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NIWA
Taihoro Nukurangi

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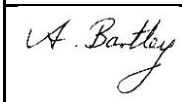	Formatting checked by:	Alison Bartley
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Executive summary

The Waikato Regional Council (WRC) is responsible for managing the status of water resources in the Waikato region. WRC have initiated investigations in the Waihou and Piako catchments to support and inform the scheduled water allocation review process in these catchments. One of the key objectives of the water allocation process is to safeguard the life-supporting capacity of freshwater ecosystems.

The scope of this study was to undertake monitoring of fish, macroinvertebrates, macrophytes and periphyton at ten sites across the Waihou and Piako catchments. Five sites were to be surveyed in each catchment. The aim was to build on and consolidate the previous ecological monitoring studies in the catchments by adding to the time series of data for these sites.

In this survey, several sites in both the Piako and Waihou catchments had substantially lower numbers of fish, particularly bullies, in 2017 than in previous years. It is likely that these declines were the result of temporary displacement of fish following heavy rains and high flows which occurred in the middle of our sampling period. The sites in both catchments which were sampled prior to the rain had the highest numbers of fish, and the relative abundances of species were comparable to previous years, supporting this conjecture.

The presence of galaxiids was variable, consistent with past surveys. Banded kokopu were found at two sites and inanga at one site, for two of the sites it was the first record for the species since monitoring began. However, galaxiids were also absent from other sites at which they had been found in past years. This suggests that these species are likely present in most sites in very low numbers, and thus are captured some years, but not others.

Exotic species were also present at multiple sites. Brown and/or rainbow trout were present at four of the five Waihou sites, and mosquitofish were captured in one.

Macroinvertebrate community index scores declined at most sites compared to the previous year, but remained within the range of variability observed over the entire monitoring period. Again, it is possible the change in scores reflects temporary displacement of individuals associated with the heavy rain and high flows immediately prior to sampling. The percentage of sensitive (EPT) individuals also declined at the majority of sites, although EPT richness and total richness was higher at most sites compared to 2016.

Habitat quality scores improved at several sites in both Waihou and Piako catchments, largely in association with increased riparian cover and bank stability and reduced sedimentation and periphyton cover. The few sites with decreased scores were primarily due to increased bank instability, likely the result of greater livestock access than in previous years. Periphyton and macrophyte cover were generally comparable to that observed in previous years, although slightly lower at some sites due to the scouring associated with recent rain events.

It is recommended that annual ecological monitoring continues at these ten sites. The year-to-year variation observed over the course of the survey indicates the importance of determining the natural inter-annual variability of native fish and macroinvertebrate populations to provide a more robust baseline against which to monitor the effects of human impacts on these river ecosystems. For example, next year's survey should help us determine whether some of the results observed this year were temporary impacts resulting from higher-than-usual flows at this time of year, or an indication of longer-term trends. Thus, this ongoing ecological monitoring will support WRC in setting appropriate, targeted and robust freshwater objectives and associated protection levels in the Waihou and Piako catchments.

1 Introduction

The Waikato Regional Council (WRC) is responsible for managing the status of water resources in the Waikato region. WRC's approach to the protection, management and use of water resources is set out in the Waikato Regional Plan (WRC 2012), hereafter referred to as the Plan. As required by the National Policy Statement for Freshwater Management (MfE 2014), the Plan includes minimum flow and allocation limits for all catchments in the region (Table 3-5 in WRC 2012). Scheduled reviews of the flow and allocation limits are also specified in the Plan (Table 3-4A in WRC 2012).

WRC has initiated investigations in the Waihou and Piako catchments to support and inform the scheduled allocation review process in these catchments. One of the key objectives of the water allocation process is to safeguard the life-supporting capacity of freshwater ecosystems (MfE 2014). WRC are seeking to improve their understanding of the ecological status of aquatic ecosystems in the Waihou and Piako river systems and have initiated ecological monitoring studies in the two catchments (Franklin and Booker 2009; Franklin, Croker et al. 2011; Franklin and Bartels 2012; Franklin, Smith et al. 2013; Franklin, Croker et al. 2014; Graham, Franklin et al. 2015; Graham, Franklin et al. 2016).

The objective of this study was to undertake repeat monitoring of fish, macroinvertebrates, macrophytes and periphyton at ten sites across the Waihou and Piako catchments. Five sites were chosen for annual surveying in each catchment based on the recommendations in Franklin, Smith et al. (2013). The aim was to build on and consolidate the previous ecological monitoring studies in the catchments by adding to the time series of data for these sites. The results will contribute knowledge of the ecological values in the catchments to the water allocation decision-making process.

2 Methodology

2.1 Sites

Monitoring was carried out at ten sites in late February 2017 (Table 2-1 & Figure 2-1). The sites were those sampled in 2014, 2015, and 2016 following the recommendations of Franklin, Smith et al. (2013). The previous samplings were also undertaken during the same summer period; consistency in sampling time is required for accurate comparisons of fish populations between years. All sites other than Site 10 on the Waitawheta River had also been sampled at least once prior to 2014. Site 10 was established in 2014 as a new site in the Ohinemuri sub-catchment, downstream of the Ohinemuri weir which is considered a barrier to upstream migration of most fish species.

Table 2-1: Location of the 2014-2017 ecological monitoring sites in the Waihou and Piako catchments. Easting and Northing given for downstream limit of survey reach (NZTM coordinates).

Site	Catchment	Stream	Easting	Northing	Distance inland (km)	Elevation (m)
1	Piako	Mangakahika Stream	1818698	5838814	59	62
2	Piako	Waitoa Stream	1831974	5803819	125	157
3	Piako	Mangapapa Stream	1836783	5809932	107	86
4	Piako	Waitakaruru Stream	1817745	5815748	92	63
5	Piako	Piakonui Stream	1831220	5809988	100	160
6	Waihou	Paiakarahi Stream	1841027	5867879	34	60
7	Waihou	Karengorengo Stream	1848393	5823235	100	30
8	Waihou	Wairere Stream	1851649	5819801	108	40
9	Waihou	Waitearikl Stream	1852566	5818150	112	97
10	Waihou	Waitawheta River	1845480	5849662	71	177

2.2 Flow

Mean daily flow (m^3/s) was calculated by the Waikato Regional Council using continuous river level measurements recorded at five minute intervals at designated monitoring sites. Each survey site was matched to the closest flow monitoring site on the same river network. Although a period of heavy rain occurred during the annual monitoring period in mid-February, flows remained well below bed-moving values, therefore a two-week stand-down period was not required. However, sampling was postponed for several days until conditions were once again safe for electric-fishing.

2.3 Fish

Fish surveys were carried out by electric fishing using the standardised methods outlined by WRC (David and Hamer 2010). At each site, a 150 m reach was surveyed by single pass electric fishing using an EFM300 with voltage adjusted dependent on local conditions. At each site, the same voltage was used in all years unless instream conditions required a change to maintain capture efficiency. Electric-fishing effort was standardized between years by matching the duration of time the electric-fishing machine was operating during each sampling. The number of each species captured, along with fish lengths, was recorded for every 15 m sub-reach.

This survey approach is designed to maximise the likelihood of capturing the full diversity of species present by encompassing the full range of habitats within a stream reach. Results are presented as relative abundance standardised by survey area (number of fish divided by total area sampled).

These abundance estimates are based on single pass electric fishing, which is a semi-quantitative method, and thus they are not equivalent to fish density and should not be used for comparison between sites. Interpretation of the relative abundance estimates is restricted to temporal comparisons at the same site, assuming the same reach is sampled, with the same level of effort and sampling efficiency on each sampling occasion.

Three representative bullies were collected from each site at which they were present for genetic analysis to resolve past concerns regarding the true identification (common vs. Cran's) of the bullies at the sites, given the relative distance inland and size range of some of the bullies captured. Each bully was stored in 100% ethanol and sent to the Cawthron Institute, where a mitochondrial gene (cytochrome b) was sequenced for phylogenetic analysis.

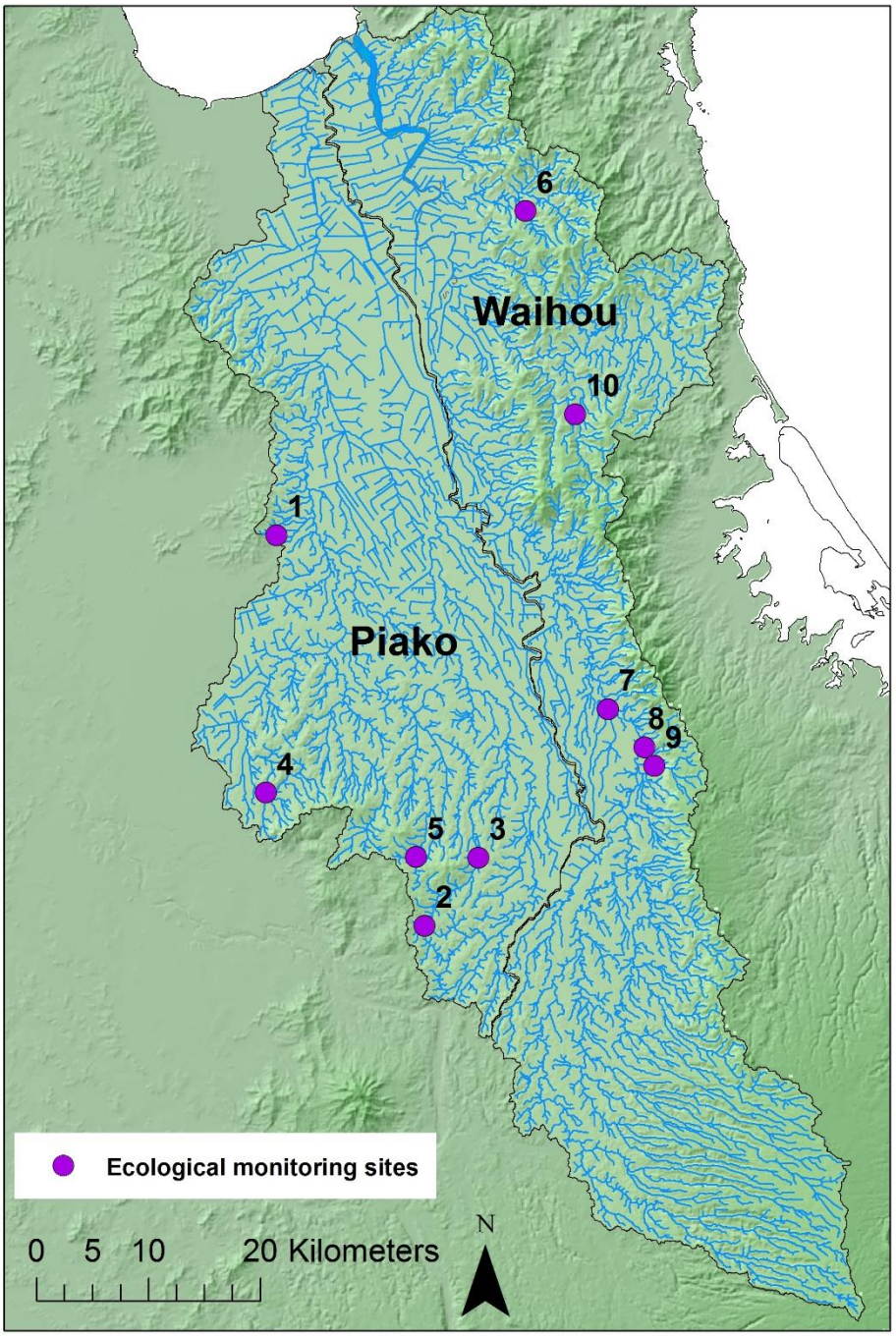

Figure 2-1: Location of the 10 ecological survey sites sampled in the Waihou and Piako catchments during 2014 – 2016. Site numbers refer to those listed in Table 2-1.

2.4 Macroinvertebrates

Macroinvertebrate sampling was carried out following the standardised procedures for wadeable streams as outlined by WRC (Collier and Kelly 2005). In soft-bottomed streams, woody debris, macrophytes and stream banks were sampled, as appropriate, using a hand net (0.5 mm mesh) following MfE Protocol C2 (Stark, Boothroyd et al. 2001). For hard-bottomed streams, a kick-sampling approach targeting riffle areas and following MfE Protocol C1 was utilised (Stark, Boothroyd et al. 2001). At each site the WRC REMS (Regional Ecological Monitoring of Streams) habitat assessment protocol was also carried out, with a Field Assessment Cover Form and a Habitat Assessment Field Data Sheet completed. All samples were preserved and returned to the laboratory for processing.

Samples were processed using the recommended MfE Protocol P2 (200 individual fixed counts and scan for rare taxa) (Stark, Boothroyd et al. 2001). This provides proportional abundance data suitable for the calculation of most invertebrate parameters (Collier and Kelly 2005). Complete taxonomic lists were compiled and a range of community metrics calculated at the taxa level indicated in Collier,Kelly (2005).

2.5 Macrophytes & periphyton

Macrophyte and periphyton surveys were carried out following the standardised procedures for wadeable streams as outlined by WRC (Collier, Hamer et al. 2014). At each of five transects located in the reach, periphyton cover was assessed at five points (10%, 30%, 50%, 70% and 90%) across the wetted width of the stream and the area of macrophyte cover occupying the 1 m wide band upstream of the transect was estimated.

Details of the thickness and cover of periphyton were recorded allowing calculation of the Periphyton Enrichment Index (PEI), Periphyton Sliminess Index (PSI) and a range of periphyton biomass indices as defined in Collier, Hamer et al. (2014)[1]. The percentage cover of different submerged and emergent species of macrophytes was also recorded, allowing calculation of the macrophyte cover indices (Collier, Hamer et al. 2014).

[1] In the course of calculating the PEI using the updated formula from Collier et al. (2014) we noticed that, because it requires dividing only by the number of transects in which periphyton were present, sites that had periphyton in one transect had higher overall enrichment scores than sites with periphyton across multiple transects, which seems counterintuitive. However, comparison of scores calculated using the new and old methods on the same data showed a 0.95 correlation, suggesting that this may have been an issue in the past calculations as well.

3 Results

3.1 Piako catchment

3.1.1 Flow

Mean daily flows were low and stable for the first half of the year preceding sampling. As expected, higher flows occurred over the autumn and winter months, with two periods of high flow, in June to July and September to October. This pattern is consistent with flow patterns in most previous years (Figure 3-1). However, in 2017, a medium-sized rain event occurred earlier than usual, during the annual monitoring period in mid-February (Figure 3-1).

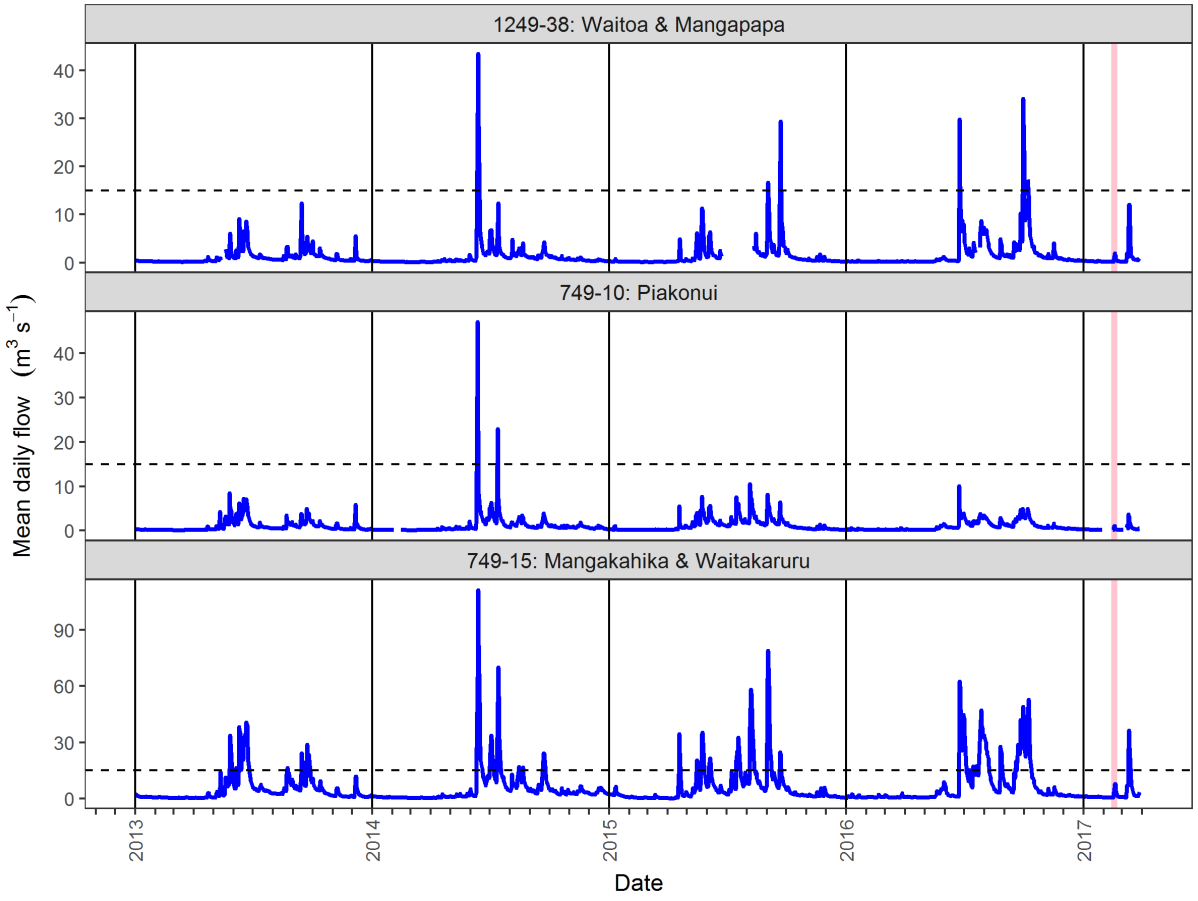

Figure 3-1: Mean daily flow ($m^3 s^{-1}$) in the Piako catchment between 2013 and 2017. Each flow monitoring site is listed first, followed by the survey sites for which it is the closest reference. Tick marks indicate months, the year label is located on the January tick mark. The 2017 sampling period is indicated by the shaded pink region. The dashed horizontal line indicates the bed-moving flow (15 $m^3 s^{-1}$ in Piako catchment; WRC personal communication) after which a sampling stand-down would have been required.

3.1.2 Fish

Six of the eight native fish species found across the five survey sites in the Piako catchment during the 2014-2016 surveys were captured in 2017 (Table 3-1). The two species not present were koaro (*Galaxias brevipinnis*), which were captured in Piakonui Stream in 2016, and torrentfish (*Cheimarrichthys fosteri*), which were captured in Waitakaruru Stream in 2014 and 2015. Shortfin

(*Anguilla australis*) and longfin (*Anguilla dieffenbachii*) eels were both present at all five sites. This was an increase in distribution of longfin eels, which were only captured at three sites in 2016. Koura (*Paranephrops planifrons*), the freshwater crayfish, were also found at all five sites, as in previous years. Freshwater shrimp (*Paratya curvirostris*) were not observed at any site, although they had been present in Waitoa Stream in 2016. Bullies were not captured in Piakonui Stream in 2017, whereas in the past bullies were present at all five sites. Phylogenetic analysis of the three fish collected per site was unable to resolve whether the bullies present were common (*Gobiomorphus cotidianus*) or Cran's (*Gobiomorphus basalis*), therefore in this report all bullies will be referred to as C. bully, pending further investigation. Banded kokopu (*Galaxias fasciatus*) were captured in the Mangakahika Stream, similar to previous years, but not in Piakonui Stream, where they have been present in past years. However, banded kokopu were captured for the first time in Mangapapa Stream. Torrentfish were not captured in any of the Piako streams in 2017, including the Waitakaruru, where they were present in 2014 and 2015. Inanga (*Galaxias maculatus*) were found in Mangakahika Stream for the first time since sampling began, although they were not captured in Mangapapa Stream, where they had been present in 2016, potentially indicating that inanga are rare in these streams, and it is likely that their populations are too small to be sampled consistently year-to-year. No exotic species were captured, even though they are known to be locally abundant in some areas of the Piako catchment.

Mangakahika Stream had the greatest diversity of fish species of the five Piako catchment sites, with five native fish species and koura. The abundance of shortfin and longfin eels in Mangakahika Stream in 2017 was similar to those recorded in previous years. The abundance of bullies, on the other hand, was slightly lower than 2016, but substantially higher than other years. Banded kokopu were captured in greater numbers than in 2016, but were still lower in abundance than in 2015 and 2014.

In Waitoa Stream, abundances of all fish species were lower in 2017 than in 2016. The largest change was in the number of bullies; only 8 were caught in 2017, compared to over 300 in 2016. The majority of the 300 captured in 2016 were young of the year; there were approximately 1.5 times as many fish in size classes 20-40 mm than in all the other size classes combined. The low numbers of bullies in 2017 could suggest either poor survival or out-migration of fish at this site during the year. There were also only around one third the number of shortfin eels in 2017 that there were in 2016.

There were approximately three times as many shortfin eels captured in Mangapapa Stream in 2017 than in 2016, but only a quarter the number of bullies. The two patterns could be linked, as eels prey upon bullies, however prior to this year there had been an increasing trend in the abundance of both species in this site, suggesting bottom-up rather than top-down control of the food web. Longfin eel abundances were similar to those observed in previous years. A banded kokopu was captured for the first time in this site.

Shortfin and longfin eel abundances in the Waitakaruru were the highest reported since 2014, but the abundance of bullies was the lowest yet observed at this site. Again, the decline in bullies could be due to greater predation by an increasing eel population. Alternatively, the low abundances of bullies in all sites but Mangakahika Stream could be associated with the heavy rain and high water levels which occurred the week before these sites were sampled (Mangakahika was the only Piako catchment site sampled prior to the rain). For example, bullies move into the shallower margins during and following floods (Jowett and Richardson 1994) or burrow into the substrate, where they are more difficult to capture via electric-fishing. Interestingly, however, torrentfish, which prefer higher velocities, were not found in the Waitakaruru in 2017 or 2016, although they were present in 2015 and 2014.

In Piakonui Stream, the abundance of shortfin eels in 2017 was the highest yet recorded, and no bullies were captured for the first time since sampling began in 2014. The lack of bullies but increase in eels suggests that the low numbers of bullies across the catchment is likely a temporary condition associated with higher flows, as otherwise there should also be fewer eels due to a decline in food resources. The galaxiids koaro and banded kokopu were also absent from Piakonui Stream in 2017, although they were captured in either the previous year (koaro) or all previous surveys (banded kokopu).

Ordinations based on dissimilarity between community matrices can be used to study assemblage composition, or relative balance of different species, over time. In an ordination plot, communities which are more similar are plotted closer together and those that are less similar are further apart. An ordination of the fish assemblages for each survey year shows that the Piako communities are more similar within streams than between streams (i.e., the sampling dates for each stream cluster closely together; Figure 3-3). However, for all sites except Mangakahika Stream the fish community composition in 2017 was substantially different (further apart in ordination space) from the preceding years. This likely reflects the much lower abundances of bullies in four sites (excluding Mangakahika Stream) in 2017 compared to other years. Shortfin eels were also less abundant in Waitoa and Waitakaruru Streams than in previous years, but more abundant in Mangapapa and Piakonui Streams. The lower abundances observed in 2017 could have been associated with the heavy rain and increased flow that occurred the week before these sites were sampled, which may have displaced some species, although the flows were not high enough to be considered "bed-moving," the discharge above which effects on fish and invertebrates are predicted and a two-week sampling stand-down period is required (WRC personal communication).

Fish length data provide information on fish recruitment and survival rates. Size distributions of shortfin eels at the Piako catchment sites in each survey year are shown in Figure 3-4 and size distributions of bullies are shown in Figure 3-5. The remaining species were not captured in sufficient numbers for development of size distributions. The size ranges of shortfin and longfin eels as well as bullies are given in Table 3-2.

The size distribution of shortfin eels was right-skewed in most sites in 2017, due to high proportions of small eels with a few large or very large eels. The size distribution of shortfin eels within a site has remained fairly consistent between 2014 and 2017 (Figure 3-4). The one exception in 2017 was the Mangapapa Stream, which had many more small eels (<200 mm in length) than in previous years. However, a similar pattern of high numbers of small eels has been observed in Piakonui and Waitoa Streams across all years. Furthermore, in Piakonui Stream the number of small eels in 2017 was the highest yet observed, and the number of large eels (400-800 mm) the lowest. There were fewer large (400-800 mm in length) and very large (>800 mm in length) eels captured at all sites in 2017 than in 2016 (Figure 3-4). The scarcity of large eels at these sites is consistent with known habitat constraints such as a lack of large pools. Additionally, the downstream migration of adult male eels, which typically migrate at between 350-500 mm in length (Todd 1980), intraspecific competition, and commercial or traditional harvest pressure may also be contributing factors to low numbers of large eels at these sites.

Longfin eels were only present in low numbers at all sites and the majority of those captured were >300 mm in length. Compared to the shortfin eel populations in the Piako, the smaller size classes appear to be significantly under-represented in the longfin eel population (Table 3-2). The lack of juvenile longfin eels may relate to either poor recruitment of this species, or be an artefact of the

limited sampling, as longfin elvers tend to stay closer to the coast for longer compared to shortfins (B. David, personal communication).

The size distribution of bullies has been variable across years at most sites (Figure 3-5). Bully size distributions tend to be approximately normal (i.e., greatest number of median-sized fish) or right-skewed (small fish most abundant). However, bimodal distributions can also occur, indicating peak densities of multiple size classes, such as in Waitoa Stream.

In 2017, Waitakaruru Stream had an approximately normal distribution, while the size distribution in Mangapapa Stream was right-skewed, with more small bullies (<30 mm in length) than larger bullies. There were very few small bullies in Mangakahika Stream, on the other hand, resulting in a more left-skewed distribution. Waitoa Stream had few bullies overall, but those captured were large adults (50-80 mm) (Figure 3-5). At some sites, such as Mangapapa Stream, the size distribution remained fairly consistent over time, with the same size class most abundant each year. At several of the other sites, however, the size class which is most abundant varied between years (Figure 3-5). Additionally, Waitoa Stream had a bimodal distribution, indicating the presence of multiple cohorts.

Table 3-1: Results of 2014-2017 electric fishing surveys at the five Piako catchment monitoring sites. A = Number caught (abundance); RA = Relative abundance (individuals per 100 m^2). The results from the 2017 survey are in blue; the results from the 2014-2016 surveys are included in black for comparison.

Site	Year	Shortfin eel		Longfin eel		Unidentified eel		C. bully		Torrentfish		Inanga		Banded kokopu		Koaro		Koura	
		A	RA	A	RA	A	RA	A	RA	A	RA	A	RA	A	RA	A	RA	A	RA
1. Mangakahika	**2017**	**27**	**9.8**	**4**	**1.5**	**9**	**3.3**	**77**	**27.9**	**-**	**-**	**2**	**0.7**	**18**	**6.5**	**-**	**-**	**3**	**1.1**
	2016	31	9.9	8	2.6	-	-	96	30.6	-	-	-	-	11	3.5	-	-	6	1.9
	2015	18	7.3	1	0.4	3	1.2	7	2.9	-	-	-	-	30	12.2	-	-	-	-
	2014	31	13.7	8	3.5	-	-	21	9.3	-	-	-	-	27	11.9	-	-	7	3.1
2. Waitoa	**2017**	**45**	**14.8**	**2**	**0.7**	**13**	**4.3**	**8**	**2.6**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**11**	**3.6**
	2016	134	54.1	4	1.6	9	3.6	321	129.7	-	-	-	-	-	-	-	-	50	20.2
	2015	80	41.3	-	-	22	11.4	67	34.6	-	-	-	-	-	-	-	-	10	5.2
	2014	120	49.1	6	2.5	-	-	135	55.2	-	-	-	-	-	-	-	-	59	24.1
3. Mangapapa	**2017**	**221**	**39.6**	**9**	**1.6**	**19**	**3.4**	**61**	**10.9**	**-**	**-**	**-**	**-**	**1**	**0.2**	**-**	**-**	**6**	**1.1**
	2016	70	12.4	13	2.3	1	0.2	222	39.4	-	-	2	0.4	-	-	-	-	34	6.0
	2015	36	7.3	5	1	7	1.4	104	21	-	-	-	-	-	-	-	-	11	2.2
	2014	26	4.8	3	0.6	-	-	91	16.6	-	-	-	-	-	-	-	-	31	5.7
4. Waitakaruru	**2017**	**47**	**13.8**	**3**	**0.9**	**9**	**2.6**	**35**	**10.2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**46**	**13.5**
	2016	17	3.9	-	-	-	-	74	25	-	-	-	-	-	-	-	-	54	18.3
	2015	30	8.7	-	-	4	1.2	63	18.3	3	0.9	-	-	-	-	-	-	14	14.1
	2014	89	29.7	10	3.3	-	-	88	29.3	1	0.3	-	-	-	-	-	-	38	12.7
5. Piakonui	**2017**	**39**	**6.6**	**2**	**0.3**	**2**	**0.3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**202**	**34.0**
	2016	17	3.9	-	-	3	0.7	34	7.8	-	-	-	-	7	1.6	1	0.2	207	47.7
	2015	13	4.1	4	1.3	6	1.9	21	6.7	-	-	-	-	5	1.6	-	-	83	26.5
	2014	7	1.9	4	1.1	-	-	22	6.0	-	-	-	-	4	1.1	-	-	200	54.6

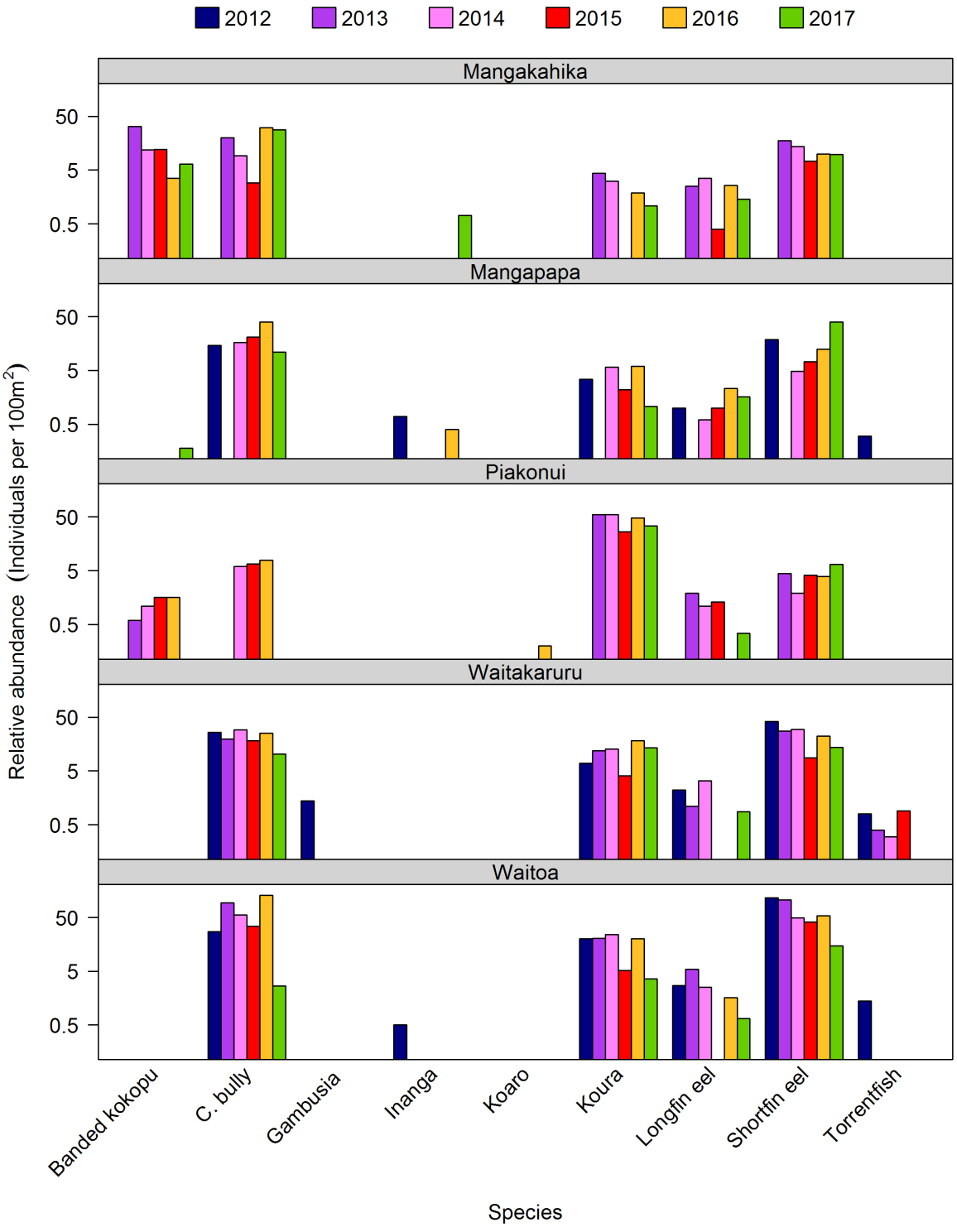

Figure 3-2: Comparison between the relative abundance of fish captured in the 2012 – 2017 Piako surveys. The Mangakahika Stream and Piakonui sites were not surveyed in 2012. The Mangapapa Stream at this location was not surveyed in 2013. Note the logarithmic y-axis.

