CAWTHRON

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A Pilot Study of the Ecology of Small Streams in the Marlborough Sounds

Prepared for

MARLBOROUGH DISTRICT COUNCIL

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by

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Cover Photo: Bottle Bay Stream. *Cawthron Institute* 2003

EXECUTIVE SUMMARY

The Marlborough Sounds Resource Management Plan (MSRMP) classifies streams or rivers entering Marlborough Sounds into three categories. Category 1 & 2 streams are recognized as having ecological and recreational values and/or represent a flood hazard. By definition, however, there is little known about the ecological (and other) values of Category 3 streams. Many of the holiday homes in the Marlborough Sounds rely on these small Category 3 streams for their domestic water supply, but the effects of these water takes on the ecology of these systems is largely unknown. This pilot study focused on Category 3 streams in Queen Charlotte Sound and aimed to characterise the ecological values of these streams and identify if water abstraction may threaten these values.

The abundance and diversity of stream life (both invertebrates and fish) were assessed at 10 sites in May 2003, along with measurements of stream flow and water quality (8 sites only). All the sites drained catchments with either native forest or regenerating native forest. The only exception to this was one site which has a catchment dominated by pine forest.

At least 65 kinds of invertebrates were collected from the sites and were typical of the kinds usually found in small forested streams in other parts of New Zealand. Nevertheless, the invertebrate communities were quite different from those found during recent studies of larger streams and rivers in other parts of Marlborough (*e.g.* Rai Catchment and spring-fed systems on the Wairau Plain). Indices of stream health, calculated from the composition of the invertebrate communities, indicated healthy stream ecosystems at most sites, although the smaller streams that we studied tended to have lower diversity.

Eight species of freshwater fish were found at the sites. Redfin bully and banded kokopu were the most common species found. Shortfin eels and giant bullies were officially recorded for the first time in the Queen Charlotte Sound, bringing the total number of freshwater fish recorded in that region to 13.

Water quality was generally good at most of the sites sampled. However, the smallest three sites had the poorest water quality with relatively high levels of suspended sediment and dissolved phosphorus and nitrogen. The concentrations of faecal indicator bacteria were also relatively high at several of the sites and above contact recreation guidelines at one site. Drinking water guideline concentrations for *E. coli* were exceeded at all of the sites.

The smallest stream sampled (0.08 l/s) had a lower diversity of fish and invertebrate species compared with the other sites and the species that were found there were generally restricted to small poorly-connected pools. The conditions in this stream are probably representative of the changes likely to occur at other sites if significant amount of flow were abstracted for domestic use. Some examples of flow diversion through water supply systems were observed and have resulted in reductions in the amount of habitat available in some streams. Water supply weirs, although not observed in these streams, are found in other areas of the Sounds and may act as fish barriers. An education campaign and guidelines for people taking water from these streams may be sufficient to overcome many of the issues highlighted in this report.

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Report reviewed by:

Dr John Stark, Senior Scientist

1. INTRODUCTION

The Marlborough Sounds Resource Management Plan (MSRMP) classifies streams or rivers entering the Marlborough Sounds into three categories. Category 1 and 2 streams are those that have been identified as having ecological, recreational or flood hazard values. There are a total of 62 Category 1 and 2 streams listed in the MSRMP with the majority being wider than 3 metres. Category 3 streams are all those not specifically listed as Category 1 or 2. There are approximately 185 Category 3 streams that flow into the sea shown on the NZMS 260 topographical maps.

The Marlborough Sounds are essentially old river valleys filled in by the sea. This process isolated the many tributary streams that fed the large rivers draining these valleys. What remains are many small streams draining short steep catchments which were formerly the mountains surrounding the valleys. The streams themselves are typically less than two metres wide, flow throughout the year and discharge directly to the sea from relatively unmodified catchments. These features make them slightly unique from small streams draining into large catchments elsewhere in New Zealand, in that they are more accessible for fish colonising them from the sea and therefore provide habitat types that might normally be found many kilometres inland in some river systems. Because these streams are small and numerous, their ecological value can be easily overlooked. Apart from fish studies in the larger Category 1 and 2 streams and rivers of the Marlborough Sounds, to date there have been few attempts at studying the smaller Category 3 streams.

The Marlborough Sounds are a popular holiday destination with many holiday homes as well as permanent residences. The majority of these homes take water from the nearest stream; many of which are Category 3 streams.

Concern that little is known of the ecological value of Category 3 streams and the unknown impact on them from domestic water supply takes, led Marlborough District Council to undertake a pilot study of some of these streams in Queen Charlotte Sound. The main aim of this pilot study was to assess how readily differences in the ecology of small Marlborough Sounds' streams could be detected, or whether they could be characterised. This report describes that study and discusses some of the issues of water abstraction in Category 3 streams.

2. METHODS

2.1 Site selection

A range of physical and biological measurements were made in eight Category 3 streams of varying size and draining a variety of catchment types typical of Queen Charlotte Sound (Figure 1). An additional two streams were described but water quality measurements not taken. Five sites were chosen each on the north and south sides of the sound. The geology of Queen Charlotte Sound is primarily schist with pockets of sandstone. Sites at Whatamango Bay, Curious Cove and Monkey Bay (4, 8, 9 and 10 respectively) were located in sandstone catchments. The remainder of the sites were located in schist catchments. Land use varied only slightly between sites as most small streams drained relatively undisturbed native forest or reverting native forest catchments. The exceptions were in Hitaua Bay (site 7) which was in a pine forest catchment and the southern stream

in Curious Cove (site 8) which was farmed in its lower reaches. Physical and biological measurements taken are described for each site in Appendix 1.

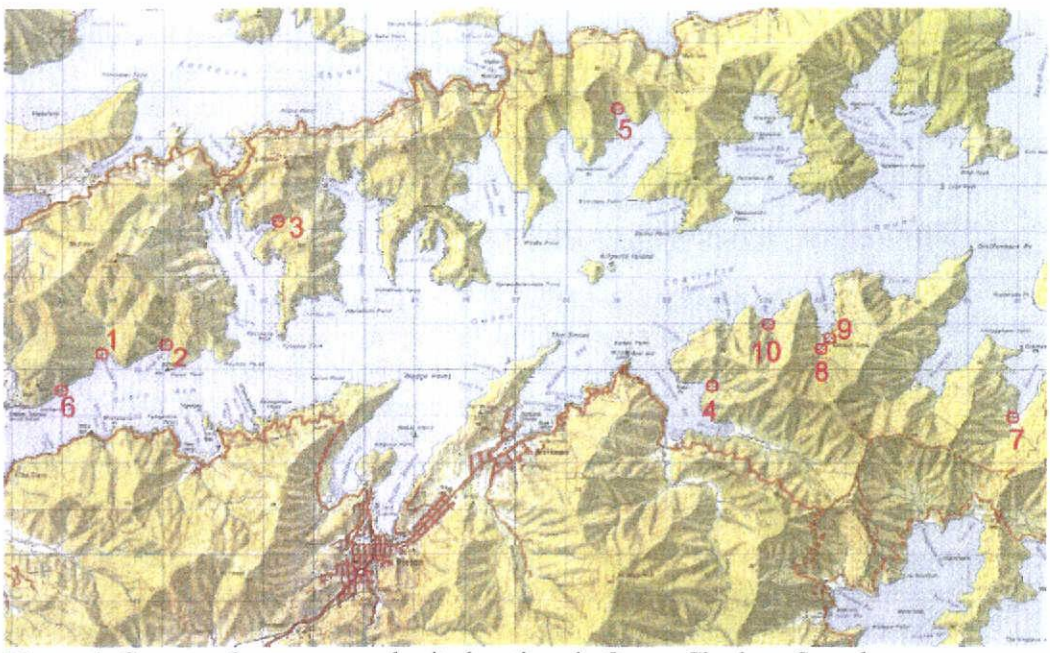

Figure 1 Category 3 stream sample site locations in Queen Charlotte Sound

2.2 Water quality

At each site water quality samples were collected for analysis of nitrate (NO_3-N), ammonium (NH_4-N), dissolved reactive phosphorus (DRP), total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), inorganic (fixed) suspended solids (FSS), organic (volatile) suspended solids (VSS) and indicator bacteria (*E. coli*). Analyses were undertaken by the Cawthron Institute's IANZ accredited water testing laboratory using appropriate standard methods. Spot measurements of dissolved oxygen, water temperature, turbidity, conductivity and pH were measured in the field using standard equipment and techniques.

2.3 Physical characteristics

Flow was measured at each site by timing the flow into a measured container. Sinuosity was measured by the number of metres the stream channel varied from an imaginary centre line over a set distance (usually 30 m). Sinuosity can be used to explain in-stream habitat diversity, *i.e.* the more sinuous the stream course is the more potential there is for in-stream habitat diversity. Information on dominant catchment land use, riparian and instream vegetation, substrate and habitat types were also recorded.

2.4 Macroinvertebrates

At each site a hand-net was used to sample the range of freshwater insects, crustaceans, worms and snails that were present. These species are known collectively as macroinvertebrates. Freshwater macroinvertebrates live almost their entire lives in water, although many of the insect forms have aerial adult stages. Some are pollution tolerant whereas others are not. As a result, the presence or absence of some macroinvertebrate species can indicate the ecological health of a stream. Samples were collected by disturbing the substrate while holding the hand-net immediately downstream to collect dislodged animals and by sweeping the hand-net through any overhanging or instream vegetation and along the bed and banks of the streams. Samples of this type are not quantitative (*i.e.* you can not get density data from them), but relative abundances of one species versus another at a site can be obtained.

Samples were preserved in 1 litre plastic jars in the field using 70 % ethanol. In the laboratory, samples were sieved, sorted by eye and identified to the lowest taxonomic level possible using standard keys.

Indices used to assist interpretation of macroinvertebrate data included:-
Species richness (or more strictly, taxa richness). This is simply the number of different kinds of animals (= taxa) present. Sometimes the different taxa are resolved down to the species level (*e.g., Austroclima sepia*), but may be at the genera level (*e.g., Austroclima* sp.), or even higher taxonomic level (*e.g.,* Leptophlebiidae), depending upon the practicality of identification.

EPT *taxa.* This is the total number of kinds of mayflies (**E**phemeroptera), stoneflies (**P**lecoptera), and caddisflies (**T**richoptera) found in a sample. These kinds of freshwater insects generally are intolerant of pollution.

Macroinvertebrate Community Index (MCI) values were calculated according to the method of Stark (1985, 1993, 1998). The MCI relies on prior allocation of scores (between 1 and 10) to different kinds of freshwater macroinvertebrates based upon their tolerance to pollution. Types of macroinvertebrates that are characteristic of unpolluted conditions and/or coarse stony substrates score more highly than those found predominantly in polluted conditions or amongst fine organic sediments. In theory, MCI values can range between 200 (when all taxa present score 10 points each) and 0 (when no taxa are present), but in practice it is rare to find MCI values greater than 150. Only extremely polluted or sandy/muddy sites score under 50.

SQMCI (Semi-Quantitative MCI) values were also calculated. Unlike the MCI, which only uses presence-absence data, the SQMCI incorporates relative abundances into the index calculation. SQMCI values, therefore, reflect the abundance and types of macroinvertebrates found at a site. Relative abundance categories are assigned based on the numbers of each taxon in a sample as follows:

Number of animals	Relative abundance category	Abbreviation used
1 - 4	Rare	R
5 – 19	Common	C
20-99	Abundant	A
100 – 499	Very Abundant	VA
> 500	Very, Very Abundant	VVA

2.5 Fish

Only one of the streams (Site 1 – Umungata Bay) sampled in Queen Charlotte Sound on this survey had previously been fished (Figure 2). Stream length sampled varied with access. In some cases the stream course was completely enclosed in thick vegetation, including gorse. Sample reaches varied from 25 m to more than 100 m. Where only a short reach could be sampled, another upstream reach was selected to complement the sample.

