NIWA research on NZ lakes and rivers: water quality, landuse pressures, monitoring, ecological responses and restoration tools

Overview

It is our pleasure to welcome you to this mini conference and workshop in Hamilton on the 4th of May 2015. The programme has been designed to align with Waicare's water quality monitoring, education and action programme for community groups, individuals, businesses and schools. The challenge of increasing pressure on freshwater systems is pressing at a time of continuing landuse intensification and a viewpoint that environmental trade-offs are necessary to support improvements in New Zealand's economic performance. The speakers at this conference have been selected to showcase both recent and ongoing research undertaken by NIWA scientists on the current state of water quality monitoring in New Zealand, the role of, and importance of, community groups and citizen scientists for extending monitoring and embracing restoration programmes, the ecological responses of aquatic life to increasing environmental pressures, and restoration tools to help alleviate the effects of intensification. We hope you find the day useful and informative.

Agenda

Work programme

Time/topic	
10:30-10:40	Introductions, quick cup of tea and seated
10:40-11:00 **Water quality monitoring in NZ – setting the scene**	10:40-11:00: Rob Davies-Colley - Water Quality Monitoring In New Zealand. Recent Changes And Future Directions
11:00-12:00 **Community group monitoring of freshwaters**	11:00-11:20: Aslan Wright-Stow - Stream monitoring by volunteers and professionals: do they tell the same story? 11:20-11:40: John Quinn - Te Awa O Waitoa stream restoration case study: it takes a community to restore a stream 11:40-12:00: Rebecca Stott – Wai care about E. coli?
12:00-12:30 **Lunch**	
	12:30-12:50: Elizabeth Graham – Land use impacts and restoration effects on invertebrate community structure and turnover

Time/topic	
12:30-2:00 **Invertebrate ecological responses to landuse pressures**	12:50-1:10: Richard Storey - Connectivity and macro-invertebrate drift influence stream restoration outcomes 1:10-1:30: Brian Smith – Impacts of landuse pressure on caddisflies and where they can lay their eggs 1:30-2:00: Sue Clearwater - Examining the potential impact of catfish and eels on declining koura populations in the upper Waikato River *and* Conservation of freshwater mussels in New Zealand
2:00-2:20 **Barriers to fish passage: effects and solutions**	2:00-2:20: Josh Smith – Fish passage barriers
2:20-2:40 **Cup of tea**	
2:40-3:00 **Pressures on lakes**	2:40-3:00: Tracey Burton – An overview of aquatic plants/freshwater biosecurity issues 3:00-3:20: Piet Verburg - Atmospheric nutrient loading, agriculture and their effects on WQ in lakes
3:20- **Workshop, wrap-up and discussions**	

Abstracts

Water quality monitoring in New Zealand. Recent changes and future directions

Robert J. Davies-Colley and Sandy H. Elliott

Introduction

Policy responses to widespread concern over water pollution, together with recent institutional changes and technological innovations, are driving changes in water quality monitoring in Aotearoa/New Zealand (NZ). The National Institute of Water and Atmospheric Research Ltd (NIWA) has operated the National Rivers Water Quality Network (NRWQN) at 77 river sites in NZ for 26 years, while 16 regional authorities have collectively monitored considerably more sites (albeit mostly for shorter periods) to support their mandate to manage environmental condition regionally. NIWA is now reducing the number of water quality sites it monitors so as to concentrate on monitoring innovations, while increased consistency of monitoring across the regions should improve future national-scale state-of-environment (SoE) reporting. This paper over-views current operational changes in water quality monitoring in NZ, and discusses likely future directions for monitoring research and development.

A brief history of water quality and its monitoring in NZ

The most comprehensive and long-running water quality monitoring network in NZ is the NRWQN – which comprises monthly monitoring at 77 sites on 35 major river systems that collectively drain half the national land area (Davies-Colley et al. 2011). The consistency and stability of the NRWQN has resulted in it being the main platform for analysis of environmental state and trend of New Zealand rivers. For example, the NRWQN records a reduction in point pollution, but increasing diffuse pollution more recently, particularly as dairying has expanded (Howard-Williams et al. 2011; Ballantine and Davies-Colley 2013). Major diffuse pollutants, notably nitrogen and E. coli, correlate strongly with proportions of catchments in pasture (Davies-Colley 2013).