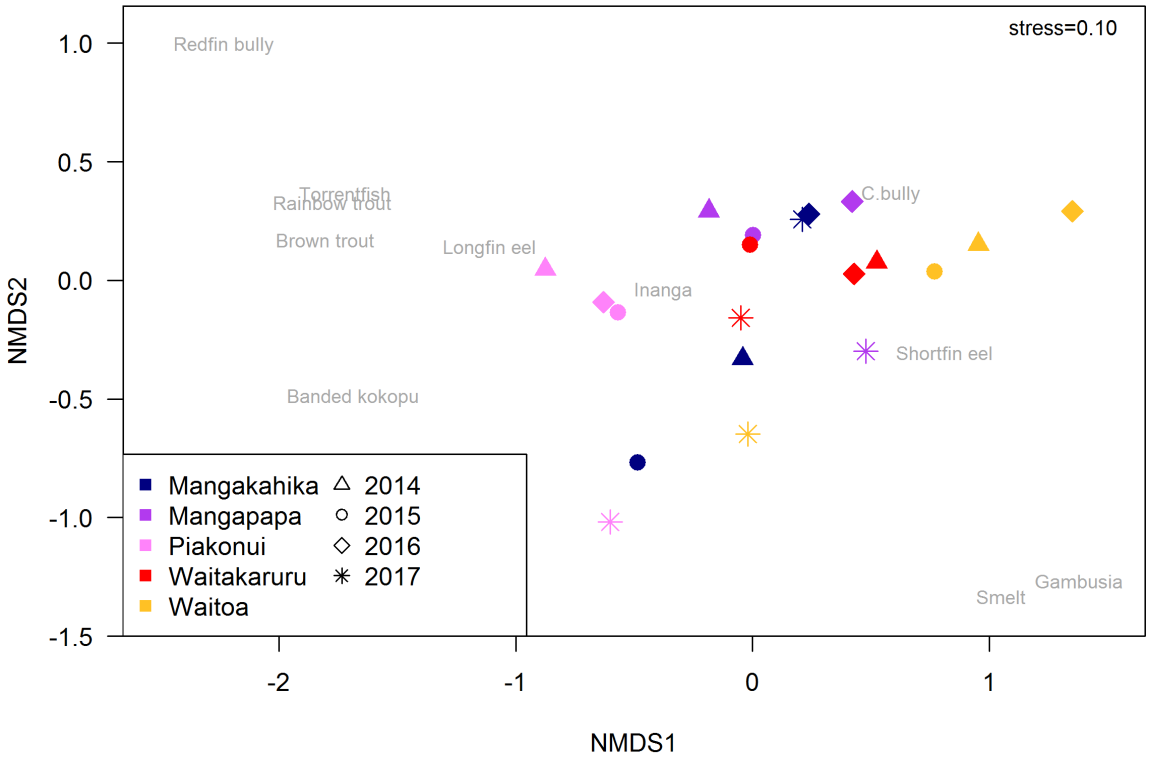

Figure 3-3: Nonmetric multidimensional scaling (NMDS) ordination plot showing fish assemblage composition over time in the Piako catchment sites. 'Stress' is a measure of how well the distances on an ordination plot reflect actual 'ecological distance' (i.e., dissimilarity) between different communities in the dataset. Stress values <0.2 are considered an acceptable representation of the data.

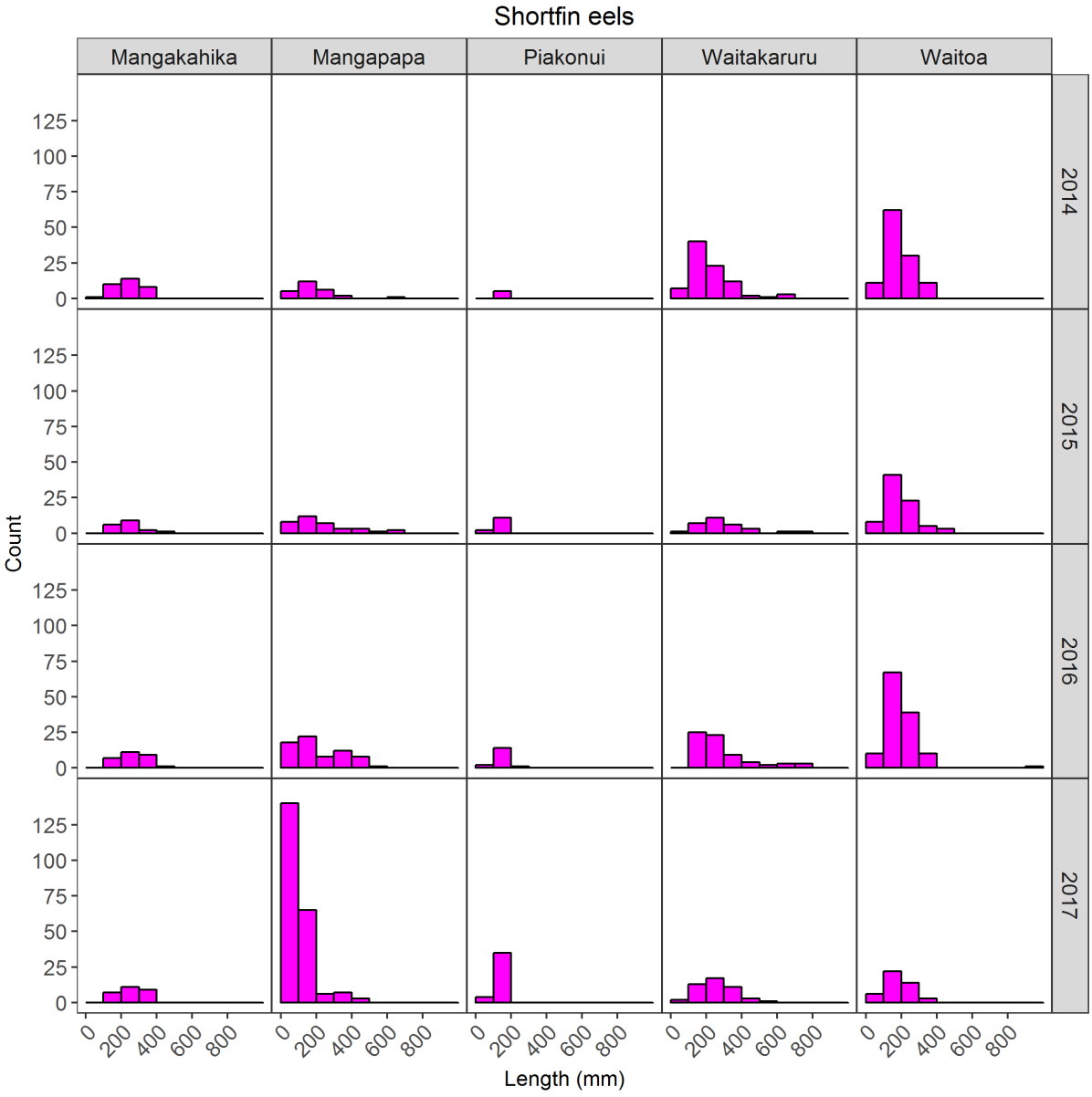

Figure 3-4: Size distributions for shortfin eels at each site in the Piako catchment between 2014 and 2017.

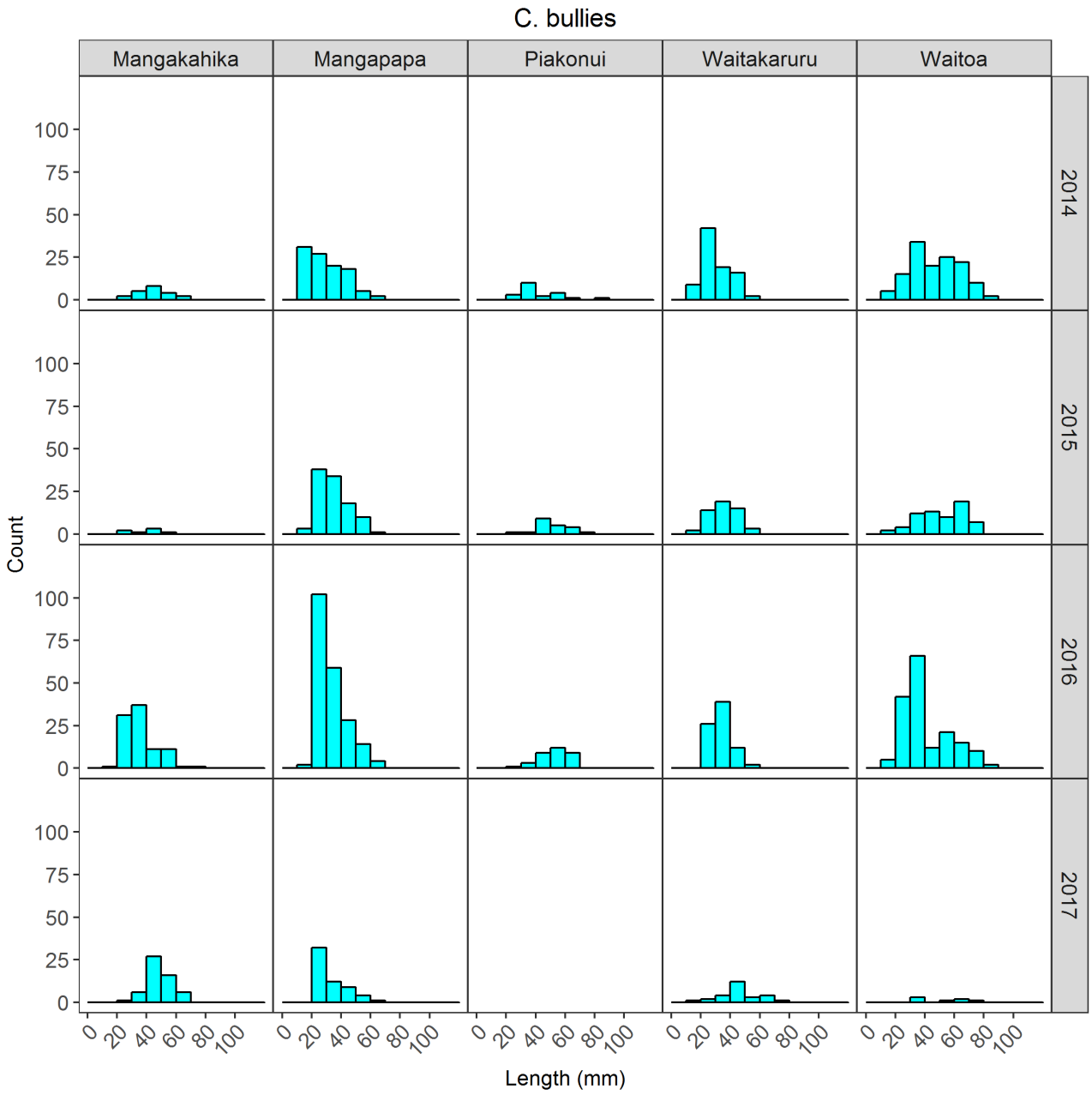

Figure 3-5: Size distributions for bullies at each site in the Piako catchment between 2014 and 2017.

Table 3-2: Size ranges (in mm) for most abundant fish (eels and bullies) captured in the Piako catchment in 2014-2017. The results from the 2017 survey are in blue; the results from the 2014-2016 surveys are included in black for comparison.

Site	Year	Shortfin eel			Longfin eel			C. bully		
		min	max	median	min	max	median	min	max	median
1. Mangakahika	**2017**	**107**	**370**	**240**	**302**	**603**	**455**	**25**	**69**	**47**
	2016	103	450	251	179	950	500	20	72	33
	2015	125	422	230	795	795	795	21	59	42
	2014	70	350	220	163	820	435	30	63	46
2. Waitoa	**2017**	**95**	**375**	**156**	**409**	**768**	**588**	**32**	**78**	**57**
	2016	81	1000	180	330	760	586	19	85	34
	2015	95	450	198	-	-	-	20	78	56
	2014	91	395	168	91	880	280	20	85	49
3. Mangapapa	**2017**	**78**	**495**	**98**	**179**	**1605**	**330**	**22**	**61**	**30**
	2016	86	590	162	92	520	238	19	62	31
	2015	84	650	164	101	700	320	20	68	37
	2014	90	610	150	500	700	600	15	65	30
4. Waitakaruru	**2017**	**94**	**525**	**234**	**132**	**480**	**343**	**15**	**73**	**45**
	2016	105	740	226	-	-	-	23	55	33
	2015	87	718	266	-	-	-	18	55	35
	2014	90	700	200	90	740	550	15	57	30
5. Piakonui	**2017**	**95**	**151**	**109**	**455**	**935**	**695**	**-**	**-**	**-**
	2016	94	240	115	-	-	-	24	70	53
	2015	97	163	111	438	642	455	30	79	50
	2014	105	185	115	400	650	620	30	87	38

3.1.3 Macroinvertebrates

All sites were sampled according to the MfE protocol C1 for hard-bottomed streams, with an area of approximately 1 m^2 sampled at each site. A full taxonomic list for each site is included in Appendix D and is summarised at the taxa level in Table 3-3 according to the methods and requirements of Collier,Kelly (2005). Total taxa richness describes the total number of different types of macroinvertebrates present at a site. Very broadly speaking, higher total taxa richness, is expected to be associated with greater quality and diversity of habitats present. Benthic invertebrates such as Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies, excluding Hydroptilidae), collectively known by the acronym EPT, are widely utilised as bio-indicators in freshwater ecosystems due to their 'heightened sensitivity' to habitat degradation or pollution. Pristine or native forest habitats typically have greater biodiversity and a higher proportion of these sensitive species than intensively developed (i.e., pasture) catchments (Boothroyd and Stark 2000). EPT richness and % EPT abundance (Table 3-3) are used to summarise the presence and significance of these taxa at a site. The Macroinvertebrate Community Index (MCI), in contrast, was developed as an indicator of the tolerance of macroinvertebrate communities to organic pollution (Stark and Maxted 2007) and, therefore, provides a complementary measure of stream health. Scores of less than 80 are classified as poor, those of 80-100 as fair, those of 100-120 as good, and those of greater than 120 as excellent (Stark and Maxted 2007).

Invertebrate taxa richness was higher at all sites except Piakonui Stream in 2017 compared to 2016, continuing the increasing trend observed between 2014 and 2016 (Table 3-3). EPT richness also increased compared to past years in three sites (Mangakahika, Waitakaruru, and Waitoa Streams), but remained the same in Mangapapa Stream and declined in Piakonui Stream. Despite the increases in EPT and total richness, MCI scores were lower in 2017 than in 2016 in all sites (Figure 3-6). Nonetheless, the 2017 scores were within the range of variability observed over the previous years, except in Piakonui Stream (at that site the 2017 MCI score was the lowest yet reported). Three of the five sites remained in the same MCI category as 2016: Mangakahika Stream remained in the 'excellent' category, Waitakaruru Stream remained in the 'good' category, and Mangapapa Stream remained in the 'fair' category. Of the remaining sites, the MCI score in Piakonui Stream dropped from 'excellent' to 'good' and the MCI score in Waitoa stream went from 'good' in 2016 to 'fair' in 2017.

While declines in MCI score are generally considered a cause for concern, in this case the concurrent increases in taxa richness and number of EPT taxa in several sites suggest that habitat conditions have not deteriorated substantially. The decline in all invertebrate metrics for Piakonui Stream could be linked to the heavy rain in the area in the week prior to sampling, as this site in particular showed evidence of recent high flows (i.e., large amounts of debris high on the banks, etc.,) which could have temporarily displaced stream invertebrates. Next year's monitoring should help determine whether this year's low score was a one-off or a wider temporal pattern.

Table 3-3: Summary of macroinvertebrate results for the Piako monitoring sites in 2014-2017. The results from 2017 are in blue; the results from the 2014-2016 surveys are included in black for comparison. MCI scores less than 80 are classified as 'poor,' scores 80-100 are 'fair,' scores 100-120 are 'good,' and scores greater than 120 are considered 'excellent' (Stark & Maxted 2007).

Site	Year	Total taxa richness	EPT richness	%EPT	MCI
1. Mangakahika Stream	**2017**	**35**	**20**	**74**	**120.6**
	2016	31	15	40.8	122.6
	2015	27	10	24.1	100
	2014	20	11	58.7	107.0
2. Waitoa Stream	**2017**	**25**	**15**	**41.9**	**95.2**
	2016	18	12	61.4	112.2
	2015	17	11	77.2	130.6
	2014	15	10	69.9	113.3
3. Mangapapa Stream	**2017**	**20**	**10**	**21.4**	**95.0**
	2016	17	10	21.7	98.8
	2015	13	8	38.7	76.9
	2014	9	6	2.0	106.7
4. Waitakaruru Stream	**2017**	**25**	**12**	**52.9**	**104.8**
	2016	17	9	42.8	110.6
	2015	14	7	15.9	94.3
	2014	13	5	38.6	90.8
5. Piakonui Stream	**2017**	**15**	**7**	**24.6**	**101.3**
	2016	33	23	76.1	134.5
	2015	34	20	86.8	134.1
	2014	28	15	83.5	137.1

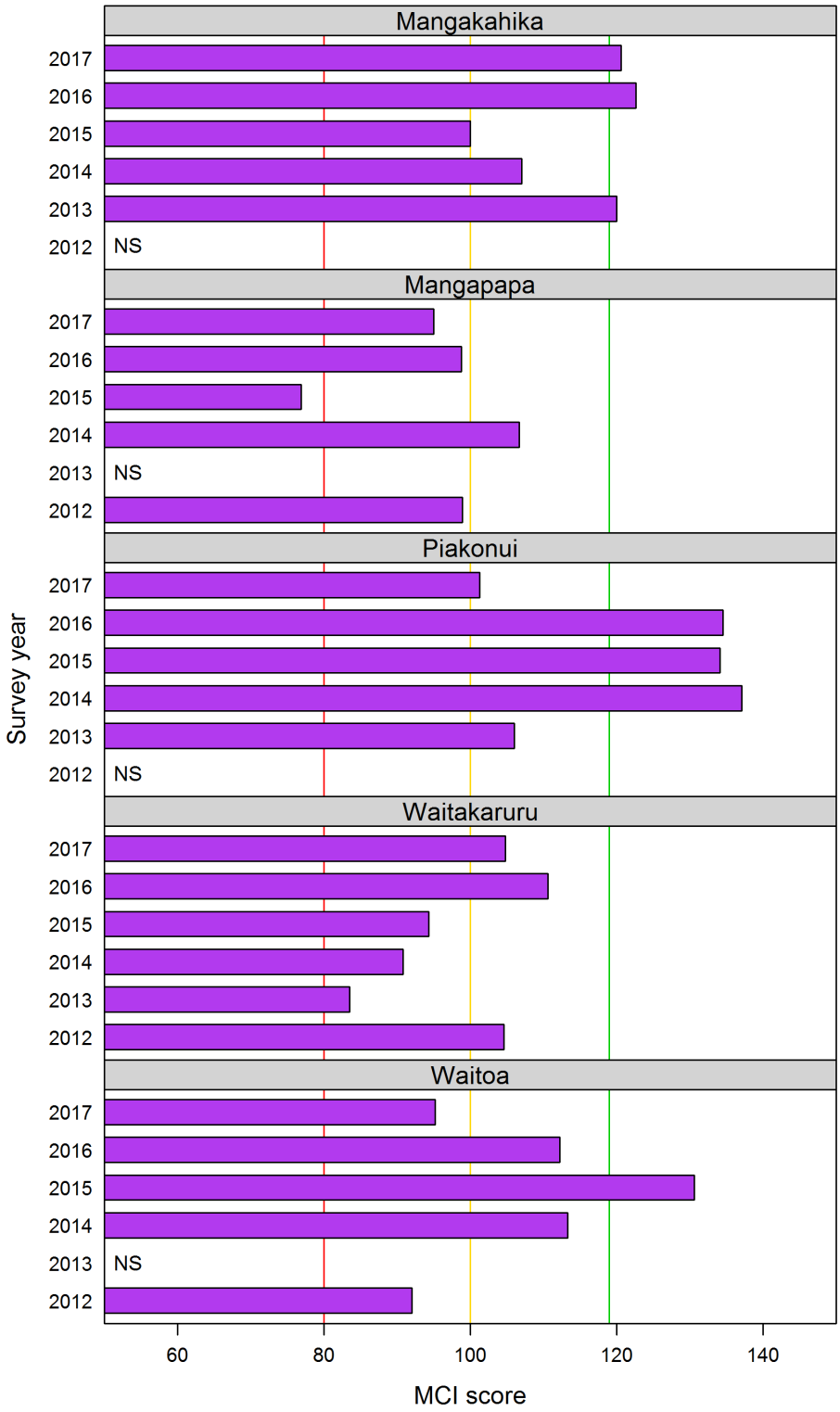

Figure 3-6: Comparison of MCI scores between survey years in the Piako catchment. Vertical lines indicate boundaries for quality classes. Anything below the red line is 'poor', between the red and yellow lines is 'fair', between the yellow and green lines is 'good' and above the green line is 'excellent' (Stark & Maxted 2007). Years in which a site was not surveyed or data is not available are marked 'NS.'

3.1.4 Macrophytes & periphyton

Four of the five sites had no or low macrophyte cover present in 2017 (Figure 3-7). Of those four sites, macrophyte cover increased slightly in Mangapapa Stream, from approximately 10% to around 15%, and declined from approximately 25% to 15% in the Waitoa (Figure 3-7). Macrophytes remained absent from Piakonui Stream and below 5% in Mangakahika Stream, similar to previous years. In the fifth site, Waitakaruru Stream, macrophyte cover doubled from approximately 25% to 55%, largely due to increased abundance of watercress, *Nasturtium officinale/microphyllum*, an emergent macrophyte.

The periphyton enrichment index (PEI) scores have remained relatively stable over time at the Piakonui and Mangakahika sites (Figure 3-8 & Figure 3-9). Both the Magapapa and Waitoa streams had higher than usual PEI scores in 2016, but the scores in 2017 were lower and comparable to 2015 scores. Waitakaruru Stream also had a lower PEI score in 2017 than 2016. It is possible this pattern is linked to hydrologic conditions, as recent heavy rains prior to the 2017 sampling could have scoured away some periphyton material. Changes in periphyton sliminess index (PSI) scores, on the other hand, varied between sites (Figure 3-8 & Figure 3-9). PSI remained low in the Piakonui and Waitakaruru Streams, fairly constant around 20% in Mangapapa Stream, increased slightly in Mangakahika Stream (from approximately 5% to 10%), and decreased substantially in Waitoa Stream (from around 25% to around 5%).

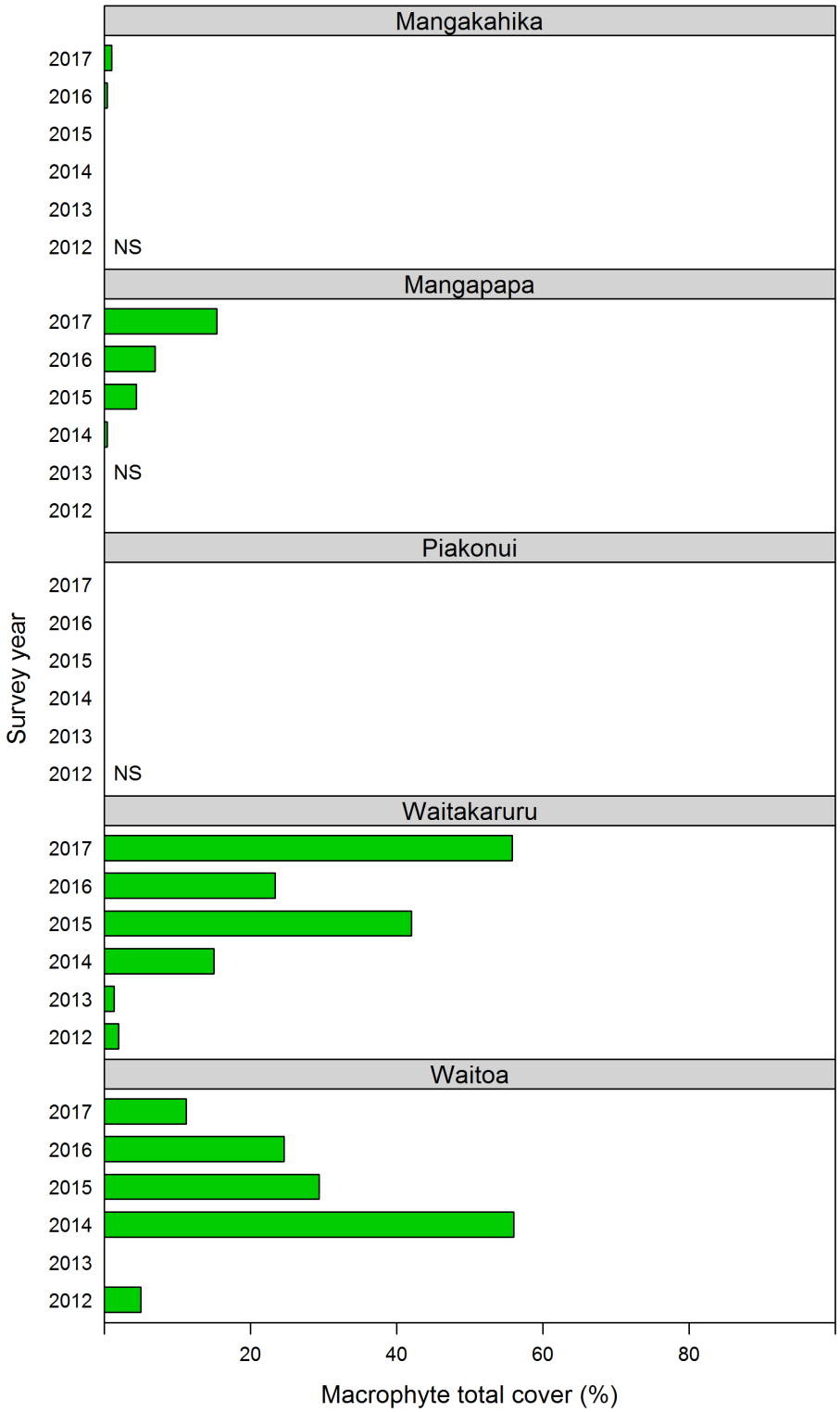

Figure 3-7: Comparison of macrophyte total cover (MTC) scores over time at the Piako survey sites. Years in which a site was not surveyed are marked 'NS.'

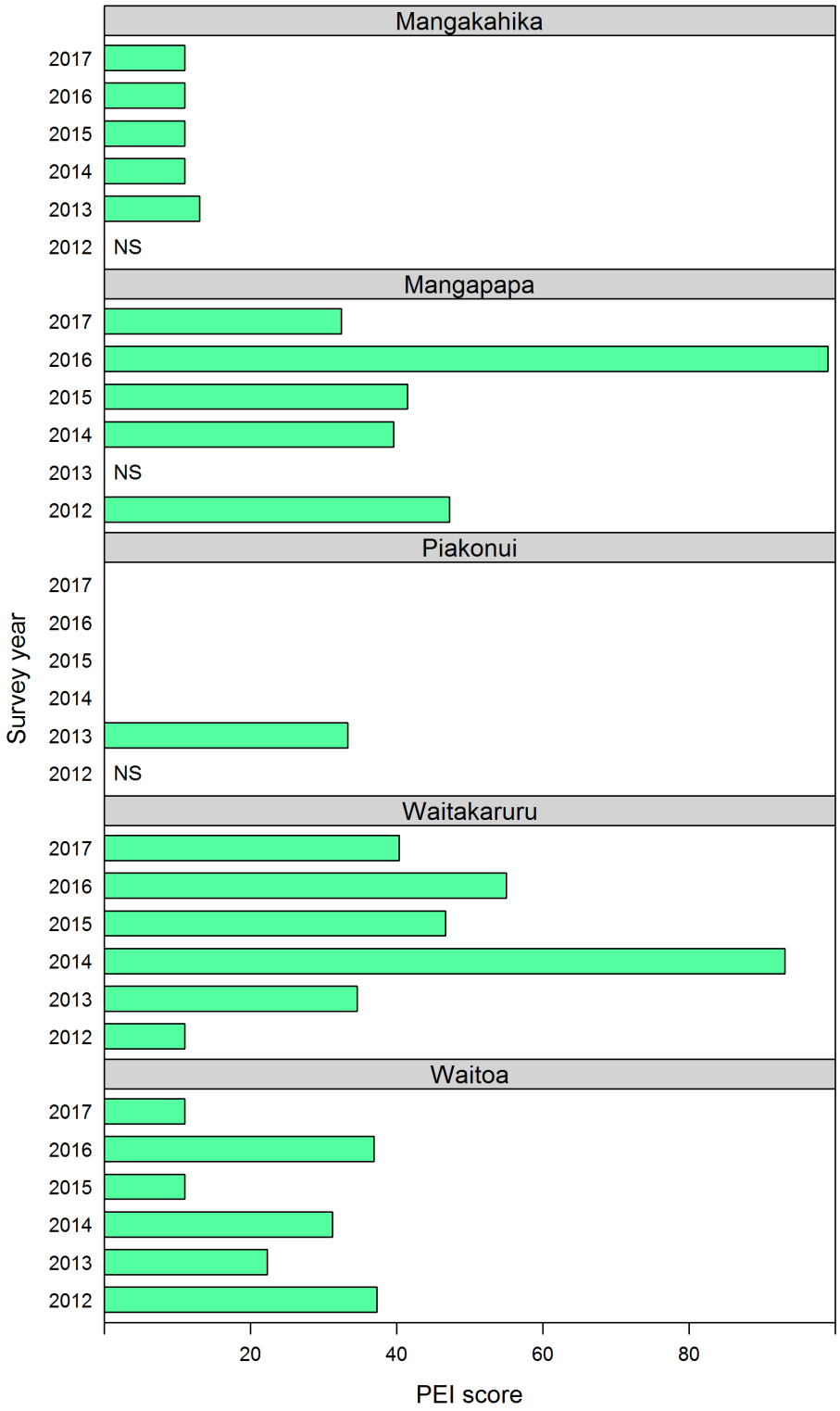

Figure 3-8: Comparison of periphyton enrichment index (PEI) scores over time at the Piako survey sites. Years in which a site was not surveyed are marked 'NS.'

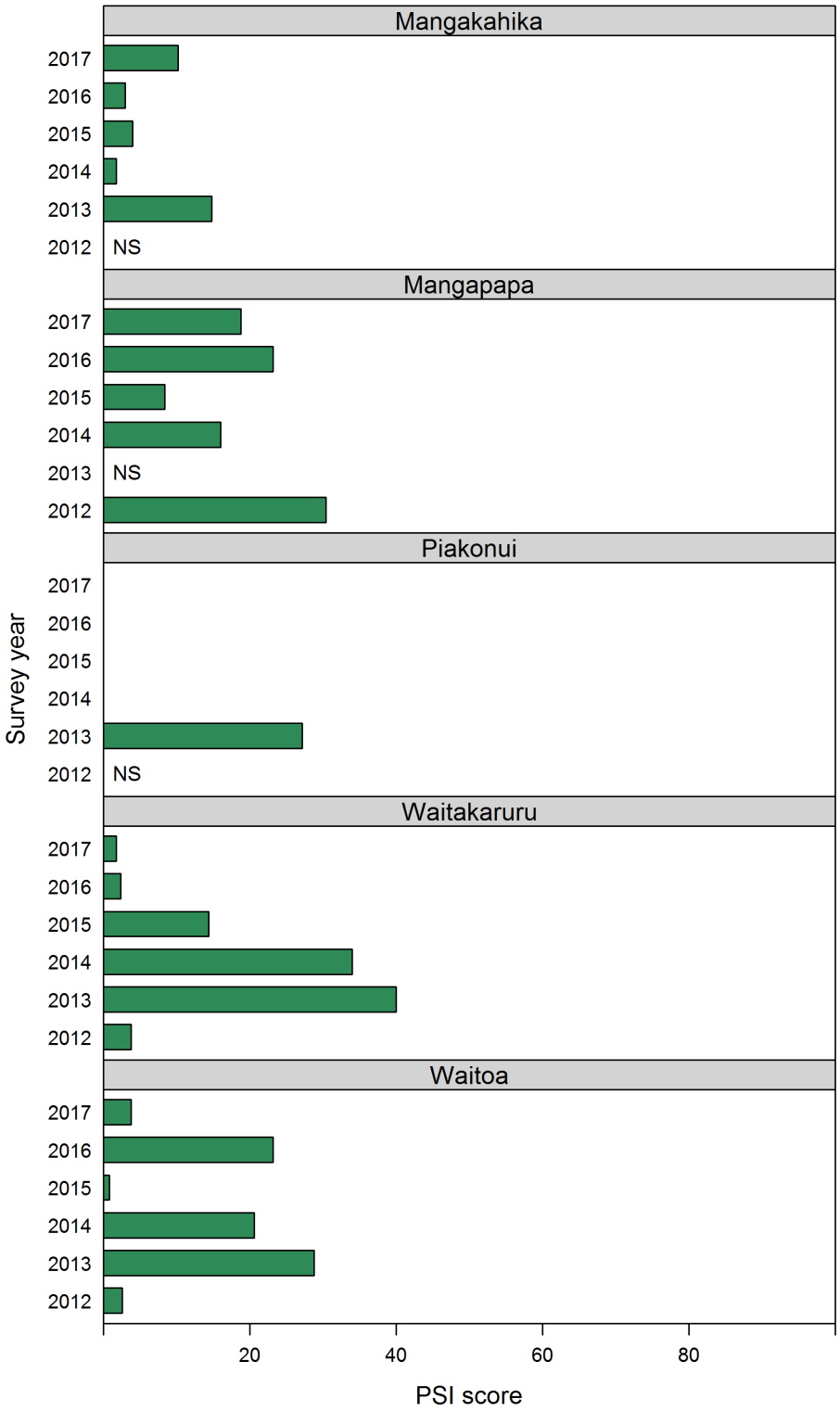

Figure 3-9: Comparison of periphyton sliminess index (PSI) scores over time at the Piako survey sites. Years in which a site was not surveyed are marked 'NS.'

3.1.5 Habitat quality scores

The habitat assessment scores provide a composite index of both reach scale and biotic characteristics of the stream, which can be used as an indicator of habitat quality. Full details of the habitat assessment results are included in Appendix A.

