Fisheries assessment of waterways throughout the Rangitaiki WMA

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Many of the streams visited were accessible only through private land, and could only be accessed with the help and cooperation of landowners throughout the area.

Funding for this work came from Rob Donald, Manager of the Science Team, Bay of Plenty Regional Council.

Dedication

This report is dedicated to Geoff Burton, who was tragically taken from us too soon whilst out running near Opotiki. Although Geoff had connections to Ngati Maniapoto (Ngati Ngutu) and was born in the Waikato, he moved with his wife and children back to Torere in the early 2000s to be closer to her whanau. Geoff had been a board member of Te Kura o Torere and was also a gazetted Ngaitai kaitiaki. He was completing studies at Te Whare Wānanga o Awanuiārangi where he was studying Te Ahu o Taiao. It was during this time that his supervisors recommended Geoff to assist with the fish survey work described in this report. During these surveys, Geoff often talked about his desire to make a positive contribution towards ensuring the sustainability of our environment for future generations.

Technical summary

1 A freshwater fish survey was undertaken throughout waterways in the Rangitaiki Water Management Area (WMA) in April 2014 to help fill knowledge gaps identified in an earlier science review of the current state of waterways in this WMA. Site selection was made by examining the New Zealand Freshwater Fish Database (NZFFD) and selecting sites with either out-dated information (i.e. >16 years), or that were flowing in catchments dominated by native bush or pine plantation, as these were under-represented in the NZFFD. A total of 82 sites were surveyed over a three week period from 10 - 19 March 2014.

2 Fish communities were assessed by electric-fishing in shallow streams. Habitats within each stream where fish were likely to occur were specifically targeted. Both hard-bottomed streams and streams dominated by fine pumice streambeds were surveyed. Tree replicate fyke nets were used to sample fish from deep, slow flowing streams or streams with fine substrates. These nets were deployed overnight and emptied the following morning. In all cases, all fish caught were identified and measured prior to release.

3 Data from the field surveys were combined with data from the NZFFD, giving a total of 318 sites throughout the WMA with information on fish community composition. Environmental factors such as climate (temperature, rainfall) catchment factors (elevation, distance to sea, slope) flow (mean and mean annual low flow), landuse and local factors (e.g., substrate and habitat) were extracted from the Freshwater Environments of New Zealand (FWENZ) database based on the individual GPS locations for each site. Ordination analysis was done to reveal any hidden structure in the data and to identify what the major environmental differences were between sites.

4 A total of nine fish species were identified in the March 2014 survey. The communities were dominated by rainbow and brown trout; longfin and shortfin eels were also common. Other fish recorded included dwarf galaxias, koaro, redfin bully, and giant kokopu. All of these fish have previously been recorded in the WMA, with the exception of koaro, which were found at four sites draining the Ikawhenua Ranges. This species is considered threatened, so its presence is significant. It is also migratory, so its presence may confirm the success of the trap and transfer undertaken by the Kokopu Trust as part of the Matahina Dam consent, as this fish may not be capable of having land locked populations in Lake Matahina. Further studies analysing the microchemistry of fish otoliths (ear bones) are needed to confirm this.

5 Another notable finding was new populations of dwarf galaxias in three small streams (the Ohutu, Hikurangi and Kopuriki) draining the Ikawhenua Ranges. Of concern was the absence of these fish at three other sites (Horomunga, Tuku houhou and Kotuku uku Stream) where they had been previously recorded in the 1960’s. The only fish currently found at these sites were shortfin eels, and rainbow trout. The absence of dwarf galaxias at these three sites most likely reflects their displacement by the more aggressive rainbow trout. In contrast, trout were not or only rarely caught at the three sites where dwarf galaxias are currently found.

6 The results of the 2014 survey were compared to the results of previous surveys extracted from the NZFFD. A higher proportion of sites with longfin eels, dwarf galaxias, and koaro were found in the 2014 survey, but this may have simply reflected differences in stream types surveyed. The 2014 survey targeted smaller streams in catchments dominated by native bush or pine forest, whereas the NZFFD had under-represented these sites. In contrast, common bully, rainbow trout and mosquito fish were less common in the contemporary survey that in the NZFFD. This may also reflect the fact that habitat conditions in the surveyed streams were unsuitable for these latter species.

7 All fish data was converted to presence-absence data, and another ordination used to explore relationships and patterns in these data, and links to environmental factors. This analysis identified that major drivers of fish communities were a mixture of elevation and distance to sea. Other factors such as average downstream slope, flood frequency, and streambed sediment were also implicated in structuring fish communities throughout the WMA.

8 The observed distribution patterns of the dominant fish species found throughout the WMA were described, along with brief notes on their natural history. The importance of free access between fresh water and the sea was emphasised for many species. The Matahina and Aniwhenua Dams in particular have had a large effect on preventing these natural longitudinal movements, although the ongoing trap and transfer work undertaken by the Kokopu Trust has had demonstrable positive effects on the population of migrant native fish throughout the Rangitaiki.

9 Predation by introduced rainbow and brown trout is another pressure faced by native fish in the Rangitāiki. Such predation is thought to be responsible for the loss of dwarf galaxias from streams where they were once found. It may be possible to install weirs or other devices in streams where non-migratory native fish such as dwarf galaxias are found to prevent trout from colonising these areas.

10 Size frequency distributions of longfin eel showed a lack of smaller size class throughout the Rangitāiki WMA. Other surveys of streams in the Kaituna-Maketū Pongakawa-Waitahanui WMA also showed a similar pattern, so the lack of small eels in the Rangitaiki Catchment above the Matahina Dam is considered unrelated to the dams. Reduced numbers of small longfin eels within populations has also been observed in other regions of New Zealand, suggesting potential future recruitment failure. However, a similar lack of small size class shortfin eels was also observed. Thus, the low numbers of small eels may reflect a combination of their reduced catch-ability by electric-fishing, or the fact that smaller eels may have been present in the lower section of the Rangitaiki which has not been surveyed. .

11 Recommendations for new studies and monitoring programmes are made, including:

- Monitoring eel numbers, sizes (length and weight) and catch per unit effort (kg/net/night) in lakes Matahina and Aniwhenua to assess eel populations and growth rates in these lakes.
- Monitoring eel population and sizes at selected sites throughout the Rangitāiki catchment, including at sites below the Matahina Dam to ensure the size composition of elvers is not an artefact of distance inland.
- Work with the Rangitāiki River Forum, the Kokopu Trust, and other relevant parties in identifying potential new sites where elvers can be liberated.
- Undertake long-term monitoring to confirm the existence of koaro throughout headwater streams within the area, and to identify potential new populations of dwarf galaxias.
- Consider creating trout-free streams by installation of weirs or other devices to prevent their upstream movement into trout-free streams.
- Undertake repeat surveys of giant kokopu and redfin bully at sites throughout the Rangitāiki, including streams and drains below the Matahina Dam, in Lake Matahina, and streams such as the Moetahanga Stream and other tributaries that flow into this lake to confirm the existence of these migratory fish above the dam. Part of this work could also involve obtaining ear bones (otoliths) from a sample of kora and giant kokopu and use microchemistry techniques to look for evidence of land locked populations.

- Ensure that there is ongoing liaison between agencies such as Bay of Plenty Regional Council (BOPRC), the Rangitāiki River Forum, Ministry of Primary Industries (MPI), and Department of Conservation (DOC) regarding the management of the commercial eel fishery. Aspirational management plans are often of little practical significance unless they become adopted by fishery managers.

Contents

Part 1: Introduction

The National Policy Statement for Freshwater Management (NPS-FM) requires regional councils to establish freshwater objectives, and subsequently set limits to give effect to those objectives. The NPS-FM also requires that the overall quality of fresh water within a region is maintained or improved. It has identified a number of specific water quality attributes under the National Objectives Framework (NOF) that councils must monitor, and has set minimum acceptable states (i.e. 'national bottom lines') for those attributes to support the compulsory values of ecosystem health and human health for recreation.

Implementing the NPS-FW requires community discussions about both the current state of fresh water as well as the desired state. BOPRC is implementing the NPS-FW progressively by working in priority catchments, which they have called Water Management Areas (WMAs). As part of the community consultation process, Carter et al. (2015) prepared a report that summarised the current state of scientific knowledge within the Rangitaiki WMA, and highlighted information gaps. This report briefly summarised information on:

- Freshwater quality.
- Periphyton (stream algae).
- Cyanobacteria (commonly called blue-green algae).
- Freshwater invertebrates.
- Fish communities.
- Hydrology.
- Landuse and soils.
- Groundwater.

The Carter et al. (2015) report emphasised that fish are one of the most important ecological values of waterways, and freshwater fish have sustained iwi for centuries; as a result, iwi have developed close relationships with the natural life cycle of our native freshwater fish. Such close relationships ensured that they could harvest a bountiful food supply. Other important freshwater fish include introduced trout, which were liberated during the 19th century throughout the country, and now form a hugely important recreational resource.

Despite their importance, both native and introduced fish are often affected by human activities. For instance, channel straightening and dredging, removal of riparian vegetation, input of excess nutrients and sediments, and water abstraction all place stress on fish communities. Such stressors are particularly evident in lowland areas where agricultural development and urban activities occur. Many of the native fish also require free access to and from the sea, and this is often interrupted by dams (either hydroelectric or water supply), as well as structures such as poorly installed road culverts and floodgates.

The Carter et al. (2015 report) made two recommendations for future fisheries work in the Rangitaiki WMA:

1 Undertake further analysis of recent fish survey data to determine if trap and transfer protocols are having positive effects on fish communities.

2 Obtain all raw data from previous eels surveys (both NIWA and Te Whare Wānanga Awanuiarangi) to better examine changes in eel size in lakes Matahina and Aniwhenua.

Many of these recommendations were based on information extracted from the New Zealand Freshwater Fisheries Database (NZFFD). The NZFFD is a nationally significant database that is maintained by NIWA, and contains over 30,000 records of freshwater fish observations throughout the country. Examination of the NZFFD showed that fish surveys have been conducted at 198 sites throughout the WMA (Figure 1). Eight records were from sites surveyed prior to 1980, while the most up-to-date records come from eight sites surveyed in 2010 and 2011 (Table 1). Most samples (86) were collected post-2000, whilst 46 and 50 sites were collected respectively during the 80s and 90s.

As part of a large-scale ecological investigation of waterways throughout the Rangitaiki River catchment (Suren 2014), a freshwater fish survey was recommended to 1) fill in data gaps where fish surveys have been under represented, and 2) to conduct more up-to-date surveys from sites previously examined. This report thus summarises the results of the recent survey, as well as analyses the combined fish data collected from the Rangitaiki Catchment to identify the common species and their distribution, as well as dominant environmental factors responsible for these distribution patterns. Some of the sites surveyed had also been surveyed previously, allowing us to see how fish community composition had changed at these sites over time.

1.1 Summary of current data

A number of different fisheries surveys have already been conducted in the Rangitaiki Catchment by a variety of organisations (Figure 1). Much work has concentrated on the fish fauna of Lake Matahina and Aniwhenua (Smith et al. 2007, 2008; Kearney et al. 2013), the mainstem of the Rangitaiki River below Lake Matahina (Kearney et al. 2013a, b), selected tributaries in the Whirinaki Catchment (Young 2000, Smith et al. 2007), the upper reaches of the Rangitaiki and Wheao rivers (Bioresearches 1976, 1985a, 1986a,b, 1987, 1988, 1989, 1991), and the lower reaches below Edgecumbe (Bioresearches 1978, 1979, 1980, 1985b). The following section reviews these studies and makes recommendations for future fisheries work in the catchment.

