UTUHINA STREAM MONITORING 2015:

EFFECTS OF CONTINUOUS ALUM DOSING ON FISH AND AQUATIC INVERTEBRATES

ERI REPORT NUMBER 81

Client report prepared for Bay of Plenty Regional Council

April 2016

Nicholas Ling

Environmental Research Institute

Faculty of Science and Engineering

University of Waikato, Private Bag 3105

HAMILTON 3240, NEW ZEALAND

Utuhina Stream monitoring 2015: effects of continuous alum dosing on fish and aquatic invertebrates

Nicholas Ling

School of Science, The University of Waikato, Private Bag 3105, Hamilton 3240, New Zealand. nling@waikato.ac.nz

This report should be cited as:

Ling, N. 2016. Utuhina Stream monitoring 2015: effects of continuous alum dosing on fish and aquatic invertebrates. ERI Report No 81. Client Report prepared for Environment Bay of Plenty. University of Waikato, Hamilton. Environmental Research Institute, Faculty of Science and Engineering, University of Waikato, Hamilton, New Zealand.15 pp.

Reviewed by:	*Approved for release by*
Brendan Hicks	John Tyrrell
School of Science	Environmental Research Institute
University of Waikato	University of Waikato
Hamilton, New Zealand	Hamilton, NewZealand

SUMMARY

This report presents the results of an ongoing assessment of the fish and aquatic macroinvertebrate communities of the Utuhina Stream from 2006 to 2015, and an assessment of the bioavailability of aluminium in fish and koura to satisfy annual resource consent conditions 9.6, 9.8 and 9.7, respectively, for the discharge of alum.

Macroinvertebrates, fish and koura were sampled from one control and two treatment reaches of the Utuhina Stream in August/September 2015. Catch rates for common bully, juvenile trout and koura have fluctuated across all sites since monitoring began in 2006. Common bully, koura and juvenile trout were present at all sites. Differences in species abundance compared with previous years is most likely due to flood related disturbances to stream bank morphology and vegetative cover. No obvious effects of alum dosing on stream fish or macroinvertebrate communities were observed.

Semiquantitative analysis of stream macroinvertebrates showed no differences between upstream control and alum-exposed sites, with similar MCI scores to previous samples obtained before and after commencement of alum dosing in 2006. Overall, all sites were characterised as fair to good quality for a soft bottomed stream.

Some evidence of aluminium bioaccumulation was seen in some tissues of common bully (gills and liver) resulting from continuous alum dosing of the Utuhina Stream but there was no evidence of bioaccumulation of aluminium in the tissues of koura. Alum exposure in these species does not appear to affect their health or abundance in the stream.

Table of Contents

Introduction 1

Methods 2

Fish community survey 2

Aquatic macroinvertebrate community survey 4

Bioaccumulation of aluminium in common bully and koura 5

Results and Discussion 6

Utuhina Stream Fish Community 6

Aquatic macroinvertebrates 11

Bioaccumulation of aluminium 12

References 14

INTRODUCTION

The Lakes Rotorua and Rotoiti Action Plan (Bay of Plenty Regional Council, 2007) proposed to lower the trophic level index (TLI) of Lake Rotorua from 4.9 to 4.2 by reducing internal and catchment-derived nutrients (N and P). Catchment reduction targets of 250 tonnes N and 10 tonnes P have been established. The Utuhina Stream carries an estimated 7.6 tonnes of P into Lake Rotorua each year, of which approximately 2 tonnes is in the form of dissolved reactive phosphorous (DRP). The Action Plan proposed P-locking in up to three streams (Utuhina, Puarenga and one other) to reduce 6 tonnes of DRP entering into Lake Rotorua using continuous alum (aluminium sulphate) treatment. It has been estimated that an alum dosing rate of 1 ppm (1 g/m3) should remove the majority of DRP (i.e. ~2 tonnes) in the Utuhina Stream. Alum dosing of the Utuhina Stream began on a trial basis in 2006 and the Bay of Plenty Regional Council granted a resource consent in November 2008 for the continuation of alum dosing until 2018. This report presents the results of an assessment of the fish and aquatic macroinvertebrate communities of the Utuhina Stream sampled in August/September 2015, and an assessment of the bioavailability of aluminium in fish and koura to satisfy annual resource consent conditions 9.6, 9.8 and 9.7, respectively, for the discharge of alum. Assessments of fish abundance in the Utuhina Stream began prior to the commencement of alum dosing in 2006 and have been undertaken annual since then. Measures of aluminium bioaccumulation in fish and koura have also been undertaken annually since 2009. Results from 2015 are compared with those from previous years since the commencement of alum dosing in the Utuhina Stream in 2006.

