenting steering groups for the Taupō Wastewater plant and Mercury Control Gates.

HE MANAWĀ-Ā-WHENUA POSTGRADUATE SCHOLARSHIP

The Executive agreed to establish a new $7,500 scholarship to be awarded to a Māori postgraduate student studying a Bachelor Honours degree (or equivalent) or Master's degree with a focus on freshwater ecosystems. The inaugural scholarship was open to applicants in 2021.

Ko te wai a Rona he manawa-ā-whenua;
e kore e mimiti e

The waters of Rona are from an underground spring which will never run dry

Alyssa Thomas, successful recipient 2022

Ko Manaia te maunga

Ko Whangārei-Terenga-Paraoa te moana

Ko Ngātiwai, ko Ngāpuhi ngā iwi

Ko Patuharakeke te hapū

Ko Takahiwai te marae

Ko Rangiora te whare tūpuna

Ko Pirihi te whānau

Ko Alyssa Thomas tōku ingoa

Alyssa has just completed her Master of Indigenous Studies at Victoria University of Wellington. Her project involved working with her iwi Patuharakeke to design a rangatahi wānanga around local taiao and freshwater management. Throughout her project she learnt that whanaungatanga between rangatahi and across generations was most valued through wānanga – hearing local perspectives on freshwater management is best achieved when founded on whanaungatanga.

The He Manawā ā Whenua scholarship supported Alyssa with travel between Wellington and the Patuharakeke rohe in Takahiwai and Whangārei. The scholarship also supported her to develop and run the wānanga kanohi kitea, as well as fund additional equipment for wānanga. She was excited to share her project at the Freshwater Downunder Conference in Brisbane in 2023.

WAITĪ WAITĀ NZMSS AND NZFSS JOINT CONFERENCE 2022

In 2022, NZFSS joined the NZMSS to deliver the Waitī Waitā conference in Auckland. The conference was opened by Ngāti Whātua Ōrākei. Our thanks to Kura-Paul Burke who supported the rōpū with conference organisation. The conference programme included over 480 presentations and included three mātauranga Māori sessions. The inaugural Best Presentation including Mātauranga Māori award was received by Channell Thoms for her presentation on "Distribution and habitat for Kākahi (Echyridella menziesii – freshwater mussels) in the South Island".

FRESHWATER DOWNUNDER CONFERENCE 2023

In 2023, NZFSS had a joint meeting with the Society for Freshwater Science and the Australian Freshwater Science Society to deliver the Freshwater Sciences Conference in Brisbane, Australia, where over 760 researchers from around the world attended. Conference organisation committees included rōpū members Ian Kusabs, Joanne Clapcott, Jane Kitson and Simon Stewart. The conference was opened by a Welcome to Country and included an invited plenary by Ian Kusabs. There were many Māori in attendance, including strong representation from Ngāti Huia, Hokonui Rūnanga o Ngāi Tahu and Ngāti Raukawa. K'Lee Begbie won the Best Presentation including Mātauranga Māori award for her presentation "Pā Tūna ki Pokaiwhenua - A Raukawa Lens." Siobhan Nuri won the Best Student Poster Presentation award for her poster "Glass eels on the move: what is driving them?" Kyea Watene-Hakaria also received commendation for her conservation presentation "Te Ārohirohi o Raukawa - Raukawa Freshwater Assessment Framework".

Main image: Jenny Webster-Brown presenting K'Lee Begbie with her award for Best Presentation including Mātauranga Māori.

Inset left: Angela Arthington with Kyea Watene-Hakaria after receiving commendation for her presentation

Inset right: Jenny Webster-Brown presenting Siobhan Nuri with her award for Best Student Poster Presentation.

INSTARS FELLOWS 2023

The INSTARS Fellowship is an initiative within the Society for Freshwater Science that aims to increase diversity and inclusivity in freshwater sciences by helping students from historically underrepresented backgrounds attend SFS Annual Meetings. In 2023, five undergraduate students (Jayde Harris, K'Lee Begbie, Mairangi Bennett, Mariah Montagnani and Tyra Begbie), two post-graduate students (Siobhan Nuri and Tāne Tamati) and one early career researcher (Alyssa Thomas) were awarded the fellowship to attend the joint Freshwater Sciences conference in Brisbane. This is the first time the initiative has been opened to people outside of the USA and included graduate and early career researchers.

RECOGNISING EXCELLENCE

NZ Biosecurity Awards: Te Arawa Lakes Trust

The NZ Biosecurity awards celebrate people across NZ who are contributing to biosecurity. Te Arawa Lakes Trust (TALT), Rotorua, won the NZ Biosecurity Māori Award for their initiatives to resolve biosecurity issues in Tipuna roto of Te Arawa.

Royal Society Te Apārangi Te Kōpūnui Māori Research Award 2022: Dr Tara McAllister (Te Aitanga ā Māhaki, Ngāti Porou)

The Royal Society Te Apārangi Te Kōpūnui Māori Research Award is awarded for research that acknowledges the underpinning of both Te Ao Māori and Mātauranga Māori and is awarded for research that has the potential to shift boundaries and change directions of inquiry. Long time rōpū member, Dr Tara Mc Allister's groundbreaking research has highlighted inequities for women, Māori and Pasifika in research institutes. Her research helped inform Te Ara Paerangi and influenced changes in education institutes.

Successful Endeavour Bids 2022

NIWA. Toitū ngā taonga waimāori: Cultural keystone species, Māori livelihoods and climate change. Dr Erica Williams (project lead)

Successful Marsden Bids 2022

Cawthron Institute. Rewilding our rivers: Quantifying the cryptic role of whitebait marine subsidies in structuring New Zealand riverine food webs. Dr. Simon Stewart (principal investigator), Dr. Eimear Egan (associate investigator), Dr. Robin Holmes (associate investigator), Dr. Jessica Leuders-Dumont (associate investigator).

RECENT PUBLICATIONS

Dr Ian Duggan and Matthew Knox. The origins of Melanoides tuberculata (Müller, 1774) in New Zealand's aquarium trade and non-indigenous population.

Garth Harmsworth and Yvonne Taura. Mātauranga Māori o ngā repo – Māori knowledge of wetlands. In: Life in the shallows: the wetlands of Aotearoa New Zealand. Auckland, NZ; Massey University Press..

Yvonne Taura. Weaving knowledge systems. In: Life in the shallows: the wetlands of Aotearoa New Zealand. Auckland, NZ; Massey University Press.

Finally, thanks to all of those who have supported and assisted the Rōpū Māori this year.

Ko aua mihi anō ki tā koutou whakahau i tō koutou Rōpū Māori i te roanga o tēnei tau.
Nā mātou, nā kāhui kaiwhakarite, me ngā mihi nui,
Nā Dr Ian Kusabs, ko Siobhan Nuri, ko Kathryn Gale, ko Tredegar Rangiātea Hall

New Zealand Freshwater Sciences Society Rōpū Māori Representatives

Get in touch with us!

For any Māori freshwater scientists, researchers or students who would like to join the NZFSS Rōpū Māori, please email māori.fwss@gmail.com.

Unveiling the potential: exploring eDNA opportunities in freshwater sciences

by Anya Kardailsky

In recent years, revolutionary scientific tools have been developed to utilise environmental DNA (eDNA), offering unprecedented opportunities to unravel the long-standing questions within freshwater ecosystems. In this article, we will explore the immense potential of eDNA in freshwater science research, from biodiversity assessment to environmental monitoring and conservation, with some personal experiences I have had working with eDNA for the past four years.

Environmental DNA, or eDNA, refers to the genetic material released into the environment by organisms through various biological processes, such as shedding skin cells or excreting waste. These genetic traces can be found in water, air, or sediment samples. When these traces are concentrated by filtering the environmental samples, the captured DNA can then be sequenced and assigned a species. This provides a rich source of information about the organisms residing within a particular ecosystem based on the DNA traces they leave behind. Importantly, eDNA analysis allows scientists to detect and identify species without the need for direct visual observation or traditional collection methods (Rishan et al., 2023).

This approach offers a comprehensive understanding of the taxa present within a given habitat, making it particularly useful for identifying rare, elusive, or endangered species that are challenging to observe directly (Greenhalgh, 2023). Additionally, eDNA enables the monitoring of invasive species, aiding in early detection and effective management strategies (Rishan et al., 2023).

Once genomic techniques are applied to environmental samples, many other genomic techniques can be utilised as well. In my own research I successfully applied a CRISPR-Cas enrichment technique, previously used to isolate antibiotic resistant bacteria in human gut samples, to eDNA samples. This was done in an attempt to detect abundance measures of taxa in a mixed sample with some preliminary success.

Hopefully I have informed and inspired you of the opportunities eDNA holds for your research! However, there are always caveats with new technologies and the methodologies involved in eDNA analysis can be intimidating in the beginning.

To fully unlock the potential of eDNA, it is imperative to follow standardized methods and techniques. The genetic material

obtained from the environment is often degraded and not fresh, necessitating laboratory methods that can effectively handle such samples. Ensuring the preservation of genetic material starts with meticulous sample collection and preservation techniques. Various approaches, such as filtration or sediment coring, are used to collect water or sediment samples, which are then appropriately preserved to prevent DNA degradation.

Once in the laboratory, the samples undergo a series of molecular analysis techniques which is dependent on the type of analysis you want to run, but more often than not includes polymerase chain reaction (PCR) and DNA sequencing (De Brauwer et al., 2023). These methods enable the identification and sometimes quantification of the genetic material present in the samples. Managing the vast amounts of sequencing data generated during the analysis process is made possible with the aid of bioinformatics tools, which assist in processing and interpreting the data effectively.

Throughout my involvement in various research projects addressing environmental health questions, eDNA has played a crucial role. The accompanying photos provide illustrative examples of the sampling procedures and precautions taken during sample processing. In the first photo I am sampling water which was then used to identify invasive seaweed species in the environment. It is important to note that similar sampling strategies would be employed in freshwater environments. Notably, the use of gloves is emphasised to minimise sample contamination with human DNA. Additionally, to ensure sample integrity, the sampling bottle was meticulously treated with bleach and DNA-free water before the actual sampling took place. In the second photo is an example of eDNA sample processing in the field on a research vessel in Fiordland. This shows the type of precautions taken during sample processing to ensure as minimal contamination as possible. Implementing such precautions is important because less degraded DNA (such as DNA directly from the person taking the sample) can be preferentially amplified and sequenced over the eDNA which is what we are actually trying to study.

While eDNA offers immense opportunities, it also faces certain challenges and limitations. False positives and negatives can occur due to contamination or low DNA concentrations. Technical limitations and methodological biases may impact the accuracy and reliability of eDNA analysis, so most studies done now focus on presence/absence of species in the environment rather than abundance measures (Rishan et al., 2023). Finally, a lack of reference sequences of the species we aim to identify are a major barrier to the application of eDNA analysis in monitoring regimes (Blackman et al., 2023). A lot of research is going into addressing these challenges to maximize the potential of eDNA in freshwater science.

The future of eDNA research in freshwater science is promising. Technological advancements, including portable DNA sequencers and miniaturized laboratory equipment, are making eDNA analysis more accessible and field-friendly (Jeunen et al., 2022). Companies focused on processing eDNA samples specifically have been developed in Australia (EnviroDNA), the UK (NatureMetrics) and in New Zealand (Wilderlab), making eDNA research more accessible than ever. Integrating eDNA with other monitoring methods, such as remote sensing and acoustic techniques, can provide a comprehensive understanding of freshwater ecosystems (Greenhalgh, 2023). Furthermore, novel applications of eDNA, such as tracing historical species presence or exploring ancient DNA in sediment cores (Barrenechea et al., 2023), offer exciting possibilities for expanding our knowledge of past and present ecosystems.

“TECHNICAL LIMITATIONS AND METHODOLOGICAL BIASES MAY IMPACT THE ACCURACY AND RELIABILITY OF E-DNA ANALYSIS, SO MOST STUDIES DONE NOW FOCUS ON PRESENCE/ABSENCE OF SPECIES IN THE ENVIRONMENT RATHER THAN ABUNDANCE MEASURES”

This article is only meant to introduce eDNA to those that may not be familiar to it and raise the interesting benefits of eDNA research to a wider audience.

If more information on how to conduct eDNA monitoring is wanted there are many resources available to help plan a study involving eDNA, including recent best practise guidelines produced by (De Brauwer et al., 2023). For those interested in using eDNA to improve your research but not in learning how to do it yourself, Wilderlab is a specialist environmental DNA (eDNA) testing laboratory based in Wellington where you can order sampling kits and send samples for processing. If you are more concerned about the usefulness of eDNA from an ecosystem managers standpoint, John Darling (2019) wrote an excellent article on the limitations and choices needed to be made when using eDNA. While challenges and limitations persist, ongoing research and collaboration among scientists, environmental managers, and the public will undoubtedly unlock new horizons in understanding and preserving freshwater habitats.

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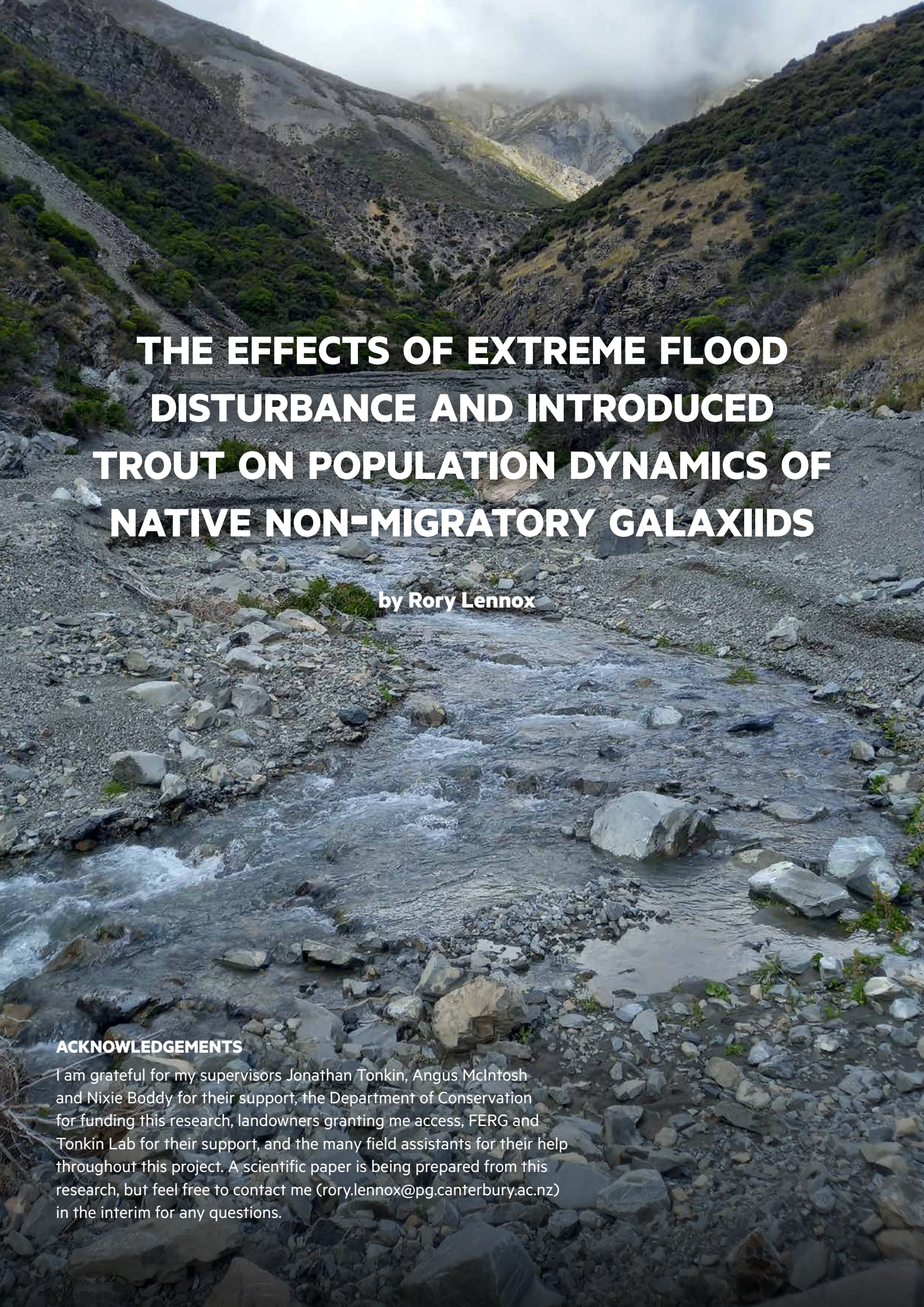

THE EFFECTS OF EXTREME FLOOD DISTURBANCE AND INTRODUCED TROUT ON POPULATION DYNAMICS OF NATIVE NON-MIGRATORY GALAXIIDS

by Rory Lennox

ACKNOWLEDGEMENTS

I am grateful for my supervisors Jonathan Tonkin, Angus McIntosh and Nixie Boddy for their support, the Department of Conservation for funding this research, landowners granting me access, FERG and Tonkin Lab for their support, and the many field assistants for their help throughout this project. A scientific paper is being prepared from this research, but feel free to contact me (rory.lennox@pg.canterbury.ac.nz) in the interim for any questions.

WHAT WE KNOW

Extreme flood events are expected to intensify by an order of magnitude over the next century (IPCC, 2021), which will significantly impact ecological assemblages in rivers. However, it remains unclear as to how increasing flow disturbances will interact with existing biotic pressures, such as non-native species, to influence the persistence and dynamics of native fish populations (Tonkin, 2022). In New Zealand, 'at risk' native non-migratory galaxiid fishes face pressure from introduced trout through interspecific competition and predation (McIntosh et al. 2010; Townsend 1996; Woodford & McIntosh 2013), which may influence the recovery of native galaxiids after flood disturbance. Given their dietary overlap and shared habitat preferences, strong foraging competition with trout is known to restrict native galaxiids to less preferred foraging positions with slower current, yielding lower feeding success (McIntosh et al., 1992) and likely reducing individual growth. Reduced growth of individual galaxiids resulting from trout pressure could have major implications for native population recovery dynamics after extreme events, because growth rates control the timing when individuals transition between ontogenetic stages and in turn influence the demography of fish populations (Houde, 1994). Yet, the relative strength of trout interactions controlling non-migratory galaxiid growth remains unclear, providing a research gap that can contribute towards the conservation of these taonga species.

In May 2021, Canterbury experienced record-breaking rainfall from a low-pressure tranche, resulting in one of the greatest flood events ever documented for many rivers in the region (Environment Canterbury, 2021). The resulting gradient of flood disturbance across a trout invaded landscape, combined with pre-flood data (Hore, 2022), presented a unique opportunity to investigate the impact of extreme flood disturbances on the population structure of non-migratory galaxiids (Galaxias vulgaris and G. paucispondylus), and the effect of trout pressure on galaxiid populations recovering from extreme events. To do so, I focused my research on two main aims:

1. Establish size-specific responses of non-migratory galaxiids to a gradient of flood disturbance, and
2. Quantify the relative strengths of interspecific and intraspecific interactions controlling non-migratory galaxiid growth rates in populations recovering from varying degrees of disturbance following the 2021 Canterbury floods.

WHAT WE DID

We conducted field surveys across twelve streams over four sampling occasions throughout the Canterbury High Country and foothills during the 2021-22 summer season after the flood event, comparing streams that spanned a gradient of flood disturbance magnitude and supporting various abundances of brown trout (absent, low and high). At each site, three-pass quantitative electrofishing (McIntosh, 2000) was employed within a 30-m reach. All captured fish were identified and their lengths (mm) were recorded. Additionally, all non-migratory galaxiids >60mm received a unique visual implant elastomer (VIE) tag to track individual growth rates over the sampling season. In total, we tagged 1256 individual non-migratory galaxiids and recaptured 419 of those individuals.

WHAT WE FOUND

After comparing galaxiid size-class abundances (YOY, 1-2 year, and +2 year) along a disturbance gradient before and after the flood event, my results revealed that high flood magnitudes reduced abundances of all non-migratory galaxiid size classes. However, abundances of smaller size classes (YOY and 1-2 year cohorts) were most negatively affected, which suggests responses of non-migratory galaxiids to extreme floods may be size-specific. Further investigation using simulations informed by an empirical model revealed that larger adult galaxiid size classes (+2 year cohorts) were more resistant to the negative effects of increasing flood magnitude.

In high numbers, trout reduced the individual growth of native non-migratory galaxiids, despite interspecific effects (trout presence) being a weaker regulator of individual growth compared to intraspecific (galaxiid abundance). The effects of trout were also size and density dependant of galaxiids, where the growth of smaller individual galaxiids in low densities was most affected by a high presence of trout reducing growth.

WHAT THAT MEANS

Extreme flood events can have severe impacts on non-migratory galaxiid populations. Disproportionate loss of smaller size classes during extreme floods may reduce recruitment and jeopardise the persistence of flood-affected native populations in future. However, these population-level impacts may be temporary if flood-resistant adult galaxiids are able to remain through high flow events and compensate for reduced recruitment by increasing reproductive output, dispersal, and individual growth at low densities.

On the other hand, pressure from trout is likely to be constant. Competition with trout in high numbers can reduce the individual growth of non-migratory galaxiids, which could disrupt density-dependent recovery mechanisms of native populations and increase their to vulnerability to local extirpation. Specifically, slower growing individuals that take longer to reach reproductive adult stages can have lower reproductive success (Allan et al., 2021), which limits population growth at low densities. Furthermore, small bodied galaxiids tend to be more vulnerable to predation from trout (Woodford & McIntosh, 2010), therefore slower growing individuals may suffer from reduced survival to adult stages (Gascho Landis et al., 2011; Houde, 1994). Thus, strong interspecific interactions with invaders that reduce the growth of natives can have major implications for the persistence of native populations, particularly in the face of larger, more frequent extreme flood events.

In summary, my results demonstrate that non-migratory galaxiid population dynamics are affected by a combination of flood disturbance regimes and introduced trout densities, which presents a challenge for conservation of these 'at risk' species under climate change (Boddy & Robertson, 2020). To minimise their risks associated from increased frequencies and magnitudes of extreme flows in combination with non-native species threats, native galaxiid populations would benefit from:

Maintaining hydrological heterogeneity across catchments, such as a combination of stable spring-fed and runoff-fed systems, to allow stable source population to recolonise after widespread catastrophic floods (Schlosser, 1998), assuming those stable sites can be kept free of non-native species such as trout that are known to impair the recruitment of native populations (Jellyman & McIntosh, 2010; Woodford & McIntosh, 2010).

Maintaining strategically placed trout-free source populations of adult galaxiids to enable native dispersal into trout affected habitat and protect future population resilience.

Continued use of detailed methods, such as individual-level growth measurements, to monitor the response of native fish species over longer time periods. Such approaches offer the ability to gain a deeper understanding of population dynamics in increasingly dynamic environments while interacting with non-native species.