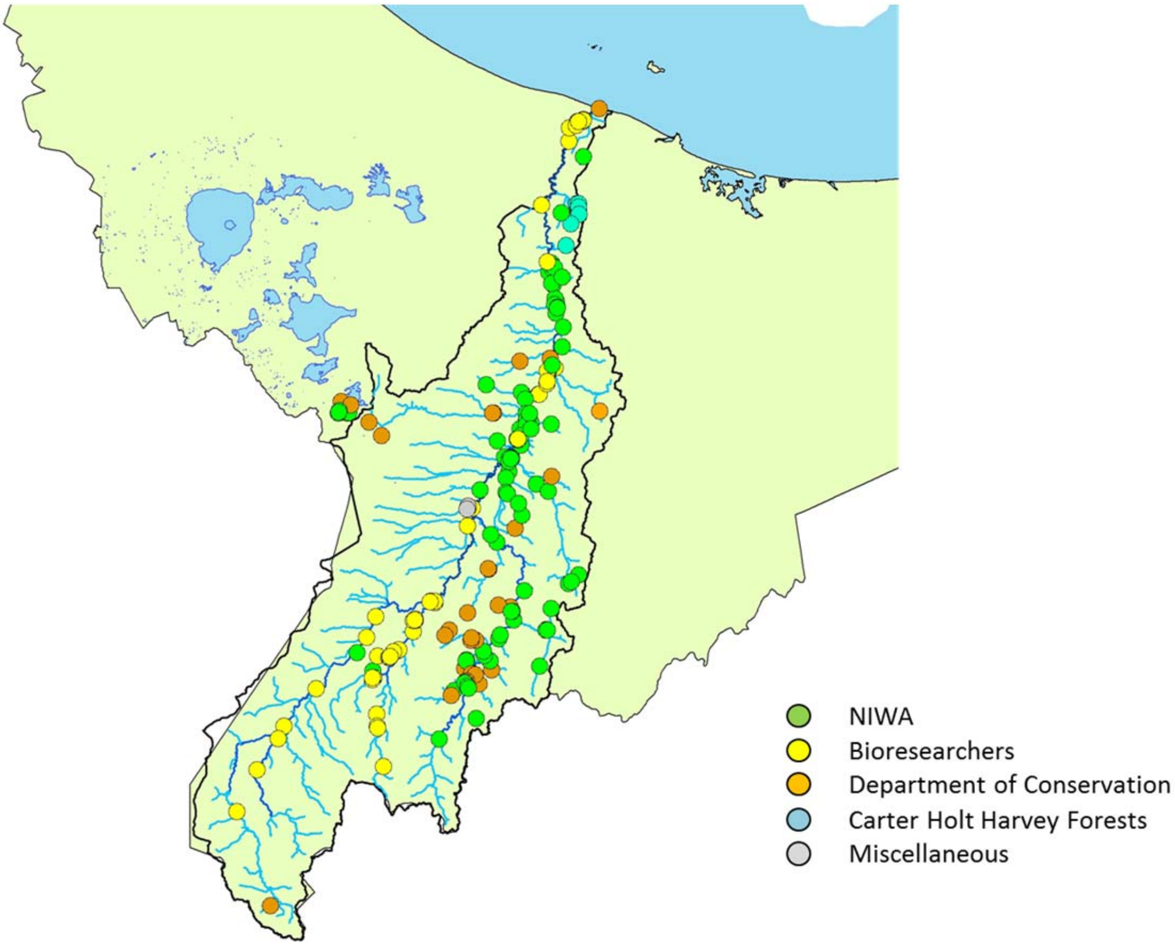


Figure 1 Match showing the spatial distribution of previous fisheries surveys undertaken throughout the Rangitaiki Catchment, colour coded by the organisation who conducted the work.

1.1.1 Eel studies

Many of the fish studies (Smith et al. 2007, 2008; Kearney et al. 2013) focused on assessing the population structure, size distribution and growth rates of both shortfin and longfin eels. For example, Smith et al. (2009) compared size distributions (length and weight) of both eel species in lakes Matahina and Aniwhenua from 1988, 1996, 2007 and 2008, based on eel numbers caught in coarse mesh fyke nets deployed in each lake. They found that both the length and weight of both species had decreased over time between the studies, with a trend for smaller eels to be found.

Smith et al. (2008) also found that eel density was low in most tributaries. Many of these tributaries were generally fast flowing streams with gravel beds, which are better suited to trout and longfin eels. These habitats are not particularly suitable for shortfin eels, which were the most commonly encountered species in the upper catchment during their survey. However, Smith et al. also noted that a number of soft-bottomed streams did support good numbers of shortfin eels, and suggested that some of these streams could be better protected and enhanced to increase shortfin densities in the area. Finally, Smith et al. (2008) suggested that growth rates of both species may be slowing in the lakes due to potential over-stocking, and subsequent competition. Because of these concerns, they recommended that the population be monitored at three to five year intervals.

Kearney et al. (2013a) assessed the distribution and abundance of eels in lakes Matahina and Aniwhenua in 2012 and 2013. Unfortunately, Kearney et al. (2013) did not compare their results with results from the earlier studies. Many of the sites they sampled had not been sampled by Smith et al. (2007, 2008) in the earlier studies, possibly confounding successful comparisons of the more recent data with the older data. However, if we assume that each of the studies caught a representative proportion of the eels within each lake (which is not an unreasonable assumption), initial examination of the long-term data (Table 1) shows a continued decline in eel weights from Lake Aniwhenua, and a potential decline in the weights of shortfin eels in Lake Matahina (Figure 2). No apparent trends to longfin weights in Lake Matahina were evident. Longer term monitoring of eel populations from the same locations as caught previously is required to confirm these trends. Ideally, any further data on eel length/biomass collected from the two hydro lakes would be combined with previous data from both Smith et al. (2007, 2008) and Kearney et al. (2013).

Table 1 Weight characteristics of shortfin and longfin eels captured in coarse mesh fyke nets (12 mm mesh in 2008, but 20 mm in other years) from a lakes Matahina and Aniwhenua. Data from 1989 to 2008 came from Smith et al. (2009); data from 2012 and 2013 came from Kearney et al. (2013a).

Location	***Year***	***Shortfin weight***				***Longfin weight***			
		n	**average**	**min**	**max**	**n**	**average**	**min**	**max**
Matahina	1989	132	699	100	1800	42	1023	830	1300
	1996	96	570	63	3320	14	1454	147	3300
	2007	80	510	130	1830	16	1170	120	2850
	2008	135	400	20	1810	11	1000	430	2250
	2012	95	526	95	1714	125	1103	135	9750
	2013	87	393	78	1145	46	781	204	3180
Aniwhenua	1996	105	656	145	1470	5	1500	400	10000
	2007	53	510	150	1470	4	460	340	600
	2008	252	350	10	1480	10	510	190	1550
	2012	202	413	30	1109	23	410	126	1477
	2013	94	362	74	947	23	207	126	678

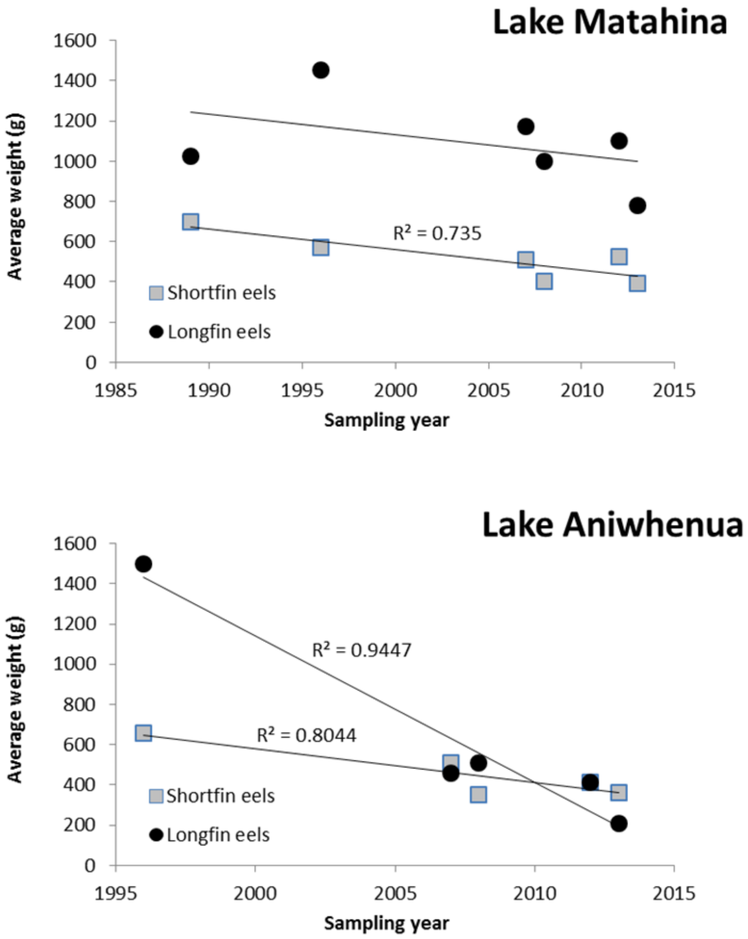


Figure 2 *Changes in average weight of eels caught in fyke nets deployed in lakes Matahina and Aniwhenua over time. The % variance explained (R^2) value is also shown for those regressions that were significant ($P < 0.05$).*

1.1.2 Other fish surveys

Many fish surveys have been done in the Rangitaiki Catchment, ranging from surveys as part of consent or compliance requirements, surveys targeting eel populations, or more general synoptic surveys. The following section summarises just some of these.

Early fisheries surveys in the catchment were done by Bioresearches (1976 – 1991), who examined sites in the upper Rangitaiki River above the confluence with the Wheao River, sites in the Whaeo River, and sites in Flaxy Creek as part of either consent or compliance investigations for the Rangitāiki-Whaeo hydroelectric scheme. These reports appeared concerned mostly with trout populations (both rainbow and brown), but did record presence of longfin eels in the upper reaches of the Rangitaiki River, and the Whaeo River. The eel in the Rangitaiki (collected on 29/11/77) was 600 mm long, while the two in the Whaeo River (collected on 2/12/77) were 600 and 900 mm long, respectively. Chisnall and Hicks (1997) examined growth rates of longfin eels collected from streams draining pasture and indigenous forest in the Waikato, as well is from two hydroelectric lakes: Lake Karapiro on the Waikato River, and Lake Matahina. Using this data, they developed relationships between length and age of eels in Lake Matahina. Using these relationships, the eels encountered by Bioresearches in 1977 were between 22 and 37 years old (for the 600 and 900 mm length respectively).

This means that these eels would have been present at these sites prior to the construction of the Hydro dams. This is important information, as it provides some context as to the natural ability of eels to penetrate that far inland up the Rangitaiki.