METHODS

FISH COMMUNITY SURVEY

The occurrence of fish species, approximate relative density and catch per unit effort (CPUE) were determined for three 50 m reaches of the Utuhina Stream (Fig. 1) on 18th August 2015. Site 1 (control) was 50 to 100 m upstream of the alum discharge in-stream diffuser, site 2 was 50 to 100 m downstream of the diffuser, and site 3 was 400 meters further downstream in the vicinity of Lake Rd. Relative fish density and CPUE (fish captured per hour) were estimated using a two-pass electrofishing procedure according to the method of Landman et al. (2008). A MAF Aquatronics pulsed DC mains set electrofishing machine, powered by a Honda 3-kVA petrol generator, operating at 420 V and approximately 3 A with two hand-held anodes was used to enable simultaneous fishing of each stream side (Fig. 2). Two teams of three people performed the fishing while one person remained on the bank for machine operation and safety. Estimates of total fish numbers (absolute density) in this stream could not be calculated from the two-pass removal method as variable and occasionally greater fish numbers are captured in the second fishing passes. Common bully, *Gobiomorphus cotidianus*, is the most abundant species in the Utuhina Stream and obtaining consecutive reductions in this species using multiple pass electrofishing is notoriously difficult. For practical purposes, an estimate of minimum fish density was determined by simply adding the total catch from both passes at each site. Total CPUE and CPUE for each pass at each site could be determined normally based on fish caught and fishing effort (time fishing). All fish/koura were counted, adult trout were measured (if captured) or their size estimated if observed, and all fish were returned alive to their respective stream reaches, except for those retained for elemental analysis (see below).