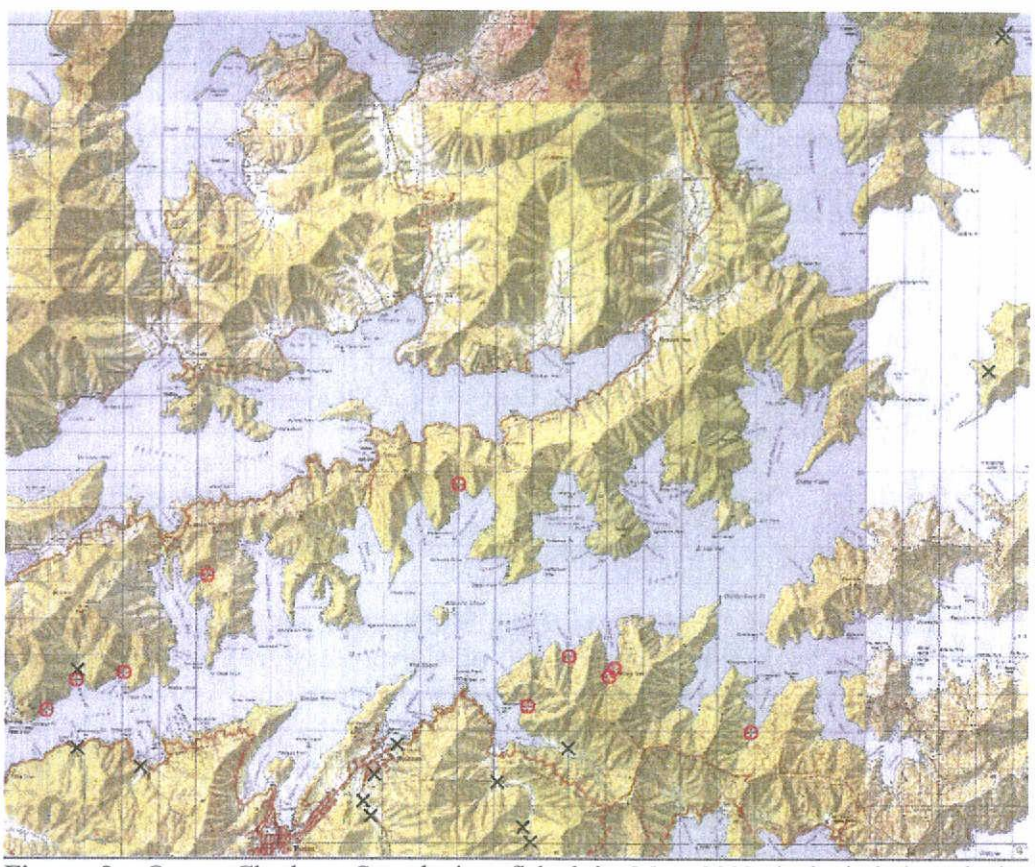

Figure 2 Queen Charlotte Sound sites fished in May 2003 (red circles) and sites previously fished and recorded on the NZFFD (black crosses).

Fish were sampled during daylight hours using a back-pack electric fishing machine. All fish were identified and released where they had been caught. The sites were revisited at night to check by spotlight that all species had been accounted for. The presence and relative abundance of fish species observed at each site using the combined techniques were recorded on NZ Freshwater Fisheries database (NZFFD) forms and were submitted for inclusion in the database. An estimate of species relative abundance based on approximate number of fish per 100 m^2 was used as follows:

Fish per 100 m²	Abundance category	Abbreviation used
< 2	Rare	R
2 - 3	Occasional	O
4 - 10	Common	C
> 10	Abundant	A

3. RESULTS

3.1 Physical character

3.1.1 Catchment and riparian vegetation

Catchment vegetation was mostly native forest or regenerating native forest. Forest type varied a little between beech, kanuka and podocarp, and sometimes were a mixture of all three (Table 1). The exceptions to this were Hitaua Bay (site 7) which was in pine forest and the western stream in Curious Cove (site 8) which had some pasture in its very lower reaches. The lower reach of the northern stream in Monkey Bay (site 10) was developed as lawn and garden in a small area surrounding several dwellings.

Riparian vegetation was similar at all sites and generally characterised by an enclosed canopy of tall native trees (Beech, Kanuka or Podocarps), with a riparian understorey of various mixes of native shrubs, tree ferns and ferns. In the lower-most reaches of the streams in Umungata, Fence, Whatamango and Hitaua bays (sites 1, 3, 4, and 7 respectively), small wetlands with up to 100 m of stream course meandering through them had been formed on small areas where the catchment flattened out slightly before entering the sea. These small wetlands were usually quite impenetrable and characterised by a dense mix of sedges, flaxes and exotics such as gorse and blackberry.

Table 1 Category 3 stream catchment and riparian vegetation in Queen Charlotte Sound

Site	Catchment vegetation	Riparian vegetation
1. Umungata	Native forest	Kanuka forest, native shrubs, tree ferns, ferns, flax, carex
2. Bottle	Native forest	Kahikatea, kanuka, tree ferns, gorse, native shrubs
3. Fence	Reverting native forest, scattered pines	Kanuka, tree ferns, gorse, native shrubs
4. Whatamango	Reverting native forest, kanuka and gorse	Kanuka, coprosma, rangiora, native shrubs
5. Kumutoto	Native podocarp forest	Podocarp forest seedlings and shrubs, kawakawa
6. Iwituaroa	Native red beech forest	Red beech, coprosmas and ferns
7. Hitaua	Pine forest	Pines, native shrubs, tree ferns
8. Curious West	Regenerating beech, and kanuka/manuka	Pasture in lower reach, otherwise mixed native shrubs and ferns
9. Curious East	Regenerating native beech and kanuka forest	Kawakawa, whitey wood and ferns
10. Monkey East	Regenerating native forest, kanuka, tree ferns	Lawn and domestic plantings adjacent to dwellings

3.1.2 *In-stream characteristics*

Some of the physical characteristics of the streams sampled were quite different while others were quite similar (Table 2). While we sampled at the end of a period of long summer low flows, there was evidence of recent freshes in the various catchments. For the purposes of this study we have assumed that flows measured might represent something close to base flows. Flows varied from 0.08 litres per second to 10 litres per second. The stream in Hitaua Bay (Site 7) had the most flow and was probably a little outside the scope of this survey. All other streams were less than 3.0 litres per second. Streams less than 0.5 litres per second were inclined to be ephemeral in some reaches.

The average width of all streams sampled varied between 0.4 m and 2 m. Sinuosity varied only from 1m to 5 m over a 30 m reach, but most had a sinuosity of 3 m. In-stream habitat characteristics were limited to pool, run and riffle at all sites, though rapids and cascades would be present in several of the higher gradient streams when flows increased during freshes. Generally, a high percentage of runs and pools characterised these streams. Substrates were generally dominated by coarse material rather than silt and sand. These features probably reflect the relatively steep but stable catchments through which they run.

Table 2 Physical characteristics of Category 3 streams in Queen Charlotte Sound

Site	Flow (litres/sec)	Mean width (m)	Sinuosity (m/30 m)	Pool (%)	Run (%)	Riffle (%)	Dominant substrate	Sub dominant substrate
1. Umungata, 1	3.00	1.2	3	50	40	10	Fine gravel	Silt
1. Umungata, 2		2.0	3	30	50	20	Coarse gravel	Fine gravel
2. Bottle, 1	1.20	1.0	5	30	50	20	Fine gravel	Coarse gravel
2. Bottle, 2		1.0	3	50	40	10	Sand/silt	Coarse gravel/ cobble
4. Whatamango	0.77	1.5	3	30	60	10	Coarse gravel	Cobble
5. Kumutoto	0.58	1.0	4	60	30	10	Cobble	Fine gravel
6. Iwituaroa	0.08	0.5	2	20	80	0	Boulder	Sand/silt
7. Hitaua	10.00	1.5	5	20	50	30	Coarse gravel	Silt
8. Curious West	1.04	1.5	4	30	50	20	Boulder	Coarse gravel
9. Curious East	0.27	1.0	3	40	50	10	Boulder	Silt
10. Monkey East	0.20	0.4	1	10	80	10	Coarse gravel	Silt

3.2 Water quality

A summary of water quality parameters at eight of the sites (all of the study sites except for Fence and Iwituaroa) is presented in Figure 3.

Indicator bacteria (*E. coli*) were detected at all of the sites (thus exceeding guideline concentrations in the 'Drinking-Water Standards for New Zealand' of less than 1 cfu/100 mL [MoH 2000]), and exceeded the "Alert Level I" guideline level for contact recreation of 126 cfu/100 mL (MfE 1999) at Kumutoto. Bacterial concentrations were also elevated at Monkey Bay.

Total phosphate (TP) concentration was highest at Monkey Bay, and the concentration of dissolved reactive phosphorus (DRP), which is the variety of phosphorus most available for uptake by aquatic plants and algae, was also high at this site. Although TP was considerably lower at Hitaua and Curious Cove East, both of these sites also had relatively high DRP concentrations.

Ammonium nitrogen (NH_4-N) concentration was relatively high at Curious Cove East, exceeding the default guideline concentration for protection of aquatic ecosystems in New Zealand lowland streams (ANZECC & ARMCANZ 2000). In contrast, total nitrogen (TN) and nitrate nitrogen (NO_3-N) concentrations were relatively low at Curious Cove East, and were highest at Hitaua and Monkey Bay.

pH was circumneutral at all of the sites, ranging from 7.09 at Monkey Bay to 7.52 at Curious Cove West. Conductivities were variable, ranging from 82 µS/cm (Kumutoto) to 185 µS/cm (Curious Cove East).

Spot temperature measurements ranged from 9.2 to 11.8 °C and spot measurements of dissolved oxygen (DO) saturation ranged from 79.4 to 99.3 %. Single spot measurements are of limited use for measuring temperature and DO, as both of these parameters vary throughout the 24 hour cycle and throughout the year. However, the low spot DO measurements at Curious Cove East (79.4 %) and Monkey Bay (87.1 %) indicate that DO saturation in these streams may periodically or occasionally drop below the 80 % saturation level, which is generally accepted as the guideline level (mean DO over a 24 hour period) for the protection of aquatic ecosystems (ANZECC 1992).

Total suspended solids (TSS) were high at Kumutoto (24 g/m^3) and Monkey Bay (16 g/m^3). Curious Cove East and Hitaua also had higher TSS than the remaining four sites, which had low concentrations of TSS ($\leq$ 2 g/m^3). Suspended sediments at all of the sites comprised both fixed (inorganic) suspended solids (FSS) and volatile (organic) suspended solids (VSS), usually with proportionately more FSS than VSS. Hitaua and Monkey Bay also had relatively high turbidities (4.49 and 3.58 NTU, respectively), whereas Kumutoto and Curious Cove East had low turbidities (1.31 and 1.19 NTU, respectively), contrasting with the TSS results. The high turbidity at Whatamango (3.09 NTU) was not reflected in the TSS results.

3.2.1 Water quality summary

Monkey Bay and Curious Cove East had the poorest water quality of the sites sampled, with relatively high concentrations of DRP, nitrogen (NH_4-N at Curious Cove East, TN

and NO_3-N at Monkey Bay) and TSS, and relatively low spot DO saturation, at both sites. Monkey Bay also had relatively high *E. coli* concentrations and high turbidity. These streams had the lowest flows of any of the sites sampled for water quality (Monkey Bay 0.20 l/s and Curious Cove East 0.27 l/s). Kumutoto, which had the third lowest flows (0.58 l/s) after Monkey Bay and Curious Cove East, also had questionable water quality in some respects, with high concentrations of bacteria and TSS.

Hitaua, the largest stream included in the study (10 l/s) also had relatively poor water quality, with high concentrations of phosphorus and nitrogen (TP, DRP, TN, NO_3-N) and high turbidity. This was the only site that flowed through exotic forest.

Umungata, Bottle, Whatamango and Curious Cove West all had similar, relatively good, water quality (with the exception of a high turbidity value at Whatamango).

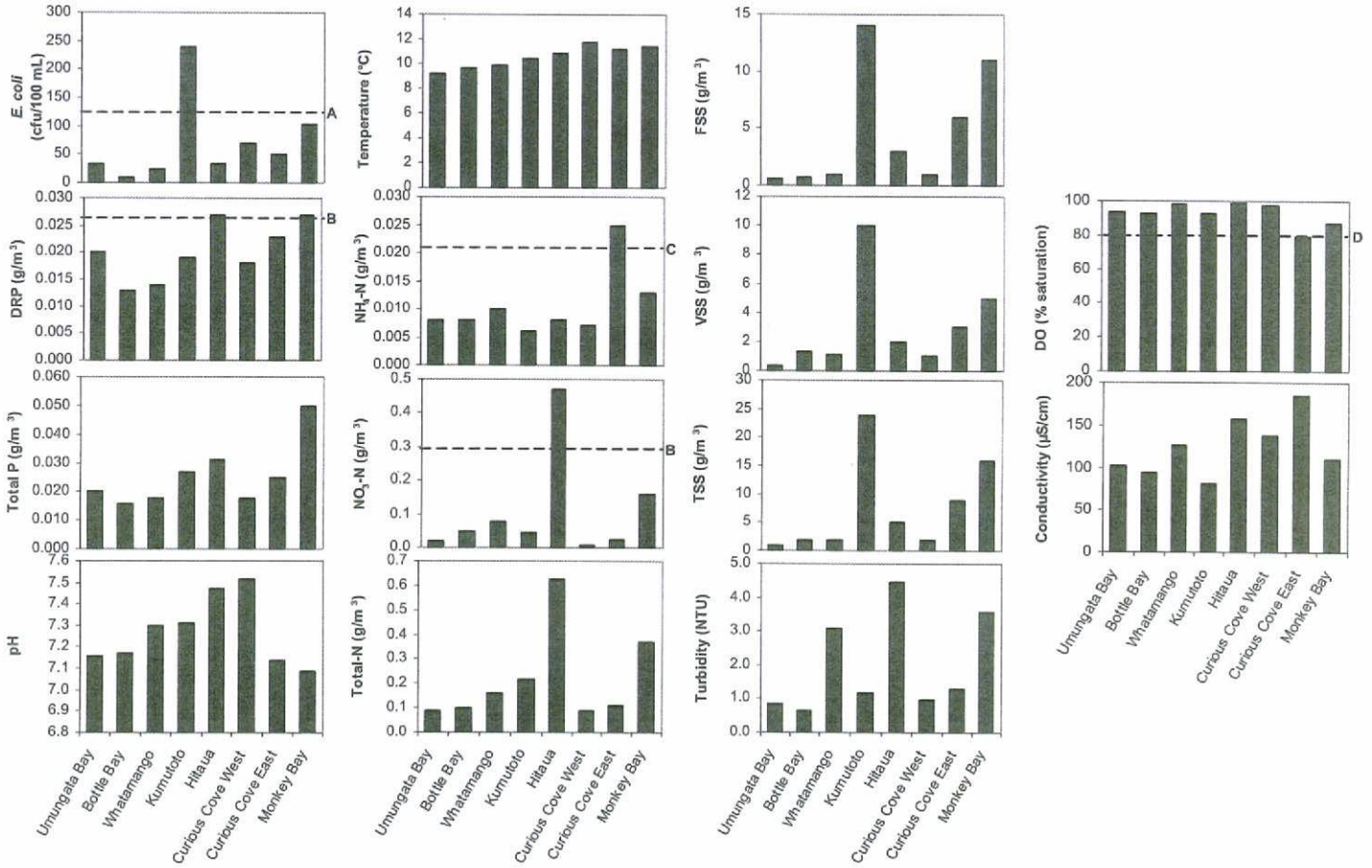

Figure 3 Summary of water quality parameters at each of the sites. **A** - MfE (1998) lower trigger level for contact recreation, **B** – MfE (2000) upper guideline concentration for limitation of periphyton biomass, **C** - ANZECC & ARMCANZ (2000) default trigger value (upper limit) for protection of aquatic ecosystems, **D** - ANZECC (1992) guideline minimum level for protection of aquatic ecosystems.

