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Upper Waiau River Benthic Invertebrates

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INTRODUCTION

The upper Waiau River drains Lake Te Anau at its southern-most end, and then enters Lake Manapouri approximately 20 km downstream. Since 1974, flows in the upper Waiau have been regulated by control gates that have an epilimnetic (surface) release from Lake Te Anau. This short reach of the Waiau supports an above average brown and rainbow trout fishery which is utilised by about 30% of adult whole season anglers in the district (Richardson et al. 1986). Recently, Southland Fish and Game Council, who manage the trout fishery, expressed concern about the upper Waiau after casual observations of lower than usual numbers of benthic invertebrates, and asked the Waiau River Working Party to a initiate a study. This study was undertaken on their behalf and had three objectives. The first two were to determine the benthic invertebrate community in the upper Waiau River, and to compare these data with other available data to see (1) if the community was typical of that at lake outlets, and (2) if taxonomic richness or total abundance had changed. A third objective was to investigate whether flow regulation or catchment development were responsible for the suspected decline in benthic invertebrates.

The control gates at the lake outlet cause flows in the upper Waiau River to vary from less than 100 to over 700 $m^3 s^{-1}$ (Fig. 1). As is often the case, there is no quantitative benthic invertebrate information specific to this stretch of river prior to 1974, which makes it difficult to determine the impact of flow regulation on the benthic community. Harding (1994) found that benthic invertebrate communities were different in regulated and unregulated South Island lake outlets. Irvine (1985) showed that initial flow changes in streams after a period of constant flow depleted benthic invertebrates in experimental streams channels in the Waitaki River, and Stancliff et al. (1982) reported a similar result for the Tekapo River. However, Irvine & Henriques (1984) could find no depletion of benthos in the Hawea River following three releases from Hawea Dam.

Catchment development has also increased in the Te Anau basin, and this could have affected water quality and, in turn, invertebrate abundance and taxonomic richness. Quinn & Hickey (1990) found summer invertebrate biomass was strongly related to catchment development. Low levels of development resulted in increased invertebrate biomass. High levels of nutrient enrichment caused the diversity of the community to decrease, but did not necessarily affect invertebrate biomass. However, Scott et al. (1994) tried to demonstrate differences in invertebrate communities in relation to land use in Southland streams, and could find no physico-chemical features that had any consistent effect.

