An update on fish and benthic macroinvertebrate populations of the Rangitata River

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Cover image: NIWA staff electrofishing the Rangitata River upstream of the Rangitata South Irrigation scheme intake. [Photo credit: Amber Sinton, NIWA]

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Executive summary

The Rangitata River is a large, braided river on the east coast of the South Island originating in the steep mountain catchments of the Southern Alps. As part of a larger research project on the effects of water abstraction on waterways, NIWA collected data from the Rangitata River in 2018–19 to examine potential effects of flood harvesting on freshwater fish communities. Where possible, methods used in the 2018–19 surveys aligned with a previous survey conducted in 1983–84 so that some temporal comparisons in fish and macroinvertebrate communities could be derived.

For the 2018–19 surveys, five sites were sampled every second month from June 2018 to June 2019. Sampling did not occur in December 2018 because of a flood event followed by consistently high flows. In total, fifteen species of fish (twelve native and three introduced species) were captured using electrofishing methods. Two of these native fish species, upland longjaw galaxias and lamprey, had a conservation status of 'Threatened – Nationally Vulnerable', but were only caught in low numbers. Six native fish species found were classified as 'At Risk – Declining'. Three of these were uncommon in the surveys (Canterbury galaxias, īnanga and longfin eel), two were abundant (bluegill bully and torrentfish) and the sixth, alpine galaxias, was relatively common at the site upstream of the gorge. Longitudinal changes in fish communities existed, with diadromous species occurring more abundantly in the lower sites, and some non-diadromous *Galaxias* fishes occurring only in the upper sites.

Forty-nine macroinvertebrate taxa were identified across all sites and survey dates. The most abundant macroinvertebrate order was Diptera (true flies), followed by Ephemeroptera (mayflies). Across the five sampling sites, macroinvertebrate taxa that were identified to species level (all within the orders Ephemeroptera, Plecoptera and Trichoptera) had a conservation of 'Not Threatened'. The composition of the macroinvertebrate community varied between sites and sampling events and this was reflected in the site scores for the Macroinvertebrate Community Index (MCI) and the Quantitative MCI. Total macroinvertebrate densities tended to be higher pre-flood (June and August 2018) than post-flood (February to June 2019), and there was a decrease in species richness at some sites after the flood event.

Compared to the 1983–84 data (Bonnett 1986), the 2018–19 surveys revealed some differences in the Rangitata River fish community although these results must be considered tentative given potential variation in methods (i.e., sampling effort) used between the two studies. Nevertheless, a noteworthy difference was that longfin eels comprised over 3% of the total catch in 1983–84 but only made up 0.5% of the 2018–19 catch. Given there are growing concerns about longfin eel abundance and population declines around New Zealand, a six-fold reduction in the percentage of longfin eels observed in the Rangitata River catch across the 35-year period could be interpreted as further evidence for this concern.

Furthermore, there was an apparent reduction in percentage abundance of Canterbury galaxias, upland longjaw galaxias, Chinook salmon and rainbow trout between 1983–84 and 2018–19. The 2018-19 surveys also revealed reduced numbers of estuarine/coastal species; giant bully (*Gobiomorphus gobioides*), common smelt (*Retropinna retropinna*) and Stokell's smelt (*Stokellia anisodon*) were notably absent from the 2018–19 study. There was also a lower percentage abundance of estuarine/coastal species found overall compared to 1983–84 data. On the contrary, a greater number of alpine galaxias and upland bully were captured in 2018–19 compared to 1983–84.

1 Introduction

The Rangitata River is a large, braided river on the east coast of the South Island. It originates in the Southern Alps, where it is fed by steep mountain catchments, and flows for over 100 km to the Pacific Ocean. The upper river flows across wide shingle flats before travelling through a narrow gorge for about 10 km. The lower part of the river gradually widens again into a shingle bed, initially entrenched between high fluvial river terraces that gradually decrease and allow the river to widen further. At the river mouth, a loose, shifting gravel bar directs the flow of water into the ocean. The lagoon/hāpua area of the Rangitata River is generally small.

As for other South Island braided rivers, the discharge of the Rangitata River is a combination of snowmelt and rainfall primarily from the west and north-west. The river flow is generally lowest between June and August as the precipitation in the catchment accumulates as seasonal snowpack. Flood events, such as the 2307 m^3/s event in December 2019, usually occur from October to May, and are associated with heavy north-westerly rain. The mean annual flow of the river from 1971 to 2015 was 95.1 m^3/s.

There are two large irrigation schemes that harvest water from the Rangitata River. The first is the Rangitata Diversion Race (RDR), which takes up to 35.7 m^3/s of water from the true left of the river immediately below the gorge (note, up to 7 m^3/s for this scheme can also be obtained from the Ashburton River). This 'run of river' scheme was completed in 1944 and takes water in a large canal north across the top of the Canterbury Plains, feeding a small power station (at Montalto), numerous smaller races and pumping stations along its length, before discharging in the Rakaia River via the 25.5 MW Highbank Power Station. During the irrigation season (September to May), water is prioritised for use on farms, with the Highbank Power Station receiving residual flow. Rangitata Diversion Race Management Limited (RDRML) is currently advancing resource consent applications for a water storage facility to supplement the RDR, with a 53 million cubic metre water storage facility the most favourable option. The second irrigation scheme, the Rangitata South Irrigation Scheme (RSIS), is located on the true right of the river at Arundel and was completed in 2013 (Figure 1-1). This scheme harvests floodwater from the river during flows over 110 m^3/s and stores water in seven large reservoirs, with a total capacity of 16.5 million cubic metres.

Figure 1-1: The Rangitata South Irrigation Scheme reservoirs, with the Rangitata River to the right. Image source: Farmers Guardian (AgriBriefing Ltd).

The data summarised in this report were collected as part of the Sustainable Water Allocation Programme (SWAP) funded by NIWA's Strategic Science Investment Funding. The data were collected as part of a wider programme of research seeking to examine the effects of water abstraction and, if possible, flood harvesting on freshwater fish communities.

The purpose of this report is to provide an update on the freshwater fish and macroinvertebrate communities in the Rangitata River and to compare the data to those collected in 1983–84 by Bonnett (1986). This report does not examine any potential changes in riverine communities in relation to the large surface water abstraction schemes that exist.

2 Methods

The field methods used for the 2018–19 surveys attempted to mirror those used by Bonnett (1986), however, sufficient methodological information was not always available (e.g., total sampling effort and sampling effort across different habitat types).

2.1 Sites and timing

Bonnett (1986) surveyed four sites in the Rangitata River: at the coast, State Highway 1 bridge, Geraldine-Arundel Road bridge and above the gorge. For the 2018–19 study, these same four sites were sampled. An extra site upstream of the RSIS irrigation intake on the true right bank near Arundel was also surveyed (Figure 2-1, Table 2-1).

Repeating the survey timing of Bonnett (1986), sites were surveyed every second month from June 2018 to June 2019, with the exception of December 2018; several significant rain events caused high flows during most of the month and staff were not able to safely access the sites[1]. Timing within the 2018–19 survey months was dictated by river flow; a flow of around 50–55 m^3/s was considered most suitable for sampling.

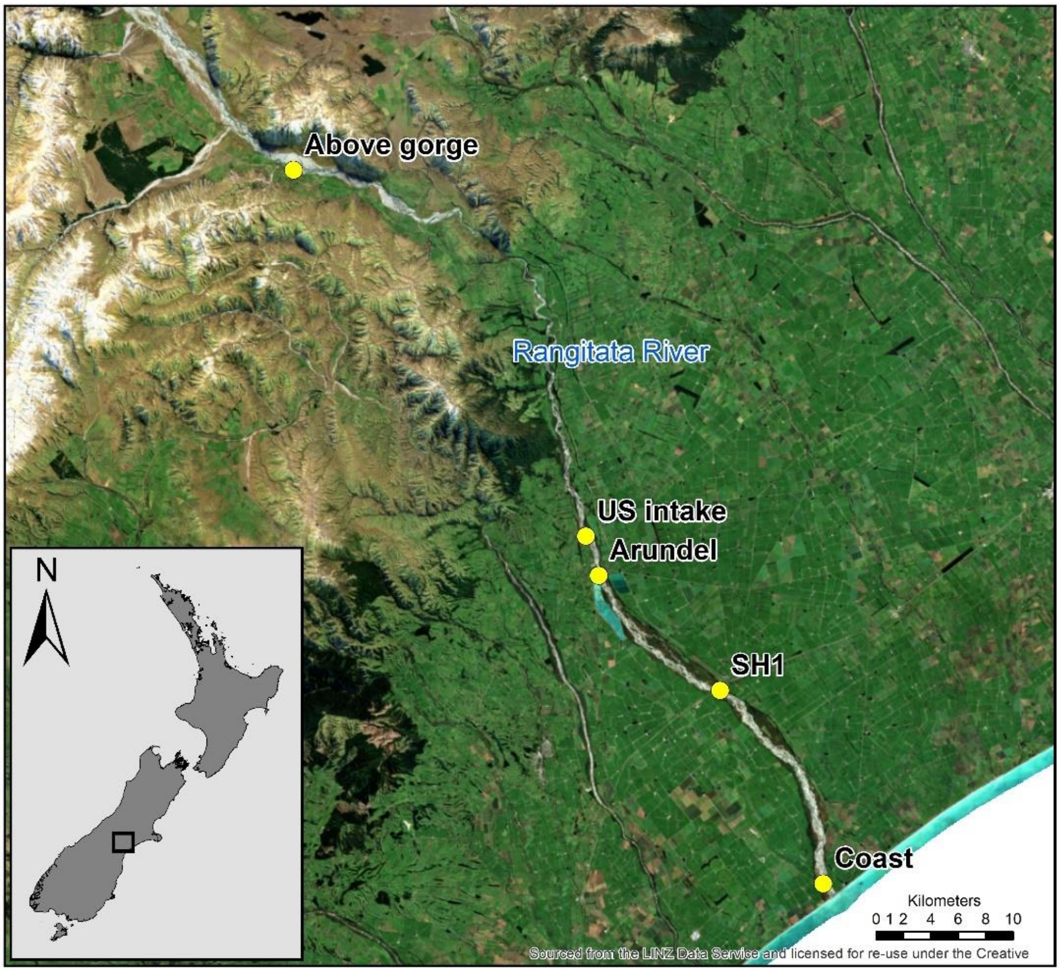

Figure 2-1: Map showing locations of the five sites surveyed in the Rangitata River during 2018–19.