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SCHOLARSHIP IN FRESHWATER RESEARCH: 2022 RECIPIENT'S REPORT

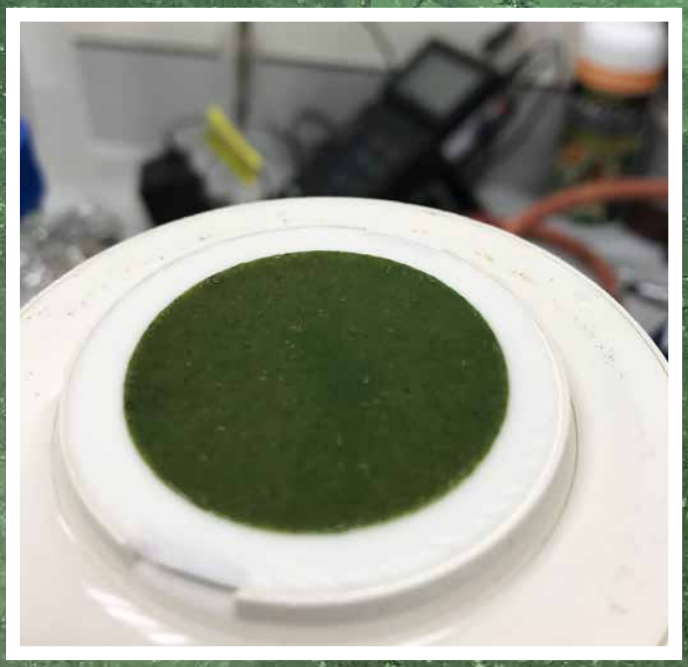
by Caitlin Wheeler

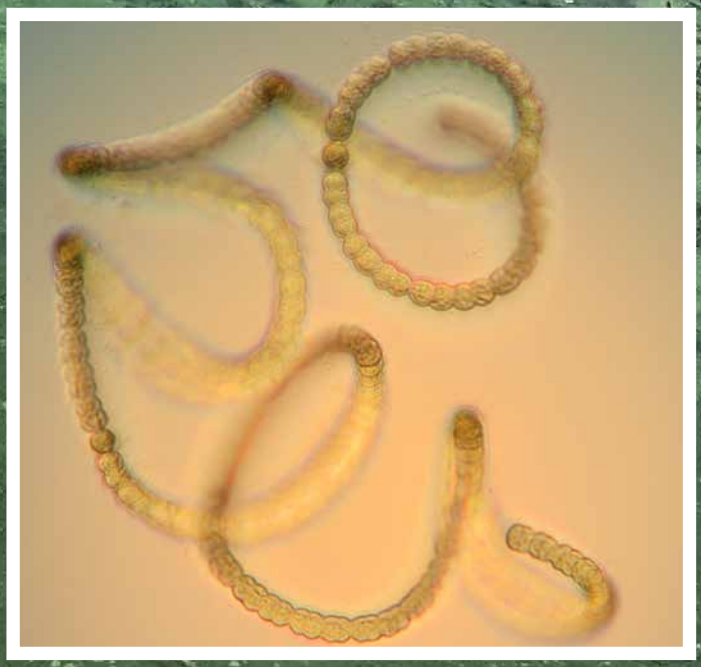
My Master of Science project at Massey University focused on cyanobacterial blooms in lakes Alice and Wiritoa, two dune lakes in Manawatū-Whanganui. Potentially toxic cyanobacterial blooms are common in these lakes, but the rarity of dune lakes globally means there is limited information available to guide their management. The aims of my thesis were to: (1) determine if cyanobacterial in the water column settle to the sediment, and (2) determine if the cyanobacterial blooms recently observed in these lakes are natural, and if not, what were the potential drivers of their formation. Lakes Alice and Wiritoa were chosen as they are similar sizes and similar catchment land-uses, but differ in depth.

A field sampling campaign was undertaken which involved collecting water and surface sediment samples over summer to investigated how representative the sediment was of pelagic cyanobacterial communities using environmental DNA (eDNA). The changes within the lakes and their catchments during human settlement were reconstructed using sediment cores taken from each lake. The sediment cores were analysed with a range of techniques including pollen and trace metal analysis, while eDNA was used to explore the historic cyanobacterial cell numbers and community composition.

Analysis of the field samples indicated the cyanobacterial communities in the sediment were very similar to the seasonal average water column communities, with some likely effects from accumulated settling from the water column, lake depth and length of the water sampling period. The cyanobacterial communities in both lakes were dynamic throughout the summer, although potentially toxic and bloom-forming genera were the most abundant eDNA reads. The results from the sediment cores showed that both lakes have experienced significant environmental change with human settlement. Their catchments were covered in podocarp wet forest prior to human arrival, and the cyanobacterial communities in both lakes were likely dominated by picocyanobacteria. Māori and early European settlement resulted in little change in the cyanobacterial communities in both lakes. Cyanobacteria cell numbers increased significantly with the onset of aerial superphosphate topdressing (detected using cadmium analysis) in around 1950. At about this time, the cyanobacterial community composition shifted towards potentially toxigenic and bloom-forming taxa. These cyanobacterial communities detected in the younger layers of the sediment cores were very similar to the seasonal average water column communities. The results of my study suggest that the nutrient levels in the lake would need to be returned to what they were in about 1950 to prevent the current cyanobacterial blooms. This is likely to involve multiple interventions including reducing nutrients entering the lake as well as actions to manage internal nutrient cycling.

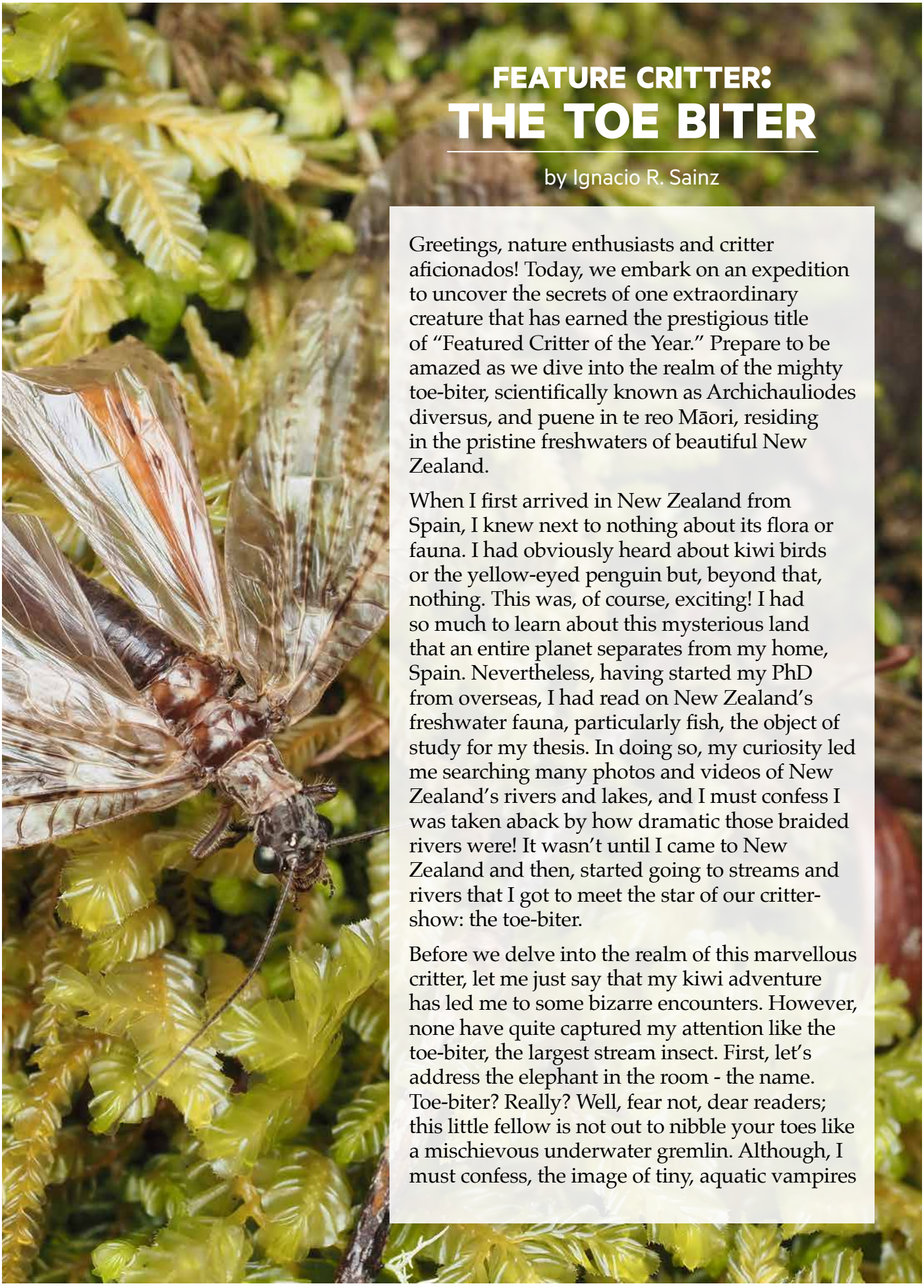
I've had a great supervisory team of Dr. Katherine Holt and Professor Steve Trewick (Massey University), and Dr. Susie Wood (Cawthron Institute). I also acknowledge the wider Lakes380 team of Mailys Picard, Georgia Thomson-Laing and Dr. John Pearman (Cawthron Institute), Dr's. Marcus Vandergoes, Xun Li, Claire Sheppard (GNS Science), Dr. Chris Moy (Otago University), and Dr. Jamie Howarth (Victoria University of Wellington). I've loved every minute of my project, and I hit the jackpot with a combination of limnology, cyanobacteria and paleolimnology. Highlights have been presenting my results at two conferences, visiting Cawthron Institute, spending six months collecting field data, and meeting so many people dedicated to freshwater science. I really appreciate receiving the NZFSS Research Scholarship and look forward to contributing to the restoration and protection our freshwater environments into the future.





IMAGES

Background: Lake Alice cyano bloom.
Inset left: Filtering cyanobacteria onto membrane. Inset right: Dolichospermum filament from Lake Alice.



FEATURE CRITTER:
THE TOE BITER

by Ignacio R. Sainz

Greetings, nature enthusiasts and critter aficionados! Today, we embark on an expedition to uncover the secrets of one extraordinary creature that has earned the prestigious title of "Featured Critter of the Year." Prepare to be amazed as we dive into the realm of the mighty toe-biter, scientifically known as Archichauliodes diversus, and puene in te reo Māori, residing in the pristine freshwaters of beautiful New Zealand.

When I first arrived in New Zealand from Spain, I knew next to nothing about its flora or fauna. I had obviously heard about kiwi birds or the yellow-eyed penguin but, beyond that, nothing. This was, of course, exciting! I had so much to learn about this mysterious land that an entire planet separates from my home, Spain. Nevertheless, having started my PhD from overseas, I had read on New Zealand's freshwater fauna, particularly fish, the object of study for my thesis. In doing so, my curiosity led me searching many photos and videos of New Zealand's rivers and lakes, and I must confess I was taken aback by how dramatic those braided rivers were! It wasn't until I came to New Zealand and then, started going to streams and rivers that I got to meet the star of our critter-show: the toe-biter.

Before we delve into the realm of this marvellous critter, let me just say that my kiwi adventure has led me to some bizarre encounters. However, none have quite captured my attention like the toe-biter, the largest stream insect. First, let's address the elephant in the room - the name. Toe-biter? Really? Well, fear not, dear readers; this little fellow is not out to nibble your toes like a mischievous underwater gremlin. Although, I must confess, the image of tiny, aquatic vampires

did cross my mind. In reality, the toe-biter is a rather remarkable insect that belongs to the family Corydalidae, also known as dobsonflies. They belong to the subfamily Chauliodinae, commonly known as fishflies. Native to the Aotearoa New Zealand, these curious critters boast quite a unique life cycle. They are true masters of metamorphosis, transforming from adorable alien-looking aquatic larvae into fierce flying adults.

During their larval stage, toe-biters spend their youth lounging in some of the cleanest streams New Zealand has to offer. Imagine spending up to seven years of your life in the luxury of clear, pristine waters - no mortgage, no 9-to-5 job, just hanging out in a personal aquatic paradise, and eating your worries away. This larval stage, of course, has the sole purpose of gathering as much energy as possible to, then, emerge as adults and reproduce. Can you blame them for taking their sweet time to grow up? But let's not judge them too harshly for their leisurely lifestyle. After all, their presence in these healthy, unpolluted streams speaks volumes about the ecosystem's well-being. As sentinels of stream health, their mere presence is an indicator of clean water and thriving biodiversity. So, kudos to the toe-biters for taking their roles seriously in keeping the environment spick and span!

Picture this: one fine day, after years of underwater revelry, our larval hero feels a calling - a sudden desire to venture into the wide blue yonder. And how do they do that, you ask? They cocoon themselves and undergo a transformation so mind-boggling that it puts even the most magical of fairy tales to shame. Emerging from their cocoon like superheroes from a phone booth, the adult toe-biters take to the skies with their majestic wings. But here's the punchline - their primary goal as adults is to find love. Yes, you heard that right! These rugged aerialists with massive, lacy wings are out there looking for a partner to share their lives with. To be honest, there is not much else they could do, since they don't have a functional gut as adults. Love is in the air, folks, and the toe-biters are here to remind us that even in the insect kingdom, it's all about finding that special someone.

Before we wrap up this delightful encounter with the toe-biter, let's take a moment to appreciate the comedic timing of nature. The females possess a not-so-secret weapon in the form of their elongated, piercing mouthparts. Picture a tiny swordfish concealed within their delicate bodies. These mouthparts, while intimidating, are mainly used for defending themselves, and let's be honest, for fending off unwelcome suitors. Can't blame them; everyone deserves a little personal space, am I right?

As our adventure with the toe-biter comes to a close, I can't help but marvel at the wonders of nature. Who would have thought that such a quirky and charming creature would play such a crucial role in ecosystem health? From their leisurely larval days to their aerial escapades in search of love, the toe-biters have woven a captivating tale that intertwines with the very fabric of the environment they call home. In the grand tapestry of life, each thread - from the mighty toe-biter to the tiniest macroinvertebrate - weaves together a tale of interconnectedness and harmony. So, let's raise our imaginary glasses to these unsung aquatic champions, applaud their resilience, and pledge to be guardians of their pristine habitats. After all, when it comes to preserving the wonders of nature, we're all in this together, savouring the laughter and marvelling at the grandeur of the great outdoors.

So next time you happen upon a clear, pristine stream in the heart of New Zealand, remember the toe-biter. Pause for a moment and reflect on the incredible journey of this fascinating critter - a symbol of nature's resilience, humour, and its uncanny ability to surprise us at every turn.

Until our next encounter, fellow adventurers, keep exploring, keep cherishing, and keep laughing at the whimsical wonders of the animal kingdom!

Freshwater expertise and training in NZ Universities: A snapshot of the landscape

Jenny Webster-Brown[1] and Holly Harris[2]

1. Our Land and Water National Science Challenge & former Professor of Water Resource Management at University of Canterbury & Lincoln University

2. Doctoral candidate in freshwater ecology, University of Canterbury

There have been some concerns raised recently about the "health" of freshwater-related teaching and expertise across our tertiary education system. The demand for freshwater expertise is still growing in commercial, regulatory and research sectors, but will we be able to meet that demand into the future? We are only too aware that many universities in Aotearoa are currently struggling to support their staff and teaching programmes, in the face of lower post-COVID student numbers and a raft of other financial pressures. At a time when a cohort of well-known, accomplished freshwater academics have recently retired, or are approach retirement, this is a critical time to check the state of freshwater teaching and research capacity in our university sector.

Membership of the NZ Freshwater Sciences Society (NZFSS) is very strong, but biased towards particular regions and their tertiary institutions. How does this reflect on our ability to understand and protect freshwater systems across the motu?

As a first step towards developing a better understanding of the landscape for freshwater research training, we surveyed official university websites, noting the number and type of freshwater courses being offered at postgraduate level and the academic staff listed with freshwater research interests. While this is clearly only a high-level analysis, it can provide a foundation for further investigation of whether there is adequate freshwater research capacity and training opportunities within our university sector.

ANALYSIS METHODS

We allowed for a range of freshwater interests and expertise, incorporating all areas of research that NZFSS typically seeks to represent. For example, we did not include courses and academics in engineering faculties, if the research interests were clearly confined to engineering applications. Such academics are typically represented by other societies. However, we did include papers and academics in all aspects of biophysical freshwater research, and in social science, law, indigenous studies and environmental management where there was an emphasis on freshwater systems.

While individual academics and their interests were identified from their university profiles on the website, they are not individually named in this article. Broad areas of expertise have been very generally identified as:

- "Biology" - including mainly ecology, but also microbiology, ecotoxiciology, biosecurity etc.
- "Physical & Chemical Sciences" - including mainly hydrology and water quality, but also biogeochemistry, climatology, aquatic chemistry etc.
- "Environment & Resource Management" - including social sciences, human geography, resource management and governance etc
- "Law and Indigenous studies" - including water law and water rights, including Māori water rights and perspectives on the management of wai within te taiao.

This is only a high-level insight into the specialist capabilities of staff at each university, not accounting for interdisciplinarity and cross-discipline alignments. The analysis is also highly dependent on the fields and research interests staff members have chosen to include on their staff profiles, and for some profiles this is limited to just a few words.

Postgraduate courses with a significant or entire focus on freshwater systems were also identified from university websites advertising course availability to prospective students. Only courses currently or recently offered (from 2022 on) have been considered here. Courses incorporating freshwater training may have been missed if their descriptions were brief and/or did not emphasis this component.

ACADEMIC STAFF WITH FRESHWATER RESEARCH INTERESTS

An indication of the number of academic staff with freshwater research expertise, at each of the universities of Aotearoa, is shown in Figure 1. Canterbury and Waikato Universities appear to have the greatest capacity for research pertaining to freshwater systems. This is consistent with our experience as a society, with students and academics from these institutions being the largest cohorts at NZFSS conferences. Otago and Auckland, our largest university, have a significant freshwater research capacity, while Massey and Victoria have only half as many academic staff in the freshwater space. Of these universities, only Massey and Otago are generally well represented in the society.

Notably when normalised for the size of each university (measured as student FTEs), Waikato has the greatest number of freshwater

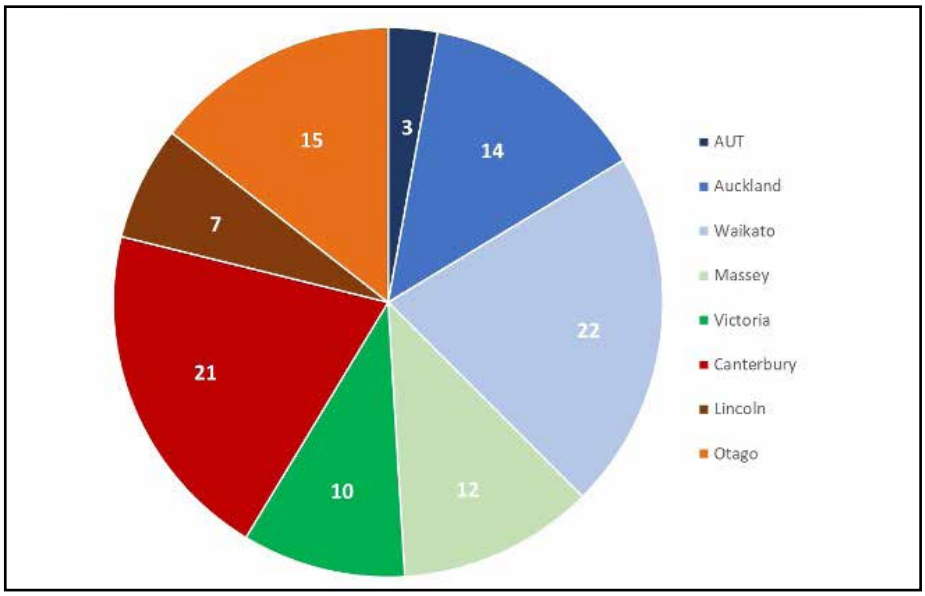


Figure 1: The number of academic staff with significant freshwater research interests inlcuded in their staff profile on their institutional websites, for each of our universities in Aotearoa.

academic staff per FTE, followed by Canterbury, Lincoln and Massey. Victoria, Auckland and AUT have the fewest freshwater academic staff per FTE. None of AUT's 60 research institutes and centres appear to have freshwater focus, with their biological science offerings tending to marine science or general environmental science. Lincoln University has relatively high level of freshwater expertise, at least partially due to the fact that three of its freshwater academic staff are shared with Canterbury as part of the joint Waterways Centre.

Looking deeper into the nature of academic staff research interests (Figure 2), it is evident that all of the universities have expertise in freshwater bioscience, and this is principally in freshwater ecology. This is strongest at Canterbury, Waikato and Auckland. There is also strong expertise in other freshwater sciences, principally hydrology and chemistry/water quality, at Waikato, Canterbury and Otago and, to a lesser degree, at Massey and Lincoln.

Expertise in environmental management is greatest in Canterbury, Auckland and Victoria where there are combined schools of geography, earth and environmental studies. Expertise in law and indigenous rights and perspective appears strongest at universities of Te Ika a Māui – principally at Waikato, followed by Auckland and Victoria.

POSTGRADUATE COURSES

The availability of postgraduate freshwater-focussed courses is key to ensuring that research-capable graduates are emerging from our tertiary system. Having academic staff with the expertise but no avenue to train student in the core methodologies and approaches required for freshwater research, too often means that students are unable to undertake the research that they, and their supervisors, feel is most useful.

The three universities of Te Waipounamu currently provide more postgraduate courses than the four universities of Te Ika ā Māui. Canterbury is particularly well served, due to the presence of both the interdisciplinary Waterways Centre, which offers NZ's only Water Resource Management postgraduate qualifications (jointly with Lincoln), and the strong Freshwater Ecology Research Group in the School of Biology. Auckland, Waikato and Massey, offer 3-4

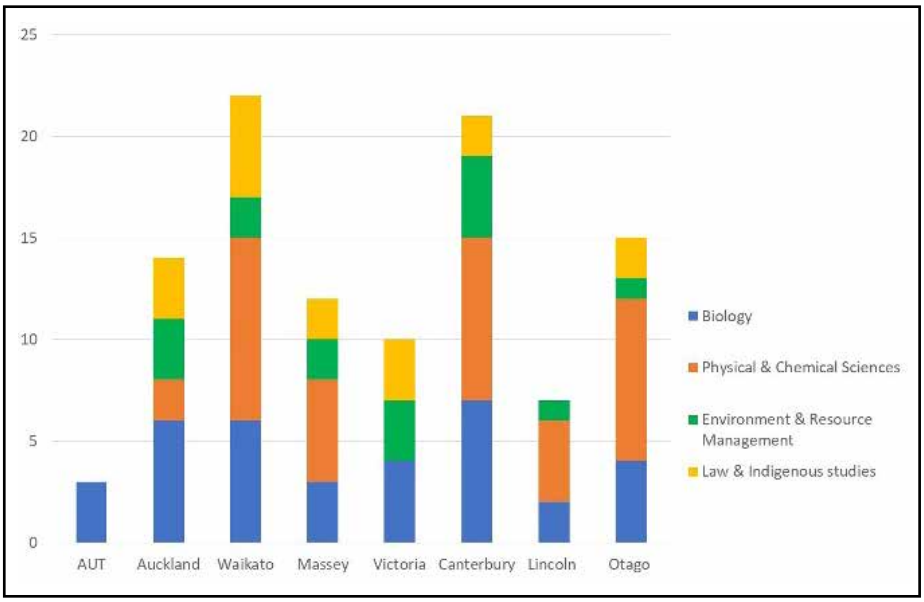


Figure 2: Broad affiliations for the freshwater research of academic staff at each university in Aotearoa. Vertical axis = number of staff with each affiliation.