The habitat scores for the Piako sites have fluctuated between years, but show few overall trends (Figure 3-10). However, there has been a positive trend over time in Piakonui stream (Figure 3-10). Improved scores at this site are related to continued growth of riparian buffers as well as increased bank stability and reduced sediment deposition. Mangakahika Stream was the only site which scored lower in 2017 than 2016, primarily due to reduced bank stability. This site is not fenced, and it is therefore likely that the decreased score may reflect increased access and damage by livestock. Habitat scores for Mangapapa and Waitakaruru Streams were higher in 2017 than 2016, and close to the highest value ever reported for both sites (Figure 3-10). The improved scores occurred in conjunction with decreased sediment and increased heterogeneity of in-stream habitat as well as reduced periphyton cover.

Correlations between habitat score and biotic indices were evaluated using the non-parametric Spearman's rank correlation (ρ). Samples from all survey years were pooled (n=26). The macroinvertebrate indices all correlated positively with the habitat score indicating a general improvement in macroinvertebrate communities with increasing habitat score. There was a modest correlation between the habitat score and MCI score (ρ=0.37; Figure 3-11). Interestingly, the correlation appears to have been stronger in the early surveys (2012-2014), whereas in 2015-2017 there are more occurrences of sites with low habitat scores having high MCI scores and vice versa. This is likely due to more temporal variability in both habitat scores and MCI scores over a longer data record. The correlations between habitat score and total macroinvertebrate richness was weak but positive (ρ=0.27; Table 3-4). Fish species richness was also weakly positively correlated with habitat score (ρ=0.27; Table 3-4). However, this includes exotic fish species as well, which could alter the relationship. For example, salmonids are often indicative of higher habitat quality scores, but their presence could in turn affect richness of native fish species. Conversely, gambusia are often abundant in lower quality habitats where diversity is also lower, making it difficult to interpret results. The relative abundance of exotic and native fish at each site will also play a role in determining habitat-richness relationships.

Table 3-4: Correlation coefficients between the habitat score and various biotic indices for the Piako catchment in 2017.

Biotic index	Spearman's rank correlation coefficient
MCI	0.37
Macroinvertebrate total richness	0.27
EPT richness	0.22
% EPT	0.18
Fish richness	0.27

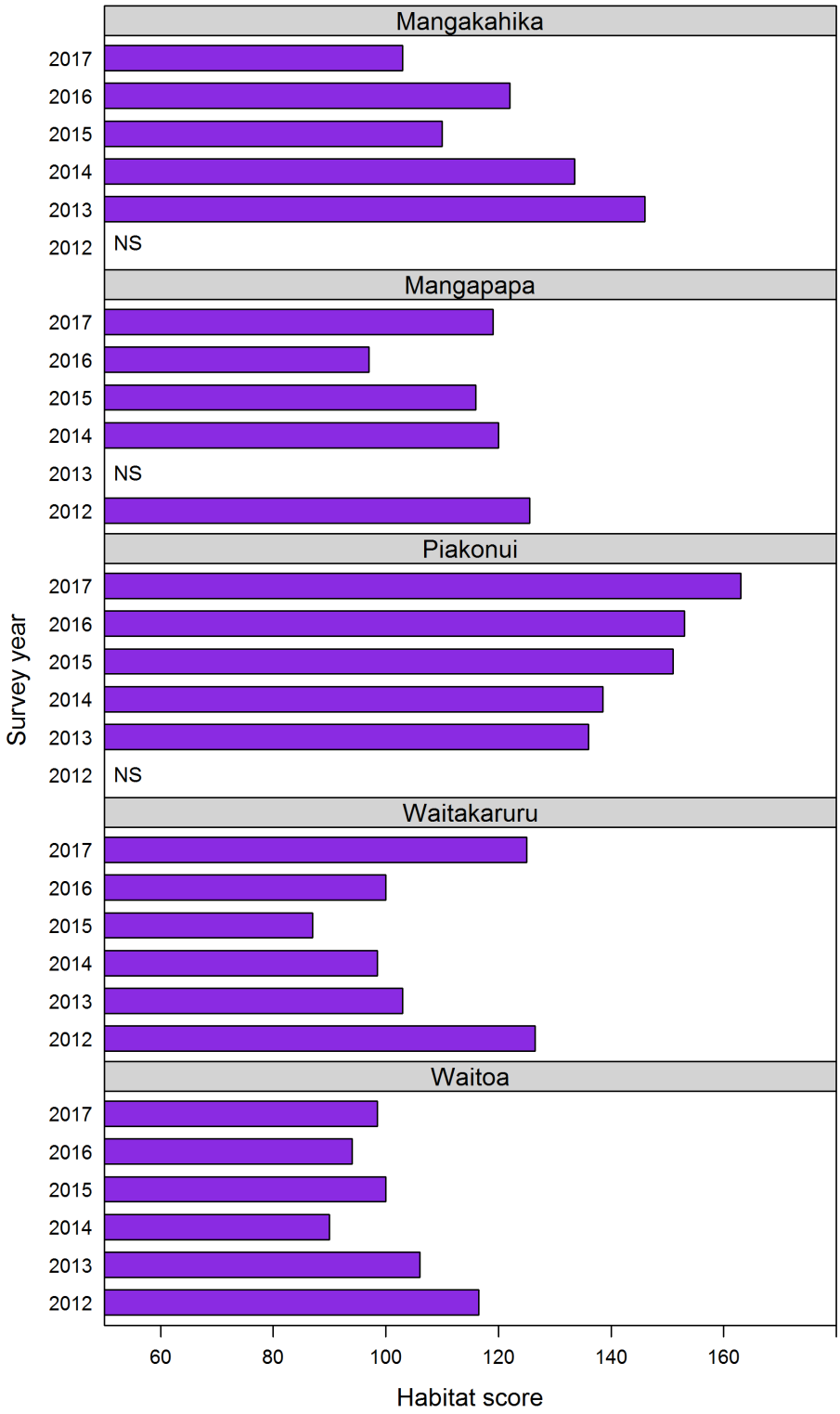

Figure 3-10: Comparison of habitat scores over time for the Piako survey sites. Years in which a site was not surveyed are marked 'NS.'

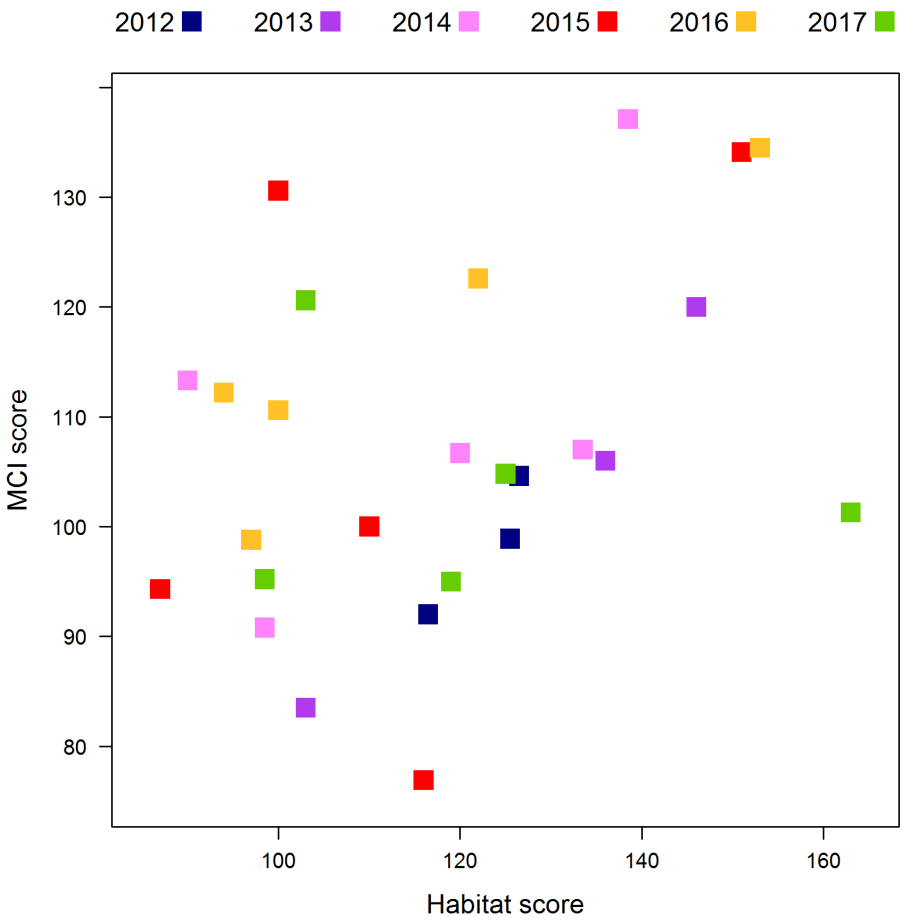

Figure 3-11: Scatterplot of habitat score against MCI score at the Piako survey sites in different survey years (ρ=0.37). No MCI score was available for the Waitoa site in 2013.

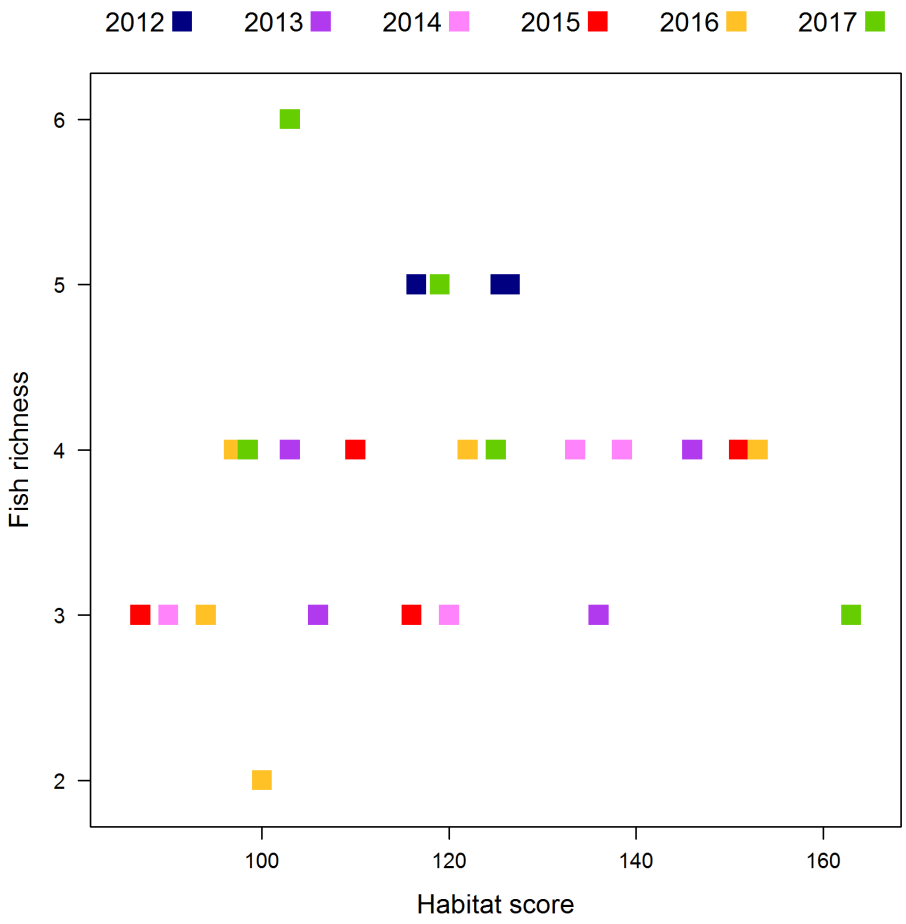

Figure 3-12: Scatterplot of habitat score against fish species richness at the Piako survey sites in different survey years (ρ=0.27).

3.2 Waihou catchment

3.2.1 Flow

Stream flows in the Waihou catchment are flashier in general than those in the Piako catchment, with more small-medium rain events throughout the year. Nonetheless, as in the Piako, flows tend to be low and stable over the summer period (Figure 3-13). However, 2016-2017 was an exception to this pattern, with several occasions of elevated flows in mid and late summer (Figure 3-13). The highest flows occurred in June to July and September to October 2016, similar to the Piako (Figure 3-13). There was also a medium-sized rain event during the sampling period in mid-February 2017 (Figure 3-13).

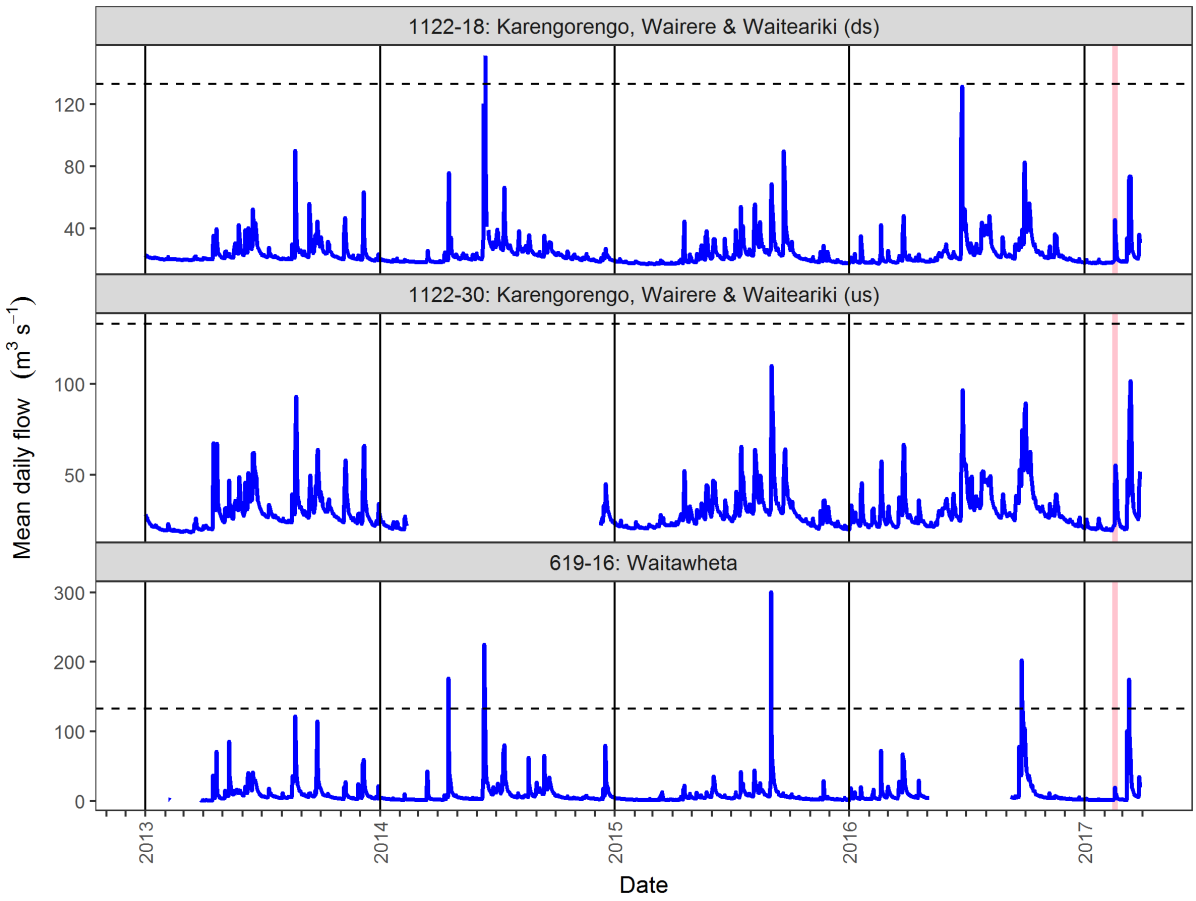

Figure 3-13: Mean daily flow ($m^3 s^{-1}$) in the Waihou catchment between 2013 and 2017. Each flow monitoring site is listed first, followed by the survey sites for which it is the closest reference. Tick marks indicate months, the year label is located on the January tick mark. The 2017 sampling period is indicated by the shaded pink region. The dashed horizontal line indicates the bed-moving flow (133 $m^3 s^{-1}$ in Waihou catchment; WRC personal communication) after which a sampling stand-down would have been required.

3.2.2 Fish

Eleven different fish species were recorded among the five Waihou survey sites in 2017, eight of which were native and three of which were exotic species (mosquitofish, rainbow trout, and brown trout; Table 3-5). Shortfin eels were the only fish species present at all five sites, along with koura (freshwater crayfish). Freshwater shrimp (*Paratya curvirostris*) were also found at two sites. Longfin eels were recorded at four sites, though in the past they have been captured at all five sites. Banded kokopu were only captured at one site, similar to 2015, although it was a different site. Inanga were not captured at any of the sites, although they were present at one site in 2016 and in two sites in 2015. Redfin bully were captured for the first time in Paiakarahi Stream, but not in Waitawheta River, where they were found in 2016. *Gambusia affinis*, the invasive mosquitofish, was captured in Karengorengo Stream for the second year in a row. Paiakarahi Stream had the greatest species richness, with 7 different species, 6 native and 1 exotic (Table 3-5). Wairere Stream had the largest total abundance of fish, due to high numbers of bullies and shortfin eels.

The relative abundance of fish is compared between survey years for each site in Figure 3-14. A high abundance of macrophytes in Karengorengo Stream severely inhibited electric fishing; therefore it is

possible that the low abundances recorded in this site are underestimates caused by the low capture efficiency. When the site was mechanically cleared of macrophytes prior to sampling in 2016, the numbers of fish captured were much higher (Table 3-5). Exotic *Gambusia* were captured for the second year in a row, and a rainbow trout was also captured for the first time in this site in 2017 (though brown trout were present in 2014). Inanga were absent after being present in very low numbers (1 individual) in 2016 and 2015.

At the Paiakarahi sampling site, the abundance of shortfin eels, longfin eels, and torrentfish were consistent with ranges observed in the previous two surveys (Figure 3-14, Table 3-5). Abundance of bullies was lower than in 2016, but similar to 2015 numbers. There were more rainbow trout captured than in previous years, but no brown trout were present, unlike past years. Inanga and banded kokopu were also both absent for the second year in a row, though they were captured in low numbers in previous surveys.

In Wairere Stream, the relative abundances of both shortfin eels and bullies were higher in 2017 than in 2016 or 2015, but not as high as in 2014 (Figure 3-14, Table 3-5). The abundance of longfin eels was low, similar to previous years. Torrentfish and both species of trout were absent in 2017, though they have been captured consistently at this site in the past.

Shortfin and longfin eel abundances in Waitawheta River were higher in 2017 than in 2016, but still lower than in 2014 and 2015. Bully abundance, on the other hand, was similar to that recorded in past years. Both species of trout were present in 2017, but banded kokopu continued to be absent (last observed in 2014). Redfin bullies, which were captured for the first time at this site in 2016, were not found again in 2017.

Abundances of all shortfin eels and bullies were the lowest yet recorded in Waiteariki Stream in 2017 (Figure 3-14, Table 3-5). This may have been due to the heavy rain that occurred in the week prior to sampling, or because the water level was still high during sampling, which made electric-fishing difficult and less effective. Both bullies and small shortfin eels (<150 mm), which are the majority of eels captured in this site in previous years, may hide in the substrate and be more difficult to capture when water levels are deeper. Longfin eels and brown trout were captured in comparable numbers to previous surveys, probably because these species are rare in general, and thus the change in abundance is less noticeable. In addition, trout are more pelagic and thus easier to capture via electric-fishing in deep water than the smaller fish, which tend to stay near the streambed. Similarly, the longfin eels present are often in the largest size classes, which also prevents them from burrowing into the substrate. Banded kokopu were absent, also consistent with variable records from prior sampling (i.e., present in 2014 and 2016, but not 2015).

Community composition was more variable between than within the five Waihou sites (Figure 3-15). Unlike the Piako sites, the community composition in 2017 was similar to previous years, indicated by clustering together in ordination space. The one exception was Waiteariki Stream, which had much lower abundances of shortfin eels and bullies in 2017 than in past years, potentially due to the heavy rain and high flows. Interestingly, the community composition in Karengorengo Stream in 2017 was quite similar to the 2015 composition, which was also the last period of high macrophyte cover, whereas the composition in 2016, when macrophytes were cleared, was more dissimilar and separated in ordination space.

Size distributions show that shortfin eel population structure has remained consistent over time in all five Waihou catchment streams (Figure 3-16). As in the Piako catchment sites, shortfin eel size

distributions tended to be right-skewed with a greater proportion of small eels (Figure 3-16). There were very few large shortfin eels >400 mm at any site. In fact, in two sites, Paiakarahi and Waiteariki Streams, there were no eels >200 mm. This may indicate a lack of suitable habitat for large eels within these sites or high fishing pressure, with the former the more probable cause.

Except for Paiakarahi Stream, the few longfin eels captured at these sites were all larger than 250 mm (Table 3-6). The scarcity of small longfin eels (no longfin eels <200 mm caught in four of the five sites and only 4 individuals in the 5th site) suggests that recruitment of longfin eels in these streams has been poor in recent years, although it could also be an artefact of the limited sampling, as longfin elvers tend to have a patchy distribution.

Bully distributions were less skewed, although the peak of the distribution shifted between years within sites, and several sites had bimodal distributions in multiple years (Figure 3-17). In Paiakarahi Stream and Waitawheta River the size distribution remains fairly similar year-to-year, while in Karengorengo and Waiteariki Streams the proportion of larger bullies appears to have been increasing over time, suggesting the aging and growth of a single cohort with little migration input (Figure 3-17). Wairere Stream, on the other hand, appears to have a cyclical two-year recruitment pattern; the size distributions in 2014 and 2016 had a similar bimodal pattern high numbers of both small bullies and large bullies, while the size distributions in 2015 and 2017 both had highest numbers of medium-sized fish (Figure 3-17).

Table 3-5: Results of 2014-2017 electric fishing surveys at the five Waihou catchment monitoring sites.

A = Number caught (abundance); RA = Relative abundance (individuals per 100 m^2). The results from 2017 are in blue; the results from the 2014-2016 surveys are included in black for comparison.

Site	Year	Shortfin eel		Longfin eel		Unid. eel		C. bully		Redfin bully		Torrent-fish		Inanga		Smelt		Gambusia		Banded kokopu		Rainbow trout		Brown trout		Unid. trout		Koura	
		A	RA	A	RA	A	RA	A	RA	A	RA	A	RA	A	RA	A	RA	A	RA	A	RA	A	RA	A	RA	A	RA	A	RA
6.	**2017**	**10**	**1.7**	**7**	**1.2**	**5**	**0.9**	**38**	**6.5**	**1**	**0.2**	**1**	**0.2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**5**	**0.9**	**-**	**-**	**-**	**-**	**70**	**11.9**
Paiakarahi	2016	8	1.4	-	-	-	-	61	10.5	-	-	3	0.5	-	-	-	-	-	-	-	-	-	-	1	0.2	-	-	5	0.9
	2015	6	1.3	10	2.2	-	-	33	7.3	-	-	1	0.2	2	0.4	-	-	-	-	1	0.2	2	0.4	2	0.4	-	-	34	7.6
	2014	8	1.6	8	1.6	-	-	64	13	-	-	5	1	1	0.2	-	-	-	-	1	0.2	3	0.6	-	-	-	-	32	6.5
7.	**2017**	**70**	**33.8**	**-**	**-**	**16**	**7.7**	**11**	**5.3**	**-**	**-**	**-**	**-**	**-**	**-**	**7**	**3.4**	**4**	**1.9**	**-**	**-**	**2**	**1.0**	**-**	**-**	**-**	**-**	**12**	**5.8**
Karengorengo	2016	360	103.4	1	0.3	-	-	25	7.2	-	-	-	-	1	0.3	13	3.7	1	0.3	-	-	-	-	-	-	-	-	75	21.6
	2015	98	32	-	-	-	-	17	5.6	-	-	-	-	1	0.3	24	7.8	-	-	-	-	-	-	-	-	4	1.3	31	10.1
	2014	33	9.1	-	-	-	-	3	0.8	-	-	-	-	-	-	2	0.6	-	-	-	-	-	-	1	0.3	-	-	9	2.5
8.	**2017**	**225**	**26.2**	**2**	**0.2**	**32**	**3.7**	**453**	**52.7**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**29**	**3.4**
Wairere	2016	120	16	1	0.1	16	2.1	293	39.1	-	-	7	0.9	-	-	-	-	-	-	-	-	-	-	1	0.1	-	-	35	4.7
	2015	148	17.5	1	0.1	34	4	208	24.6	-	-	2	0.2	-	-	-	-	-	-	-	-	3	0.4	5	0.6	-	-	15	1.8
	2014	254	31.1	2	0.3	-	-	965	118	-	-	1	0.1	-	-	-	-	-	-	-	-	-	-	1	0.1	-	-	58	7.1
9.	**2017**	**12**	**1.2**	**4**	**0.4**	**-**	**-**	**18**	**1.8**	**-**	**-**	**3**	**0.3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**0.2**	**-**	**-**	**8**	**0.8**
Waitearikl	2016	28	2.2	4	0.3	-	-	173	13.4	-	-	7	0.5	-	-	-	-	-	-	5	0.4	-	-	-	-	-	-	120	9.3
	2015	51	5.5	15	1.6	-	-	87	9.4	-	-	2	0.2	-	-	-	-	-	-	-	-	1	0.1	1	0.1	-	-	125	13.5
	2014	20	2.1	10	1.1	-	-	47	5	-	-	1	0.1	-	-	-	-	-	-	7	0.7	-	-	6	0.6	-	-	88	9.4
10.	**2017**	**11**	**2.1**	**7**	**1.3**	**12**	**2.2**	**81**	**15.1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**0.6**	**1**	**0.2**	**2**	**0.4**	**24**	**4.5**
Waitawheta	2016	8	1.3	3	0.5	-	-	96	15.3	15	2.4	-	-	-	-	-	-	-	-	-	-	1	0.2	-	-	-	-	10	1.6
	2015	12	2.9	17	4	-	-	53	12.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.2	-	-	25	6
	2014	23	4.5	16	3.1	-	-	64	12.6	-	-	-	-	-	-	-	-	-	-	1	0.2	-	-	3	0.6	-	-	10	2.0

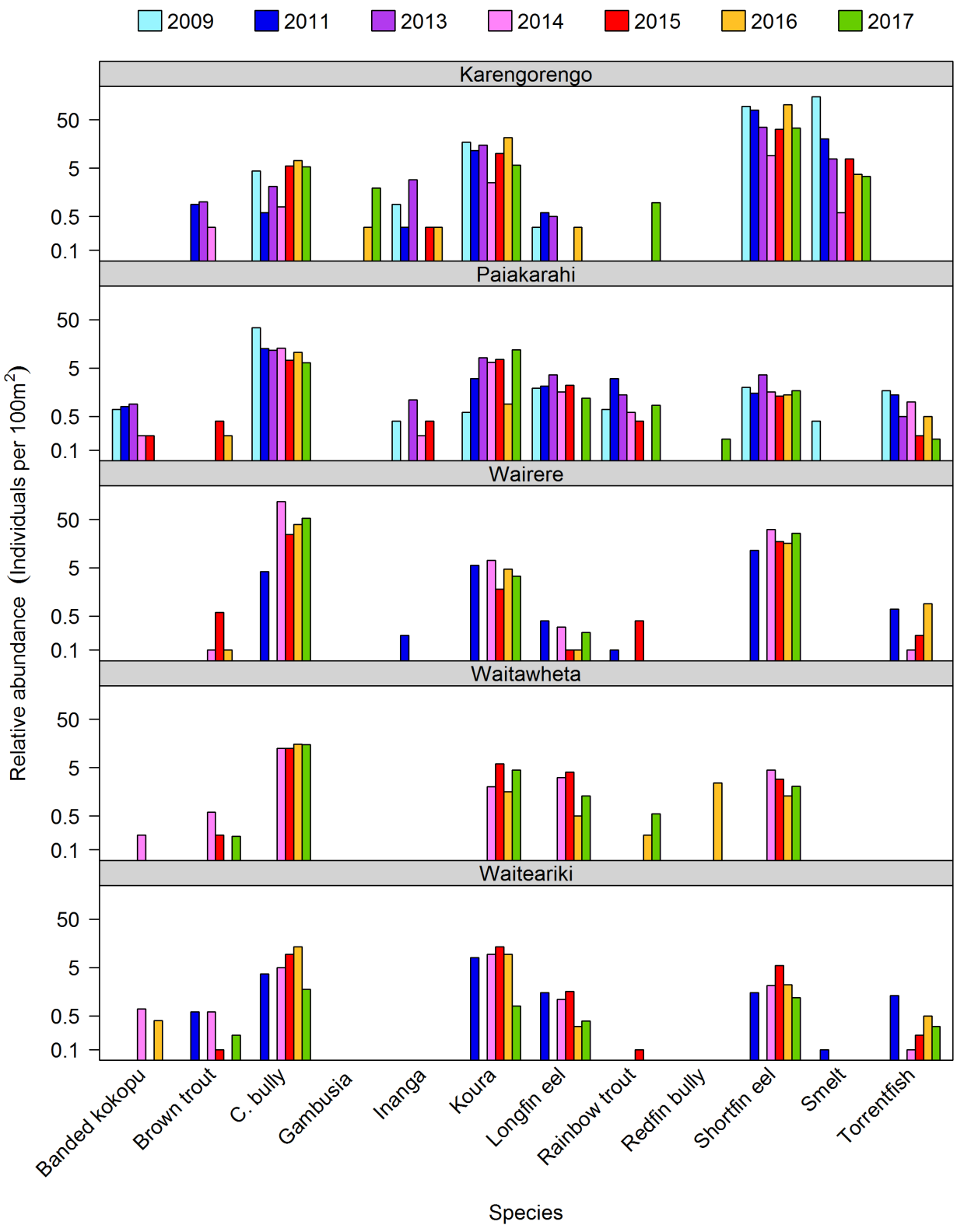

Figure 3-14: Comparison between the relative abundance of fish captured in the 2009, 2011, and 2013 - 2017 Waihou surveys. Wairere Stream and Waiteariki Stream were only sampled in 2011 and 2014-2017. The Waitawheta was only sampled in 2014-2017. Note the logarithmic y-axis.

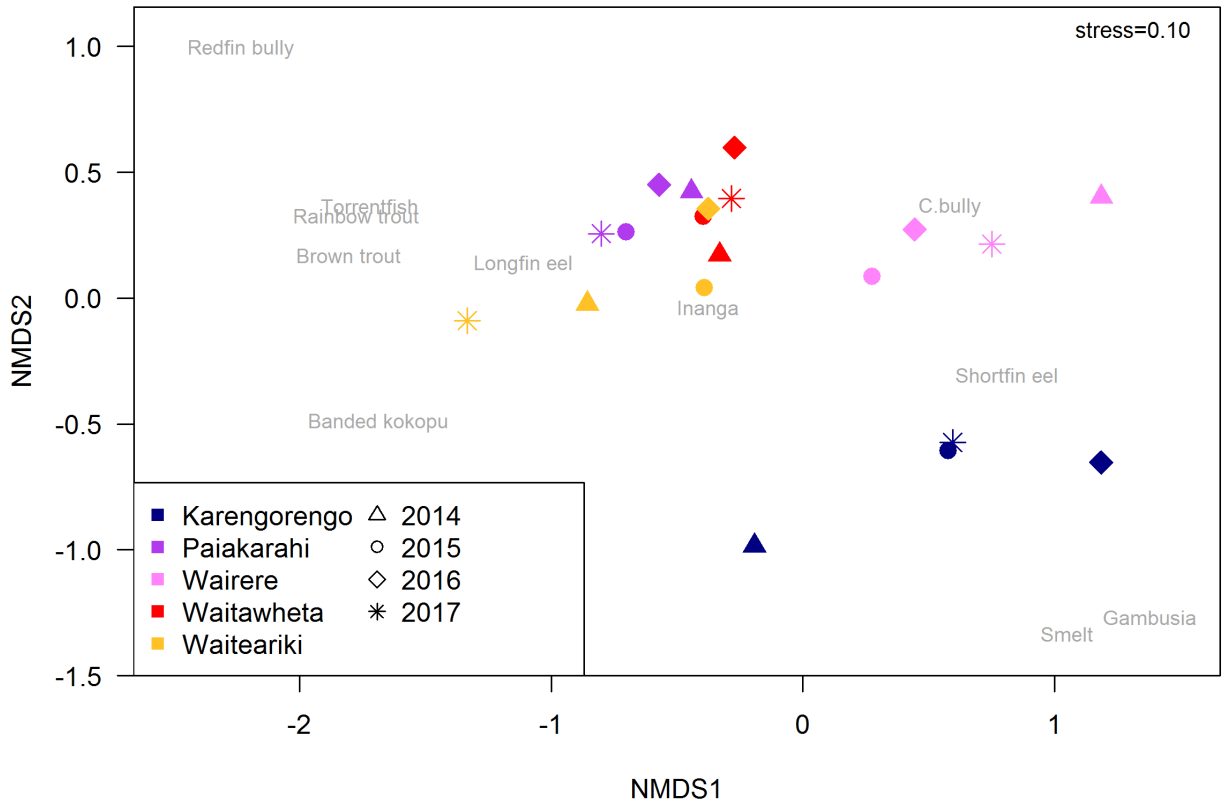

Figure 3-15: Nonmetric multidimensional scaling (NMDS) ordination plot showing fish assemblage composition over time in the Waihou catchment sites. 'Stress' is a measure of how well the distances on an ordination plot reflect actual 'ecological distance' (i.e., dissimilarity) between different communities in the dataset. Stress values <0.2 are considered an acceptable representation of the data (Clarke & Warwick 2001).