The NRWQN has also been the main platform for the development of national-scale statistical modelling of water quality, particularly nutrients using the SPARROW model framework (e.g., Elliott et al. 2005).

A much larger number of river sites (~ 1000) are, or have been, monitored, collectively, by New Zealand's 16 regional authorities, although very few of these sites have been running longer than the NRWQN. Unfortunately, monitored variables and protocols differ in different regions of the country, and this inconsistency continues to make for severe difficulties with aggregation of datasets for national state and trend reporting.

Changes in water quality monitoring in NZ

Recent policy initiatives in NZ, particularly the National Policy Statement for Freshwater Management (NPS-FM 2014), are driving an increased need for reliable and consistent water quality monitoring. The NZ Ministry for the Environment, the main (national) environmental reporting agency, recently sought to improve the consistency and "reliability" (i.e., accuracy) of regional SoE monitoring of waters. The NRWQN was identified as a model for regional SoE monitoring, and regional authorities are currently adopting NRWQN variables and protocols.

With regional SoE monitoring expected to become increasingly (nationally) consistent in future, there is less need for operational SoE monitoring at national scale. Consequently, NIWA is reducing its water quality monitoring operations by transferring some NRWQN sites to regional authorities, while consolidating efforts at a lesser number of 'Benchmark' sites that are intended to demonstrate best practice in operational monitoring. The Benchmark Network will also provide a test-bed for monitoring innovations that are expected, over time, to improve SoE monitoring in NZ.

The NPS-FM (2014) also anticipates increased community involvement in water planning, and this may be expected to promote increased community monitoring activity on waters – ideally supported by professionals in regional authorities.

Future directions for water quality monitoring research and development in NZ

We anticipate the following major areas of development in water quality monitoring in NZ, based particularly, but not exclusively, on innovation at Benchmark sites.

• Better integration of water quality with hydrometric (and sediment) monitoring and bio-monitoring to support SoE reporting

• Improved quality assurance (QA) in SoE monitoring. (The Benchmark network could provide a valuable focus for a national QA programme in SoE monitoring.)

• Continuous monitoring of water quality using datasondes, stand-alone sensors, and hyperspectral sensors to measure:

• oxygen and temperature (and potentially other 'physiological' variables) to characterise river metabolism and capture extrema that are damaging to aquatic life

• turbidity by nephelometry as a proxy for fine sediment, and some other variables (light attenuation, E. coli, total phosphorus) (e.g., Hughes et al. 2014)

• hyper-spectral UV-vis-NIR absorptiometers to detect a range of water constituents, most notably nitrate (e.g., Etheridge et al. 2014).

- Automatic sampling, particularly over hydrological events, so as to calibrate continuous sensors, notably turbidity, for improved load estimation of diffuse pollutants.

- Fostering community volunteer monitoring, often by catchment care groups conducting environmental restoration work such as riparian planting. Community volunteers need improved tools, as well as on-going support by regional authority staff and other professionals.

Conclusions

Water quality in NZ continues to be of high public concern as reflected in recent policy initiatives and increased community interest. Monitoring of water quality in NZ is changing as regional authorities become increasingly (nationally) consistent on variables and protocols, while NIWA is reducing national-scale operations so as to concentrate on innovation and QA. Continuous instrumental monitoring of water quality, supported by auto-sampling, seems likely to become increasingly important in NZ as elsewhere, reflecting technological innovations as well as policy demands.

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Stream monitoring by volunteers and professionals: do they tell the same story?

Wright-Stow, A.E., Storey, R. and Davies-Colley, R.

Monitoring water quality and aquatic biota actively engages communities with their local streams. Group members, and the wider community, learn to value freshwaters and understand the impacts on them. Such engagement is becoming increasingly important, as the New Zealand Government's recent freshwater reforms encourage greater stakeholder involvement in freshwater planning. But is monitoring useful only for education, or are the data themselves useful for empowering communities to engage in freshwater planning? And could the data be used, formally or informally, to extend regional authority monitoring networks both temporally and spatially? At present, stream data collected by volunteer groups is often perceived to lack the robustness and quality of data acquired by professional agencies such as government research institutes and regional councils. But overseas research suggests that community monitoring can be robust and useful if volunteer monitors have on-going professional support.

We are investigating the 'concordance' between community monitoring data and 'professional' State of Environment data, (obtained by regional councils). If the concordance is high, and community data can separate sites of good vs. poor health, this study may contribute to advancing community engagement in freshwater management in NZ, and open the opportunity for community groups to extend the monitoring capacity of regional councils.