3.3 Macroinvertebrates

At least 65 kinds of macroinvertebrates were taken from nine sites (all of the study sites except for Fence Stream) throughout Queen Charlotte Sound. Caddisflies were the most diverse group with at least 23 taxa collected, followed by true flies (14 kinds), mayflies, stoneflies and beetles (5 kinds of each) and Crustacea (4 kinds). Many of the macroinvertebrates were typical representatives of small stony streams in forested catchments, such as the mayfly *Deleatidium* (taken from 89 % of the sites), snail *Potamopyrgus* (100 % of sites), stonefly *Stenoperla* (78 % of sites) and caddisflies *Hydrobiosella* (89 % of sites) and *Pycnocentria* (78 % of sites) (Winterbourn, Rounick & Cowie 1981; Rounick & Winterbourn 1982; Winterbourn, Gregson & Dolphin 2000).

Macroinvertebrate indices commonly used to assess stream 'health' are presented in Figure 4, and the dominant / sub-dominant macroinvertebrate taxa collected from each site are listed in Table 3. A complete list of macroinvertebrate taxa collected in this study, and their relative abundances can be found in Appendix 3.

Most of the sites had high taxa richness, with over half having more than 30 kinds of macroinvertebrates present. However, Iwituaroa and Monkey Bay had comparatively low numbers of taxa, with only 10 and 14 taxa, respectively. Percentage of pollution-sensitive EPT taxa was high (over 40 %) at all of the sites, and was 60 % or higher at Whatamango, Kumatoto, Iwituaroa and Hitaua. The lowest proportions were found in two of the smallest streams, Monkey Bay (42.9 %) and Curious Cove East (44.8 %).

MCI scores were indicative of 'clean/unpolluted' water (scoring over 120) at all sites except Monkey Bay, which had a lower MCI (104), indicative of 'possible mild pollution'. SQMCI scores provided more separation of the sites in terms of macroinvertebrate community health, with five sites (Umungata, Bottle, Whatamango, Iwituaroa and Hitaua) scoring highly (over 6.00, indicative of 'clean/unpolluted' water), one site (Kumutoto) scoring between 5.00 and 6.00, (indicative of 'possible mild pollution'), and three sites (Curious Cove West, Curious Cove East and Monkey) scoring between 4.00 and 5.00, indicative of 'probable moderate pollution'.

High SQMCI scores at Umungata, Bottle, Whatamango, Iwituaroa and Hitaua were due to dominance by pollution-sensitive taxa, such as mayflies (*Deleatidium*, *Coloburiscus* and/or *Zephlebia*) and caddisflies (*Helicopsyche*, *Hydrobiosella* and/or *Pycnocentria*), although less sensitive amphipods (*Phreatogammarus*) and snails (*Potamopyrgus*) were also dominant at most of these sites. All of these sites also had high MCI scores and % EPT, so together, the three indices indicate that water quality is sufficient to support pollution-sensitive communities. These results correspond well with water quality results, with the possible exception of Hitaua, which had some evidence of slightly to moderately impacted water quality due to relatively high nutrient concentrations and turbidity. However, the nutrient concentrations recorded at Hitaua are unlikely to impact the macroinvertebrate assemblage unless they lead to proliferations of filamentous algae, which in turn can cause a more tolerant macroinvertebrate assemblage to develop. Filamentous algae were not observed in Hitaua, probably because the stream was well shaded. Iwituaroa supported a less diverse macroinvertebrate community than the other sites, and the overall abundance of macroinvertebrates in the sample was low, with less than 20 individuals of each of the dominant taxa. This is likely to be due to physical characteristics of the stream, most notably the very low and intermittent flow (Table 2).

Kumutoto's lower SQMCI score was due to dominance by pollution-tolerant snails (*Potamopyrgus*), with none of the more sensitive mayfly or caddisfly taxa in the top abundance category. Two of the three sub-dominant taxa at Kumutoto were also relatively 'pollution-tolerant' taxa (midge larvae Tanypodinae and the caddisfly *Triplectides*). There is some evidence that water quality may be slightly to moderately impacted at this site (high concentrations of indicator bacteria and TSS), but the close proximity of the sampling reach to the tidal zone may also have contributed to the poorer quality of the macroinvertebrate assemblage. However, Kumutoto had relatively high taxa richness, percentage EPT taxa and MCI scores, indicating that although more tolerant taxa were dominant, a large proportion of sensitive taxa were present at the site, albeit in lower abundance.

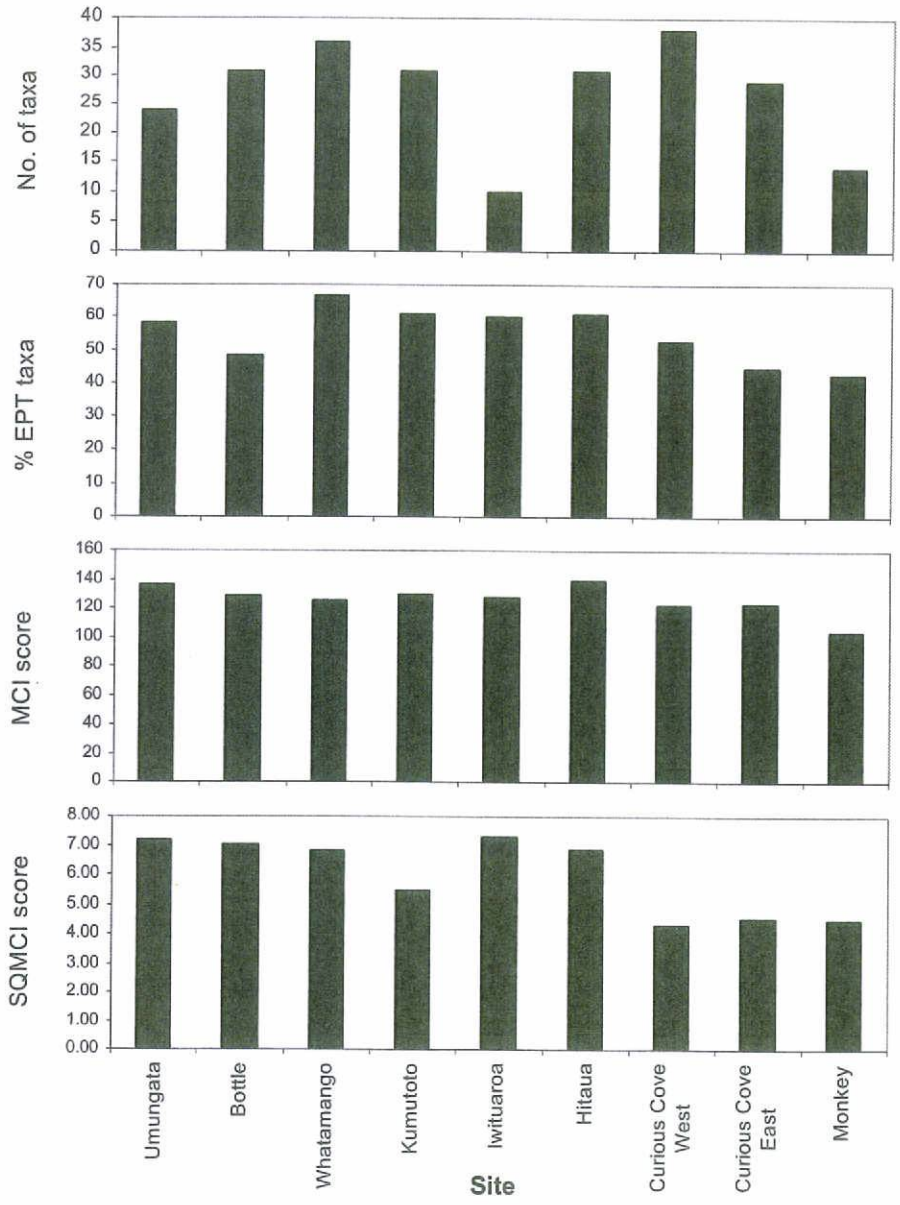

Figure 4 Summary of biotic indices for the study sites.

Table 3 Dominant and sub-dominant macroinvertebrate taxa collected from the study sites, shown alongside their relative abundance category (as described in section 2.4) Individual taxon scores are shown in parentheses for the dominant taxa.

	Site		
	Umungata	Bottle	Whatamango
VVA			
VA	***Deleatidium*** *(8)* ***Helicopsyche*** *(10)* ***Phreatogammarus*** *(5)*	***Helicopsyche*** *(10)* ***Potamopyrgus*** *(4)*	***Helicopsyche*** *(10)* ***Potamopyrgus*** *(4)*
A	*Coloburiscus* *Archichauliodes* Hydraenidae *Olinga* Worms *Potamopyrgus*	*Deleatidium* *Austroperla* *Spaniocerca* Ptilodactylidae *Tanytarsus* *Hydrobiosella* *Pycnocentria* *Triplectides*	*Coloburiscus* *Deleatidium* *Neozephlebia* *Austroperla* *Spanicerca* Orthocladiinae Tanypodinae *Olinga* *Pycnocentria* *Triplectides* *Phreatogammarus*

	Site		
	Kumutoto	Iwituaroa	Hitaua
VVA			
VA	***Potamopyrgus*** *(4)*		***Coloburiscus*** *(9)* ***Pycnocentria*** *(7)* ***Potamopyrgus*** *(4)*
A	Tanypodinae *Helicopsyche* *Triplectides*		*Deleatidium* Ptilodactylidae *Helicopsyche* *Hydrobiosella* *Paratya*
C*		***Deleatidium*** *(8)* ***Zephlebia*** *(7)* ***Hydrobiosella*** *(9)*	

* only shown for Iwituaroa, where overall abundance was low and dominant macroinvertebrates were in the 'C' class.

	Site		
	Curious West	Curious East	Monkey
VVA	**Orthocladiinae** *(2)* ***Pycnocentrodes*** *(5)* ***Potamopyrgus*** *(4)*		
VA	*Deleatidium* *Neozephlebia* *Phreatogammarus*	***Potamopyrgus*** *(4)*	***Potamopyrgus*** *(4)*
A	*Coloburiscus* *Spaniocerca* *Zelandobius* *Austrosimulium* Tanypodinae *Helicopsyche* *Hydrobiosella* *Olinga* *Oxyethira* *Triplectides* Ostracoda Worms	*Nothodixa* *Polypedilum* Tanypodinae *Phreatogammarus*	*Phreatogammarus*

The three sites with low SQMCI scores (Curious Cove West, Curious Cove East and Monkey Bay) were also all dominated by *Potamopyrgus*. However, Curious Cove West had a different assemblage to the other two sites, with orthoclad midge larvae and the relatively tolerant cased-caddisfly *Pycnocentrodes* also occurring as dominant taxa. Sub-dominant taxa included pollution-sensitive mayflies (as well as the more tolerant amphipod *Phreatogammarus*), and a wide range of taxa with pollution tolerances ranging from 1 to 10 also occurred in abundance. In fact, this site had the highest number of taxa in this study. This was probably due to the sample being collected from two distinctly different reaches of the stream, one (approximately 10 m upstream of tidal zone) in an open aspect with dense watercress and filamentous green algae growth, and the other (approx 200 m upstream) under a canopy of native trees with a typical boulder / coarse gravel bed. Orthoclad midges, amphipods and possibly *Potamopyrgus*, as well as other more tolerant taxa, are likely to have inhabited the watercress / filamentous algae habitat, whereas the upstream site is likely to have hosted a more typical, pollution-sensitive 'small forested stream' assemblage.