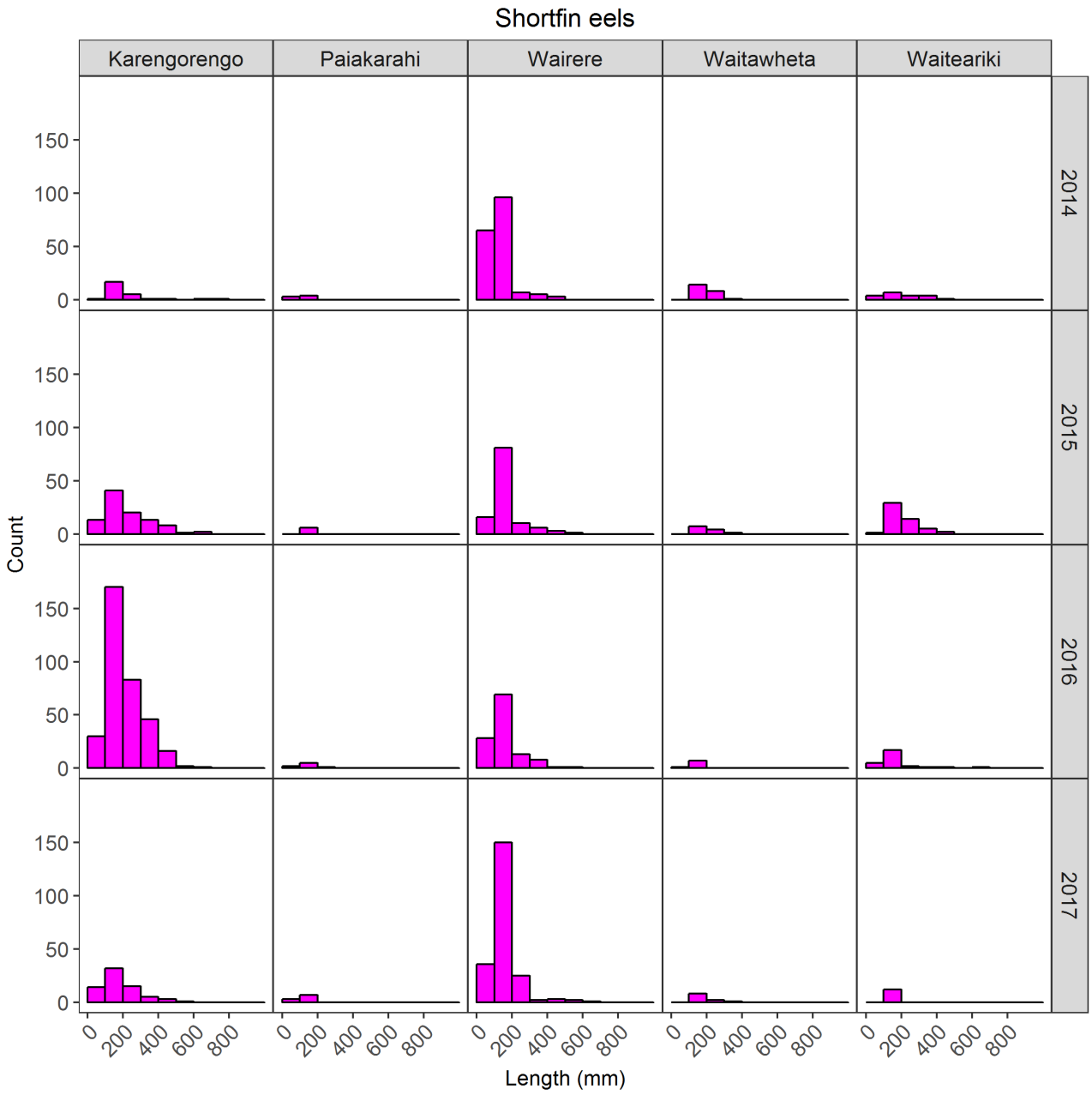

Figure 3-16: Size distributions for shortfin eels at each site in the Waihou catchment between 2014 and 2017.

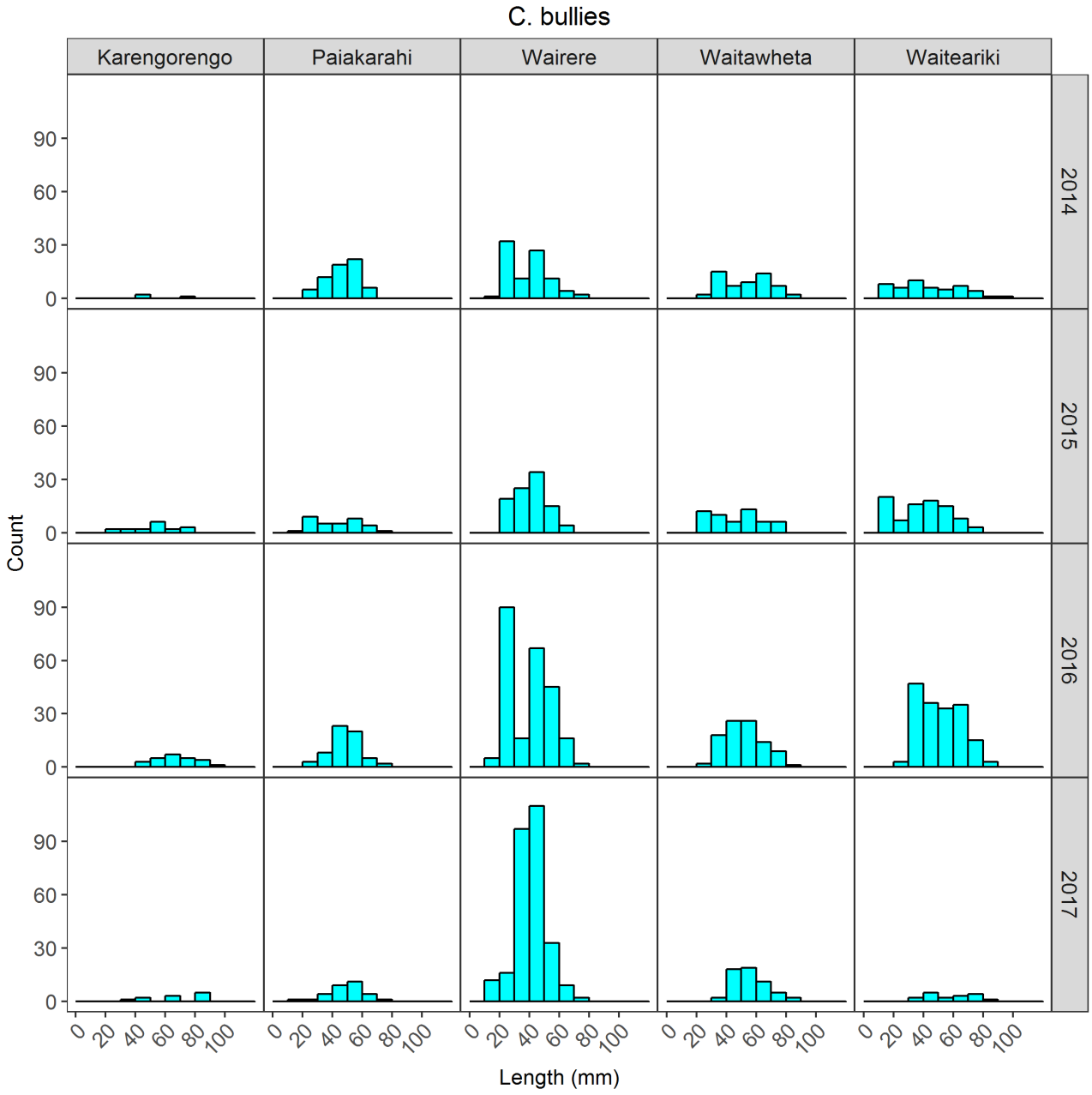

Figure 3-17: Size distributions for bullies at each site in the Waihou catchment between 2014 and 2017.

Table 3-6: Size ranges (mm) for most abundant fish (eels and bullies) captured in the Waihou catchment in 2014-2017. The results from the 2017 survey are in blue; the results from the 2014-2016 surveys are included in black for comparison.

Site	Year	Shortfin eel			Longfin eel			C. bully		
		min	max	median	min	max	median	min	max	median
6. Paiakarahi	**2017**	**89**	**165**	**111**	**109**	**1016**	**153**	**20**	**71**	**51**
	2016	92	250	124.5	-	-	-	25	74	50
	2015	108	170	131	162	650	259	20	75	47
	2014	86	190	115	98	1002	207.5	26	70	49.5
7. Karengorengo	**2017**	**82**	**530**	**154**	**-**	**-**	**-**	**32**	**89**	**70**
	2016	76	620	187	350	350	350	47	93	70
	2015	75	675	200	-	-	-	30	74	56
	2014	100	750	165	-	-	-	45	74	45
8. Wairere	**2017**	**80**	**665**	**119**	**632**	**700**	**666**	**16**	**75**	**42**
	2016	85	570	123	1000	1000	1000	16	74	42
	2015	86	530	128	930	930	930	21	68	42
	2014	75	450	110	880	930	905	20	76	40.5
9. Waitearikl	**2017**	**110**	**195**	**121**	**357**	**600**	**550**	**36**	**171**	**60**
	2016	89	660	156	450	600	570	30	90	51
	2015	95	430	200	150	850	490	20	75	42
	2014	90	410	170	350	850	505	14	95	42
10. Waitawheta	**2017**	**117**	**376**	**174**	**271**	**740**	**349**	**36**	**85**	**55**
	2016	100	173	139	345	470	350	30	81	52
	2015	132	351	195	205	710	360	30	80	46
	2014	115	350	190	250	750	350	30	85	57.5

3.2.3 Macroinvertebrates

Taxa richness was higher at four of the five Waihou catchment sites in 2017 than in 2016, and unchanged at the fifth site (Waiteariki Stream). EPT richness was also higher in 2017 at three sites, but unchanged in the fourth site (Karengorengo Stream) and lower in the fifth site (Waiteariki Stream). MCI scores, on the other hand, were lower in 2017 than in 2016 at all sites except Waiteariki Stream (Figure 3-18). The percentage of total individuals which were EPT taxa also declined at four of the five sites, with Wairere Steam the one exception.

Taxa richness was higher in 2017 than ever previously recorded at three sites: Paiakarahi, Wairere, and Waitawheta Streams. EPT richness was higher than ever before in Paiakarahi and Waitawheta Streams in 2017. The percentage of EPT individuals, however, was lower in 2017 than in 2016 at all sites except Wairere Stream (Table 3-5).

MCI scores declined from 'excellent' to 'good' at two sites, Paiakarahi and Wairere Streams, and from 'good' to 'fair' in Karengorengo Stream. However, both Waitawheta River and Waiteariki Stream remained in the 'excellent' category.

As in the Piako catchment sites, there does not appear to be strong correlation between EPT richness and MCI scores; for example in 2017 EPT richness increased but MCI declined at four of the five Waihou catchment sites, while at the fifth site EPT richness was lower in 2017 but the MCI score was higher. Whereas in 2016 both EPT richness and MCI scores improved at two sites, and EPT richness declined, but MCI increased at another two sites. The fifth site, Karengorengo Stream, highlights the disconnect, as EPT richness has remained constant over the last four years but the MCI score has varied considerably year to year.

The decline in MCI scores observed in 2017 may be associated with the heavy rainfall that occurred the week prior to sampling. However, Waiteariki Steam, which was one of the two Waihou catchment sites sampled after the rain and had much higher water level than in previous years, did not show large decreases in taxa richness or EPT richness and had an improved MCI score, suggesting that the rain and increased flows may not have had a large effect on invertebrate metrics.

Table 3-7: Summary of macroinvertebrate results for the Waihou monitoring sites in 2014-2017. The results from 2017 are in blue; the results from the 2014-2016 surveys are included in black for comparison. MCI scores less than 80 are classified as 'poor,' scores 80-100 are 'fair,' scores 100-120 are 'good,' and scores greater than 120 are considered 'excellent' (Stark & Maxted 2007).

Site	Year	Total taxa richness	EPT richness	%EPT	MCI
6. Paiakarahi Stream	**2017**	**38**	**22**	**36.4**	**114.7**
	2016	19	13	43.0	122.1
	2015	32	19	61.6	111.3
	2014	18	9	50.2	105.6
7. Karengorengo Stream	**2017**	**19**	**7**	**21.5**	**94.7**
	2016	18	7	25.7	105.6
	2015	22	7	22.1	82.7
	2014	18	7	22.1	97.8
8. Wairere Stream	**2017**	**33**	**15**	**38.3**	**107.3**
	2016	18	12	30.1	124.4
	2015	32	20	51.2	116.8
	2014	17	10	35.2	101.2
9. Waitearikí Stream	**2017**	**26**	**14**	**46.5**	**123.1**
	2016	26	16	72.7	120
	2015	26	13	74.2	111.5
	2014	29	20	78.3	117.2
10. Waitawheta River	**2017**	**40**	**28**	**38.3**	**124.0**
	2016	33	26	42.9	138.8
	2015	31	22	25.6	134.2
	2014	29	21	23.5	125.5

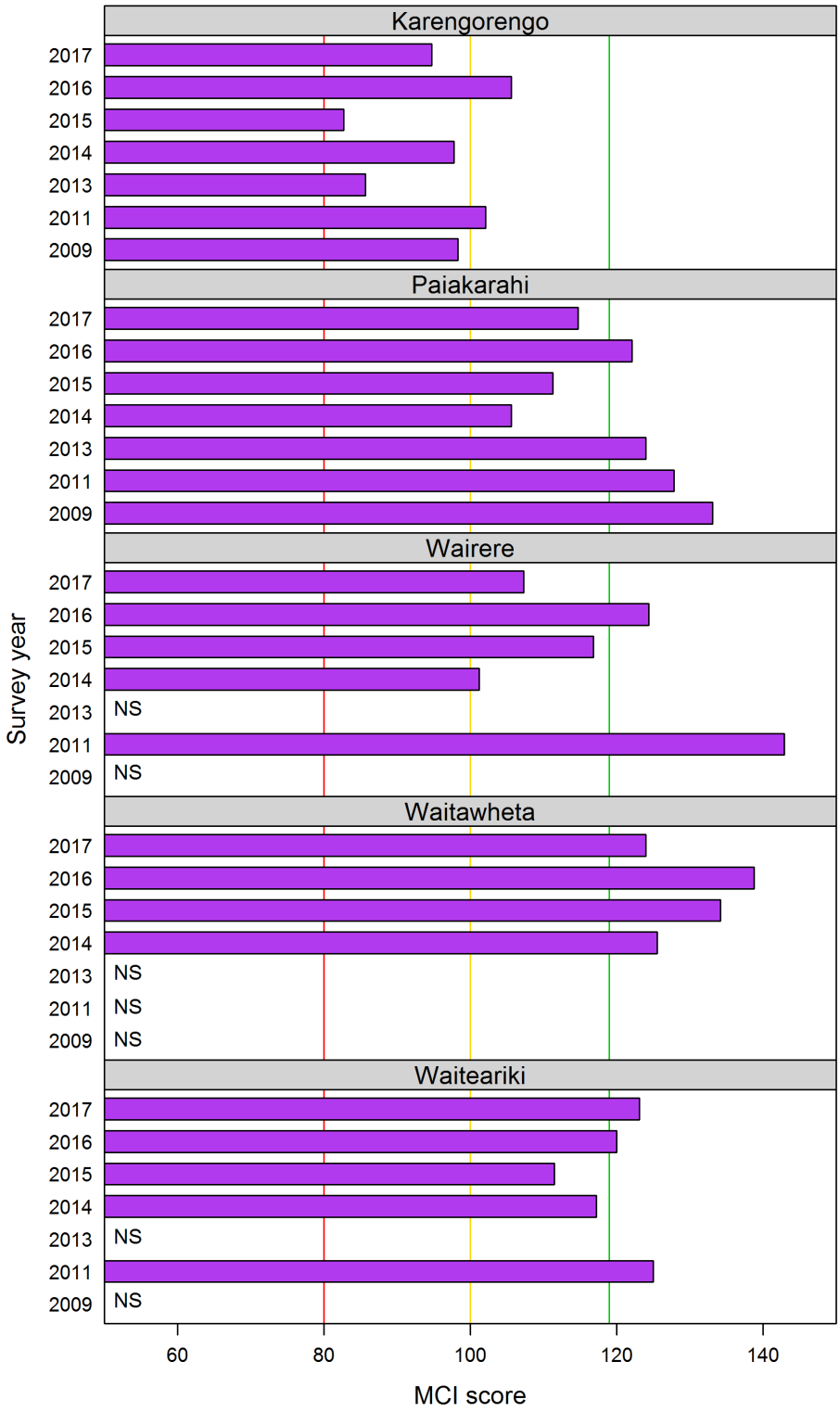

Figure 3-18: Comparison of MCI scores between survey years in the Waihou catchment. Vertical lines indicate boundaries for quality classes. Anything below the red line is 'poor', between the red and yellow lines is 'fair', between the yellow and green lines is 'good' and above the green line is 'excellent' (Stark & Maxted 2007). Years in which a site was not surveyed are marked 'NS.'

3.2.4 Macrophytes & periphyton

Macrophyte cover was low at all the Waihou survey sites in 2017 except Karengorengo Stream, which had high coverage as it has in most past years (Figure 3-19). Although several sites had noticeable macrophyte growth for the first time in 2016, no (Waitawheta River and Waiteariki Stream) or very little (Wairere Stream) macrophytes were recorded in 2017, indicating that the previous year's increase was not the beginning of a trend.

Periphyton enrichment scores (PEI) were higher in all sites except Waiteariki Stream in 2017 compared to 2016 (Figure 3-20). However, the PEI scores at the four sites were all still within the range of previous reports for those sites. The PEI score in Karengorengo Stream was higher than ever before reported, 90%, due to the presence of long green filamentous algae. Conversely, the PEI score in Waiteariki Stream was low due to the absence of long filamentous green algae, which had been abundant in previous years. It is possible that algal mats were scoured during heavy rain and increased flows that occurred the week prior to sampling this site. Periphyton sliminess index (PSI) scores were higher in Paiakarahi and Wairere Streams in 2017 than previous years (except for 2015 in Paiakarahi Stream) (Figure 3-21), indicating greater prevalence of thin film algae in those sites. PSI scores remained fairly constant with past values in the other three sites.

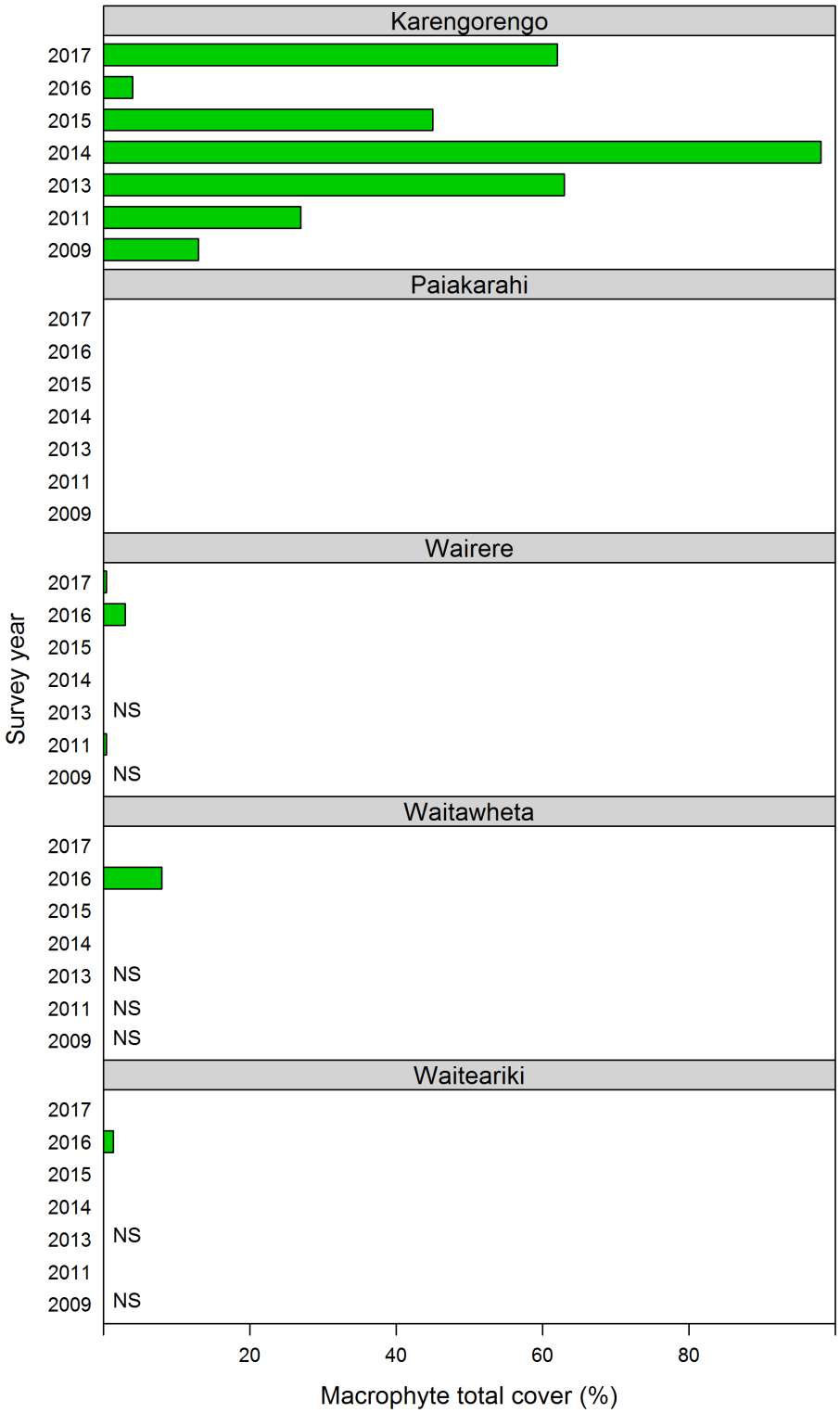

Figure 3-19: Comparison of macrophyte total cover (MTC) scores over time at the Waihou survey sites. Years in which a site was not surveyed are marked 'NS.'

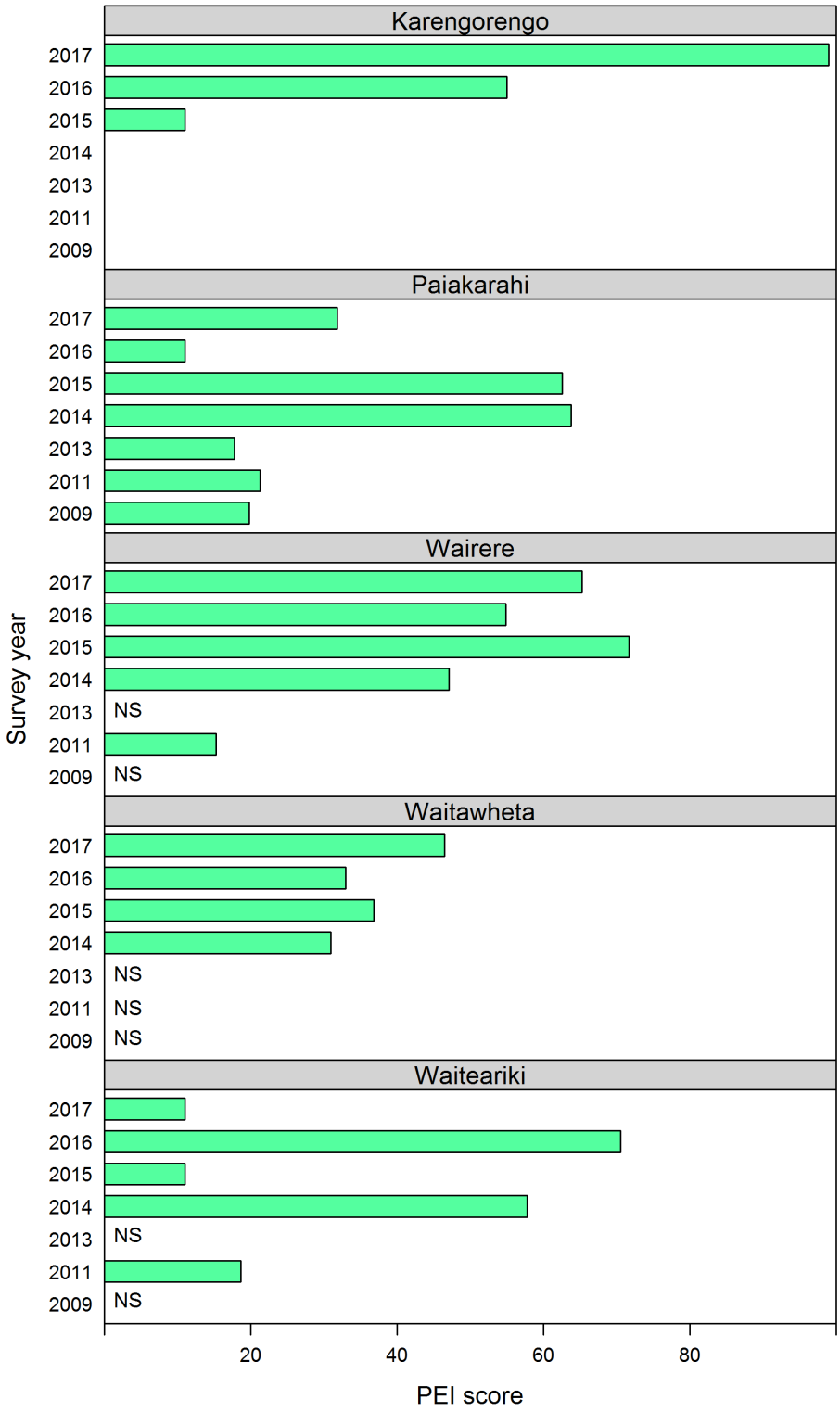

Figure 3-20: Comparison of periphyton enrichment index (PEI) scores over time at the Waihou survey sites. Years in which a site was not surveyed are marked 'NS.'

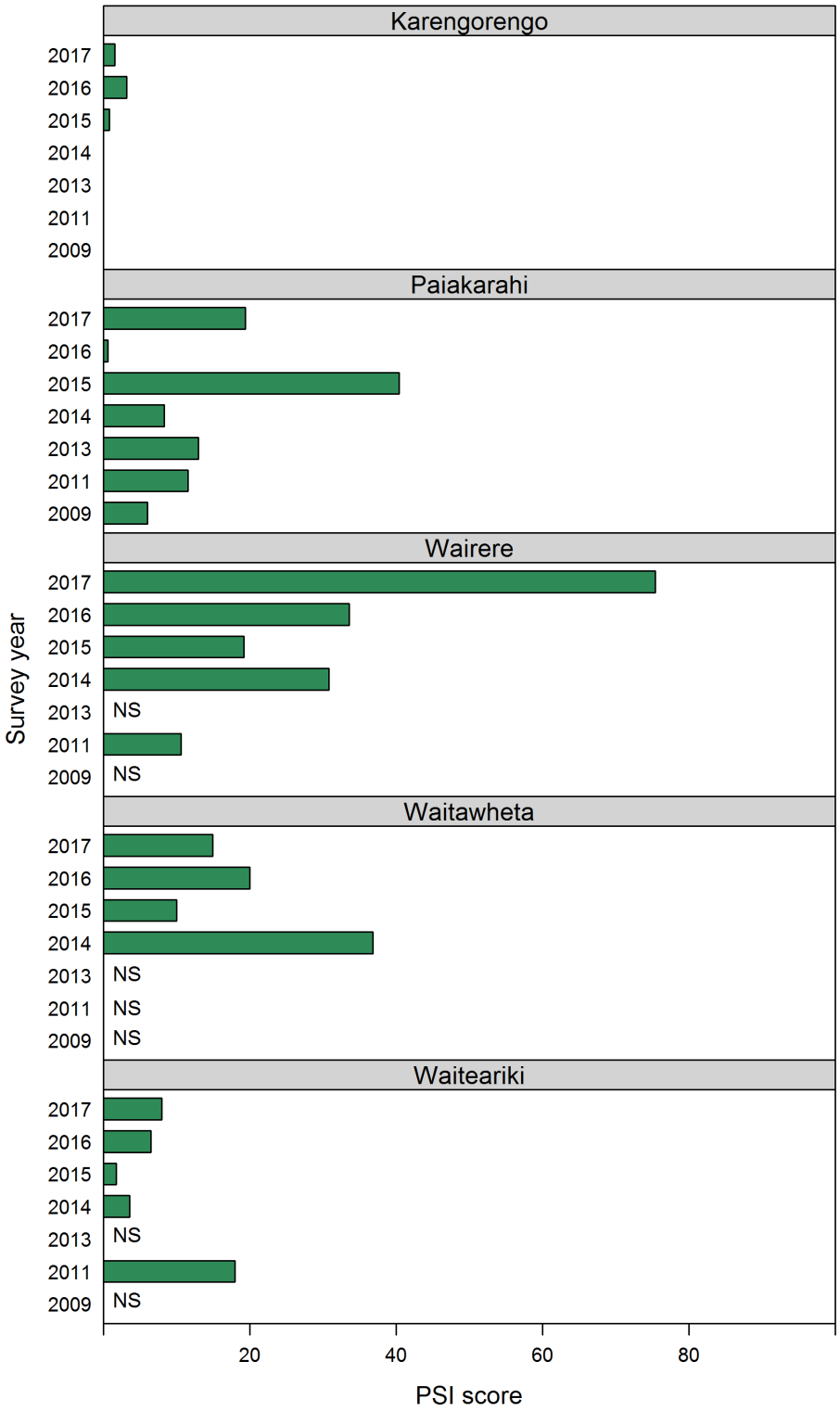

Figure 3-21: Comparison of periphyton sliminess index (PSI) scores over time at the Waihou survey sites. Years in which a site was not surveyed are marked 'NS.'

3.2.5 Habitat quality scores

The habitat quality scores have fluctuated over time at all of the Waihou survey sites, but remain largely within the same range (Figure 3-22). Waitawheta River and Waiteariki Stream both show a positive trend in habitat scores over time since 2014. Karengorengo Stream had a substantial improvement in habitat quality score in 2017 compared to previous years. This improvement was primarily associated with increased riparian vegetation cover and bank stability. Waiteariki Stream also had a slightly higher habitat score in 2017 than 2016, due to reduced periphyton growth (or increased scour, as discussed above).

Correlations between total habitat scores and biotic indices indicated a positive association between the macroinvertebrate indices and habitat quality, as in the Piako catchment (n=23; MCI ρ=0.41; %EPT ρ=0.63) (Table 3-8 & Figure 3-23). There was also a positive correlation between fish species richness and habitat score at the Waihou sites (ρ=0.42; Figure 3-24), although it was not as strong as in past years (2015: ρ=0.69). This may be a reflection of the changes in fish species richness that have occurred in the past two years.

Table 3-8: Correlation coefficients between the habitat score and various biotic indices for the Waihou catchment in 2017.

Biotic index	Spearman's rank correlation coefficient
MCI	0.41
Macroinvertebrate total richness	0.38
EPT richness	0.44
% EPT	0.63
Fish richness	0.42

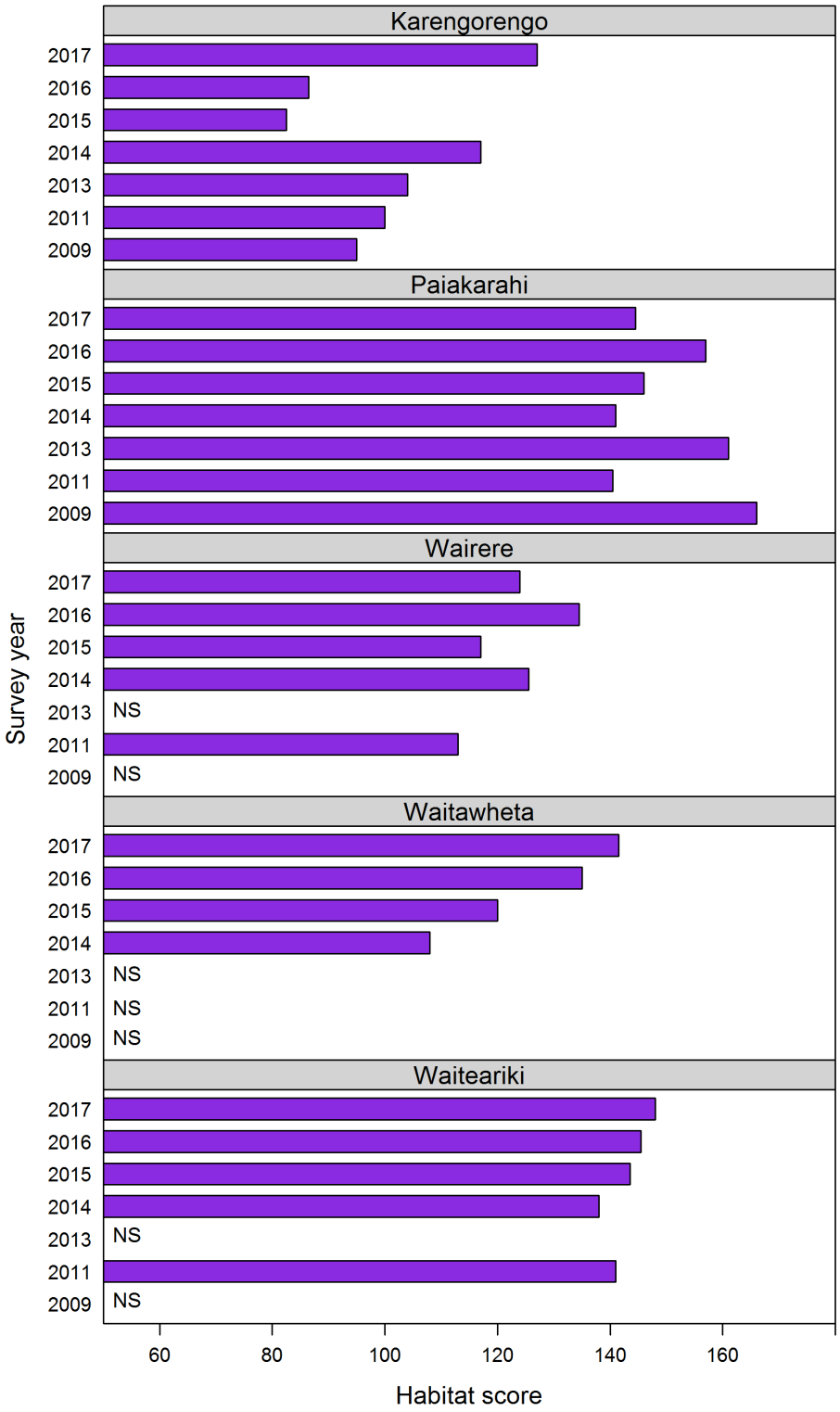

Figure 3-22: Comparison of habitat scores over time for the Waihou survey sites. Years in which a site was not surveyed are marked 'NS.'