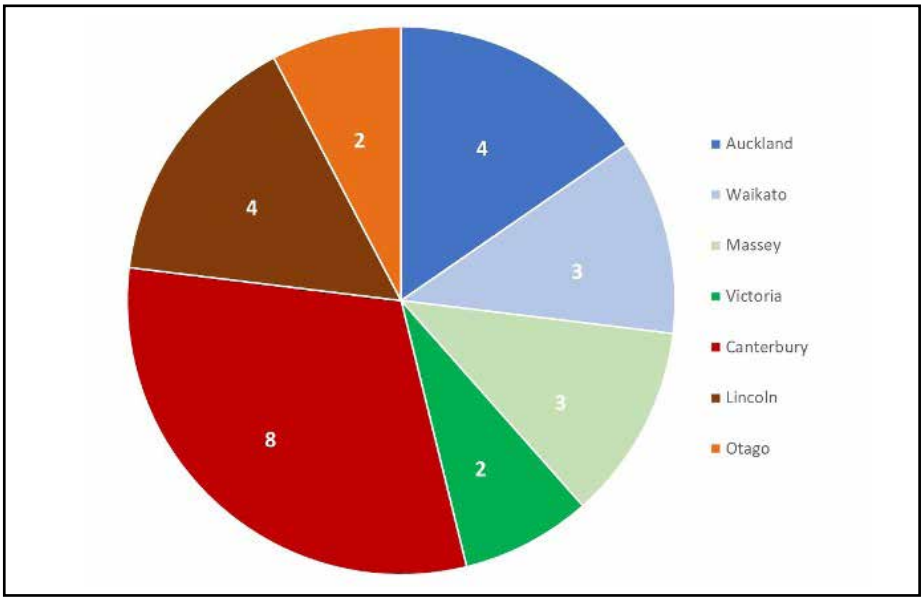


Figure 3: Postgraduate courses currently offered at each university, based on institutional website information for students.

courses each, mainly across the fields of ecology, hydrology and resource management. AUT appear to have been offering a single freshwater ecology course until recently.

INITIAL CONCLUSIONS

Based entirely on website information, augmented to an uneven degree by the authors' own knowledge, this is by no means an in-depth analysis of the state of freshwater research and training across the universities of Aotearoa. It does, however, provide an initial assessment of potential strengths and weaknesses developing within our tertiary education system, when it comes to training the next generation of freshwater researchers and practitioners.

The following observations are offered for further consideration:

- There are over 100 academic staff engaged in some type of freshwater research in the universities of Aotearoa
- A range of freshwater-relevant research is being undertaken at all of our universities, but Waikato and Canterbury have the strongest cohorts of active academic staff. These are also the universities who have the highest profiles within NZFSS.
- By comparison, Otago, Auckland, Massey and Victoria have fewer (and similar) numbers of academic staff in freshwater-relevant fields. Of these, only Massey and Otago are currently strongly represented in NZFSS.
- Freshwater expertise appears to be still strong in the traditional areas of biological and physical/chemical sciences, particularly ecology, hydrology and water quality.
- Interdisciplinary research to support environmental management is strongest at those universities with interdisciplinary environment-focussed schools. Water law, water rights and governance, including Māori rights and interests in wai, are still emerging focus areas for most universities, with most progress at Waikato.
- Canterbury currently offers the most comprehensive suite of freshwater-related postgraduate courses (some are shared with Lincoln).
- Interestingly, the number of freshwater-related postgraduate courses at Waikato appears low, when compared to the relatively high number of Waikato academic staff with freshwater expertise. This may reflect the limitations of our methods, which relied heavily on course titles and brief website descriptions to identify freshwater content, or it may reflect a different teaching emphasis at this university.

We suggest that further analysis could build a more accurate picture of the state of "health" of freshwater-related teaching and expertise across our tertiary education system, through interviews of academic staff and more informed assessment of postgraduate course content. Furthermore, undergraduate courses may need to be investigated to understand whether base freshwater skills are being taught at an earlier stage.

Once greater confidence has been gained about the landscape, this could provide a foundation for assessing whether the current level of expertise and training available in our universities is appropriate, and in appropriate areas, to support the ongoing effective management and protection of our freshwater systems.

For example, the apparently low numbers of courses including freshwater-related aspects of law and indigenous studies would tend to suggest that growth in this area should be supported. There is certainly a growing demand for individuals skilled in mātauranga Māori, law and governance research, as well as interdisciplinarity, in all aspects of freshwater research and management. Self-reflection would suggest that NZFSS membership mirrors this bias towards the more traditional freshwater sciences. What can we do as a society to bolster these areas of freshwater research

REFERENCES

Academic staff profiles and descriptions of available postgraduate courses were taken from the official websites of the 8 universities of Aotearoa referenced in this article. The websites were consulted between 3 July and 13 July, 2023.

University of Canterbury

New staff or students

Naomi Heller (PhD), Saskia Brown (MSc), Christina McCabe (MSc), Zoe Hamilton (Research assistant), Tadeu Siqueira (Senior Lecturer)

Organisation update

Tadeu Siqueira arrived from Brazil in November last year and we are pleased to have him finally here and part of the team. Chanell Thoms successfully defended her PhD thesis, Issie Barrett continues her connection with FERG and has joined Waterways as a Lecturer, and Jono Tonkin is now an Associate Professor; we'd like to say a huge congratulations to all three. Helen Warburton and Anne McLeod have also now moved into Research Fellow positions. Angus McIntosh has finished a 6-month sabbatical and has been working on some amazing freshwater photography and field research. Very significantly Linda Morris will retire in June 2023, after more than 35 years at the University of Canterbury and at least 20 years in FERG as our technician. Linda has shepherded countless postgraduate students through their degrees, organized a huge number of field courses, and generally prevented the academics from running amuck. Her behind-the-scenes contributions have been immense, and she'll be missed by all the collective FERG whānau, both past and present.

This past year has included fieldwork at all times of the year- some in very cold conditions! Group focus is currently centered around dynamic systems and dynamic biotic interactions and both these areas have projects underway using a variety of methods and freshwater systems across the South Island. The FERG teaching staff been working particularly hard to maintain contact and engagement, and are now facing a new challenge in the record number of students enrolled in the 300-level freshwater ecosystems course.

Feature projects

Retired but, actually, not so much:
Jon Harding (Emeritus Professor) although retired, is still chipping away at a few projects. Jon has been producing freshwater videos on YouTube with the aim of providing sources of freshwater ecology information for students and interested public. Jon has also become involved in the Styx Living Laboratory Trust. The Styx River is the third largest river in Christchurch City and has some interesting challenges. In the past Jon has been skeptical about the use of eDNA, but he has been conducting longitudinal sampling of the Styx and finding some interesting results. One of which was the detection of long-tail bat DNA at one site.

High country Potamopyrgus – invasive macrophyte facilitation cascade experiment
Non-native emergent macrophytes are becoming increasingly common in waterways across New Zealand, however it is unclear which species can take advantage of the macrophyte habitat. Zoe Hamilton, Saskia Brown, and Dr Helen Warburton wanted to test if macrophytes promote changes in macroinvertebrate community composition.

Using a mesocosm experiment, we investigated if the invasive macrophyte, monkey musk (Erythranthe guttata), preferentially facilitated Potamopyrgus snails over sensitive species including mayflies and caddisflies.

Interactive effects of non-native fish and environmental conditions on galaxiid demography
Naomi Heller is a new PhD student in FERG supervised by Prof Angus McIntosh and Dr Jono Tonkin. Her project is a part of the "predicting future freshwater fish outcomes" theme of Fish Futures and aims to improve our understanding of the mechanisms in trout-non-migratory galaxiid (NMG)-interactions. Focusing on effects on NMG demography, she will investigate the mechanisms facilitating the persistence of NMG in the presence of trout. Mechanistic understanding of these interactions could then be used to predict future interactions under a range of environmental conditions, including those under climate change.

Freshwater biodiversity in determining the ecological state of freshwater ecosystems in the Pacific Islands Countries is minimal, particularly in Vanuatu.

Little has been known about the Vanuatu macroinvertebrate, which makes this research exciting. Michael Maniel (MSc) is investigating the interaction between the benthic invertebrates like the Mayflies, Stoneflies and Caddisflies with the land-use changes along the longitudinal gradient of streams on Banks Peninsula. These serve as excellent biological indicators for determining the ecological health of freshwater biodiversity which he aims to put together with all the information on the Vanuatu fauna, particularly the freshwater biodiversity, to provide recommendations for a biomonitoring plan in Vanuatu.

Interventions benefitting non-migratory galaxiids in the South Island of Aotearoa New Zealand

Natural and engineered barriers may protect endemic NMG populations from introduced sports fish (trout). Known as isolation management, this intervention is the principal mechanism currently securing vulnerable populations. Knowledge gaps around using isolation management effectively include population viability and habitat requirements for NMG and the feasibility of trout removal from protected reaches. Martha Jolly is investigating these knowledge gaps through her PhD. It is hoped that by better understanding these interactions, reaches containing isolated populations can be extended to stream or catchment level in future restoration efforts.

'Stable-yet-disturbed': spatio-temporal biomass dynamics of a high-country braided river.

During the second half of her PhD Holly Harris is sampling invertebrates in different sites across the Cass River, Takapō, over the course of many months. This data, accompanied by some fish and bird data collected on larger time scales, will be used to study scales of biomass variation through time: from individual channels to whole river stability. While biomass in individual channels may fluctuate with flooding and disturbance, the wider river biomass could have reduced variation when aggregated at larger scales. This research aims to reframe the scales we consider when researching the impacts of disturbance on river systems.

Disturbance timing mediates trophic cascade strength in river ecosystems.

Anne McLeod (Postdoc) and Jack Anderson (Summer scholar) have been working on food web model with algal resource, shelled and non-shelled invertebrates, and brown trout and galaxiids. They are looking at how different levels of disturbance and different dispersal mechanisms affect trophic cascade strength.

Characterizing the drivers of macroinvertebrate responses to drying.

Elysia Harcombe (MSc) has been working with Dr Helen Warburton and Prof. Angus McIntosh to untangle the roles of abiotic drying stress, the history of drying, and the location of a perennial site. She found that macroinvertebrate responses were not solely due to abiotic drying stress, although this did play an important role. The drying history of a site pre-set macroinvertebrate species diversity, and the density of macroinvertebrates, which sometimes limited how much communities could respond to drying. Whether invertebrate densities increased or decreased in response to drying depended on how frequently drying historically occurred at the location. Additionally, proximity to a perennial site was enough to mask the effects of drying, as drifting invertebrates settled on the benthos to 'top up' species that would otherwise be lost. This research demonstrated that multiple important drivers must be considered when studying the effects of drying. This is also critical for management, as observed community responses to drying are unlikely to match future trajectories if drying intensifies.

Interacting effects of extreme floods and introduced trout on population dynamics of native non-migratory galaxiids

In New Zealand, native non-migratory galaxiid fishes face pressure from introduced trout through interspecific competition and predation. There is currently a lack of understanding around how galaxiid-trout relationships will change under future flow regimes. Following an extreme flood event in May 202, Rory Lennox (MSc) conducted a field survey which compared galaxiid population densities and individual growth along a gradient of flood magnitude across rivers supporting various abundances of trout to investigate how galaxiid populations have responded to the major flood disturbance and the role of trout in mediating those dynamics.

Kōkopu whitebait as biotransport vectors of marine nutrients
For the final chapter of Ben Crichton's PhD, he is using food wed analyses to evaluate the role of migratory kōkopu whitebait as biotransport vectors of marine nutrients in supporting freshwater fish food webs. Specifically, he found that the greater influx of kōkopu whitebait in protected streams act as an important marine-derived subsidy, enriching the diets of larger-bodied fish, including adult kōkopu. This research will detail the community-wide implications of whitebait fishing which are required to robustly evaluate fishery sustainability.

Can environmental DNA solve the braided river sampling conundrum to better inform management?
To overcome the logistical and technical challenges associated with broad and representative sampling of braided rivers Inge Martens has employed a new molecular sampling technique, environmental DNA (eDNA). She measured eDNA at multiple scales and used this data to first, investigate if eDNA can be used as a biomonitoring tool in braided rivers to assess biodiversity across broader, and second, evaluate how river heterogeneity affects biodiversity in braided rivers. She has found that eDNA can be a powerful biomonitoring tool alongside our traditional sampling methods, however, there are some limitations that must be addressed.

The role of seasonality: ecological communities in dynamic environments.
Daniel Hernández continues to work on his PhD focusing on ecological communities in fluctuating environments: the role of seasonality and predictability. He is in the thick of data collection for a global synthesis project that he is leading and continues to work on a large review on seasonality.

Fish-flow response guilds in a changing flow regime
Nacho Reyes is researching how Climate Change will impact freshwater fish in New Zealand for his PhD. He is investigating how freshwater fish species relate

Below-left: Participants in the mesocosm experiments hard at work. Photo: Zoe Hamilton.

Below-right: Frozen channels on the Cass River, Takapō. Photo: Holly Harris.

to flow regimes in New Zealand. By understanding their flow distributions, he intends to characterize how New Zealand's fish group in response to flow - termed fish-flow response guilds. These guilds will be a useful first step to overcome data challenges that preclude the development of mechanistic models which are a powerful tool to forecasting species' reaction to Climate Change.

RESEARCH ACROSS CONTINENTS

PI update: Tadeu Siqueira

Tadeu Siqueira is busy on two main projects, with several students and collaborators back in Brazil. These projects are funded by Fapesp (Brazil) and NSF (USA). The first project aims to understand how unpredictable environmental change and dispersal regimes affect freshwater metacommunities. They carried out a manipulative experiment in aquatic mesocosms, in which replicated metacommunities were exposed to unpredictable environmental change and different dispersal regimes. The dynamics of local communities and metacommunities will be analyze through an integrative approach that considers taxonomic composition (e.g., alpha, beta and gamma diversity), emergent properties of food webs (e.g., modularity and nesting) and medium-term responses via production of dormancy stages. Tadeu has also been working on a project with collaborators in Brazil and the USA to understand how stream ecosystems respond to global change by examining three elements: 1) how stream networks affect ecosystem function; 2) how community size influences population dynamics; and 3) how these factors interact under future climate scenarios.

RESEARCH PROJECTS ACROSS FRESHWATER REALMS

PI update: Angus McIntosh

The 2022 highlight for Angus McIntosh was spending the second semester on study leave, which meant he got to spend much more time in the field - a welcome change. He is currently working on three main research projects involving: (1) predicting future assemblages of native and non-native fish as part of the Fish Futures research program, (2) investigations of braided river ecology, (3) and the role of biotic interactions in stream restoration. Angus and Jon Harding are also working on an illustrated book project.

COMMUNITY ECOLOGY, THEORY, AND FORECASTING

PI update: Jono Tonkin

Jono Tonkin's time mostly comprises working with his group of Postdoctoral Fellows and Postgraduate students, many of which are discussed here. Beyond these freshwater flavoured projects, his group is working on a range of topics including Antarctic species distributions, host-parasitoid coevolution, global crop-pest coevolution, multilayer interaction networks of plant-bacteria-fungal communities, and marine intertidal community dynamics. Outside of his group's work he has been involved in several working group projects including the Dry Rivers RCN in the USA and the Theory Group of the Ecological Forecasting Initiative. He continues to work with his close collaborators on topics focused on forecasting community dynamics and issues related to hydroclimatic extremes.

Recent publications

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University of Waikato

Freshwater ecology teaching and research continues to be a strong component of the science curriculum at the University of Waikato. Under the supervision of Frank Burdon, MSc student Brooklyn Lea is using functional traits of macroinvertebrates to investigate land-use impacts on streams flowing into Te Awanui / Tauranga Harbour. MSc student Shana Edgecombe continues her research on weaving cultural values with environmental DNA and conventional stream biomonitoring in the Kuratau River catchment entering Lake Taupō (co-supervised by Deniz Özkundakci and Mike Pingram, WRC). Brooklyn and Shana have funding from the Department of Conservation (DOC) and Shana has received support from Wilderlab. In collaboration with Kerry Bodmin, Nigel Binks, and Dave West from DOC and Shaun Wilkinson (Wilderlab), MSc student Ashton Reiser is investigating different eDNA sampling methods to detect non-native fish species in freshwater ecosystems. As part of his MSc research, Ashton was able to borrow a Cruising Speed Net sampler from Xavier Pochon (Cawthron Institute) and deploy this method of eDNA collection in Lake Puketirini with boating support from Adam Daniels (Fish & Game). Frank is continuing his own research on stream ecosystems using new methods (eDNA, fatty acid biomarkers) alongside conventional approaches (benthic macroinvertebrate sampling, decomposition assays) to investigate questions focused on community ecology, biomonitoring, and stream restoration.

Ian Duggan has been busy supervising a horde of MSc students recently. Gaby Marshall has recently graduated, with her thesis focussing on the effects of marine intrusions on zooplankton in small ponds in the Auckland region. Kelly Jamieson examined zooplankton diapausing eggs in waterfowl faecal droppings at Lake Rotoroa (Hamilton) and Lake Rotorua, to determine their importance as a transport vector. Flavian Ember, co-supervised by Nick Ling, has submitted his thesis on competition between mosquitofish and common bullies for zooplankton, and their effects on zooplankton community composition using both a stable isotope and a mesocosm approach. Amber Taylor is soon to submit her thesis on long-term changes in zooplankton communities in North Island lakes. Current student Charmaine Eludo is plugging a gap in the knowledge of Waikato River zooplankton ecology by examining changes in community composition along the river estuary. On another tangent completely, Ethan Renner is investigating the diversity of monogenean parasites in New Zealand freshwater fishes, focussing on those that infect non-native species. PhD student Nico Donovan-Pereira (Te Arawa), co-supervised by Erica Williams (NIWA), is investigating how lake management decisions made by Te Arawa, and specifically by his hapū Tūhourangi, can be Mātauranga informed, and how western science can be utilised for the benefit of the Tūhourangi hapū.

Supervised by Ang McGaughran, PhD student Vanessa Barbosa (co-supervised by Ian Hogg, Polar Canada, University of Waikato adjunct and Elizabeth Graham, NIWA) recently graduated. Vanessa's research focused on dispersal and connectivity of stream insect populations in fragmented landscapes, combining DNA sequencing with spatial data analysis to assess the population genetic structure of stream insects in the North Island. MSc student Nicola Pyper is comparing eDNA with traditional netting for the invasive pest, the brown bullhead catfish. Nicola's research is partially supported by the Department of Conservation, who are keen to optimise eDNA for catfish monitoring. MSc student Starsha Bird is also optimising eDNA methods for ongoing monitoring work with support from the Waikato Regional Council and Waikato River Authority. Starsha is looking at eDNA in wetlands to determine the best filtering method and to understand the residence time, and spatial and temporal variability of eDNA in the wetland environment. Both Nicola and Starsha have also received Lilian Valder Conservation Grants and benefit from ongoing collaboration with Wilderlab.

Deniz Özkundakci continues to work with Mortiz Lehmann (Xerra Earth Observation), Chris McBride (Limnotrack), and Mat Allan (Waikato Regional

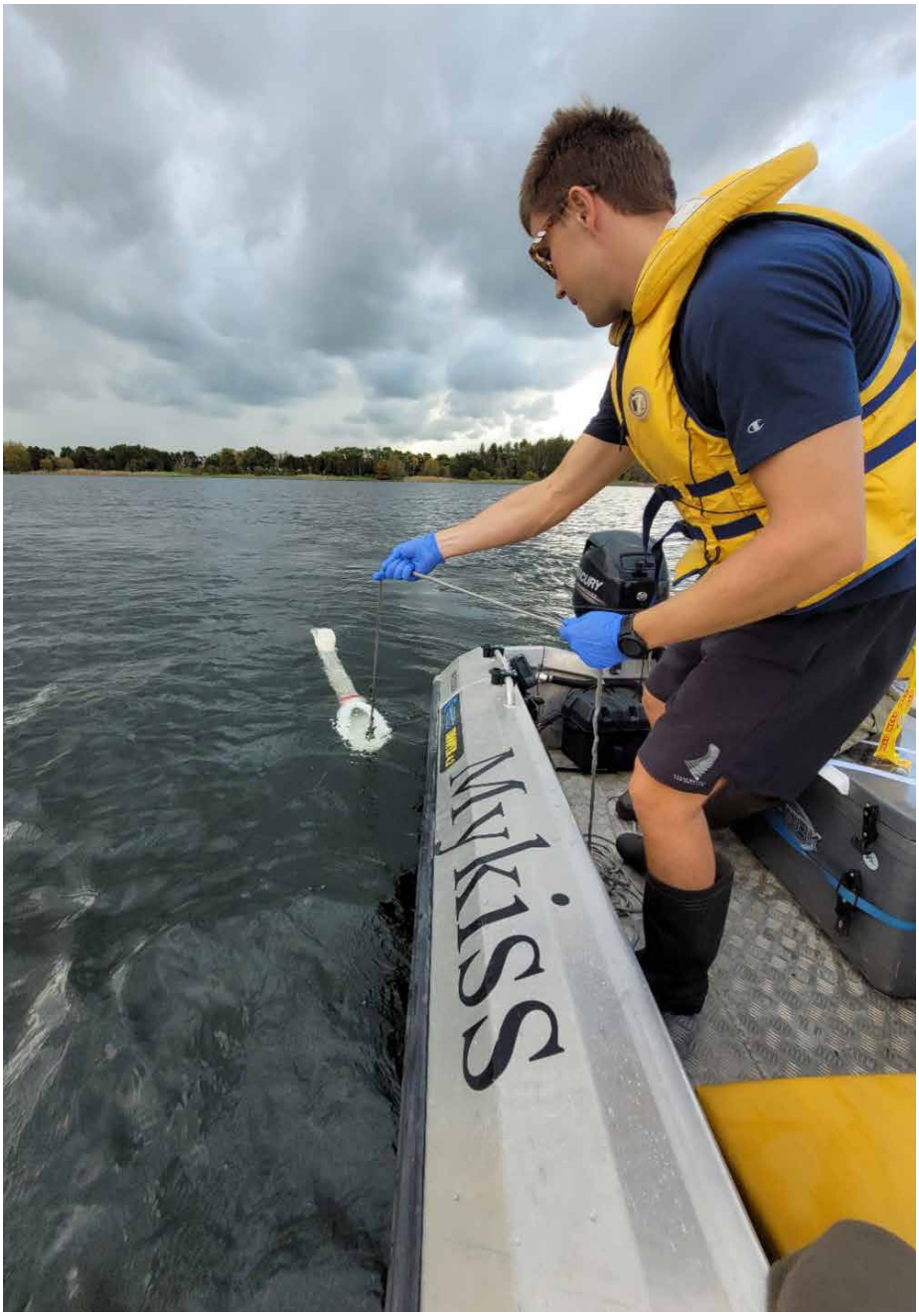

Photo: University of Waikato MSc student Ashton Reiser using a Cruising Speed Net sampler on loan from Xavier Pochon (Cawthron Institute) to collect eDNA samples from Lake Puketirini. Photo credit: Kerry Bodmin (DOC)

Council) on developing a national scale lake ecosystem modelling platform. Tadhg Moore has recently joined the modelling team remotely and will be moving to New Zealand in September. Meti Yulianti has handed in her PhD thesis with the title 'Identifying control points of excessive nitrate load in a pastoral catchment to support lake management'. Meti has moved back home to Indonesia where she has taken up a role at the Research Center for Limnology and Water Resources. Iola Reis Lopes Da Rosa has started her PhD research in March (co-supervised by Grant Tempero). As part of her research, she will use a functional trait-based approach to study how climate change will affect phytoplankton communities. Matthew Prentice has started work on developing a three-dimensional coupled hydrodynamic-ecological model for Lake Rotoiti to investigate the effects of the Ōhau diversion wall on lake water quality. Hemanth Vundavilli is currently working on completing his work on a three-dimensional hydrodynamic model for Lake Tarawera to investigate the effects of the Coriolis force on circulation patterns in the lake. Grant Tempero and Sarah Tetzlaff are investigating the nutrient and contaminant transport from septic tanks at Lake Tarawera.

Recent publications

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Tawatahi River estuary, Waikato district.

NIWA

STAFF UPDATES

Principal Scientist – Freshwater Ecology Paul Champion has retired after 28 years' service to NIWA and 42 overall to research in botany, freshwater biosecurity, ecology and conservation in New Zealand. New recruitments: Thanh Dang, a water quality catchment modeller (catchment processes); Joeppette Hermosilla, an aquatic ecologist (algal services); Kane Clare, a freshwater ecology technician (aquatic plants), all are based at the Hamilton office. Early career researcher Grace Mitchell is the 2022-23 Sir Peter Blake Trust Ambassador for NIWA's Freshwater Science Centre and is working with the Aquatic Pollution Group, Hamilton.