Monitoring at twelve stream sites was undertaken at the same location and same time by both regional council staff and community volunteers, beginning in late summer 2014. Prior to starting, all community groups were given training by professionals on methods to measure water quality, habitat quality and aquatic biota (macroinvertebrates and periphyton) using inexpensive, commonly available field equipment. Water quality variables and periphyton were measured monthly whereas habitat quality and macroinvertebrate surveys were undertaken six-monthly (summer and winter). The SHMAK kit, developed by NIWA in the late 90's, was used as the basis for equipping community groups, but with pilot 'extensions' to include dissolved nutrient and oxygen kits, 'professional' quality black disc visual clarity equipment, and Petrifilm ® plates for measuring the faecal bacterial indicator, E. coli.

Here we present interim results from the first half of this 18 month study, comparing community group and regional council monitoring data on stream water quality, habitat quality and aquatic biota.

TE AWA O WAITAO STREAM RESTORATION CASE STUDY: IT TAKES A COMMUNITY TO RESTORE A STREAM

John Quinn, Thomas Cooper, Hinenui Cooper, Paula Blackett, Aslan Wright-Stow, Robyn Skelton

Waitao Stream flows from native forest headwaters into Tauranga Harbour's Rangataua Bay, crossing the locally iconic Kaiate Falls on the way. Half of the 3700 ha catchment is native bush and scrub, with around 40% in pasture and the remainder in pines. Since 2003, the stream's riparian zones have been progressively fenced and planted with native vegetation. Restoration was initiated by local hapu, who are landowners in the lower catchment in response to long-held concerns about the health of the stream and bay. Hinenui and Thomas Cooper played key roles for Nga Papaka o Rangataua in initiating "Te Awa o Waitao Restoration Project" as a collaboration between hapu, NZ Landcare Trust and NIWA. The relationship and project was founded on philosophies of (i) combining mātauranga Maori and contemporary science; and (ii) measuring social and biophysical responses to restoration actions.

Working in an "action research" mode, the results of baseline environmental and community/social monitoring and the restoration vision developed by Te Awa o Waitao were shared with the wider catchment community in workshops in 2007 and 2008. Some landowners had begun fencing and planting their stream banks and, with their new-found connections and common concerns, others came aboard to form the Waitao-Kaiate Environmental Group, now numbering around 15 families. The group runs a native plant nursery to grow locally-sourced native plants, assists landowner applications to Bay of Plenty Regional Council (BOPRC) for funding support, helps with planting days and runs a community notice board. The group also produces community newsletters and organises popular neighbourhood events such as picnics, quiz nights and art exhibitions. All of these activities not only bring the community together but also raise awareness of the individual landowners' environmental responsibilities while giving the opportunity for the residents to work more collaboratively in the various environmental activities.

Since 2003, 12 stream sites have been monitored, monthly for water temperature, clarity, pH and conductivity and bi-annually for SHMAK macroinvertebrates and fish, by local kaitiaki and NIWA. BOPRC has monitored water quality monthly at a lower river site since 1990 and currently monitor bathing water quality seasonally at Kaiate Falls. Social surveys were conducted in 2004, 2007 and 2011.

Results show improving trends in total nitrogen and dissolved reactive phosphorus. In addition there is improved clarity near the stream outlet and in general water clarity and temperature. SHMAK macroinvertebrate community index values have increased at headwater sites – some associated with community riparian fencing and planting actions. There are also recent signs of improved E. coli levels. Social surveys have shown increased local knowledge of the links between stream and harbour health and land activities/management and increased social capital over the course of the project.

Overall, the project suggests it takes a community to restore a stream and the process can help restore a community

Wai care about E. coli?

Stott, R, Davies-Colley, R, Storey, R, Wright-Stow, A, Winstanley, A, Tanner, C.

Introduction,

Health risks from faecal contamination of water are a major concern for communities. Community involvement in sampling and measurement of faecal indicator organisms using simple microbial water testing methods can be a significant driver of community capacity building and action to improve sanitation practices and environmental management.