[1] These floods also altered the bed profile resulting in an incorrect stage-discharge relationship at the Rangitata @ Klondyke flow recorder. A sampling trip was attempted, based on the information from the flow recorder, only to find flows were far higher than expected.

Table 2-1: Site location co-ordinates of the five sites sampled in the Rangitata River during 2018–19.

Site name	Site location	Easting (NZTM)	North (NZTM)
Coast	1.3 km upstream from coast, true right bank	1480037	5107090
SH1	At State Highway 1 road bridge	1472520	5121216
Arundel	At Geraldine-Arundel Road bridge	1463648	5129606
US intake	Upstream RSIS irrigation intake, Ferry Road	1462728	5132476
Above gorge	At Lodge Stream, true right bank	1441380	5159231

2.2 Fish sampling methods

Fish populations were sampled in 2018–19 using a Kainga EFM 300 backpack electric fishing machine (NIWA Instrument Systems, Christchurch, N.Z.) with 200–400 V pulsed DC (pulse width ~3 ms, 100 pulses s^{-1}). Bonnett (1986) used both generator and backpack electric fishing machines (machine settings not known). The electric fishing operator typically moved in a downstream direction towards a 1 m wide push net (mesh size 3 × 2 mm ellipse) held by a second person.

Bonnett (1986) did not detail all aspects of field methods used but stated "as wide a range of habitats in each area as possible" were sampled. For the 2018–19 surveys, fish were sampled in "plots", usually of 30 m^2, across all habitats present. Each site usually consisted of approximately 13 plots. Only wadeable water was sampled as electric fishing cannot be safely or effectively carried out in deep water. For each plot, fish were identified, counted and measured for length. Captured fishes were usually anaesthetized with 2-phenoxyethanol. The only exception to this was for large eels (>500 mm) which had the potential to be taken for consumption by the public. These fish were anaesthetized using a natural clove-oil based fish anaesthetic (AQUI-S[2]). Any large salmonids caught (>300 mm) were measured for length immediately (anaesthetic was not required) and released downstream of the sampling reach. All fish were measured to the nearest 1 mm; species were measured based on either fork length or total length depending on the species-specific recommendations from Jellyman et al. (2013).

2.3 Macroinvertebrate sampling methods

Three quantitative Hess samples for macroinvertebrates (area of each: 0.0962 m^2, mesh size 500 µm mesh) were collected from a medium- to large-sized riffle at each site. For 2018–19 surveys, Hess samples were collected from five survey dates from all sites, except for the US intake site, where Hess samples were collected on three survey dates.

Each Hess sample was washed through a 500 µm sieve. Macroinvertebrates were identified to the Macroinvertebrate Community Index (MCI) level (Stark & Maxted 2007) or lower (species level where practicable) and counted. All individuals in each sample were counted (i.e., no subsampling was undertaken).

[2] AQUI-S © was the anaesthetic used for all catch processing because it is the only fish anaesthetic registered under the Agricultural Compounds and Veterinary Medicine (AVCM) Act 1997. It also contains biodegradable ingredients. This anaesthetic was chosen to ensure that any tuna and pātiki taken for eating by Ngāi Tahu were safe for consumption and that no fish returned to the water would be unsafe for future consumption should they be captured for customary harvest.

For an indication of stream health, the MCI, and its quantitative variant, QMCI, were calculated (Stark & Maxted 2007). Index score interpretations are provided in Table 2-2. Taxonomic richness (the number of different taxa), the percentage of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa and percentage EPT abundance (percentage of EPT individuals) were also calculated (EPT taxa are generally the more pollution sensitive taxa in a stream macroinvertebrate community).

Table 2-2: MCI and QMCI score interpretations. Source: Stark & Maxted (2007).

Quality category	Description	MCI	QMCI
Excellent	Clean water	> 119	> 5.99
Good	Doubtful quality or possibly mild pollution	100–119	5.00–5.90
Fair	Probable moderate pollution	80–99	4.00–4.99
Poor	Probable severe pollution	< 80	< 4.00

2.4 Collation of 1983–84 data

Data from the 1983–84 study by Bonnett (1986) were obtained from the original paper field data sheets. Because there was a lack of clarity in some of the summary tables in the Bonnett (1986) report as to which data were included (e.g., some data may have been from additional sites), we felt it was safer to use the original data. Note that there are some differences between the data from the field data sheets and those presented in the Bonnett (1986) report.

3 Results

3.1 Rangitata River flow

The flow data for the Rangitata River for the six months leading up to the first survey in June 2018, and for the 12 months during the 2018–19 surveys are shown in Figure 3-1. The mean flow for this 18-month period was 92 m^3/s. Flow was variable from January 2018 until June 2018 but stable during winter and spring months (June to November). A significant flood event occurred on 9 December 2018, with the maximum flow reaching ~1920 m^3/s. Mean flow remained high in November and December but decreased from January onwards although smaller floods and freshes occurred relatively frequently over the last six months of the survey. A flood event of ~1040 m^3/s occurred on 27 March 2019 (Figure 3-1).

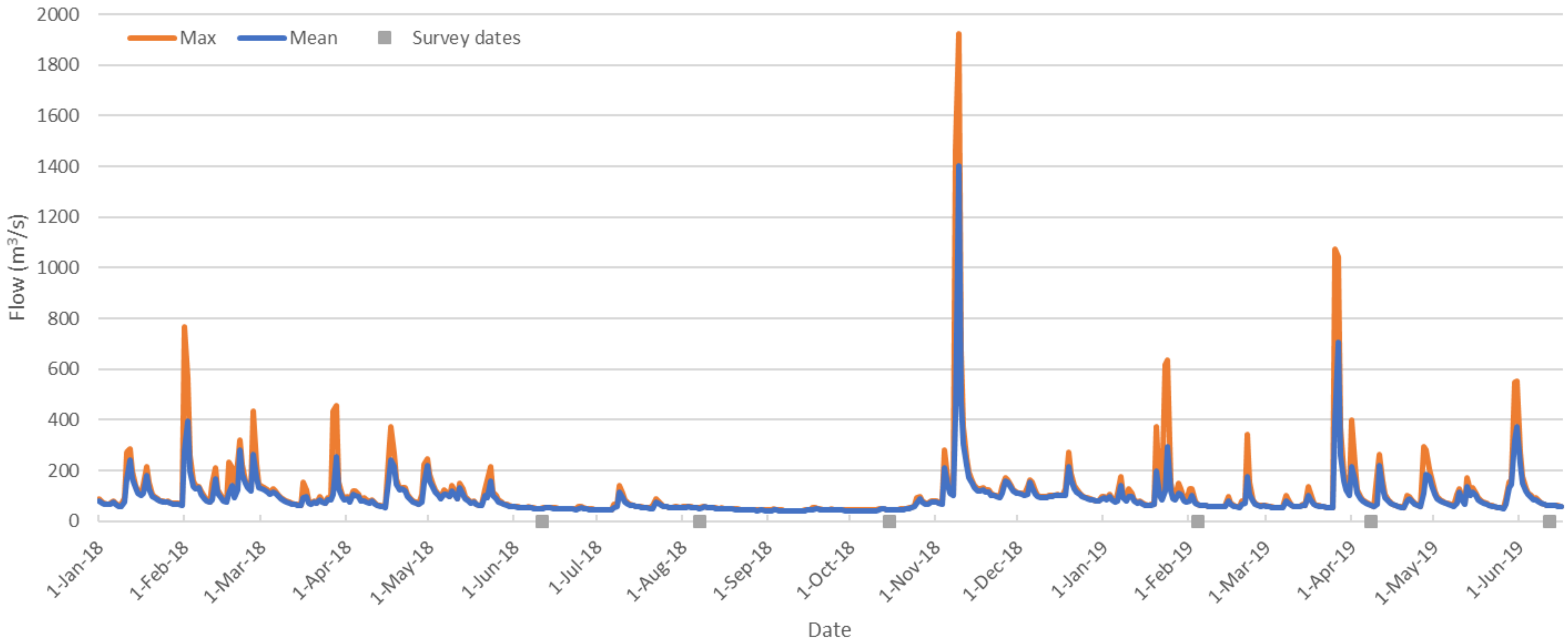

Figure 3-1: Mean and maximum flow in the Rangitata River from 1 January 2018 to 16 June 2019. Data sourced from the Environment Canterbury flow recorder at Klondyke.

3.2 Fish populations from 2018–19 surveys

Fifteen species of fish were found and a total of 2811 individuals were captured across the five sites during the 2018–19 electric fishing surveys. Twelve species were native and included four galaxiid species, three bully species, two eel species, black flounder, lamprey and torrentfish (Table 3-1). The three introduced species were brown trout, Chinook salmon and rainbow trout. The native species included two with a conservation status of 'Threatened – Nationally Vulnerable' (upland longjaw galaxias and lamprey), and six that were classified as 'At Risk – Declining' (Table 3-1).

Table 3-1: Freshwater fish species found at five sites in the Rangitata River during 2018–19. Conservation status as per Dunn et al. (2018).

	Common name	Scientific name	Native or introduced	Conservation status
Galaxiids	Alpine galaxias	*Galaxias paucispondylus*	Native	At Risk – Declining
	Canterbury galaxias	*G. vulgaris*	Native	At Risk – Declining
	Īnanga	*G. maculatus*	Native	At Risk – Declining
	Upland longjaw galaxias	*G. prognathus*	Native	Threatened – Nationally Vulnerable
Bullies	Bluegill bully	*Gobiomorphus hubbsi*	Native	At Risk – Declining
	Common bully	*G. cotidianus*	Native	Not Threatened
	Upland bully	*G. breviceps*	Native	Not Threatened
Eels	Longfin eel	*Anguilla dieffenbachii*	Native	At Risk – Declining
	Shortfin eel	*A. australis*	Native	Not Threatened
Other native species	Black flounder	*Rhombosolea retiaria*	Native	Not Threatened
	Lamprey	*Geotria australis*	Native	Threatened – Nationally Vulnerable
	Torrentfish	*Cheimarrichthys fosteri*	Native	At Risk – Declining
Introduced fish	Brown trout	*Salmo trutta*	Introduced	Introduced & Naturalised
	Chinook salmon	*Oncorhynchus tshawytscha*	Introduced	Introduced & Naturalised
	Rainbow trout	*O. mykiss*	Introduced	Introduced & Naturalised

Bluegill bully and upland bully were the two most abundant species captured during the 2018–19 surveys, with a total of 959 and 813 fish captured respectively (Table 3-2). Infrequently caught species were īnanga, shortfin eel, black flounder, lamprey and rainbow trout, all of which were only captured one or two times across all surveys. The number of species at each site across all survey dates was similar, ranging from seven to ten (Table 3-2). Upland bully, longfin eel, brown trout and

Chinook salmon were the only species caught at all five sites. Some native migratory species, such as common and bluegill bully were absent from the Above gorge site, while upland longjaw galaxias and Canterbury galaxias were exclusively found here. Alpine galaxias were found that the three up-stream-most sites, though only once at the Arundel and US intake sites.