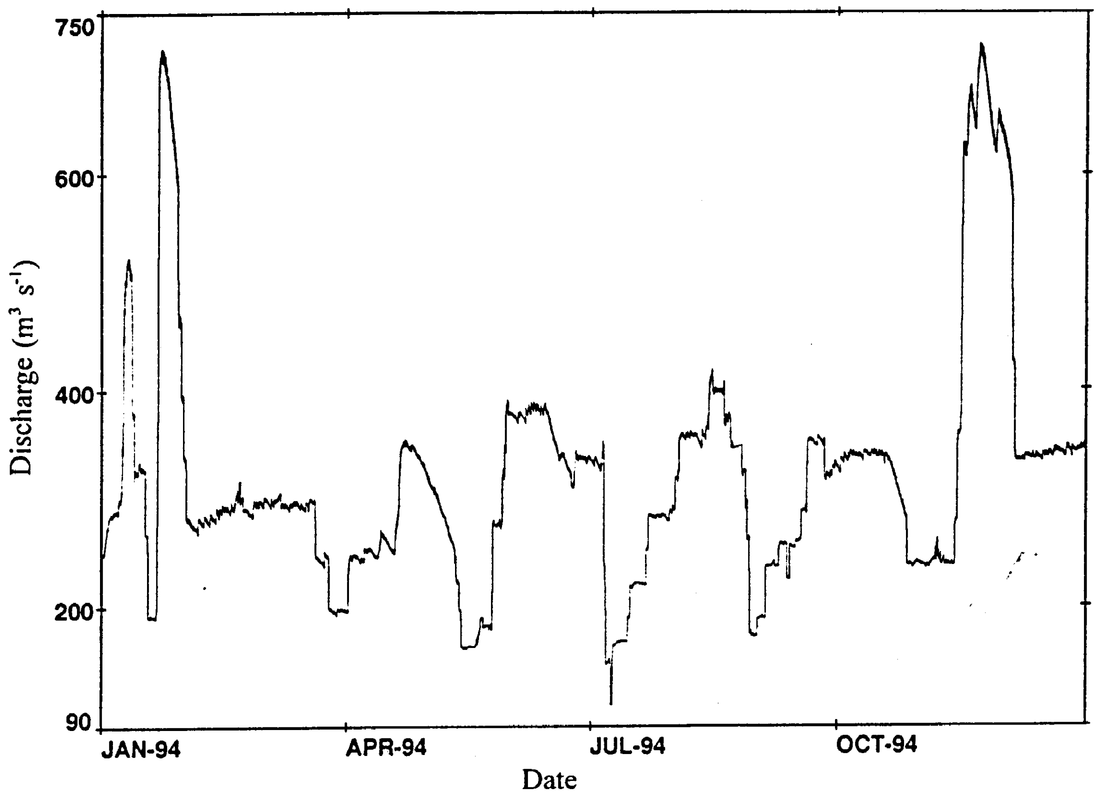

Figure 1. Measured discharge in the upper Waiau River at Lake Te Anau outlet, January to December 1994.

STUDY SITES AND METHODS

Benthic invertebrates were sampled once on 8 February 1995 from two sites in the upper Waiau River. Site 1 was approximately 2.6 km below the Lake Te Anau control gates, while site 2, which had been sampled in 1990 (J.D. Stark, Cawthron Institute, pers. comm.), was a further 2.7 km downstream. For comparative purposes, one site in the Mararoa River between North and South Mavora Lakes was also sampled the next day. Seven Surber samples (0.1 m^2, 0.25 mm mesh) were taken at each site over about a 20 m long reach at velocities between 0.4 to 0.8 m^{-1} and depths of 0.3 to 0.6 m; these seven samples were combined in the field to give one sample per site and this was preserved in 10% formalin.

The current velocity and water depth were measured at each of the seven invertebrate sampling areas and the substrate composition was visually assessed in order to calculate the substrate index (Jowett & Richardson 1990). In addition, one water sample was collected from each site to assess water quality by measuring dissolved reactive phosphorus, nitrate, total nitrogen, absorbance, and chlorophyll *a*.

In the laboratory, benthic invertebrates were identified to the lowest taxonomic level possible and counted. Species were assigned to functional feeding groups after Quinn & Hickey (1990) and Harding (1994). Invertebrate data were then compared to the other data available from the Waiau River, from other rivers (Quinn & Hickey 1990) and other lake outlets (Harding 1994; NIWA unpublished data).

RESULTS

Physico-chemical data from the three sites (Table 1) showed that site 2 had the deepest, swiftest water and the Mararoa River the shallowest and slowest with the finest substrate. Apart from water depth, these differences in the physical features were not significant (P>0.05). Dissolved reactive phosphorus, total nitrogen, and absorbance were similar at all three sites, and were always highest at site 1. Nitrate and chlorophyll *a*, which did vary, were also higher at site 1.

Table 1. Physico-chemical data from the three sampling sites.

Factor	Waiau River Site 1	Waiau River Site 2	Mararoa River
Altitude (m)	201	200	614
Mean depth (m)	0.38	0.40	0.33
Mean velocity (m s^{-1})	0.579	0.619	0.473
Substrate index	5.9	5.4	4.7
Dissolved reactive phosphorus (μg l^{-1})	4	2	3
Nitrate (μg l^{-1})	32	19	2
Total nitrogen (μg l^{-1})	69	58	42
Absorbance @ 270 nm	.132	.111	.083
Chlorophyll *a* (μg l^{-1})	1.01	0.41	0.41

The benthic invertebrate communities of all three sites (Table 2) had some similarities, notably an absence or poor representation of mayflies, stoneflies, beetles, and snails, and high abundance of Diptera. Otherwise the three sites differed markedly. Site 1, which was closest

Table 2. Benthic invertebrate numbers from seven Surber samples at each of three sites.