In New Zealand, the 2014 National Policy Statement for Freshwater Management (NPS-FW) requires that water quality must be maintained or improved and that freshwater is to be managed to safeguard two compulsory national values ecosystem health and human health for recreation. These recent freshwater reforms (NPS-FM 2014) anticipate and encourage greater community involvement in water management which could certainly extend to monitoring. Already, many community groups around NZ are undertaking stream rehabilitation work but with limited monitoring to demonstrate the benefits to ecosystem health, water quality and public health from these efforts. Therefore opportunities to foster community engagement and "buy-in" from other stakeholders in water management and planning may not be fully realised.

We are conducting a study in NZ to trial the use of a simple microbial water testing method (Petrifilm™ E.coli plates) for volunteer monitoring of water quality as an extension of an existing community monitoring kit (SHMAK- the Stream Health Monitoring and Assessment Kit) that was originally developed about 15 years ago (Biggs et al. 2000) to support engagement and mobilisation of community volunteer monitoring. Common professional perception of volunteer monitoring is that it lacks robustness and quality assurance (QA). An objective of the study is therefore to compare community monitoring (citizen science) with that of professionally-collected data by regional councils for State of the Environment reporting and to assess the concordance of testing for E.coli, the preferred faecal indicator bacteria for freshwaters in NZ.

In Fiji, a collaborative project funded by NZAid is developing and demonstrating sustainable community water supply and wastewater treatment solutions for Fijian villages that protect public health and reduce contaminant loadings to surface and coastal waters. Social, scientific and engineering approaches have been integrated with local and indigenous knowledge, resources and infrastructure to engage the local community and build capacity at village level. An objective of this study was to raise community awareness of the linkages between water and health needed to underpin the implementation of water and wastewater infrastructure. Simple low-cost methods for determining faecal pollution levels in water were used to engage Fijian villagers (in particular focussing on women, children and water and health committee members) in water quality monitoring (surface and drinking water) alongside a variety of other participatory- based activities.

Here we report on our experiences in New Zealand and Fiji with microbial testing by communities.

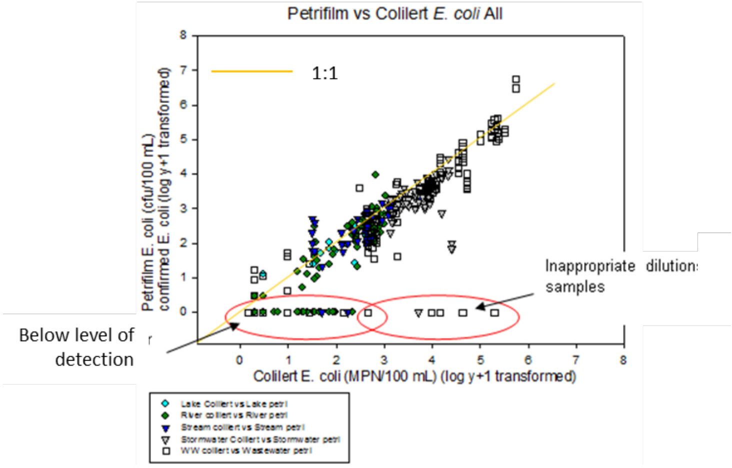
Methods

Petrifilm E.coli/coliform™ (3M 2010), and Compact Dry EC™ (Hyserve) tests (Fiji only) for E.coli enumeration and the hydrogen sulphide test (H2S) (WHO, 2002) as a general indicator of microbial contamination (Fiji only) were adapted for community use (Swales et al 2011) and used by communities in 3 Fijian villages and by 8 community groups in New Zealand. These community groups were selected from locations across New Zealand and paired with their local Regional Councils. In each location, the community group and council measure water quality (for a variety of variables including E.coli concentrations) at the same site over the same time period on a monthly basis. Community groups were given written and video instructions in the use of Petrifilm plates for E.coli enumeration with large volumes (up to 100ml) and supplied with a simple 35°C field incubator for incubation of E. coli on the Petrifilm media.

Results

Results from Petrifilm plates had previously been compared against a standard method (Colilert™) for low (<100 MPN/100mL), medium (102-103 MPN/100mL) and high densities (103-105 MPN/100mL) of E.coli in a variety of environmental waters in New Zealand. Overall concordance was good suggesting that Petrifilm may be a useful method for evaluating faecal pollution status of waters and one that may be suitable for inclusion in the SHMAK volunteer monitoring kit (Figure 1a).

With limited briefing, NZ community volunteers demonstrated competency in the use of Petrifilm and supporting equipment for the E.coli assay. Results show generally good agreement of volunteer measurements with that from Regional Council staff (using accredited laboratory methods) (Figure 1b).