Table 3-2: Number of individuals of each fish species caught at five sites in the Rangitata River across all 2018–19 surveys. Data from six survey dates, except for US intake, which was from five survey dates.

	Common name	Coast	SH1	Arundel	US intake	Above gorge	Total
Galaxiids	Alpine galaxias	-	-	1	1	116	**118**
	Canterbury galaxias	-	-	-	-	8	**8**
	Īnanga	1	-	-	-	-	**1**
	Upland longjaw galaxias	-	-	-	-	11	**11**
Bullies	Bluegill bully	726	200	24	9	-	**959**
	Common bully	217	6	-	-	-	**223**
	Upland bully	56	314	56	19	368	**813**
Eels	Longfin eel	3	5	4	2	1	**15**
	Shortfin eel	-	1	-	-	-	**1**
Other native species	Black flounder	2	-	-	-	-	**2**
	Lamprey	1	1	-	-	-	**2**
	Torrentfish	250	79	96	43	-	**468**
Introduced fish	Brown trout	4	45	38	25	8	**120**
	Chinook salmon	2	3	9	23	32	**69**
	Rainbow trout	-	-	-	-	1	**1**
Total number of species		**10**	**9**	**7**	**7**	**8**	**15**

The total estimated density of fish varied between sites and survey dates (Figure 3-2). The Coast site had the highest fish density of all sites for all survey dates except August 2018. The Arundel and US intake sites had the two lowest fish densities for all survey dates.

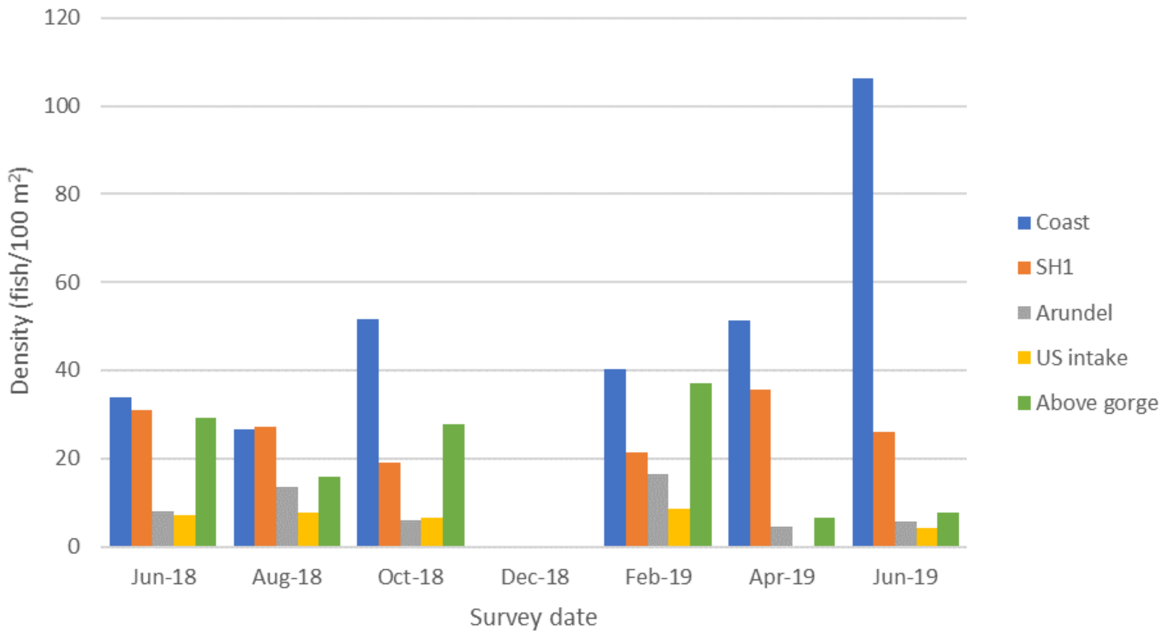

Figure 3-2: Estimated fish density at each site (n=5) in the Rangitata River for each survey date during 2018–19. Note, sampling was not undertaken in December 2018, and the US intake site was not sampled in April 2019.

Fish community composition at each site varied between survey dates (Figure 3-3). At the Coast site, bluegill bully had the highest density at all survey dates, with common bully and torrentfish always the second and third most abundant. Bluegill density between survey dates was variable, while common bully and torrentfish densities were generally similar between survey dates. Salmonid species were only found in very low numbers at the Coast site. At the SH1 site, either bluegill bully or upland bully had the highest density, with the dominant species changing between survey dates. Salmonids (mostly brown trout) were generally found in low densities, except for the October 2018 where they were the second most abundant species. The Arundel site was dominated by upland bully in 2018 surveys, but this species was absent in 2019 surveys. Torrentfish were found in much higher numbers at the Arundel site in 2019 compared to 2018 and were the dominant species at this site in 2019. The fish community was relatively stable at the US intake site, with salmonids (mostly brown trout), torrentfish and upland bully usually the three most abundant species. Upland bully occurred in the highest densities at all survey dates at the Above gorge site, though their density varied between survey dates. Alpine galaxias and salmonid species were present at all survey dates, and densities also varied between survey dates for these species.

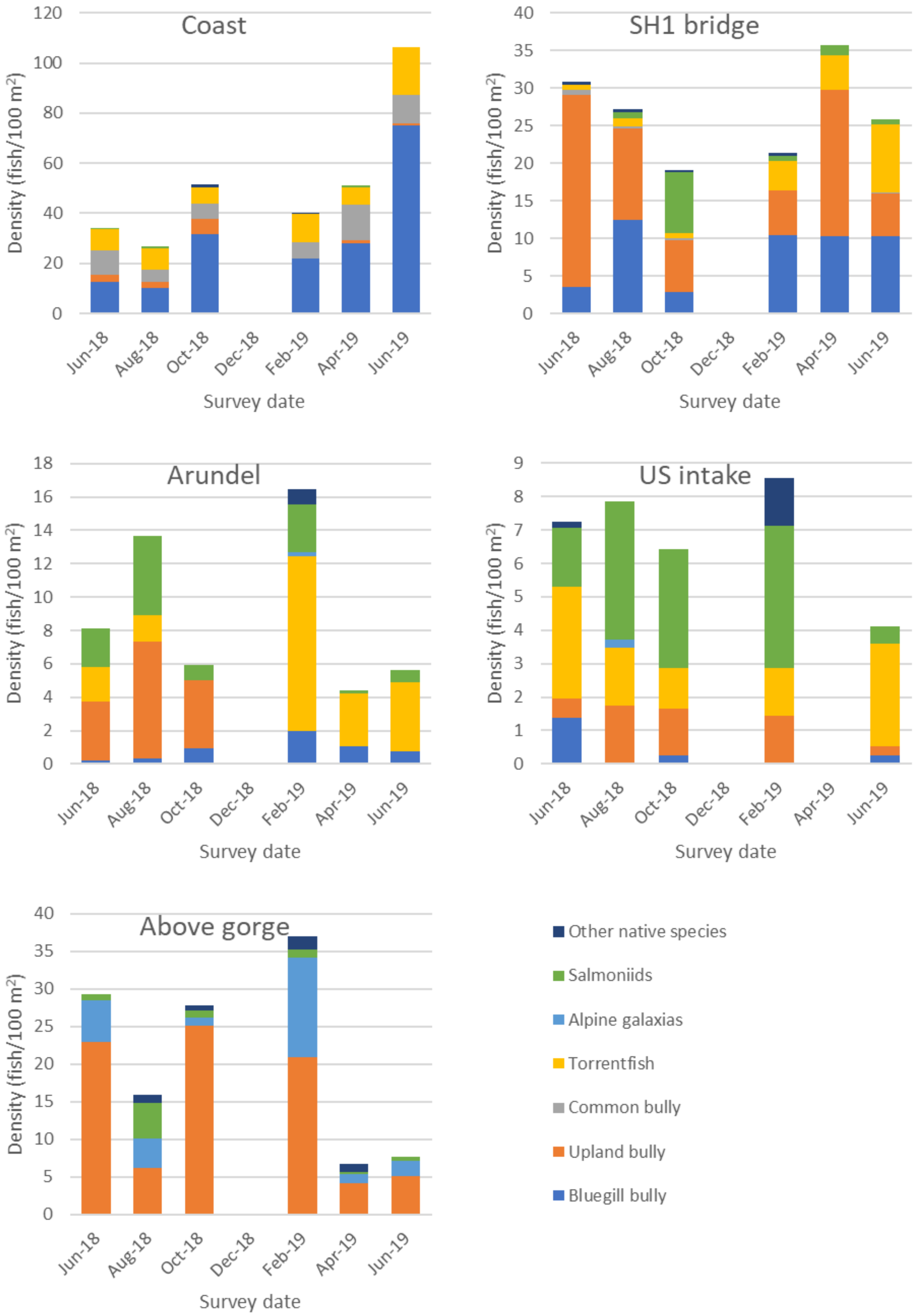

Figure 3-3: Fish community composition at the five sites in the Rangitata River at each survey date during 2018–19. Note, the y-axis varies between graphs to better illustrate compositional differences at a site. Sampling was not undertaken in December 2018, and the US intake site was not sampled in April 2019.