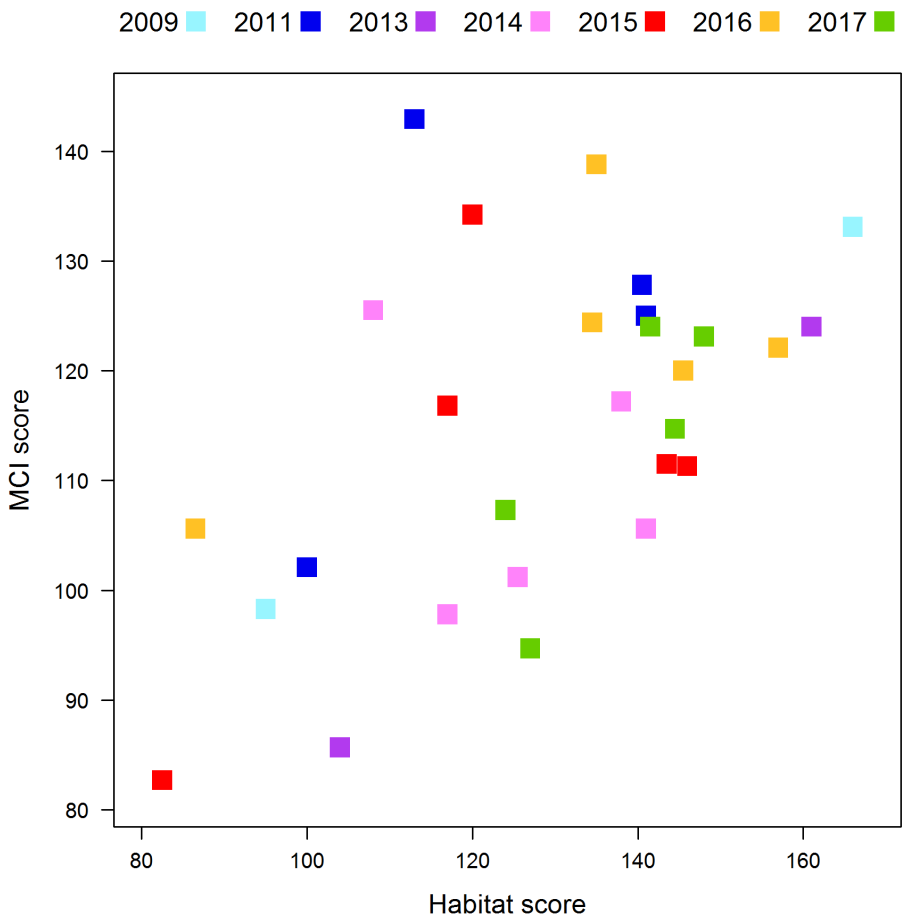

Figure 3-23: Scatterplot of habitat score against MCI score at the Waihou survey sites in different survey years (ρ=0.41).

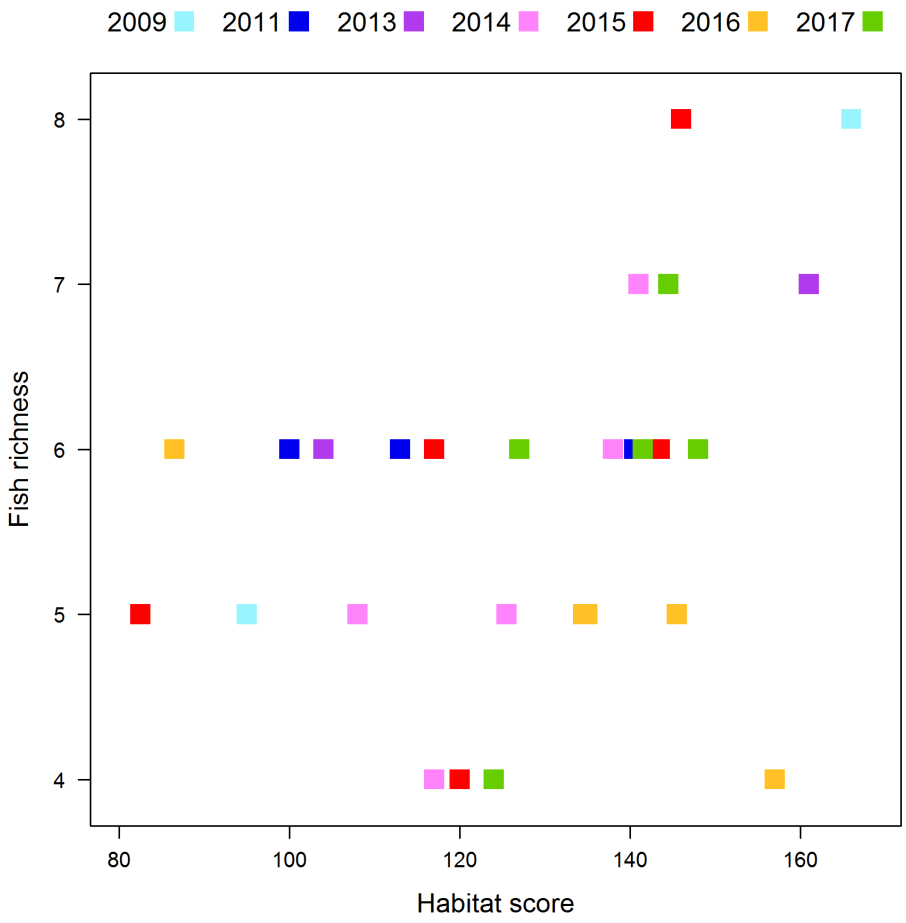

Figure 3-24: Scatterplot of habitat score against fish species richness at the Waihou survey sites in different survey years (ρ=0.42).

4 Discussion

One of the fundamental objectives of setting water resource use limits is the protection of ecosystem health. Setting robust limits requires an understanding of both the current status of ecological communities and changes in their status over time. The current status of ecological communities represents the combined effects of both natural environmental and biotic controls, e.g., distance inland, elevation, river type, species' life histories, and the consequences of human induced changes to the environment, e.g., land use change, reduced water quality, changing flows and river channel engineering. Changes in status over time will also be driven by a combination of natural variability in environmental and biotic conditions (i.e., wet v. dry years; warm v. cold years; good v. bad recruitment; high v. low survival), and human induced changes to the environment, e.g., water abstraction, pollutant discharges, land drainage and stream restoration.

Ecological monitoring is essential to understanding ecological status and trends. Therefore five sites were chosen in each of the Waihou and Piako catchments for annual ecological monitoring with the aim of supporting the water allocation decision making process. This recommendation was based on attaining a compromise between spatial coverage of the catchments and characterising natural inter-annual variations in the biotic communities. The ten sites are representative of a range of river types typical of each catchment (i.e., lowland, upland, more modified, less modified, different tributaries), with the aim of providing a broad catchment scale overview of ecological status. The ten sites have now been monitored for four years (2014 – 2017), and all but one (Waitawheta River) of the selected sites were also surveyed in either 2009, 2011, or 2013 (or a combination of those years).

The results of the 2017 monitoring may have been complicated by the rain event which occurred mid-way through the sampling period. Although flows remained well-below the bed-moving cut-off which would have required a two-week stand-down period, we observed lower abundances of fish and invertebrates in 2017 than in past years primarily in sites sampled after the heavy rain. There are several possible explanations for these results. First, there is a question of how well flow measured at the nearest gauging station represents changes in flow within the sample sites, which are smaller tributaries of the larger streams and rivers the gauging stations are located on. The relative increase in flow in the smaller tributaries may be greater than further downstream. Second, it is difficult to determine whether fewer fish were captured because they were absent due to physical displacement or avoidance behaviour, or because electric-fishing efficiency decreases in deeper water, and therefore we may have simply missed more fish in sites with increased flow post-rainfall. Thus, the 2017 results may indicate that increases in flow below the threshold may still have impacts on fish and invertebrate communities, we are currently unable to definitively attribute the observed declines in fish and invertebrate abundance with the rain event.

4.1 Piako catchment

The total number of fish caught in the 2017 survey was slightly lower, but similar to the total number of fish caught the previous year at all sites except Waitoa, which had much lower fish abundance in 2017. In general, the relative abundance of shortfin eels was higher than in past years, but the relative abundance of bullies was lower. Galaxiids (inanga, banded kokopu, and koaro) were found in some sites in which they had not been previously captured, but were absent from others in which they had been found in past years, which suggests that they are likely present in most sites in very low numbers, and thus are captured some years, but not others.

Community composition was similar to that in previous years in three sites, Mangakahika, Piakonui, and Waitakaruru Streams, but differed in 2017 in Mangapapa and Waitoa Streams, primarily due to the large reduction in bully abundance in those sites.

Genetic analysis was conducted on a subsample of three bullies per site, but there was no clear clustering of cytochrome b sequences between common and Cran's bullies, therefore it remains uncertain which of the two species were present in each site. In general, the bullies from the two catchments (Waihou versus Piako) cluster somewhat separately, although some tributaries from both catchments fall in the space between the two clusters (Figure E-1). This could be indicative of a difference in the dominant species in each catchment. However, the lack of clear differentiation is likely due to either interbreeding and hybridization between the two species or misidentification of the original samples used to establish a baseline genetic sequence of *G. basalis* (Jonathan Banks, Cawthron Institute, personal communication), making definitive identification currently difficult. We hypothesize that taxonomic identification of the original samples could have been confused by morphological differences between migratory and non-migratory common bullies. Further sampling and sequencing will be required to resolve this question (see recommendations).

Comparison of size distributions between years indicated that shortfin eel population dynamics have remained consistent, with the greatest proportion of eels in the middle size classes (100-200 mm and 200-300 mm) each year. One exception to this pattern was the large number of small (< 100 mm) eels found in Mangapapa Stream in 2017. Large eels also continued to be absent at two (Mangakahika and Piakonui) of the five sites. Bully size distributions, on the other hand, have been more variable between years, and show different patterns in different sites, perhaps indicating the relative influence of migration versus local recruitment. For example, in Mangapapa Stream there are more small fish than large fish every year, possibly suggestive of migration of larvae into the stream every year, whereas in the other sites the peak abundance shifts between size classes in successive years, indicating an aging population followed by recruitment. The use of otolith microchemistry to determine the migratory history of the bullies at different sites (i.e., whether they are diadromous or locally recruited) could be informative for better understanding these dynamics. Furthermore, this may assist with clarifying the species differentiation between common bullies (generally considered to be diadromous in rivers) versus Cran's bullies (considered to be non-diadromous).

Macroinvertebrate community index scores were lower in all Piako sites than the previous year, but within the range of variability observed over time in all but one site (Piakonui). Although decreasing MCI scores are often associated with declining stream health, Mangakahika and Waitakaruru Streams also had higher percentages of EPT taxa than in past years, potentially an indication of improving stream health. Thus, it is possible that the low MCI scores were due to the heavy rainfall that occurred the week prior to sampling; the only Piako site which was sampled before the rain, Mangakahika Stream, had the smallest change in MCI score, while Piakonui, which showed the greatest evidence of recent flooding, had the largest decline.. Future monitoring will determine whether the low scores observed this year were a one-off due to the heavy rains and increased flow.

Habitat conditions and periphyton and macrophyte growth also affect macroinvertebrate and fish populations. Habitat scores were higher in 2017 than in 2016 at 4 of the 5 Piako sites. The improved scores were associated with reduced sediment deposition and reduced periphyton cover. However, it is important to note that both sediment and periphyton may have been scoured off during the high flows, and thus this year's data might not represent typical baseflow conditions.

4.2 Waihou catchment

In the Waihou catchment, the total number of fish captured was lower at four sites, and particularly low at two of those sites, in 2017 than in 2016. The two sites with substantially lower abundance were also the only two Waihou sites sampled after, rather than before, the heavy rain and high flow event, supporting our conjecture that the low fish abundances observed in the Piako catchment sites this year were associated with recent unusual hydrological conditions. Additionally, one of the two sites, Karengorengo Stream, likely also had low fish abundance due to decreased electric-fishing effectiveness in dense macrophyte beds, which had been cleared in 2016. The densities recorded for Karengorengo Stream in 2017 were comparable to those in other years when high macrophyte cover was present. Wairere Stream, which was sampled before the rain, was the only site in which total abundance was higher than the previous year, due to a large increase in the number of bullies. Inanga and banded kokopu were absent in 2017 from sites at which they had been previously found, although, as in the Piako catchment, this most likely means they are present in very low numbers and are rarely captured, rather than that they are truly absent some years and present other years.

Community composition in the Waihou sites in 2017 was similar to composition in previous years at all but one of the five sites. The dissimilarity in the remaining site, Waiteariki, was likely related to the low abundances following heavy rainfall in the week prior to sampling.

As in the Piako catchment, shortfin eel size distributions were similar across years, with the greatest proportion of eels in the 100-200 mm size class. There were also very few large shortfin eels at any site except Wairere Stream. Bully size distributions were more variable between years, with shifting peak abundances, and frequently bimodal, indicating the presence of multiple cohorts, and potentially suggesting populations were sustained by a mix of both migration and local recruitment.

Macroinvertebrate community index scores were lower in 2017 than in 2016 at four of the five sites, but not outside the range of scores previously observed. Interestingly, EPT richness increased at three of the four sites in which MCI scores dropped (and in the remaining site EPT richness did not change), while the one site which had a higher MCI score in 2017 had lower EPT richness. This suggests that the lower MCI scores did not result from losses of EPT taxa.

Lower MCI scores may be associated with increased periphyton cover, as all four sites at which MCI scores declined had higher periphyton enrichment scores in 2017 than 2016. Waiteariki was the one site at which periphyton cover was much lower than the previous year, probably because this was the one Waihou site sampled after the heavy rain, during which benthic scouring likely occurred. Waiteariki was also the only site at which the MCI score was higher in 2017 than in 2016, although both EPT richness and percent EPT were lower this year.

5 Conclusions

Ecosystem health has been identified as a core national value that must be sustained (MfE 2014). The NPS-FM requires that regional councils set freshwater objectives and associated limits to water resource use that will ensure those objectives are met (MfE 2014). Reliable information on the status and temporal dynamics of instream ecosystems is therefore critical to both setting appropriate protection levels and ensuring that freshwater objectives are met.

The results of this survey help to support the water allocation decision making process by informing WRC on the status and trends in ecological communities of the Waihou and Piako. The reported inter-annual variation between yearly samples highlights the need for long-term monitoring to accurately characterise natural population dynamics and recruitment cycles versus long-term trends in stream communities and stream health that result from human activities.

The 2017 survey results were complicated by the rain event which occurred halfway through the monitoring work. This has made it difficult to compare the data collected this year to previous years. On the other hand, however, it has provided some useful information about the impact high flow events can have on fish and invertebrate communities, and highlights the extreme importance of flow to aquatic communities.

Therefore, it is recommended that the same ten sites continue to be monitored annually using the same survey methods. It would also be beneficial to install in-stream loggers to collect continuous measurements of flow (or a proxy such as water level), water temperature and dissolved oxygen to examine the relative importance of different environmental variables in determining the observed variations in ecology. This will help to build understanding of the natural variability in the ecological communities of these sites and to identify critical interactions and drivers of community stability and/or change.

In addition to the continued annual monitoring, data from the standard WRC REMS monitoring program can be added to future analyses to improve the spatial coverage of the study, although they are not all sampled every year. It would also be useful to collect additional data on water quality at the annual monitoring sites, including continuous measurements of water temperature and dissolved oxygen to better understand the relative impact of environmental factors on the observed variations in ecology. This will support WRC in identifying appropriate freshwater objectives and setting related ecosystem protection levels in these catchments.

6 Recommendations

- It is recommended that annual ecological monitoring continues at these ten sites. This will help to determine and understand the temporal dynamics of ecological communities, providing a more robust baseline against which to monitor the effects of human impacts on these river ecosystems over time.
- Installing stage height loggers at each site to monitor continuous water levels as a proxy for flow would be helpful for detecting high flow events and establishing relationships between ecological response variables and flow. This will enable investigation of factors such as the frequency, magnitude and duration of high and low flow events and possible relationships to community responses; understanding these relationships is critical for informing future water allocations decisions.
- It would be beneficial to collect additional physico-chemical variables at each of the sites, particularly water temperature and dissolved oxygen, to allow evaluation of the relative importance of different environmental variables in determining the observed variations in ecology. Ideally this would be done via continuous data loggers.
- To improve the spatial coverage of the monitoring, fish and physico-chemical data from the WRC REMS sites, which are sampled randomly every three years, can be included in future analyses.
- Further genetic work is needed to resolve the Cran's or common bully question. First, a reliable Cran's bully sequence needs to be identified by collecting and comparing samples from other known populations of Cran's bullies outside the Waihou and Piako catchments. Additionally, juvenile bullies from the Waihou and Piako sites should be collected and sequenced, as it was the presence of these smallest size classes that initially suggested non-migratory populations and may have led to the mistaken identification as Cran's.
- Otolith samples could be collected from all bully samples collected for the genetic analyses and their microchemistry analysed to determine whether they have a diadromous or potamodromous life-history. It has generally been assumed that common bullies in running waters typically have a diadromous life-history, whereas Cran's bullies are potamodromous, so this could help with confirming species differentiation between sites.

7 Acknowledgements

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8 References

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Appendix A Habitat assessment forms

Field Assessment Cover Form
Wadeable Hard-Bottomed and Soft-Bottomed Streams

Stream name: Mangakahika Stream		Assessor: Peter Williams	
Site number: 376-4	Sample number: 4	Date: 14/02/2017	Time: 14:36
GPS coordinates	Downstream:	E 1818698	N 5838814
	Upstream:	E 1818618	N 5838767

Channel & riparian features

Canopy cover:

Open	Partly shaded	**Very shaded**

Fencing:	Dominant riparian vegetation:	
None/ineffective	Crops	Retired vegetation
One side/partial	**Pasture**	**Native shrub**
Complete	Exotic trees	Native trees

Instream hydraulic conditions

Estimated or measured reach average:

Stream width (active channel): 2.27m
Stream width (water): 1.84m
Stream depth: 0.20m
Surface velocity: <1 m/s

Water quality

Temperature:	18.5	°C	Conductivity:	176.8	µS cm^{-1}
Dissolved oxygen:	80.3	%	7.52		mg l^{-1}

Turbidity:	**Clear**	Slightly turbid	Highly turbid	Stained	Other

Stream-bottom substrata

Compaction (inorganic substrata):

Assorted sizes tightly packed &/or overlapping
Moderately packed with some overlapping
Mostly a loose assortment with little overlap
No packing/loose assortment easily moved

Embeddedness:

(% gravel-boulder particles covered by fine sediment)

<5%	5-25%	26-50%	**51-75%**	>75%

% surficial inorganic substratum size composition:

Substratum	Dimension	Percentage
Bedrock	-	0
Boulder	>256mm	1
Cobble	>64-256mm	80
Gravel	>2-64mm	15
Sand	>0.06-2mm	3
Silt	0.004-0.06mm	0
Clay	<0.004mm	1

Organic material (% cover)

Large wood (>10cm diameter)

<5%	5-25%	26-50%	51-75%	>75%

Coarse detritus (small wood, sticks, leaves etc., >1mm)

<5%	5-25%	26-50%	51-75%	>75%

Fine (<1mm) organic deposits

<5%	**5-25%**	26-50%	51-75%	>75%

Instream plant cover (% streambed area)

Filamentous algae & mats:

<5%	5-25%	26-50%	51-75%	>75%

Macrophytes:

<5%	5-25%	26-50%	51-75%	>75%

Mosses/liverworts:

<5%	5-25%	26-50%	51-75%	>75%

Habitat types sampled

(% of effort)

Stones:	89%		
Wood:	1%	Riffles:	35 %
Macrophyte:	%	Runs:	65%
Edges:	10%		

Number of invertebrates returned:

Koura: Y	Shrimps: N
Crabs: N	Mussels: N
Other:	
Mussel type:	
Hyridella	*Cucumerunio*

Comments:

Wadeable Hard-Bottomed Streams
Qualitative Habitat Assessment Field Data Sheet

Stream name: Mangakahika	Site number: 374-4	
Sample number: 4	Assessor: Peter Williams	Date: 14/02/2017

Habitat parameter	Category																			
	Optimal					Suboptimal					Marginal					Poor				
1. Riparian vegetative zone width	• Bankside vegetation buffer >10m • Continuous & dense					• Bankside vegetation buffer is <10m • Mostly continuous					• Pathways present and/or stock • Mostly healed over					• Breaks frequent • Human activity obvious				
Left bank: 7	20	19	18	17	16	15	14	13	12	11	10	9	8	**7**	6	5	4	3	2	1
Right bank: 6	20	19	18	17	16	15	14	13	12	11	10	9	8	7	**6**	5	4	3	2	1
Mean: 6.5																				
2. Vegetative protection	• Bank surfaces & immediate riparian zones covered by native vegetation • Trees, under-storey shrubs or non-woody plants present • Vegetative disruption minimal					• Bank surfaces covered mainly by native vegetation • Disruption evident • Banks may be covered by exotic forestry					• Bank surfaces covered by mixture of grasses/shrubs, blackberry, willow & introduced species • Vegetation disruption obvious • Bare soil/closely cropped vegetation common					• Bank surfaces covered by grasses & shrubs • Disruption of stream bank vegetation very high • Grass heavily grazed • Significant stock damage to bank				
Left bank: 11	20	19	18	17	16	15	14	13	12	**11**	10	9	8	7	6	5	4	3	2	1
Right bank:11	20	19	18	17	16	15	14	13	12	**11**	10	9	8	7	6	5	4	3	2	1
Mean: 11																				
3. Bank stability	• Banks stable • Erosion/bank failure absent/minimal • <5% of bank affected					• Moderately stable • Infrequent, small areas of erosion mostly healed over • 5-30% of bank eroded					• Moderately unstable • 30-60% of bank in reach has areas of erosion • High erosion potential during floods					• Unstable • Many eroded areas • 60-100% of bank has erosional scars				
Left bank: 8	20	19	18	17	16	15	14	13	12	11	10	9	**8**	7	6	5	4	3	2	1
Right bank: 5	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	**5**	4	3	2	1
Mean: 6.5																				
4. Frequency of riffles	• Riffles relatively frequent • Distance between riffles divided by stream width=5-7 • Variety of habitat is key					• Occurrence of riffles infrequent • Distance between riffles divided by stream width=7-15					• Occasional riffle or run • Bottom contours provide some habitat • Distance between riffles divided by stream width=15-25					• Generally flat water, shallow riffles • Poor habitat • Distance between riffles divided by stream width=>25				
Score: 17	20	19	18	**17**	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
5. Channel alteration	• Changes to channel/dredging absent/minimal • Stream with normal pattern					• Some changes to channel/dredging • Evidence of past channel/dredging • Recent channel/dredging not present					• Channel changes/dredging extensive • Embankments/shoring structures present on both banks • 40-80% of reach channelized & disrupted					• Banks shored with gabion/cement • >80% of stream reach channelized or disrupted • Instream habitat altered/absent				
Score: 20	**20**	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

Habitat parameter	Category Optimal					Habitat parameter					Category Optimal					Habitat parameter				
6. Sediment deposition	• Little/no islands or point bars present • <20% of bottom affected by sediment deposition					• New increase in bar formation, mostly from gravel, sand or fine sediment • 20-50% of bottom affected • Slight deposition in pools					• Some deposition of new gravel, sand or fine sediment on old & new bars • 50-80% of bottom affected • Sediment deposits at obstructions, constrictions & bends					• Heavy deposits of fine material • Increased bar development • >80% of bottom changing frequently • Pools almost absent due to sediment deposition				
Score: 11	20	19	18	17	16	15	14	13	12	**11**	10	9	8	7	6	5	4	3	2	1
7. Velocity/depth regimes	• 4 velocity/depth regimes present • Slow/deep, slow/shallow, fast/shallow, fast/deep					• 3 0f 4 velocity/depth regimes present • If fast/shallow is missing then score lower					• 2 of 4 velocity/depth regimes present • If fast/shallow or slow/shallow are missing, score low					• Dominated by 1 velocity/depth regime • Usually deep/slow				
Score: 8	20	19	18	17	16	15	14	13	12	11	10	9	**8**	7	6	5	4	3	2	1
8. Abundance & diversity of habitat	• >50% substrate favourable for invertebrate colonisation & wide variety of woody debris, riffles, root mats • Snags/ submerged logs/undercut banks/cobbles provides abundant fish cover • Must not be new or transient					• 30-50% substrate favourable for invertebrate colonisation • Snags/ submerged logs/undercut banks/cobbles • Fish cover common • Moderate variety of habitat types. Can consist of some new material					• 10-30% substrate favourable for invertebrate colonisation • Fish cover patchy • 60-90% substrate easily moved by foot • Woody debris rare or may be smothered by sediment					• <10% substrate favourable for invertebrate colonisation • Fish cover rare or absent • Substrate unstable or lacking • Stable habitats lacking or limited to macrophytes				
Score: 8	20	19	18	17	16	15	14	13	12	11	10	9	**8**	7	6	5	4	3	2	1
9. Periphyton	• Periphyton not evident on hand held stones • Stable substrate • Surfaces rough to touch					• Periphyton not visible on stones • Stable substrate • Periphyton obvious to touch					• Periphyton visible • <20% cover of available substrates					• Periphyton obvious & prolific • >20% cover of available substrates				
Score: 15	20	19	18	17	16	**15**	14	13	12	11	10	9	8	7	6	5	4	3	2	1
TOTAL SCORE: 103																				

Field Assessment Cover Form
Wadeable Hard-Bottomed and Soft-Bottomed Streams

Stream name: Waitoa Stream U/S		Assessor: Kathryn Reeve	
Site number: 1249-121	Sample number: 6	Date: 20/02/2017	Time: 9:10
GPS coordinates	Downstream:	E1831974	N5803819
	Upstream:	E1831878	N5803808

Channel & riparian features

Canopy cover:

Open	Partly shaded	Very shaded

Fencing:	Dominant riparian vegetation:	
None/ineffective	Crops	Retired vegetation
One side/partial	**Pasture**	Native shrub
Complete	Exotic trees	Native trees

Instream hydraulic conditions

Estimated or measured reach average:

Stream width (active channel): 6.8 m
Stream width (water): 1.9 m
Stream depth: 0.25 m
Surface velocity:

Water quality

Temperature:	19	°C	Conductivity:	109.2	µS cm^{-1}
Dissolved oxygen:	95.9	%	8.88	mg l^{-1}	

Turbidity:	**Clear**	Slightly turbid	Highly turbid	Stained	Other

Stream-bottom substrata

Compaction (inorganic substrata):

Assorted sizes tightly packed &/or overlapping
Moderately packed with some overlapping
Mostly a loose assortment with little overlap
No packing/loose assortment easily moved

Embeddedness:

(% gravel-boulder particles covered by fine sediment)

<5%	**5-25%**	26-50%	51-75%	>75%

% surficial inorganic substratum size composition:

Substratum	Dimension	Percentage
Bedrock	-	10
Boulder	>256mm	20
Cobble	>64-256mm	20
Gravel	>2-64mm	15
Sand	>0.06-2mm	
Silt	0.004-0.06mm	
Clay	<0.004mm	35

Organic material (% cover)

Large wood (>10cm diameter)

<5%	5-25%	26-50%	51-75%	>75%

Coarse detritus (small wood, sticks, leaves etc., >1mm)

<5%	5-25%	26-50%	51-75%	>75%

Fine (<1mm) organic deposits

<5%	5-25%	26-50%	51-75%	>75%

Instream plant cover (% streambed area)

Filamentous algae & mats:

<5%	5-25%	26-50%	51-75%	>75%

Macrophytes:

<5%	5-25%	26-50%	51-75%	>75%

Mosses/liverworts:

<5%	5-25%	26-50%	51-75%	>75%

Habitat types sampled

(% of effort)

Stones:	95%		
Wood:	%	Riffles:	50%
Macrophyte:	%	Runs:	50%
Edges:	5%		

Number of invertebrates returned:

Koura: Y	Shrimps: N
Crabs: N	Mussels: N
Other:	
Mussel type:	
Hyridella	*Cucumerunio*

Comments:

Wadeable Hard-Bottomed Streams Qualitative Habitat Assessment Field Data Sheet																					
Stream name: Waitoa Stream U/S										Site number: 1249-121											
Sample number: 6						Assessor: Kathryn Reeve										Date: 20/02/2017					
Habitat parameter	Category Optimal					Suboptimal					Marginal					Poor					
1. Riparian vegetative zone width	• Bankside vegetation buffer >10m • Continuous & dense					• Bankside vegetation buffer is <10m • Mostly continuous					• Pathways present and/or stock • Mostly healed over					• Breaks frequent • Human activity obvious					
Left bank: 3	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	**3**	2	1	
Right bank: 4	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	**4**	3	2	1	
Mean: 3.5																					
2. Vegetative protection	• Bank surfaces & immediate riparian zones covered by native vegetation • Trees, under-storey shrubs or non-woody plants present • Vegetative disruption minimal					• Bank surfaces covered mainly by native vegetation • Disruption evident • Banks may be covered by exotic forestry					• Bank surfaces covered by mixture of grasses/shrubs, blackberry, willow & introduced species • Vegetation disruption obvious • Bare soil/closely cropped vegetation common					• Bank surfaces covered by grasses & shrubs • Disruption of stream bank vegetation very high • Grass heavily grazed • Significant stock damage to bank					
Left bank: 3	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	**3**	2	1	
Right bank: 5	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	**5**	4	3	2	1	
Mean: 4																					
3. Bank stability	• Banks stable • Erosion/bank failure absent/minimal • <5% of bank affected					• Moderately stable • Infrequent, small areas of erosion mostly healed over • 5-30% of bank eroded					• Moderately unstable • 30-60% of bank in reach has areas of erosion • High erosion potential during floods					• Unstable • Many eroded areas • 60-100% of bank has erosional scars					
Left bank: 5	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	**5**	4	3	2	1	
Right bank: 3	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	**3**	2	1	
Mean: 4																					
4. Frequency of riffles	• Riffles relatively frequent • Distance between riffles divided by stream width=5-7 • Variety of habitat is key					• Occurrence of riffles infrequent • Distance between riffles divided by stream width=7-15					• Occasional riffle or run • Bottom contours provide some habitat • Distance between riffles divided by stream width=15-25					• Generally flat water, shallow riffles • Poor habitat • Distance between riffles divided by stream width=>25					
Score: 17	20	19	18	**17**	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
5. Channel alteration	• Changes to channel/dredging absent/minimal • Stream with normal pattern					• Some changes to channel/dredging • Evidence of past channel/dredging • Recent channel/dredging not present					• Channel changes/dredging extensive • Embankments/shoring structures present on both banks • 40-80% of reach channelized & disrupted					• Banks shored with gabion/cement • >80% of stream reach channelized or disrupted • Instream habitat altered/absent					
Score: 17	20	19	18	**17**	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	

Habitat parameter	Category					Habitat parameter					Category					Habitat parameter				
	Optimal										Optimal									
6. Sediment deposition	• Little/no islands or point bars present • <20% of bottom affected by sediment deposition					• New increase in bar formation, mostly from gravel, sand or fine sediment • 20-50% of bottom affected • Slight deposition in pools					• Some deposition of new gravel, sand or fine sediment on old & new bars • 50-80% of bottom affected • Sediment deposits at obstructions, constrictions & bends					• Heavy deposits of fine material • Increased bar development • >80% of bottom changing frequently • Pools almost absent due to sediment deposition				
Score: 13	20	19	18	17	16	15	14	**13**	12	11	10	9	8	7	6	5	4	3	2	1
7. Velocity/depth regimes	• 4 velocity/depth regimes present • Slow/deep, slow/shallow, fast/shallow, fast/deep					• 3 0f 4 velocity/depth regimes present • If fast/shallow is missing then score lower					• 2 of 4 velocity/depth regimes present • If fast/shallow or slow/shallow are missing, score low					• Dominated by 1 velocity/depth regime • Usually deep/slow				
Score: 9	20	19	18	17	16	15	14	13	12	11	10	**9**	8	7	6	5	4	3	2	1
8. Abundance & diversity of habitat	• >50% substrate favourable for invertebrate colonisation & wide variety of woody debris, riffles, root mats • Snags/ submerged logs/undercut banks/cobbles provides abundant fish cover • Must not be new or transient					• 30-50% substrate favourable for invertebrate colonisation • Snags/ submerged logs/undercut banks/cobbles • Fish cover common • Moderate variety of habitat types. Can consist of some new material					• 10-30% substrate favourable for invertebrate colonisation • Fish cover patchy • 60-90% substrate easily moved by foot • Woody debris rare or may be smothered by sediment					• <10% substrate favourable for invertebrate colonisation • Fish cover rare or absent • Substrate unstable or lacking • Stable habitats lacking or limited to macrophytes				
Score: 12	20	19	18	17	16	15	14	13	**12**	11	10	9	8	7	6	5	4	3	2	1
9. Periphyton	• Periphyton not evident on hand held stones • Stable substrate • Surfaces rough to touch					• Periphyton not visible on stones • Stable substrate • Periphyton obvious to touch					• Periphyton visible • <20% cover of available substrates					• Periphyton obvious & prolific • >20% cover of available substrates				
Score: 13	20	19	18	17	16	15	14	**13**	12	11	10	9	8	7	6	5	4	3	2	1
TOTAL SCORE: 98.5																				

Field Assessment Cover Form
Wadeable Hard-Bottomed and Soft-Bottomed Streams

Stream name: Mangapapa Stream		Assessor: Kathryn Reeve	
Site number: 433-14	Sample number: 7	Date: 20/02/2017	Time: 14:55
GPS coordinates	Downstream:	E 1836783	N 5809932
	Upstream:	E 1836750	N 5809802

Channel & riparian features

Canopy cover:

Open	Partly shaded	Very shaded

Fencing:	Dominant riparian vegetation:	
None/ineffective	Crops	Retired vegetation
One side/partial	**Pasture**	Native shrub
Complete	Exotic trees	Native trees

Instream hydraulic conditions

Estimated or measured reach average:

Stream width (active channel):

Stream width (water): 3.7 m

Stream depth:

Surface velocity:

Water quality

Temperature:	20.7	°C	Conductivity:	100	µS cm^{-1}
Dissolved oxygen:	85.0	%	8.55	mg l^{-1}	

Turbidity:	**Clear**	Slightly turbid	Highly turbid	Stained	Other

Stream-bottom substrata

Compaction (inorganic substrata): -SEE BEDROCK

Assorted sizes tightly packed &/or overlapping

Moderately packed with some overlapping

Mostly a loose assortment with little overlap

No packing/loose assortment easily moved

Embeddedness:

(% gravel-boulder particles covered by fine sediment)

<5%	5-25%	26-50%	51-75%	>75%

% surficial inorganic substratum size composition:

Substratum	Dimension	Percentage
Bedrock	-	95
Boulder	>256mm	
Cobble	>64-256mm	
Gravel	>2-64mm	
Sand	>0.06-2mm	
Silt	0.004-0.06mm	5
Clay	<0.004mm	

Organic material (% cover)

Large wood (>10cm diameter)

<5%	5-25%	26-50%	51-75%	>75%

Coarse detritus (small wood, sticks, leaves etc., >1mm)

<5%	5-25%	26-50%	51-75%	>75%

Fine (<1mm) organic deposits

<5%	5-25%	26-50%	51-75%	>75%

Instream plant cover (% streambed area)

Filamentous algae & mats:

<5%	5-25%	26-50%	51-75%	>75%

Macrophytes:

<5%	**5-25%**	26-50%	51-75%	>75%

Mosses/liverworts:

<5%	5-25%	26-50%	51-75%	>75%

Habitat types sampled

(% of effort)

Stones:	80%		
Wood:	%	Riffles:	70%
Macrophyte:	10%	Runs:	30%
Edges:	10%		

Number of invertebrates returned:

Koura: Y	Shrimps: N
Crabs: N	Mussels: N
Other:	
Mussel type:	
Hyridella	*Cucumerunio*

Comments:

Wadeable Hard-Bottomed Streams Qualitative Habitat Assessment Field Data Sheet																				
Stream name: Mangapapa Stream						Site number: 433-14														
Sample number: 7						Assessor: Kathryn Reeve										Date: 20/02/2017				
Habitat parameter	Category																			
	Optimal					Suboptimal					Marginal					Poor				
1. Riparian vegetative zone width	• Bankside vegetation buffer >10m • Continuous & dense					• Bankside vegetation buffer is <10m • Mostly continuous					• Pathways present and/or stock • Mostly healed over					• Breaks frequent • Human activity obvious				
Left bank: 5	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Right bank: 3	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Mean: 4																				
2. Vegetative protection	• Bank surfaces & immediate riparian zones covered by native vegetation • Trees, under-storey shrubs or non-woody plants present • Vegetative disruption minimal					• Bank surfaces covered mainly by native vegetation • Disruption evident • Banks may be covered by exotic forestry					• Bank surfaces covered by mixture of grasses/shrubs, blackberry, willow & introduced species • Vegetation disruption obvious • Bare soil/closely cropped vegetation common					• Bank surfaces covered by grasses & shrubs • Disruption of stream bank vegetation very high • Grass heavily grazed • Significant stock damage to bank				
Left bank: 6	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Right bank: 6	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Mean: 6																				
3. Bank stability	• Banks stable • Erosion/bank failure absent/minimal • <5% of bank affected					• Moderately stable • Infrequent, small areas of erosion mostly healed over • 5-30% of bank eroded					• Moderately unstable • 30-60% of bank in reach has areas of erosion • High erosion potential during floods					• Unstable • Many eroded areas • 60-100% of bank has erosional scars				
Left bank: 14	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Right bank: 14	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Mean: 14																				
4. Frequency of riffles	• Riffles relatively frequent • Distance between riffles divided by stream width=5-7 • Variety of habitat is key					• Occurrence of riffles infrequent • Distance between riffles divided by stream width=7-15					• Occasional riffle or run • Bottom contours provide some habitat • Distance between riffles divided by stream width=15-25					• Generally flat water, shallow riffles • Poor habitat • Distance between riffles divided by stream width=>25				
Score: 18	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
5. Channel alteration	• Changes to channel/dredging absent/minimal • Stream with normal pattern					• Some changes to channel/dredging • Evidence of past channel/dredging • Recent channel/dredging not present					• Channel changes/dredging extensive • Embankments/shoring structures present on both banks • 40-80% of reach channelized & disrupted					• Banks shored with gabion/cement • >80% of stream reach channelized or disrupted • Instream habitat altered/absent				
Score:16	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

Habitat parameter	Category Optimal					Habitat parameter					Category Optimal					Habitat parameter				
6. Sediment deposition	• Little/no islands or point bars present • <20% of bottom affected by sediment deposition					• New increase in bar formation, mostly from gravel, sand or fine sediment • 20-50% of bottom affected • Slight deposition in pools					• Some deposition of new gravel, sand or fine sediment on old & new bars • 50-80% of bottom affected • Sediment deposits at obstructions, constrictions & bends					• Heavy deposits of fine material • Increased bar development • >80% of bottom changing frequently • Pools almost absent due to sediment deposition				
Score: 20	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
7. Velocity/depth regimes	• 4 velocity/depth regimes present • Slow/deep, slow/shallow, fast/shallow, fast/deep					• 3 0f 4 velocity/depth regimes present • If fast/shallow is missing then score lower					• 2 of 4 velocity/depth regimes present • If fast/shallow or slow/shallow are missing, score low					• Dominated by 1 velocity/depth regime • Usually deep/slow				
Score: 15	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
8. Abundance & diversity of habitat	• >50% substrate favourable for invertebrate colonisation & wide variety of woody debris, riffles, root mats • Snags/ submerged logs/undercut banks/cobbles provides abundant fish cover • Must not be new or transient					• 30-50% substrate favourable for invertebrate colonisation • Snags/ submerged logs/undercut banks/cobbles • Fish cover common • Moderate variety of habitat types. Can consist of some new material					• 10-30% substrate favourable for invertebrate colonisation • Fish cover patchy • 60-90% substrate easily moved by foot • Woody debris rare or may be smothered by sediment					• <10% substrate favourable for invertebrate colonisation • Fish cover rare or absent • Substrate unstable or lacking • Stable habitats lacking or limited to macrophytes				
Score: 13	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
9. Periphyton	• Periphyton not evident on hand held stones • Stable substrate • Surfaces rough to touch					• Periphyton not visible on stones • Stable substrate • Periphyton obvious to touch					• Periphyton visible • <20% cover of available substrates					• Periphyton obvious & prolific • >20% cover of available substrates				
Score: 10	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
TOTAL SCORE: 119																				

Field Assessment Cover Form
Wadeable Hard-Bottomed and Soft-Bottomed Streams

Stream name: Waitakaruru Stream		Assessor: Peter Williams	
Site number: 1231-54	Sample number: 3	Date: 14/02/2017	Time: 8:46
GPS coordinates	Downstream:	E 1817745	N 5815748
	Upstream:	E 1817903	N 5815670

Channel & riparian features

Canopy cover:

Open	Partly shaded	Very shaded

Fencing:	Dominant riparian vegetation:	
None/ineffective	Crops	Retired vegetation
One side/partial	**Pasture**	Native shrub
Complete	**Exotic trees**	Native trees

Instream hydraulic conditions

Estimated or measured reach average:

Stream width (active channel):3.64m
Stream width (water): 2.0m
Stream depth: 0.6m
Surface velocity:

Water quality

Temperature:	19.4	°C	Conductivity:	134	µS cm^{-1}
Dissolved oxygen:	104.2	%	9.58		mg l^{-1}

Turbidity:	**Clear**	Slightly turbid	Highly turbid	Stained	Other

Stream-bottom substrata

Compaction (inorganic substrata):

Assorted sizes tightly packed &/or overlapping
Moderately packed with some overlapping
Mostly a loose assortment with little overlap
No packing/loose assortment easily moved

Embeddedness:

(% gravel-boulder particles covered by fine sediment)

<5%	**5-25%**	26-50%	51-75%	>75%

% surficial inorganic substratum size composition:

Substratum	Dimension	Percentage
Bedrock	-	
Boulder	>256mm	10
Cobble	>64-256mm	40
Gravel	>2-64mm	35
Sand	>0.06-2mm	
Silt	0.004-0.06mm	10
Clay	<0.004mm	5

Organic material (% cover)

Large wood (>10cm diameter)

<5%	**5-25%**	26-50%	51-75%	>75%

Coarse detritus (small wood, sticks, leaves etc., >1mm)

<5%	**5-25%**	26-50%	51-75%	>75%

Fine (<1mm) organic deposits

<5%	5-25%	26-50%	51-75%	>75%

Instream plant cover (% streambed area)

Filamentous algae & mats:

<5%	5-25%	26-50%	51-75%	>75%

Macrophytes:

<5%	5-25%	**26-50%**	51-75%	>75%

Mosses/liverworts:

<5%	5-25%	26-50%	51-75%	>75%

Habitat types sampled

(% of effort)

Stones:	40%		
Wood:	5%	Riffles:	20%
Macrophyte:	40%	Runs:	80%
Edges:	15%		

Number of invertebrates returned:

Koura: Y	Shrimps: N
Crabs: N	Mussels: N
Other:	
Mussel type:	
Hyridella	*Cucumerunio*

Comments:

Wadeable Hard-Bottomed Streams
Qualitative Habitat Assessment Field Data Sheet

Stream name: Waitakaruru Stream		Site number: 1231-54
Sample number: 3	Assessor: Peter Williams	Date: 14/02/2017

Habitat parameter	Category: Optimal	Suboptimal	Marginal	Poor
1. Riparian vegetative zone width	• Bankside vegetation buffer >10m • Continuous & dense	• Bankside vegetation buffer is <10m • Mostly continuous	• Pathways present and/or stock • Mostly healed over	• Breaks frequent • Human activity obvious
Left bank: 4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 **4** 3 2 1
Right bank: 4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 **4** 3 2 1
Mean: 4				
2. Vegetative protection	• Bank surfaces & immediate riparian zones covered by native vegetation • Trees, under-storey shrubs or non-woody plants present • Vegetative disruption minimal	• Bank surfaces covered mainly by native vegetation • Disruption evident • Banks may be covered by exotic forestry	• Bank surfaces covered by mixture of grasses/shrubs, blackberry, willow & introduced species • Vegetation disruption obvious • Bare soil/closely cropped vegetation common	• Bank surfaces covered by grasses & shrubs • Disruption of stream bank vegetation very high • Grass heavily grazed • Significant stock damage to bank
Left bank:9	20 19 18 17 16	15 14 13 12 11	10 **9** 8 7 6	5 4 3 2 1
Right bank:9	20 19 18 17 16	15 14 13 12 11	10 **9** 8 7 6	5 4 3 2 1
Mean: 9				
3. Bank stability	• Banks stable • Erosion/bank failure absent/minimal • <5% of bank affected	• Moderately stable • Infrequent, small areas of erosion mostly healed over • 5-30% of bank eroded	• Moderately unstable • 30-60% of bank in reach has areas of erosion • High erosion potential during floods	• Unstable • Many eroded areas • 60-100% of bank has erosional scars
Left bank:15	20 19 18 17 16	**15** 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Right bank:15	20 19 18 17 16	**15** 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Mean: 15				
4. Frequency of riffles	• Riffles relatively frequent • Distance between riffles divided by stream width=5-7 • Variety of habitat is key	• Occurrence of riffles infrequent • Distance between riffles divided by stream width=7-15	• Occasional riffle or run • Bottom contours provide some habitat • Distance between riffles divided by stream width=15-25	• Generally flat water, shallow riffles • Poor habitat • Distance between riffles divided by stream width=>25
Score: 16	20 19 18 17 **16**	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
5. Channel alteration	• Changes to channel/dredging absent/minimal • Stream with normal pattern	• Some changes to channel/dredging • Evidence of past channel/dredging • Recent channel/dredging not present	• Channel changes/dredging extensive • Embankments/shoring structures present on both banks • 40-80% of reach Channelized & disrupted	• Banks shored with gabion/cement • >80% of stream reach channelized or disrupted • Instream habitat altered/absent
Score: 18	20 19 **18** 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Habitat parameter	Category Optimal	Habitat parameter	Category Optimal	Habitat parameter
6. Sediment deposition	• Little/no islands or point bars present • <20% of bottom affected by sediment deposition	• New increase in bar formation, mostly from gravel, sand or fine sediment • 20-50% of bottom affected • Slight deposition in pools	• Some deposition of new gravel, sand or fine sediment on old & new bars • 50-80% of bottom affected • Sediment deposits at obstructions, constrictions & bends	• Heavy deposits of fine material • Increased bar development • >80% of bottom changing frequently • Pools almost absent due to sediment deposition
Score: 17	20 19 18 **17** 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7. Velocity/depth regimes	• 4 velocity/depth regimes present • Slow/deep, slow/shallow, fast/shallow, fast/deep	• 3 0f 4 velocity/depth regimes present • If fast/shallow is missing then score lower	• 2 of 4 velocity/depth regimes present • If fast/shallow or slow/shallow are missing, score low	• Dominated by 1 velocity/depth regime • Usually deep/slow
Score: 15	20 19 18 17 16	**15** 14 13 12 11	10 9 8 7 6	5 4 3 2 1
8. Abundance & diversity of habitat	• >50% substrate favourable for invertebrate colonisation & wide variety of woody debris, riffles, root mats • Snags/ submerged logs/undercut banks/cobbles provides abundant fish cover • Must not be new or transient	• 30-50% substrate favourable for invertebrate colonisation • Snags/ submerged logs/undercut banks/cobbles • Fish cover common • Moderate variety of habitat types. Can consist of some new material	• 10-30% substrate favourable for invertebrate colonisation • Fish cover patchy • 60-90% substrate easily moved by foot • Woody debris rare or may be smothered by sediment	• <10% substrate favourable for invertebrate colonisation • Fish cover rare or absent • Substrate unstable or lacking • Stable habitats lacking or limited to macrophytes
Score: 12	20 19 18 17 16	15 14 13 **12** 11	10 9 8 7 6	5 4 3 2 1
9. Periphyton	• Periphyton not evident on hand held substrates (macrophytes, wood etc.,) or fine sediments	• Periphyton not visible on substrates but obvious to touch	• Periphyton visible • <20% cover of available substrates	• Periphyton obvious & prolific • >20% cover of available substrates
Score: 19	20 **19** 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
TOTAL SCORE: 125				

Field Assessment Cover Form
Wadeable Hard-Bottomed and Soft-Bottomed Streams

Stream name: Piakonui Stream		Assessor: Kathryn Reeve	
Site number: 765-15	Sample number: 8	Date: 21/02/2017	Time: 12:30
GPS coordinates	Downstream:	E 1831220	N 5809988
	Upstream:		

Channel & riparian features

Canopy cover:

Open | Partly shaded | **Very shaded**

Fencing:	Dominant riparian vegetation:	
None/ineffective	Crops	Retired vegetation
One side/partial	Pasture	**Native shrub**
Complete	Exotic trees	**Native trees**

Instream hydraulic conditions

Estimated or measured reach average:

Stream width (active channel):

Stream width (water): 4 m

Stream depth:

Surface velocity:

Water quality

Temperature:	16.6	°C	Conductivity:	72.2	µS cm^{-1}
Dissolved oxygen:	87.1	%	8.48		mg l^{-1}

Turbidity:	**Clear**	Slightly turbid	Highly turbid	Stained	Other

Stream-bottom substrata

Compaction (inorganic substrata):

Assorted sizes tightly packed &/or overlapping

Moderately packed with some overlapping

Mostly a loose assortment with little overlap

No packing/loose assortment easily moved

Embeddedness:

(% gravel-boulder particles covered by fine sediment)

<5% | 5-25% | 26-50% | **51-75%** | >75%

% surficial inorganic substratum size composition:

Substratum	Dimension	Percentage
Bedrock	-	
Boulder	>256mm	50
Cobble	>64-256mm	25
Gravel	>2-64mm	10
Sand	>0.06-2mm	5
Silt	0.004-0.06mm	10
Clay	<0.004mm	

Organic material (% cover)

Large wood (>10cm diameter)

<5% | **5-25%** | 26-50% | 51-75% | >75%

Coarse detritus (small wood, sticks, leaves etc., >1mm)

<5% | **5-25%** | 26-50% | 51-75% | >75%

Fine (<1mm) organic deposits

<5% | 5-25% | **26-50%** | 51-75% | >75%

Habitat types sampled

(% of effort)

Stones:	80%		
Wood:	10%	Riffles:	65%
Macrophyte:	%	Runs:	35%
Edges:	10%		

Number of invertebrates returned:

Koura: Y	Shrimps: N
Crabs: N	Mussels: N
Other:	
Mussel type:	
Hyridella	*Cucumerunio*

Instream plant cover (% streambed area)

Filamentous algae & mats:

<5% | 5-25% | 26-50% | 51-75% | >75%

Macrophytes:

<5% | 5-25% | 26-50% | 51-75% | >75%

Mosses/liverworts:

<5% | 5-25% | 26-50% | **51-75%** | >75%

Comments:

Wadeable Hard-Bottomed Streams Qualitative Habitat Assessment Field Data Sheet																				
Stream name: Piakonui Stream								Site number: 753-15												
Sample number: 8						Assessor: Kathryn Reeve								Date: 21/02/2017						
Habitat parameter	Category																			
	Optimal					Suboptimal					Marginal					Poor				
1. Riparian vegetative zone width	• Bankside vegetation buffer >10m • Continuous & dense					• Bankside vegetation buffer is <10m • Mostly continuous					• Pathways present and/or stock • Mostly healed over					• Breaks frequent • Human activity obvious				
Left bank: 20	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Right bank: 20	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Mean: 20																				
2. Vegetative protection	• Bank surfaces & immediate riparian zones covered by native vegetation • Trees, under-storey shrubs or non-woody plants present • Vegetative disruption minimal					• Bank surfaces covered mainly by native vegetation • Disruption evident • Banks may be covered by exotic forestry					• Bank surfaces covered by mixture of grasses/shrubs, blackberry, willow & introduced species • Vegetation disruption obvious • Bare soil/closely cropped vegetation common					• Bank surfaces covered by grasses & shrubs • Disruption of stream bank vegetation very high • Grass heavily grazed • Significant stock damage to bank				
Left bank: 20	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Right bank: 20	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Mean: 20																				
3. Bank stability	• Banks stable • Erosion/bank failure absent/minimal • <5% of bank affected					• Moderately stable • Infrequent, small areas of erosion mostly healed over • 5-30% of bank eroded					• Moderately unstable • 30-60% of bank in reach has areas of erosion • High erosion potential during floods					• Unstable • Many eroded areas • 60-100% of bank has erosional scars				
Left bank: 19	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Right bank: 19	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Mean: 19																				
4. Frequency of riffles	• Riffles relatively frequent • Distance between riffles divided by stream width=5-7 • Variety of habitat is key					• Occurrence of riffles infrequent • Distance between riffles divided by stream width=7-15					• Occasional riffle or run • Bottom contours provide some habitat • Distance between riffles divided by stream width=15-25					• Generally flat water, shallow riffles • Poor habitat • Distance between riffles divided by stream width=>25				
Score: 19	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
5. Channel alteration	• Changes to channel/dredging absent/minimal • Stream with normal pattern					• Some changes to channel/dredging • Evidence of past channel/dredging • Recent channel/dredging not present					• Channel changes/dredging extensive • Embankments/shoring structures present on both banks • 40-80% of reach Channelized & disrupted					• Banks shored with gabion/cement • >80% of stream reach channelized or disrupted • Instream habitat altered/absent				
Score: 20	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

Habitat parameter	Category Optimal					Habitat parameter					Category Optimal					Habitat parameter				
6. Sediment deposition	• Little/no islands or point bars present • <20% of bottom affected by sediment deposition					• New increase in bar formation, mostly from gravel, sand or fine sediment • 20-50% of bottom affected • Slight deposition in pools					• Some deposition of new gravel, sand or fine sediment on old & new bars • 50-80% of bottom affected • Sediment deposits at obstructions, constrictions & bends					• Heavy deposits of fine material • Increased bar development • >80% of bottom changing frequently • Pools almost absent due to sediment deposition				
Score: 16	20	19	18	17	**16**	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
7. Velocity/depth regimes	• 4 velocity/depth regimes present • Slow/deep, slow/shallow, fast/shallow, fast/deep					• 3 0f 4 velocity/depth regimes present • If fast/shallow is missing then score lower					• 2 of 4 velocity/depth regimes present • If fast/shallow or slow/shallow are missing, score low					• Dominated by 1 velocity/depth regime • Usually deep/slow				
Score: 14	20	19	18	17	16	15	**14**	13	12	11	10	9	8	7	6	5	4	3	2	1
8. Abundance & diversity of habitat	• >50% substrate favourable for invertebrate colonisation & wide variety of woody debris, riffles, root mats • Snags/ submerged logs/undercut banks/cobbles provides abundant fish cover • Must not be new or transient					• 30-50% substrate favourable for invertebrate colonisation • Snags/ submerged logs/undercut banks/cobbles • Fish cover common • Moderate variety of habitat types. Can consist of some new material					• 10-30% substrate favourable for invertebrate colonisation • Fish cover patchy • 60-90% substrate easily moved by foot • Woody debris rare or may be smothered by sediment					• <10% substrate favourable for invertebrate colonisation • Fish cover rare or absent • Substrate unstable or lacking • Stable habitats lacking or limited to macrophytes				
Score: 15	20	19	18	17	16	**15**	14	13	12	11	10	9	8	7	6	5	4	3	2	1
9. Periphyton	• Periphyton not evident on hand held substrates (macrophytes, wood etc.,) or fine sediments					• Periphyton not visible on substrates but obvious to touch					• Periphyton visible • <20% cover of available substrates					• Periphyton obvious & prolific • >20% cover of available substrates				
Score: 20	**20**	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
TOTAL SCORE: 163																				

Field Assessment Cover Form
Wadeable Hard-Bottomed and Soft-Bottomed Streams

Stream name: Paiakarahi Stream D/S		Assessor: Peter Williams	
Site number: 718-5	Sample number: 1	Date: 13/02/2017	Time: 09:45
GPS coordinates	Downstream:	E1841027	N5867879
	Upstream:	E1841098	N5867799

Channel & riparian features

Canopy cover:

Open	Partly shaded	**Very shaded**

Fencing:	Dominant riparian vegetation:	
None/ineffective	Crops	Retired vegetation
One side/partial	Pasture	**Native shrub**
Complete	Exotic trees	**Native trees**

Instream hydraulic conditions

Estimated or measured reach average:

Stream width (active channel):
Stream width (water): 3.9m
Stream depth: 0.30m
Surface velocity: <1 m/s

Water quality

Temperature:	18.5	°C	Conductivity:	124.4	µS cm^{-1}
Dissolved oxygen:	96.7	%	9.06	mg l^{-1}	

Turbidity:	**Clear**	Slightly turbid	Highly turbid	Stained	Other

Stream-bottom substrata

Compaction (inorganic substrata):

Assorted sizes tightly packed &/or overlapping
Moderately packed with some overlapping
Mostly a loose assortment with little overlap
No packing/loose assortment easily moved

Embeddedness:

(% gravel-boulder particles covered by fine sediment)

<5%	5-25%	**26-50%**	51-75%	>75%

% surficial inorganic substratum size composition:

Substratum	Dimension	Percentage
Bedrock	-	
Boulder	>256mm	40
Cobble	>64-256mm	50
Gravel	>2-64mm	9
Sand	>0.06-2mm	1
Silt	0.004-0.06mm	
Clay	<0.004mm	

Organic material (% cover)

Large wood (>10cm diameter)

<5%	5-25%	26-50%	51-75%	>75%

Coarse detritus (small wood, sticks, leaves etc., >1mm)

<5%	**5-25%**	26-50%	51-75%	>75%

Fine (<1mm) organic deposits

<5%	5-25%	**26-50%**	51-75%	>75%

Instream plant cover (% streambed area)

Filamentous algae & mats:

<5%	**5-25%**	26-50%	51-75%	>75%

Macrophytes:

<5%	5-25%	26-50%	51-75%	>75%

Mosses/liverworts:

<5%	5-25%	26-50%	51-75%	>75%

Habitat types sampled

(% of effort)

Stones:	92%		
Wood:	%	Riffles:	71%
Macrophyte:	%	Runs:	29%
Edges:	8%		

Number of invertebrates returned:

Koura: Y	Shrimps: N
Crabs: N	Mussels: N
Other: N	
Mussel type:	
Hyridella	*Cucumerunio*

Comments:

Wadeable Hard-Bottomed Streams Qualitative Habitat Assessment Field Data Sheet																				
Stream name: Paiakarahi Stream D/S						Site number: 718-5														
Sample number: 1						Assessor: Peter Williams										Date: 13/02/2017				
Habitat parameter	Category																			
	Optimal					Suboptimal					Marginal					Poor				
1. Riparian vegetative zone width	• Bankside vegetation buffer >10m • Continuous & dense					• Bankside vegetation buffer is <10m • Mostly continuous					• Pathways present and/or stock • Mostly healed over					• Breaks frequent • Human activity obvious				
Left bank: 20	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Right bank: 19	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Mean: 19.5																				
2. Vegetative protection	• Bank surfaces & immediate riparian zones covered by native vegetation • Trees, under-storey shrubs or non-woody plants present • Vegetative disruption minimal					• Bank surfaces covered mainly by native vegetation • Disruption evident • Banks may be covered by exotic forestry					• Bank surfaces covered by mixture of grasses/shrubs, blackberry, willow & introduced species • Vegetation disruption obvious • Bare soil/closely cropped vegetation common					• Bank surfaces covered by grasses & shrubs • Disruption of stream bank vegetation very high • Grass heavily grazed • Significant stock damage to bank				
Left bank: 17	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Right bank: 15	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Mean: 16																				
3. Bank stability	• Banks stable • Erosion/bank failure absent/minimal • <5% of bank affected					• Moderately stable • Infrequent, small areas of erosion mostly healed over • 5-30% of bank eroded					• Moderately unstable • 30-60% of bank in reach has areas of erosion • High erosion potential during floods					• Unstable • Many eroded areas • 60-100% of bank has erosional scars				
Left bank: 15	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Right bank: 11	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Mean: 13																				
4. Frequency of riffles	• Riffles relatively frequent • Distance between riffles divided by stream width=5-7 • Variety of habitat is key					• Occurrence of riffles infrequent • Distance between riffles divided by stream width=7-15					• Occasional riffle or run • Bottom contours provide some habitat • Distance between riffles divided by stream width=15-25					• Generally flat water, shallow riffles • Poor habitat • Distance between riffles divided by stream width=>25				
Score: 19	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
5. Channel alteration	• Changes to channel/dredging absent/minimal • Stream with normal pattern					• Some changes to channel/dredging • Evidence of past channel/dredging • Recent channel/dredging not present					• Channel changes/dredging extensive • Embankments/shoring structures present on both banks • 40-80% of reach Channelized & disrupted					• Banks shored with gabion/cement • >80% of stream reach channelized or disrupted • Instream habitat altered/absent				
Score: 20	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

Habitat parameter	Category					Habitat parameter					Category					Habitat parameter				
	Optimal										Optimal									
6. Sediment deposition	• Little/no islands or point bars present • <20% of bottom affected by sediment deposition					• New increase in bar formation, mostly from gravel, sand or fine sediment • 20-50% of bottom affected • Slight deposition in pools					• Some deposition of new gravel, sand or fine sediment on old & new bars • 50-80% of bottom affected • Sediment deposits at obstructions, constrictions & bends					• Heavy deposits of fine material • Increased bar development • >80% of bottom changing frequently • Pools almost absent due to sediment deposition				
Score: 18	20	19	**18**	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
7. Velocity/depth regimes	• 4 velocity/depth regimes present • Slow/deep, slow/shallow, fast/shallow, fast/deep					• 3 0f 4 velocity/depth regimes present • If fast/shallow is missing then score lower					• 2 of 4 velocity/depth regimes present • If fast/shallow or slow/shallow are missing, score low					• Dominated by 1 velocity/depth regime • Usually deep/slow				
Score: 17	20	19	18	**17**	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
8. Abundance & diversity of habitat	• >50% substrate favourable for invertebrate colonisation & wide variety of woody debris, riffles, root mats • Snags/ submerged logs/undercut banks/cobbles provides abundant fish cover • Must not be new or transient					• 30-50% substrate favourable for invertebrate colonisation • Snags/ submerged logs/undercut banks/cobbles • Fish cover common • Moderate variety of habitat types. Can consist of some new material					• 10-30% substrate favourable for invertebrate colonisation • Fish cover patchy • 60-90% substrate easily moved by foot • Woody debris rare or may be smothered by sediment					• <10% substrate favourable for invertebrate colonisation • Fish cover rare or absent • Substrate unstable or lacking • Stable habitats lacking or limited to macrophytes				
Score: 16	20	19	18	17	**16**	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
9. Periphyton	• Periphyton not evident on hand held substrates (macrophytes, wood etc.,) or fine sediments					• Periphyton not visible on substrates but obvious to touch					• Periphyton visible • <20% cover of available substrates					• Periphyton obvious & prolific • >20% cover of available substrates				
Score: 6	20	19	18	17	16	15	14	13	12	11	10	9	8	7	**6**	5	4	3	2	1
TOTAL SCORE: 144.5																				

Field Assessment Cover Form
Wadeable Hard-Bottomed and Soft-Bottomed Streams

Stream name: Karengorengo Stream		Assessor: Kathryn Reeve	
Site number: 232-3	Sample number: 9	Date: 21/02/2017	Time: 15:20
GPS coordinates	Downstream:	E 1848393	N 5823235
	Upstream:	E 1848423	N 5823069

Channel & riparian features

Canopy cover:

Open	Partly shaded	Very shaded

Fencing:	Dominant riparian vegetation:	
None/ineffective	Crops	Retired vegetation
One side/partial	**Pasture**	Native shrub
Complete	**Exotic trees**	Native trees

Instream hydraulic conditions

Estimated or measured reach average:

Stream width (active channel): 2.9 m
Stream width (water): 1.5 m
Stream depth: 0.37m
Surface velocity: m s^{-1}

Water quality

Temperature:	19.0	°C	Conductivity:	191.4	µS cm^{-1}
Dissolved oxygen:	85.4	%	7.92	mg l^{-1}	

Turbidity:	**Clear**	Slightly turbid	Highly turbid	Stained	Other

Stream-bottom substrata

Compaction (inorganic substrata):

Assorted sizes tightly packed &/or overlapping
Moderately packed with some overlapping
Mostly a loose assortment with little overlap
No packing/loose assortment easily moved

Embeddedness:

(% gravel-boulder particles covered by fine sediment)

<5%	5-25%	26-50%	51-75%	>75%

% surficial inorganic substratum size composition:

Substratum	Dimension	Percentage
Bedrock	-	
Boulder	>256mm	
Cobble	>64-256mm	
Gravel	>2-64mm	10
Sand	>0.06-2mm	80
Silt	0.004-0.06mm	10
Clay	<0.004mm	

Organic material (% cover)

Large wood (>10cm diameter)

<5%	5-25%	26-50%	51-75%	>75%

Coarse detritus (small wood, sticks, leaves etc., >1mm)

<5%	5-25%	26-50%	51-75%	>75%

Fine (<1mm) organic deposits

<5%	5-25%	26-50%	51-75%	>75%

Habitat types sampled

(% of effort)

Stones:	%		
Wood:	5%	Riffles:	%
Macrophyte:	95%	Runs:	100%
Edges:	%		

Number of invertebrates returned:

Koura: Y	Shrimps: N
Crabs: N	Mussels: N
Other:	
Mussel type:	
Hyridella	*Cucumerunio*

Instream plant cover (% streambed area)

Filamentous algae & mats:

<5%	5-25%	26-50%	51-75%	>75%

Macrophytes:

<5%	5-25%	26-50%	51-75%	**>75%**

Mosses/liverworts:

<5%	5-25%	26-50%	51-75%	>75%

Wadeable Soft-Bottomed Streams Qualitative Habitat Assessment Field Data Sheet																					
Stream name: Karengorengo Stream						Site number: 232-3															
Sample number: 9						Assessor: Kathryn Reeve										Date: 21/02/2017					
Habitat parameter	Category																				
	Optimal					Suboptimal					Marginal					Poor					
1. Riparian vegetative zone width	• Bankside vegetation buffer >10m • Continuous & dense					• Bankside vegetation buffer is <10m • Mostly continuous					• Pathways present and/or stock • Mostly healed over					• Breaks frequent • Human activity obvious					
Left bank: 16	20	19	18	17	**16**	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
Right bank: 16	20	19	18	17	**16**	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
Mean: 16																					
2. Vegetative protection	• Bank surfaces & immediate riparian zones covered by native vegetation • Trees, under-storey shrubs or non-woody plants present • Vegetative disruption minimal					• Bank surfaces covered mainly by native vegetation • Disruption evident • Banks may be covered by exotic forestry					• Bank surfaces covered by mixture of grasses/shrubs, blackberry, willow & introduced species • Vegetation disruption obvious • Bare soil/closely cropped vegetation common					• Bank surfaces covered by grasses & shrubs • Disruption of stream bank vegetation very high • Grass heavily grazed • Significant stock damage to bank					
Left bank: 9	20	19	18	17	16	15	14	13	12	11	10	**9**	8	7	6	5	4	3	2	1	
Right bank: 9	20	19	18	17	16	15	14	13	12	11	10	**9**	8	7	6	5	4	3	2	1	
Mean: 9																					
3. Bank stability	• Banks stable • Erosion/bank failure absent/minimal • <5% of bank affected					• Moderately stable • Infrequent, small areas of erosion mostly healed over • 5-30% of bank eroded					• Moderately unstable • 30-60% of bank in reach has areas of erosion • High erosion potential during floods					• Unstable • Many eroded areas • 60-100% of bank has erosional scars					
Left bank: 13	20	19	18	17	16	15	14	**13**	12	11	10	9	8	7	6	5	4	3	2	1	
Right bank: 13	20	19	18	17	16	15	14	**13**	12	11	10	9	8	7	6	5	4	3	2	1	
Mean: 13																					
4. Channel sinuosity	• Bends increase stream length 3-4 times longer than if it was straight					• Bends increase stream length 2-3 times longer than if it was straight					• Bends increase stream length 1-2 times longer than if it was straight					• Channel straight					
Score: 10	20	19	18	17	16	15	14	13	12	11	**10**	9	8	7	6	5	4	3	2	1	
5. Channel alteration	• Changes to channel/dredging absent/minimal • Stream with normal pattern					• Some changes to channel/dredging • Evidence of past channel/dredging • Recent channel/dredging not present					• Channel changes/dredging extensive • Embankments/shoring structures present on both banks • 40-80% of reach channelized & disrupted					• Banks shored with gabion/cement • >80% of stream reach channelized or disrupted • Instream habitat altered/absent					
Score:19	20	**19**	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	