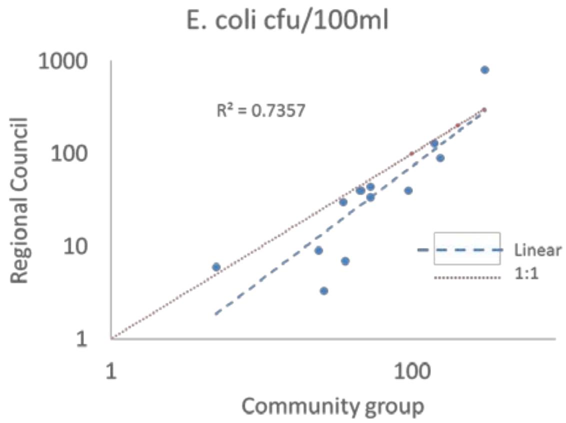


Figure 1. (a) Comparison of E.coli concentrations in a variety of water samples as measured by Petrifilm or Colilert (1:1 line shown for method comparison. (b). E.coli water measurements obtained by community groups compared with those by local regional council SOE staff (interim data).

For communities in Fiji, the H2S test provided a simple message and was particularly effective in engaging children in health and hygiene messages (Figure 2a). However the H2S showed only moderate concordance with E.coli suggesting it can only be considered as a proximate indicator of health risk and its resolution is generally insufficient for evaluating water supplies. In comparison, village participation in using simple E.coli enumeration methods provided a visual narrative of the contamination of surface water used for washing and recreation as it was possible to identify relative inputs into waterways and discriminate the main faecal contamination loading points into the river (Figure 2b and c). This was an effective tool in enhancing local capacity at village-scale to understand the linkage between water provision and use, wastewater management, health risks and environmental quality. Visualising the otherwise “unseen” microbiological faecal contamination has proven successful in facilitating village awareness of their accountability for water degradation and promoted a keener interest in taking on responsibility for environmental management. Furthermore, identifying the main sources of contamination (e.g. the impact of seepage from drains and piggeries on water contamination and re-contamination of household drinking supplies) has enabled targeting of action where the health benefits are likely to be greatest.

Figure 2. (a). Children using H2S to learn about hand hygiene, (b) participating in Petrifilm testing of waters in the village, (c) river profile of E.coli concentration upstream and downstream of the village

Conclusions

Simple microbiological methods to enumerate faecal indicator bacteria have proven to be reliable in community volunteer monitoring (citizen science) and effective in engaging communities in water quality management in New Zealand. Volunteer data were comparable with professional monitoring by regional authority field staff which should encourage regional councils to support greater community monitoring thereby empowering communities for greater engagement in water management

In Fiji, these low cost methods have proven to be a useful aid in raising community awareness of the linkages between water and health which has been crucial in supporting better management at village-scale of human and environmental health issues related to water pollution and to support the implementation of appropriate water and wastewater infrastructure.

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Landuse impacts and restoration effects on invertebrate community structure and turnover

Elizabeth Graham

Landuse change, particularly agricultural intensification and urbanisation, affects invertebrate communities in a variety of ways. First, there are anthropogenic inputs associated with each landuse change, including nutrients and/or pollutants. Second, removal of riparian vegetation affects temperature, instream plant growth, and terrestrial resources to stream food webs. Shifts in resource availability at the base of the food web often result in altered community composition at higher trophic levels, which can in turn affect food web shape and structure. One of the key questions in restoration is: can environmental restoration reverse or ameliorate these community-level changes? A short-term experiment in which terrestrial resources were reintroduced showed that defended generalist invertebrates such as snails continued to dominate communities even after resource availability and balance were restored, resulting in resistance of impacted communities to restoration efforts. Long-term experiments, on the other hand, have had more positive results, and do show that communities in restored sites become more similar to those in reference sites over long time scales (10-20 years). Furthermore, shifts in invertebrate communities post-restoration were significantly correlated with associated changes in environmental variables predicted to improve following restoration. This work reinforces the necessity of monitoring restored sites for many years post-intervention, and the role of temporal turnover as well as environmental change in structuring invertebrate communities.