3.3 Macroinvertebrates from 2018–19 surveys

The total number of macroinvertebrates counted from all samples was just over 20,000 and 49 different taxa were identified across all sites and survey dates (Table A-1). The most abundant macroinvertebrate 'order'[3] was Diptera (true flies), which accounted for 58% of the individuals collected. Ephemeroptera (mayflies) were the second most abundant insect order, accounting for 32%. Trichoptera (caddisflies) were the order that was third most common making up 6% of all individuals. Together these three orders made up 96% of all macroinvertebrates collected. The most abundant taxon was the chironomid midge Orthocladiinae (43% of all individuals counted), followed by the mayfly *Deleatidium* spp. (32%) (Table 3-3). All other taxa accounted for less than 10% of all individuals and included other chironomid midges, caddisflies and Plecoptera (stoneflies). All macroinvertebrate taxa identified to species level (all within the orders Ephemeroptera, Plecoptera and Trichoptera) had a conservation of 'Not Threatened' (Grainger et al. 2014).

Table 3-3: The ten most abundant macroinvertebrate taxa in samples collected at five sites in the Rangitata River during 2018–19. *Includes all three recorded species for that genus.

Taxon (taxonomic grouping)	% of total count	Taxon (taxonomic grouping)	% of total count
Orthocladiinae (Diptera: Chironomidae)	42.6	*Zelandobius furcillatus* (Plecoptera)	2.1
Deleatidium spp. (Ephemeroptera)	31.9	*Aoteapsyche* spp. (Trichoptera)*	1.8
Tanytarsini (Diptera: Chironomidae)	8.7	*Hydrobiosis* spp. (Trichoptera)*	1.7
Maoridiamesa spp. (Diptera: Chironomidae)	3.8	*Austrosimulium australense*-group (Diptera)	1.2
Pycnocentrodes aeris (Trichoptera)	2.4	Eriopterini (Diptera)	1.1

Macroinvertebrate densities varied at each site and between survey dates (Figure 3-4). Densities were generally higher in June and August 2018 than in 2019, but there were no other clear patterns between sites or survey dates. Taxa richness (the number of different macroinvertebrate taxa) also varied at each site and between survey dates (Figure 3-5). The highest richness recorded was 29 taxa, found at the Coast site in June 2018, and the lowest was six taxa, recorded at the Arundel site in February 2019. In June and August 2018, the Coast and Above gorge sites had higher taxa richness than the other three sites, but in 2019 surveys, richness at these two sites was more similar to the other sites.

Community composition at each site for each sampling month is shown in Figure 3-6. Dipterans (mainly Orthocladiinae) were abundant at the Arundel, US intake and Above gorge sites in June and August 2018 but were found in much lower numbers at these sites in 2019. The density of dipterans did not show the same decline at the Coast site, though there was a large decline at the SH1 site between February and April 2019. Mayflies (almost entirely *Deleatidium*), varied in density at each site between survey dates, but did not show the same decrease as Diptera between 2018 and 2019 surveys at the Arundel, US intake and Above gorge sites.

[3] Insects (Class Insecta) are divided into a number of orders. Within each order taxa are further split into family, genus and then species.

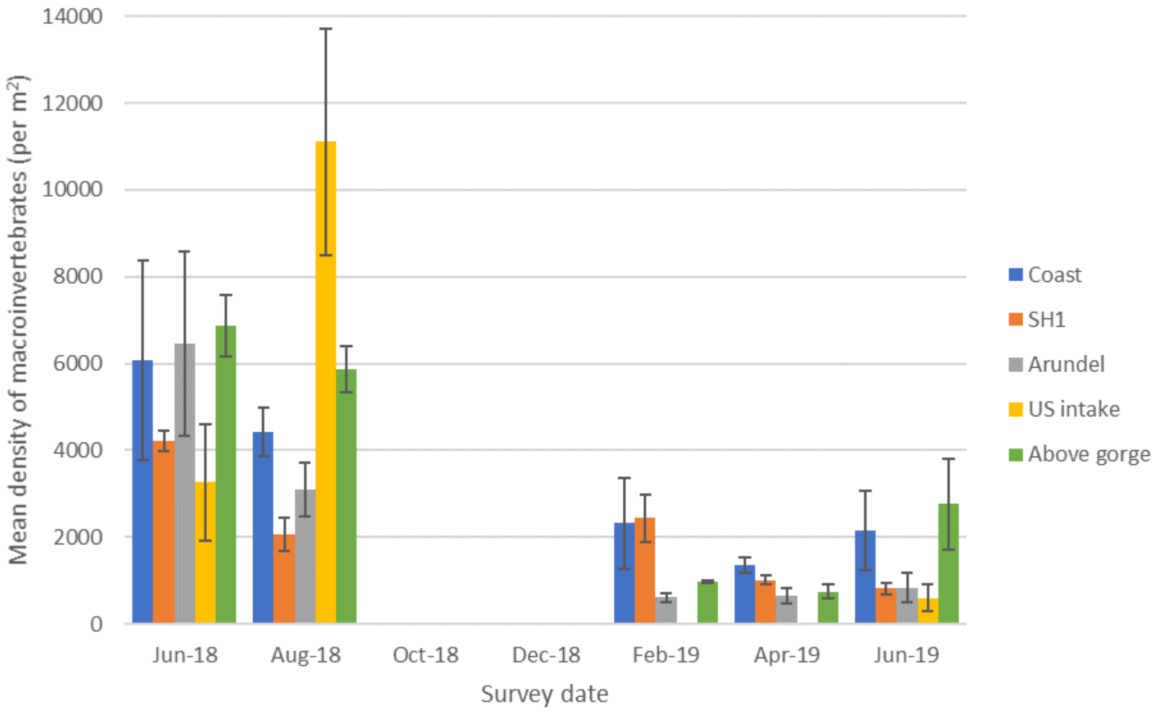

Figure 3-4: Mean density (±1 SE) of macroinvertebrates at each site (n=5) in the Rangitata River at each survey date during 2018–19. Data were not available for all sites in October and December 2018, or for US intake in February and April 2019.

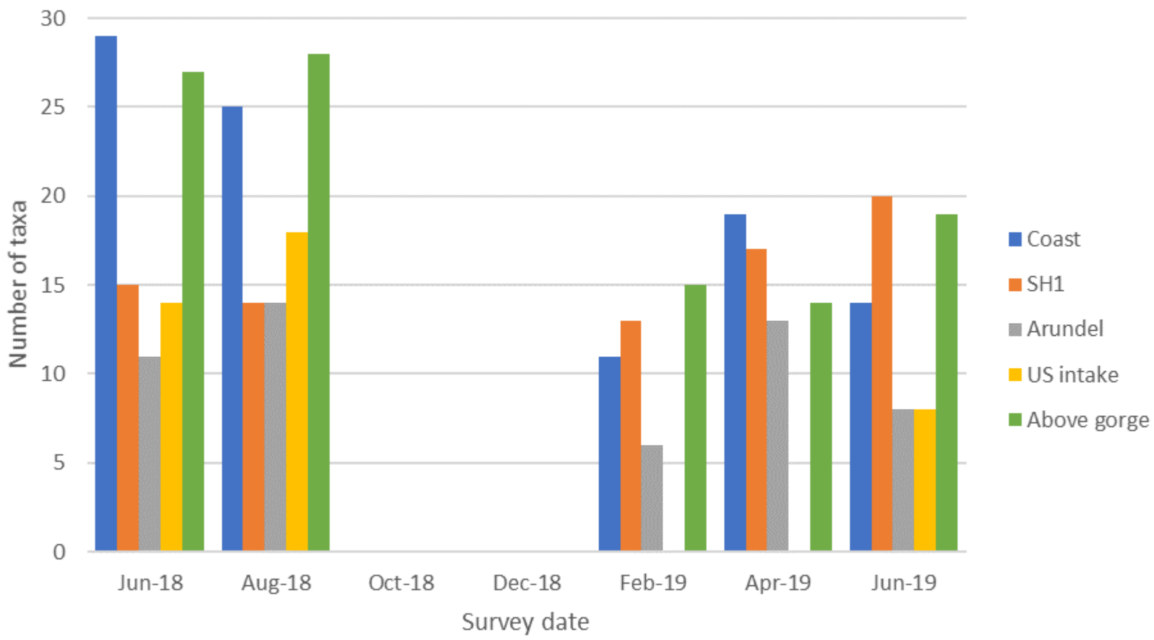

Figure 3-5: Total number of macroinvertebrate taxa at each site (n=5) in the Rangitata River at each survey date during 2018–19. Data were not available for all sites in October and December 2018, or for US intake in February and April 2019.