Smith et al. (2008) also surveyed a number of tributary streams in the upper Rangitaiki River Catchment immediately upstream and downstream of Lake Aniwhenua. Most of the streams were electro fished close to their confluence with the mainstem of the Rangitaiki River. Catchment landuse in these streams was dominated by either exotic forestry or farming, although many sites had riparian margins of scrub or native bush. The only fish encountered were trout (rainbow and brown) and eels (longfin and shortfin). Young (2000) surveyed 18 tributary streams in the Whirinaki River, and encountered a similar fauna. Young found less than 30 longfin eels and only five shortfin eels in their surveys: numbers which were very low in comparison with other Bay of Plenty rivers and streams. . Most of the eels also comprised larger individuals, and no small eels (<170 mm) were collected. Young (2000) highlighted that the low numbers and lack of small eels in her survey revealed a lack of continuous and recent recruitment to the Whirinaki system. She suggested that the decline of eel populations in the Whirinaki tributaries was a result of the hydro dams limiting natural recruitment from the upstream migration of elvers.

NIWA coordinated a multidisciplinary study of the Rangitaiki River above Lake Aniwhenua, investigating parameters such as soils, land use, rainfall, surface and groundwater hydrology, water quality and ecology, and produced a large (352 page) report (Boubee et al. 2009). In this report, they comment that the diversity, distribution and quality of native fish such as eels and kokopu have declined in the upper Rangitaiki, reflecting fish passage issues, over exploitation, loss of habitat, and competition from trout. They also did not know if isolated populations of native kokopu still remain, and if so, how to protect them and their habitat.

Given that the surveys of tributary streams were done up to 13 years ago, and that many of the smaller streams in the area had not yet been surveyed, a new fish survey was conducted in the autumn of 2014. The aims of this new survey were to resurvey some of the sites examined earlier by Bioresearches (1976 – 1991), Young (2000), Smith et al. (2008) and Boubee et al. (2009), and to survey new areas where fish surveys had not previously been conducted. Such areas included the upper reaches of rivers flowing from the Ikawhenua Ranges before they flowed out through the Galatea Plains. Rivers in these areas were in catchments dominated by native bush, and were characterised by coarse substrates and generally steep gradients, seemingly ideal conditions for many species of native fish.

Part 2: Methods

2.1 Contemporary field survey

Eighty-two sites were selected throughout the Rangitaiki Catchment to be surveyed, mainly above the Matahina and Aniwhenua dams. While many sites were in catchments dominated by native bush, others were in catchments draining exotic plantation forest, or pasture. The latter sites, in particular, were generally re-visiting sites where previous surveys were more than 15 years old. Access was either from sites close to roads or, at remote sites within the Ikawhenua Ranges, from helicopters. Fish communities were assessed in shallow streams by single pass electric-fishing using a Kāinga EFM3000 (Figure 3). Fishing progressed in an upstream direction, with stunned fish collected into a downstream net. At deep, slow flowing sites where electric fishing was unsuitable, fish communities were examined by deploying a set of three unbaited fyke nets (mesh size = 4 mm) overnight. These nets were set at angles from the bank with the cod-end facing downstream. Because the focus of this work was to document species composition of fish in different streams, and not to assess fish densities, quantitative fishing assessments such as multiple pass electric-fishing were not done. Choice of fishing method at each site was based on National Protocols (Joy et al. 2013), with some sites being fished with both methods.

Figure 3 Fish survey work was conducted in streams by electric fishing, whereby an electric current was pulsed through the water, stunning any fish present in the electric field. These stunned fish were easily collected in a downstream net.

Electric fishing specifically targeted habitats in streams where fish were likely to occur, instead of surveying all habitats in a reach. Thus, for example, areas of fine, highly mobile pumice sand, or cobbles in fast flowing riffles were not extensively fished, as these habitats rarely supported any fish. In contrast, undercut banks, debris jams and macrophyte beds were specifically targeted within a reach, as these habitats often supported fish. The average area sampled was 50 m^2, ranging from 20 m^2 in small tributaries in the Horomunga and Whirinaki rivers, and a small unnamed tributary into the Rangitaiki near its confluence with the Whaeo, to 125 m^2 in the Mangakotokutuku Stream. Voltages used during fishing ranged from 200 – 500 volts, with the majority of sampling using 300 volts. All collected fish were kept in buckets, and anaesthetised using phenoxy-ethanol (diluted to about 5 ml per 10 litres). Each fish was measured to the nearest millimetre, identified, and replaced into a bucket containing natural stream water to recover. All fish were subsequently released back into the stream.

2.2 Statistical analysis

2.2.1 Physical characteristics

A total of 82 additional sites were surveyed during April 2014. All this data was combined with data extracted from the NZFFD, giving a total of 318 sites from the Rangitāiki WMA. Individual GPS locations for each new site were plotted using ARC-GIS to ensure that they were located on the appropriate NZReach. Where necessary, sites were manually moved to the appropriate NZReach. This occurred mainly where sites had been surveyed close to a tributary to ensure the appropriate NZReach had been selected.

The representativeness of all fish surveyed in relation to all waterways throughout the Rangitaiki WMA was assessed using techniques outlined in Snelder and Scarsbrook (2005). Briefly, this involved calculating the proportion of fish survey sites of a particular classification class to the total number of sites throughout the WMA. The proportion of river lengths in each class throughout the WMA was then calculated, and expressed as a proportion of the total river length in the WMA. The ratio of the first proportion to the second proportion illustrated the representativeness of the fish survey sites to other waterways within the WMA. Numbers close to one suggest that the number of fish survey sites was similar to the ratio of waterway length in that class; numbers greater than one indicate an over-representation of fish survey sites when compared to waterway length; numbers less than one indicate under-representation. Site representativeness was calculated firstly for sites extracted from the NZFFD, and secondly for all combined fishing sites.

Environmental factors such as elevation, distance to sea, slope etc. were then extracted from the Freshwater Environments of New Zealand (FENZ) database based on the NZReach ID. A total of 19 environmental factors describing each site were derived for the 318 sites. This environmental data described overall physical, climatic, and flow features at each site which may have influenced fish community composition. To reduce the inherent complexity of this data (19 factors/site for 318 sites), a Principal Components Analysis (PCA) was used to reveal any structure in the data. In this way it was possible to identify what the major environmental differences were between sites. Prior to the PCA, all factors were standardised so that measures with different units could be analysed together. The PCA also identified what environmental parameters were responsible for any observed gradients in the data. This was done by examining correlation coefficients between the environmental factors and the PCA axis 1 and 2 scores.

Following the PCA, a similarity matrix was calculated to show the similarity of all sites to each other based on their environmental data. The Euclidean distance measure was used for this analysis, which measures the “straight-line” distance between samples, and is appropriate for physical data. Thus, for example, consider three sites: A, B and C. If Sites A and B were generally small, far inland, and dominated by native bush, and Site C was a large river close to the coast flowing through a catchment dominated by pasture, then the Sites A and B would have a very small Euclidean distance measure as all environmental factors would be similar. However, there would be a greater Euclidean distance between sites A and C, and B and C, reflecting the fact that site C was different to the other sites. The resultant similarity matrix for all 318 sites thus summarised the similarity of all sites to each other, based on their environmental data. This similarity matrix was used to compare to a second similarity matrix that was created based on the fish survey data (see below). Having two similarity matrices allowed us to see how well the relationships in the ecological data matrix match up with the patters in the environmental data matrix.

2.2.2 Fish community patterns

All fish data was converted to presence-absence, and ordination (non-metric multidimensional scaling: NMDS) was used to examine and explore relationships and patterns in the fish community composition. Ordination is a statistical method used in exploratory data analysis to search for patterns in the data, such as being done here, rather than in testing specific hypothesis. It orders objects (in this case individual sampling sites) that are characterised by values of multiple variables (in this case the presence or absence of different fish at each site) so that similar sites are located near each other on an x-y graph, and dissimilar sites are located farther from each other. The first step in an ordination is to calculate a similarity matrix of all sites to each other. The Bray-Curtis similarity measure was used for this analysis. This measure results in scores ranging from zero (i.e. two sites having no species in composition) to one (i.e. two sites having exactly the same species composition). An NMDS ordination was then run on this similarity matrix to examine relationships between all the individual sites. NMDS produces a statistical score (called stress) that indicates the strength of the resultant ordination. Stress values greater than 0.3 indicate the resultant sample configurations are no better than arbitrary (i.e., there are no underlying patterns to fish community composition at each site). This would occur where the fish communities do not differ greatly between the different streams. Under such a scenario, no differences would be expected between streams flowing through native forest or through pasture. Generally speaking, sample configurations should not be interpreted unless the stress value is less than 0.2 (Clarke and Gorley 2001). The ordination thus identifies major gradients in the data, with the x-axis representing the greatest difference between samples, and the Y axis representing the second greatest difference. Analysing correlations of both species distribution and environmental variables against these axes determines which species and environmental variables were responsible for the observed gradients in the data.

The similarity matrices developed from the environmental and ecological data were examined to determine how well the relationships between sites matched each other. For this analysis we used the RELATE command in Primer (Ver 6.0), which calculates the Spearman rank correlation of the similarity matrices based on environmental or ecological data. If the fish communities were structured by the derived environmental variables, then we would expect a strong correlation between the two similarity matrices, whereas if fish communities were responding to other non-measured environmental variables and such strong correlations would not exist. Following this analysis we examined relationships between environmental variables and fish communities using the BEST procedure.

This procedure determines which environmental variables were responsible for the any observed patterns to the fish data. Because of the large number of environmental variables (13), we used a stepwise approach for this analysis, whereby the BEST procedure iteratively added or removed variables and selected only those which explained the highest degree of variation to the fish communities. This analysis was complemented by a regression analysis of environmental variables against the NMDS axis scores.

Both the BEST and regression analysis enabled us to determine which of the environmental variables were responsible for structuring the fish communities.

Finally, the effects of the Matahina Dam on fish community composition were examined. All sites in the combined NZFFD and 2014 survey were allocated to their location either above or below the Matahina Dam. The statistical analysis ANOSIM was then used to see whether there were differences in the fish community structure above and below the Matahina Dam. The number of different fish species collected at sites above and below the Matahina Dam was also examined using paired t-tests, as was the number of exotic and native fish.

These analyses were done to help search for and explain any observed patterns found in the distribution of fish throughout the Rangitāiki WMA. Following this analysis, commentary was made about selected species, including comments on their distribution throughout the WMA.

2.2.3 Assessment of fish integrity

Suren (2016) recently developed a fish index of biotic integrity (Fish IBI) to describe the ecological integrity of fish communities at sites throughout the Bay of Plenty. This Fish IBI was based on work developed by Joy and Death (2004) that examined the behaviour of six different metrics describing the fish community at each site along a gradient of elevation and distance to sea. The metrics used by Suren (2016) included the number of: native species; riffle dwelling species; benthic pool species; pelagic pool species; intolerant species; and the proportion of native species at a site. Joy (2007) demonstrated the use of quantile regression analysis that, when fitted to each metric plotted against either elevation or distance to sea, divided the data into two regression lines. The lowermost regression line was based on 33% of the data points occurring below this line, while the upper regression line was based on 66% of the data occurring below this. Where the number of species of a particular metric at a site of a given and altitude (or distance to sea) was below the 33% regression line, that site scored 1 for that particular metric. Where the number of species was above the 66% regression line, the sites were scored 5 for that metric. Sites where the number of species were between the two lines at a given altitude were scored 3. The total Fish IBI was based on the sum of the scores for the six metrics for both elevation and distance to sea.