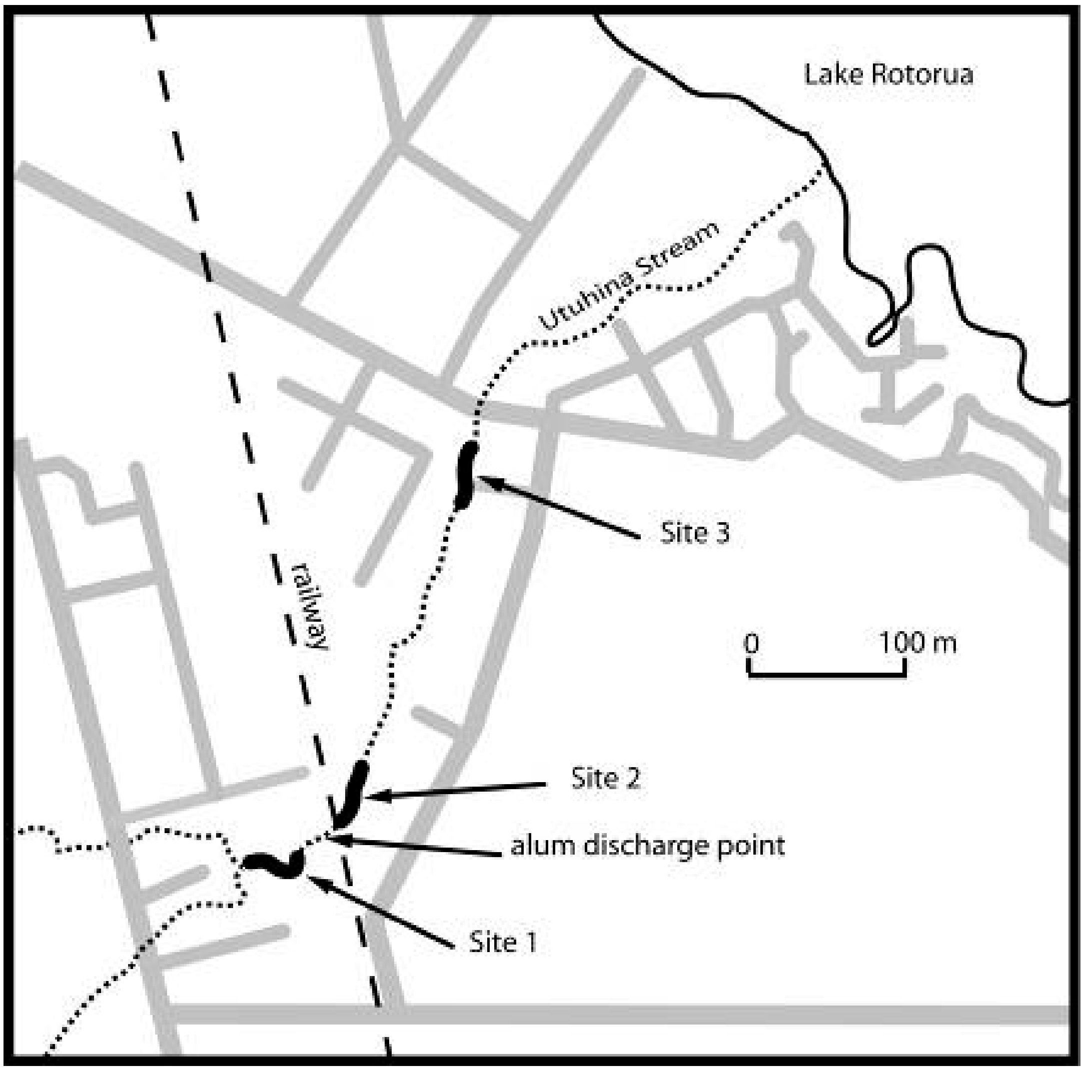


Fig. 1. The Utuhina Stream with fish community survey sites marked above the alum discharge (Site 1), in the alum mixing zone (Site 2) and upstream of Lake Rd (Site 3).

AQUATIC MACROINVERTEBRATE COMMUNITY SURVEY

Semiquantitative analysis of aquatic macroinvertebrates was undertaken in September 2015 within the same three stream reaches examined for relative fish abundance above. Sampling and analysis was carried out as prescribed for soft-bottomed streams by Stark et al. (2001). Briefly, a 0.5 mm mesh, 0.3 m-wide D-net was used to provide ten replicated 1-m sweeps through representative stream bank habitat, sampling a total area of approximately 3 m^2 at each site. True left and true right banks were sampled and enumerated separately at each of the three stream reaches. Samples were preserved in isopropyl alcohol.

Fig. 2. One of two teams electrofishing the Utuhina Stream bank habitat (site 3).

BIOACCUMULATION OF ALUMINIUM IN COMMON BULLY AND KOURA

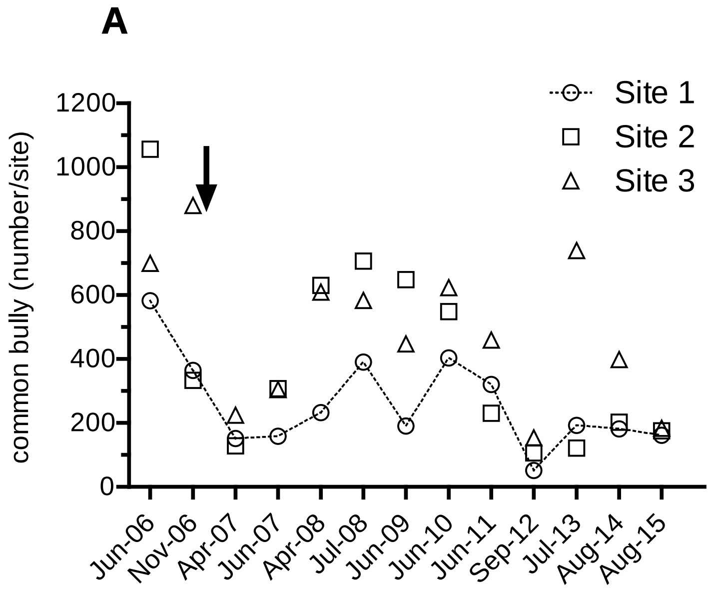
A suite of 28 elements was measured in bully and koura tissue samples based on established methods (USEPA, 1987). In brief, tissue samples were accurately weighed and digested using tetramethylammonium hydroxide, heat and mixing. The colloidal suspension was then partially oxidized by the addition of hydrogen peroxide and metals solubilised by acidification with nitric acid and heating. Samples were diluted and filtered prior to analysis by inductively-coupled plasma mass spectrometry (Department of Chemistry, Waikato University, Hamilton, NZ). All tissue element concentrations were determined on a wet weight basis. Skeletal muscle, liver and gills were analysed from ten common bully from each site. Hepatopancreas, tail muscle and gills were analysed from up to ten koura from each site. Method blanks and matrix certified reference material standards (DOLT and DORM; Canadian Research Council) were run in parallel with all samples.