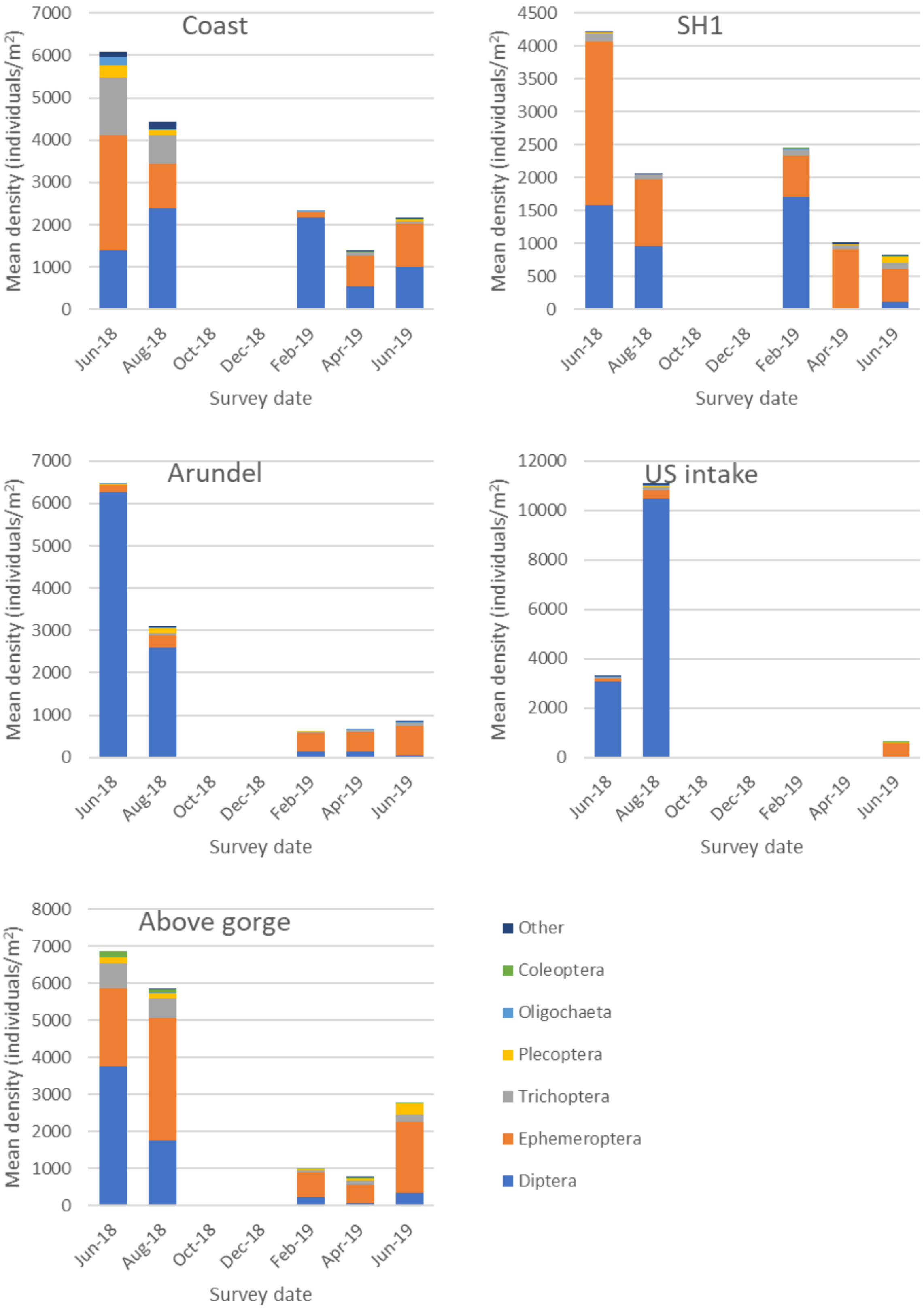

Figure 3-6: Macroinvertebrate community composition at five sites in the Rangitata River at each survey date during 2018–19. Note, the y-axis varies between graphs to better illustrate compositional differences at a site. Data were not available for all sites in October and December 2018, or for US intake in February and April 2019.

The Macroinvertebrate Community Index (MCI) classified most sites during 2018–19 surveys as 'Good' or 'Fair' and only once classified a site as 'Excellent' (no sites were ever classified as 'Poor') (Table B-1). The QMCI mostly classified sites as 'Excellent' or 'Good', but classified sites as 'Fair' twice and as 'Poor' on six occasions. The mean, minimum and maximum MCI and QMCI scores for each site are provided in Table 3-4 and Table 3-5 respectively. Mean MCI and QMCI scores across survey dates gave classifications of 'Good' or 'Fair' for all sites except the Above gorge site, which had a mean QMCI score within the 'Excellent' classification. The 'Poor' scores were driven by the prevalence of Chironomidae midge larvae in 2018 surveys. The MCI and QMCI scores at each site for each survey are shown in Figure 3-7 and Figure 3-8.

Table 3-4: Mean, minimum and maximum MCI scores and categories for the Rangitata River sites (n=5) from 2018–19 surveys. Mean score for each site was from five sampling dates, except for US intake site, where mean score was from three sampling dates. MCI categories as per Stark & Maxted (2004, 2007).

Site	Mean MCI score		Min. MCI score		Max. MCI score	
Coast	102	Good	98	Fair	107	Good
SH1	105	Good	99	Fair	110	Good
Arundel	98	Fair	87	Fair	120	Excellent
US intake	92	Fair	88	Fair	100	Good
Above gorge	105	Good	94	Fair	115	Good

Table 3-5: Mean, minimum and maximum QMCI scores and categories for the Rangitata River sites (n=5) from 2018–19 surveys. Mean score for all sites is from five sampling dates, except for US intake site, where mean score is from three sampling dates. QMCI categories as per Stark & Maxted (2004, 2007).

Site	Mean QMCI score		Min. QMCI score		Max. QMCI score	
Coast	4.78	Fair	2.76	Poor	5.89	Good
SH1	5.88	Good	3.88	Poor	7.58	Excellent
Arundel	5.21	Good	2.21	Poor	7.45	Excellent
US intake	4.13	Fair	2.41	Poor	7.59	Excellent
Above gorge	6.25	Excellent	4.74	Fair	6.95	Excellent

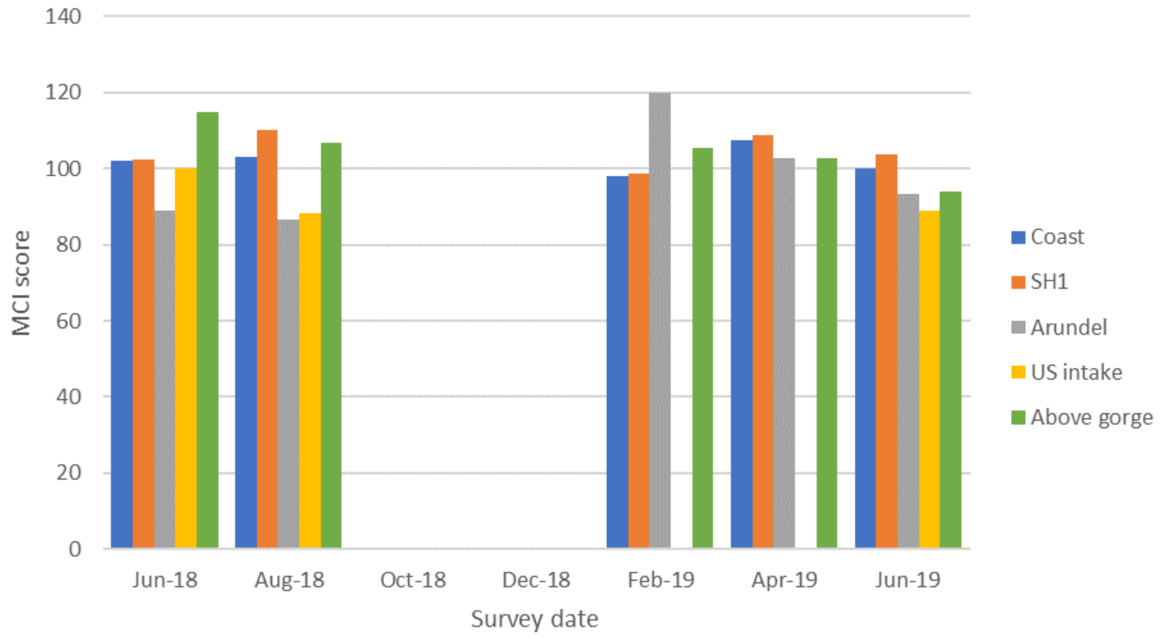

Figure 3-7: 2018–19 MCI score for the Rangitata River sites (n=5) for each survey date. Data were not available for all sites in October and December 2018, or for US intake in February and April 2019.

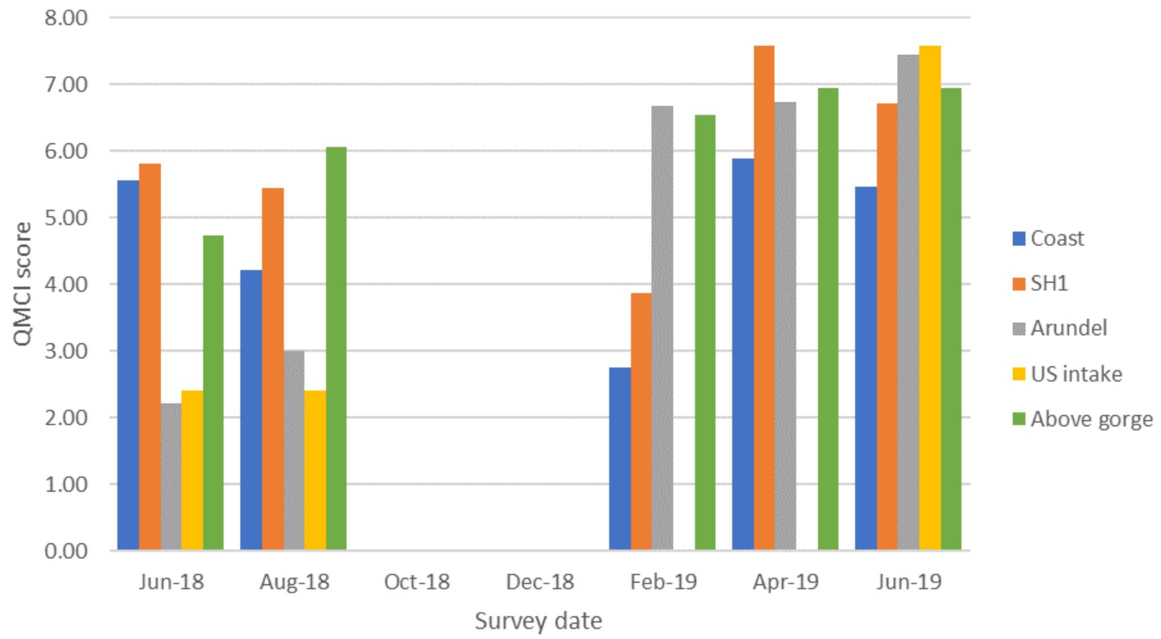

Figure 3-8: 2018–19 QMCI score for the Rangitata River sites (n=5) for each survey date. Data were not available for all sites in October and December 2018, or for US intake in February and April 2019.

The mean percentage of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa at each site across all survey dates ranged from 50% to 60% and varied relatively little between sites and survey dates; the minimum percentage EPT taxa across all survey dates was 43% (Coast site) and the maximum was 69% (Arundel site) (Table 3-6). Percentage EPT abundance was more variable, with site means across survey dates ranging from 36% to 72%. The lowest minimum percentage EPT abundance was 3% (Arundel site in June 2018) and the highest maximum was 96% (US intake site in June 2019). The percentage EPT taxa and percentage EPT abundance at each site for each survey is shown in Figure 3-9 and Figure 3-10.

Table 3-6: Percentage of EPT taxa and percentage EPT abundance for each site in the Rangitata River at each survey date during 2018–19. EPT = Ephemeroptera, Plecoptera and Trichoptera.