Connectivity and macro-invertebrate drift influence stream restoration outcomes

Richard Storey, Sebastien Jobert, Sanjay Wadhwa, Chris Fowles and John Quinn

In the past, most stream restoration projects have proceeded without robust monitoring of ecological outcomes. The general assumption has been called the “field of dreams hypothesis”: If we build it, they will come. Now that monitoring is more common, ecologists are starting to discover that ecological outcomes are highly variable. In some cases, significant changes in macroinvertebrate community occur over just a few years. In other cases, no changes are detectable. One likely explanation is that macroinvertebrates are unable to reach restored habitats from source populations, either by drift or by flight. Our initial aim was to determine whether connectivity to a source of colonists makes a difference to the amount of improvement in the macroinvertebrate community following riparian enhancement. However, we first needed to determine whether connectivity makes a difference to the initial state of the invertebrate community (before riparian enhancement), and over what distances. Although there have been many studies on macroinvertebrate drift, there is still very little information on how drift shapes the macroinvertebrate community at different distances from the source. The Taranaki ringplain, a region of intensive dairy farming with an almost circular national park at its centre, is an ideal place to answer these questions. Over 100 stream sites monitored for up to 30 years are spread among two types of stream: those with their source within the national park (“IN” sites) and those arising outside the park (“OUT” sites). We found that among IN sites, the number of mayfly, stonefly and caddisfly taxa declined with increasing distance from the national park, whereas among OUT sites it did not. At a point about 4-5 km from the national park, the difference between IN sites and OUT sites was negligible, indicating that drift affects macroinvertebrate community composition over roughly this distance. Specialist forest-dwelling taxa at the IN sites also showed strong correlation with distance from the park, but some were found up to 20 km from the park. In addition, some forest-specialist taxa were found at OUT sites. This indicates that some insect taxa with strong flying ability (such as caddisflies) may be able to disperse up to 20 km from source populations. For people restoring streams, these results mean that sites within this distance of a colonist source have a good chance of restoring a reasonably complete forest-stream community if instream habitat is restored.

However, it may also mean that the change in community composition is not as great as at more distant sites, since many forest-dwelling taxa may already be present at the site before restoration works.

Oviposition rocks!

Brian J. Smith, Richard Storey, David J. Reid

A lack of suitable oviposition habitat may produce a bottleneck to successful recolonisation of restored streams by aquatic insects. Adult females returning to a stream may respond to a suite of cues when selecting an oviposition site. Egg mass distribution of different insect species is expected to vary both within and among stream reaches relative to hydrology and land use. What are these cues, and can we quantify them by characterising the occurrence and distributions of egg masses?

We recorded egg mass density and distributions of a selection of aquatic organisms (caddisflies, blackflies and a freshwater limpet) along transects within a 50m reach at six streams (three native forest, three agricultural) in spring and summer. Approximately 20 physical stream and channel parameters ranging from overhead riparian cover to substrate size and embeddedness were measured for each intersecting rock.

We tested whether the distribution of these egg masses varied between small (reach-level) and large (landuse) spatial scales, and determined what parameters were the best predictors of egg mass presence and density within a stream.

Results indicated the taxa considered here have a range of oviposition requirements and females do respond to physical cues when selecting suitable oviposition habitats. Egg mass abundance is affected by landuse, but this possibly due to a few species. At a coarse scale, clear oviposition preferences are shown by some taxa, and therefore successful recruitment from a range of taxa to restored streams will require a diversity of oviposition habitats.

DECLINING KŌURA POPULATIONS IN THE UPPER WAIKATO RIVER?

Clearwater, S.J, Quinn, J. Kusabs I.

In early 2014 an 80km section of the upper Waikato River was surveyed from Huka Falls to Ātiamuri dam to determine the current distribution of freshwater crayfish (Paranephrops planifrons) or kōura. The survey included the three most upstream hydro lakes, Aratiatia, Ohakurī and Ātiamuri. Divers revisited transects where crayfish were observed in the mid 1990’s, and additional locations offering apparently favourable habitat (as the earlier surveys did not target crayfish). The dive survey was followed by a trapping survey using tau kōura (a traditional Māori method of crayfish harvest using bundles of bracken fern) modified for a riverine environment. Thirty-three tau kōura bundles were deployed for seven weeks at locations distributed amongst riverine and lacustrine sections of the hydro lakes, and up- and down-stream of major geothermal inputs such as Orākei-Kōrako.