In contrast, assemblages at Curious Cove East and Monkey Bay were both dominated by *Potamopyrgus* alone, and had relatively tolerant sub-dominant taxa (amphipod *Phreatogammarus* and true-fly larvae). Both sites also had relatively low % EPT (44.8 % and 42.9 %, respectively), but while Curious Cove East had high taxa richness and a high MCI, Monkey had comparatively poor taxa richness and a low MCI. These two sites had the poorest water quality of the sites sampled (both sites had high nutrient and TSS concentrations, low DO; Monkey Bay had high concentrations of bacteria, high turbidity). The very low and probably intermittent flows of these two small streams (Table 2) are also likely to have influenced the quality and diversity of their communities. In addition, both were sampled in their lower reaches (approximately 10 m upstream of their tidal zones), where snail and amphipod-dominated communities commonly establish.

The distribution of Crustacea throughout the study sites is shown in Table 4. Seed-shrimp (Ostracoda) were only found at Curious Cove West, and were probably taken from the watercress / filamentous green algae reach. Seed-shrimp are likely to inhabit other small streams in the region if suitable habitat (such as macrophyte beds, slow-moving stream sections, isolated pools in intermittent streams) is available.

Amphipods (*Phreatogammarus helmsii*) and koura (*Paranephrops* sp.) were found in half of the streams sampled, and shrimp (*Paratya curvirostris*) were found at 7 sites. Koura are widely distributed throughout Queen Charlotte Sound (Figure 5).

Table 4 Distribution of Crustacea throughout the study sites.

Taxon	Umungata	Bottle	Fence	Whatamango	Kumutoto	Iwituaroa	Hitaua	Curious West	Curious East	Monkey
Seed-shrimp			*					■		
Amphipods	■		*	■				■	■	■
Shrimp	■	■			■		■	■	■	■
Koura		■	■	■	■	■				

* may be present, this site was not sampled by hand-net. Note: data for shrimp and koura was supplemented with information from fish surveys.

Figure 5 Koura presence in Queen Charlotte Sound (red circles) and sites sampled (black crosses).

A DECORANA ordination of macroinvertebrate communities found in this study (9 sites) and previous studies of the Wairau Plain springs (32 sites, including Spring Creek sites) and Rai River catchment (18 sites), using presence-absence data is presented in Figure 6. The separation of sites is proportional to the relative similarity of their macroinvertebrate communities. Characteristic taxa (from a taxon ordination which is not shown) are plotted near the sites where they were most commonly represented.

The Marlborough Sounds communities were very similar to the Rai River catchment communities along Axis-1, but the two groups were clearly separated from the Wairau Plain springs communities which correlated most strongly with hydroptilid caddis larvae, damselfly larvae (*Xanthocnemis*), snails (*Physella*) and amphipods. These taxa are all characteristic of standing / soft-bottomed waterbodies with macrophyte beds. In contrast, the Rai River catchment and Marlborough Sounds sites were most strongly correlated with taxa characteristic of stony-bottomed, faster-flowing rivers. The Marlborough Sounds and Rai River catchment sites separated along Axis-2, with the Marlborough Sounds sites correlating most strongly with the stony-cased caddisfly *Helicopsyche*, stonefly *Stenoperla* and mayfly *Deleatidium*, all pollution-sensitive taxa with individual MCI scores of 8 or more. The Rai River catchment sites were strongly correlated with a large number of taxa – some pollution-sensitive such as the mayfly *Coloburiscus*, caseless-caddisfly

Psilochorema and cased-caddisfly *Olinga*, others pollution-tolerant such as midge larvae (*Maoridiamesa*) and net-spinning caddisfly *Aoteapsyche.*

There was considerable spread within the cluster of Marlborough Sounds sites, particularly along Axis-2, with the community at Iwituaroa separating from the other sites. The position of this site within the ordination is likely to have been strongly influenced by low taxonomic diversity of this community, compared with the other Marlborough Sounds sites.

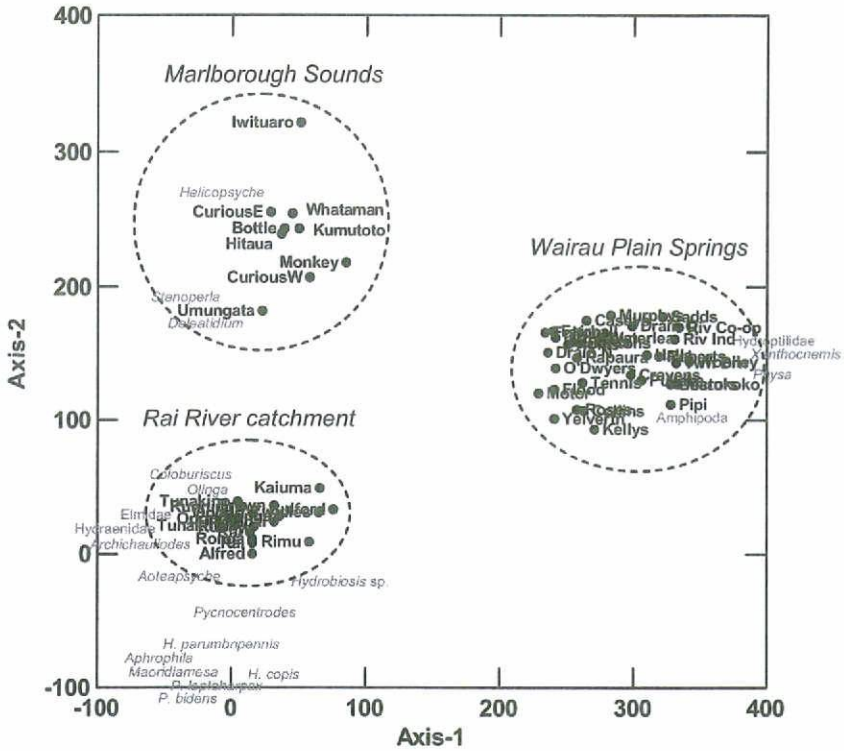

Figure 6 DECORANA ordination of macroinvertebrate communities found in this study, and previous studies of the Wairau Plain springs and Rai River catchment, using presence-absence data. Sites with the most similar macroinvertebrate communities are plotted closest together.

3.4 Fish

Eight species of freshwater fish were found at the sites sampled (Table 5). These were shortfin eel (*Anguilla australis*), banded kokopu (*Galaxias fasciatus*), koaro (*G. brevipinnis*), inanga (*G. maculatus*), redfin bully (*Gobiomorphus huttoni*), common bully (*G. cotidianus*), giant bully (*G. gobioides*), bluegill bully (*G. hubbsi*). Redfin bully and banded kokopu were the most commonly found species and were found at all but two sites. The Monkey Bay stream (site 10) was barely flowing, very shallow and open, so of marginal suitability for banded kokopu, more typically found in forest pools. The Iwituaroa Point creek (site 6) had only one fish species present (koaro) which may have been due to the lack of flow and disconnected habitats. The two koaro found at this site were only juveniles and would have found habitat a limiting factor within the reach we

surveyed. If they were able to make it further upstream during freshes, it is possible they would find small pockets of habitat.

Table 5 Fish presence and abundance in Category 3 streams of Queen Charlotte Sound

Site	Shortfin eel	Eel spp.	Banded kokopu	Koaro	Inanga	Redfin bully	Common bully	Giant bully	Bluegill bully
1. Umungata	O	-	O	-	A	C	C	R	-
	-	R	C	-	C	C	-	-	R
2. Bottle	-	-	O	-	C	C	-	-	-
	-	-	C	-	-	C	-	-	-
3. Fence	-	-	C	-	-	C	-	-	-
4. Whatamango	-	-	C	-	-	C	-	-	-
5. Kumutoto	-	-	C	-	C	C	-	-	-
6. Iwituaroa	-	-	-	R	-	-	-	-	-
7. Hitaua	O	-	C	-	A	C	-	-	-
8. Curious West	-	C	C	-	A	C	-	-	-
9. Curious East	-	-	C	-	-	C	-	-	R
10. Monkey East	-	O	-	-	C	C	-	-	-

Fish per 100 m²	Abundance category	Abbreviation used
< 2	Rare	R
2 - 3	Occasional	O
4 - 10	Common	C
> 10	Abundant	A

Our impression of fish species richness in these small streams was very much determined by where in the catchment samples were taken. Suitable habitat for some species may have only been represented over a few metres of the stream course as we found for species such as bluegill and giant bully. In such cases, it is very easy to miss any of the species that only occur occasionally or rarely. In some streams, increased flows may create temporary habitat for some species. This means that at any time of the year small portions of habitat in most of these small streams could become available and support a few of any of the species listed in Table 5 or Appendix 2.

Perhaps surprising was the low occurrence and abundance of eels. In nearly all cases eels were only found in the very lower reaches of these streams. This could be explained by the slightly ephemeral nature of many of these small streams which would not make it easy for larger fish such as eels to find suitable long term habitat. Species such as banded kokopu are able to persist for long periods of time in remnant pools which may explain their ubiquity in these small streams compared with eels.

Previous fish surveys in Queen Charlotte Sound, which have mostly focused on the larger streams and rivers of the Sound, found 11 species of fish (See full list of species found in Queen Charlotte Sound streams in Appendix 2). As well as those found during our survey, these included: longfin eel (*A. dieffenbachii*), shortjaw kokopu (*G. postvectis*), giant kokopu (*G. argenteus*), dwarf galaxias (*G. divergens*), and goldfish (*Carassius auratus*), but did not include shortfin eel or giant bully. Previous surveys found that longfin eels were abundant in the larger streams, but as we found, were rare or absent in smaller streams. Likewise, the most ubiquitous of the species were redfin bullies and banded

kokopu. Three previous records of shortjaw kokopu indicate they were not common and except for one instance were found in larger streams (Graham and Waikawa) than sampled on our survey. A previous single record of giant kokopu being found in a stream in Ngakuta Bay is for one specimen caught in 1988. This stream also appears larger than the Category 3 type streams that we sampled.

4. DISCUSSION

4.1 The effects of low flow, flow reduction and flow diversion

The smallest stream, in terms of flow, that we sampled was Iwituaroa (site 6), which could be described as a series of semi-connected and unconnected pools. The species assemblage and richness typically found in all other streams were not present in this one. The biological characteristics of this stream could be likened to the effect that would be created in any of the other streams if their flow was to be reduced. An example of this was found in the stream at Fence Bay where about 50 m of the stream barely flowed between a water supply intake, which diverted a substantial portion of the stream, and a header tank. The overflow mechanism on the header tank allowed unused water to re-enter the stream, from which point downstream the stream supported banded kokopu, redfin bullies and koura. Between the intake and header tank only a few koura were found. The simple addition of a ballcock valve in the header tank would prevent unused water from being diverted. Instead, unused water would recharge the portion of stream currently depleted of sufficient flow to maintain viable habitat for at least two species of fish.

We also encountered a dwelling that appeared to have intentionally kept a tap at the lower end of their water system continuously flowing. This practice may have been a maintenance necessity so that silt and debris did not clog the lines. This was unfortunately coming from a stream that already had some of its course depleted of water due to a piped diversion from intake to header tank. An alternative means of keeping the lines free should be investigated in the interest of water and habitat conservation.

Although we found no examples of water supply weirs, such practices have been reported from the Marlborough Sounds. In such cases, the issue of stream channel dewatering would arise where any piped diversion was incorporated. Additionally, these weirs are possibly migratory barriers for fish.

Many of the issues highlighted here could be overcome with a campaign of education and recommendation of best practices for landowners utilising small streams for water supply in the Marlborough Sounds.

4.2 The effects of water supply takes

The quantity of water that each household uses varies depending on such things as the number of people per household, the appliances they use and their personal requirements. For the purpose of estimating the quantity of water for domestic use, most Regional Councils allow one cubic metre of water per household per day. Holiday homes, such as the majority in the Marlborough Sounds without road access, are likely to use less than permanent residences. Estimates of water use and their impact on streams in the Marlborough Sounds are therefore likely to be a worst case scenario.

Flows at sites sampled and the capacity of these streams to supply water for domestic use are shown in Table 6. As mentioned (section 3.1.2), streams less than 0.5 litres per second tended to become ephemeral in some reaches. Despite this, these same streams supported biota characteristic of other Category 3 streams. For streams with flows close to 0.5 litres per second (e.g. Kumutoto), the effect of having 10 homes drawing water from them could have the potential for parts of the stream to dry up. However for streams with flows of 1 litre/second or more (e.g. Bottle), it is possible that up to 50 homes could draw water from them before they were at risk of drying up. The clusters of homes surrounding and utilising the same small stream in the Marlborough Sounds rarely exceeds six homes. Exceptions to this are likely to be communal water supplies in some of the larger settlements such as Duncan Bay. However, it appears that in most instances the quantities of water that might potentially be taken from most small streams is not significant enough to effect the biotic community make up, but we are uncertain of the effects on quantity of biota.