	Percentage of EPT taxa			Percentage EPT abundance		
Site	**Mean**	**Min.**	**Max.**	**Mean**	**Min.**	**Max.**
Coast	50	43	55	46	7	72
SH1	57	50	65	65	30	95
Arundel	58	50	69	54	3	93
US intake	60	57	61	36	5	96
Above gorge	58	50	59	72	43	88

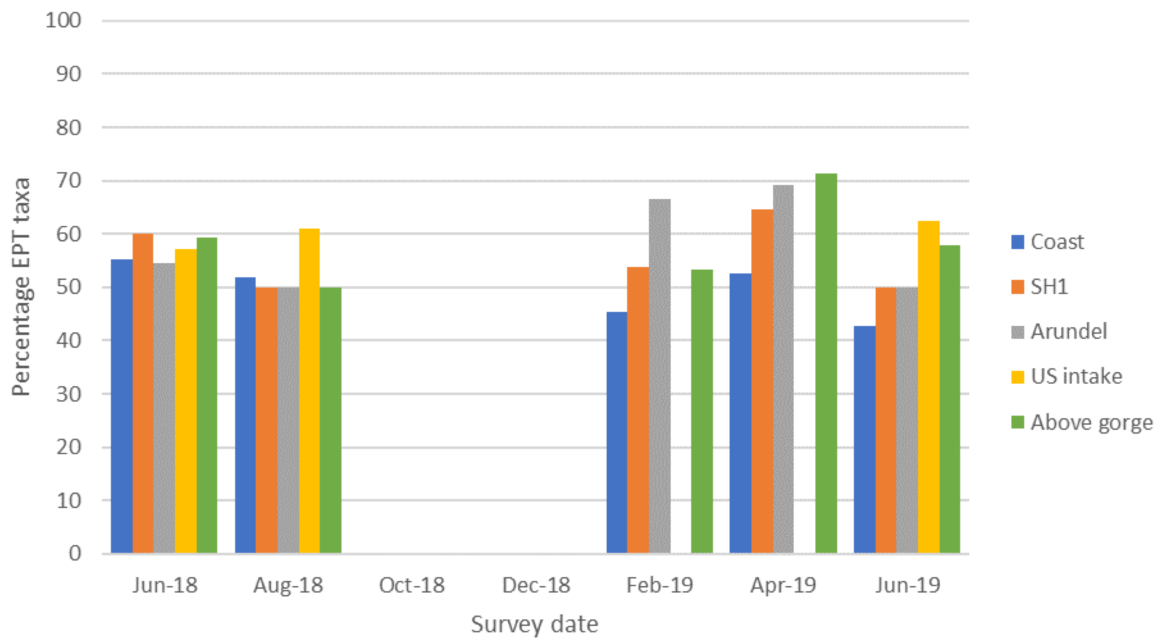

Figure 3-9: Percentage EPT taxa for each site in the Rangitata River at each survey date during 2018–19. EPT = Ephemeroptera, Plecoptera and Trichoptera. Data were not available for all sites in October and December 2018, or for US intake in February and April 2019.

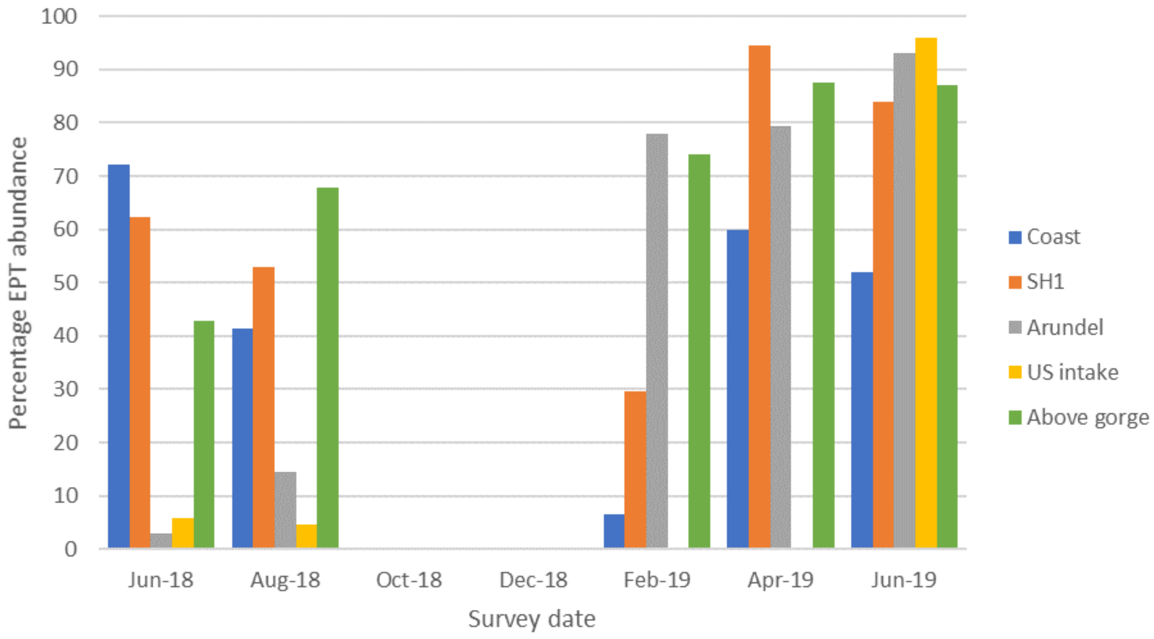

Figure 3-10: 2018-19 percentage EPT abundance for the Rangitata River sites (n=5) for each survey date. EPT = Ephemeroptera, Plecoptera and Trichoptera. Data were not available for all sites in October and December 2018, or for US intake in February and April 2019.

3.4 Comparison of 1983–84 and 2018–19 data

3.4.1 Fish

Bonnetts' 1983–84 study captured 4154 individual fish in total across seven survey dates (Bonnett 1986). By comparison, in 2018–19, 2811 fish were caught across six survey dates (Table 3-7). All 15 fish species caught in 2018–19 were also caught in 1983–84, however there were three additional species caught in 1983–84: giant bully (*Gobiomorphus gobioides*), common smelt (*Retropinna retropinna*) and Stokell's smelt (*Stokellia anisodon*) (Table 3-7). Bluegill bully was the most numerous species caught in both the 1983–84 and 2018–19 studies, and together with torrentfish, common bully and upland bully, these were the four most common fish species in both studies (Table 3-7).

Table 3-7: Percentage of total catch and number of individuals of each fish species caught at each site in the Rangitata River across 1983–84 and 2018–19 surveys. 1983–84 data is from seven surveys and 2018–19 data is from six surveys. Fish species caught in 1983–84 but not in 2019–19 are shaded.

	Common name	Scientific name	1983–84 % abundance (total number	2018–19 % abundance (total number
Galaxiids	Alpine galaxias	*Galaxias paucispondylus*	2.4 (101)	4.2 (118)
	Canterbury galaxias	*G. vulgaris*	1.1 (44)	0.3 (8)
	Īnanga	*G. maculatus*	3.3 (139)	0.04 (1)
	Upland longjaw galaxias	*G. prognathus*	1.9 (81)	0.4 (11)
Bullies	Bluegill bully	*Gobiomorphus hubbsi*	25.2 (1048)	34.1 (959)
	Common bully	*G. cotidianus*	15.2 (631)	7.9 (223)
	Giant bully	*Gobiomorphus gobioides*	0.1 (4)	0 (0)
	Upland bully	*G. breviceps*	10.9 (452)	28.9 (813)
Eels	Longfin eel	*Anguilla dieffenbachii*	3.3 (138)	0.5 (15)
	Shortfin eel	*A. australis*	0.02 (1)	0.04 (1)
Smelt	Common smelt	*Retropinna*	1.1 (46)	0 (0)
	Stokell's smelt	*Stokellia anisodon*	0.1 (4)	0 (0)
Other native species	Black flounder	*Rhombosolea retiaria*	1.1 (45)	0.1 (2)
	Lamprey	*Geotria australis*	0.05 (2)	0.1 (2)
	Torrentfish	*Cheimarrichthys fosteri*	20.9 (868)	16.6 (468)
Intro-duced fish	Brown trout	*Salmo trutta*	4.4 (181)	4.3 (120)
	Chinook salmon	*Oncorhynchus tshawytscha*	7.8 (326)	2.5 (69)
	Rainbow trout	*O. mykiss*	1.0 (43)	0.04 (1)
TOTAL			**100 (4154)**	**100 (2811)**

Because of the potential difference in sampling techniques between 1983–84 and 2018–19 studies (e.g., total sampling effort and varying sampling effort across different habitat types), it is not possible to make direct comparisons about the numbers and percentage abundance of each species. Nevertheless, potentially noteworthy differences include the reduced percentage abundance of Canterbury galaxias, upland longjaw galaxias, longfin eels, Chinook salmon and rainbow trout between 1983–84 and 2018–19 (Table 3-7). There were also a lower number of estuarine/coastal species and a lower percentage abundance of individuals of these species in 2018–19 compared to

1983–84. All three species found in 1983–84 but not 2018–19 usually inhabit estuarine/coastal waters, and there was a lower percentage abundance of īnanga and black flounder captured in 1983–84 compared to 2018–19. While the 2018–19 study tried to use the same sites as in 1983–84, it is possible that the Coast site used in the 1983–84 surveys was closer to the river mouth, or the river morphology present at the Coast site in 1983–84 created more favourable habitat for estuarine/coastal species. Alpine galaxias and upland bully were the only species that had more individuals captured in 2018–19 than in 1983–84. A comparison of the mean fish community at each site across all survey dates for each study is shown in Figure 3-11. The densities of fish in the 1983–84 study is not known, as area fished was not recorded, therefore a comparison with 2018–19 data is not possible.