Crayfish were found in moderate densities from Huka Falls to the confluence with Wairākei Stream (3 km). From Wairākei Stream to approximately 1 km downstream of Wairākei Geothermal Power Station crayfish were present in low densities. No crayfish were found further downstream in Lake Aratiatia just upstream of the dam, downstream of Aratiatia dam in the riverine section around Ohaki, Lake Ohakurī, nor in Lake Ātiamuri.

A review of published information on the eight Waikato River hydro lakes from the late 1980’s until the present indicates that crayfish densities decreased around the mid until the late 1990’s and are now low or absent – there is sparse information about the last 15 years. The decline in crayfish abundance is generally coincident with the arrival of catfish Ameiurus nebulosus in the early 1990's and the stocking of elvers (juvenile longfin eel Anguilla dieffenbachii and juvenile shortfin eels A. australis) in the hydro lakes from 1992 onwards. The overlap of the establishment of eels and catfish in the lakes makes it difficult to separate any potential impact that each species has on crayfish populations, for example through mechanisms such as increased predation pressure or habitat modification. The data indicate that when eels are not present that crayfish can sustain the presence of catfish at low densities. Both species are still present in the Huka Falls to Lake Aratiatia section of the river. At higher densities of catfish, or higher combined densities of eels and catfish, crayfish densities are consistently lower. There is limited information about the effect of eels on crayfish in the absence of catfish in the hydro lakes. The present study was focussed on the potential impact of catfish and eels, however, other factors may be causing, or contributing to the decline of crayfish in the upper Waikato, for example disease, loss of edge habitat due to flow-ramping for hydro power generation, sedimentation, and changes in water quality. Our findings do however raise the issue that artificial stocking of elvers may increase eel densities to the point that crayfish populations decrease. Future investigations may determine that catfish or other factors are the primary cause of the decline of kōura in the upper Waikato River, however, for now a precautionary approach is advised depending on the desired outcomes.

FRESHWATER MUSSEL CONSERVATION NETWORK IN AOTEAROA.

S.J Clearwater, NIWA.

Unbeknownst to many New Zealanders, three species of relatively large freshwater mussels inhabit our streams, rivers and lakes. Maori consider freshwater mussels a taonga species and they are known by many names, such as kākahi and kāeo. The adult freshwater mussels are about 6-10 cm long and the most widespread species Echyridella menziesii is found throughout New Zealand. Echyridella aucklandica has a more northerly distribution found from Whanganui northwards with some curiously isolated populations found in Lake Wairarapa near Wellington and Lake Hauroko in Southland. Echyridella onekaka is found in the northwest of the South Island around Golden Bay and through the Kahurangi National Park area. Freshwater mussels are intriguing creatures, being long-lived - the oldest specimens can be more than 50 years old – and having a life cycle that includes a parasitic larvae known as a glochidia. The glochidia are less than half a millimetre in size and develop in a special brood pouch in the gill of the female adult mussel. They are ejected from the female mussel during the summer months and, in order to survive, must find a fish host to attach to within 3 days. So far we know that the larvae can successfully develop on native koaro, bullies and the introduced rainbow trout. After developing for two to three weeks on their host the juvenile mussels drop off and are thought to continue their development in the sediments of waterways. In fact this part of the life cycle is not particularly well understood. Eventually, after two to three years the juveniles are found in habitat similar to the adult mussels, nestled in flow refuges in streams and rivers and along the shores of lakes. Freshwater mussels are known as "ecosystem engineers" and each adult has the ability to filter 1 litre of water per hour. In smaller lakes dense populations of freshwater mussels can filter the entire volume of the lake in a matter of days to weeks. Freshwater mussels can also transfer significant amounts of nutrients from terrestrial origins into aquatic systems, alter substrate characteristics (e.g., stabilizing them) and increasing biodiversity.

There is however a significant knowledge gap about the conservation status of these important species, and there is evidence we are losing freshwater mussels from habitats such as the eutrophic shallow lakes in the Waikato and streams affected by agriculture or urbanisation (i.e., streams nationwide!). The official conservation status of the species is "declining" for E. menziesii, "nationally vulnerable" for E. aucklandica and "naturally uncommon" for E. onekaka. A network for the conservation of freshwater mussels in Aotearoa was formed in November 2014. We aim to share information about freshwater mussels, develop standardized protocols for mussel monitoring that can be used by community groups and experts, develop a national mussel database, protect their habitat, improve our knowledge of the reasons for their decline, develop techniques for their restoration and enhance public and government understanding and support for the issue. We need support from community groups such as WaiCare, so please contact us for further information and assistance. And, finally, you may be wondering “are they good to eat”? Most who have tried say, “no” – which is fortunate for these long-lived creatures. Email: sue.clearwater@niwa.co.nz

EVALUATION OF A REMEDIATED FISH BARRIER

Josh Smith, Cindy Baker, Paul Franklin

In-stream structures such as culverts, tide-gates and dams, which are commonly found in waterways throughout New Zealand, can obstruct fish migrations. These barriers prevent fish from reaching critical habitats, impacting on connectivity and reducing aquatic biodiversity.