Table 6 Flow and supply capacity of Category 3 streams in Queen Charlotte Sound

Site	l/sec	m³/day	Flow (l/sec) remaining if supplying 10 homes	Potential number of homes supplied using 50% of the flow
1. Umungata	3.00	259.20	2.884	130
2. Bottle	1.20	103.68	1.084	52
4. Whatamango	0.77	66.53	0.654	33
5. Kumutoto	0.58	50.11	0.464	25
6. Iwituaroa	0.08	6.91	0.0	3
7. Hitaua	10.00	864.00	9.884	432
8. Curious West	1.04	89.86	0.924	45
9. Curious East	0.27	23.33	0.154	12
10. Monkey East	0.20	17.28	0.084	9

4.2 Can the ecology of Category 3 streams be characterised

The results of this pilot study indicate that Category 3 streams in Queen Charlotte Sound can be characterised according to their physical, chemical and biological attributes.

At base flow, the streams typically had flows of 3.0 l/s or less, widths of 2 m or less, sinuousities ranging from 1 to 5 and coarse substrates (boulders, cobbles or coarse gravels dominant).

Water quality showed some variation according to stream size and catchment landuse. Larger streams (base flow > 0.7 l/s) in native / reverting native catchments had the best water quality, typically having low concentrations of indicator bacteria and TSS, low turbidity, well oxygenated water, low to moderate levels of nutrient enrichment, variable conductivity and circumneutral pH. Small streams (base flow < 0.6 l/s) and the single stream draining an exotic forest catchment, had poorer water quality, with all or some of the following attributes: elevated concentrations of indicator bacteria, moderate to high nutrient concentrations, high TSS concentration, high turbidity, and occasional / periodically low oxygen saturation.

Macroinvertebrate assemblages were generally characteristic of those found in small, stony, native forested catchments, and were clearly distinct from macroinvertebrate communities found in other waterways in the Marlborough region (Wairau Plain springs, Rai River catchment). Assemblages were highly diverse, with a high proportion of pollution sensitive EPT taxa, and dominant taxa typically included mayflies and caddisflies, but also more tolerant taxa such as snails. However, some departures were seen from these 'typical' native forest stream assemblages, for example in reaches where macrophytes / algae proliferated and in the lower tidal zones of streams, where more tolerant assemblages dominated by *Potamopyrgus* alone, orthoclad midge larvae or amphipod *Phreatogammarus* were found. Poorer quality macroinvertebrate assemblages were also found in the very small streams (base flow < 0.3 l/s), which typically had low diversity, lower proportions of pollution-sensitive EPT taxa and/or lower SQMCI scores. This is likely to be a direct result of either the low / intermittent flow, the relatively poor water quality at these sites, or more likely a combination of the two factors.

Eight species of freshwater fish were found during this survey, which brings the total number of freshwater fish recorded in Queen Charlotte Sound to 13. The most common species found were redfin bully and banded kokopu. Eels are usually the most common fish found in larger New Zealand streams, but were not typical of the Category 3 streams we sampled in Queen Charlotte Sound. The very small size of these streams and their potential ephemeral nature, limits fish habitat. These features can limit long term habitation for larger fish species and those with specific flow requirements. When species other than redfin bully and banded kokopu are found, it is because the stream occasionally offers a small portion of suitable habitat. Thus any of the freshwater fish species that have been recorded in larger streams in Queen Charlotte Sound, could occasionally be found in Category 3 streams, but are most often typified by redfin bully and banded kokopu.

This pilot study has shown that the ecology of Category 3 streams in Queen Charlotte Sound are similar and can in broad terms be characterised. The next step would be to check whether Category 3 streams in Pelorus, Kenepuru and the outer sounds can be similarly characterised and whether similar or other issues relating to methods of abstraction occur.

5. ACKNOWLEDGEMENTS

Peter Hamill assisted with fieldwork and project design. Aaron Quarterman assisted with fieldwork and ably navigated us about Queen Charlotte Sound.

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7. APPENDICES

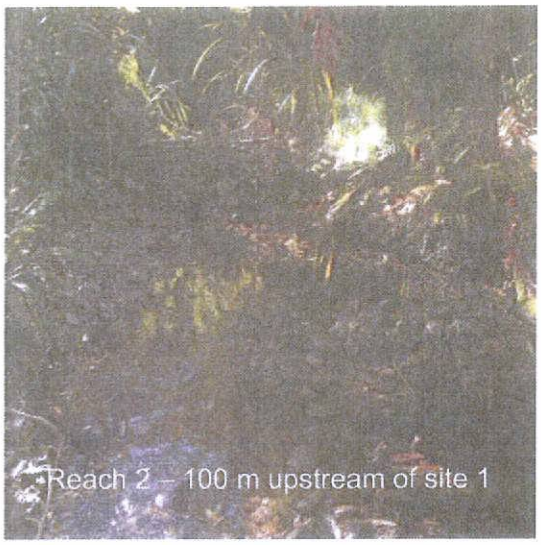
Appendix 1 Site Summary Sheets

In this section a short summary of the site, its catchment, water quality and ecology are provided. Most of the streams are unnamed, but for convenience and to give them an identity we have referred to them by the bay that they flow into or the nearest named landmark.

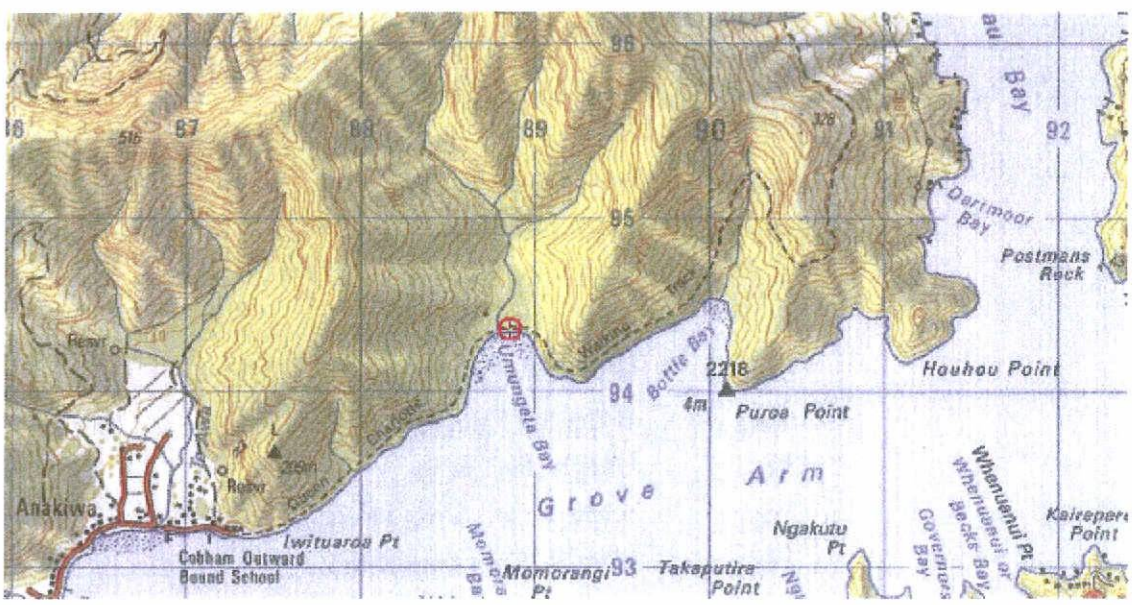
Site 1	Umungata Bay Stream
Site 2	Bottle Bay Stream
Site 3	Fence Bay Stream
Site 4	Whatamango Bay Stream
Site 5	Kumutoto Bay Stream
Site 6	Iwituaroa Point Creek
Site 7	Hitaua Bay Stream
Site 8	Curious Cove West Stream
Site 9	Curious Cove East Stream
Site 10	Monkey Bay East Stream

SITE 1 Umungata Bay Stream
Queen Charlotte Sound

13 May 2003


Reach 2 – 100 m upstream of site 1


Reach 1 – 5 m above salt water influence



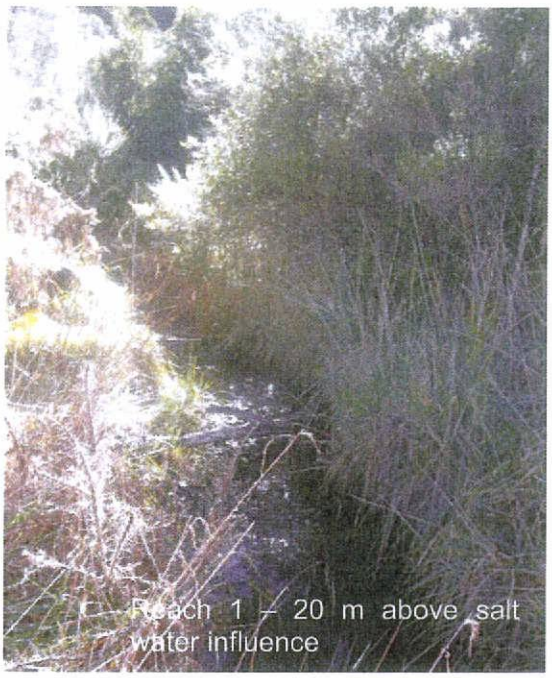
MAP COORDINATES	2588765E 5994340N
CATCHMENT LAND USE	Native forest
WATER ABSTRACTION	Department of Conservation camp ground
FLOW	3 litres per second

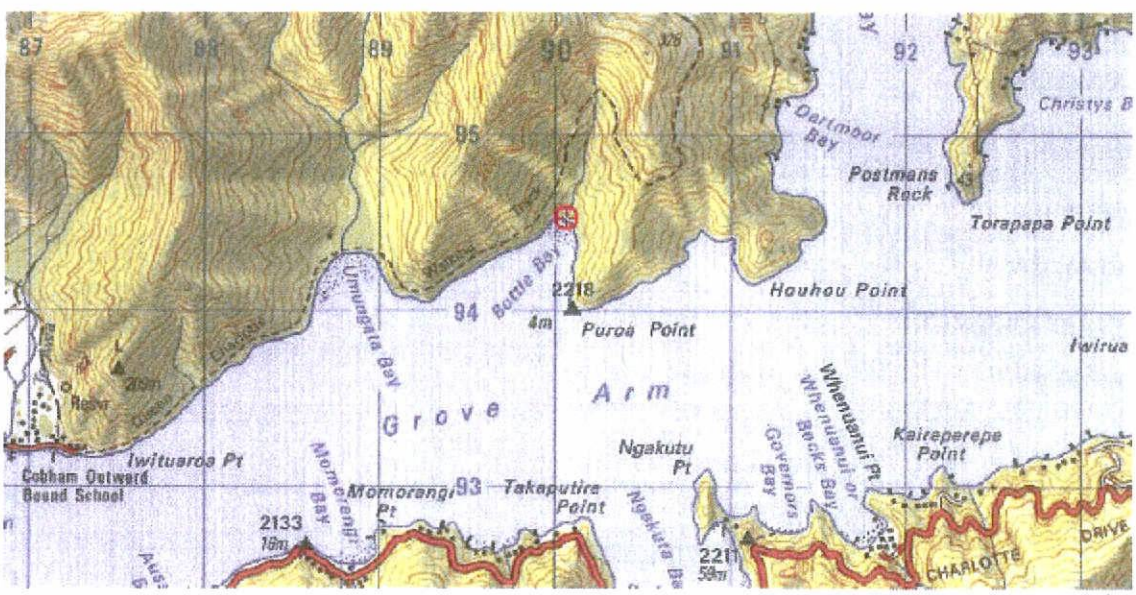
PHYSICAL PROPERTIES	DO = 10.8 mg/l, 93.9% Temperature = 9.2 °C pH = 7.16 Conductivity = 103 µS/cm Turbidity = 0.85 NTU
CHEMICAL PROPERTIES	Faecal coliforms = 35 cfu/100ml *E. coli* = 35 cfu/100ml Total suspended solids = 1 g/m³ Fixed suspended solids = 0.6 g/m³ Volatile suspended solids = 0.4 g/m³ Ammonia-N = 0.008 g/m³ Dissolved reactive phosphorus = 0.020 g/m³ Nitrate-N = 0.021 g/m³ Total Nitrogen = 0.09 g/m³ Total phosphorus = 0.020 g/m³
MACROINVERTEBRATES	MCI = 136 SQMCI = 7.21 EPT taxa = 58 % Taxa richness = 24 Dominant taxa = *Deleatidium, Helicopsyche, Phreatogammarus*
CRUSTACEA	Shrimp (*Paratya curvirostris*) – abundant Amphipods (*Phreatogammarus helmsii*) – very abundant
REACH 1	Just above any tidal influence
LENGTH	25 m
ELEVATION	2 m
AVERAGE WIDTH	1.2 m
SINUOSITY	3 m over 25 m
HABITAT	Pool = 50% Run = 40% Riffle = 10%
SUBSTRATE	Dominant = fine gravel Sub-dominant = mud
RIPARIAN VEGETATION	Tree ferns and native shrub canopy with fern, flax, carex and scrub wetland understorey.
INSTREAM VEGETATION	Nil, but overhanging carex and ferns
FISH	Shortfin eel - occasional Banded kokopu - occasional