Fig. 3. Utuhina Stream koura

RESULTS AND DISCUSSION

UTUHINA STREAM FISH COMMUNITY

Four species, common bully (*Gobiomorphus cotidianus*), rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and koura (*Paranephrops planifrons*), were captured across all three stream sites. In addition, two longfin eels were captured at the upstream control site, one common smelt at site 2 (alum mixing zone) and one shortfin eel at the downstream site. Common bully relative density (fish per 50 m reach) and CPUE (fish/h) were slightly higher at all sites than the record lows recorded in 2012 but lower at site 3 than in 2013 and 2014 (Fig. 4). The low catch of common bully and koura at site 3 downstream of the alum mixing zone is possible due to an obvious reduction in stream bank vegetated habitat due to clearing of bankside weeds as part of a replanting programme. Juvenile trout were more abundant at all sites than in 2014 (Fig. 5). Koura were less abundant at all sites than in 2014 but most abundant at site 1 (control) compared with sites 2 and 3 (Fig. 6), presumably due to the presence of much better habitat, particularly the rocky bank on the true right. Koura numbers have remained consistently low at site 2 (alum mixing zone) since before the commencement of alum dosing and numbers at the downstream reach (site 3) have fluctuated widely since before dosing began, presumably due to interannual variability in habitat quality, particularly the impacts of floods on stream bank vegetation. There has been no discernable impact of alum dosing on the fish community of the stream.



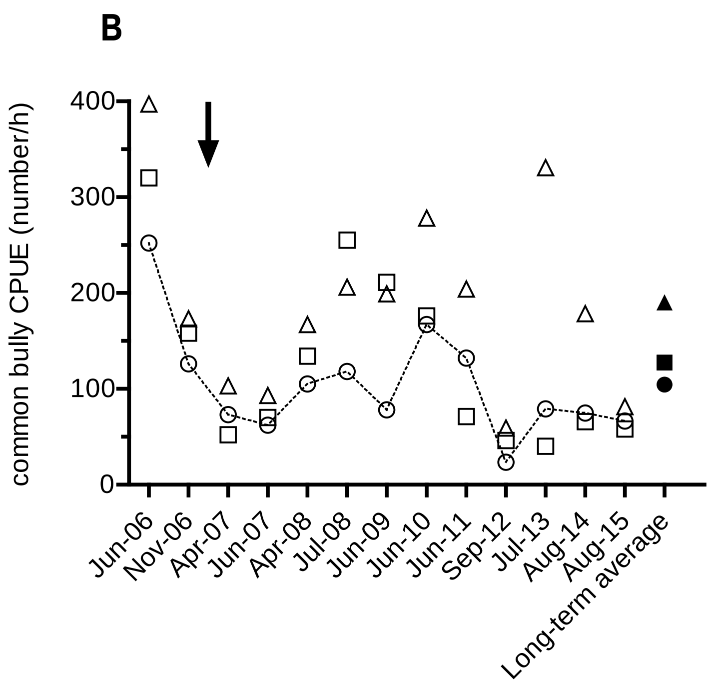


Figure 4. Relative density (A) and CPUE (B) of common bully in the Utuhina Stream since June 2006. Arrows indicate the commencement of alum dosing in the stream.