Taxon	Waiau River Site 1	Waiau River Site 2	Mararoa River
Ephemeroptera (Mayflies)			
Deleatidium sp.	1	1	-
Plecoptera (Stoneflies)			
Zelandoperla decorata	7	5	-
Diptera (Two-winged Flies)			
Crane Flies			
Aphrophila neozelandica	3	12	-
Sandflies			
Austrosimulium sp.	12	1192	2064
Chironomids			
Maoridiamesia sp.	56	124	272
Cricotopus sp.	26	56	120
Orthoclad sp. A	212	100	72
Eukiefferiella sp.	70	48	-
Tanytarsus vespertinus	18	68	-
Chironomus zelandica	6	-	-
Others			
Muscidae	-	1	-
Trichoptera (Caddisflies)			
Aoteapsyche tepoka	422	26	-
Aoteapsyche raruraru	-	-	3
Costachorema xanthoptera	22	3	3
Neurochorema sp.	2	2	3
Oxytheria albiceps	-	1	7
Pycnocentrodes sp.	-	3	-
Hudsonema amabilis	-	1	-
Pycnocentria evecta	-	6	-
Mollusca (Snails)			
Potamapyrgus antipodarum	-	19	5
Oligochaeta (Worms)			
Eiseniella	-	9	1
Tubificid	-	6	1520
Naididae	-	1	144
Total taxa	13	21	12
Total number of individuals	857	1684	4214

to the control gates, had about equal numbers of chironomids (*Maoridiamesia* sp., *Cricotopus* sp., Orthoclad sp. A, *Eukiefferiella* sp., *Tanytarsus vespertinus*, and *Chironomus zelandica*) and the net spinning caddisfly, *Aoteapsyche tepoka*. No worms or snails were present at site 1. Site 2 was dominated by sandfly larvae (*Austrosimulium* sp.), followed by chironomids. Overall, the density and species richness of invertebrates at site 2 were nearly twice that of site 1. Sandfly larvae also dominated the fauna in the Mararoa River, but oligochaetes made a significant contribution to the high density of animals.

DISCUSSION

Comparison of the chemical data with similar data from other rivers (Close & Davies-Colley 1990a, 1990b; Davies-Colley & Close 1990) showed that dissolved reactive phosphorus, nitrate, and total nitrogen were lower than average for New Zealand rivers, indicating low levels of nutrients. Absorbance was also low, typical of clear water conditions. Chlorophyll *a* at site 1, although higher than the other sites, was within the range considered indicative of oligotrophic lake conditions.

The invertebrate data from the three sites sampled in this survey were compared to other available data to assess whether the community was typical of that expected at a lake outlet. Quinn & Hickey (1990) classified 88 river sites throughout New Zealand into 10 classes based on the functional feeding group composition of the community and total invertebrate biomass. Few lake outlets were included among these 88 rivers, and none of the communities found in this survey resembled those described by Quinn & Hickey. However, total invertebrate densities at sites 1 and 2 were close to the median (1903 m^{-2}) reported by Quinn & Hickey (1990), while the Mararoa River was in the top 10% of all rivers. Comparison of taxonomic richness showed that site 1 and the Mararoa River had low richness, whereas site 2 was about average (Quinn & Hickey 1990).

We also compared the communities in the upper Waiau and Mararoa to those from 20 South Island lake outlets which were classified into one of four groups according to their outlet condition and elevation (Harding 1994) (Table 3). The upper Waiau at site 1 generally matched Harding's (1994) description of a regulated epilimnetic (surface release) outlet. He found the faunas of such outlets were dominated by *Aoteapsyche* spp., *Potamapyrgus antipodarum*, Chironomidae, and *Austrosimulium* sp., with beetles, mayflies, and stoneflies absent or poorly represented. Invertebrate density and species richness were generally low in this group of lake outlets.

Harding's (1994) group of unregulated mid to low elevation outlets displayed considerable variation in species diversity and abundance, which he attributed to differences in physico-chemical factors. The North Mavora outlet contained high numbers of *Austrosimulium* sp., but oligochaete numbers were also very high. Although the Mararoa did not fit the picture of a typical unregulated outlet too well, it is certainly within the range described by Harding (1994) for this type of outlet. For example, one unregulated outlet (Lake Daniels) had high numbers of *Austrosimulium* sp., whereas another, Lake Mapourika, was dominated by oligochaetes.