	Inanga - abundant Common bully - common Redfin bully - common Giant bully - rare
REACH 2	Adjacent to the top of Davies Clearing
LENGTH	100 m
ELEVATION	5 m
AVERAGE WIDTH	2 m
SINUOSITY	3 m over 30 m
HABITAT	Pool = 30% Run = 50% Riffle = 20%
SUBSTRATE	Dominant = coarse gravel Sub-dominant = fine gravel
RIPARIAN VEGETATION	Kanuka forest, tree ferns and native shrubs.
INSTREAM VEGETATION	Nil, but overhanging ferns
FISH	Eel spp. - rare Banded kokopu - common Inanga - common Redfin bully - common Bluegill bully - rare

SITE 2 **Bottle Bay Stream** 13 May 2003
Queen Charlotte Sound


Reach 2 – 50 m upstream of site 1


Reach 1 – 20 m above salt water influence



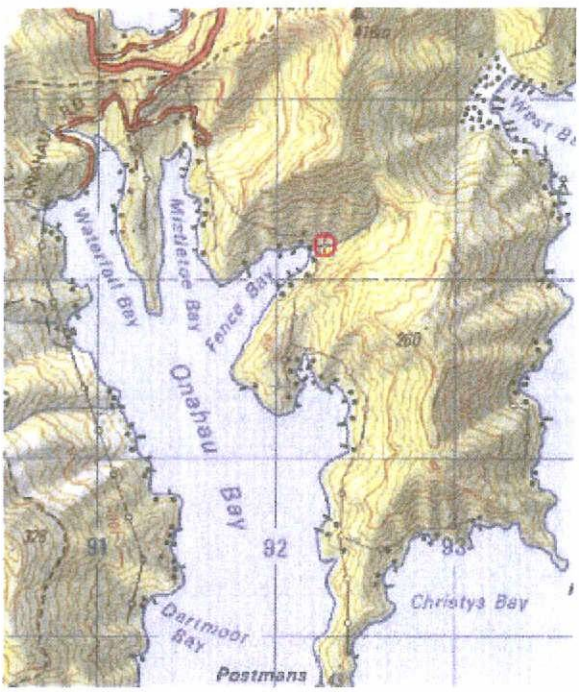
MAP COORDINATES	2590045E 5994535N
CATCHMENT LAND USE	Native forest
WATER ABSTRACTION	Nil

FLOW	1.2 litres per second
PHYSICAL PROPERTIES	DO = 10.52 mg/l, 92.5% Temperature = 9.67 °C pH = 7.17 Conductivity = 94 µS/cm Turbidity = 0.65 NTU
CHEMICAL PROPERTIES	Faecal coliforms = 10 cfu/100ml *E. coli* = 10 cfu/100ml Total suspended solids = 2 g/m³ Fixed suspended solids = 0.7 g/m³ Volatile suspended solids = 1.3 g/m³ Ammonia-N = 0.008 g/m³ Dissolved reactive phosphorus = 0.013 g/m³ Nitrate-N = 0.049 g/m³ Total Nitrogen = 0.10 g/m³ Total phosphorus = 0.016 g/m³
MACROINVERTEBRATES	MCI = 129 SQMCI = 7.03 EPT taxa = 48 % Taxa richness = 31 Dominant taxa = *Helicopsyche, Potamopyrgus*
CRUSTACEA	Koura - common Shrimp (*Paratya curvirostris*) - abundant
REACH 1	20 m upstream of any tidal influence
LENGTH	30 m
ELEVATION	2 m
AVERAGE WIDTH	1 m
SINUOSITY	5 m over 30 m
HABITAT	Pool = 30% Run = 50% Riffle = 20%
SUBSTRATE	Dominant = fine gravel Sub-dominant = coarse gravel
RIPARIAN VEGETATION	Kahikatea, kanuka, tree ferns, gorse and native shrubs
INSTREAM VEGETATION	Overhanging sedges and ferns
FISH	Banded kokopu - occasional Inanga - common

	Redfin bully - common
REACH 2	80 m upstream from site 1
LENGTH	50 m
ELEVATION	3 m
AVERAGE WIDTH	1 m
SINUOSITY	3 m over 50 m
HABITAT	Pool = 50% Run = 40% Riffle = 10%
SUBSTRATE	Dominant = Mud/sand Sub-dominant = Coarse gravel/cobble
RIPARIAN VEGETATION	Dense overhead canopy of tree ferns and native shrubs
INSTREAM VEGETATION	Nil
FISH	Banded kokopu - common Redfin bully - common

SITE 3 Fence Bay Stream
Queen Charlotte Sound

13 May 2003

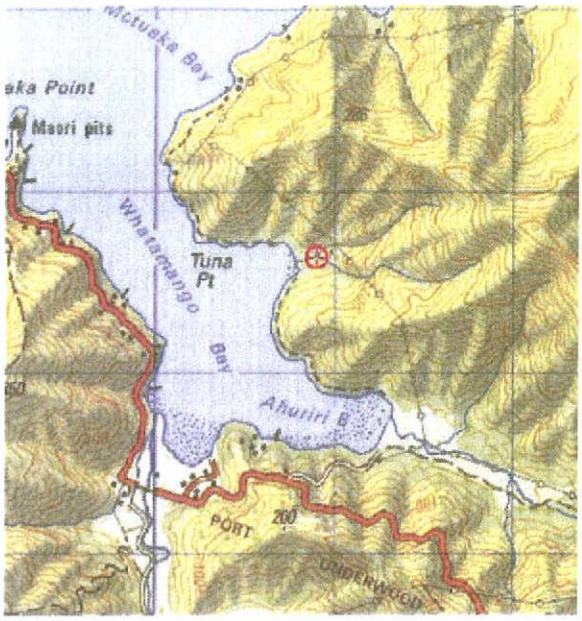


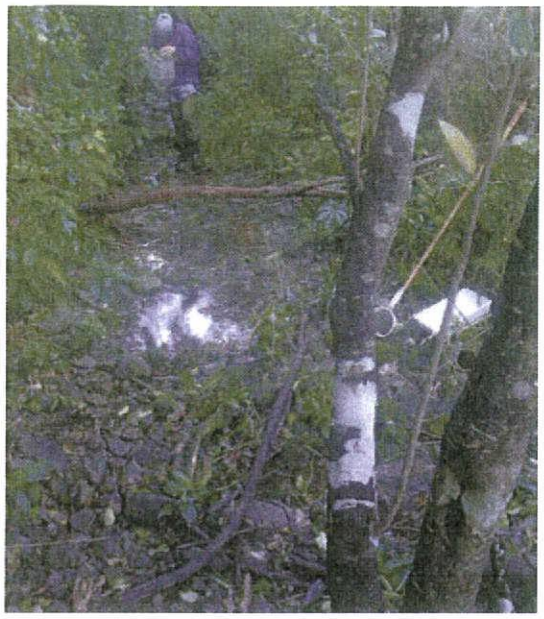
One of several domestic supply abstractions in this stream. This one showing diversion through a filtering system.

MAP COORDINATES	2592250E 5997175N
CATCHMENT LAND USE	Reverting native shrubs and scattered pines
WATER ABSTRACTION	Several to at least 4 dwellings
FLOW	0.5 litres per second
	No physical or chemical data collected because of unusually high iron input, possibly from old railway track surrounding lower catchment
LENGTH	50 m
ELEVATION	10 m
AVERAGE WIDTH	1 m
RIPARIAN VEGETATION	Kanuka, tree ferns, gorse and native shrubs
INSTREAM VEGETATION	Overhanging ferns
CRUSTACEA	Koura - occasional
FISH	Banded kokopu - common Redfin bully - common

SITE 4 Whatamango Bay Stream
Queen Charlotte Sound

13 May 2003

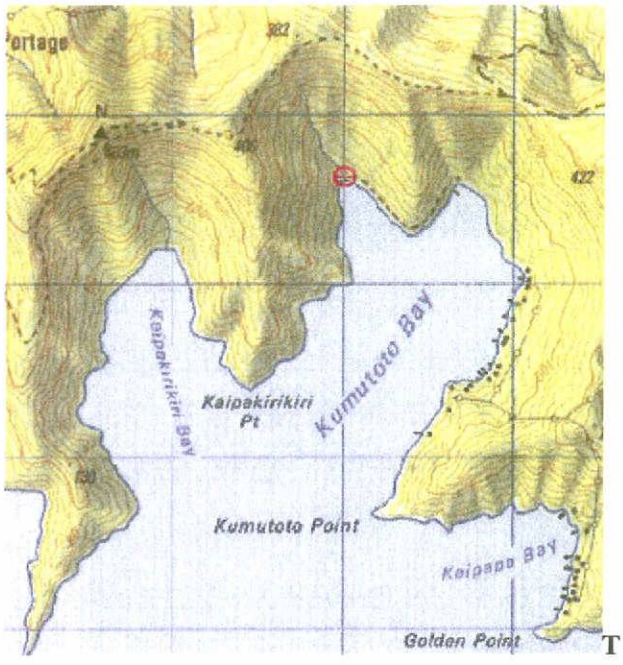


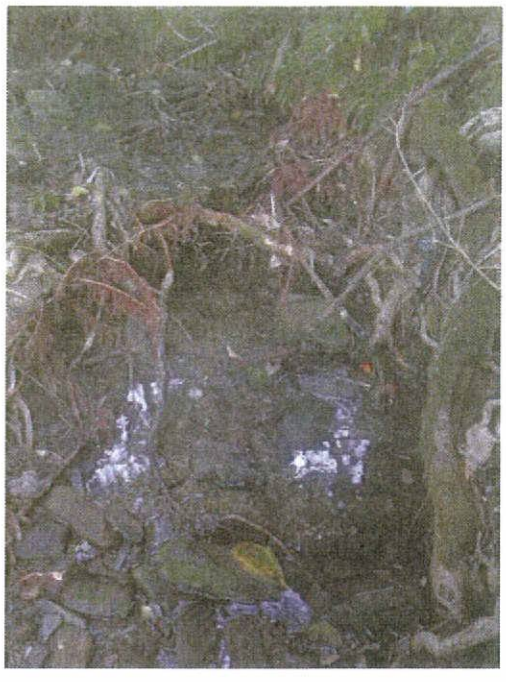


MAP COORDINATES	2600910E 5993625N
CATCHMENT LAND USE	Reverting native forest, kanuka and gorse
WATER ABSTRACTION	Not known
FLOW	0.77 litres per second
PHYSICAL PROPERTIES	DO = 11.09 mg/l, 98.3% Temperature = 9.9 °C pH = 7.3 Conductivity = 127 µS/cm Turbidity = 3.09 NTU
CHEMICAL PROPERTIES	Faecal coliforms = 25 cfu/100ml *E. coli* = 25 cfu/100ml Total suspended solids = 2 g/m³ Fixed suspended solids = 0.9 g/m³ Volatile suspended solids = 1.1 g/m³ Ammonia-N = 0.010 g/m³ Dissolved reactive phosphorus = 0.014 g/m³ Nitrate-N = 0.079 g/m³ Total Nitrogen = 0.16 g/m³ Total phosphorus = 0.018 g/m³

MACROINVERTEBRATES	MCI = 125 SQMCI = 6.83 EPT taxa = 67 % Taxa richness = 36 Dominant taxa = *Helicopsyche, Potamopyrgus*
CRUSTACEA	Koura – common Amphipods (*Phreatogammarus helmsii*) - abundant
REACH 1	>100 m upstream of any tidal influence
LENGTH	50 m
ELEVATION	10 m
AVERAGE WIDTH	1.5 m
SINUOSITY	3 m over 30 m
HABITAT	Pool = 30% Run = 60% Riffle = 10%
SUBSTRATE	Dominant = coarse gravels Sub-dominant = cobbles
RIPARIAN VEGETATION	Overhead canopy of kanuka, coprosma, rangiora and other native shrubs
INSTREAM VEGETATION	Overhanging ferns and shrubs
FISH	Banded kokopu - common Redfin bully - common