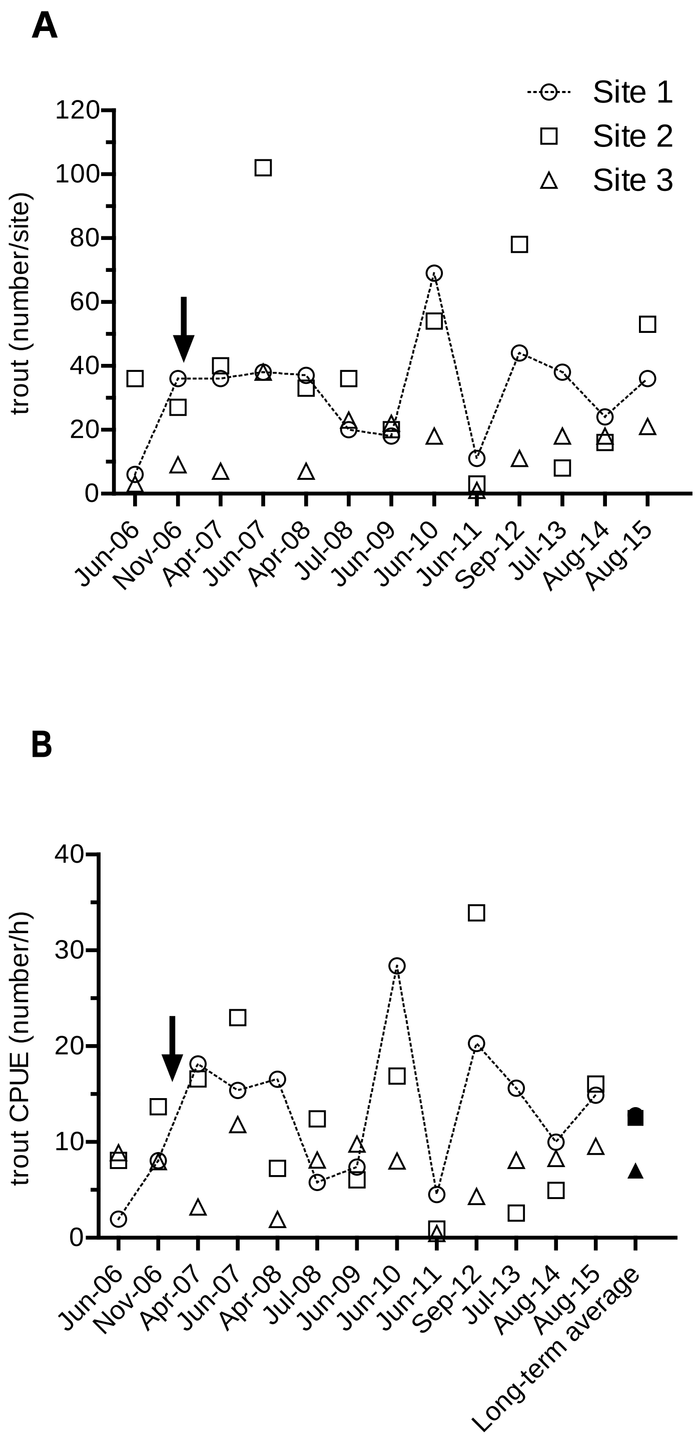


Figure 5. Relative density (A) and CPUE (B) of juvenile trout in the Utuhina Stream. Arrows indicate the commencement of alum dosing in the stream.