Although Suren (2016) found slightly different relationships between some metrics and distance to sea and elevation than found by Joy (2007) in the Waikato region, the overall range of scores was very similar. Joy (2007) also developed five integrity classes based on percentile scores of the calculated Fish IBI, and Suren (2016) used a similar method in the Bay of Plenty. The range of Fish IBI scores found by Suren were very similar to those found by Joy (2007), despite the subtle differences in the fish community composition between the regions, and differences in the behaviour of each metric against altitudinal or distance to sea gradients.

The Fish IBI was thus calculated for each site sampled throughout the WMA. Regression analysis was used to see how the scores varied with parameters such as elevation, distance to sea, and percentage land cover. ANOVA was also used to see whether the Fish IBI differed between streams draining different land use classes, and a paired t-test was used to determine whether Fish IBI differed above and below the Matahina Dam.

Part 3: Results

3.1 Site representativeness

Representativeness of fishing sites extracted from either the NZFFD, or NZFFD sites combined with the 2014 survey sites was assessed in comparison to the nature of water ways throughout the WMA. There were no major changes in site representativeness between the NZFFD surveys and the combined surveys for each of the four REC categories (Table 2). For the REC Climate class, the Warm-Dry (WD) class was under-represented in both the NZFFD and combined data, while the Cool-Wet (CW) and Warm-Wet (WW) were generally well represented. For Source of Flow, Hill country sites (H) and Lowland sites were only slightly under-represented (Table 2), while representation of lake fed sites decreased in the combined survey. This simply reflected the focus of the 2014 survey on river and stream environments, as lake surveys had been done relatively recently (Kearney et al. 2013a, b).

The dominant catchment geology in the WMA was volcanic, and this was well represented in both the NZFFD and the combined data (Table 2). There was also slight over-representation of sites in non-volcanic geology in the NZFFD data, and this had increased slightly in the combined data, reflecting the concentration of sites in the non-volcanic Ikawhenua ranges, and Whirinaki region.

Examination of land cover data showed some differences in site representativeness between the NZFFD data and the combined data (Table 2). In particular, the proportion of streams draining native bush had increased in the combined data, while the proportion of streams draining agricultural and exotic forest streams had decreased slightly. This simply reflected the fact that catchments that drained native bush were in part, specifically targeted in the contemporary survey, as these had been identified previously as being under-represented (Carter et al. 2015).

Table 2 *Calculation of site representativeness of the fish sites extracted from the NZFFD, or the combined data from there and the contemporary survey when compared with streams throughout the WMA for different climate, source of flow, geology and land cover classes. Shading indicates whether particular REC classes were under represented (light red), overrepresented (green), or sampled approximately according to the proportion found in the region (blue).*

REC class	***Number of NZFFD sites***	***Combined NZFFD + 2016 survey***	***Total length of class (km)***	***Length of class as a proportion of total river length (%)***	***Representation of class by NZFFD sites***	***Representation of class by combined sites***
Climate						
Cool-Wet	220	284	4.86	85.29	1.03	1.05
Warm-Dry	1	1	3771.46	1.47	0.27	0.21
Warm-Wet	30	33	64.85	13.14	0.91	0.79
Source of flow						
Hill	201	263	580.92	77.12	1.04	1.07
Lowland	49	54	3410.15	21.97	0.89	0.77
Lake	1	1	971.65	0.73	0.55	0.43
Geology						
Non_Volcanic	19	34	8.18	6.46	1.17	1.66
Volcanic	232	284	285.68	93.54	0.99	0.95
Land cover						
Agriculture	50	53	4136.41	21.43	0.93	0.78
Exotic_Forest	115	123	946.41	50.54	0.91	0.77
Native	86	142	2231.84	28.03	1.22	1.59

3.2 Physical characteristics

The Rangitāiki River (Figure 4) is the longest river in the Bay of Plenty region, and at 2,947 km^2 has the largest catchment. It originates in small headwater streams arising on the northern flanks of the Kaimanawa Ranges, which coalesce and flow north for about 155 km to the coast. A number of large tributaries such as the Wheao, Whirinaki and Horomunga rivers join the Rangitāiki in the upper half of its catchment. Plantation forestry covers approximately 52% of the catchment followed by native bush, (28%) and pasture (18%) which comprises a mix of dairy farming and beef. Native bush occurs along the eastern side of the catchment in the Urewera and Whirinaki state forests, while intensive dairy farming occurs mainly in the Galatea and Rangitāiki Plains.

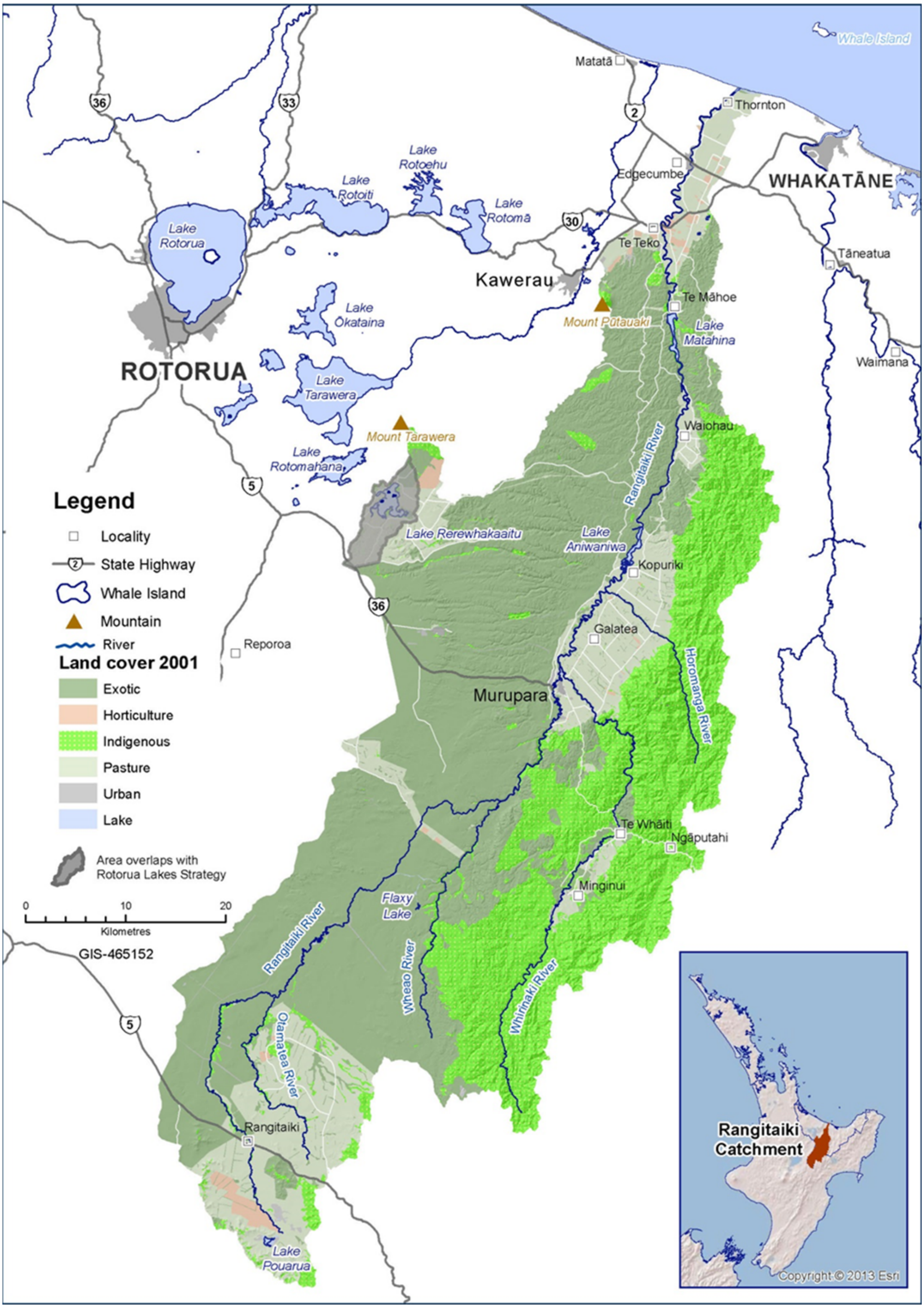
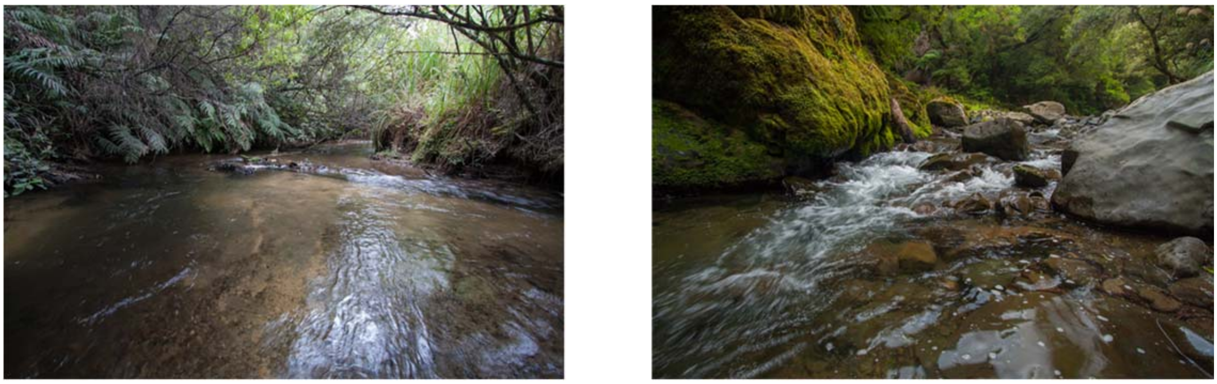


Figure 4 *Map of the Rangitaiki Catchment, showing major place names, and the dominant land uses.*

Three hydroelectric power schemes occur in the river. The Wheao Power Scheme in the upper part of the catchment diverts water from the Rangitāiki River, the Wheao River and Flaxy Creek through a series of constructed canals leading to a power house, where it discharges back into the Wheao. This was constructed in 1982. Midway down the catchment is the second hydro scheme, where the Rangitāiki River was dammed above the Aniwhenua Falls in 1979. The resultant Lake Aniwhenua (area = 2.1 km^2) is a major recreational resource supporting a significant trout fishery, duck shooting opportunities and is a popular water-skiing area. The lowermost hydro-scheme on the river is the Matahina Dam which was commissioned in 1967. It is approximately 20 km from the coast and is the highest earth dam in the North Island. Behind this dam is Lake Matahina, which is slightly larger than Lake Aniwhenua (area = 2.5 km^2) and also much deeper (60 + m). Both lakes have only relatively limited drawdown ranges (about 3 m or less) and limited storage, and thus operate as a mix between run-of river and peaking schemes. As expected, fish surveys have been undertaken throughout a wide variety of waterways in the Rangitaiki Catchment. Streams sampled varied greatly with respect to their locations, with some streams located in low elevations close to the coast, and others more inland at higher elevations (Table 3). Overall elevation gradients of the 319 sites were not particularly large, but most sites were located relatively far from the coast. This reflects the fact that, below the Matahina Dam, the mainstem of the Rangitāiki River receives very few inflowing tributaries, whereas most surveys in the catchment have occurred in areas above the Matahina Dam.