SITE 5 **Kumutoto Bay Stream** 13 May 2003
Queen Charlotte Sound



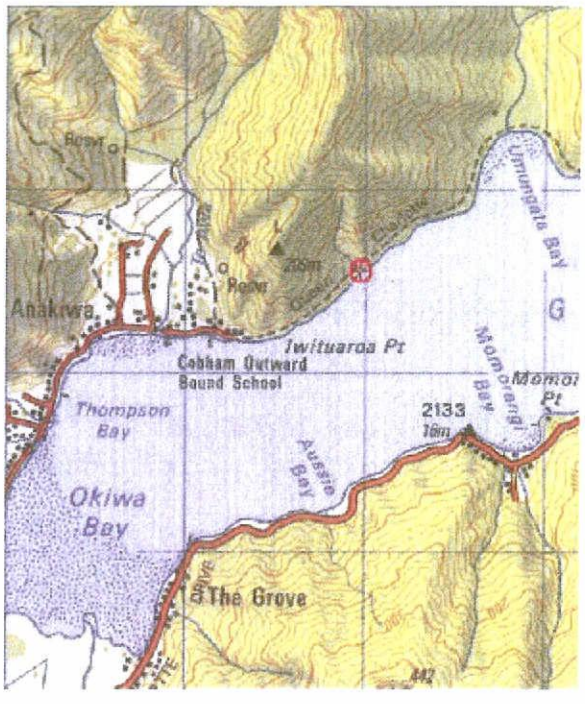


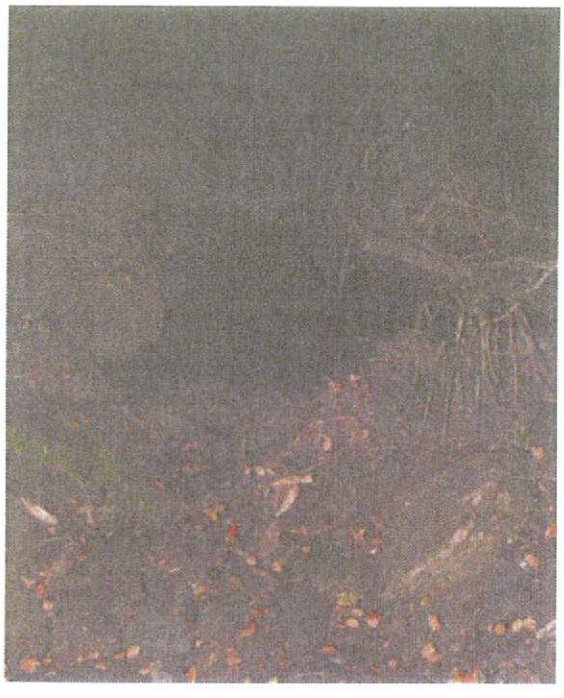
MAP COORDINATES	2599015E 5999625N
CATCHMENT LAND USE	Native podocarp forest
WATER ABSTRACTION	Nil
FLOW	0.58 litres per second
PHYSICAL PROPERTIES	DO = 10.35 mg/l, 92.8% Temperature = 10.48 °C pH = 7.31 Conductivity = 82 µS/cm Turbidity = 1.19 NTU
CHEMICAL PROPERTIES	Faecal coliforms = 240 cfu/100ml *E. coli* = 240 cfu/100ml Total suspended solids = 24 g/m³ Fixed suspended solids = 14 g/m³ Volatile suspended solids = 10 g/m³ Ammonia-N = 0.006 g/m³ Dissolved reactive phosphorus = 0.019 g/m³ Nitrate-N = 0.045 g/m³ Total Nitrogen = 0.22 g/m³ Total phosphorus = 0.027 g/m³

MACROINVERTEBRATES	MCI = 130 SQMCI = 5.45 EPT taxa = 61 % Taxa richness = 31 Dominant taxon = *Potamopyrgus*
CRUSTACEA	Koura - common Shrimp (*Paratya curvirostris*) - common
REACH 1	5 m upstream of any tidal influence
LENGTH	50 m
ELEVATION	1 m
AVERAGE WIDTH	1 m
SINUOSITY	4 m over 30 m
HABITAT	Pool = 60% Run = 30% Riffle = 10%
SUBSTRATE	Dominant = cobbles Sub-dominant = fine gravels/sand
RIPARIAN VEGETATION	Native podocarp forest
INSTREAM VEGETATION	Overhanging kawakawa and seedling podocarps
FISH	Banded kokopu - common Redfin bully - common Inanga - common

SITE 6 Iwituaroa Point Stream
Queen Charlotte Sound

14 May 2003

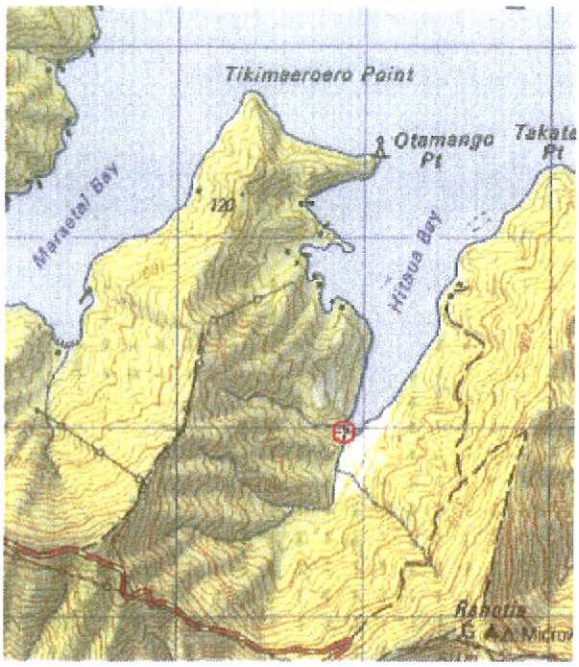




MAP COORDINATES	2587955E 5993545N
CATCHMENT LAND USE	Native forest (red beech)
WATER ABSTRACTION	Nil
FLOW	0.08 litres per second
PHYSICAL PROPERTIES	DO = 10.31 mg/l, 90.8% Temperature = 9.81 °C pH = 7.21 Conductivity = 100 µS/cm Turbidity = 0.88 NTU
CHEMICAL PROPERTIES	Not sampled
MACROINVERTEBRATES	MCI = 128 SQMCI = 7.27 EPT taxa = 60 % Taxa richness = 10 Dominant taxa = *Deleatidium, Zephlebia, Hydrobiosella*
CRUSTACEA	Koura - common
REACH 1	20 m upstream of any tidal influence

LENGTH	30 m
ELEVATION	5 m
AVERAGE WIDTH	0.5 m
SINUOSITY	2 m over 30 m
HABITAT	Pool = 20% Run = 80%
SUBSTRATE	Dominant = boulder Sub-dominant = sand/silt
RIPARIAN VEGETATION	Overhead canopy of beech, coprosmas and ferns
INSTREAM VEGETATION	Overhanging ferns
FISH	Koaro – juveniles- 1 observed climbing up wet rock ledge - rare

SITE 7 Hitaua Bay Stream 14 May 2003
Queen Charlotte Sound

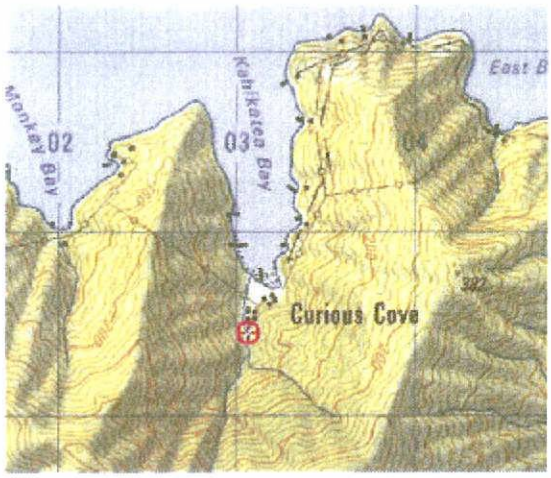


MAP COORDINATES	2606905E 5992955N
CATCHMENT LAND USE	Pine forest
WATER ABSTRACTION	Nil
FLOW	10 litres per second
PHYSICAL PROPERTIES	DO = 10.97 mg/l, 99.3% Temperature = 10.91 °C pH = 7.47 Conductivity = 158 µS/cm Turbidity = 4.49 NTU
CHEMICAL PROPERTIES	Faecal coliforms = 35 cfu/100ml *E. coli* = 35 cfu/100ml Total suspended solids = 5 g/m³ Fixed suspended solids = 3 g/m³ Volatile suspended solids = 2 g/m³ Ammonia-N = 0.008 g/m³ Dissolved reactive phosphorus = 0.027 g/m³ Nitrate-N = 0.47 g/m³ Total Nitrogen = 0.63 g/m³ Total phosphorus = 0.031 g/m³

MACROINVERTEBRATES	MCI = 139 SQMCI = 6.86 EPT taxa = 61 % Taxa richness = 31 Dominant taxa = *Coloburiscus, Pycnocentria, Potamopyrgus*
CRUSTACEA	Shrimp (*Paratya curvirostris*) – abundant
REACH 1	100 m upstream of any tidal influence
LENGTH	100 m
ELEVATION	3 m
AVERAGE WIDTH	1.5 m
SINUOSITY	5 m over 30 m
HABITAT	Pool = 20% Run = 50% Riffle = 30%
SUBSTRATE	Dominant = coarse gravels Sub-dominant = silt
RIPARIAN VEGETATION	Native shrub and tree fern understorey below pine canopy
INSTREAM VEGETATION	Overhanging ferns
FISH	Banded kokopu - common Redfin bully - common Inanga - abundant Shortfin eel - occasional

SITE 8 Curious Cove West Stream
Queen Charlotte Sound

15 May 2003



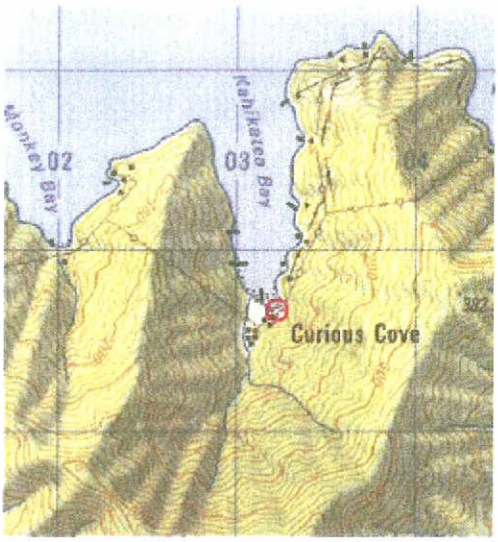
MAP COORDINATES	2603075E 5994440N
CATCHMENT LAND USE	Regenerating native beech forest – kanuka and manuka
WATER ABSTRACTION	School camp
FLOW	1.04 litres per second
PHYSICAL PROPERTIES	DO = 10.57 mg/l, 97.6% Temperature = 11.77 °C pH = 7.52 Conductivity = 138 µS/cm Turbidity = 0.98 NTU
CHEMICAL PROPERTIES	Faecal coliforms = 70 cfu/100ml *E. coli* = 70 cfu/100ml Total suspended solids = 2 g/m³ Fixed suspended solids = 1 g/m³ Volatile suspended solids = 1 g/m³ Ammonia-N = 0.007 g/m³ Dissolved reactive phosphorus = 0.018 g/m³ Nitrate-N = 0.008 g/m³ Total Nitrogen = 0.09 g/m³ Total phosphorus = 0.018 g/m³
MACROINVERTEBRATES	MCI = 123 SQMCI = 4.33 EPT taxa = 53 % Taxa richness = 38 Dominant taxa = Orthocladiinae, *Pycnocentrodes, Potamopyrgus*

CRUSTACEA	Shrimp (*Paratya curvirostris*) – abundant Amphipods (*Phreatogammarus helmsii*) – very abundant Seed-shrimp (Ostracoda) - abundant
REACH 1	200 m upstream of any tidal influence
LENGTH	100 m
ELEVATION	3 m
AVERAGE WIDTH	1.5 m
SINUOSITY	4 m over 30 m
HABITAT	Pool = 30% Run = 50% Riffle = 20%
SUBSTRATE	Dominant = boulder Sub-dominant = coarse gravel
RIPARIAN VEGETATION	Mixed native shrubs and ferns
INSTREAM VEGETATION	Overhanging kawakawa and ferns. Dense watercress in lower 100 m.
FISH	Banded kokopu - common Redfin bully - common Inanga - abundant Eel spp. - common

SITE 9 Curious Cove East Stream

Queen Charlotte Sound

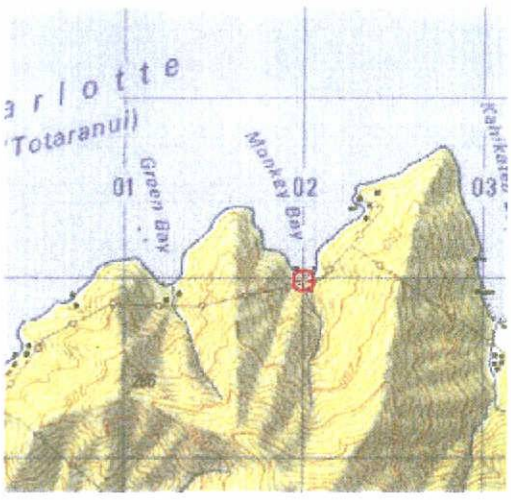
15 May 2003



MAP COORDINATES	2603235E 5994670N
CATCHMENT LAND USE	Regenerating native beech and kanuka forest
WATER ABSTRACTION	3 dwellings
FLOW	0.27 litres per second
PHYSICAL PROPERTIES	DO = 8.72 mg/l, 79.4% Temperature = 11.17 °C pH = 7.14 Conductivity = 185 µS/cm Turbidity = 1.31 NTU
CHEMICAL PROPERTIES	Faecal coliforms = 50 cfu/100ml *E. coli* = 50 cfu/100ml Total suspended solids = 9 g/m³ Fixed suspended solids = 6 g/m³ Volatile suspended solids = 3 g/m³ Ammonia-N = 0.025 g/m³ Dissolved reactive phosphorus = 0.023 g/m³ Nitrate-N = 0.023 g/m³ Total Nitrogen = 0.11 g/m³ Total phosphorus = 0.025 g/m³
MACROINVERTEBRATES	MCI = 123 SQMCI = 4.57 EPT taxa = 45 %