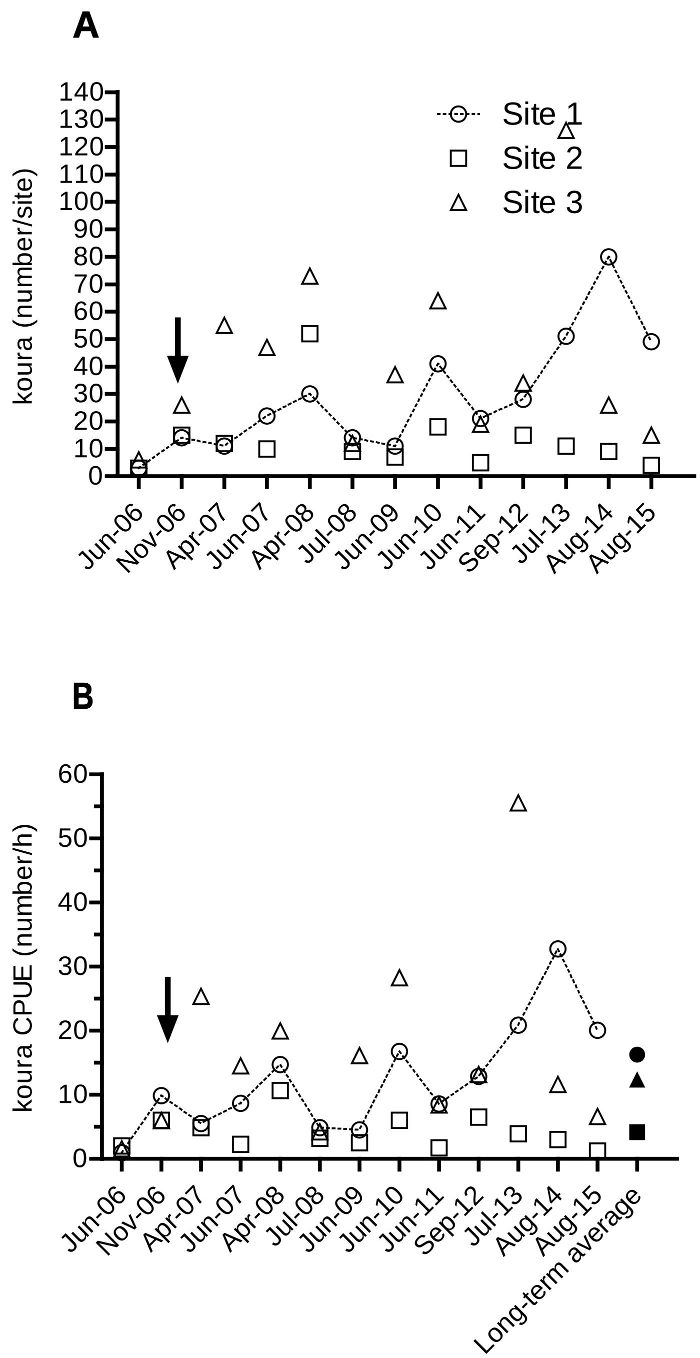


Figure 6. Relative density (A) and CPUE (B) of koura in the Utuhina Stream. Arrows indicate the commencement of alum dosing in the stream.

Figure 7. A fallen willow and bamboo blocking a section of the true left bank in August 2014 at site 1 (control).

Ling (2013) noted that significant modification of the true right bank had occurred at site 1 in 2012 due to scouring downstream of a poorly installed stormwater drain. In July 2013 it was observed that bank remediation had occurred at that site, however, a fallen willow on the opposite bank had created a narrowing and deepening of the channel close to the true right bank creating a section (approximately 5 m) of unfishable water. Accumulation of a large bank of fine muddy sediment immediately downstream of the fallen tree has caused significant changes in stream habitat for fish, however the abundance of all species seems unaffected. This feature on the true left bank was still present in August 2014 (Fig. 7) but much reduced in August 2015.

AQUATIC MACROINVERTEBRATES

Semi-quantitative macroinvertebrate community analysis (for soft-bottomed streams) showed no obvious differences between sites and values close to the long-term average for years 2009-2015 (Figure 7). Values for the MCI-sb index fell within the “fair to good” quality classes (Table 1) of Stark & Maxted (2007) for all three sites, with the lowest value recorded from the control reach. As has been observed in previous years, there was no pattern of change across the sites that could indicate impacts of the alum dosing on macroinvertebrate community composition. Previous studies of macroinvertebrates at the same study sites, both prior to the commencement of alum dosing (May/June 2006), and subsequently (June/July 2006, Feb 2007) showed very similar MCI scores with no significant differences between sites (Clarke 2006, EBOP Unpubl. Data).