Habitat parameter	Category					Habitat parameter					Category					Habitat parameter				
	Optimal										Optimal									
6. Sediment deposition	• Little/no islands or point bars present • <20% of bottom affected by sediment deposition					• New increase in bar formation, mostly from gravel, sand or fine sediment • 20-50% of bottom affected • Slight deposition in pools					• Some deposition of new gravel, sand or fine sediment on old & new bars • 50-80% of bottom affected • Sediment deposits at obstructions, constrictions & bends					• Heavy deposits of fine material • Increased bar development • >80% of bottom changing frequently • Pools almost absent due to sediment deposition				
Score: 14	20	19	18	17	16	15	**14**	13	12	11	10	9	8	7	6	5	4	3	2	1
7. Pool variability	• Pools evenly mixed • Large/shallow, large/deep, small/shallow, small/deep					• Majority of pools large/deep • Very few shallow pools					• Prevalence of shallow pools					• Majority of pools small/shallow				
Score: 15	20	19	18	17	16	**15**	14	13	12	11	10	9	8	7	6	5	4	3	2	1
8. Abundance & diversity of habitat	• >50% substrate favourable for invertebrate colonisation & wide variety of woody debris, riffles, root mats • Snags/ submerged logs/undercut banks/cobbles provides abundant fish cover • Must not be new or transient					• 30-50% substrate favourable for invertebrate colonisation • Snags/ submerged logs/undercut banks/cobbles • Fish cover common • Moderate variety of habitat types. Can consist of some new material					• 10-30% substrate favourable for invertebrate colonisation • Fish cover patchy • 60-90% substrate easily moved by foot • Woody debris rare or may be smothered by sediment					• <10% substrate favourable for invertebrate colonisation • Fish cover rare or absent • Substrate unstable or lacking • Stable habitats lacking or limited to macrophytes				
Score: 12	20	19	18	17	16	15	14	13	**12**	11	10	9	8	7	6	5	4	3	2	1
9. Periphyton	• Periphyton not evident on hand held stones • Stable substrate • Surfaces rough to touch					• Periphyton not visible on stones • Stable substrate • Periphyton obvious to touch					• Periphyton visible • <20% cover of available substrates					• Periphyton obvious & prolific • >20% cover of available substrates				
Score: 19	20	**19**	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
TOTAL SCORE: 127																				

Field Assessment Cover Form
Wadeable Hard-Bottomed and Soft-Bottomed Streams

Stream name: Wairere Stream		Assessor: Peter Williams	
Site number: 1224-5	Sample number: 5	Date: 15/02/2017	Time: 14:30
GPS coordinates	Downstream:	E 2742184	N 6365455
	Upstream:	E 2742094	N 6365394

Channel & riparian features

Canopy cover:

Open | **Partly shaded** | Very shaded

Fencing:	Dominant riparian vegetation:	
None/ineffective	Crops	Retired vegetation
One side/partial	**Pasture**	**Native shrub**
Complete	**Exotic trees**	Native trees

Instream hydraulic conditions

Estimated or measured reach average:

Stream width (active channel):
Stream width (water): 5.7m
Stream depth: 0.3m
Surface velocity: 1-2 m/s

Water quality

Temperature:	16.6	°C	Conductivity:	64.9	µS cm^{-1}
Dissolved oxygen:	89.2	%	8.69		mg l^{-1}

Turbidity:	**Clear**	Slightly turbid	Highly turbid	Stained	Other

Stream-bottom substrata

Compaction (inorganic substrata):

Assorted sizes tightly packed &/or overlapping
Moderately packed with some overlapping
Mostly a loose assortment with little overlap
No packing/loose assortment easily moved

Embeddedness:

(% gravel-boulder particles covered by fine sediment)

<5% | **5-25%** | 26-50% | 51-75% | >75%

% surficial inorganic substratum size composition:

Substratum	Dimension	Percentage
Bedrock	-	
Boulder	>256mm	2
Cobble	>64-256mm	65
Gravel	>2-64mm	25
Sand	>0.06-2mm	7
Silt	0.004-0.06mm	1
Clay	<0.004mm	

Organic material (% cover)

Large wood (>10cm diameter)

<5% | 5-25% | 26-50% | 51-75% | >75%

Coarse detritus (small wood, sticks, leaves etc., >1mm)

<5% | 5-25% | 26-50% | 51-75% | >75%

Fine (<1mm) organic deposits

<5% | **5-25%** | 26-50% | 51-75% | >75%

Habitat types sampled

(% of effort)

Stones:	90%		
Wood:	%	Riffles:	50%
Macrophyte:	%	Runs:	40%
Edges:	10%		

Number of invertebrates returned:

Koura: Y	Shrimps: Y
Crabs: N	Mussels: N
Other:	
Mussel type:	
Hyridella	*Cucumerunio*

Instream plant cover (% streambed area)

Filamentous algae & mats:

<5% | 5-25% | 26-50% | **51-75%** | >75%

Macrophytes:

<5% | 5-25% | 26-50% | 51-75% | >75%

Mosses/liverworts:

<5% | 5-25% | 26-50% | 51-75% | >75%

Wadeable Hard-Bottomed Streams Qualitative Habitat Assessment Field Data Sheet																				
Stream name: Wairere stream										Site number: 1224-5										
Sample number: 5						Assessor: Peter Williams									Date: 15/02/2017					
Habitat parameter	Category																			
	Optimal					Suboptimal					Marginal					Poor				
1. Riparian vegetative zone width	• Bankside vegetation buffer >10m • Continuous & dense					• Bankside vegetation buffer is <10m • Mostly continuous					• Pathways present and/or stock • Mostly healed over					• Breaks frequent • Human activity obvious				
Left bank: 11	20	19	18	17	16	15	14	13	12	**11**	10	9	8	7	6	5	4	3	2	1
Right bank: 20	**20**	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Mean: 15.5																				
2. Vegetative protection	• Bank surfaces & immediate riparian zones covered by native vegetation • Trees, under-storey shrubs or non-woody plants present • Vegetative disruption minimal					• Bank surfaces covered mainly by native vegetation • Disruption evident • Banks may be covered by exotic forestry					• Bank surfaces covered by mixture of grasses/shrubs, blackberry, willow & introduced species • Vegetation disruption obvious • Bare soil/closely cropped vegetation common					• Bank surfaces covered by grasses & shrubs • Disruption of stream bank vegetation very high • Grass heavily grazed • Significant stock damage to bank				
Left bank: 6	20	19	18	17	16	15	14	13	12	11	10	9	8	7	**6**	5	4	3	2	1
Right bank: 10	20	19	18	17	16	15	14	13	12	11	**10**	9	8	7	6	5	4	3	2	1
Mean: 8																				
3. Bank stability	• Banks stable • Erosion/bank failure absent/minimal • <5% of bank affected					• Moderately stable • Infrequent, small areas of erosion mostly healed over • 5-30% of bank eroded					• Moderately unstable • 30-60% of bank in reach has areas of erosion • High erosion potential during floods					• Unstable • Many eroded areas • 60-100% of bank has erosional scars				
Left bank: 15	20	19	18	17	16	**15**	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Right bank: 18	20	19	**18**	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Mean: 16.5																				
4. Frequency of riffles	• Riffles relatively frequent • Distance between riffles divided by stream width=5-7 • Variety of habitat is key					• Occurrence of riffles infrequent • Distance between riffles divided by stream width=7-15					• Occasional riffle or run • Bottom contours provide some habitat • Distance between riffles divided by stream width=15-25					• Generally flat water, shallow riffles • Poor habitat • Distance between riffles divided by stream width=>25				
Score: 18	20	19	**18**	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
5. Channel alteration	• Changes to channel/dredging absent/minimal • Stream with normal pattern					• Some changes to channel/dredging • Evidence of past channel/dredging • Recent channel/dredging not present					• Channel changes/dredging extensive • Embankments/shoring structures present on both banks • 40-80% of reach channelized & disrupted					• Banks shored with gabion/cement • >80% of stream reach channelized or disrupted • Instream habitat altered/absent				
Score: 20	**20**	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

Habitat parameter	Category Optimal					Habitat parameter					Category Optimal					Habitat parameter				
6. Sediment deposition	• Little/no islands or point bars present • <20% of bottom affected by sediment deposition					• New increase in bar formation, mostly from gravel, sand or fine sediment • 20-50% of bottom affected • Slight deposition in pools					• Some deposition of new gravel, sand or fine sediment on old & new bars • 50-80% of bottom affected • Sediment deposits at obstructions, constrictions & bends					• Heavy deposits of fine material • Increased bar development • >80% of bottom changing frequently • Pools almost absent due to sediment deposition				
Score: 19	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
7. Velocity/depth regimes	• 4 velocity/depth regimes present • Slow/deep, slow/shallow, fast/shallow, fast/deep					• 3 0f 4 velocity/depth regimes present • If fast/shallow is missing then score lower					• 2 of 4 velocity/depth regimes present • If fast/shallow or slow/shallow are missing, score low					• Dominated by 1 velocity/depth regime • Usually deep/slow				
Score: 14	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
8. Abundance & diversity of habitat	• >50% substrate favourable for invertebrate colonisation & wide variety of woody debris, riffles, root mats • Snags/ submerged logs/undercut banks/cobbles provides abundant fish cover • Must not be new or transient					• 30-50% substrate favourable for invertebrate colonisation • Snags/ submerged logs/undercut banks/cobbles • Fish cover common • Moderate variety of habitat types. Can consist of some new material					• 10-30% substrate favourable for invertebrate colonisation • Fish cover patchy • 60-90% substrate easily moved by foot • Woody debris rare or may be smothered by sediment					• <10% substrate favourable for invertebrate colonisation • Fish cover rare or absent • Substrate unstable or lacking • Stable habitats lacking or limited to macrophytes				
Score: 11	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
9. Periphyton	• Periphyton not evident on hand held stones • Stable substrate • Surfaces rough to touch					• Periphyton not visible on stones • Stable substrate • Periphyton obvious to touch					• Periphyton visible • <20% cover of available substrates					• Periphyton obvious & prolific • >20% cover of available substrates				
Score: 2	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
TOTAL SCORE 124																				

Field Assessment Cover Form
Wadeable Hard-Bottomed and Soft-Bottomed Streams

Stream name: Waiteariki stream		Assessor: Kathryn Reeve	
Site number: 1430-10	Sample number: 10	Date: 22/02/2017	Time: 12:15
GPS coordinates	Downstream:	E 1852566	N 5818150
	Upstream:	E 1852697	N 5818212

Channel & riparian features

Canopy cover:

Open	**Partly shaded**	Very shaded

Fencing:	Dominant riparian vegetation:	
None/ineffective	Crops	Retired vegetation
One side/partial	**Pasture**	Native shrub
Complete	Exotic trees	**Native trees**

Instream hydraulic conditions

Estimated or measured reach average:

Stream width (active channel):
Stream width (water): 7.9 m
Stream depth:
Surface velocity:

Water quality

Temperature:	14.2	°C	Conductivity:	38.3	µS cm^{-1}
Dissolved oxygen:	102.2	%	10.46		mg l^{-1}

Turbidity:	**Clear**	Slightly turbid	Highly turbid	Stained	Other

Stream-bottom substrata

Compaction (inorganic substrata):

Assorted sizes tightly packed &/or overlapping
Moderately packed with some overlapping
Mostly a loose assortment with little overlap
No packing/loose assortment easily moved

Embeddedness:
(% gravel-boulder particles covered by fine sediment)

<5%	5-25%	26-50%	51-75%	>75%

% surficial inorganic substratum size composition:

Substratum	Dimension	Percentage
Bedrock	-	
Boulder	>256mm	50
Cobble	>64-256mm	30
Gravel	>2-64mm	20
Sand	>0.06-2mm	
Silt	0.004-0.06mm	
Clay	<0.004mm	

Organic material (% cover)

Large wood (>10cm diameter)

<5%	5-25%	26-50%	51-75%	>75%

Coarse detritus (small wood, sticks, leaves etc., >1mm)

<5%	5-25%	26-50%	51-75%	>75%

Fine (<1mm) organic deposits

<5%	5-25%	26-50%	51-75%	>75%

Habitat types sampled

(% of effort)

Stones:	80%		
Wood:	%	Riffles:	80%
Macrophyte:	%	Runs:	20%
Edges:	20%		

Instream plant cover (% streambed area)

Filamentous algae & mats:

<5%	5-25%	26-50%	51-75%	>75%

Macrophytes:

<5%	5-25%	26-50%	51-75%	>75%

Mosses/liverworts:

<5%	5-25%	26-50%	51-75%	>75%

Number of invertebrates returned:

Koura: Y	Shrimps: Y
Crabs: N	Mussels: N
Other:	
Mussel type:	
Hyridella	*Cucumerunio*

Comments:

Wadeable Hard-Bottomed Streams
Qualitative Habitat Assessment Field Data Sheet

Stream name: Waiteariki Stream	Site number: 1430-10	
Sample number: 10	Assessor: Kathryn Reeve	Date: 22/02/2017

Habitat parameter	Category: Optimal	Suboptimal	Marginal	Poor
1. Riparian vegetative zone width	• Bankside vegetation buffer >10m • Continuous & dense	• Bankside vegetation buffer is <10m • Mostly continuous	• Pathways present and/or stock • Mostly healed over	• Breaks frequent • Human activity obvious
Left bank: 16	20 19 18 17 **16**	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Right bank: 11	20 19 18 17 16	15 14 13 12 **11**	10 9 8 7 6	5 4 3 2 1
Mean: 13.5				
2. Vegetative protection	• Bank surfaces & immediate riparian zones covered by native vegetation • Trees, under-storey shrubs or non-woody plants present • Vegetative disruption minimal	• Bank surfaces covered mainly by native vegetation • Disruption evident • Banks may be covered by exotic forestry	• Bank surfaces covered by mixture of grasses/shrubs, blackberry, willow & introduced species • Vegetation disruption obvious • Bare soil/closely cropped vegetation common	• Bank surfaces covered by grasses & shrubs • Disruption of stream bank vegetation very high • Grass heavily grazed • Significant stock damage to bank
Left bank: 19	20 **19** 18 17 16	15 14 13 12 11	10 9 **8** 7 6	5 4 3 2 1
Right bank: 8	20 19 18 17 16	15 14 13 12 11	10 9 **8** 7 6	5 4 3 2 1
Mean: 13.5				
3. Bank stability	• Banks stable • Erosion/bank failure absent/minimal • <5% of bank affected	• Moderately stable • Infrequent, small areas of erosion mostly healed over • 5-30% of bank eroded	• Moderately unstable • 30-60% of bank in reach has areas of erosion • High erosion potential during floods	• Unstable • Many eroded areas • 60-100% of bank has erosional scars
Left bank:18	20 19 **18** 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Right bank:18	20 19 **18** 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
Mean: 18				
4. Frequency of riffles	• Riffles relatively frequent • Distance between riffles divided by stream width=5-7 • Variety of habitat is key	• Occurrence of riffles infrequent • Distance between riffles divided by stream width=7-15	• Occasional riffle or run • Bottom contours provide some habitat • Distance between riffles divided by stream width=15-25	• Generally flat water, shallow riffles • Poor habitat • Distance between riffles divided by stream width=>25
Score: 19	20 **19** 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
5. Channel alteration	• Changes to channel/dredging absent/minimal • Stream with normal pattern	• Some changes to channel/dredging • Evidence of past channel/dredging • Recent channel/dredging not present	• Channel changes/dredging extensive • Embankments/shoring structures present on both banks • 40-80% of reach Channelized & disrupted	• Banks shored with gabion/cement • >80% of stream reach channelized or disrupted • Instream habitat altered/absent
Score: 20	**20** 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Habitat parameter	Category Optimal	Habitat parameter	Category Optimal	Habitat parameter
6. Sediment deposition	• Little/no islands or point bars present • <20% of bottom affected by sediment deposition	• New increase in bar formation, mostly from gravel, sand or fine sediment • 20-50% of bottom affected • Slight deposition in pools	• Some deposition of new gravel, sand or fine sediment on old & new bars • 50-80% of bottom affected • Sediment deposits at obstructions, constrictions & bends	• Heavy deposits of fine material • Increased bar development • >80% of bottom changing frequently • Pools almost absent due to sediment deposition
Score: 20	**20** 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7. Velocity/depth regimes	• 4 velocity/depth regimes present • Slow/deep, slow/shallow, fast/shallow, fast/deep	• 3 0f 4 velocity/depth regimes present • If fast/shallow is missing then score lower	• 2 of 4 velocity/depth regimes present • If fast/shallow or slow/shallow are missing, score low	• Dominated by 1 velocity/depth regime • Usually deep/slow
Score: 9	20 19 18 17 16	15 14 13 12 11	10 **9** 8 7 6	5 4 3 2 1
8. Abundance & diversity of habitat	• >50% substrate favourable for invertebrate colonisation & wide variety of woody debris, riffles, root mats • Snags/ submerged logs/undercut banks/cobbles provides abundant fish cover • Must not be new or transient	• 30-50% substrate favourable for invertebrate colonisation • Snags/ submerged logs/undercut banks/cobbles • Fish cover common • Moderate variety of habitat types. Can consist of some new material	• 10-30% substrate favourable for invertebrate colonisation • Fish cover patchy • 60-90% substrate easily moved by foot • Woody debris rare or may be smothered by sediment	• <10% substrate favourable for invertebrate colonisation • Fish cover rare or absent • Substrate unstable or lacking • Stable habitats lacking or limited to macrophytes
Score: 17	20 19 18 **17** 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
9. Periphyton	• Periphyton not evident on hand held substrates (macrophytes, wood etc.,) or fine sediments	• Periphyton not visible on substrates but obvious to touch	• Periphyton visible • <20% cover of available substrates	• Periphyton obvious & prolific • >20% cover of available substrates
Score: 18	20 19 **18** 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
TOTAL SCORE: 148				

Field Assessment Cover Form
Wadeable Hard-Bottomed and Soft-Bottomed Streams

Stream name: Waitawheta River		Assessor: Peter Williams	
Site number: 1235-11	Sample number: 2	Date: 13/02/2017	Time: 15:00
GPS coordinates	Downstream:	E 1845480	N 5849622
	Upstream:	E 1845388	N 5849622

Channel & riparian features

Canopy cover:

Open | **Partly shaded** | Very shaded

Fencing:	Dominant riparian vegetation:	
None/ineffective	Crops	Retired vegetation
One side/partial	**Pasture**	**Native shrub**
Complete	Exotic trees	Native trees

Instream hydraulic conditions

Estimated or measured reach average:

Stream width (active channel): 5.1m
Stream width (water): 3.35m
Stream depth: 0.13m
Surface velocity:

Water quality

Temperature:	18.3	°C	Conductivity:	66.8	µS cm^{-1}
Dissolved oxygen:	93.1	%	8.62		mg l^{-1}

Turbidity:	**Clear**	Slightly turbid	Highly turbid	Stained	Other

Stream-bottom substrata

Compaction (inorganic substrata):

Assorted sizes tightly packed &/or overlapping
Moderately packed with some overlapping
Mostly a loose assortment with little overlap
No packing/loose assortment easily moved

Embeddedness:

(% gravel-boulder particles covered by fine sediment)

<5%	5-25%	26-50%	51-75%	>75%

% surficial inorganic substratum size composition:

Substratum	Dimension	Percentage
Bedrock	-	
Boulder	>256mm	15
Cobble	>64-256mm	70
Gravel	>2-64mm	10
Sand	>0.06-2mm	5
Silt	0.004-0.06mm	
Clay	<0.004mm	

Organic material (% cover)

Large wood (>10cm diameter)

<5%	5-25%	26-50%	51-75%	>75%

Coarse detritus (small wood, sticks, leaves etc.,. >1mm)

<5%	**5-25%**	26-50%	51-75%	>75%

Fine (<1mm) organic deposits

<5%	5-25%	26-50%	51-75%	>75%

Habitat types sampled

(% of effort)

Stones:	90%		
Wood:	%	Riffles:	70%
Macrophyte:	%	Runs:	30%
Edges:	10%		

Number of invertebrates returned:

Koura: Y	Shrimps: N
Crabs: N	Mussels: N
Other:	
Mussel type:	

Instream plant cover (% streambed area)

Filamentous algae & mats:

<5%	5-25%	26-50%	51-75%	>75%

Macrophytes:

<5%	5-25%	26-50%	51-75%	>75%

Mosses/liverworts:

<5%	5-25%	26-50%	51-75%	>75%

Comments:

Wadeable Hard-Bottomed Streams
Qualitative Habitat Assessment Field Data Sheet

Stream name: Waitawheta River	Site number: 1235-11	
Sample number: 2	Assessor: Peter Williams	Date: 13/02/2017

Habitat parameter	Category				
	Optimal	Suboptimal	Marginal	Poor	
1. Riparian vegetative zone width	• Bankside vegetation buffer >10m • Continuous & dense	• Bankside vegetation buffer is <10m • Mostly continuous	• Pathways present and/or stock • Mostly healed over	• Breaks frequent • Human activity obvious	
Left bank: 16	20 19 18 17 **16**	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1	
Right bank: 13	20 19 18 17 16	15 14 **13** 12 11	10 9 8 7 6	5 4 3 2 1	
Mean: 14.5					
2. Vegetative protection	• Bank surfaces & immediate riparian zones covered by native vegetation • Trees, under-storey shrubs or non-woody plants present • Vegetative disruption minimal	• Bank surfaces covered mainly by native vegetation • Disruption evident • Banks may be covered by exotic forestry	• Bank surfaces covered by mixture of grasses/shrubs, blackberry, willow & introduced species • Vegetation disruption obvious • Bare soil/closely cropped vegetation common	• Bank surfaces covered by grasses & shrubs • Disruption of stream bank vegetation very high • Grass heavily grazed • Significant stock damage to bank	
Left bank: 14	20 19 18 17 16	15 **14** 13 12 11	10 9 8 7 6	5 4 3 2 1	
Right bank: 15	20 19 18 17 16	**15** 14 13 12 11	10 9 8 7 6	5 4 3 2 1	
Mean: 14.5					
3. Bank stability	• Banks stable • Erosion/bank failure absent/minimal • <5% of bank affected	• Moderately stable • Infrequent, small areas of erosion mostly healed over • 5-30% of bank eroded	• Moderately unstable • 30-60% of bank in reach has areas of erosion • High erosion potential during floods	• Unstable • Many eroded areas • 60-100% of bank has erosional scars	
Left bank: 17	20 19 18 **17** 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1	
Right bank: 18	20 19 **18** 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1	
Mean: 17.5					
4. Frequency of riffles	• Riffles relatively frequent • Distance between riffles divided by stream width=5-7 • Variety of habitat is key	• Occurrence of riffles infrequent • Distance between riffles divided by stream width=7-15	• Occasional riffle or run • Bottom contours provide some habitat • Distance between riffles divided by stream width=15-25	• Generally flat water, shallow riffles • Poor habitat • Distance between riffles divided by stream width=>25	
Score: 19	20 **19** 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1	
5. Channel alteration	• Changes to channel/dredging absent/minimal • Stream with normal pattern	• Some changes to channel/dredging • Evidence of past channel/dredging • Recent channel/dredging not present	• Channel changes/dredging extensive • Embankments/shoring structures present on both banks • 40-80% of reach channelized & disrupted	• Banks shored with gabion/cement • >80% of stream reach channelized or disrupted • Instream habitat altered/absent	
Score: 20	**20** 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1	

Habitat parameter	Category Optimal	Habitat parameter	Category Optimal	Habitat parameter
6. Sediment deposition	• Little/no islands or point bars present • <20% of bottom affected by sediment deposition	• New increase in bar formation, mostly from gravel, sand or fine sediment • 20-50% of bottom affected • Slight deposition in pools	• Some deposition of new gravel, sand or fine sediment on old & new bars • 50-80% of bottom affected • Sediment deposits at obstructions, constrictions & bends	• Heavy deposits of fine material • Increased bar development • >80% of bottom changing frequently • Pools almost absent due to sediment deposition
Score: 20	**20** 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7. Velocity/depth regimes	• 4 velocity/depth regimes present • Slow/deep, slow/shallow, fast/shallow, fast/deep	• 3 0f 4 velocity/depth regimes present • If fast/shallow is missing then score lower	• 2 of 4 velocity/depth regimes present • If fast/shallow or slow/shallow are missing, score low	• Dominated by 1 velocity/depth regime • Usually deep/slow
Score: 15	20 19 18 17 16	**15** 14 13 12 11	10 9 8 7 6	5 4 3 2 1
8. Abundance & diversity of habitat	• >50% substrate favourable for invertebrate colonisation & wide variety of woody debris, riffles, root mats • Snags/ submerged logs/undercut banks/cobbles provides abundant fish cover • Must not be new or transient	• 30-50% substrate favourable for invertebrate colonisation • Snags/ submerged logs/undercut banks/cobbles • Fish cover common • Moderate variety of habitat types. Can consist of some new material	• 10-30% substrate favourable for invertebrate colonisation • Fish cover patchy • 60-90% substrate easily moved by foot • Woody debris rare or may be smothered by sediment	• <10% substrate favourable for invertebrate colonisation • Fish cover rare or absent • Substrate unstable or lacking • Stable habitats lacking or limited to macrophytes
Score: 13	20 19 18 17 16	15 14 **13** 12 11	10 9 8 7 6	5 4 3 2 1
9. Periphyton	• Periphyton not evident on hand held stones • Stable substrate • Surfaces rough to touch	• Periphyton not visible on stones • Stable substrate • Periphyton obvious to touch	• Periphyton visible • <20% cover of available substrates	• Periphyton obvious & prolific • >20% cover of available substrates
Score: 8	20 19 18 17 16	15 14 13 12 11	10 9 **8** 7 6	5 4 3 2 1
TOTAL SCORE: 141.5				

Appendix B Fish surveys

Fish collection form – Wadeable streams/rivers

Team members: Kathryn Reeve, Peter Williams, Mike Martin, Elizabeth Graham	GPS (d/s): E1818698 N5838814	Site: Mangakahika Stream				Date: 14/02/2017
	GPS (u/s): E1818618 N5838767	Not fished	Fished none collected	Fished 10 sub-reaches	Fished 5-9 sub-reaches	Fished <5 sub-reaches	FLAG for fished/not fished

Fish sample id: P.W.	Total shock time (min): 54	Fishing time: Start 12:48 Finish 15:15	Sample distance (m): 150	Wetted width (m):	A	2.6	C	1.9	E	0.5	G	1.7	I	2.5
					B	2.1	D	0.6	F	2.4	H	2.1	J	2.0

Sampling gear: Spotlight	EFM	Seine	Length (m) / Mesh (mm)	Water visibility:	Good	Average	Poor	Water temp. (°C): 18.5	Conductivity (µS): 176.8
EFM anode: Big / Small	EFM volts (x100): 3	EFM pulse rate (Hz or pps): 60	EFM pulse width (ms): 2	Spotlight (watts):

Species	Sub-reach tally										Total count	Sample count	Length (mm)		FLAG
	A	B	C	D	E	F	G	H	I	J			Min.	Max.	
C. bully	9	5	7	4	2	7	24	8	9	2	77		25	69	
Banded kokopu	1		2	4	1		4	6			18		52	226	
Shortfin eel	1	4	1	2	1	1	3	7	2	5	27		107	370	
Longfin eel				1	1				2		4		302	603	
Inanga							1		1		2		125	125	
Koura	1	1								1	3				
Unidentified eel	1	1		1	1	1		1	2	1	9				
Total	13	11	10	12	6	9	32	22	16	9	140				

FLAG	Comment	FLAG	Comment
	Water level very low compared to previous years		Missed bully total: 21 (included in count)
			Missed eel total: 9 (included in count as “unidentified eels”)

Fish collection form – Wadeable streams/rivers

Team members: Kathryn Reeve, Mike Martin, Kit Squires, Elizabeth Graham, Gareth van Assema	GPS (d/s): E 1831914 N 5803819 GPS (u/s): E 1831878 N 5803808	Site: Waitoa Stream 1249-121	Date: 20/02/2017	

Not fished	Fished none collected	Fished 10 sub-reaches	Fished 5-9 sub-reaches	Fished <5 sub-reaches	FLAG for fished/not fished

Fish sample id: K.R.	Total shock time (min): 50	Fishing time: Start 9:09 Finish 11:03	Sample distance (m): 150	Wetted width (m):	A	1.5	C	2.5	E	1.7	G	2.2	I	1.4
					B	2.1	D	3.4	F	2.2	H	1.1	J	2.1

Sampling gear:	Spotlight	EFM	Seine	Length (m) / Mesh (mm)	Water visibility:	Good	Average	Poor	Water temp. (°C): 19		Conductivity (µS): 109.2	

EFM anode: Big / Small	EFM volts (x100): 3	EFM pulse rate (Hz or pps): 60	EFM pulse width (ms): 2	Spotlight (watts):

Species	Sub-reach tally A	B	C	D	E	F	G	H	I	J	Total count	Sample count	Length (mm) Min.	Max.	FLAG
C. bully	3		1	3				1			8		32	78	
Shortfin eel	3	7	4	5	3	6	2	9	2	4	45		95	375	
Longfin eel								2			2		409	768	
Koura	1		1	3			1			5	11				
Unidentified eel	1	1	4	3			2			2	13				
Total	8	8	10	14	3	6	5	12	2	11	79				

FLAG	Comment	FLAG	Comment
	Had heavy rain over 4 days prior to sampling		Missed bully total: 1 (included in count)
			Missed eel total: 13 (included in count as “unidentified eels”)

Fish collection form – Wadeable streams/rivers

Team members: Kathryn Reeve, Mike Martin, Kit Squires, Elizabeth Graham, Gareth van Assema	GPS (d/s): E 1836783 N 5809932	Site: Mangapapa Stream 433-14		Date: 20/02/2017
	GPS (u/s): E 1836750 N 5809802	Not fished	Fished none collected	Fished 10 sub-reaches
		Fished 5-9 sub-reaches	Fished <5 sub-reaches	FLAG for fished/not fished

Fish sample id: M.M./ E.G.	Total shock time (min): 60	Fishing time:	Start 12:00	Finish 14:30	Sample distance (m): 150	Wetted width (m):	A	5.3	C	5.1	E	2.8	G	3.7	I	3.1
							B	4.7	D	3.9	F	2.9	H	5.8	J	

Sampling gear:	Spotlight	**EFM**	Seine	Length (m) / Mesh (mm)	Water visibility:	**Good**	Average	Poor	Water temp. (°C): 20.7	Conductivity (µS): 100.0

EFM anode: **Big** / Small	EFM volts (x100): 3	EFM pulse rate (Hz or pps): 60	EFM pulse width (ms): 2	Spotlight (watts):

Species	Sub-reach tally										Total count	Sample count	Length (mm)		FLAG
	A	B	C	D	E	F	G	H	I	J			Min.	Max.	
C. bully	6	2	14	5	7	9	9	5	4		61		22	61	
Banded kokopu	1										1		50	50	
Shortfin eel	14	2	30	12	24	93	24	15	7		221		78	495	
Longfin eel		2	2	3			1		1		9		179	1605	
Koura	1		1		1		1		2		6				
Unidentified eel	1	1	5	2	3		2	2	3		19				
Total	23	7	52	22	35	102	37	22	17	0	317				

FLAG	Comment	FLAG	Comment
	Heavy rain over 4 days prior to sampling		Missed bully total: 5 (included in count)
	Reach J too deep to fish		Missed eel total: 19 (included in count as “unidentified eels”)

Fish collection form – Wadeable streams/rivers

Team members: Kathryn Reeve, Paul Franklin, Mike Martin, Peter Williams, Elizabeth Graham	GPS (d/s): E 1817745 N 5815748	Site: Waitakaruru Stream 1231-54				Date: 14/02/2017
	GPS (u/s): E 1817903 N 5815670	Not fished	Fished none collected	Fished 10 sub-reaches	Fished 5-9 sub-reaches	Fished <5 sub-reaches	FLAG for fished/not fished

Fish sample id:	K.R./ P.F.	Total shock time (min):	57	Fishing time:	Start	8:46	Sample distance (m):	150	Wetted width (m):	A	1.8	C	3.1	E	3.5	G	2.8	I	2.3
					Finish	11:15				B	1.9	D	2.2	F	2.2	H	0.8	J	2.3

Sampling gear:	Spotlight	EFM	Seine	Length (m) / Mesh (mm)	Water visibility:	Good	Average	Poor	Water temp. (°C):	19.4	Conductivity (µS):	134.0								

EFM anode: Big / Small	EFM volts (x100): 3	EFM pulse rate (Hz or pps): 60	EFM pulse width (ms): 2	Spotlight (watts):	

Species	Sub-reach tally A	B	C	D	E	F	G	H	I	J	Total count	Sample count	Length (mm) Min.	Max.	FLAG
C. bully	6	6	1	5	1	1	9	3	1	2	35		15	73	
Shortfin eel	6	2	6	5	2	3	14	2	6	1	47		94	525	
Longfin eel	1	1				1					3		132	480	
Koura		3	5	3	4	2	4	6	13	6	46				
Unidentified eel	1			2		1	2	3			9				
Total	14	12	12	15	7	8	29	14	20	9	140				