KEY PROJECTS

Focus on ecocultural wastewater treatment systems

NIWA's Aquatic Pollution Group is midway through a five-year MBIE Endeavour Fund research programme to co-develop and mainstream a suite of innovative ecocultural wastewater treatment technologies for small rural and Māori communities. Many existing rural wastewater treatment systems are failing or do not provide effluent quality to achieve desired cultural and freshwater objectives, such as the objectives set out in the National Policy Statement for Freshwater Management. Conventional treatment upgrades are costly for small scale treatment systems and require specialist operators who are difficult to attract to rural towns. NIWA researchers are investigating options to transform wastewater into a resource by linking mātauranga Māori with scientific advances. The research includes trialling intensified multi-layered wetland filters, high-rate filamentous algae ponds, final effluent wetlands, accumulating volume sludge digestion ponds, and sludge treatment wetlands that convert wastewater sludge to soil. A co-development team guides the project's progress, working with marae, rural communities, industry and local government. The aim is to provide resilient, affordable, highly effective and culturally acceptable options to upgrade and operate rural wastewater treatment infrastructure, that is future-proofed for population rise and the impacts of climate change.

Staff involved: Rupert Craggs, Chris Tanner.

Output/s: https://niwa.co.nz/freshwater/freshwater-and-estuaries-update/freshwater-update-89-january-2023/using-algae-for-nutrient-pollution-mitigation

Barriers to freshwater fish migration

NIWA freshwater ecologist Paul Franklin led a team of researchers to conduct the first nationwide assessment of river fragmentation, looking for structures that can act as barriers to fish. The study determined nearly half of New Zealand's river network is partially or fully inaccessible to migratory fish. The barriers are often human-made and include dams, culverts, and weirs. New Zealand has some of the highest densities of barriers to fish passage in the world, with approximately 0.16 barriers/km. This works out at a minimum of 48% of the river network being at least partially inaccessible to migratory fish, and a further 36% that could be restricted but has not yet been assessed for risk to fish passage. Fragmentation of river systems is a key driver of freshwater biodiversity loss. New Zealand has more than 50 native fish species, with around 85% not existing anywhere else in the world. Many iconic fishes, such as eels and the whitebait species, migrate between the sea and rivers to complete their life cycle but often encounter structures. To address this challenge, NIWA is studying the swimming abilities of fish and coming up with solutions to help them migrate.

Researchers involved: Paul Franklin, Jane Robbins, Douglas Booker, Cindy Baker (NIWA); Sjaan Bowie (Department of Conservation); Julian Sykes (formerly NIWA, now Environment Canterbury) and Eleanor Gee, (formerly NIWA, now Waikato Regional Council).

Output/s: Franklin et al 2022 - A national fish passage barrier inventory for NZ.pdf
https://vimeo.com/niwanz/fishmigration

Project: **Focus on ecocultural wastewater treatment systems.** Multi-layered vertical flow constructed wetland treating wastewaters at the Te Kopua Whanau Campground. Photo: Chris Tanner/NIWA.

Project: **Barriers to freshwater fish migration.** Research continues into solutions to help fish migrate between the sea and rivers. Photo: Stuart Mackay/ NIWA.

Ecological impacts on freshwater insects from LED streetlight conversions

NIWA released the research findings of a four-year MBIE-funded Smart Idea project, investigating the ecological impact of modern LED street lighting on an integral component of our urban waterways, flying freshwater insects. A project team led by NIWA freshwater ecologist Michelle Greenwood investigated the influence that the conversion of traditional streetlights to LEDs had on attraction rates of flying freshwater insects. They also adapted a method for visualising city-scale streetlighting to quantify spatial patterns in lighting across Ōtautahi - Christchurch. By mapping city "lightscapes" and investigating changes in the behaviour of adult insects under different lighting scenarios, this research aimed to provide information that could assist in the design of ecologically sensitive streetlighting plans and help identify critical areas where alternative lighting solutions might be required. The researchers concluded that using lights that emit less blue light is likely to benefit certain groups of insects (particularly moths and caddisflies), with the magnitude of effect depending on the relative light intensity and colour spectrum of the lamps being replaced, and on the focal

taxa. Placing lights further from waterways or behind screens such as riparian plants, where possible, will also likely reduce the attraction of freshwater insect to streetlights.

Researchers involved: Michelle Greenwood, Kristy Hogsden, Amy Whitehead and Brian Smith (NIWA); University of Canterbury PhD student, Jessica Schofield; University of Exeter; Waka Kotahi; Connections.

Output: Investigating ecological impacts on freshwater insects from LED streetlight conversions | NIWA

Making community-based freshwater monitoring data count

A national quality assurance (QA) framework for community-based monitoring (CBM) initiatives is nearing completion. Led by Juliet Milne and focused on stream health, the framework seeks to unlock the value of CBM by ensuring that the data collected are of a known quality and 'fit for purpose'. Over 25 variables spanning physical, chemical and microbiological water quality, aquatic life, physical habitat and hydrology are included in the framework. Two ArcGIS Survey123 electronic field form templates have been developed with built-in, automated calculations and quality checks to support efficient capture of stream health measurements and site visit metadata. Early versions of these forms have been trialled with CBM support organisations and several catchment groups in Wairarapa. The QA framework, which also includes an electronic monitoring plan template and guidance documents, has been funded through an MBIE Envirolink Tool grant. Championed by Greater Wellington Regional Council, on behalf of all regional councils, the tool project involves partnerships with a wide range of government and non-government organisations, including Mountains to Sea Community Trust, Hill Laboratories and EOS Ecology.

NIWA staff involved: Juliet Milne (primary contact) and others.

Principles of effective riparian buffer design

Scientists in NIWA's Mitigation Systems Programme, led by Fleur Matheson, aim to provide effective tools to enable landowners to manage contaminant losses and reduce the impacts of land use on aquatic environments.

Project: **Ecological impacts on freshwater insects from LED streetlight conversions.** Insects were captured on sticky sample sheets around different types of lights near waterways to inform research on the impact of new LED street lighting on flying freshwater insects. Photo: Brian Smith/NIWA

The programme is leading the development, testing, and design of several effective mitigation systems, and assisting with their implementation and ongoing performance assessment.

Programme researchers recently released NIWA's Riparian Buffer Design Guide which complements the Effective Mitigation Systems video and case study released in 2022. The Riparian Buffer Design Guide discusses design principles and provides high-level information about the likely performance of riparian buffers.

The information in the guide is based on NIWA's "Preliminary riparian buffer guidelines. Filtering surface runoff and nitrate removal from subsurface flow" (McKergow et al. 2020b), which was developed following a review of New Zealand and international performance data (McKergow et al. 2020a).

The Riparian Buffer Design Guide shows how riparian buffers may be used to reduce the inputs of suspended sediment (SS), nitrogen (N) and phosphorus (P) from agricultural lands to surface and groundwater (principally on dairy farms) under pasture, and during pasture renewal and cropping.

It does not address the use of plantings to reduce stream bank or channel erosion, and is not applicable to situations where runoff from irrigated pasture, feed pads or areas subject to farm dairy effluent application occurs.

The information supplied will assist farmers, farm advisors, rural contractors, and regional council staff to appropriately size, design, construct and maintain effective riparian buffer zones designed to deliver positive water quality outcomes.

Staff involved: Lucy McKergow, Fleur Matheson, Brandon Goeller, Ben Woodward.

Outputs: Riparian Guidelines.indd (niwa.co.nz)
https://vimeo.com/manage/videos/685304857/388a90f569

Better outcomes for downstream water quality

NIWA researchers recently completed a project which aims to prove the performance of constructed wetlands on New Zealand farms.

A suite of six new constructed wetlands were built on farms around the country as part of a four-year,

Project: **Principles of effective riparian buffer design.** Aquatic biogeochemist Fleur Matheson, who leads NIWA's Mitigation Systems programme. Photo: Lana Young/NIWA.

$1.95 million project funded by the Ministry of Primary Industries. Instrumentation has been installed to monitor performance of the wetlands, and analysis of flow and water quality data for the first year of operation of the existing three wetlands has been compiled and quality checked.

The project is led by a NIWA riparian and wetland scientist Brandon Goeller (Nelson) and principal scientist – aquatic pollution, Chris Tanner (Hamilton), supported by NIWA staff from around the country.

NIWA is working with five regional councils (Tasman, Taranaki, Hawke's Bay, Bay of Plenty and Environment Canterbury) and landowners in each region to design constructed wetlands for each unique environment. The regional councils have funded the construction of the wetlands and are co-funding and assisting with monitoring. Water quality data gathered from the sites aims to demonstrate the ability of constructed wetlands to reduce losses of nutrients, suspended solids and faecal microbes from farmland to waterways.

DairyNZ and Beef+Lamb New Zealand are also partnering with NIWA and the councils to demonstrate the capability of wetlands to their members and networks. The constructed wetlands receive a mixture of surface run-off, ground water and tile drainage from agricultural catchments.

A standardised monitoring programme has been set up for each wetland. Flows in and out of the wetland are continuously monitored. Flow, turbidity and nitrate-N are continuously monitored in the inflow and outflow from the wetlands.

Grab water samples are collected from the inflow and outflow using automatic samplers over a range of flow conditions assessed for a wider range of contaminants. Comparisons of water quality in inlet and outlet samples will help researchers quantify the performance of each wetland over 2-3 years.

Some of the constructed wetlands are at remote locations, so significant investment has been made in equipment for automated and telemetered sampling, alongside regular grab sampling by regional council staff.

Next steps involve calculating the mass loads of contaminants entering and leaving the wetlands.

Comparison of inflow and outflow loads over

Project: **Better outcomes for downstream water quality.** Brandon Goeller taking a water sample at the inlet of a constructed wetland built on a kiwifruit orchard owned by Baygold in the Bay of Plenty. Photo: Rebekah Parsons-King/NIWA.

appropriate periods of time allows mass load reduction and attenuation rates for nitrogen, phosphorus, sediment and E.coli to be estimated. Project researchers will work with councils to see how these data can be used in tools and models to manage nutrient losses from agricultural land to achieve improved water quality outcomes.

Staff involved: Brandon Goeller, Chris Tanner, Lucy Mckergow.

Output: Constructed wetland guidelines | NIWA

Updating a plan to restore Lake Hayes

A NIWA study has helped secure funding to restore the water quality of Lake Hayes in the Wakatipu Basin in Central Otago.

NIWA researchers Brandon Goeller, James Sukias and Andrew Hughes were commissioned by the Friends of Lake Hayes to investigate nutrient hot spots around the lake's catchment. The results of their research were used by Friends of Lake Hayes in a successful application for funding from the Government's Jobs for Nature programme. The catchment group was awarded $4.45 million in September 2021, which will resource the group to implement several of the options NIWA researchers recommended.

There have been many studies aimed at improving the water quality of Lake Hayes, but the NIWA study, in September 2019, was one of the first to focus on hot spots around the catchment where water quality and riparian management could be improved to reduce nutrient and sediment loads to the lake.

Various scientists and PhD students have looked at options to mitigate the effects of nutrients and sediment in the lake but rehabilitation requires looking at the catchment as a whole, focusing on all the tributaries and their specific contributions to lake water quality issues.

The study had a strong focus on Mill Creek as it provides most of the water flow into Lake Hayes. The researchers reviewed catchment data collected by Otago Regional Council and other authorities dating as far back as 1969. They visited 16 locations in the 60 km2 catchment to identify sources of nutrients and sediments.

The study suggested that restoration of existing natural wetlands to improve sediment trapping and

Project: **Updating a plan to restore Lake Hayes.** Upper reaches of Mill Creek where re-instating wetland hydrology and vegetation could improve sediment and nutrient capture and enhance biodiversity. Photo: NIWA.

nutrient removal was likely to be the best option in terms of cost and restoring water quality of the lake over time.

Other actions likely to improve the quality of water in Mill Creek are, excluding livestock from riparian areas to reduce erosion and reduce the potential for faecal pollution and riparian planting along stream margins to enhance water quality benefits and biodiversity values.

Implementing the recommendations of the 2019 study had the potential to deliver a range of excellent environmental outcomes for the Lake Hayes catchment, including restoring native trees in the landscape and improving habitat for native birds, bats, and insects.

Riparian planting will also reduce stream water temperatures through shading, and cooler temperatures will be beneficial for fish and aquatic invertebrates. The research was funded by Otago Regional Council, Queenstown Lakes District Council and the Department of Conservation.

Staff involved: Brandon Goeller, James Sukias, Andrew Hughes.

Output: Goeller, B., Sukias, J., & Hughes, A. (2020). Scoping of diffuse pollution mitigation options for Mill Creek (No. 2020009HN; p. 71). NIWA National Institute of Water & Atmospheric Research.

Optimising aquatic alligator weed management

Alligator weed (Alternanthera philoxeroides) is an aggressive invader of aquatic, semi-aquatic and terrestrial environments. Floating mats of alligator weed can exclude native plant species, degrade water quality, and restrict water flow.

Alligator weed was introduced to Northland, New Zealand in the 1880s-1900s, and is now well established in the region and further south to the Waikato. More recent infestations have been recorded in Taranaki, Manawatu and Bay of Plenty regions.

Alligator weed is actively managed in the Waikato and further south in New Zealand with goals of either eradication or progressive containment to minimise its spread and impacts. However, alligator weed is difficult to control using existing methods. New infestations of alligator weed can be physically removed if they are detected early, when the infested area is small.

Herbicides are the most effective control tools in cases where alligator weed extends across large areas, or when site access is hazardous for physical weed removal.

The herbicides available to use over water in New Zealand are limited and provide sub-optimal levels of control of alligator weed with single applications. The research NIWA is doing in collaboration with Waikato Regional Council and Mississippi State University is focused on identifying the best herbicide tools available and developing use profiles (rates and frequencies of application) that minimise herbicide use and associated costs, whilst providing effective weed control, which will in turn minimise the further spread of alligator weed in New Zealand.

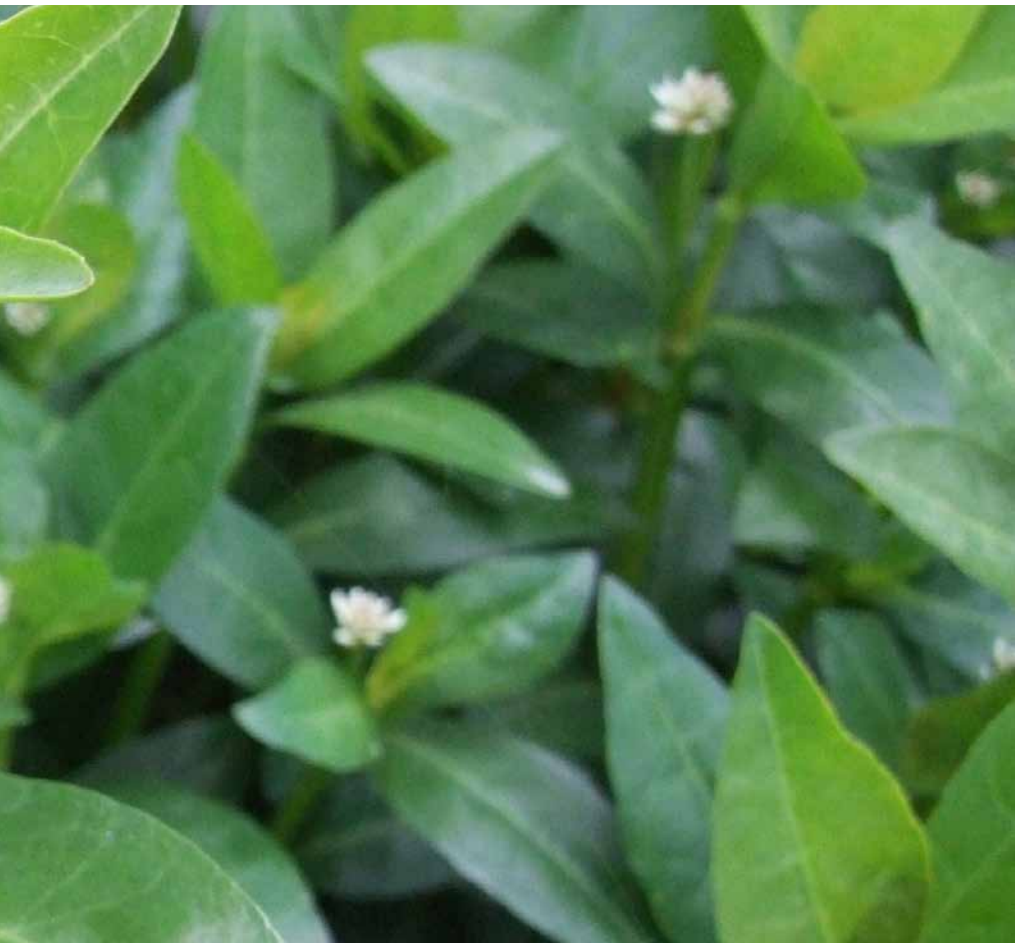
Potential options include combining herbicide treatments and repeating herbicide treatments at short intervals. The herbicides evaluated included glyphosate, metsulfuron, and triclopyr.

Our research team has conducted field trials in New Zealand (NIWA, WRC) and the US (MSU) to evaluate the effectiveness of herbicide combinations and repeated treatments for alligator weed control. The New Zealand field trial was carried out in 2020 at Te Otamanui Lagoon, Te Kowhai, in the Waikato region. Five different herbicide control options were tested on 20 x 20 m replicated plots.

The NIWA team is also running laboratory trials to evaluate the impact of herbicide treatments on the production of viable alligator weed stem fragments following treatment.

Staff involved: NIWA Freshwater Biosecurity Team: Daniel Clements, Paul Champion, Deborah Hofstra, Inigo Zabarte-Maeztu, Aleki Taumoepeau, Svenja David, Louis Skovsholt and Denise Rendle; Waikato Regional Council Biosecurity Staff: Ben Elliot, Frances McKinnon, Chris Hale and Darion Embling; Mississippi State University: Gray Turnage; Contractor: Green Streams Limited (RMAX aerial and ground control).

Output: The results of the field trial were presented at The New Zealand Biosecurity Institute (NZBI) conferences: (i) NETS2022: Changing Landscapes - Christchurch (3 – 5 August 2022) and (ii) Lower North Island and Central Branch miniNETS - Tongariro (8 – 9 September 2022).



Project: **Optimising aquatic alligator weed management.** Research continues for options to manage Alternanthera philoxeroides – alligator weed. Photo: Daniel Clements/NIWA.

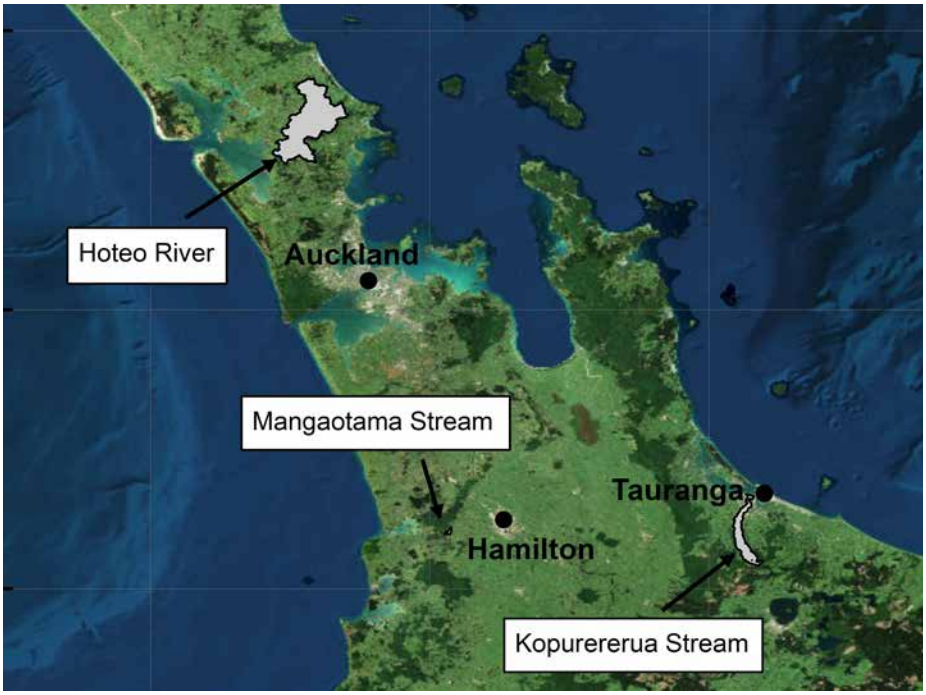
Fallout from nuclear testing helps reveal the importance of streambank erosion in New Zealand catchments

The obvious and sometimes dramatic nature of streambank erosion suggests that it may be a significant contributor of sediment to New Zealand rivers. Despite this, there have been very few attempts to determine the relative importance of streambank erosion as a source of sediment in New Zealand catchments.

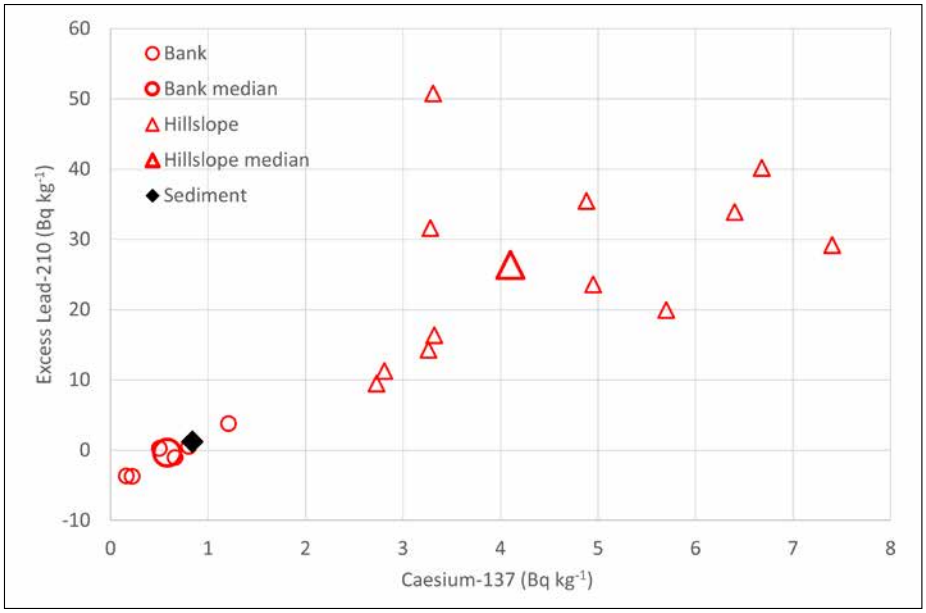
In this study we used a radionuclide-based sediment tracing approach to determine the importance of stream bank erosion within three catchments (Hoteo, Mangaotama and Kopurererua) in the upper North Island of New Zealand (Figure 1).

One of the radionuclides (caesium-137) used in this study was derived from fallout from atmospheric nuclear testing from the 1950s through to the 1970s. Fallout from nuclear testing deposited low levels of the radioactive isotope caesium-137 across the surface of the earth and this became strongly absorbed to sediment in the upper soil layers.

In effect the nuclear fallout marked the upper soil layers (top 10 cm) with caesium-137, while the underlying soil layers (deeper than 10 cm) remained devoid of caesium-137. This means that sediment



Project: **Fallout from nuclear testing helps reveal the importance of streambank erosion in New Zealand catchments.** Location of study catchments for the streambank erosion study. Photo: NIWA.



Project: **Fallout from nuclear testing helps reveal the importance of streambank erosion in New Zealand catchments.** A graph showing where sediment samples were captured for the streambank erosion study. Graph: NIWA.

eroded from surface layers (by hillslope sheetwash erosion) has higher concentrations of caesium-137 than that sediment which is derived from deeper layers (such as gully and streambank erosion). The same surface vs sub-surface disparity in the concentrations of other (naturally occurring) radionuclides (e.g., lead-210, radium-226 and radium-228) also exists and these were also utilised in this study.