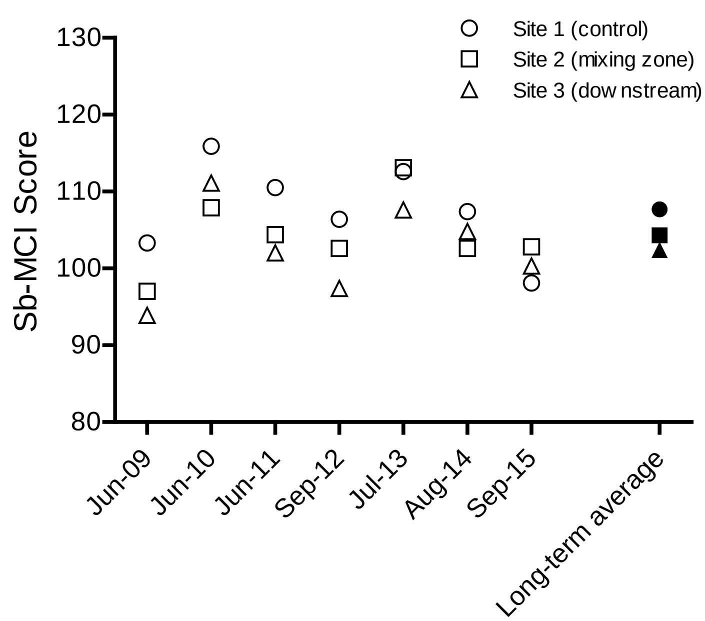


Figure 7: Soft-bottom stream semi-quantitative macroinvertebrate community assessment (Sb-MCI) for the Utuhina Stream since June 2009.

Table 1. Interpretation of soft-bottomed stream MCI indices.

Stark & Maxted (2007) quality class	**Stark (1998) descriptions**	**MCI-sb**
Excellent	Clean water	>119
Good	Doubtful quality or possible mild pollution	100-119
Fair	Probable moderate pollution	80-99
Poor	Probable severe pollution	<80

BIOACCUMULATION OF ALUMINIUM

Only one koura large enough for tissue analysis was captured at site 2 (alum mixing zone) but a sufficient number of large koura were obtained at the other sites and adequate numbers of common bully were obtained from all three sites.

In some of the previous years there was some evidence of aluminium bioaccumulation downstream of the Utuhina Stream alum diffuser, but total aluminium concentrations were generally low in tissues from both species (Ling 2015). Concentrations of aluminium in the tissues of koura and common bully are generally highly consistent across years with highest concentrations occurring in the gill tissue followed by higher aluminium in the hepatopancreas (HP) and liver of koura and common bully, respectively, than in the flesh. All animals appeared healthy and unaffected by these relatively low tissue aluminium levels.

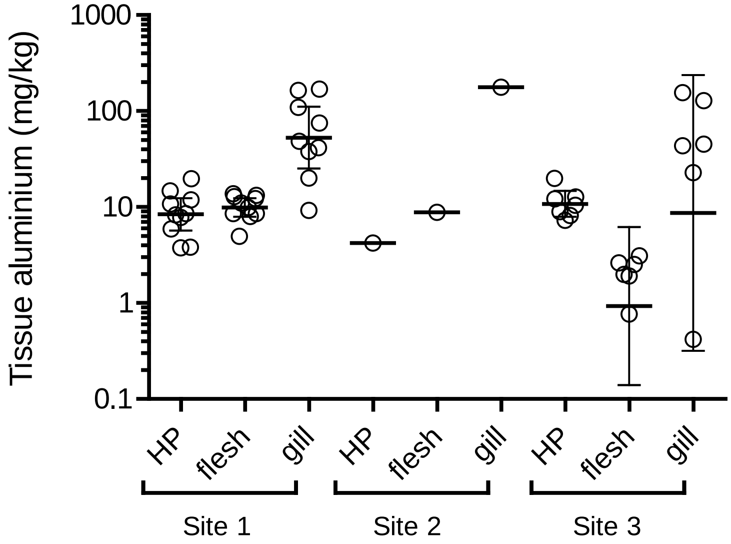


Figure 8: Koura tissue aluminium concentrations (mg/kg) - geometric mean with lower and upper 95% confidence intervals (CI). Site 1 = upstream control reach, Site 2 = alum mixing zone, Site 3 = downstream reach.