	Taxa richness = 29 Dominant taxon = *Potamopyrgus*
CRUSTACEA	Shrimp (*Paratya curvirostris*) – rare Amphipods (*Phreatogammarus helmsii*) - abundant
REACH 1	10 m upstream of any tidal influence
LENGTH	50 m
ELEVATION	1 m
AVERAGE WIDTH	1 m
SINUOSITY	3 m over 30 m
HABITAT	Pool = 40% Run = 50% Riffle = 10%
SUBSTRATE	Dominant = boulder Sub-dominant = silt
RIPARIAN VEGETATION	Kawakawa, whitey wood and ferns
INSTREAM VEGETATION	Overhanging ferns and shrubs. Deeply incised.
FISH	Banded kokopu - common Redfin bully - common Bluegill bully - rare

SITE 10 **Monkey Bay East Stream** 15 May 2003
Queen Charlotte Sound



MAP COORDINATES	2602015E 5994975N
CATCHMENT LAND USE	Regenerating native bush – kanuka/manuka, tree ferns
WATER ABSTRACTION	At least 1 dwelling
FLOW	0.2 litres per second. Indiscernible 150 m from H.T. mark.
PHYSICAL PROPERTIES	DO = 9.49 mg/l, 87.1% Temperature = 11.5 °C pH = 7.09 Conductivity = 110 µS/cm Turbidity = 3.58 NTU
CHEMICAL PROPERTIES	Faecal coliforms = 105 cfu/100ml *E. coli* = 105 cfu/100ml Total suspended solids = 16 g/m³ Fixed suspended solids = 11 g/m³ Volatile suspended solids = 5 g/m³ Ammonia-N = 0.013 g/m³ Dissolved reactive phosphorus = 0.027 g/m³ Nitrate-N = 0.16 g/m³ Total Nitrogen = 0.37 g/m³ Total phosphorus = 0.050 g/m³
MACROINVERTEBRATES	MCI = 104 SQMCI = 4.47 EPT taxa = 43 % Taxa richness = 14

	Dominant taxon = *Potamopyrgus*
CRUSTACEA	Shrimp (*Paratya curvirostris*) – common Amphipods (*Phreatogammarus helmsii*) - abundant
REACH 1	10 m upstream of any tidal influence
LENGTH	20 m
ELEVATION	1 m
AVERAGE WIDTH	0.4 m
SINUOSITY	1m over 30 m
HABITAT	Pool = 10% Run = 80% Riffle = 10%
SUBSTRATE	Dominant = Coarse gravel Sub-dominant = silt
RIPARIAN VEGETATION	Lawn and domestic plantings, ferns and grasses.
INSTREAM VEGETATION	Grasses.
FISH	Inanga – common Redfin bully – common Eel spp. - occasional

Appendix 2 Fish species, including Crustacea, found in Queen Charlotte Sound streams

Common name	Scientific name	This survey	Previous surveys
FISH			
Longfin eel	*Anguilla dieffenbachii*		X
Shortfin eel	*A. australis*	X	
Eel unidentified		X	
Giant kokopu	*Galaxias argenteus*		X
Banded kokopu	*G. fasciatus*	X	X
Shortjaw kokopu	*G. postvectis*		X
Koaro	*G. brevipinnis*	X	X
Inanga	*G. maculatus*	X	X
Dwarf galaxias	*G. divergens*		X
Galaxias unidentified			X
Goldfish	*Carassius auratus*		X
Redfin bully	*Gobiomorphus huttoni*	X	X
Common bully	*G. cotidianus*	X	X
Giant bully	*G. gobioides*	X	
Bluegill bully	*G. hubbsi*	X	X
CRUSTACEA			
Koura	*Paranephrops planifrons*	X	X
Shrimp	*Paratya curvirostris*	X	

Appendix 3 Macroinvertebrates collected in hand-net samples

Site number:		1	2	4	5	6
Site name:		Umungata Bay	Bottle Bay	Whatamango Bay	Kumutoto Bay	Iwituaroa Pt
Collection date:	MCI	13/05/2003	13/05/2003	13/05/2003	13/05/2003	14/05/2003
Mayflies	score					
Coloburiscus humeralis	9	A	-	A	R	-
Deleatidium sp.	8	VA	A	A	C	C
Icthybotus hudsoni	6	-	-	-	-	-
Neozephlebia scita	7	-	-	A	C	-
Zephlebia dentata	7	-	-	-	R	C
Stoneflies						
Austroperla cyrene	9	C	A	A	R	-
Spaniocerca sp.	8	-	A	A	C	-
Stenoperla prasina	10	-	C	C	R	-
Stenoperla sp.	10	-	-	-	-	-
Zelandobius confusus	5	-	-	C	R	-
Zelandoperla sp.	10	-	R	-	-	-
Dobsonflies						
Archichauliodes diversus	7	A	R	-	-	-
Beetles						
Elmidae type A	6	C	-	-	R	-
Hydraenidae	8	A	C	-	R	-
Hydrophilidae	5	-	-	R	-	-
Ptilodactylidae	8	C	A	-	-	-
Scirtidae	8	R	-	-	-	-
True Flies						
Anthomyiidae	3	-	-	-	-	-
Austrosimulium spp.	3	-	R	-	-	-
Ceratopogonidae	3	-	-	R	R	R
Thaumaleidae	9	-	-	-	-	-
Empididae type A	3	-	R	-	-	-
Eriopterini	9	R	C	-	-	-
Hexatomini	5	-	-	R	-	-
Nothodixa sp.	4	-	C	R	R	R
Orthocladiinae	2	-	C	A	C	-
Paralimnophila sp.	6	-	-	-	-	-
Parochlus sp.	8	-	R	-	-	-
Polypedilum spp.	3	-	R	R	R	-
Tanypodinae	5	-	R	A	A	-
Tanytarsus sp.	3	-	A	R	R	R

Site number:		1	2	4	5	6
Site name:		Umungata Bay	Bottle Bay	Whatamango Bay	Kumutoto Bay	Iwituaroa Pt
Collection date:	MCI	13/05/2003	13/05/2003	13/05/2003	13/05/2003	14/05/2003
Caddisflies	score					
Aoteapsyche spp.	4	C	-	C	R	-
Costachorema spp.	7	-	R	R	-	-
Diplectrona sp.	9	C	-	C	-	R
Edpercivalia sp.	9	-	-	-	-	R
Helicopsyche sp.	10	VA	VA	VA	A	-
Hudsonema alienum	6	R	R	-	-	-
Hudsonema amabile	6	-	-	-	-	-
Hydrobiosella stenocerca	9	C	A	C	R	C
Hydrobiosis gollanis	5	-	-	R	-	-
Hydrobiosis spp.	5	-	-	R	-	-
Hydrochorema crassicaudatum	9	-	R	R	R	-
Neurochorema confusum	6	R	-	-	-	-
Oeconesus sp.	9	-	C	C	R	-
Olinga feredayi	9	A	-	A	R	-
Oxyethira albiceps	2	-	-	-	-	-
Polyplectropus puerilis	8	-	-	R	C	R
Psilochorema tautoru	8	-	-	R	-	-
Psilochorema spp.	8	-	-	R	R	-
Pycnocentrella eruensis	9	-	-	R	-	-
Pycnocentria evecta	7	-	-	-	-	-
Pycnocentria funerea	7	C	A	R	-	-
Pycnocentria sylvestris	7	-	R	A	R	-
Pycnocentria sp.	7	-	-	-	-	-
Pycnocentrodes sp.	5	C	-	-	-	-
Triplectides obsoletus	5	C	A	A	A	-
Zelolessica cheira	10	R	C	-	C	-
Crustacea						
Ostracoda	3	-	-	-	-	-
Paratya curvirostris	5	C	R	-	R	-
Phreatogammarus helmsii	5	VA	-	A	-	-
Neuroptera						
Kempynus sp.	5	-	-	-	-	-
Cnidaria						
Hydra sp.	3	-	-	-	-	-
Worms	1	A	R	R	R	-
Flatworms	3	-	-	C	-	-
Springtails	6	-	-	-	R	-
Snails						
Potamopyrgus antipodarum	4	A	VA	VA	VA	R
Mites	5	-	-	-	-	-
Horse-hair worms	3	-	R	-	-	-
Number of taxa		25	32	37	32	11
MCI		136	129	125	130	128
SQMCI		7.21	7.03	6.83	5.45	7.27
EPT_{taxa}		58.3	48.4	66.7	61.3	60.0

Site number:		7	8	9	10
Site name:		Hitaua Bay	Curious Cove West	Curious Cove East	Monkey Bay East
Collection date:		14/05/2003	15/05/2003	15/05/2003	15/05/2003
	MCI score				
Mayflies					
Coloburiscus humeralis	9	VA	A	R	-
Deleatidium sp.	8	A	VA	R	-
Icthybotus hudsoni	6	R	-	-	-
Neozephlebia scita	7	-	A	C	R
Zephlebia dentata	7	-	-	-	-
Stoneflies					
Austroperla cyrene	9	R	C	-	-
Spaniocerca sp.	8	R	A	-	-
Stenoperla prasina	10	R	-	R	R
Stenoperla sp.	10	-	R	-	-
Zelandobius confusus	5	R	A	-	-
Zelandoperla sp.	10	R	-	-	-
Dobsonflies					
Archichauliodes diversus	7	C	R	-	-
Beetles					
Elmidae type A	6	-	R	R	R
Hydraenidae	8	R	-	R	-
Hydrophilidae	5	-	R	-	-
Ptilodactylidae	8	A	R	-	-
Scirtidae	8	-	-	-	-
True Flies					
Anthomyiidae	3	-	R	R	-
Austrosimulium spp.	3	C	A	-	R
Ceratopogonidae	3	-	-	C	-
Thaumaleidae	9	-	R	-	-
Empididae type A	3	-	-	-	-
Eriopterini	9	R	-	-	-
Hexatomini	5	R	R	R	-
Nothodixa sp.	4	R	C	A	-
Orthocladiinae	2	C	VVA	C	R
Paralimnophila sp.	6	R	-	-	-
Parochlus sp.	8	-	-	-	-
Polypedilum spp.	3	-	-	A	R
Tanypodinae	5	C	A	A	-
Tanytarsus sp.	3	-	-	-	R

Site number:		7	8	9	10
Site name:		Hitaua Bay	Curious Cove West	Curious Cove East	Monkey Bay East
Collection date:		14/05/2003	15/05/2003	15/05/2003	15/05/2003
	MCI				
Caddisflies	score				
Aoteapsyche spp.	4	-	-	-	-
Costachorema spp.	7	-	-	-	-
Diplectrona sp.	9	R	C	C	-
Edpercivalia sp.	9	-	-	-	-
Helicopsyche sp.	10	A	A	C	C
Hudsonema alienum	6	-	-	-	-
Hudsonema amabile	6	C	C	R	-
Hydrobiosella stenocerca	9	A	A	R	-
Hydrobiosis gollanis	5	R	-	-	-
Hydrobiosis spp.	5	-	R	-	-
Hydrochorema crassicaudatum	9	R	R	R	-
Neurochorema confusum	6	-	-	-	-
Oeconesus sp.	9	R	C	-	C
Olinga feredayi	9	-	A	R	-
Oxyethira albiceps	2	-	A	-	R
Polyplectropus puerilis	8	R	-	-	-
Psilochorema tautoru	8	-	-	R	-
Psilochorema spp.	8	R	C	-	R
Pycnocentrella eruensis	9	-	-	-	-
Pycnocentria evecta	7	-	R	-	-
Pycnocentria funerea	7	VA	-	-	-
Pycnocentria sylvestris	7	-	-	-	-
Pycnocentria sp.	7	-	-	R	-
Pycnocentrodes sp.	5	-	VVA	-	-
Triplectides obsoletus	5	C	A	C	-
Zelolessica cheira	10	-	-	-	-
Crustacea					
Ostracoda	3	-	A	-	-
Paratya curvirostris	5	A	R	R	-
Phreatogammarus helmsii	5	-	VA	A	A
Neuroptera					
Kempynus sp.	5	-	-	R	-
Cnidaria					
Hydra sp.	3	-	-	R	-
Worms	1	-	C	-	C
Flatworms	3	-	R	-	-
Springtails	6	-	R	R	-
Snails					
Potamopyrgus antipodarum	4	VA	VVA	VA	VA
Mites	5	-	-	R	-
Horse-hair worms	3	-	-	-	-
Number of taxa		32	39	30	15
MCI		139	123	123	104
SQMCI		6.86	4.33	4.57	4.47
EPT_{taxa}		61.3	52.6	44.8	42.9