Sediment samples were collected from both catchment sources (stream banks (red circles in Figure 2) and hillslopes (red triangles in Figure 2) and downstream stream locations. (black diamond in Figure 2). The source samples were used to characterise the radionuclide content of sediment derived from the two sources. The downstream samples represent the sediment that was eroded from the catchment and transported by the river. Our results showed that the radionuclide concentrations of the sediment being transported within all three study catchments was very similar to that which is derived from streambanks (Figure2).

A statistical mixing model was used to predict the relative contribution of sediment derived from streambank and hillslope. The mixing model predicted that over 90% of the sediment at the downstream locations within all three study catchments was derived from stream bank erosion.

The finding that streambank erosion sources is a significant source of sediment was supported by previous independent field-based assessments of bank erosion from within each catchment.

This is the first such study to quantify the relative contribution of streambank erosion to the sediment loads of New Zealand catchments. Further work is required to determine how the contribution of stream bank erosion may vary within and between catchments.

Information on the relative importance of different sediment sources is crucial if limited catchment rehabilitation resources are to be targeted to where they will have the most impact.

The data for this work came from three independent Strategic Science Investment Fund (SSIF) and commercial projects.

Staff involved: Andrew Hughes.

Output: A recent paper bringing the work together was funded by NIWA's subcontract to the Smarter Targeting of Erosion Control MBiE Endeavour Programme: Hughes AO, Huirama MK, Owens PN, Petticrew EL (2022). Stream bank erosion as a source of sediment within New Zealand catchments. New Zealand Journal of Marine and Freshwater Research 56(4): 632-655.

Department of Conservation

GENERAL UPDATE

DOC's freshwater work continues to build its profile after an internal organisational re-set resulting in more changes to DOC's freshwater management structure. The science and technical teams are led by Amber Bill, Director of Biodiversity System & Aquatic (which includes both freshwater and marine), with our Freshwater Ecosystems and Threats team managed by Nicki Atkinson, and Freshwater Species team managed by Emily Funnell. On the operational side, Sarah McRae is the Aquatic Delivery manager, responsible for managing the three national freshwater programmes: Ngā Awa River Restoration, Migratory Freshwater Species and Freshwater Biosecurity.

Within the freshwater technical teams, we farewelled Philippe Gerbeaux, who retired from DOC after over 30 years' service, and Tanya Vance, who returned to the United States. We have welcomed Ollie Wigmore (who retains a part time role with the Victoria University) and Amber Sinton (who we stole from NIWA). We farewelled some of our Operations freshwater staff (Dave Nathan and Susan Stoddart) and welcomed Milly Farquhar (River Ranger in Waipoua), Kim Wright (River Ranger in Hoteo/Mahurangi), and Freshwater Biosecurity/Migratory Fish Rangers Anita Pearson (Hamilton), Aroha Greenhalgh (Whanganui / Taumaranui), Matt Brady (Napier) and Anna Henderson (Picton).

Read on for an update about some of the things we've been up to across our freshwater programmes.

KEY PROJECTS

Ngā Awa river restoration programme – working together with our communities towards 14 healthy, thriving rivers from source to sea.

The fourth year of the Ngā Awa river restoration programme continued to see relationships with mana whenua at place strengthen.

We met as a DOC team in Wellington in early December 2022 to reconnect, celebrate progress across the programme and build our skills around facilitation and working with complexity and polarity. We included DOC's new Chief Science Advisor Mike Bunce along with Shaun Wilkinson from Wilderlab for an engaging panel discussion on the use of eDNA.

The programme is made up of a network of river rangers who coordinate and drive the work in their catchments: Milly Farquhar (Waipoua, currently on maternity leave), Maddy Jopling (Waihou and Doubtless Bay catchments), Kim Wright (Hoteo and Mahurangi), Jane Taylor (Whanganui), Steve Bielby (Waikanae), Heli Wade (Pelorus/Te Hoiere), Shay Dallow (Arahura), Brad Edwards (Rakitata and Waitaki) and Chris Kavasos (Taiari). We have recently engaged with Oraka Aparima Runaka to confirm our 14th river as the Waimatuku. A ranger has yet to be appointed for this river or for the Waikawa, but Pat Hoffman is helping out on a part-time secondment from the Living Water programme.

The programme continues to be coordinated by Rosemary Miller and supported with science advice from Sue Clearwater and technical advice from the wider DOC freshwater team. Crucial to the programme's success has been drawing on the science of engagement with communities led by Senior Engagement Advisor Maria Deutsch. Catchment-scale monitoring programmes are being initiated at several catchments with support from DOC's Monitoring and Implementation Support team. Elaine Wright is leading the freshwater monitoring programme, with Ashley Alberto and Amber Sinton providing freshwater technical input.

The programme's research is built around four themes: geomorphology, socio-economic, monitoring tools and climate change. Some of research supported this year includes:

- Digging deeper (literally) into the geomorphology of the Waikanae to explore options for allowing the river more space with Jon Tunnicliffe (University of Auckland).

- Exploring how to support landowners with complex landuse decisions with agricultural consultant Liz Dooley.
- Exploring the implications of climate change in the Taiari.
- Studying gravel complexity in the Rakitata with Justin Rogers (University of Canterbury).

https://www.doc.govt.nz/our-work/freshwater-restoration/nga-awa/

Migratory Freshwater Species programme

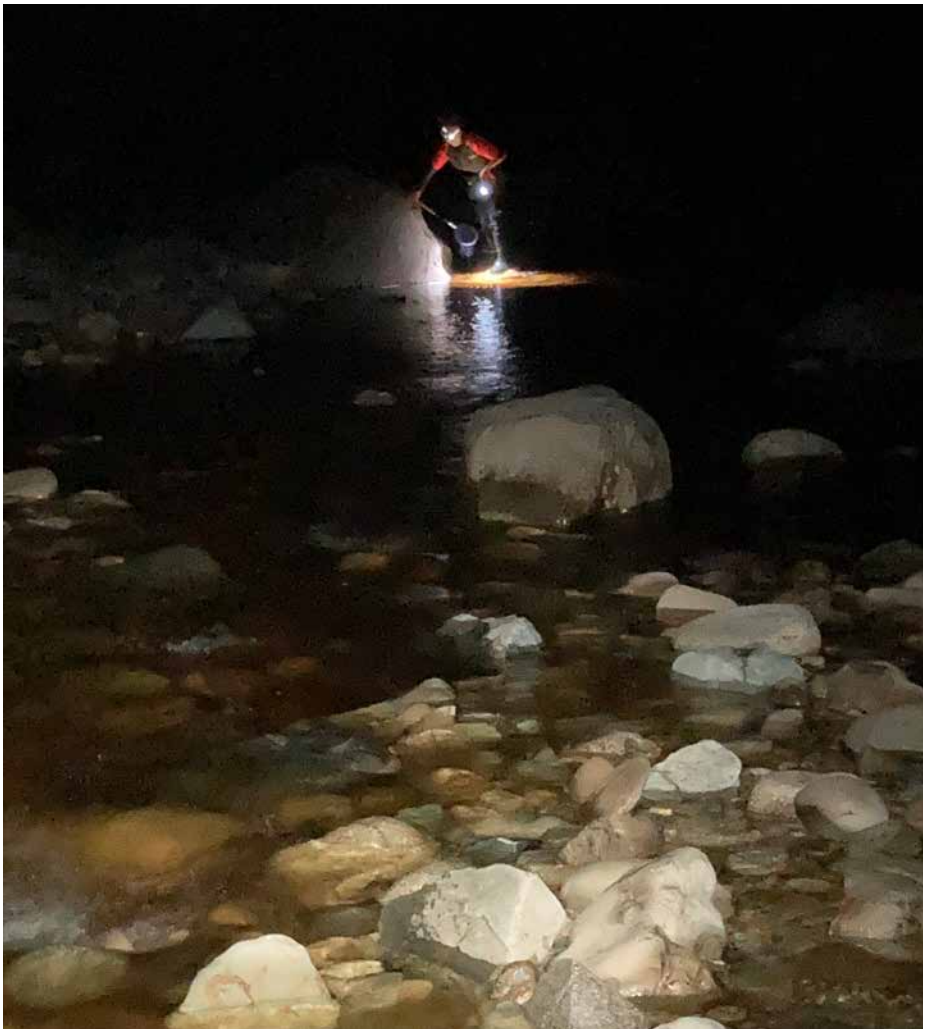
Our migratory species work programme aims to secure the populations of four migratory fish species (tuna/longfin eel, shortjaw kōkopu, īnanga and kanakana/piharau/lamprey) across 12 bioregions.

Carol Nicholson and Chris Woolmore coordinate the operational work programme and provide technical advice to the rangers and other staff. Additional technical and science advice is provided by DOC's national freshwater teams.

The team now includes operational rangers Nathan Lightbourne (New Plymouth), Bjorn Leigh (Whangārei), Natalia Rangiwananga (Palmerston North), Aroha Greenhalgh (Whanganui), Mithuna Sothieson (Whakatane), Anita Pearson (Hamilton), Kate Hunt (Motueka), Anna Henderson (Renwick), Matt Brady (Napier) and Suze Harris (Hokitika). The rangers have dual roles with the Freshwater Biosecurity Programme (see below). There are still two ranger roles to be filled in the South Island, so keep an eye out for the job advertisements.

For shortjaw kōkopu, additional distributional surveys carried out by DOC staff and contractors has contributed to a greater understanding of where they are found. Some rangers were also involved in activities to locate and formally identify shortjaw kōkopu spawning habitat; visiting sites regularly to assess fish for spawning condition and searching waterway margins for eggs.

For lamprey, NIWA has produced new monitoring guidance for detecting lamprey ammocoetes using



Project: **Migratory Freshwater Species programme.** Spotlighting for shortjaw kōkopu. Image: DOC.

electro-fishing methodologies, and juvenile lamprey in catchments using pheromone samplers as a delimitation tool. Monitoring using this guidance has been carried out by some rangers who are supporting local council existing projects and iwi initiatives.

Freshwater Biosecurity programme

This work addresses freshwater biosecurity threats nationwide. Key outcomes for the team are to reduce the rate of spread of koi carp, gambusia, rudd and hornwort, and reduce the effects of freshwater weeds and other priority freshwater pest species.

This is achieved through increased operational capacity with a number of new rangers established throughout the country who have dual roles with the Freshwater Migratory Fish Programme (see above). Helen McCaughan and Kerry Bodmin coordinate the operational work programme and provide technical advice. Additional technical and science advice is provided by Phoenix Hale and Nigel Binks.

Several eradication programmes are underway, many of which are in partnership with regional councils such as rudd control in Christchurch's Travis wetland, and ongoing Cape pondweed control in Canterbury and near Lake Te Anau. Hornwort eradication on Pouto Peninsula is being led by Northland Regional Council

Project: **Critical Ecosystem Pressures (CRESP) research programme.** CRESP project with University of Canterbury MEng student Steph Patchett evaluating the effectiveness of spoiler vs flexible baffles in culverts for enhancing native fish passage. Image: Phoenix Hale (DOC)

Project: **Critical Ecosystem Pressures (CRESP) research programme.** Removing trout from above a built barrier in the Mackenzie Basin, Canterbury in an ongoing collaboration with ECan.

with DOC working in partnership with Waikaretu Marae. Initial knockdown of hornwort has successfully occurred which reduces the risk of spread from Lake Tutaki to other lakes. Eradication in progress as part of a multi-year programme.

Tool development and research are a focus to help achieve our outcomes. We seek to improve detection techniques, develop better control and eradication tools, and improve methods for preventing spread of invasive freshwater species. The programme is not just about controlling pests – it is also about increasing surveillance and reporting, and raising public awareness.

Freshwater pests are a multi-agency issue and we are also working to improve coordination and partnerships between DOC and other government agencies, iwi and community groups.

https://www.doc.govt.nz/nature/pests-and-threats/animalpests/freshwater-pest-species/

Critical Ecosystem Pressures (CRESP) research programme

This programme addresses four pressures on New Zealand's freshwater ecosystems: water levels and flows, sediment and nutrients, critical habitat loss, and fish passage. The key outcome for the programme is to fill critical knowledge gaps to improve freshwater advocacy and conservation in New Zealand.

This is a very externally-facing programme, and we are currently doing research in partnership with a wide range of organisations, including rūnanga, universities, councils, CRIs, and government departments. At present we have 9 projects underway, including two MSc projects, two PhD projects, one MEng project and four partnership projects with external agencies.

We have a webpage if you would like more information on what we are doing or to view some of our outputs, and a research strategy containing our research priorities if you would like some ideas of how you could work with us!

CRESP continues to be led by Nixie Boddy, with support from Sjaan Bowie, Phoenix Hale, Nicholas Dunn and Hugh Robertson.

https://www.doc.govt.nz/our-work/critical-ecosystem-pressures-on-freshwater-environments/

DOC Fish Passage programme

DOC's Biodiversity fish passage programme continues to be led and coordinated by Sjaan Bowie, with support from Natasha Petrove, Marine Richarson, Jane Bowen, Dave West and Katie Collins. Some key work for fish passage improvement and assessments is also being undertaken by our fantastic migratory rangers, inspectors and other DOC staff at place, including supporting removal and remediation of fish passage barriers. We have developed some guidance (e.g. flow charts) to aid decision making for structures, and have developed a DOC categorisation and prioritisation tool (using the Fish Passage Assessment Tool plus other key layers) to aid prioritisation, improvement and progress reporting of fish passage management (Bowie et al 2022). We have started to undertake assessments and consider improvements needed for some of the top priority public conservation land and priority site structures. DOC are supporting key external organisations such as Waka Kotahi, Living Water and Councils with improved fish passage management.

DOC have developed and are trialing a multi-method monitoring methodology for pre and post fish passage remediation (Bowie 2022), and have been supporting students who are making progress on filling priority fish passage research gaps—Stephanie Patchett (Effectiveness of flexible and spoiler baffles in helping native fish passage through culverts) and Martha Jolly (Interventions benefitting non-migratory galaxias in the South Island, New Zealand).

Sjaan continues as the DOC representative on the multi-agency water intake technical working group that is inputting into a multi-year research programme (led by Irrigation NZ). This programme aims to see re-design of typical water intakes that meet good practice and adoption of good practice nationally for fish screening to prevent impingement and entrainment of fish in water intakes.

Daniel Jack has finalized a review of the use of a built barrier and trout removal at Akatore Creek to protect Taieri flathead galaxias.

The New Zealand Fish Passage Advisory Group (NZFPAG) continues to be coordinated by DOC and MfE and has continued to promote a more consistent and improved approach to fish passage management in New Zealand. Current key roles of the group are

around communication, implementation of national resources, promotion and uptake of key research gaps, and creation of key resources to support improved fish passage management. NZFPAG has supported development of guidance to support the implementation of the new NPS/NES Fish Passage requirements in New Zealand (Fish passage | Ministry for the Environment). NZFPAG has continued to keep the fish passage webpages updated with key information and guidance, shared new updates via group newsletters and email updates, and created some resources including two new factsheets; one on installation of baffles to remediate fish passage barriers and one on improving fish passage at pump stations (see https://www.doc.govt.nz/nature/habitats/freshwater/fish-passage-management/resources/). NZFPAG also coordinated and developed some guidance on mistakes and fixes that need consideration for future updates to the current national fish passage guidelines. DOC and NZFPAG have continued to work with Paul Franklin (NIWA) to support improvements and use of the Fish Passage Assessment Tool. Marine and Sjaan represent DOC on the NZFPAG, and Sjaan coordinates and leads the Guidance sub-team.

Living Water

The 10-year partnership between DOC and Fonterra is in its 10th and final year of working together, driving change and finding solutions to improve freshwater ecosystems and increase biodiversity in agricultural landscapes.

In Wairua, Northland, Site Lead Anh Nguyen has worked tirelessly within the Waimā Waitai Waiora partnership that is wrapping up its five year freshwater improvement funded project to reduce sediment entering the Wairoa River. 137 farm plans, over 8kms of fencing and 350,000 native plants have been planted over the life of the project. The Kaipara Moana Remediation (KMR) programme will continue to build on this work, with a longer-term plan to halve the amount of sediment reaching the Kaipara Harbour.

On-farm support: Living Water has now completed on-farm activities in the Okarika pocket, delivering 13 Farm Environment Plans (76% of Fonterra farms in the pocket), 100,000 native plants in the ground and fencing of 5km of waterways.

Mātauranga Māori: Te Kawa Waiora focused on bringing people together through wānanga, to discuss a new pathway of ecological management based in mātauranga Māori. A final report was recently published, concluding that the only way for tangata whenua and their awa is work that is led by those who whakapapa to the area and can drive grassroots action alongside their communities. A major part of the project was ensuring that the communities who participated in the research were able to build the skills and capacity to continue their own discovery. This will be the key to ensuring that the findings can translate into action and Living Water is supporting Kaitiaki Networks to continue this mahi.

In Pūkorokoro-Miranda, Hauraki, Site Lead Dion Patterson and ranger Rose Graham have worked with the Western Firth Catchment Group to co-design a project to create a freshwater biodiversity corridor through farmland from hilltop to the coast. The catchment prioritisation tool (CAPTure) has identified priority areas for interventions to improve freshwater. Funding Farm Environment Plans (FEPs) for large land blocks and creating hybrid FEPs for smaller blocks (under 20ha) has provided more options/flexibility for landowners to make changes. In the last year 17,000 natives have been planted and significant gains have been made through the predator trapping programme.

Partnering for progress: The Tiaki Repo ki Pūkorokoro Trust was established in 2019 to manage the farmland purchased to expand critical shorebird habitat as adjacent reserve. The Trust includes community members who are working together to determine the best way to manage and restore the reserve. An initial restoration plan was developed in June 2019 and the Trust has recently passed a resolution to develop the site for shorebird habitat, continuing to work with The Nature Conservancy (TNC) around Blue Carbon credit development and managing drainage through the reserve for upstream landholders while meeting restoration objectives.

At Lakes Areare, Ruatuna and Rotomānuka/Ngā roto o Areare, o Ruatuna, o Rotomānuka, Waikato, Site Lead Dion and ranger Rose helped the Manga-o-tama Ōhaupō Peat Lakes to Waipā River Connection project secure funding from the WRA for a two year work programme. The project brings together iwi partners, farmers and stakeholders in a catchment-wide approach to improve water quality and restore

Project: Living Water. Rose Graham planting harakeke at Lake Ruatuna. Photo: Carisse Enderwick.

habitat along the Manga-o-tama stream. The project will maintain 30 hectares of planted areas, bring pest weeds under control, retire two hectares of farmland, install 8kms of fencing to protect riparian waterways and plant 16,000 natives. Four primary schools around the catchment participated in planting days in 2022 with representatives of Ngati Apakura.

Real time water quality monitoring: Two continuous water quality monitoring sensors were installed in the Manga-o-tama catchment in May 2022. This is a trial to see if the sensors can help identify sources of nutrients and sediment so that interventions can be prioritised for the catchment-wide project. The sensors collect data hourly on nitrate, sediment, temperature, conductivity and dissolved oxygen and send information to an online dashboard.

Mātauranga Māori: Eleven varieties of harakeke/flax are thriving in the Pā harakeke rongoā education trail run in collaboration with Ngati Apakura. Additional rongoā species have recently been planted and Pā harakeke maintained. The harakeke is still a year or two away from being ready to harvest but arrangements will be made to link this site into iwi cultural harvest plans to ensure ease of legal requirement for weavers to access this resource.

In Ararira-LII River/Te awa o Āraiara, Canterbury, Site Lead Robin Smith has worked with Te Taumutu Rūnanga, Selwyn District Council, LII Drainage Committee and Environment Canterbury to take a catchment approach to redesigning the Ararira-LII drainage network to recognise that waterways have values beyond drainage, such as supporting native biodiversity including fish, invertebrates and aquatic plants and to highlight that healthy waterway networks are essential for overall ecosystem resilience. As well as producing a catchment plan that reimagines the drainage network, the project also developed a guide to support the implementation of the catchment plan. The implementation guide identifies organisational and institutional changes, funding options and delivery arrangements that are needed to bring about change.

Sediment and nutrient reduction: Trials of in-stream sediment traps are complete and have proven to be a cost-effective way to reduce sediment. They require

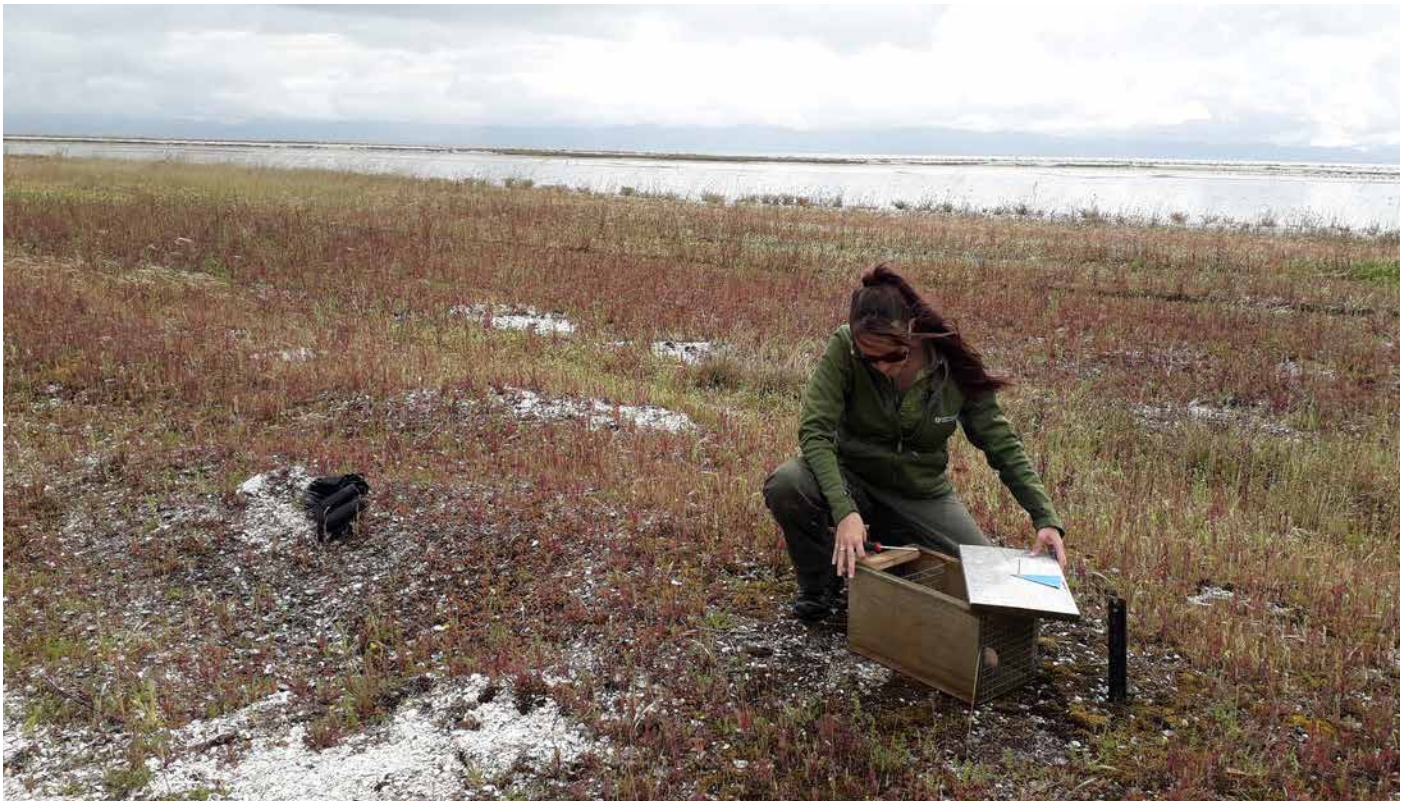
minimal maintenance with clearing required roughly once a year. Excess sediment can be used on-farm or easily removed.