Stream size was also highly variable, ranging from very small streams with low discharge through to the mainstem of the Rangitaiki, with correspondingly higher discharge (Table 3). Land cover also varied greatly between catchments, with a high proportion of catchments draining native bush and exotic plantation forests. Average modelled sediment size was also relatively large, emphasising the fact that many of the streams to the east of the Rangitaiki flow through catchments dominated by greywacke, and thus have a generally coarse streambed. This contrasts to streams in the western part of the catchment, which are dominated by finer pumice material (Figure 5). Stream shade was also highly variable, ranging from streams without any overhead shade, through to streams that were well-shaded. Shade was also independent of dominant land use, as some of the braided streams draining catchments dominated by native bush had little, if any, overhead shade (Figure 5).



a) Pumice dominated stream

b) Boulder – cobble dominated stream

c) Well shaded stream

d) Open stream

Figure 5 Examples of the variety of waterways throughout the catchment, showing large differences in stream substrate size (a and b) and shade (c and d), even in streams draining catchments dominated by native bush.

Table 3 Summary of environmental factors in the 319 sites where fish surveys have been conducted in the Rangitaiki WMA, showing the average, minimum and maximum values.

Factor class	***Factor***	***Abbreviation***	***Average***	***Min***	***Max***
Catchment	Catchment Area (km^2)	CatchArea	366.1	0.4	2939.2
	Distance to Sea (km)	DistSea	91.1	0.6	194.4
	Downstream Average slope (^{o})	DS_Av_Slope	0.2	0.0	0.4
	Elevation (m ASL)	Elevat	291.0	5.5	774.2
	Segment Slope (^{o})	SegSlope	1.4	0.0	15.6
	Upstream average slope (^{o})	US_Av_Slope	14.3	0.6	32.0
Climate	January air temperature (^{o}C)	JanAirT	17.3	14.5	18.9

Factor class	***Factor***	***Abbreviation***	***Average***	***Min***	***Max***
Hydrology	Upstream rain days (>200 mm/day)	US_Rain_Days	12.1	9.1	17.8
	FRE3	FRE3	9.3	3.7	17.2
	Segment flow (m^3/s)	SegFlow	8.8	0.0	68.3
	Segment Low flow(m^3/s)	SegLowflow	3.2	0.0	23.7
Landuse	CLUES_N (mg/l)	CLUES_N	487.6	4.6	2898.4
	% Exotic Forest	Exotic_Forest	35.5	0.0	100.0
	% Exotic Scrub	Exotic_Scrub	0.3	0.0	19.0
	% Agriculture	Agriculture	11.1	0.0	93.0
	% Native Vegetation	Native_Veg	51.7	0.0	100.0
Stream	Habitat	Habitat	4.0	3.1	4.9
	Sediment	Sediment	3.8	1.5	5.6

Relationships between distance inland and altitude showed some interesting differences between the major catchments (Figure 6). For example, the surveys at highest altitude were in the Whaeo catchment, while the most inland were at the head of the Rangitaiki. Catchment slope was higher in the Whaeo and Horomanga, and slopes in the Rangitaiki appeared steepest in its mid reaches, from about 65 km to 140 km inland. The location of the two hydroelectric dams that Lake Matahina and Aniwhenua are clearly shown, and this emphasises the fact that the vast majority of sites surveyed (92%) are above the lowermost dam (Matahina).

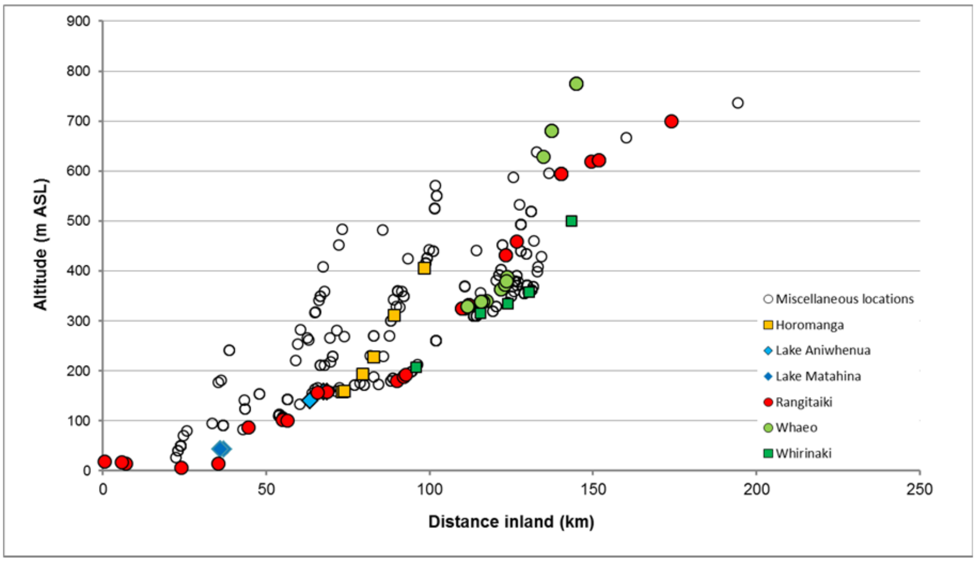


Figure 6 *Relationship between distance inland and altitude of sites where fisheries assessments have been made in the Rangitaiki WMA. Also shown are general relationships for selected individual rivers, as well as the location of the two lowermost hydro-electric schemes.*

The PCA of the 18 environmental factors was used to identify any major gradients in the data, and to determine if any natural groupings could be made according to environmental factors. The first two axes of the PCA explained 44% of the total variability in the data. A major gradient along the PCA axis 1 was related to inherent catchment conditions such as distance to sea elevation, catchment size and slope, stream hydrology (mean flow and flood frequency), and land cover (native vegetation, horticulture or pasture, and CLUES-N). Local conditions such as substrate size and habitat diversity were also important. Similar variables were also correlated to PCA axis 2 (Figure 7). These results suggested that physical conditions in the 319 sites were influenced by a strong gradient of physical location (elevation and distance to sea), catchment slope, climatic variables, land use and local variables such as substrate and habitat.

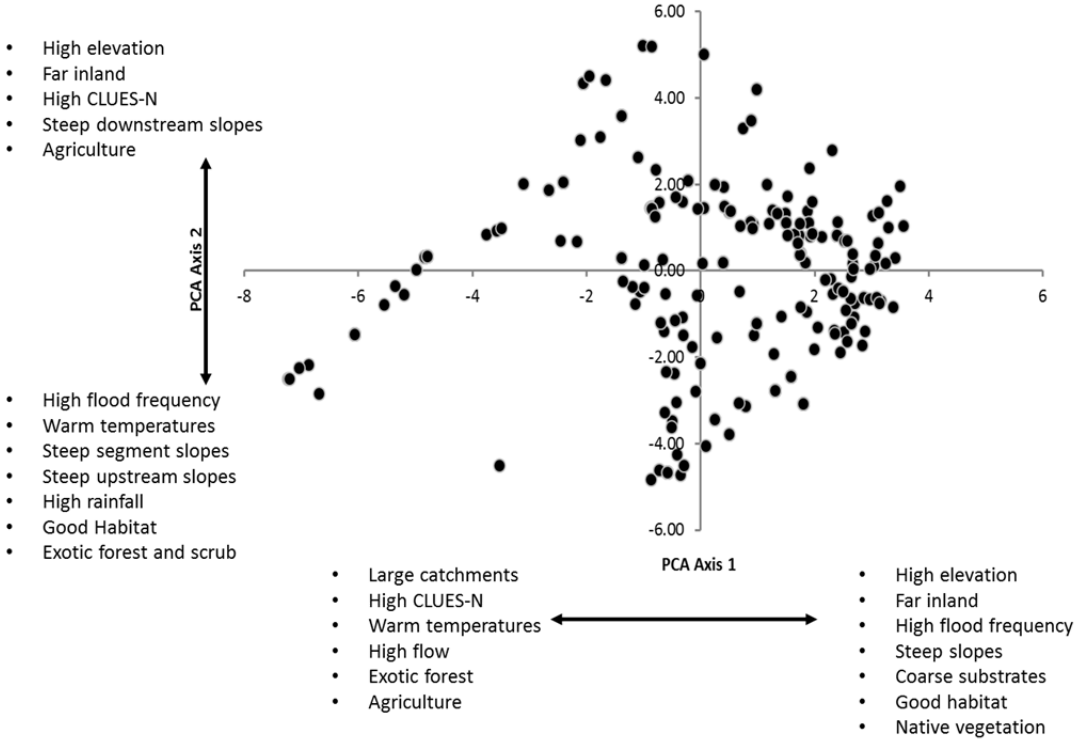


Figure 7 Results of a principal components analysis (PCA) of environmental data collected at the 319 sites extracted from the NZFFD, and the 2014 fish survey. Also shown are specific environmental factors that displayed strong correlations in either the PCA axes 1 or 2 scores.

3.3 The fish fauna

A total of 82 sites were surveyed between 10 - 19 March 2014. Fish were found in 66 of these sites. A total of eight fish species were encountered in the survey, and 1180 individual fish caught. Brown and rainbow trout were the most numerous species encountered, making up 54 and 15% of total abundance respectively (Table 4). The next most commonly caught fish were longfin eels (12%), followed by dwarf galaxias (11%) and shortfin eels (4%). Longfin eels and rainbow trout were the most widespread species, and found in 55 and 42% of sites respectively. Brown trout and shortfin eels were the next most widespread species, found in 23 and 15% of sites respectively.

Table 4 List of fish species recorded within the Rangitaiki WMA from the recent 2014 survey, showing the % abundance of the different fish species caught to the total number caught, as well as the % of sites that each species was found at. Species in bold indicate introduced fish. Species highlighted in pink indicate those listed by the Department of Conservation as being "Threatened, nationally vulnerable"; those highlighted in orange indicate those identified as being "At risk, declining".

Species	***Common name***	***% abundance***	***% frequency of occurrence***
Oncorhynchus mykiss	Rainbow trout	54.0	52.4
Salmo trutta	Brown trout	15.1	23.2
Anguilla dieffenbachii	Longfin eel	11.7	54.9
Galaxias divergens	Dwarf galaxias	10.4	4.9
Anguilla australis	Shortfin eel	6.5	15.9
Galaxias brevipinnis	Koaro	1.0	4.9
Gobiomorphus huttoni	Redfin bully	1.0	1.2
Galaxias argenteus	Giant kokopu	0.2	1.2
***Anguilla* sp**	Eel_unidentified	0.1	1.2

The large number of dwarf galaxias caught (123) was surprising, given the fact that these fish have only been previously reported from three sites in the catchment, and that these populations of these fish were thought to be declining. Previous surveys of these fish in the 1960's showed that they were found in the Horomanga River, the Kotuku uku Stream, and the Tukuhouhou Stream, with densities in the Tukuhouhou Stream particularly high (100 individuals encountered). No dwarf galaxias were found in the same sites when resurveyed in 2014. Instead, only large numbers of rainbow trout were found (Figure 8). For example, 94 rainbow trout were found in an area of 60 m² in the Horomanga River site.

Figure 8 Examples of young rainbow trout parr found in a tributary of the upper Horomunga River, where dwarf galaxias had been previously recorded. In the present survey, only trout and a few longfin eels were found at these sites.