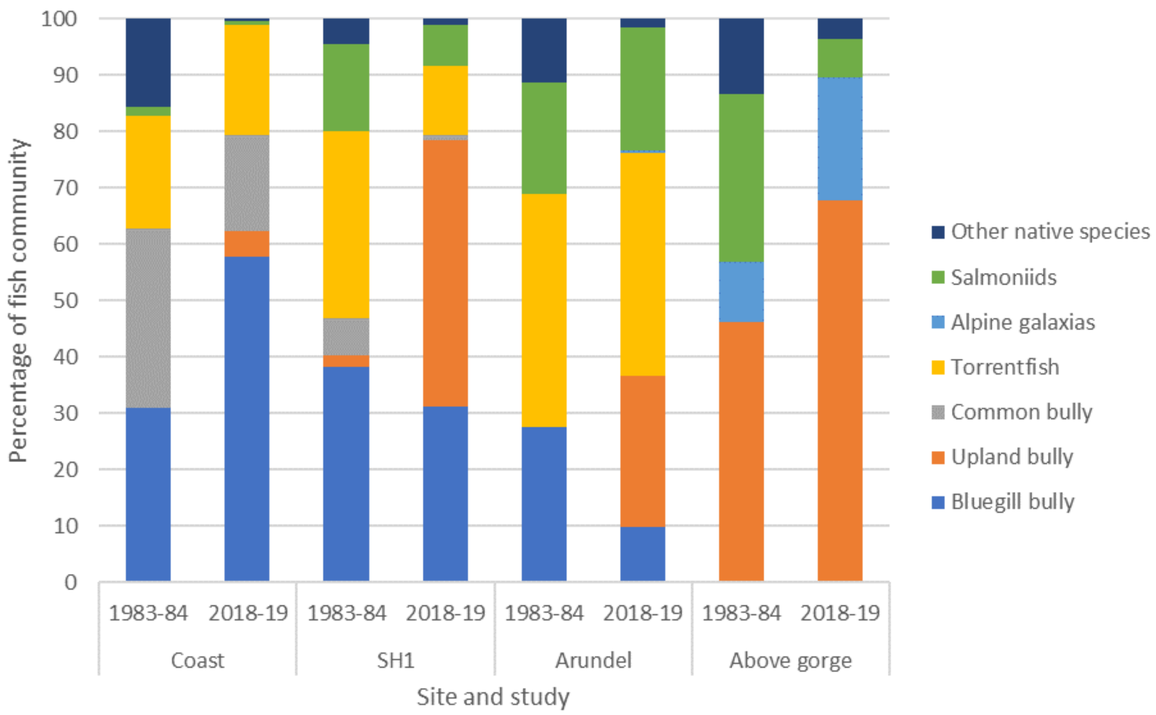

Figure 3-11: Mean fish community composition across all surveys at four sites in the Rangitata River from studies in 1983–84 and 2018–19. 1983–84 data is from seven survey dates and 2018–19 data is from six survey dates.

3.4.2 Macroinvertebrates

Bonnett (1986) surveyed four sites every two months between June 1983 and June 1984, resulting in seven sampling dates (cf. five for 2018–19). From these samples, a total of 8391 individuals were identified and counted (cf. 15,457 for the same four sites and same sampling area in 2018–19) and 27 different macroinvertebrate taxa were identified (note one original identification has been assumed to be incorrect and has been combined with another taxon) (Table 3-8). The identification level differed for some taxa compared to 2018–19 surveys – Chironomidae were not identified to lower levels (tribe or genus) in 1983–84. When 2018–19 data identification level is matched to that of 1983–84 data, there would be 43 different taxa (for the same four sites). Only four taxa identified in 1983–84 were not also found in 2018–19 surveys (three caddisfly species and one dipteran species). A higher number of taxa might be expected from 2018–19 samples as a greater number of individuals generally increases the likelihood of encountering 'rare' or less common taxa. Indeed, a greater number of rare taxa were identified in 2018–19 than in 1983–84 – all 19 of the taxa found in 2018–19 but not in 1983–84 each accounted for between 0.01–0.20% of the total individuals counted.

Table 3-8: Summary of macroinvertebrate data from surveys at four sites in the Rangitata River in 1983–84 and 2018–19.

	Coast	SH1	Arundel	Above gorge	TOTAL
1983–84					
Number of surveys	6	7	7	7	27
Total individuals counted	1031	1991	1342	4027	8391
Number individuals/survey	172	284	192	575	311
Number of taxa	16	16	16	25	27
2018–19					
Number of surveys	5	5	5	5	20
Total individuals counted	4722	3046	3365	4975	16108
Number individuals/survey	944	609	673	995	805
Number of taxa	31	31	18	34	43

The greater number of macroinvertebrates collected in the 2018–19 surveys may be due to a number of reasons, including sampling and sample processing methods such as sample collection technique, sampling washing sieve mesh size (four small taxa found in 2018–19 are notably absent from 1983–84 samples) or sample processor identification skill level (some taxa may have been missed). It may also be due to environmental effects, for example, if there were a longer period of stable flows or lower intensity floods prior to the 2018–19 surveys, more macroinvertebrates may have been able to colonise the river.

The mean community composition (combined into higher taxonomic groupings) across survey dates for the 1983–84 and 2018–19 studies is shown in Figure 3-12. Diptera and Ephemeroptera were the two most abundant taxa in both studies, but Diptera accounted for a larger part of the community at all sites in 2018–19. Mean MCI scores across all survey dates were similar between the 1983–84 and 2018–19 studies for all sites, placing all but one site in the 'Good' category (Table 3-9). The lower MCI category ('Fair') for the Arundel site in 2018–19 is due to only a relatively small decrease in MCI score. Mean QMCI scores were lower for all sites in the 2018–19 study. In 1983–84, all sites fell within the 'Excellent' category, but in 2018–19 only the Above gorge site was in the 'Excellent' category. Declines in mean QMCI score for the Coast and Arundel sites occurred in alongside declines in mean percentage EPT abundance, however this was not the case for the SH1 site (though this site had a much small decrease in QMCI than the Coast and Arundel sites). Percentage EPT taxa and EPT abundance were very similar for the Above Gorge site in 1983–84 and 2018–19 studies.

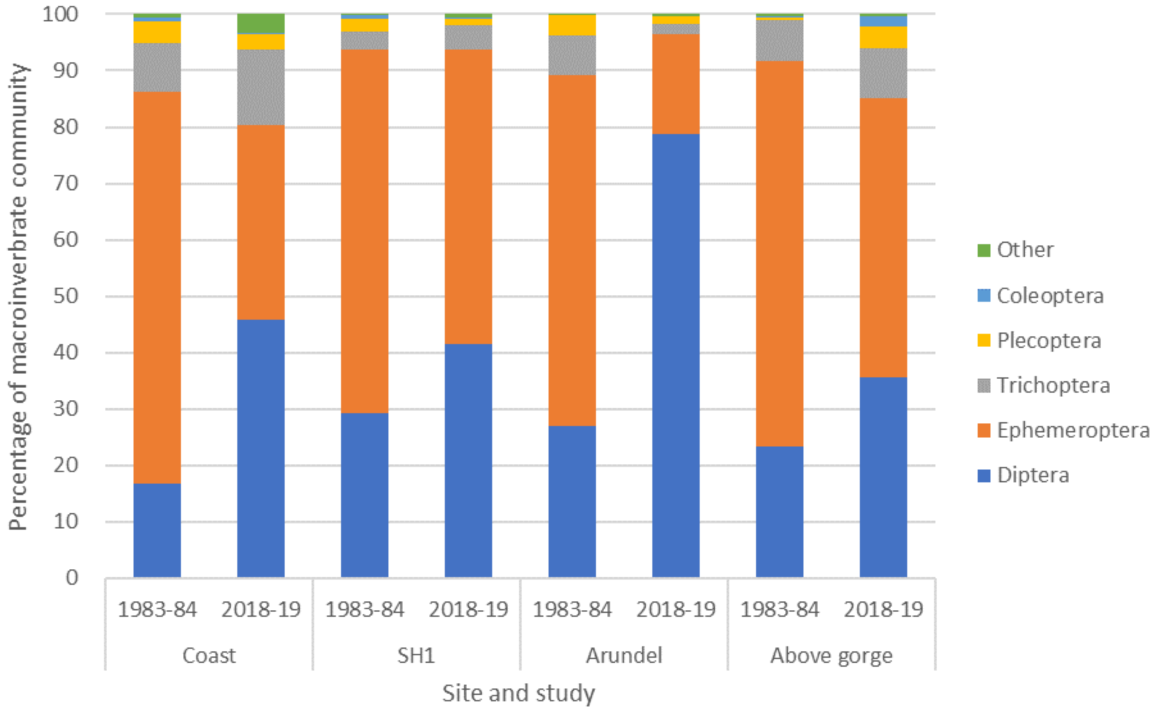

Figure 3-12: Mean macroinvertebrate community composition across all surveys at four sites in the Rangitata River from studies in 1983–84 and 2018–19. 1983–84 data is from seven survey dates for all sites but Coast (six survey dates) and 2018–19 data is from five survey dates for all sites.

Table 3-9: Invertebrate indices for four sites in the Rangitata River from studies in 1983–84 and 2018–19. 1983–84 data is from seven survey dates for all sites but Coast (six survey dates) and 2018–19 data is from five survey dates for all sites.

Site	Study years	Mean MCI score	MCI category	Mean QMCI score	QMCI category	% EPT taxa	% EPT abundance
Coast	1983–84	101	Good	6.80	Excellent	51.3	84.0
	2018–19	102	Good	4.78	Fair	49.6	46.4
SH1	1983–84	108	Good	6.26	Excellent	45.9	66.4
	2018–19	105	Good	5.88	Good	55.7	64.6
Arundel	1983–84	103	Good	6.55	Excellent	58.1	78.3
	2018–19	98	Fair	5.21	Good	58.1	53.6
Above gorge	1983–84	103	Good	6.65	Excellent	58.4	76.0
	2018–19	105	Good	6.25	Excellent	58.4	71.9

4 Discussion

4.1 Longitudinal changes in freshwater community composition

The Rangitata River fish and macroinvertebrate communities differ along the length of the river. Unsurprisingly, the diadromous species commonly found in this study – torrentfish, common bully and bluegill bully – were all found in much higher numbers at the most downstream site. However, bluegill bully and torrentfish were found as far up as the US intake site, but numbers were low. One longfin eel (diadromous species) was captured above the gorge, however, it is not unusual for longfins to occur this high up in river catchments (McDowall 2000).

The non-diadromous galaxias species alpine galaxias, Canterbury galaxias and upland longjaw galaxias were found higher in the river (at the Arundel to Above gorge sites). The latter two species were only found at the site above the gorge, though both are known to occur on the Canterbury Plains (McDowall 2000). Upland bully, longfin eel, brown trout and Chinook salmon were the only species caught at all five sites.