Many New Zealand freshwater fish species (e.g. whitebait species, eels, smelt and bullies) are migratory and require free access to and from the sea, and within waterways to complete their life-cycle. Around 75% of native fish species are classified as at risk or threatened, and unrestricted access to habitats is vital to the continued survival of a number of these species. Investment in remediation of problem barriers can be significant, therefore it is important to make sure that solutions implemented are fit for purpose. In conjunction with Horizons Regional Council, a recently retrofitted rock-ramp at a perched culvert in Manawatu was assessed in spring 2014, to determine how effective it was in promoting the passage of inanga (Galaxias maculatus), a swimming fish with no climbing ability. Results from this monitoring can be used to inform the remediation of other key migration barriers within the Manawatu region as well as nationwide. The more information and certainty that is available around fish pass solutions, the greater the reassurance that can be given to stakeholders prior to them re-establishing connectivity within our freshwaters.

WATCHING FOR INVASIVE SPECIES: PUBLIC ENGAGEMENT

Tracey Burton

More than 70 freshwater aquatic plants have been introduced into New Zealand, with devastating consequences for our native aquatic plants and other wildlife. Aquatic weeds also cause serious problems for electricity generation by clogging up hydro dams, and can negatively impact on tourism values in an area by making recreational activities such as swimming and boating difficult.

Of the invasive aquatic plants that have established in New Zealand, it is the alien submerged species that have arguably been the most successful. In particular, four of these species, Ceratophyllum demersum (Hornwort), Hydrilla verticillata, Egeria densa, and Lagarosiphon major; have invaded with great success and are now regarded as New Zealand’s worst submerged invasive species. Through their superior competitive abilities, ease of transfer and difficulty to control they continue to pose a significant threat to the condition of our lakes and rivers.

Invasive species continue to be one of the greatest threats to New Zealand lakes and include not only water weeds, but other organisms too. Invasive molluscs such as zebra and quagga mussels have the potential to cause wide spread devastation to our freshwater ecosystems and are just one example of other invasive aquatic species not yet found in our lakes.

The management of invasive species is a shared problem that requires the cooperation and support of a diverse range of stakeholders, interest groups and members of the general public. The early detection of an invasive species is critical and may make the difference in being able to appropriately manage, control or eradiate a species before it has a chance to spread.

Anyone can help prevent the incursion and spread of invasive species into our lakes. In New Zealand, we can learn from the success of programs in other countries where they are recruiting citizen scientists to look for anything new or unusual. Volunteers are able to increase their knowledge and understanding of the environment, learn more about local issues of importance, and contribute to science based recommendations. In addition, observations collected by citizen scientists can provide valuable records and knowledge that otherwise wouldn't have been available.

ATMOSPHERIC DEPOSITION OF NUTRIENTS IN LAKES IN NEW ZEALAND, AS A PROPORTION OF TOTAL NUTRIENT LOADS

P Verburg, S Wadwha, A Semadeni-Davies, S Elliott, M Harvey, M Schallenberg,

In general, New Zealand air is considered relatively clean as we are surrounded by ocean and only spot monitoring of atmospheric concentrations and atmospheric deposition of nutrients is occasionally carried out, in contrast to European countries where intensive continuous monitoring programs are maintained. Based on New Zealand literature, we have estimated the mean loading rate of nutrients by atmospheric deposition and estimated the proportion of the total nutrient load in lakes accounted for by atmospheric deposition. This proportion turned out to be unexpectedly large: on average 15% for nitrogen and 7 % for phosphorus. Maximum atmospheric deposition for both nutrients can be as high as 60% of the total load in some lakes. This is far more than was expected by leading atmospheric scientists in New Zealand and has opened eyes to the fact that New Zealand should carry out more monitoring of atmospheric concentrations and atmospheric deposition rates of nutrients.