In Waituna/Waipārera, Southland, Site Lead Pat Hoffmann has undertaken the last two fish surveys in Waituna Creek. Evidence from 8 years of fish population monitoring shows that the large woody structures installed on the stream bed have significantly improved habitat for native fish at the trial sites as summarized in Waituna Cawthron Report . 11,600 native plants have been planted along the stream edges. A report published on the 2-stage channel presented evidence that this is an effective way to control bank erosion and thereby reduce sediment inputs to Waituna Lagoon, without compromising fish habitat.

Sediment and nutrient reduction: Farm Environment Plans for all Fonterra dairy farms in the catchment have now been completed. The plans include an assessment of the industry agreed good farming practices being achieved and recommendations for edge of field treatments and other initiatives to reduce contaminant losses. The trial of four Peak Run Off Control structures installed in April 2021 in the Carrans Creek sub-catchment shows promising results, after the two earthen bunds were redesigned and rebuilt after flood damage. These will continue to be monitored through the next year.

Partnering for progress: Through the collective efforts of Whakamana Te Waituna, a further 16.5 hectares of land was purchased in 2022 to begin the process of acquiring suitable land on the western side of the catchment for a large scale constructed wetland. The site has several ecological features on it, including one of the few remaining areas of podocarp forest on the western side of Waituna. Approximately half the land is in mature or regenerating natives with stands of rimu and kahikatea. This piece of land forms one piece of land in a larger acquisition that would be required to develop a 100ha+ wetland in the lower Waituna Creek Catchment.

Daniel Jack working on the vulnerable species project, continues to collaborate with Coastal Otago District staff Chris Kavazos, and Rosemary Clucas from Environment Canterbury, to improve the knowledge, distribution and identification of habitats occupied by chronically threatened non-migratory galaxiid species. Highlights include the improved understanding of waterfall barriers protecting Nevis galaxias in the Nevis Valley (Fig A); waterfall barrier in Hope Creek (Fig B),



Project: Living Water. Rose Graham checking a trap at Pukorokoro-Miranda. Photo: Ken Brown.

which protects the largest known population of Clutha flathead galaxias; and new distribution records of Canterbury mudfish in the Pareora River catchment.

Nicholas Dunn continues his focus on threatened freshwater fish research and management. In particular the development of a geospatial and demographic decision support system to map distributions, analyse, prioritise, and report on the status of threatened freshwater fishes1. He is also leading the conservation status assessments for freshwater fishes and progressing the taxonomic description of eastern and southern South Island non-diadromous Galaxias.

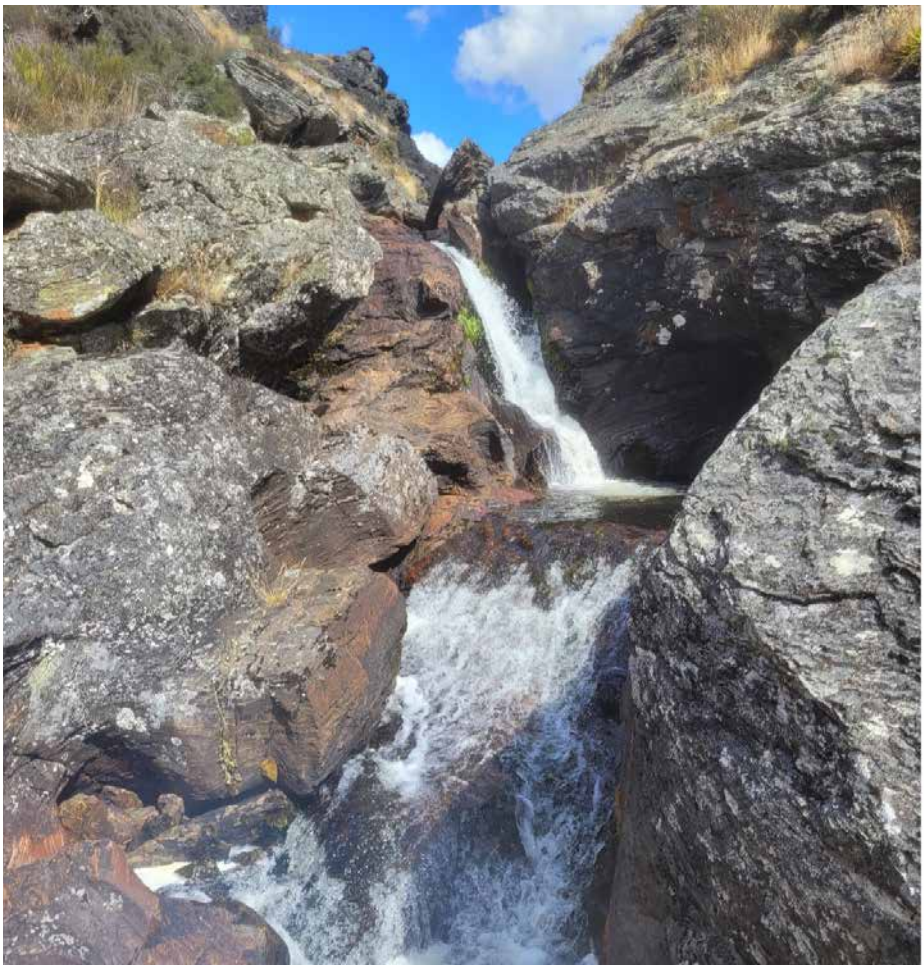
Publications

Bowie, S. 2022. Fish sampling methodology – to determine fish community differences across a remediated instream structure in small streams and assess success of remediation. Department of Conservation report. Christchurch. 18p.

Bowie, S. & Bradshaw, P. 2022: DOC's Fish Passage Categorisation & Prioritisation of Instream Structures. Department of Conservation report. Christchurch. 17p.

Franklin, P.A., Sykes, J., Robbins, J., Booker, D.J., Bowie, S., Gee, E., Baker, C. 2002: A national fish passage barrier inventory to support fish passage policy implementation and estimate river connectivity in New Zealand. Ecological Informatics 71. To view full article see https://authors.elsevier.com/c/1fq2n5c6cK~i5z

Jack, D., Campbell, C., & Bowie, S. 2023: Taieri flathead galaxias – Akatore Creek built barrier and trout removal. Unpublished Department of Conservation report. Dunedin.



Top: Fig.A. Waterfall barrier in Drummonds Creek, Nevis River (Nov 2022).
Bottom: Fig.B.Waterfall barrier in Hopes Creek, Clutha River (Mar 2023)

Waikato Regional Council

GENERAL UPDATE

Nicole Squires has been co-ordinating the SOE freshwater invertebrate monitoring programme (REMS)

Josh Smith has been co-ordinating the SOE freshwater fish monitoring programme.

Michael Pingram, working with a number of collaborators (including Michele Melchior – NIWA and Jonathan Abell – EcoFish, Nicole Wheeler - Hydrobiology) we have completed a number of research and reporting projects covering large river restoration, biodiversity, river geomorphology, and state of the environment.

Bruno David has left WRC to focus on other interests and **Mark Hamer** is currently taking a year long sabbatical.

Alicia Williams has been coordinating research into the impacts and assessments of new flood pump infrastructure on migrating eels and monitoring of the impacts of river works on aquatic communities.

Mafalda Baptista lakes/water scientist

Mat Allan has been continuing implementation of remote sensing of water quality and wetlands as a potential operational mapping/monitoring tool (using machine learning). Mat is also collaborating with the University of Waikato on research into a modelling platform for all New Zealand lakes (led by Deniz Özkundakci).

Freshwater Ecology Summer Students: Marieka van der Lee, Flavian Ember and Rian Southwell

Regional Ecological Monitoring of Streams (REMS) Programme – Around 140 sites are scheduled to sample between January and the end of March 2023. At each site, ecological habitat assessments are undertaken and invertebrate samples collected using standardised methodologies. We have been collecting paired samples over the last two summers to compare WRC methods to NEMS sampling methods. This year's field monitoring team consisted of Nicole Squires and Marieka van der Lee (Student) with support from Michael Pingram, Josh Smith Flavian Ember and Rian Southwell. For any information about this programme please contact Nicole Squires (Nicole.Squires@waikatoregion. govt.nz). Outputs: Latest round of REMS report is Pingram et al. 2023.

Josh Smith and Nicole Squires led a fish and invertebrate sampling demonstration day alongside WRC's Integrated Catchment Management team (ICM) for the Puniu River Care Goup.

KEY PROJECTS

Pathways To The Sea (PTTS) - Improving fish passage at pump stations.

Various research and investigative projects aimed at supporting the development of a strategy for

improving fish survival and passage at pump stations in the Waikato region.

A main focus this migration season (2023) is testing of a new encased Archimedes screw pump for fish friendliness on NZ eels, a pump that has been reported overseas to have no impact on fish that pass through it. This work has been a collaborative effort between Alicia Williams (ICM), Mike Lake (Tonkin & Taylor) and Brenda Bartels (2 Awa Ecology).

Outputs:
Eel migration pathways at the Steiners flood pump station 2020 -2022. Reported prepared for Waikato Regional Council, NIWA2022285HN.

PUBLICATIONS

Abell, Jonathan M; Pingram, Michael A; Özkundakci, Deniz; David, Bruno O; Scarsbrook, Mike; Wilding, Thomas; Williams, Alicia; Noble, Matt; Brasington, James; Perrie, Alton; (2023). Large floodplain river restoration in New Zealand: synthesis and critical evaluation to inform restoration planning and research, Regional Environmental Change, 23: 1-18

Melchior, Michele; Williams, Alicia; Hamer, Mark; Pingram, Michael; Squires, Nicole; Collier, Kevin; (2023). Distribution and current state of freshwater mussel populations (Kāeo, Kākahi) in wadeable Waikato streams, Waikato Regional Council, TR 2022/01

Pingram, Michael; David, Bruno; Squires, Nicole; Smith, Josh; Hamer, Mark; (2023). Current ecological state of wadeable streams in the Waikato region 2018-2020; Waikato Regional Council, TR 2022/32.

Images from left:
Summer student Marieka van der Lee (top) and Erena Cockle on the annual REMS training day collecting transect information in Bankwood Stream, Hamilton.

Nicole Squires collecting an invertebrate sample for the SOE invertebrate monitoring programme. Photo: Marieka van der Lee.

Josh Smith demonstrating how to use the NIWA citizen science app for culvert assessments and demonstrating the consequences of a perched culvert in the Mangatutu stream to the Puniu River Care group. Photo: Nicole Squires.

Greater Wellington Regional Council

GENERAL UPDATE

Greater Wellington is undergoing a significant change in the way we work, moving to delivering services at a catchment level and organized into catchment delivery teams. The new Environment Group includes a number of new positions with recruitment ongoing. Dave Hipkins, formerly Toitū Te Whenua (LINZ), has recently joined GW in the role of Pou Māramatanga, Rangahau me Aromātai, Director Knowledge and Insights for the Environment Group.

We are saying goodbye to a number of amazing staff. Lucy Baker, Manager Environmental Science, is leaving GW and returning to the UK to spend more time with her family as is Louise Algeo, Team Leader Hydrology. Faline Drummond (Freshwater Scientist) is leaving for a two-year working holiday visa in Canada and Liliana Martis (Environmental Monitoring Officer) has accepted an Honours scholarship at the University of Auckland. Lauren Visser (Environmental Monitoring Officer) is also leaving to pursue her dreams of working on yachts in the Mediterranean.

KEY PROJECTS

Sky TEM

GW is using a helicopter to fly equipment over the Ruamāhanga Valley to scan aquifers from the air. SkyTEM is the company chosen conducting this survey using their technology, the electromagnetic SkyTEM system, which creates a gentle electrical current that travels up to 300-metres underground. This current behaves differently based on the materials it passes through underground which is recorded by the equipment. This will help us identify what materials underground layers are made up of (e.g., sand, gravel, and clay). After SkyTEM collects the data, GNS Science will process it and use it to build a 3D map. It will take two years to analyse the data and develop a 3D map of the aquifers. The insights we gain from this project will help us better understand the interconnections between groundwater and surface water and make better decisions about water.

Contact: Rebecca Morris

Toxic algae sign trial

As part of our evolving journey in recreational water quality communications, this summer we have deployed new and much bigger toxic algae "risk-level" signage at or near several key sites around the region. We hope these will improve public awareness and safety at what tend to be our most problematic areas. If they work well and have good feedback, we will look to roll these out a further sites next summer. At a national level, MfE are currently revising the Recreational Cyanobacteria Guidelines in preparation for their finalisation. As part of this, they are developing a new section providing more comprehensive guidance on toxic algae communications, with a case study on GW as exemplar of how to develop and manage a formal communications strategy.

Contact: Penny Fairbrother

eDNA applications

Environmental Science has been exploring the use of eDNA methods for information on fish distribution, presence absence, biodiversity values, fish passage assessment, consent applications and environmental prosecution cases. Our most recent applications have included sampling in lakes, wetlands and rivers.

The Lake eDNA assessment project (LEAP) is exploring the potential for eDNA to contribute to lake ecological assessments by providing accurate and cost-effective data on the presence (and potentially the relative abundance) of phytoplankton, macrophytes, zooplankton, and fish. eDNA sampling has also benefitted our biosecurity team who have used eDNA analysis to supplement their traditional survey methods for aquatic pest plants including eelgrass, Senegal tea, and Manchurian wild rice. Through their supplementary sampling, they unexpectedly had a sample return positive for eelgrass DNA in an area that had been searched using traditional survey methods. The team conducted a second survey which led to the

finding of an unknown, but well-established eelgrass infestation.

Contact: Ashley Mitchell

Implementing the NPSFM

Our third Whaitua process, Te Whanganui-a-Tara, was completed in late 2021 and produced two complementary documents. Outcomes from these will be incorporated into GW's Natural Resources Plan through a plan change process.

A morning of whakawhanaugatanga with some emotional speeches, followed by an incredibly interesting field trip was an auspicious start to Whaitua Kāpiti, the fourth Whaitua process. To support this process, the science team have been developing packages of information including: an investigation of soil infiltration rates and compaction in urban areas, stormwater modelling case studies, and panel assessments to understand how water quality might be expected to change under different management scenarios.

There has also been science work to support freshwater plan change processes for some of the completed whaitua processes. This has included: identifying where there could be simplification of targets and new sites for target states, defining targets for attributes that were introduced after the Whaitua's were completed, and assessing the similarity of the policy packages with the scenarios tested and targets set.

Contact: Penny Fairbrother

Output: Te Whaitua te Whanganui-a-Tara Implementation Programme (produced by the full Committee) and Te Mahere Wai, a Mana Whenua Whaitua Implementation Programme (produced by Te Kāhui Taiao).

Mahi Waiora

The Mahi Waiora ('wellbeing of water') programme helps us achieve our water quality and biodiversity goals. GW teams are working with mana whenua and territorial local authorities in an integrated way. The programme is currently working to benefit three areas: Waitohu (Ōtaki), Pouewe and Parkvale. We've achieved a lot in the past year. The Waitohu team have helped local iwi carry out regular fish monitoring for native species and then improved their habitat based on the monitoring results. Some of the improvements were removing trees that shaded grassy banks, restoring the channel shape and replanting grasses to provide spawning habitat. Many of these waterways are home to inanga and provide an important food source for locals and in mana whenua's role in providing manaakitanga.

Contact: Lisa Young and Caleb Royal (Ngā Hāpu o Ōtaki)

Outputs: https://www.gw.govt.nz/environment/freshwater/mahi-waiora/

Biodiversity strategy release

Regional biodiversity conservation is one of GW's core functions and many teams carry out a range of programmes that contribute to this. Last year we released our first Te Pane Matua Taiao Annual Biodiversity Report 2021-22 to summarise our progress towards the objectives in the GW's Biodiversity Strategy 2016. The report summarises GW's progress against our Long Term Plan performance measure for biodiversity and highlights key strategic shifts within the council and at the national level for biodiversity conservation and identifies opportunities where we can improve our approach to achieving positive outcomes for regional biodiversity. It also highlights some of the exceptional mahi that GW teams carry out for biodiversity conservation.

Contact: Micheline Evans

Kākahi count programme

The programme is the longest-standing citizen science monitoring programme in NZ and is held annually at Lake Wairarapa. The team are now in their ninth year of monitoring, with the count alternating each year between the western and northern side of the lake. Kākahi are amazingly long-lived, and some are thought to be over 50 years old. Kākahi are and sensitive to changes in water quality and temperatures and by monitoring their population structure, we can infer what the conditions in the moana are like. This year, we had a perfectly calm day, which was ideal for spotting kākahi underwater. The count is part of the Wairarapa Moana Wetlands Project.

Contact: Renee Mason

Output: The 2022 Kākahi Monitoring Report

Image previous page: Lilliana Martis-Geor collecting eDNA in a wetland in the Kapiti Coast.
Images this page, clockwise from top: Lauren Visser and Shyam Morar electrofishing; Shyam Morar and a giant kokopu; measuring kākahi (photo: Andrew Stewart); Ashley Mitchell, sister Madison and Freya the dog standing by the new sign at Waipoua River, Masterton.

Fish & Game

GENERAL UPDATE

Over the past 12-months Eastern Fish & Game staff have been undertaking intensive winter monitoring of the Lake Waikaremoana trout fishery. This has been a multifaceted project combining on-water and lake shore/ tributary angler creel surveys to gain metrics of angler catch rates, fish size and condition along with timing and numbers of escapement to spawning tributaries. Waikaremoana has been shown to have performed as one of Eastern Region's top fisheries during the past 3 years providing exceptional catch rate and fish condition. Manipulation of the lake as a hydro generation reservoir has not affected the trout fishery within recent times.

We are nearing the completion of a Cawthron Institute study investigating the drivers of productivity to Lake Tarawera's trout fishery. This study commenced in 2019 and has experienced a number of challenges along the way. We have been seeking to identify management triggers that inform of pending boom or bust productivity scenarios so that we may undertake management actions (liberation actions and regulatory decisions) to alleviate poor trout performance along with provision of better information to licence holders regarding what is likely coming up in terms of fishery performance.

In collaboration with DOC Taupo Fishery and NIWA, Fish & Game staff have been undertaking acoustic transects to capture the magnitude and spatial aggregation of food supply (smelt and juvenile bully) within Lake Tarawera. Transects have been undertaken twice yearly, prior to lake-turnover event (April) and post lake-turnover (November). We are hoping this research, along with the Cawthron Food web study, will feed into our future management decisions for Lake Tarawera and other similarly acting lakes.

Following the terrible events of Cyclone Hale and Gabrielle, Eastern staff will be putting a much higher emphasis in the coming years on riverine monitoring to understand effects that have happened and what is required to remedy our East Coast fisheries.

Fish & Game are beginning a project to research whether black swan populations are increasing in size or whether larger aggregations are being encountered due to birds travelling from degrading wetlands to areas that have healthier weedbeds for foraging. Sedimentation of wetlands/ estuaries degrades zostera beds that swan feed upon.

Botulism causes large mortality events within freshwater fish communities (native and introduced) and waterfowl/ wetland birds. Can lowland drain management and effluent pond management regimes be altered to reduce these destructive outbreaks from occurring?

TARANAKI REGION: GENERAL UPDATE

Taranaki staff have been carrying out catchment-wide electric fishing surveys in December each year to assess juvenile trout recruitment. Juvenile trout densities are higher in catchments originating on Mt. Ruapehu that those draining Taranaki Maunga, with differences likely due to differing intensities of landuse, and flow and temperature regimes. All native fish caught during these surveys are recorded and results entered into the NZFFDB.

Staff also carried out an electric fishing survey of Timaru Stream at sites upstream and downstream of a disused concrete weir at Tataraimaka in coastal Taranaki to assess the impact of the weir on trout and native fish populations prior to the weir's removal. Results confirmed the weir is a complete barrier to non-climbing native species such as inanga and a partial barrier to species with moderate climbing ability, such as redfin bully. Strong climbers like shortjaw kokopu and koaro were found upstream, but even their migration is likely to be impeded at times. Trout densities were low at all sites sampled and the impact of the weir on trout is less certain. What we do know is that weir removal will restore unimpeded access for all fish species to high quality habitat in the upper reaches of Timaru Stream. Fish & Game will conduct a follow-up survey of the same sites a year or two after

demolition to document changes in fish distribution and abundance.

The Waiaua River near Opunake was surveyed to assess the river's recovery from a significant headwater erosion event that occurred during a flood in mid-July 2021. Erosion on a massive scale on Taranaki Maunga filled the river with sand and saw it run grey with ash for several months, decimating the river's fish and macroinvertebrate populations. In early February 2022 staff electro-fished three sites in the Waiaua mainstem and one site in each of two headwater tributaries that were unaffected by the erosion. The survey revealed that nearly seven months on, the native fish and trout populations showed little recovery, although the aquatic invertebrate fauna and some juvenile eels were beginning to return. By contrast the unaffected tributaries contained healthy populations of invertebrates, redfin bullies, eels, koura and juvenile brown trout that will provide a reservoir for reintroduction to the mainstem as conditions improve.

A koaro from Timaru Stream upstream from the Tataraimaka weir.

Our Land and Water

Our Land and Water National Science Challenge (OLW) will, like all of the 11 National Science Challenges, end in June 2024. The Challenges were an experiment in a different way of funding mission-led research, focussed on the questions that the people of Aotearoa had identified as critical questions for science to answer. OLW's question was how to enhance the production and productivity of New Zealand's primary sector, while maintaining and improving the quality of the country's land and water for future generations.

Collaborative research teams have been created drawing on the expertise of various research agencies, consultancies, community members and iwi as well as stakeholder organisations. The emphasis has been on co-designing and co-producing research, ranging in scope from think pieces (<$100K) to major research programmes (>$1M). In order to foster real land-use change, all research outputs are open access and

OLW has invested significant time and resources in their effective communication of research results. Te Ao Māori has been central to Challenge research since 2019, and there is now a strong cohort of mātauranga Māori, as well as merged western science-mātauranga, research programmes.

Research on freshwater systems has been an important component of OLW's operations, as our changing water quality aspirations for Aotearoa dictate many of changes that will be required in how we use our land. A brief summary of recent freshwater research funded by OLW is given below. There is a wealth of water and land-use related research and research outputs ranging from journal articles to interactive tools, videos and webinars, on the OLW website: https://ourlandandwater.nz. This is all free to use and download.

Recent Freshwater Research

MONITORING FRESHWATER IMPROVEMENT ACTIONS

Actions are being taken to improve freshwater quality through activities such as stream fencing and planting, wetland restoration, and changes in farming practices. Better monitoring practices and techniques are urgently needed to detect the effect of these activities on freshwater health. Current freshwater monitoring methods and networks require long periods to detect reducing contaminant loads or improving ecological health.

This programme is developing a toolkit to help groups involved in freshwater improvement actions to design monitoring programmes to measure the success (or failure) of actions taken. It will also help them select the best monitoring technologies to enable early detection of water quality change. This research includes a kaupapa Māori approach to detecting the effects of whenua-based mitigation actions on wai Māori.

https://ourlandandwater.nz/project/monitoring-freshwater-improvement-actions/

MAPPING FRESHWATER CONTAMINANTS

Building from the earlier Physiographics model research, four research programmes collectively seek to map New Zealand landscapes in terms of their contaminant delivery from source to sink:

- Identifying how differences in landscape and climate increase the risk of E.coli being transported to water;
- Improving the accuracy of maps of groundwater 'redox' zones (areas with the natural potential to remove nitrogen) that determine whether nitrogen is reduced in aquifers;
- Identifying patterns, variability and uncertainties (at catchment scale) associated with the natural processes that attenuate (reduce) nitrogen and phosphorus impacts on water; and
- Mapping the natural susceptibility of soil loss and transport from surficial erosion

These maps should help central and regional government to plan, develop and implement policy related to water quantity and contaminant discharge. They can also inform land managers of the risk profile of their landscapes and support management decisions.