Longitudinal changes in the macroinvertebrate community composition are much less obvious. For example, mayflies, stoneflies and caddisflies have the highest abundances at the Coast and US intake sites. Most macroinvertebrate taxa were found throughout the five sites.

4.2 Hydrological regime influences on the riverine communities

The Rangitata River, as with other similar South Island braided rivers, is flood-prone during rain-bearing west and north-westerly weather systems. The fish and macroinvertebrate communities within the river comprise taxa that can cope with this hydrological regime, though flood events will still alter these communities. There were some changes to the fish and macroinvertebrate communities between the October 2018 and February 2019 surveys that may be attributable to the large (~1920 m^3/s) flood event in December 2018. Macroinvertebrate communities showed the most distinct changes. Total macroinvertebrate densities tended to be lower in the February 2019 to June 2019 surveys compared to June 2018 and August 2018, and there was a decrease in species richness at some sites between August 2018 and February 2019. For some sites, the most abundant taxon, Orthocladiinae midge larvae, were found in much lower numbers in 2019 compared to 2018. Flood events not only remove the macroinvertebrates themselves, but also the biofilm on the rocks on which they feed; field staff noted that the thick periphyton was significantly reduced at all sites between October 2018 and February 2019 and it was slow to recover over the following surveys.

For the fish community, differences between October 2018 and February 2019 surveys were less obvious. There was a much lower catch of Chinook salmon in 2019 surveys compared to 2018 (though this may also be a natural 'population thinning' abundance change) and upland bully were absent from the Arundel site after October 2018.

The Arundel and US intake sites seemed to be more affected by the December 2018 flood event – changes to the bed morphology were more pronounced at these two sites than the others (the US intake site was unrecognisable in February 2019). This is potentially because the channel is narrower at these sites and the effect of the flood water may be concentrated (channel widths: Arundel 300 m, US intake 450 m, vs SH1 580 m, Coast 650 m and Above gorge 1230 m). This increased 'stream power' effect of flooding at these narrower sites could potentially explain why fish densities were lower at these sites prior to the flood event (i.e., fewer fish can establish here over longer timeframes). While it was variable, the macroinvertebrate communities were generally less diverse at the Arundel and US intake sites compared to other sites.

4.3 Changes in species of interest to fishery and conservation managers

Data collected in 1983–84 by Bonnett (1986) allows a few general comparisons of the fish communities of the Rangitata River to be made. One of the more notable differences is the reduced number of estuarine species; giant bully, common smelt and Stokell's smelt were found in 1983–84 but were absent in 2018–19 (though note these were found in low abundances in 1983–84), and a lower percentage īnanga and black flounder were captured in 2018–19. While Bonnett (1986) may have sampled marginally further downstream, the 2018–19 surveys were only 1300 m upstream of the ocean and well within known inland penetrations of these species (McDowall 2000). Morphological changes in the lagoon/hāpua and river mouth are likely to have occurred between 1983–84 and 2018–19; examination of satellite images for the previous decade show marked differences between years.

There was a lack of diadromous galaxiids captured in the 2018–19 surveys. Only one īnanga was caught and no kōaro found, despite the latter being known from tributaries of the Rangitata River (McDowall 2000). There were also potentially reduced numbers of non-diadromous galaxiids Canterbury galaxias and upland longjaw galaxias between 1983–84 and 2018–19 (i.e., these species made up a lower percentage of the catch in 2018–19). Longfin eels comprised over 3% of the total catch in the 1983–84 but only made up 0.5% of 2018–19 catch. There are growing concerns about the abundance and declines for this species around New Zealand and a six-fold reduction in the percentage of longfin eels in the catch across the 35-year period could be interpreted as further evidence for this concern.

Two of the three introduced salmonid species (Chinook salmon and rainbow trout) made up a smaller percentage of the catch in the 2018–19 surveys compared to 1983–84. While brown trout comprised a similar percentage of the catch across both studies (around 4%), there was a much more pronounced decrease in the percentage abundance of Chinook salmon and rainbow trout. Major declines in abundance of adult salmon have been noted over the last couple of decades in the catchment so this result was not unexpected but the marked decline in rainbow trout probably warrants further investigation.

5 Acknowledgements

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Appendix A Macroinvertebrate taxa at each site across all 2018–19 surveys

Table A-1: Total number of each macroinvertebrate taxa from each site in the Rangitata River from five surveys during 2018–19. *US intake site from three surveys. **includes both *Aoteapsyche colonica* and *A. tepoka* – too few *Aoteapsyche* were large enough to identify to species with certainty and count separately.

	Coast	SH1	Arundel	US intake*	Above gorge	Total
Ephemeroptera	**1636**	**1591**	**596**	**2454**	**294**	**6571**
Austroclima jollyae	1	1	1	1	7	11
Coloburiscus humeralis	33	2	-	-	-	35
Deleatidium spp.	1597	1587	595	2452	287	6518
Neozephlebia scita	5	1	-	-	-	6
Nesameletus ornatus	-	-	-	1	-	1
Plecoptera	**131**	**36**	**46**	**194**	**18**	**425**
Zelandobius furcillatus	131	36	46	192	18	423
Zelandoperla decorata	-	-	-	2	-	2
Trichoptera	**632**	**130**	**58**	**446**	**57**	**1323**
Aoteapsyche spp.**	203	52	13	92	4	364
Aoteapsyche colonica	p	P	-	p	P	NA
Aoteapsyche raruraru	-	-	-	-	1	1
Aoteapsyche tepoka	P	p	p	p	p	NA
Beraeoptera roria	-	-	-	3	-	3
Confluens olingoides	-	-	-	1	-	1
Costachorema spp.	1	2	-	3	-	6
Costachorema xanthopterum	-	1	2	10	-	13
Hudsonema amabile	3	1	-	2	-	6
Hydrobiosis spp.	27	24	25	58	17	151
Hydrobiosis frater	2	21	6	64	17	110
Hydrobiosis parumbripennis	5	2	-	5	2	14
Hydrobiosis umbripennis	25	6	4	27	4	66
Neurochorema forsteri	-	-	-	-	9	9
Olinga spp.	5	2	-	1	-	8
Oxyethira albiceps	6	1	1	5	-	13
Psilochorema bidens	7	-	-	1	-	8
Psilochorema leptoharpax	11	9	6	7	1	34

	Coast	SH1	Arundel	US intake*	Above gorge	Total
Trichoptera continued	**632**	**130**	**58**	**446**	**57**	**1323**
Pycnocentria evecta	10	4	-	12	-	26
Pycnocentrodes aeris	327	3	1	154	2	487
Triplectides cephalotes	-	2	-	-	-	2
Zelolessica cheira	-	-	-	1	-	1
Diptera	**2159**	**1266**	**2652**	**1776**	**3919**	**11772**
Aphrophila spp.	-	1	-	8	-	9
Austrosimulium australense-group	37	95	67	27	13	239
Empididae	3	1	3	-	1	8
Eriopterini	88	36	15	82	2	223
Lobodiamesa spp.	3	-	-	-	-	3
Maoridiamesa spp.	85	71	7	608	5	776
Molophilus spp.	4	-	-	5	-	9
Muscidae	1	-	-	15	-	16
Orthocladiinae	1575	828	2317	709	3271	8700
Pelecorhynchidae	-	1	-	7	-	8
Tanypodinae	1	1	-	2	-	4
Tanytarsini	362	232	243	313	627	1777
Coleoptera	**10**	**5**	**-**	**84**	**2**	**101**
Berosus spp.	4	-	-	10	1	15
Hydora spp.	6	5	-	74	1	86
Crustacea	**1**	**7**	-	-	-	**8**
Ostracoda	1	-	-	-	-	1
Paracalliope spp.	-	4	-	-	-	4
Paraleptamphopus spp.	-	3	-	-	-	3
Mollusca	**53**	**3**	**1**	**-**	**1**	**58**
Physa spp.	-	1	-	-	-	1
Potamopyrgus spp.	53	2	1	-	1	57
Acari	20	4	-	4	-	28
Hydra	**-**	-	-	1	-	1
Nematoda	13	-	2	4	21	40
Oligochaeta	67	4	10	12	12	105
GRAND TOTAL	**4722**	**3046**	**3365**	**4975**	**4324**	**20432**

Appendix B Macroinvertebrate indices for each site at each survey

Table B-1: Macroinvertebrate indices for each site at each survey.

Site	Month	MCI score	MCI classification	QMCI score	QMCI classification	%EPT taxa	%EPT abundance
Coast	Jun-18	102	Good	5.57	Good	55	72.1
Coast	Aug-18	103	Good	4.21	Fair	52	41.4
Coast	Feb-19	98	Fair	2.76	Poor	45	6.6
Coast	Apr-19	107	Good	5.89	Good	53	59.9
Coast	Jun-19	100	Good	5.47	Good	43	52.0
SH1	Jun-18	103	Good	5.81	Good	60	62.3
SH1	Aug-18	110	Good	5.44	Good	50	52.9
SH1	Feb-19	99	Fair	3.88	Poor	54	29.5
SH1	Apr-19	109	Good	7.58	Excellent	65	94.6
SH1	Jun-19	104	Good	6.70	Excellent	50	83.9
Arundel	Jun-18	89	Fair	2.21	Poor	55	3.0
Arundel	Aug-18	87	Fair	2.99	Poor	50	14.6
Arundel	Feb-19	120	Excellent	6.67	Excellent	67	78.0
Arundel	Apr-19	103	Good	6.73	Excellent	69	79.5
Arundel	Jun-19	93	Fair	7.45	Excellent	50	93.0
US intake	Jun-18	100	Good	2.41	Poor	59	5.8
US intake	Aug-18	88	Fair	2.41	Poor	50	4.5
US intake	Feb-19	89	Fair	7.59	Excellent	53	96.0
Above gorge	Jun-18	115	Good	4.74	Fair	71	42.8
Above gorge	Aug-18	107	Good	6.06	Excellent	58	67.9
Above gorge	Feb-19	105	Good	6.54	Excellent	57	74.2
Above gorge	Apr-19	103	Good	6.95	Excellent	61	87.6
Above gorge	Jun-19	94	Fair	6.95	Excellent	63	87.1