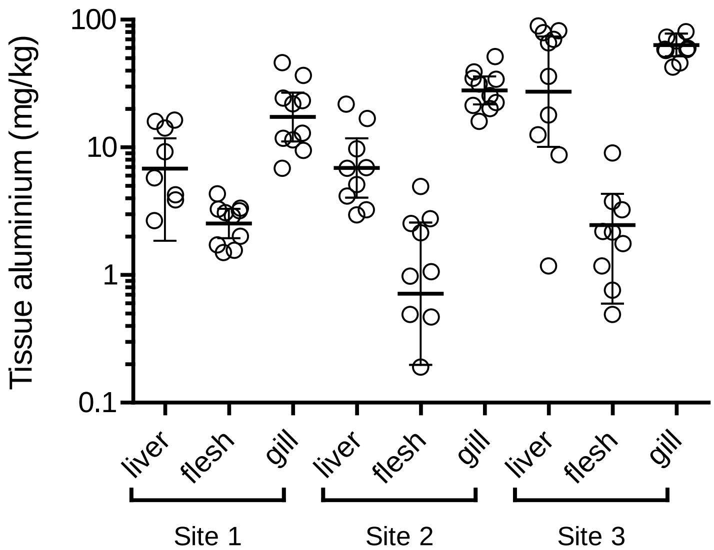


Figure 9: Common bully tissue aluminium concentrations (mg/kg) - geometric mean with lower and upper 95% confidence intervals (CI). Site 1 = upstream control reach, Site 2 = alum mixing zone, Site 3 = downstream reach.

REFERENCES

Allin, C.J., Wilson, R.W. (2000) Effects of pre-acclimation to aluminium on the physiology and swimming behaviour of juvenile rainbow trout (*Oncorhynchus mykiss*) during a pulsed exposure. *Aquatic Toxicology* 51: 213-224.

Bay of Plenty Regional Council (2007) Proposed Lakes Rotorua and Rotoiti Action Plan: A programme for the long-term restoration of Lakes Rotorua and Rotoiti's water quality. Environmental Publication 2007/11. Environment Bay of Plenty, Whakatane, New Zealand. 165 pp.

Clarke, H. (2006) The effects of alum on the macroinvertebrate community index (MCI) in the Utuhina Stream. Unpublished project report. Auckland University of Technology.

Landman, M., Ling, N., Taylor, S. (2008) Fish community surveys and biomonitoring in selected Rotorua Streams. Technical report prepared for Environment Bay of Plenty. Scion, Rotorua New Zealand. 28 pp.

Ling, N. (2013) 2013. Utuhina Stream monitoring 2012: effects of continuous alum dosing on fish and aquatic invertebrates. Client Report prepared for Environment Bay of Plenty. University of Waikato, Hamilton. 18 pp.

Ling, N.. 2015. Utuhina Stream monitoring 2014: effects of continuous alum dosing on fish and aquatic invertebrates. Client Report prepared for Environment Bay of Plenty. University of Waikato, Hamilton. 16 pp.

Stark, J.D., Maxted, J.R. (2007) A user guide for the Macroinvertebrate Community Index. Prepared for the Ministry for the Environment. Cawthron Report No. 1166. 58 p.

Stark, J.D., Boothroyd, I.K.G., Harding, J.S., Maxted, J.R., Scarsbrook, M.R. (2001) Protocols for sampling macroinvertebrates in wadeable streams. New Zealand Macroinvertebrate Working Group Report No. 1. Prepared for the Ministry for the Environment. Sustainable Management Fund Project No. 5103. 57p.

United States Environmental Protection Agency (USEPA). (1987) Determination of Metals in Fish Tissue by Inductively Coupled Plasma – Atomic Emission Spectrometry. EPA Method 200.11, Revision 1.3, April 1987.