Two surveys were undertaken in the Kopuriki Stream in the 1990's which showed relatively high densities of dwarf galaxias (30 individuals per 50 m²). Similarly high densities were recorded in the present survey from the same site, with 42 individuals being found from approximately 35 m². Populations of dwarf galaxias were also found in the Ohutu Stream, where only a single rainbow trout was caught. There large numbers suggests that populations of this threatened fish appear relatively stable in a few streams in the Ikawhenua Ranges, especially where trout are not present. These results reinforce the negative interaction between introduced trout and small native fish such as dwarf galaxias (McDowall 2006; Woodford and McIntosh 2013), and highlight the fact that when trout colonise a stream, native fish such as galaxiids often disappear.

Four streams surveyed were found to contain Koaro, making these the first records for the catchment. These streams include two sites on both the Te Weramata Stream and Okahu Stream. Some of these sites had been surveyed previously but koaro were not recorded, so their presence in the catchment now is likely to reflect the success of the trap and transfer work being undertaken by the Kokopu Trust. Although koaro can form landlocked populations, it is not known if they can in Lake Aniwhenua, as the residence time within this lake may be too short to allow the planktonic larval stage of their life cycle to be successfully completed (Mitchell 1996). However, the existence of land locked populations can only be truly ascertained by examining the microchemistry of otoliths, the chemical composition of which can reveal where the fish were from.

Many of the sites surveyed around the Whirinaki and its tributaries were previously surveyed by DOC between November 1999 and February 2000 (Young 2000). This earlier survey found that numbers of longfin and shortfin eels in the Whirinaki tributaries were low. Preliminary analysis suggests that the number of eels at the same sites resurveyed in 2014 was higher; again emphasising that the trap and transfer work appears to be successful in relocating eels into sites where they were once uncommon or absent. Further surveys need to be conducted to confirm this trend.

The results of the 2014 survey were compared to the results of the fish surveys extracted from the NZFFD. In particular, the frequency of occurrence of each fish species at sites throughout the WMA was compared between the two datasets. Examination of the ratio of the frequency of occurrence in the 2014 surveys to those from the NZFFD showed that three fish species were more frequently encountered in the contemporary survey (Table 5). The higher proportion of sites with longfin eels, dwarf galaxias and koaro in the 2014 survey may reflect the differences in stream types, as many of these streams were in smaller catchments dominated by native bush or pine forest which traditionally had not been surveyed. Finding the first records of koaro in the catchment may also reflect the fact that it may have just taken this length of time before these fish were able to colonise the upper headwater streams following the trap and transfer by the Kokopu Trust. Other fish encountered in previous surveys were less common or absent in the contemporary survey (Table 5). This may simply reflect the fact that habitat conditions in many of the small forested streams that were surveyed in 2014 were unsuitable for these species. For example, common bullies, goldfish and mosquito fish prefer generally slow flowing streams with fine substrates, whereas many of the streams surveyed in 2014 were relatively fast flowing with coarser substrates. Furthermore, the 2014 survey made no attempt at surveying sites in the Rangitaiki River below the Matahina Dam. This would explain the absence of fish such as smelt, inanga, torrentfish and Cran’s bully.

Table 5 List of fish species recorded within the Rangitaiki WMA showing the ratio of the frequency of occurrence of different species in the 2014 surveys and in the NZFFD data. Fish more commonly encountered in the 2014 survey highlighted in green; fish less commonly encountered highlighted in orange. Fish encountered with roughly the same proportion in both surveys are also indicated (blue). Migratory native fish are also indicated (Y), and those that can form land locked populations are also indicated (Y).*

Common name	***Species***	***Migratory***	***% NZFFD***	***% 2016***	***Ratio Contemporary: NZFFD***
Rainbow trout	*Oncorhynchus mykiss*		65.9	52.4	🟦 0.81
Brown trout	*Salmo trutta*		46.3	23.2	🟧 0.47
Longfin eels	*Anguilla dieffenbachii*	Y	28.5	54.9	🟩 2.00
Shortfin eels	*Anguilla australis*	Y	25.2	15.9	🟧 0.64
Giant kokopu	*Galaxias argenteus*	Y*	8.5	1.2	🟧 0.15
Goldfish	*Carassius auratus*		8.1	0.0	🟧
Common bully	*Gobiomorphus cotidianus*	Y*	5.7	0.0	🟧
Unidentified bully	*Gobiomorphus*		5.3	0.0	🟧
Unidentified eel	*Anguilla sp*		4.5	1.2	🟧 0.28
Redfin bully	*Gobiomorphus huttoni*	Y	3.3	1.2	🟧 0.38
Dwarf galaxias	*Galaxias divergens*	N	2.0	4.9	🟩 2.45
Mosquito fish	*Gambusia affinis*		2.0	0.0	🟧
Smelt	*Retropinna retropinna*	Y*	2.0	0.0	🟧
Banded kokopu	*Galaxias fasciatus*	Y*	1.2	0.0	🟧
Inanga	*Galaxias maculatus*	Y*	1.2	0.0	🟧
Torrentfish	*Cheimarrichthys fosteri*	Y	0.4	0.0	🟧
Crans bully	*Gobiomorphus basalis*	N	0.4	0.0	🟧
Koaro	*Galaxias brevipinnis*	Y*	0.0	4.9	🟩 4.90

3.4 Fish community patterns

The NMDS analysis of fish presence-absence data throughout the WMA had a stress score of 0.08, suggesting that there were strong patterns in the data. Correlations of individual species and environmental factors to the axis 1 and 2 scores revealed interesting patterns. Native fish such as longfin eels and giant kokopu were found in sites with high axis 1 scores, and these were typified as streams from catchments with warm summer temperatures and high rainfall (Figure 9). In contrast, rainbow trout were found in samples with low axis 1 scores, and these sites were at high elevation and were far inland. They generally had steep catchment slopes and coarse substrates. Longfin eels were more abundant in sites with low axis 2 scores. These sites were from areas of high rainfall, and had a high flood frequency. Samples with high axis two scores were characterised by brown trout. These sites were typified by having a high percentage of land in agricultural development, and had high CLUES-N levels (Figure 9).

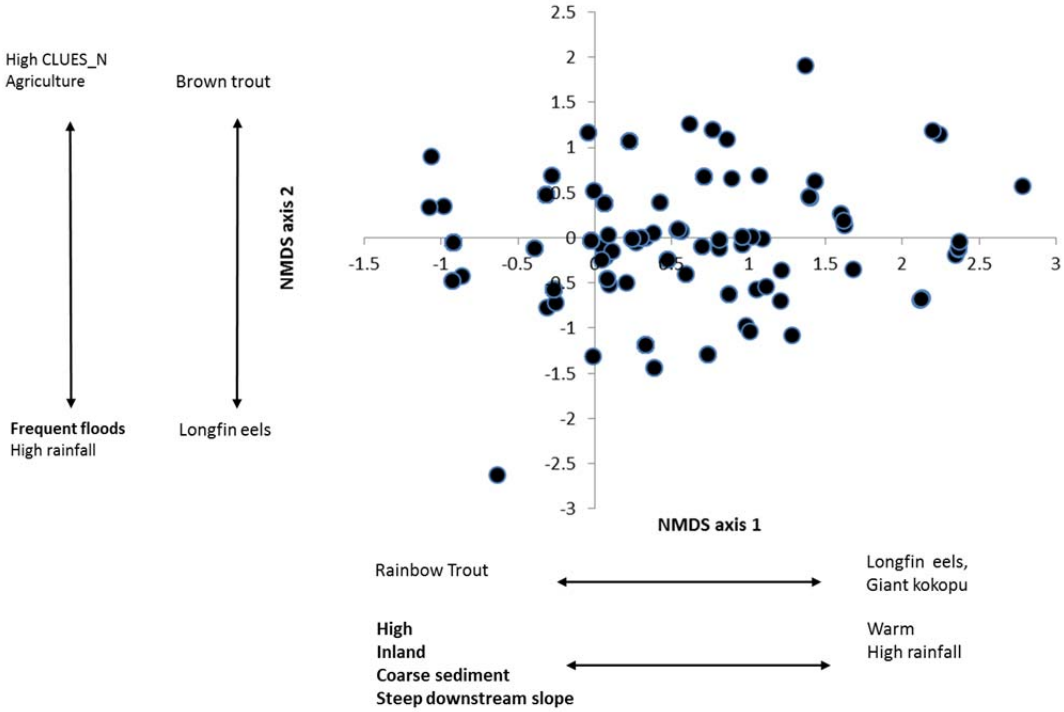


Figure 9 Results of a NMDS ordination of fish species presence-absence collected from the combined data set of 251 sites of both the NZFFD and the 2016 survey. Graph shows which fish species, and environmental factors were correlated to each of the NMDS axis 1 and 2 scores. Factors in bold were also identified in the BEST analysis. (Note, some symbols may represent more than one site, due to very similar NMDS scores).

The RELATE analysis showed a significant similarity between the similarity matrices based on environmental or ecological data (Spearman rank correlation coefficient = 0.303, P <0.001). This suggested that the fish communities were structured in a predictable manner by the measured environmental factors. The BEST procedure identified five environmental variables that were shown to be responsible the observed patterns to the fish data (Table 6). Four of these were also identified in the regression analysis of environmental data against NMDS axis 1 scores.

Table 6 Summary of the major environmental factors that had significant correlations to the ordination scores of fish presence absence throughout the Rangitaiki, as well as their individual correlation coefficients. Also shown are the variables selected by the BEST analysis to explain variation to the fish communities.

NMDS Ordination				
Axis1	**Correlation coefficient**	**Axis 2**	**Correlation coefficient**	**BEST analysis**
Elevation	-0.602	High CLUES-N	0.308	Elevation
Distance to sea	-0.556	Agriculture	0.278	Distance to sea
Coarse sediment	-0.418	FRE3	-0.262	Coarse sediment
Av_Ds_Slope	-0.397	RainDays	-0.290	Av_Ds_Slope
JanAirTemp	0.517			FRE3
RainDays	0.308			
FRE3				

Fish community composition was closely related to environmental parameters such as distance to sea and elevation, which were identified in both the NMDS ordination and BEST analysis. For example, species richness declined with increasing elevation (Figure 10), and this mirrors general patterns throughout the country. Climatic factors such as January air temperature and rainfall, as well as other factors such as catchment slope, flood frequency (FRE3) and substrate size were also implicated in structuring fish community patterns. Landuse did not appear to have a major effect on fish communities, although the amount of agricultural land, and predicted CLUES-N were implicated in having some effect on fish community composition.

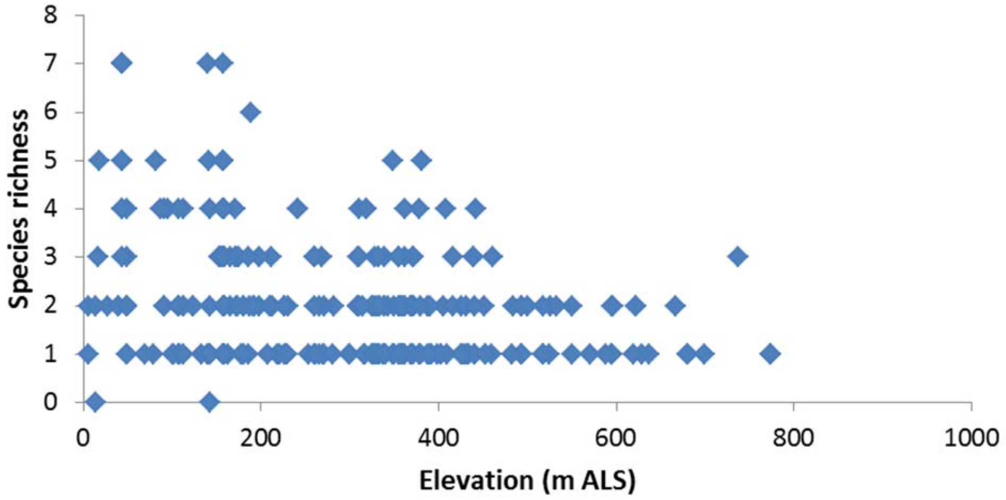


Figure 10 Relationship between the number of fish species found at each site and elevation, showing a strong reduction in species richness in higher elevation sites.