Find out more:
https://ourlandandwater.nz/project/mapping-freshwater-contaminants/

HEALTHY ESTUARIES

The health and functioning of estuaries are affected by the cumulative effects of contaminants from their upstream freshwater systems, in ways which can be difficult to predict. In partnership with the Sustainable Seas National Science Challenge and the Ministry for the Environment.

OLW researchers are estimating freshwater contaminant loads to New Zealand estuaries historically, now, and under a changed climate in the future. Sustainable Seas researchers are using this information to determine critical stressor thresholds for cumulative effects on estuarine ecology and mātauranga Māori values. In case study estuaries, Māori researchers are working with whānau, hapū, iwi and local community groups to identify aspirations for their estuary, and present uses and stressors.

Find out more:
https://ourlandandwater.nz/project/healthy-estuaries/

IMPLEMENTING AND ENABLING TE MANA O TE WAI

Te Mana o Te Wai is now the first principle for freshwater management in Aotearoa. In a paradigm shift, the NPS-Freshwater Management (2020) puts the rights of a water to be healthy and to sustain itself ahead of all other "uses". Only once this has been provided for, can we determine the quality and quantity of water available to support human health, followed by the wellbeing of people and communities (socially, economically, and culturally).

This research engages with iwi and hapū to explore what Te Mana o te Wai is for them, and how Te Mana o Te Wai can be implemented with integrity. This perspective has created tools, guidance, and support for all users of water in Aotearoa, where many are struggling to understand and give effect to this mātauranga Māori-centered concept. This research continues now to develop training for those tasked with implementing this policy.

Find out more:
https://ourlandandwater.nz/project/implementing-te-mana-o-te-wai/

CONNECTING SOIL AND WATER QUALITY

This research is the first attempt at a national scale to directly link soil quality to both agricultural land use pressures over time and to water quality response. It makes use of existing soil and water quality data for Aotearoa: data on land use and management, soil quality monitoring data and water quality data for ca. 700 catchments. The results will be compiled into an interactive map.

Find out more:
https://ourlandandwater.nz/project/connecting-soil-and-water-quality/

LINKING LEGACIES TO WAI

Changes made on land today can take many years to be reflected in the health of our rivers and groundwater systems. This 'lag time' can confuse the relationship between wai and whenua. Having previously determined a national average lag time for nutrients to reach our streams and rivers from agricultural land (4.5 years), this research currently focusses on nitrate transfer into groundwater systems.

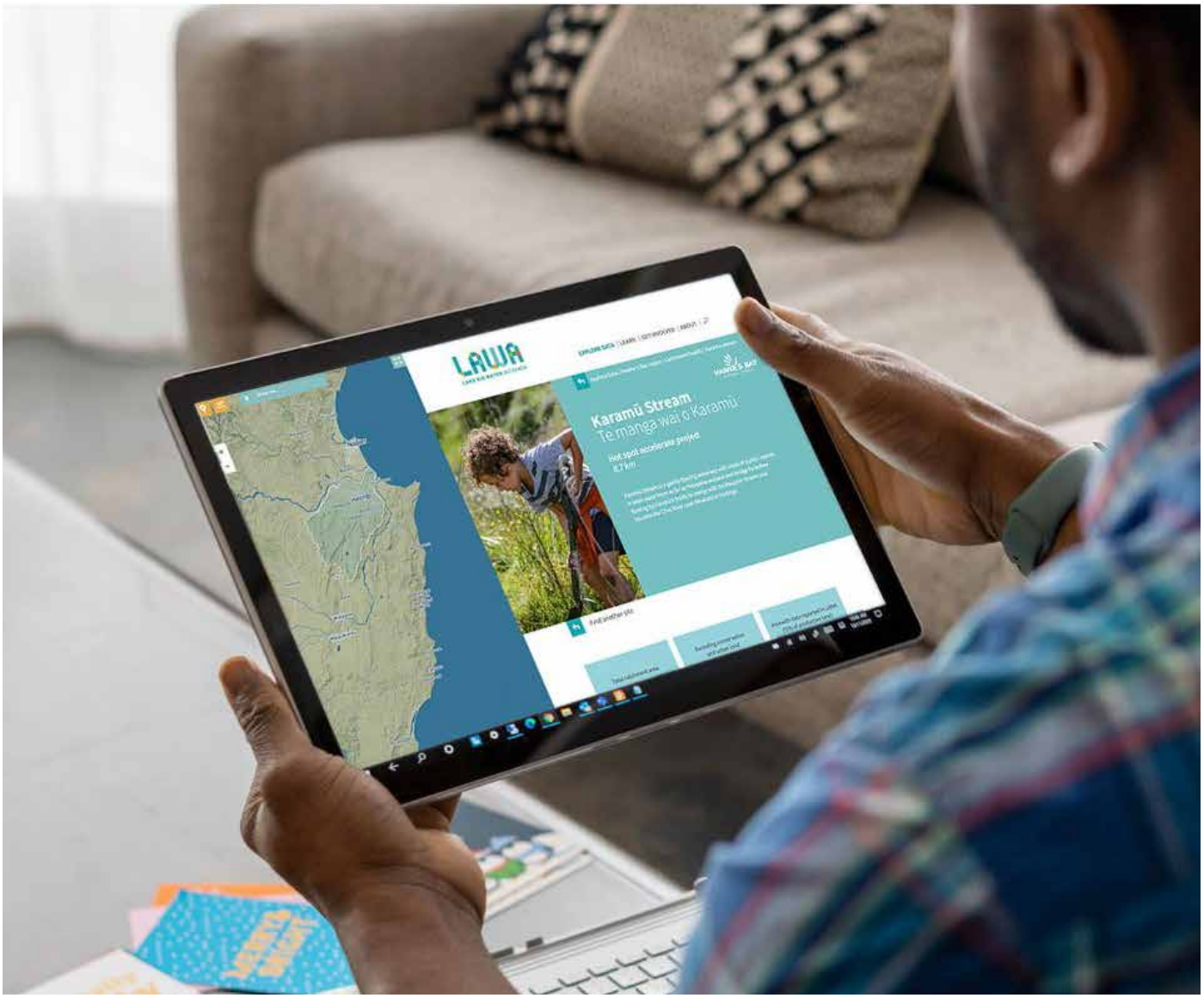
This research will help to quantify both the effects of agriculture on our freshwater over the past 170 years and the most realistic timeframes for future water quality responses to on- land actions such as destocking and riparian planting.

Find out more:
https://ourlandandwater.nz/project/linking-legacies-to-wai/

NEW MODELS OF COLLECTIVE RESPONSIBILITY

In most catchments, healing the mauri of land and water will require neighbouring landowners to coordinate their actions. Catchments Groups are an increasingly important component in the implementation of new legislation to reduce the effects of farming and to protect and improve the health of our freshwater systems.

This research explored ways to strengthen the connection and effectiveness of people working in Catchment Groups in Aotearoa, supporting them to consolidate and accelerate collective actions to benefit water, land and people. The research outputs support them to diagnose and address issues, prioritise investments, and scale up their efforts to meet their community's goals.



Find out more:
https://ourlandandwater.nz/project/new-models-of-collective-responsibility/

REGISTER OF LAND MANAGEMENT ACTIONS

Land management actions that help improve water quality include planting trees, fencing riverbanks and changed grazing and fertiliser management practices. To find out which actions are most effective, we need to record these land management actions and link them to water quality outcomes. Inter-catchment comparisons can then show which actions have worked best and over what timeframe, to give landowners the confidence to invest in the most efficient land management actions.

This research has produced an online register to record the efforts made to improve water quality within each rural catchment. The register uses existing records of the initiatives by farmers, growers, iwi and hapū, primary sector bodies, community groups and councils, and is able to be updated as additional actions are undertaken.

The register will soon be incorporated into the Land Air Water Aotearoa (LAWA) platform, displaying information in a way that reflects the combined effort in a catchment, and the extent and intensity of actions undertaken. This will provide a clearer picture of how far we have come, and what and where actions are still needed.

Find out more:
https://ourlandandwater.nz/project/register-of-land-management-actions

Cawthron Institute

New staff or students: Aisling Rayne, Finnbar Lee

We welcome Finnbar Lee who joined Cawthron as a quantitative ecologist and is working on developing lake food web models to explore fish interactions with Simon Stewart in the Fish Futures project. We also welcome Aisling Rayne to Cawthron who joins the Fish Futures team as a social-ecological scientist exploring how people relate to freshwater fish across Aotearoa. Growing our inter-disciplinary expertise continues to be a strong focus for us and shapes our involvement in multiple research and consulting projects throughout the country (see feature projects below). For example, Kati Doehring is in her final year for her PhD in Science Communication. She has been testing how storytelling can be used as a freshwater restoration tool and her work directly feeds into the development of the National Register of Land Management Actions. We congratulate Katie Brasell on completing her PhD studies using molecular and paleolimnology tools to study ecological shifts in lake communities, alongside other Lakes380 students Lena Schallenberg (PhD) and Carrie Page (MSc).

Meanwhile, Susie Wood and Laura Kelly recently produced a report for MPI investigating the potential for eDNA to contribute to freshwater biosecurity monitoring. Laura is also excited to begin research on her co-led Marsden grant with Kim Handley (University of Auckland) to investigate the interaction of toxin and non-toxin producing species of benthic cyanobacteria. Roger Young has helped Auckland and Horizons RCs with analysis and reporting of continuous DO and ecosystem metabolism data and assisted Tasman DC on the Water Conservation Order for Te Waikoropupū. Dave Kelly has been developing lake restoration plans for Lakes Waipu (Horizons), and Lakes Tuakitoto and Tomahawk Lagoon (ORC). Karen Shearer and Roland Eveleens continued to provide freshwater macroinvertebrate taxonomy services, including implementing the NEMS Macroinvertebrates standards and identifying less commonly found critters while processing samples from the DOC National Freshwater Monitoring Program. Annika Wagenhoff contributed to MfE's guidance on the setting of instream nutrient concentration thresholds for nutrient-affected attributes in rivers.

Feature projects

FISH FUTURES

The Fish Futures research program (www.fishfutures.co.nz) met for their first annual research symposium in September 2022 in Nelson. Working with multiple local, national and international partners we are aiming to transform the way we think about and manage freshwater fish through the co-development of new knowledge. Early outputs include an understanding of divergent perspectives on introduced trout and quantification of marine subsidies in trout and eel diets in Waituna streams. Cawthron researchers are Joanne Clapcott, Robin Holmes, Marc Tadaki, Finnbar Lee, Aisling Rayne, Simon Stewart, Calum MacNeil, Kiely McFarlane, Alaric McCarthy, McKayla Holloway.

LAKES380 RESEARCH UPDATE

The recent focus of the Lakes380 team (www.lakes380.com) has been analysing and reporting on the large amount of data obtained from the sampling of over 300 lakes! A highlight was working in partnership with Ngāti Koata and the Department of Conservation to produce a virtual reality platform (https://lakes380.com/he-reo-no-te-puehu/) to tell the story of Lake Moawhitu. Other research highlights include development of a new and highly sensitive way to detect kākahi eDNA in water and sediment samples; identifying the environmental drivers (spoiler alert – catchment land cover) of different microbial communities in lake surface sediment and the water column; a tool (https://lakes380.upshift.co.nz) to predict water quality of NZ lakes; and 12 new documentaries focussed on rohe studies of Wairarapa, Rangitīkei and Otago (https://www.lakestoriesnz.org). Cawthron staff involved in Lakes380: Susie Wood, Dave Kelly, Kiely McFarlane, John Pearman, McKayla

Top: Heading in to survey the Roaring Meg Stream (inland Kaikoura) – not a bad view on a field day. Some dense matagouri scrub and billygoats to contend with to access the site. Photo: Laura Kelly.

Bottom: Lakes380. He reo nō te puehi – a virtual reality platform produced with Ngāti Koata and the Department of Conservation telling the story of how Lake Moawhitu has changed over the last 1,000 years.

Holloway, Konstanze Steiner, Javier Atalah, Jacob Thomson-Laing, Jonathan Puddick, Laura Biessy, Lucy Thompson, Roger Young, Sean Waters, Xavier Pochon.

INSPIRING THE NEXT GENERATION OF LAKE SCIENTISTS

In 2022, Cawthron staff (led by Jonathan Puddick and Karen Goodger) delivered a science education outreach programme to over 300 kids at schools and holiday programmes in the Nelson/Tasman region. The 1.5-hour 'Time-Travelling Lake Detectives' programme teaches school children about modern lake science, the plight of lakes in Aotearoa NZ and how paleolimnology can be used to travel back in time and discover what our lakes used to be like 1,000-years ago - before humans arrived here. Activities and resources from the initiative and the Lakes380 project are freely available to schools and educators through a collaboration with the Science Learning Hub (https://www.sciencelearn.org.nz/resources/3212-lakes380-a-context-for-learning).

DONALD CREEK CATCHMENT STUDY

We have been undertaking bi-annual ecological surveys at Donald Creek as part of a paired catchment study with OneFortyOne Forestry. In the third year of a seven-year study, the project was featured on TVNZ's show Rural Delivery - https://www.youtube.com/watch?v=BUMyR3a4APM. The study aims to quantify the effectiveness of different types of forestry erosion and sediment controls on nearby waterways. This is the third year of a seven-year study and the project was featured on TVNZ's show Rural Delivery - Cawthron researchers involved are Karen Shearer, Roland Eveleens, Simon Madill.

MITIGATION EFFECTIVENESS MONITORING DESIGN

This Our Land and Water NSC-funded program aims to develop a national web-based tool to inform monitoring network design to detect change in freshwater values in response to mitigation and restoration action. This program is collaborating with two catchment restoration projects (Te Hoiere, Pokaiwhenua) where we are working with Iwi and catchment groups to test the tools and identify how science tools can support cultural monitoring. A review of the use of science attributes in cultural monitoring tools was an early output of this project. Cawthron researchers are Joanne Clapcott, Roland Eveleens, Aneika Young.

PATHWAYS TO ECOSYSTEM REGENERATION

This Biological Heritage NSC-funded program aims to build social and ecological resilience by understanding and restoring connections between people and nature. We are working with three exemplars (Predator Free Wellington, Ōpāwaho Heathcote River Network, Reconnecting Northland) to develop tools and approaches that reflect their unique needs and contexts, and ultimately support their efforts to scale-

Project: Inspiring the next generation of lake scientists. The Time-Travelling Lake Detectives schools outreach program.

Left: Roland Eveleens undertaking a periphyton and sediment assessment in the Te Hoiere Pelorus River. Photo: Laura Kelly. **Right:** A leaf-veined slug spotted on a rock mid-stream in a small tributary of the Wakamarina River. Photo: Laura Kelly.

up for impact. Aligned resources include Farming with Native Biodiversity (www.biodiversity.nz), Freshwater Biodiversity Monitoring Guide (www.j4n-monitoring-guide.cawthron.org.nz). Cawthron researchers are Joanne Clapcott, Kiely McFarlane, Marc Tadaki, Robin Holmes.

PHD RESEARCH ON HISTORICAL FISH COMMUNITIES IN OUR LAKES USING E-DNA

Georgia Thomson-Laing is two-years into her PhD focused on the development and optimisation of DNA extraction and PCR methods to examine changes in fish and mussel environmental DNA in sediment cores. Investigating Lake Pounui (Wairarapa), she has used this approach to detect the native shortfin tuna (eel) and kākahi (mussel), detecting DNA pre-dating human occupation in this catchment. This new information allows us to start investigating relationships between non-native fish introductions and recent changes in lake health, i.e., water quality decline, cyanobacteria blooms and eutrophication. Further research is underway to use this approach to investigate and better understand the impacts of extreme storm events on lake ecosystems in Hawke's Bay.

MAKING SURE THAT TUNA (EELS) ARE SAFE TO EAT

We have started a new project with The Whakakī Lake Trust and the New Zealand Food Safety Science and Research Centre – He pākū ā uta, he pākū a rō wai / Food from the land, food from the water. Vision Mātauranga Capability Funding will enable the team to dive deep into the potential risks posed by the accumulation of cyanobacterial toxins (cyanotoxins) in tuna from Whakakī Lake (located north of Wairoa). The project aims to better understand how the water quality of Whakakī Lake (cyanobacteria and cyanotoxin concentrations and how they change through the year) relates to cyanotoxin concentrations in tuna harvested from the lake, and to determine when tuna are safe to eat. Cawthron researchers are Jonathan Puddick, Emillie Burger, Tim Harwood, Cath McLeod and Summer Scholarship recipient Sylvia Orr.

A FRAMEWORK FOR SELECTING REFERENCE STREAMS

Selecting appropriate reference conditions remains important for assessing current state in rivers and setting appropriate targets for improvement if needed. Cawthron has developed a framework for selecting reference streams by defining a projected reference state using a set of catchment land cover criteria. This framework facilitates the identification of reference sites for specific stream types and locates them via an interactive map. Identified reference sites can then be used for a range of applications, such as informing the strategic sampling of reference streams to develop stream-type specific MCI thresholds (a process that Otago RC and Tasman DC are following). Cawthron researchers involved are Annika Wagenhoff and Paula Casanovas.

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Beca

EXPERTS WANTED FOR NEW FRESHWATER SERVICE

By Raymond Chang, Beca, A2E Programme Director

A new service designed to help restore and protect the health of our waterways is launching across the motu – and could well benefit from your expertise.

It's called A2E – Access to Experts.

With support from the Ministry for the Environment and run by Beca and NZ Landcare Trust, the service will give assistance to regional council staff, community groups and iwi to implement the government's Essential Freshwater reform package by connecting them to specialists who can advise on everything from nutrients and sediments to wetlands and mahinga kai.

Here's where you come in. If you're a freshwater subject matter expert interested in joining our panel and helping those who could use your expertise, we'd like to hear from you.

We're looking for those who can provide support and guidance on all aspects of the Essential Freshwater Reform package (with the exception of Freshwater Farm Plans which will be supported by a separate piece of work from MfE). Examples of this could be in areas of the National Policy Statement for Freshwater Management such as:

- Developing freshwater management plans
- Integrating mātauranga Māori into freshwater management
- Setting nutrient limits
- Reducing sediment loads
- Managing wetlands.

Support could include technical, policy or more general expertise. The service is focused on building capability, not capacity – experts are intended to provide advice but not implement actions (like monitoring) themselves. Your time and involvement will be scoped and agreed up front.

Once we 'match' you to someone needing assistance, you'll be paid for your advice and support.

Your expert knowledge could help:

- Community catchment groups that have seen something that's not right or want to build on their existing data for their next move.
- Regional councils wanting to create a model for nutrient limit setting, as well as an expert to check, review, and assess the methodology and outcomes.
- Iwi and Māori who want to contribute to applying Te Mana o te Wai in their region.

We all want to see Aotearoa New Zealand's rivers, streams and wetlands restored and protected. If you'd like to contribute to this important mahi, we have the people who'll need your help.

You may also be connected to catchment groups or be part of our target market. If you think the service can help, we're keen to hear how our service can support you in achieving outcomes associated with the Essential Freshwater reform package.

To register your services and/or request support for your council, community group or iwi:

- Visit us online at access2experts.net.nz
- Email freshwater@access2experts.net.nz
- Call our team 0800 MFE A2E (0800 633 223)

Ka ora te wai, Ka ora te whenua. Ka ora te whenua, Ka ora te tangata.

If the water is healthy, the land will be nourished. If the land is nourished, the people will be provided for.

ORGANISATION UPDATES

Tonkin + Taylor

NEW STAFF

2022 has again seen a number of changes in staff for the Tonkin + Taylor Ecology & Water Science Team now with 53 specialists in the wider team! This includes new starts, those going on and coming back from parental leave, as well as summer interns. New permanent staff in the freshwater space include Jamie MacKay, Jasmine Dungey and Monique Watson (Auckland); Alice Dee (Hamilton). Rob Van de Munckhof has also moved from our Environmental Engineering team into the Science space to better integrate water quality and ecology in our projects. We loved having Ruby Leeves as a summer intern this year and we are so excited that Liza Kabrle and Kylie Park are now back from maternity leave.

ORGANISATION UPDATE

We continue to see growth in the freshwater space, and a wide range of projects have drawn on the expertise of our freshwater specialists throughout the past year across all our market sectors. We are keeping a close eye on the changes to freshwater legislation at a national level; keeping our clients abreast of the changes is particularly important. These changes alongside the incoming Natural and Built Environments Act, have reinforced to us the need for an ecosystem approach. Our marine, freshwater and terrestrial specialists continue to work closely together to provide cohesive and holistic advice, embracing te mana o te wai and ki uta ki tai.

Many of our team attended and enjoyed face-to-face interactions with clients and other specialists at conferences and events this year. These included the NZFSS, Rivers Group, NZ Ecological Society and Water NZ Stormwater conference and several Environment Institute of Australia and New Zealand events. With freshwater being in the regulatory spotlight, we also had representatives at the Resource Management Law Association conference. Members of our team continue to have extracurricular involvement in the Rivers Group, Fish Passage Advisory Group and NZFSS.

FEATURE PROJECTS

Ecology and water quality services to the Energy Sector

T+T's project work in the Energy Sector has been growing and diversifying with freshwater science services covering water quality, stream, river, lake and wetland ecology and fluvial geomorphology. Our clients in this sector include Manawa Energy, Mercury NZ, Genesis Energy, Meridian and Transpower among others. Our specialists have been providing advice on national and regional policy changes, undertaking investigations for new and existing hydro, wind and solar generation and preparing and implementing ecological management plans for current construction projects.

Dean Miller, Peter Cochrane, Justine Quinn and Selene Conn continue to provide specialist technical advice and guidance to our energy industry clients covering water quality, fluvial geomorphology and wetlands. Steven Pratt, Kylie Park, Duncan Law, Georgia Cummings, Kate Rogers, Claire Bullock, Laura Francis, Tumanako Ritchie, Clare Wilkinson and Sam Heggie Gracie are busy 'on the ground' assisting our clients with ecological and environmental consent investigations and monitoring programmes for a variety of hydro schemes, windfarm and transmission projects throughout NZ.

Freshwater ecology work within the waste sector

T+T has had a busy year within the waste sector, supporting both private and council clients with a variety of projects in regions including Auckland, Waikato, Hawkes Bay, Wellington, Canterbury and Otago. Working with existing and new projects, our work has involved everything from high level strategic advice, specialist consent processing support for councils, technical investigations and reporting for consent applications, as well as monitoring and fauna salvaging.

In the Auckland region Kylie, Danielle Cairns, Shaun

Images, clockwise from top: Awataha Stream in its final stages of daylighting (photo: Justine Quinn); Counting fish in the lower Maitai River, Nelson (photo: Patrick Lees); Rosa Kirkham with a giant kōkopu captured from the Mimi Stream, Taranaki (photo: Mike Lake); Jasmine Dungey setting a fyke net in the Mimi Stream, Taranaki (photo: Mike Lake).

Morgan and Kate have been involved in baseline water quality and ecological assessments to inform consenting of a new proposed modern landfill. Justine and Rob spent much of 2022 presenting this work in Environment Court. Lucky Sam got to head to Great Barrier Island and Dean, Rob, Claire and Toni Shell have been assisting clients in the Waikato, Hawkes Bay and Wellington regions with consenting the next stages of existing landfills.

In the Christchurch region, Duncan and Patrick Lees have provided technical advice in response to closed landfill remediation works for our clients. This work has also involved undertaking īnanga spawning habitat assessment and the response of banded kōkopu populations to an unforeseen discharge event. Heading further south, Josh Markham and Mike Lake have been supporting Otago Regional Council with technical advice reviewing consent applications.

Maitai Flood Management Options: Geomorphology and Ecology Assessment

Clare, Selene, Patrick, Mike, and Dean have been preparing an assessment of the geomorphic processes and ecologic values in the lower Maitai River (between Saltwater Creek and Hanby Park), for Nelson City Council. The purpose was to identify potential geomorphic and/or ecological constraints that may affect future flood management options.