Table 3. Percentage composition of the benthic invertebrate communities from the three sites in this study, compared with data from the Waiau River in 1990 (J.D. Stark, Cawthron Institute, pers. comm.), and two types of lake outlet (Harding 1994).

Invertebrate group	Typical regulated epilimnetic outlet	Waiau Site 1	Waiau Site 2	Waiau 1990	Mararoa	Typical unregulated outlet, mid/low elevation
Ephemeroptera	1	0.1	0.1	-	-	4
Plecoptera	1	0.8	0.3	0.3	-	1
Diptera	20	47.0	95.1	95.2	60.0	18
Trichoptera	53	52.1	2.5	3.0	0.4	45
Mollusca	22	-	1.1	1.3	0.1	9
Others	3	-	0.9	0.2	39.5	23
Filter feeder	28	49.2	1.5	3.0	<0.1	59
Collector/browser/grazer	48	48.0	98.1	96.9	99.9	15
Total taxa	10 to 15	13	21	18	12	>15
Total density (no. m^{-2})	<1000	1224	2406	16493	6020	3000 to 4000

Although the benthic community at site 1 was similar to that of a regulated, surface release, lake outlet according to Harding's (1994) classification, the community at site 2, with its lack of Trichoptera and high species diversity and density, was not. Nor did it resemble a typical unregulated outlet, although like the Mararoa River, some features were within the ranges described by Harding (1994) for an unregulated outlet. Regardless of the grouping, the community found at site 2 in 1995 was virtually identical to that found at the same location by J.D. Stark in 1990 (Cawthron Institute, pers. comm.). However, Stark found an exceptionally high density of sandfly larvae compared to our sample. This discrepancy could be explained by the different sampling dates; Stark collected samples in November, whereas our survey was in February, when many sandfly larvae had already hatched. A large hatch of sandflies was noted by B. Jarvie (Southland Fish and Game Council, pers. comm.) a few days before we sampled, and it is possible this caused reduced *Austrosimulium* sp. numbers. *Austrosimulium* sp. accounted for 93% and 71% of total invertebrate density at this site in 1990 and 1995 respectively.

Data from three other lake outlets, Lakes Monowai, Tarawera, and Wanaka, which have been sampled annually since 1989, were used to demonstrate the effect of constantly fluctuating flows on benthic invertebrate communities (NIWA unpublished data). All three rivers had typical lake outlet communities dominated by sandflies, chironomids, caddisflies, and snails. Lake Monowai outlet is also in the Waiau River catchment and has an extremely variable flow as it is used for hydro-electric power production; since changes to the operating regime in 1989 just prior to the first sampling occasion, flows can, and usually do, range from zero to up to 20 $m^3\ s^{-1}$ over a 24 hour period. The benthic invertebrate community in this extreme example of a regulated outlet had low abundance and was very impoverished (Table 2), with snails accounting for most of the biomass. Total density and taxonomic richness in the Monowai outlet are in the lowest 10% and 20% of rivers respectively according to Quinn & Hickey (1990).

The sampling site on the Clutha River (Lake Wanaka outlet) is below the Hawea River confluence, which has hydro-electric control gates upstream at Lake Hawea, and this site is subject to fluctuating flows rather like the upper Waiau River. Although the total number of taxa was constant at this site, the total density of invertebrates varied greatly from year to year. To some extent, this was caused by variations in short-lived species such as chironomids and oligochaetes. However, total density of invertebrates, including the Trichopteran *Aoteapschye* spp., also changed from year to year at Lake Tarawera, which is an unregulated outlet with flows that vary only slightly (Fig. 2).

When both sites 1 and 2 were considered, the invertebrate community in the upper Waiau had some characteristics of both a regulated epilimnetic outlet and an unregulated mid/low elevation outlet. The low nutrient levels measured at our study sites, coupled with little evidence of a structural community change in recent years, indicates that neither flow fluctuations nor catchment development are affecting the species composition of the benthic community at this time. Total invertebrate densities have varied from year to year, and it seems possible that flow fluctuations could be partially responsible for this. Benthic invertebrate density fluctuations are found in unregulated lake outlets, but these natural fluctuations can be exacerbated in lake outlets with fluctuating flows, as demonstrated in the Lake Monowai outlet.