Fish community structure was significantly different at sites above and below the Matahina Dam (ANISOM Global R = 0.321, P <0.001). Results of the paired t-tests showed significantly higher mean species richness at the sites below the Matahina Dam (3.1 species per site) than sites above (2.0 species per site). There were significantly more native species caught at each site below the dam, but significantly more exotic species at sites above the dam (Figure 11).

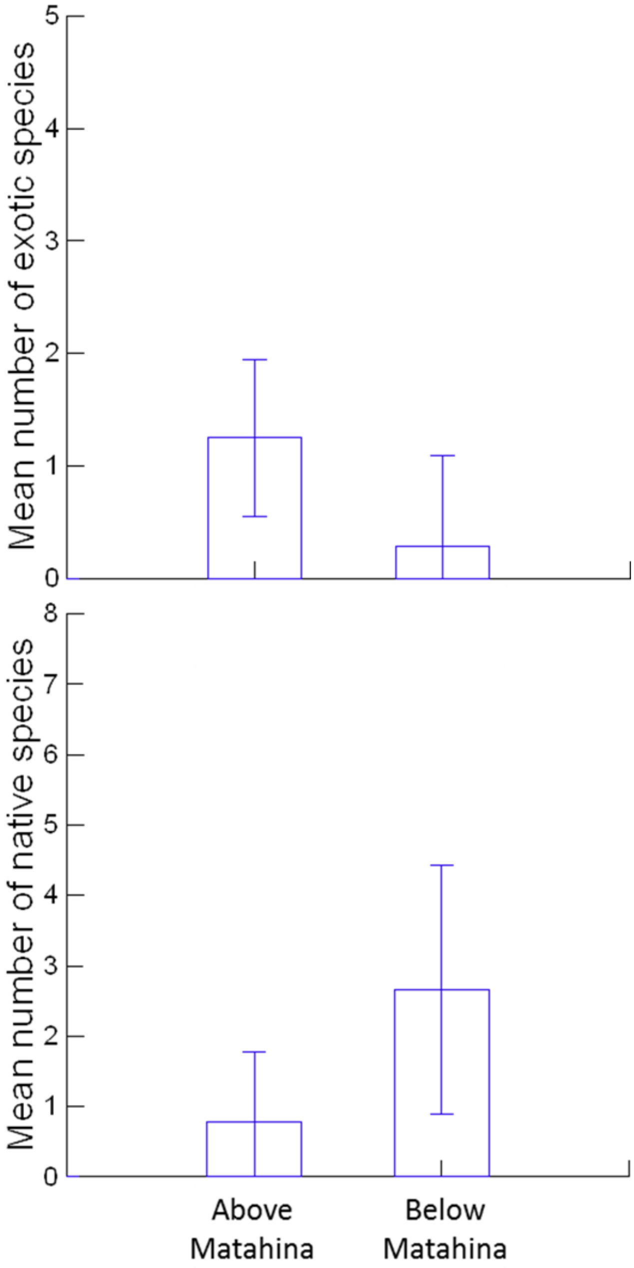


Figure 11 Differences in the number of native or exotic species found at sites above and below the Matahina Dam.

3.5 Assessment of fish integrity

Of the 318 sites throughout the Rangitaiki WMA, approximately one third had Fish IBI scores characteristic of poor (95 sites) or moderate (90 sites) integrity classes (Figure 12). Only about 15% of sites had scores characteristic of sites of excellent fish integrity. Six sites had no fish.

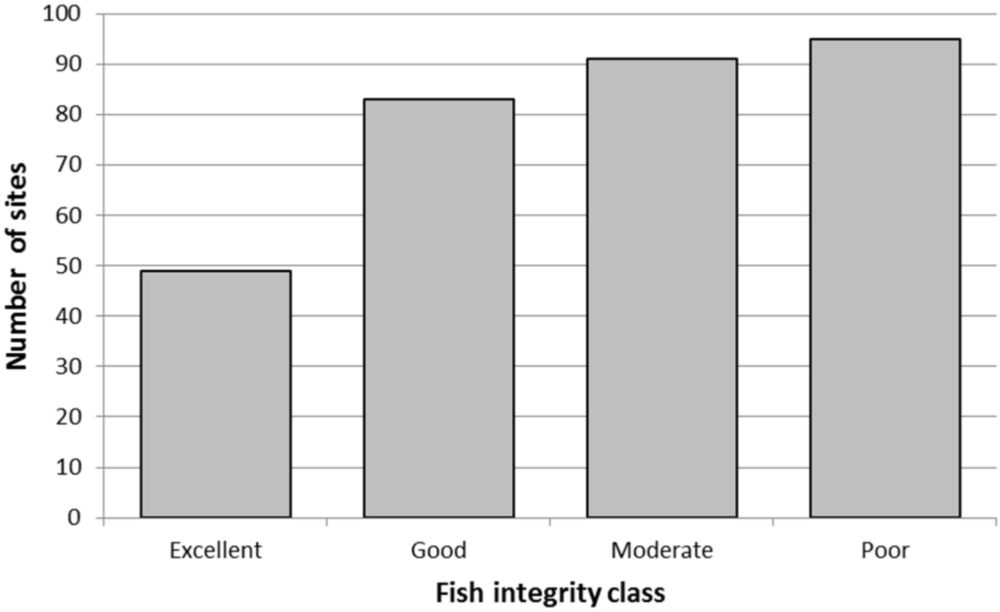


Figure 12 Number of sites throughout the Rangitāiki WMA allocated to one of five Fish integrity classes based on the Fish IBI scores.

ANOVA showed no significant difference between Fish IBI score and dominant land cover within the catchment of each site (Figure 13). Significant regressions (P <0.001) were found between Fish IBI scores and both distance to sea and elevation, but the explanatory power of these regressions was very low (less than 10%). This meant that although Fish IBI scores did vary according to distance to sea or elevation, the effect of this was very small. No significant relationships existed between Fish IBI scores and the percentage of land cover of indigenous forest, exotic forest, horticulture and pasture showed. No differences were evident in the Fish IBI and the location of sites above or below the Matahina Dam. These results suggest that factors other than elevation, distance to sea and land cover, as well as location above or below the Matahina Dam, were important in determining the overall Fish IBI at a site.

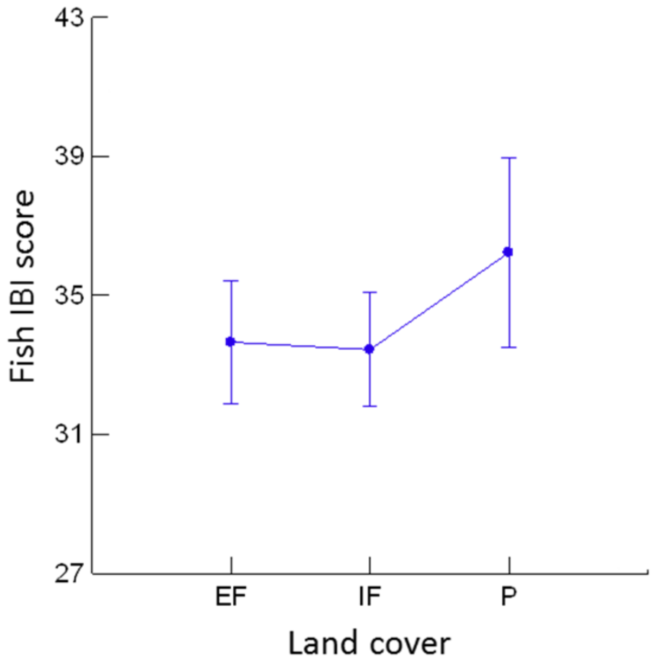


Figure 13 Mean (± 1 SE) of Fish IBI score of streams draining different dominant land cover within the Rangitāiki WMA. EF = exotic forest; IF = indigenous forest; P = pasture.

Examination of the spatial distribution of the five different Fish integrity classes showed a clear pattern within the Rangitāiki WMA (Figure 14), with sites assessed as having good or excellent fish integrity in inland areas in the upper parts of the catchment. However, the main reason for the high Fish IBI scores in the upper part of the catchment reflected the widespread presence of trout (usually rainbow) at these sites. Trout are regarded as "honorary native" fish for calculations of the Fish IBI, due to their requirements for cool, swiftly flowing water and good in stream habitat conditions. Presence of trout therefore results in a stream with a high Fish IBI score. Trout were some of the most widespread fish in the upper parts of the Rangitāiki: indeed of 91 sites in the upper Rangitāiki, the Whirinaki and Whaeo rivers, trout were found in all but two. This is in sharp contrast to eels, which were found in only 25 of these rivers. This may explain why there was no difference in fish IBI between sites above and below the Matahina Dam.

Further analysis is required to better tease out whether there are any relationships between environmental factors and Fish IBI scores within sites throughout the Rangitaiki WMA. For instance, stream habitat may play a major role in structuring fish communities, yet this factor was assessed using from modelled habitat data. Analysis of habitat data such as shade, overhanging vegetation, undercut banks and presence of debris jams may show that these small-scale factors are also important in influencing the fish IBI at a site.