Based on the results of the geomorphic and ecologic assessments, a number of constraints were identified that will be considered for any future flood mitigation or gravel management activities in the Maitai River.

Outputs.A project report that will be used by Nelson City Council to assist in developing future flood mitigation and gravel management plans.

Ecology and water quality services to New Zealand Steel

T+T is working alongside NZ Steel on a variety of freshwater science services covering water quality, and stream and wetland ecology. Our specialists have been providing advice on national and regional policy changes, continuation of long-term monitoring programmes, and the preparation of technical assessments for a reconsenting project.

Our work with NZ Steel includes several members of the T+T Ecology and Water Science team from around NZ. Rob, Patrick, Justine, Abbas Akbaripasand, John Ward, and Danielle continue to provide specialist technical advice and guidance to NZ Steel covering stream and wetland ecology, fish passage, and water quality. The team are also busy assisting NZ Steel with ecological and environmental enhancement investigations and the preparation of technical Ecological Impact Assessments for the replacement of the expiring Glenbrook Steel Mill stormwater and process water discharge permits.

Freshwater work for the Transport Sector

T+T's Ecology + Water Science team continues to contribute to transport projects across New Zealand. This work has involved everything from consenting to construction of 'big roads' and rail as well as strategic advice in the fish passage space.

Construction of Te Ara o Te Ata (Mt Messenger Bypass) is now in full swing with the Alliance team involved in ongoing fish salvage operations led on the ground by Alice. Mike, Rosa Kirkham and Jasmine Dungey have been continuing with the aquatic monitoring which has now entered the construction phase.

Mike is also the freshwater lead on the O Mahurangi (Penlink) roading project. The T+T team successfully submitted the required suite of management plans at the end of 2023 and Abbas and Danielle have been involved in fish salvage work to facilitate early works. Construction is expected to ramp up in the second half of 2023.

Construction of Te Ahu a Turanga Manawatū Tararua Highway is progressing well. David Pickett has been working with the project team during construction of new stream diversions to ensure the freshwater habitat requirement are met.

The opening of Ara Tūhono – Pūhoi to Warkworth motorway extension is approaching, and Duncan Law has been reviewing the projects stream diversions to ensure that the freshwater habitat provided meets the requirements to mitigate for the loss of stream on the project.

Stream daylighting and instream restoration

Tonkin & Taylor have been working on a variety of

2 year wetland restoration monitoring in the Wellington Region. Photo: David Pickett.

stream enhancement projects, particularly in the northern parts of the motu.

Selene, Andrew Steele and Justine are thrilled to see the final product of several years of hard mahi with the daylighting of the Awataha Stream in Tāmaki Makaurau. This was a great example of cross-discipline collaboration, with T+T fluvial geomorphology, civil engineering and ecology experts working alongside our project partners, mana whenua and the community to bring this hidden gem to the surface.

Andrew, Selene, Jasmine and Justine also worked collaboratively to design instream restoration measures for a small stream with important community and cultural values. They incorporated a number of measures to improve fish passage, enhance instream habitat and reduce severe erosion in a remnant section of urban stream which is home to banded kōkopu and shortfin eels / tuna.

In Tauranga, Selene has been leading the ecological and geomorphological inputs for restoration and enhancement of the Kopurererua Valley Reserve. This has included realignment and restoration of a reach of the Kopurererua River, to improve freshwater habitat and amenity values. The project also aims to reinstate a historic wetland to improve both ecological and cultural values, as well as add to climate change resilience for the city. Rosa and Mike will be heading up the freshwater fauna management as the old, straightened channel is infilled and the new, enhanced channel is livened.

Pohe Enviro

It's been a case of 'heads down, tails up' this past year. Everything seems to be just that little bit harder to do, and there's not quite the time to do it in. Steve has ramped up the bread and butter part of the business again, taking on more aquatic biodiversity surveys and biomonitoring type work, processing and identifying benthic invertebrate samples for SoE monitoring, and adult aquatic insects collected with light and intercept traps. Steve also continues his research, to improve our understanding of aquatic insect biodiversity, with current projects looking at:

- Mayfly taxonomy, ecology, and conservation
- Mayfly phylogenetics, in collaboration with Lara Shepherd (Te Papa–Museum of New Zealand), Olly Ball (Wildlands), Mike Winterbourn (University of Canterbury) and Sharyn Goldstien (Science Synthesiser)
- Assessing methods used to survey and monitor aquatic insect biodiversity, in collaboration with Brian Smith (NIWA), Olly Ball, Russell Death (Massey University), Mike Winterbourn and Tom Drinan (Department of Conservation)
- 'Data Deficient' EPT insect distributions, in collaboration with Olly Ball, Elizabeth Graham (NIWA) and Brian Smith (NIWA), and terrestrial amphipod and spider diversity and conservation status in collaboration with Olly Ball and Mike Fitzgerald (Te Papa–Museum of New Zealand)
- An autecological study of the mayfly Acanthophlebia cruentata, in collaboration with Steven Trewick, Ian Henderson and Mary Morgan-Richards (all Massey University). Note: This published work is the most comprehensive New Zealand aquatic insect population genetics study to date, showing clear patterns of haplotype diversity for this species (see: https://doi.org/10.3390/insects13070567)
- An autecological study of the mayfly genus Ichthybotus, in collaboration with Steven Trewick, Charlotte Bridger (Massey University MSc student) and Mary Morgan-Richards
- Testing the effectiveness of eDNA for detecting aquatic insects, in collaboration with Graham McCulloch (University of Otago), Shaun Wilkinson (Wilderlab) and Tom Drinan (Department of Conservation)
- Development of an aquatic insect voucher collection and DNA barcode library, an EnviroLink funded initiative done in collaboration with various regional council staff, and interested stakeholders

Publications

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EOS Ecology

Cut Slope Soil Erosion Control Trial

EOS Ecology completed their three-year monitoring programme (2019–2022) to assess the best combination of 'soft' erosion control measures to reduce erosion and sediment runoff from loess cut slopes, to support the reduction of sediment inputs to streams and Whakaraupō/Lyttelton Harbour. The work marked the culmination of an eight-year programme supported by Christchurch City Council (CCC), Environment Canterbury, and the Banks Peninsula Zone Committee. Following an initial desktop study in 2015, EOS Ecology undertook a pilot study to summarise the existing knowledge of erosion around the Harbour, define the character of road-side cuttings around Whakaraupō, and identify possible locations for undertaking field trials of erosion control methods. In 2018 scientists from EOS Ecology and Manaaki Whenua-Landcare Research undertook more detailed site investigations to short-list potential field trial sites and develop an appropriate construction design and experimental setup. Having agreed on a suitable site along an access road within the Christchurch Adventure Park (CAP), Shelley McMurtrie and the EOS Ecology team, along with specialists from Manaaki Whenua-Landcare Research (Ian Lynn, Robyn Simcock and Colin Meurk), oversaw construction work to make the site suitable to implement a replicated study, and application of different erosion control products and plants in 2019. From 2019–2022 EOS staff undertook detailed monitoring of the trial plots, including development of erosion features, product condition and coverage, and plant growth, condition, and coverage. The results of the study have been written up in a technical report along with a summary report for wider dissemination. These will be made available online.

Outputs:

- CCC, Cut Slope Soil Erosion Control Trial – CAP Site 1: Report Summary (2022)
- CCC, Cut Slope Soil Erosion Control Trial – CAP Site 1: Year 3 Monitoring Report (2022)

Tararua District Dairy Farm Freshwater Survey

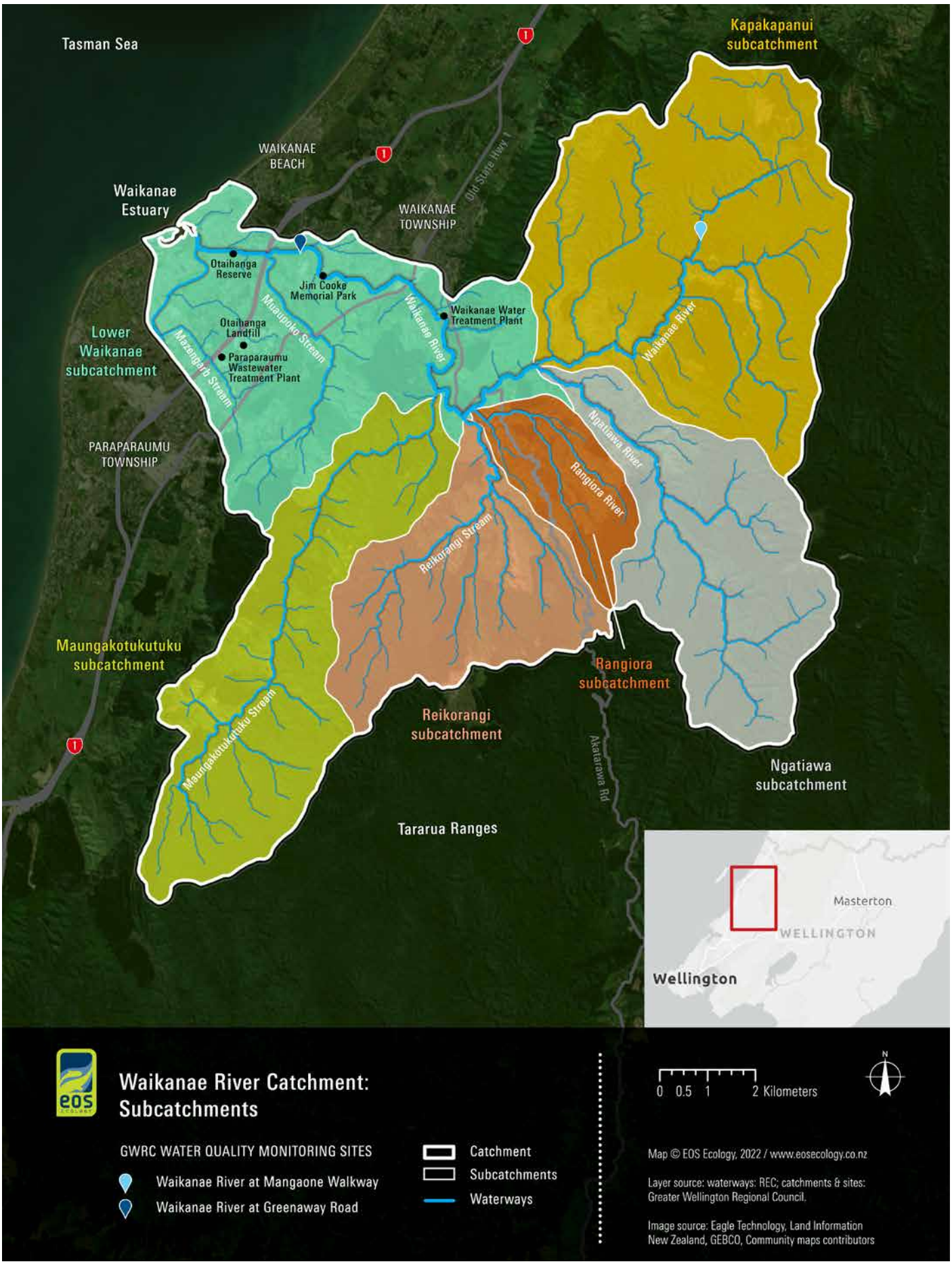
In 2021 DairyNZ began a farmer-led, monthly water quality monitoring programme at 21 stream sites in the Tararua District (upper Manawatū River catchment) where dairy farming is the dominant catchment land use. For the last three years Alex James has collected macroinvertebrate samples and habitat data annually from the same sites, following the Horizons Regional Council SOE procedure. Macroinvertebrate samples were processed by our lab team of Emily Demchick, Ariana Painter, Oly Hall, and Ciara Espiner. To aid data interpretation, our science interpreter/graphic designer Bronwyn Gay creates a large format summary map for use at farmer open days that is updated each year with the latest data.

Outputs:

- Dataset
- Large format map summarizing site MCI scores.

Waikanae River Catchment & Estuary: Biodiversity Information Review

The Waikanae River catchment is part of the Department of Conservation's Ngā Awa River Restoration Programme, which is about taking a whole catchment approach, and working in partnership with others to restore the biodiversity of priority catchments from the mountains to the sea. During 2022, Zoë Dewson researched and wrote a biodiversity information review for the Waikanae River catchment and estuary to support their ongoing work in this catchment. The report gathered existing information on the biodiversity of the catchment, as well as summarising the pressures on the catchment and making recommendations for research and survey work that would fill the identified knowledge gaps. The report was illustrated with maps prepared by Ariana Painter & Bronwyn Gay, displaying the subcatchments, land use, locations of fish and invertebrate records, as well as known fish barriers.



River catchment map, including major subcatchments and the locations of Greater Wellington Regional Council (GWRC) long term water quality monitoring sites.

Outputs:

- Report available online: www.doc.govt.nz/globalassets/documents/our-work/nga-awa-river-restoration/waikanae-river-and-estuary-catchment-biodiversity-information-review.pdf

Supporting Regional Council Science Teams

The EOS Ecology team has been working with both Greater Wellington and Environment Canterbury to support their technical and science teams. Shelley McMurtrie & Bronwyn Gay produced a technical science writing guide for Environment Canterbury's science team to support their staff writing science reports, while Shelley McMurtrie, Liz Butcher, and Bronwyn Gay produced a guidance document for Greater Wellington regarding the most suitable digital data collection options for freshwater citizen science programmes.

Outputs:

- Environment Canterbury, Science Report Writing Guide for Staff (2022)
- Greater Wellington, Digital Data Collection for Freshwater Citizen Science (2022)

Teviotdale Forest Harvest Monitoring Programme

Following on from an AEE for the proposed forest harvesting of the Teviotdale forest on waterways within the Selby Stream catchment in Mid Canterbury, the EOS Ecology team (Zoe Dewson, Shelley McMurtrie, Emily Demchick, Ariana Painter) has since developed and implemented a biological monitoring programme to assess sediment-related effects during the harvesting and post-harvesting period. This included field work to determine flow periodicity of waterways within the catchment, and approval of the monitoring programme by Environment Canterbury prior to implementation of the pre-harvest monitoring.

Outputs:

- Teviotdale Forest Harvest: Ecological Monitoring Programme for Upper Selby Stream (2022)
- GIS mapping of flow
- Pre-harvest Monitoring Report

Mid Canterbury Catchment Collective

EOS Ecology provided specialist ecological advice to contribute to the development of a catchment framework for the Mid Canterbury Catchment Collective (MCCC), which aims to unite rural communities to protect their local environments. Members of the EOS science (Shelley McMurtrie, Alex James, Zoe Dewson), GIS (Ariana Painter), and interpretation/design (Bronwyn Gay) teams sourced, analysed and summarised water quality, fish, and invertebrate data from Environment Canterbury and other sources. This provided an overview of the existing ecological knowledge within the Hekeao/Hinds lowland, Hekeao/Hinds hill country, and the foothills catchment group areas. This data was represented via GIS-based map output files that included the classification of waterway types based on GIS-sourced information on topography, waterway size, and channel form, along with identifying knowledge gaps and how the collective could fill these.

Outputs:

- Mid Canterbury Catchment Collective, Catchment Map Report (2022)

Ōtaki to North of Levin – New 24 km Section of SH1

Alex James has continued working on the proposed Ōtaki to North of Levin highway (Ō2NL Project), a new 24 km section of SH1 in the Horowhenua. Alex has completed the fieldwork and technical freshwater effects assessments that have been lodged in support of the Project's Notices of Requirement and resource consent applications which were lodged on 1 November 2022. He is currently involved in various post-lodgment tasks, such as addressing further information requests, public submissions, and writing evidence for the forthcoming Environment Court hearings phase. As part of the project's biodiversity offsetting package Alex has also been identifying suitable locations for stream enhancement, including meeting with Project iwi partners, the Department of Conservation, Forest and Bird, Councils, landowners and undertaking fieldwork.

Outputs:

- Various presentations and a technical assessment which can be found at https://nzta.govt.nz/assets/projects/o2nl-proposed-new-highway/consent-applications/Vol-4-Final-Technical-Assessment-K-Freshwater-Ecology-v2.pdf

Top: Cut Slope Soil Erosion Control Trial. EOS Ecology team undertaking the first round of plot monitoring.

Bottom: Ōtaki to North of Levin – New 24 km Section of SH1. Potential stream offsetting site on the Manakau Stream.

Science Interpretation & Design

Bronwyn Gay worked on a number of interesting projects over the year, providing plain English writing and easy to understand graphics with a professional finish. The latest version of the New Zealand Environmental Perceptions Survey: 2022 (now undertaken by Manaaki Whenua-Landcare Research) is a continuation of a series she has produced over the years. She also worked with Greater Wellington to produce two of their best-practice guides – Good Practices for the Mechanical Management of Highly Modified Waterways and Managing Adverse Effects on Indigenous Biodiversity in the Wellington Region.

Outputs:

- Manaaki Whenua-Landcare Research, New Zealand Environmental Perceptions Survey (2022)
- Greater Wellington, Good Practices for the Mechanical Management of Highly Modified Waterways (2022)
- Greater Wellington, Managing Adverse Effects on Indigenous Biodiversity in the Wellington Region (2002)

Transition to Use of the NEMS Macroinvertebrates Processing Protocols

With the release of the National Environmental Monitoring Standards (NEMS) Macroinvertebrates protocols in June 2022, regional councils have now begun the transition to using these protocols for their State of the Environment macroinvertebrate samples. Having provided expert advice to the NEMS working group as part of the laboratory advisory panel, the EOS team is very familiar with the details of the protocols and how to apply them and have thus been able to support regional councils through this transition process. The laboratory team of Nick Hempston, Emily Demchick, Ariana Painter, Oly Hall, and Ciara Espiner processed samples using the new methods in 2022 to provide regional councils with initial data on the implications of the change in methods.

Outputs:

- State of the Environment macroinvertebrate samples.

'Nature Agents – Ngā Kaitaunaki Taiao'

The number of schools now monitoring their local awa with the support of the EOS Ecology 'Nature Agents – Ngā Kaitaunaki Taiao' participatory science programme (funded by the Ministry of Education's 'Enriching Local Curriculum' programme) has grown to 40 as we start to expand beyond Ōtautahi/Christchurch into Selwyn and Waimakariri. Over the past few months, we've built on our existing award-winning ArcGIS module to create the 'Nature Agents' online hub site. With Nathan McKinley (Geospatial Manager) and Jessica Halsey (Engagement Manager) coming onboard, they've worked with the existing science and design teams to look at how to make the data collection/entry easier for teachers and students. This greatly simplifies the data entry process so teachers can focus on engaging students with the science concepts and looking after their awa. This will also play a key role in the creation of our upcoming Years 9+ programme for high schools.

Outputs:

- Online data hub – www.natureagents.co.nz

Publications:

Butcher, E. & Gay, B. 2022. Digital Data Collection for Freshwater Citizen Science. EOS Ecology Report No. GRE01-21055-01. 33 p.

Dewson, Z. 2022. Waikanae River Catchment & Estuary: Biodiversity Information Review, Summary of Pressures, and Recommendations. EOS Ecology Report No. DEP01-22005-01. 44 p.

McMurtrie, S. 2022. Cut Slope Soil Erosion Control Trial – CAP Site 1: Report Summary. EOS Ecology Report No. CHR01-20077-03. 50 p.

McMurtrie, S., James, A., Lyn, I., Meurk, C. & Simcock, R. 2022. Cut slope soil erosion control trial CAP Site 1: Year 3 monitoring report. EOS Ecology Report No. CHR01-20077-02. 84 p.

Stark Environmental

John and Yvonne Stark established Stark Environmental Limited (SEL) in June 2007 and have been offering specialist freshwater ecological research and consulting services (primarily concerned with macroinvertebrates, biotic indices, and biomonitoring) and processing macroinvertebrate samples for over 15 years. Over the years we have employed part-time staff to assist, but since Covid-19 surfaced we have managed on our own and had our busiest years.

Sample processing dominates our activity these days and in the past 12 months we processed over 1000 samples for 19 different clients from throughout New Zealand and prepared nine consent biomonitoring reports. Overall, SEL has prepared 182 client reports and processed over 11,000 samples for 70 different clients.

John and Yvonne have had SuperGold cards for a few years now and are still working towards retirement. In the last two years we have had discussions with people that were interested in taking over our business. The fifth of these, however, is the brightest prospect and we are confident that a mutually agreeable arrangement will be reached in coming months. It is likely that Yvonne and John will assist the new owners and staff with the business during a transition period (especially training staff to process samples), so complete retirement is not imminent.

We are confident that the standard of service that our existing clients have experienced will be maintained and that the business will have the capacity to take on even more work in future.

Ecology NZ

NEW STAFF OR STUDENTS

Francis Dale, Ashlee Cooper, Carrie Reyden, Melanie Vermeulen, Matthew Moore, Sophie Carr, Hong Yao Lim, Susannah Graham, Doug Bridge, Elena Miller.

ORGANISATION UPDATE

We are excited to introduce Ecology New Zealand, a leading provider of professional ecological services throughout New Zealand. As part of the Omah Group of companies, Ecology New Zealand specialize in terrestrial, freshwater, and marine ecology, while our sister companies offer biosecurity services, infrastructure ground development and training.

With an office in Auckland and recently established office in Hamilton, we are dedicated to expanding our services to other areas of New Zealand. Over the past year, we have significantly grown our team at various professional levels, enabling us to provide top-quality ecological services to our clients.

Our team of freshwater specialists, including Chad Croft, Dylan Smith, and Melanie Vermeulen, bring a wealth of experience in ecological project management, impact assessments, mitigation and restoration, fish surveys and rescues, stream habitat assessments, biological monitoring, and fauna management.

We are thrilled to contribute to the NZFSS annual letter for the first time and are committed to collaborating with the freshwater community to sustainably manage New Zealand's unique freshwater ecosystems.

FEATURE PROJECTS

Te Awa Lakes Ecological Rehabilitation Management Plan (ERMP)

Te Awa Lakes is a multi-stage development for a planned community at Horotiu, Hamilton. Ecology New Zealand was commissioned to implement the ERMP which has involved fauna management for lizards, bats, birds and fish. On the freshwater front, our team has prepared multiple Ecological Impact Assessments for the wetlands, lakes and gully and provided specific culvert fish passage and water quality advice, dabchick management, fish salvage and translocation. As a result of our efforts, we were able to save a total of 1100 shortfin eels so far. Staff involved: Dylan Smith, Melanie Vermeulen, Ashlee Cooper, Matthew Moore, Carrie Reyden, Chad Croft.

Peacocke Whatukooruru Drive Mudfish Survey

The Southern Links project in the Waikato aims to develop a strong transport network for Hamilton city's growth. Ecology New Zealand conducted an ecological impact assessment as part of the Peacocke Whatukooruru road construction's resource consent process. A fish survey was carried out to identify freshwater values, with a focus on detecting black mudfish, found in the Waikato and conservation-listed as At Risk-Declining. The survey used multiple methods including trapping, spotlighting and eDNA but only eDNA sampling detected black mudfish, demonstrating the importance of a multi-method approach. Other native species found were shortfin eel, longfin eel, banded kōkopu, giant kōkopu, and redfin bully. Staff involved: Dylan Smith, Ashlee Cooper, Francis Dale, Kelly Hayhurst.

Waikato River Bridge Construction

Ecology New Zealand has played a key role in the construction of a new bridge connecting Peacockes and State Highway 1 in Kirikiriroa. Our team has been involved in various terrestrial and aquatic roles including fish passage design advice, ecological impact assessments, management plans and implementation. Staff involved: Dylan Smith, Chad Croft, Kelly Hayhurst, Francis Dale.

Clevedon Culvert Replacement

Ecology New Zealand was commissioned by Auckland Council to provide an ecological impact assessment and subsequent fauna management plans including best practice fish passage design for a culvert replacement project in Clevedon. Staff involved: Dylan Smith, Chad Croft, Melanie Vermeulen.

Translocation of shortfin eel from a reclaimed pond.