FLAG	Comment	FLAG	Comment
	Lots of macrophytes across entire reach; made electric-fishing difficult		Missed bully total: 8 (included in count)
			Missed eel total: 9 (included in count as “unidentified eels”)

Fish collection form – Wadeable streams/rivers

Team members: Kathryn Reeve, Elizabeth Graham, Mike Martin, Mike Meredyth-Young	GPS (d/s): E 1831220 N 5809988 GPS (u/s):	Site: Piakonui Stream 753-15			Date: 21/02/2017
		Not fished	Fished none collected	**Fished 10 sub-reaches**	Fished 5-9 sub-reaches	Fished <5 sub-reaches	FLAG for fished/not fished

Fish sample id: M.M.	Total shock time (min): 61	Fishing time: Start 10:05 Finish 12:20	Sample distance (m): 150	Wetted width (m):	A	4.5	C	2.9	E	5.0	G	3.6	I	3.8
					B	3.8	D	5.5	F	4.7	H	3.3	J	2.6

Sampling gear:	Spotlight	**EFM**	Seine	Length (m) / Mesh (mm)	Water visibility:	**Good**	Average	Poor	Water temp. (°C): 16.6	Conductivity (µS): 72.2
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EFM anode: **Big** / Small	EFM volts (x100): 3	EFM pulse rate (Hz or pps): 60	EFM pulse width (ms): 2	Spotlight (watts):
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Species	Sub-reach tally A	B	C	D	E	F	G	H	I	J	Total count	Sample count	Length (mm) Min.	Max.	FLAG
Shortfin eel	2			2	2	3	20	2	4	4	39		95	151	
Longfin eel			1						1		2		455	935	
Koura	3	9		5	22	26	26	28	53	30	202				
Unidentified eel					1	1					2				
Total	5	9	1	7	25	30	46	30	58	34	245				

FLAG	Comment	FLAG	Comment
	Heavy rain 2-5 days prior to sampling		Missed eel total: 2 (included in count as “unidentified eels”)

Fish collection form – Wadeable streams/rivers

Team members: Kathryn Reeve, Peter Williams, Mike Martin, Elizabeth Graham	GPS (d/s): E 1841027 N 5867879	Site: Paiakarahi Stream D/S 718-5				Date: 13/02/2017
	GPS (u/s): E 1841098 N 5867799	Not fished	Fished none collected	Fished 10 sub-reaches	Fished 5-9 sub-reaches	Fished <5 sub-reaches	FLAG for fished/not fished

Fish sample id: P.W.	Total shock time (min): 69	Fishing time:	Start 10:10	Finish 13:03	Sample distance (m): 150	Wetted width (m):	A	5.7	C	5.2	E	3.9	G	4.3	I	3.4
							B	2.5	D	4.5	F	3.3	H	2.4	J	4.2

Sampling gear:	Spotlight	EFM	Seine	Length (m) / Mesh (mm)	Water visibility:	Good	Average	Poor	Water temp. (°C): 18.5	Conductivity (µS): 124.4
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EFM anode: Big / Small	EFM volts (x100): 4	EFM pulse rate (Hz or pps): 60	EFM pulse width (ms): 2	Spotlight (watts):
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Species	Sub-reach tally										Total count	Sample count	Length (mm)		FLAG
	A	B	C	D	E	F	G	H	I	J			Min.	Max.	
C. bully	6	2	5		1	5	8	4	5	2	38		20	71	
Redfin bully				1							1				
Shortfin eel			3	1	4			1	1		10		89	165	
Longfin eel	1		1		1			1	1	2	7		109	1016	
Torrentfish									1		1		122	122	
Rainbow trout	1				1		1			2	5		92	133	
Koura	1	7	8	17	4	9	6	13	2	3	70				
Unidentified eel					3				1	1	5				
Total															

FLAG	Comment	FLAG	Comment
	Deep pool present in reach 1, difficult to fish		Missed bully total: 8 (included in count); 1 was redfin
			Missed eel total: 5 (included in count as “unidentified eels”)

Fish collection form – Wadeable streams/rivers

Team members: Kathryn Reeve, Mike Martin, Elizabeth Graham, Mike Meredyth-Young	GPS (d/s): E 1848393 N 5823235	Site: Karengorengo Stream 232-3			Date: 21/02/2017
	GPS (u/s): E 1848423 N 5823069	Not fished	Fished none collected	Fished 10 sub-reaches	Fished 5-9 sub-reaches

Fish sample id: Yes	Total shock time (min): 31	Fishing time: Start 15:00 Finish 17:14	Sample distance (m): 150	Wetted width (m):	A	2.2	C	1.7	E	2.3	G		I		B	1.8	D	1.8	F		H	2.4	J	2.9

Sampling gear: Spotlight	EFM	Seine	Length (m) / Mesh (mm)	Water visibility:	Good	Average	Poor	Water temp. (°C): 19.0	Conductivity (µS): 191.4											
EFM anode: Big / Small	EFM volts (x100): 3	EFM pulse rate (Hz or pps): 60	EFM pulse width (ms): 2	Spotlight (watts):																

Species	Sub-reach tally A	B	C	D	E	F	G	H	I	J	Total count	Sample count	Length (mm) Min.	Max.	FLAG
C. bully	3	1	1	1				5			11		32	89	
Shortfin eel	25	14	11	10	2			5		3	70		82	530	
Smelt				3	1			3			7		59	86	
Gambusia	1	3									4		23	27	
Rainbow trout		1								1	2		152	320	
Koura	2			3	2			5			12				
Unidentified eel	3	5	3	1	1			1		2	16				
Total															

FLAG	Comment	FLAG	Comment
	Skipped reaches F, G, and I because too weedy to fish		Missed bully total: 1 (included in count)
	Missed 6 m in reach C because it was too weedy to fish		Missed smelt total: 2 (included in count)
	Missed 5 m in reach E because it was too weedy to fish		Missed eel total: 16 (included in count as “unidentified eels”)
	Saw school of smelt just above the end of reach J		

Fish collection form – Wadeable streams/rivers

Team members: Kathryn Reeve, Peter Williams, Mike Martin, Elizabeth Graham	GPS (d/s): E 1851649 N 5819801	Site: Wairere Stream 1224-5				Date: 15/02/2017
	GPS (u/s): E 1851719 N 5819721	Not fished	Fished none collected	Fished 10 sub-reaches	Fished 5-9 sub-reaches	Fished <5 sub-reaches	FLAG for fished/not fished

Fish sample id: K.R.	Total shock time (min): 152	Fishing time: Start 9:45 Finish 15:15	Sample distance (m): 150	Wetted width (m):	A	5.6	C	7.4	E	6.1	G	5.6	I	5.7
					B	6.7	D	5.8	F	6.1	H	3.8	J	4.5

Sampling gear: Spotlight	EFM	Seine	Length (m) / Mesh (mm)	Water visibility:	Good	Average	Poor	Water temp. (°C): 16.6	Conductivity (µS): 54.5
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EFM anode: Big / Small	EFM volts (x100): 3	EFM pulse rate (Hz or pps): 60	EFM pulse width (ms): 2	Spotlight (watts):

Species	Sub-reach tally A	B	C	D	E	F	G	H	I	J	Total count	Sample count	Length (mm) Min.	Max.	FLAG
C. bully	53	21	6	47	40	34	74	42	62	74	453		16	75	
Shortfin eel	43	17	17	10	17	16	26	35	19	25	225		80	665	
Longfin eel									1	1	2		632	700	
Koura	3	5	6	3	4		5		2	1	29				
Unidentified eel	4	6	6	2	2		2	4	4	2	32				
Total	103	49	35	62	63	50	107	81	88	107	741				

FLAG	Comment	FLAG	Comment
	Fished using 2 electric-fishing machines simultaneously		Missed bully total: 121 (included in count)
	Many small bullies on edges not captured by EF		Missed eel total: 32 (included in count as “unidentified eels”)

Fish collection form – Wadeable streams/rivers

Team members: Kathryn Reeve, Mike Martin, Elizabeth Graham, Callum Brown	GPS (d/s): E 1852566 N 5818150	Site: Waiteariki Stream 1430-10			Date: 22/02/2017
	GPS (u/s): E 1852697 N 5818212	Not fished	Fished none collected	Fished 10 sub-reaches	Fished 5-9 sub-reaches

Fish sample id: K.R.	Total shock time (min): 42	Fishing time: Start 10:25 Finish 13:47	Sample distance (m): 150	Wetted width (m):	A	8.4	C	5.6	E		G	9.5	I	8.6					
					B	7.1	D	8.0	F	7.9	H	11.3	J	7.3					

Sampling gear:	Spotlight	EFM	Seine	Length (m) / Mesh (mm)	Water visibility:	Good	Average	Poor	Water temp. (°C): 14.2										
															Conductivity (µS): 38.3				

EFM anode: Big / Small	EFM volts (x100): 4	EFM pulse rate (Hz or pps): 60	EFM pulse width (ms): 2	Spotlight (watts):

Species	Sub-reach tally A	B	C	D	E	F	G	H	I	J	Total count	Sample count	Length (mm) Min.	Max.	FLAG
C. bully	1	1	2	2		1	7	2	1	1	18		36	171	
Shortfin eel	1		1	1			5	3		1	12		110	195	
Longfin eel			1	1			1	1			4		357	600	
Torrentfish				2				1			3		60	136	
Brown trout							1		1		2		123	134	
Koura	2	2	1	2						1	8				
Total	4	3	5	8	0	1	14	7	2	3	47				

FLAG	Comment	FLAG	Comment
	Heavy rain over 3-6 days prior to sampling		
	Very strong current and high water level; difficult to fish		
	Missed 5 m of reach B because too deep and swift to fish		
	Reach E skipped because too deep and swift to fish		
	Missed 5 m of reach F because too deep and swift to fish		

Fish collection form – Wadeable streams/rivers

Team members: Kathryn Reeve, Peter Williams, Mike Martin, Elizabeth Graham	GPS (d/s): E 1845480 N 5849662	Site: Waitawheta River 1235-11				Date: 13/02/2017
	GPS (u/s): E 1845388 N 5849622	Not fished	Fished none collected	Fished 10 sub-reaches	Fished 5-9 sub-reaches	Fished <5 sub-reaches	FLAG for fished/not fished

Fish sample id: K.R.	Total shock time (min): 54	Fishing time:	Start 14:56	Finish 17:29	Sample distance (m): 150	Wetted width (m):	A	3.6	C	3.2	E	3.5	G	3.8	I	3.5
							B	3.3	D	3.2	F	3.3	H	4.8	J	3.6

Sampling gear:	Spotlight	EFM	Seine	Length (m) / Mesh (mm)	Water visibility:	Good	Average	Poor	Water temp. (°C): 18.3	Conductivity (µS): 66.8
---	---	---	---	---	---	---	---	---	---	---

EFM anode: Big / Small	EFM volts (x100): 4	EFM pulse rate (Hz or pps): 60	EFM pulse width (ms): 2	Spotlight (watts):
---	---	---	---	---

Species	Sub-reach tally A	B	C	D	E	F	G	H	I	J	Total count	Sample count	Length (mm) Min.	Max.	FLAG
C. bully	9	10	12	11	11	5	8	4	8	3	81		36	85	
Shortfin eel			3	2	3	1		2			11		117	376	
Longfin eel		1			1		1	2		2	7		271	740	
Rainbow trout							2	1			3		87	104	
Brown trout									1		1		117	117	
Koura	7	8	2		1	2	1	2	1		24				
Unidentified trout								2			2				
Unidentified eel			2	1	1		1	2	2	3	12				
Total	16	19	19	14	17	8	13	15	12	8	141				

FLAG	Comment
	Water level lower than previous year

FLAG	Comment
	Missed bully total: 24 (included in count)
	Missed trout total: 2 (included in count as “unidentified trout”)
	Missed eel total: 12 (included in count as “unidentified eels”)

Appendix C Macrophytes and periphyton

Periphyton Assessment							
Stream: Mangakahika Stream		Date: 14/02/2017					
Sample Number: 4		Located number: 376-4					
Thickness category	**Colour category**	**A**	**B**	**C**	**D**	**E**	**Mean cover**
Thin (<0.5mm) Mat/Film	NA (% cover)	25					5
Medium mat/film (0.5-3mm thick)	Green (% cover)						0
	Light brown (% cover)	50					10
	Black/dark brown (% cover)			10	5		3
Thick (>3mm) mat/film	Green/light brown (% cover)					5	1
	Black/dark brown (% cover)						0
Filaments short (<2cm)	NA (% cover)			2	2		0.8
Filaments long (>2cm)	Green (% cover)		30				6
	Brown/Reddish (% cover)						0
Submerged bryophytes	NA						0
Iron Bacteria growths	NA						0

Macrophyte recording sheet											
Stream: Mangakahika Stream			**Located number**: 376-4				**Sample Number**: 4			**Date**: 14/02/2017	
Transect	Wetted width (m)	Channel width (m)	Vegetation cover (% wetted area)								
			Total cover	Submerged plants						Emergent plants	
				Total submerged	Surface-reaching		Below surface			Total emergent	Species
					Sub-total	Species	Sub-total	Species			
1	1.83	2.63	0								
2	1.06	1.56	0								
3	1.55	1.86	0								
4	2.10	2.10	5	5	5	Du (duckweed)					
5	1.95	3.20	0								

Periphyton Assessment							
Stream: Waitoa Stream U/S		Date: 20/02/2017					
Sample Number: 6		Located number: 1249-121					
Thickness category	**Colour category**	**A**	**B**	**C**	**D**	**E**	**Mean cover**
Thin (<0.5mm) Mat/Film	NA		60	25		10	19
Medium mat/film (0.5-3mm thick)	Green (% cover)						0
	Light brown (% cover)						0
	Black/dark brown (% cover)						0
Thick (>3mm) mat/film	Green/light brown (% cover)						0
	Black/dark brown (% cover)						0
Filaments short (<2cm)	NA (% cover)						0
Filaments long (>2cm)	Green (% cover)						0
	Brown/Reddish (% cover)						0
Submerged bryophytes	NA						0
Iron Bacteria growths	NA						0

Macrophyte recording sheet										
Stream: Waitoa Stream U/S			**Located number**: 1249-121				**Sample Number**: 6		**Date**: 20/02/2017	
Transect	Wetted width (m)	Channel width (m)	Vegetation cover (% wetted area)							
			Total cover	Submerged plants					Emergent plants	
				Total submerged	Surface-reaching		Below surface		Total emergent	Species
					Sub-total	Species	Sub-total	Species		
1	1.49	6.03	0							
2	2.45	9.60	2						2	Gr 1, Na 1
3	1.70	3.93	23						23	Gr 1, Na 2, Ph 20
4	2.24	3.56	31						31	Gr 30, Ph 1
5	1.40	11.12	0							

Periphyton Assessment							
Stream: Mangapapa Stream		Date: 20/02/2017					
Sample Number: 7		Located number: 433-14					
Thickness category	**Colour category**	**A**	**B**	**C**	**D**	**E**	**Mean cover**
Thin (<0.5mm) Mat/Film	NA	80	20				20
Medium mat/film (0.5-3mm thick)	Green (% cover)			20			4
	Light brown (% cover)		20	30			10
	Black/dark brown (% cover)						0
Thick (>3mm) mat/film	Green/light brown (% cover)						0
	Black/dark brown (% cover)						0
Filaments short (<2cm)	NA (% cover)				80		16
Filaments long (>2cm)	Green (% cover)						0
	Brown/Reddish (% cover)						0
Submerged bryophytes	NA	10	60	50			24
Iron Bacteria growths	NA						0

Macrophyte recording sheet											
Stream: Mangapapa Stream			**Located number**:				**Sample Number**: 7			**Date**: 20/02/2017	
Transect	Wetted width (m)	Channel width (m)	Vegetation cover (% wetted area)								
			Total cover	Submerged plants					Emergent plants		
				Total submerged	Surface-reaching		Below surface		Total emergent	Species
					Sub-total	Species	Sub-total	Species		
1	5.10		1							
2	3.90		0							
3	2.84		20	5	5	Lm 3, Po 2			15	Gr 10, Ve 5
4	5.80		40						40	Ph 10, Ve 30
5	3.10		16	10	10	Lm 10			6	Ph 1, Ve 5

Periphyton Assessment							
Stream: Waitakaruru Stream		Date: 14/02/2017					
Sample Number: 3		Located number: 1231-54					
Thickness category	**Colour category**	**A**	**B**	**C**	**D**	**E**	**Mean cover**
Thin (<0.5mm) Mat/Film	NA		20		20		8
Medium mat/film (0.5-3mm thick)	Green (% cover)						0
	Light brown (% cover)						0
	Black/dark brown (% cover)						0
Thick (>3mm) mat/film	Green/light brown (% cover)						0
	Black/dark brown (% cover)						0
Filaments short (<2cm)	NA (% cover)						0
Filaments long (>2cm)	Green (% cover)	1					0.2
	Brown/Reddish (% cover)						0
Submerged bryophytes	NA						0
Iron Bacteria growths	NA						0

Macrophyte recording sheet										
Stream: Waitakaruru Stream			**Located number**: 1231-54				**Sample Number**: 3		**Date**: 14/02/2017	
Transect	Wetted width (m)	Channel width (m)	Vegetation cover (% wetted area)							
			Total cover	Submerged plants					Emergent plants	
				Total submerged	Surface-reaching		Below surface			
					Sub-total	Species	Sub-total	Species	Total emergent	Species
1	1.90		50						50	Na 50
2	2.20		60	30	30	Lm 30			30	Na 30
3	2.18		70	50	50	Lm 20, Pk 30			20	Na 20
4	2.80		29	22	22	Lm 10, Pk 10, Du (duckweed) 2			7	Na 2, Ps 5
5	2.30		70	50	50	Lm 20, Pk 25, Du (duckweed) 5			20	Lp 18, Ps 2

Periphyton Assessment							
Stream: Piakonui Stream		Date: 21/02/2017					
Sample Number: 8		Located number: 753-15					
Thickness category	**Colour category**	**A**	**B**	**C**	**D**	**E**	**Mean cover**
Thin (<0.5mm) Mat/Film	NA						0
Medium mat/film (0.5-3mm thick)	Green (% cover)						0
	Light brown (% cover)						0
	Black/dark brown (% cover)						0
Thick (>3mm) mat/film	Green/light brown (% cover)						0
	Black/dark brown (% cover)						0
Filaments short (<2cm)	NA (% cover)						0
Filaments long (>2cm)	Green (% cover)						0
	Brown/Reddish (% cover)						0
Submerged bryophytes	NA	80	20	35	25	25	37
Iron Bacteria growths	NA						0

Macrophyte recording sheet										
Stream: Piakonui Stream			**Located number**: 753-15				**Sample Number**: 8		**Date**: 21/02/2017	
Transect	Wetted width (m)	Channel width (m)	Vegetation cover (% wetted area)							
			Total cover	Submerged plants					Emergent plants	
				Total submerged	Surface-reaching		Below surface		Total emergent	Species
					Sub-total	Species	Sub-total	Species		
1	3.77		0							
2	5.54		0							
3	4.66		0							
4	3.34		0							
5	2.58		0							

Periphyton Assessment							
Stream: Paiakarahi Stream D/S		Date: 13/02/2017					
Sample Number: 1		Located number: 718-5					
Thickness category	**Colour category**	**A**	**B**	**C**	**D**	**E**	**Mean cover**
Thin (<0.5mm) Mat/Film	NA	2	20	50	50	5	25.4
Medium mat/film (0.5-3mm thick)	Green (% cover)			0.1	0.1	2	0.44
	Light brown (% cover)	5	10	5	10	5	7
	Black/dark brown (% cover)						0
Thick (>3mm) mat/film	Green/light brown (% cover)		1	1	3	5	2
	Black/dark brown (% cover)						0
Filaments short (<2cm)	NA (% cover)	5	5	2	5	10	5.4
Filaments long (>2cm)	Green (% cover)	0.1	0.1		0.1	5	1.06
	Brown/Reddish (% cover)	0.1	0.1	0.1		30	6.06
Submerged bryophytes	NA		0.1				0.02
Iron Bacteria growths	NA						0

Macrophyte recording sheet										
Stream: Paiakarahi Stream D/S			**Located number**: 718-5				**Sample Number**: 1		**Date**: 13/02/2017	
Transect	Wetted width (m)	Channel width (m)	Vegetation cover (% wetted area)							
			Total cover	Submerged plants					Emergent plants	
				Total submerged	Surface-reaching		Below surface		Total emergent	Species
					Sub-total	Species	Sub-total	Species		
1	2.53		0							
2	4.51		0							
3	3.25		0							
4	2.40		0							
5	4.22		0							

Periphyton Assessment							
Stream: Karengorengo Stream		Date: 21/02/2017					
Sample Number: 9		Located number: 232-3					
Thickness category	**Colour category**	**A**	**B**	**C**	**D**	**E**	**Mean cover**
Thin (<0.5mm) Mat/Film	NA						0
Medium mat/film (0.5-3mm thick)	Green (% cover)						0
	Light brown (% cover)						0
	Black/dark brown (% cover)						0
Thick (>3mm) mat/film	Green/light brown (% cover)						0
	Black/dark brown (% cover)						0
Filaments short (<2cm)	NA (% cover)						0
Filaments long (>2cm)	Green (% cover)	10					2
	Brown/Reddish (% cover)						0
Submerged bryophytes	NA						0
Iron Bacteria growths	NA						0

Macrophyte recording sheet											
Stream: Karengorengo			**Located number**: 232-3				**Sample Number**: 9			**Date**: 21/02/2017	
Transect	Wetted width (m)	Channel width (m)	Vegetation cover (% wetted area)								
			Total cover	Submerged plants					Emergent plants		
				Total submerged	Surface-reaching		Below surface		Total emergent	Species
					Sub-total	Species	Sub-total	Species		
1	1.84	2.93	50	10			10	Nh 10	40	Ve 40
2	1.73	1.75	80						80	Ve 80
3	1.76	2.23	70						70	Ve 70
4	2.31	3.12	30						30	Ph 15 Le (gypsywort) 15
5	2.35	4.38	80						80	Ve 80

Periphyton Assessment							
Stream: Wairere		Date: 15/02/2017					
Sample Number: 5		Located number: 1224-5					
Thickness category	**Colour category**	**A**	**B**	**C**	**D**	**E**	**Mean cover**
Thin (<0.5mm) Mat/Film	NA						0
Medium mat/film (0.5-3mm thick)	Green (% cover)			20			4
	Light brown (% cover)						0
	Black/dark brown (% cover)						0
Thick (>3mm) mat/film	Green/light brown (% cover)	90	95	40	80	60	73
	Black/dark brown (% cover)						
Filaments short (<2cm)	NA (% cover)						
Filaments long (>2cm)	Green (% cover)						
	Brown/Reddish (% cover)						
Submerged bryophytes	NA	5					1
Iron Bacteria growths	NA						0

Macrophyte recording sheet											
Stream: Wairere			**Located number**: 1224-5				**Sample Number**: 5			**Date**: 15/02/2017	
Transect	Wetted width (m)	Channel width (m)	Vegetation cover (% wetted area)								
			Total cover	Total submerged	Submerged plants				Emergent plants		
					Surface-reaching		Below surface		Total emergent	Species	
					Sub-total	Species	Sub-total	Species			
1	5.60		0								
2	7.60		0								
3	6.11		2						2	Lp 2	
4	5.47		0								
5	5.70		0								

Periphyton Assessment							
Stream: Waitearikiki Stream		Date: 22/02/2017					
Sample Number: 10		Located number: 1430-10					
Thickness category	**Colour category**	**A**	**B**	**C**	**D**	**E**	**Mean cover**
Thin (<0.5mm) Mat/Film	NA	20	35	10	60	75	40
Medium mat/film (0.5-3mm thick)	Green (% cover)						0
	Light brown (% cover)						0
	Black/dark brown (% cover)						0
Thick (>3mm) mat/film	Green/light brown (% cover)						0
	Black/dark brown (% cover)						0
Filaments short (<2cm)	NA (% cover)						0
Filaments long (>2cm)	Green (% cover)						0
	Brown/Reddish (% cover)						0
Submerged bryophytes	NA						0
Iron Bacteria growths	NA						0

Macrophyte recording sheet										
Stream: Waiteariki Stream			**Located number**: 1430-10				**Sample Number**: 10		**Date**: 22/02/2017	
Transect	Wetted width (m)	Channel width (m)	Vegetation cover (% wetted area)							
			Total cover	Submerged plants					Emergent plants	
				Total submerged	Surface-reaching		Below surface			
					Sub-total	Species	Sub-total	Species	Total emergent	Species
1	8.40									
2	5.63									
3	7.93									
4	11.33									
5	7.34									

Periphyton Assessment							
Stream: Waitawheta River		Date: 13/02/2017					
Sample Number: 2		Located number: 1235-11					
Thickness category	**Colour category**	**A**	**B**	**C**	**D**	**E**	**Mean cover**
Thin (<0.5mm) Mat/Film	NA	25					5
Medium mat/film (0.5-3mm thick)	Green (% cover)						0
	Light brown (% cover)	50					10
	Black/dark brown (% cover)			10	5		3
Thick (>3mm) mat/film	Green/light brown (% cover)					5	1
	Black/dark brown (% cover)						0
Filaments short (<2cm)	NA (% cover)			2	2		0.8
Filaments long (>2cm)	Green (% cover)		30				6
	Brown/Reddish (% cover)						0
Submerged bryophytes	NA						0
Iron Bacteria growths	NA						0

Macrophyte recording sheet											
Stream: Waitawheta River			**Located number**: 1235-11				**Sample Number**: 2			**Date**: 13/02/2017	
Transect	Wetted width (m)	Channel width (m)	Vegetation cover (% wetted area)								
			Total cover	Submerged plants					Emergent plants		
				Total submerged	Surface-reaching		Below surface		Total emergent	Species
					Sub-total	Species	Sub-total	Species		
1	3.31		0							
2	3.21		0							
3	3.50		0							
4	3.52		0							
5	4.75		0							

Appendix D Macroinvertebrate taxa list

Species	Sites									
	1	2	3	4	5	6	7	8	9	10
Archichauliodes diversus	44	10	1	1		53		79	7	63
Antipodochlora braueri						5				
Xanthocnemis zealandica				1						
Acanthophlebia cruentata								9	1	
Ameletopsis percistus						5				21
Atalophlebioides cromwelli										7
Austroclima sepia	9	20		292		14	85	44	1	14
Austroclima sp.	9			140		9	30	9	3	21
Coloburiscus humeralis						22		132	14	63
Deleatidium spp.	237	32		269		27		9	1	140
Ichthybotus hudsoni										1
Neozephlebia scita	44									7
Nesameletus sp.						27			11	49
Oniscigaster wakefieldi									1	
Zephlebia borealis	9									1
Zephlebia dentata	70	32	12	397	17	5	50	62	1	7
Zephlebia inconspicua				35						
Zephlebia spectabilis	9		24			1				1
Zephlebia spp.		4	12	82	1	5				
Zephlebia versicolor						5	30			7
Acroperla sp.									1	
Austroperla cyrene					2					
Zelandoperla decorata					2				1	7
Aoteapsyche catherinae		13	12							
Aoteapsyche colonica		42	12	70		9		62	3	28
Aoteapsyche spp.	193	42	12	210	1	35		114	7	42
Beraeoptera roria						5				14
Helicopsyche spp.						5				14
Hudsonema alienum							1	18		14
Hudsonema amabilis	105		12			9		53		
Hydrobiosella mixta	9									
Hydrobiosis copis		10		1						
Hydrobiosis gollanis (pupae)	1	4								
Hydrobiosis parumbripennis	1	4		1		1		9		

Species	Sites									
	1	2	3	4	5	6	7	8	9	10
Hydrobiosis spatulata										7
Hydrobiosis spp.	9	10				14		9		14
Neurochorema armstrongi										7
Neurochorema spp.	18					9		27		
Olinga feredayi	114									1
Orthopsyche fimbriata										1
Orthopsyche sp.					5					
Oxyethira albiceps		7	24	12	1	44	25	35		14
Polyplectropus sp.	1					9				
Psilochorema sp.	9									
Pycnocentria evecta	70	16	152					210		98
Pycnocentrodes spp.	447	55	362	164		14			12	21
Triplectides obsoleta/dolichos	1	4				75	5			1
Zelolessia cheira									2	
Elmidae (adult)								18		
Elmidae (larvae)	27	10	59	595		136		692	1	7
Hydraenidae (A)								9		
Hydrophilidae							10			
Ptilodactylidae (larvae)	1			1					1	1
Aphrophila neozealandica	1					31		79	1	1
Austrosimulium sp.			12	59	72		45	9		42
Chironomus zealandicus		7				5				
Corynoneura sp.							10			
Cricotopus sp.					1	27		27	10	
Empididae								18		
Eriopterini sp.						1		1		
Eukiefferiella sp.		7							1	
Hexatomini sp.	1									
Kaniwhaniwhanus sp.									2	
Limonia nigrescens	9									
Lobodiamesinae									1	42
Macropelopiini sp.	1					31	5	62		14
Maoridiamesa sp.		10								
Muscidae								1	1	
Naonella forsythi						9		44		

Species	Sites									
	1	2	3	4	5	6	7	8	9	10
Paradixa sp.	27						65			
Pirara					1					
Polypedilum spp.	9	4			1	5	40	9	2	1
Tabanidae						5				
Tanyderidae	1			1	1					
Tanytarsus spp.		29	1			35	5	53	7	
Latia sp.			59	12		5				14
Physa sp.							1			
Potamopygrus antipodarum	263	312	2147	665	10	237	600	140	34	756
Sphaerium sp.			12							
Acarina	9			12						
Eiseniella sp.				12						
Naididae								35		
Oliogochatae unident	9	13	24	47	2	5	10	9		42
Ostracoda		7					5			
Paracalliope fluviatillis	62			70		18	30	9		
Paranephrops planifrons					1					
Planaria	18		12	12						14
Sigara spp.			1							

Appendix E Bully phylogenetic analysis

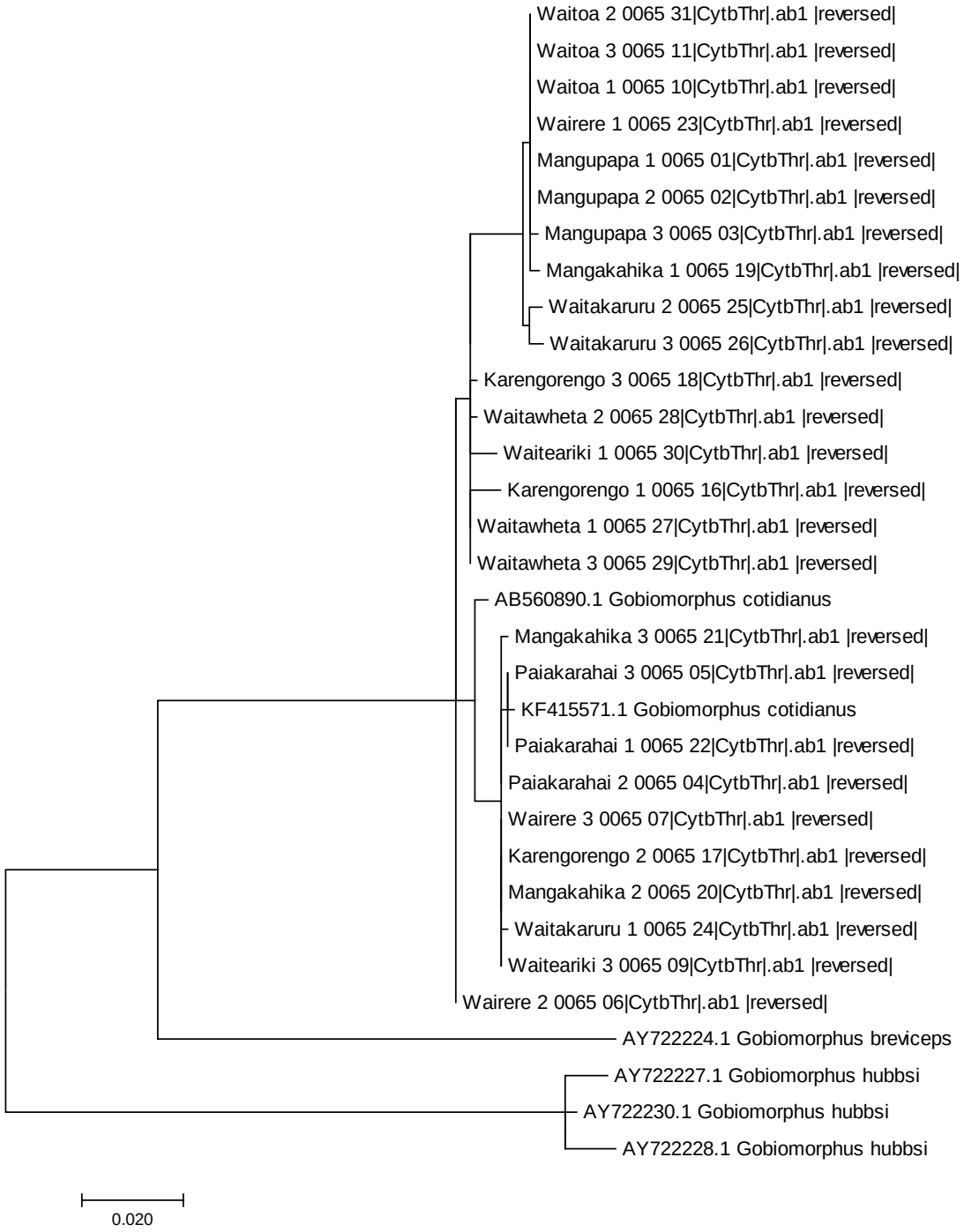

Figure E-1: Molecular Phylogenetic analysis of bullies. The phylogenetic tree is drawn to scale, with branch lengths measured in the number of substitutions per site.