SUMMARY

- Invertebrate densities are variable in both time and space, and even those in stable lake outlet rivers can vary 10 fold.

- Extreme flow fluctuations can reduce invertebrate abundance to less than 200 m^{-2}.

- The upper Waiau River had benthic invertebrate densities of 1200 and 2400 m^{-2} in 1995. These densities are comparable with those commonly found in rivers and at lake outlets.

- Given the natural variability in invertebrate density, it will never be possible to quantify the effects of flow fluctuations on the invertebrate community of the upper Waiau. The results from this study have found that the benthic invertebrate community is diverse, and that abundance is within normal ranges.

Table 4. Changes in benthic invertebrate diversity and density in three lake outlets between 1989 and 1994.

Lake outlet	1989	1990	1991	1992	1993	1994
Lake Monowai						
Total number of taxa	no	19	9	7	9	5
Total density (no. m^{-2})	data	751	131	173	180	37
Lake Tarawera						
Total number of taxa	22	23	15	21	21	21
Total density (no. m^{-2})	2031	517	343	2080	1927	2746
Lake Wanaka						
Total number of taxa	22	17	16	14	15	9
Total density (no. m^{-2})	3263	229	3536	9201	357	110

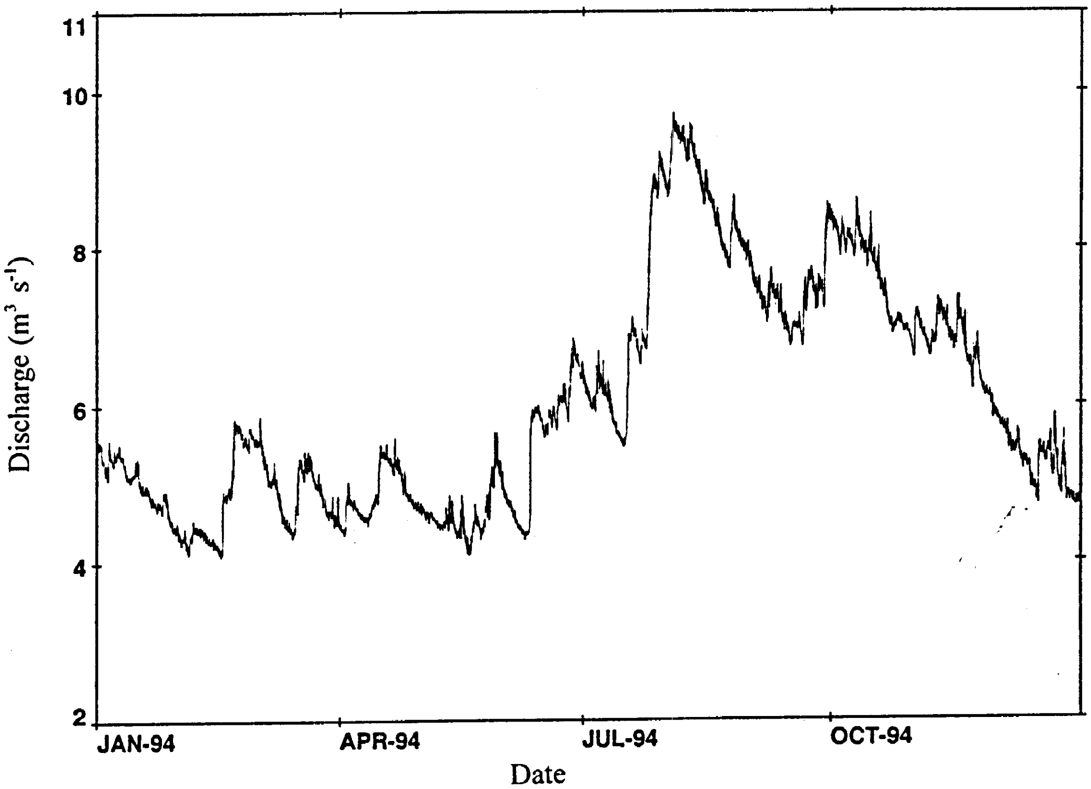

Figure 2. Measured discharge in the Tarawera River at Lake Tarawera outlet, January to December 1994.

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