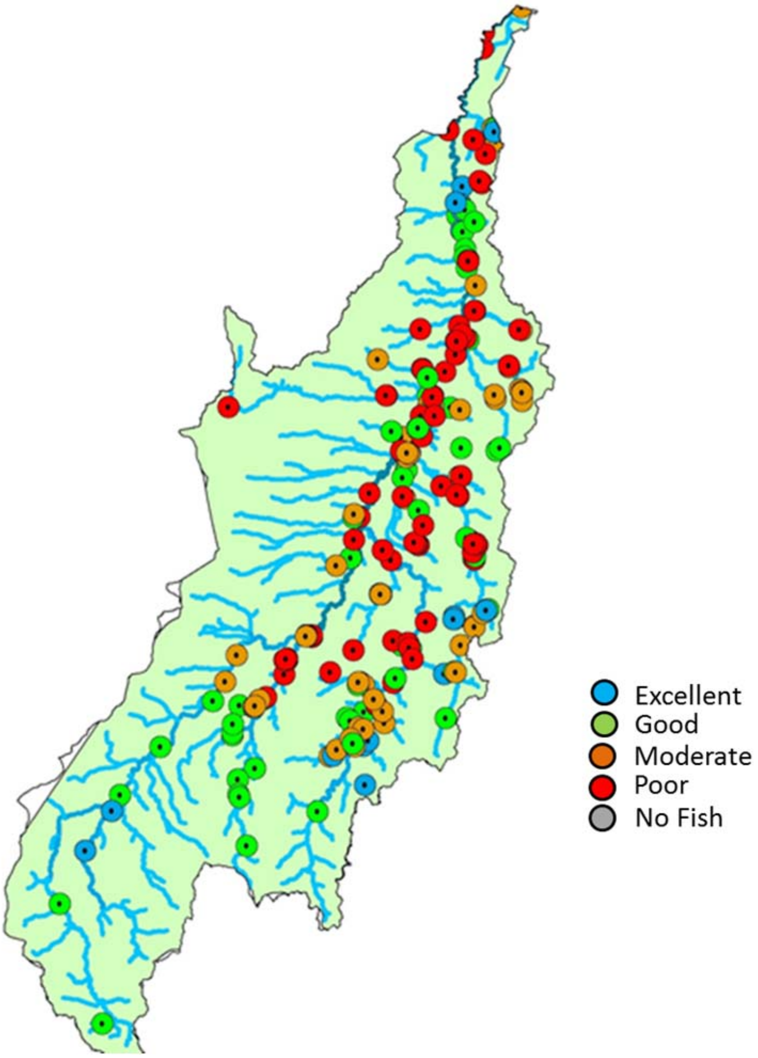


Figure 14 *Distribution of Fish IBI classes throughout the Rangitaiki WMA. Note the generally high fish IBI Scores in the upper catchment, due mainly to the presence of trout in these sites.*

3.6 Distribution of dominant taxa

3.6.1 Overview of native fish

In this section the observed distribution patterns of the dominant fish species found throughout the Rangitaiki WMA are described. Although brief notes on the natural history features of each species is given, interested readers are encouraged to consult the wide range of textbooks written by the late Dr Robert McDowall (see (McDowall 1990; McDowall 2000; McDowall 2011), as well as selected webpages such as those produced by both NIWA (see https://www.niwa.co.nz/freshwater-and-estuaries/nzffd/identification-guides-and-keys) and the Department of Conservation (see http://www.doc.govt.nz/nature/native-animals/freshwater-fish/) should they wish to obtain further information. Much of the information about the individual species below has been gleaned from these sources.

As a general note preceding the section, the reader is reminded that many of the 12 native fish occurring in the WMA exhibit a diadromous behaviour: i.e., they need to migrate between the sea and fresh water as a part of their life cycle. These migrating fish need to move freely between rivers and streams with good habitat and the sea. The two large hydroelectricity dams (Matahina and Aniwhenua) represent critical barriers to this natural longitudinal migration. These dams are of significant concern to local iwi, as they prevent the natural upstream migration of elvers, and downstream migration of mature migrant eels. In particular, concern exists about mortality of migrating downstream longfin eels at the dams, particularly females, which can contain upwards of 7 million eggs. These large migrant eels would undoubtedly die as they are either impinged upon screens in front of the penstock intakes, or as they pass through the turbines. Given the natural decline of longfin eels, any mortality associated with fish passage past these dams is of great concern. Although many species need free access to the sea, other species such as koaro, giant and banded kokopu, common bullies, smelt and inanga can form landlocked populations, especially where there are large lakes in the catchments where the larval fish can grow.

As part of their resource consents, TrustPower (the owner operator of the Matahina Dam) has a number of consent conditions to ensure the upstream passage of migrating fish (including elvers, and any migrating galaxiids), and are currently working on developing methods to maximise the safe downstream passage of migrant eels. A permanent trap and transfer facility has been installed at the base of the Matahina Dam in 1997/1998, and since then, Bill Kerrison, of the Kokopu Trust, has successfully translocated millions of eels (both longfin and shortfin) and migrating galaxiid species to sites above both the Matahina and Aniwhenua dams (Kearney et al. 2013a). This work has successfully ensured a continual repopulation of young migrant fish to the streams above both these dams. The Kokopu Trust is also involved with trapping migrant eels during the autumn, to ensure they can successfully bypass the dams and carry on downstream and out to sea where they can breed.

3.6.2 **Eels**

Figure 15 Shortfin eel (source Auckland Council).

Figure 16 Longfin eel © Tony Eldon.

There are two main species of eel in New Zealand: shortfin and longfin eels (Figure 15, Figure 16). Longfin eels typically penetrate further inland, and are more commonly found in stony bottomed, fast-flowing streams. Longfin eels can remain in rivers and streams for many years until they undergo physiological changes in readiness for their downstream migration out to sea. Some large females do this only after 60+ years. Shortfin eels, in contrast, are primarily found in lowland areas, particularly in slow flowing rivers, ponds and wetlands with generally soft bottomed substrates. Short fin eels usually migrate at a much earlier age than longfin eels, at around 20+ years. Although the conservation status of shortfin eels appears stable, considerable concern exists as to the conservation of longfin eels: indeed they are regarded by the Department of Conservation as “In decline, threatened” (Goodman et al. 2014).

As with many native fish, both eel species require access to the sea to complete their life cycle. In this instance, eels display a catadromous behaviour whereby mature adults swim downstream from rivers during autumn and into the ocean to breed. Although the exact location of spawning sites is yet to be determined, evidence suggests that eels spawn in deep ocean trenches somewhere to the west of Fiji. Once the fertilised eggs have hatched in these deep trenches, the larval eels undergo a series of complex metamorphic changes, and slowly drift back to New Zealand on the prevailing ocean currents. Once they return to coastal areas around the country, the small larval eels (which at this stage are called leptocephalus) transform themselves into juvenile glass eels. These gather in river estuaries prior to migrating back upstream - usually in spring. These glass eels soon develop pigmentation, and turn into elvers that swim upstream in search of suitable habitat. They then live here from anywhere between 20 to 80+ years (depending on the species), before migrating back to sea to spawn again before dying.

Obviously, the existence of both the Matahina and Aniwhenua dams has huge implications on the upstream and downstream migration of eels in the Rangitaiki WMA. As mentioned, these effects have arguably been mitigated to some degree with the trap and transfer work being undertaken by the Kokopu Trust, and by recent consent conditions for TrustPower set by the Bay of Plenty Regional Council to ensure that the Matahina Dam does not adversely affect the native fish communities within the Rangitaiki River. The operation of the Aniwhenua Dam presently has no such conditions, and is still operating under the consent issued prior to the RMA. It is understood that the operators of this dam are, however, working with organisations such as TrustPower and the Kokopu Trust to trap migrant eels during the autumn as they swim downstream. It is likely that consent conditions to formalise this downstream trapping process to ensure adequate fish passage will be a requirement of any new consent issued to the operator of the Aniwhenua Dam when this consent comes up for renewal in 2026.

Within the Rangitaiki WMA, differences in the distribution of shortfin and longfin eels are clearly evident, with longfin eels being found further inland and at higher elevations than shortfin eels (Figure 17, Figure 19). Longfin eels are found at many sites in the upper reaches of the Horomunga and Whirinaki Rivers, while shortfin eels are generally not as commonly encountered in the upper reaches of the Whirinaki, and appear to be absent from the upper reaches of the Horomunga. Longfins were found in the catchment at altitudes up to ca. 600 m (Figure 18) while the maximum altitude that shortfin eels were found at was only ca. 400 m (Figure 20).

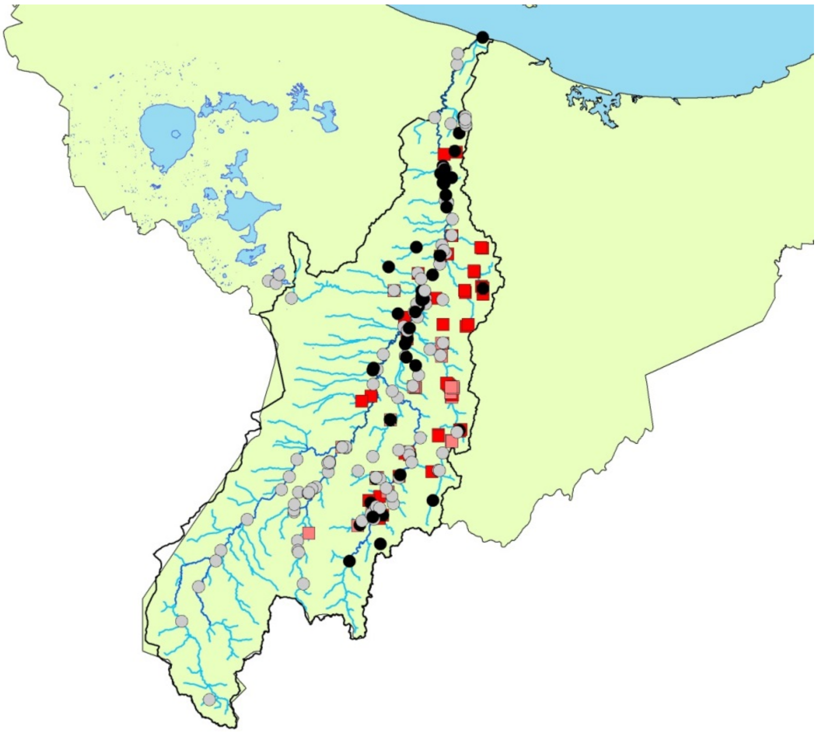


Figure 17 Distribution of longfin eel throughout the Rangitaiki WMA. NZFFD sites represented by grey symbols (species absent) or black symbols (species present), while the 2014 surveys represented by pink symbols (species absent) or red symbols (species present).

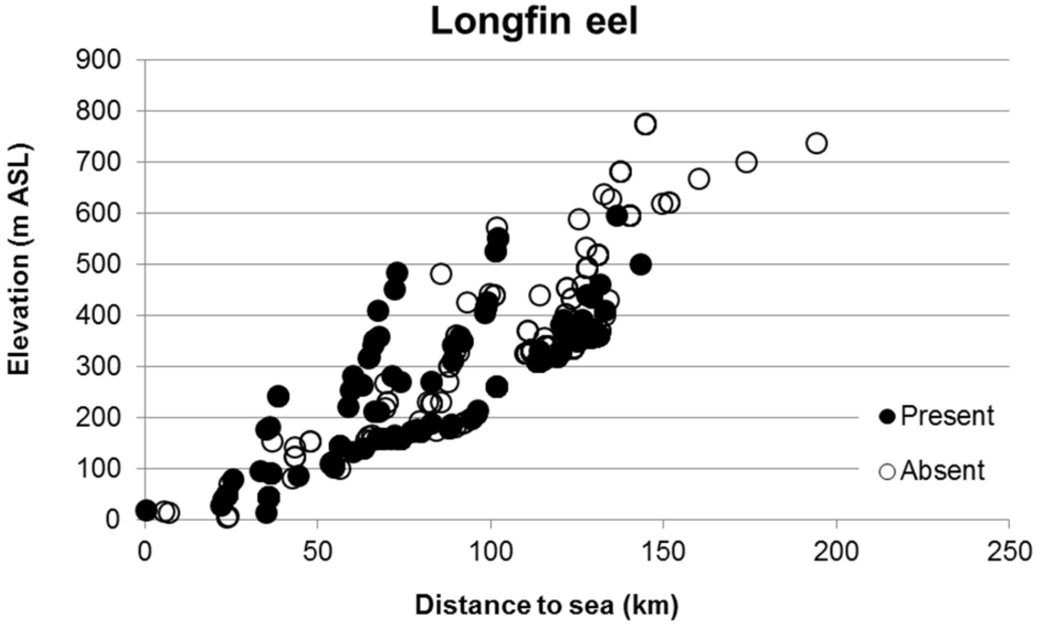


Figure 18 *Distribution of longfin eel showing its relationship to distance to sea and altitude.*

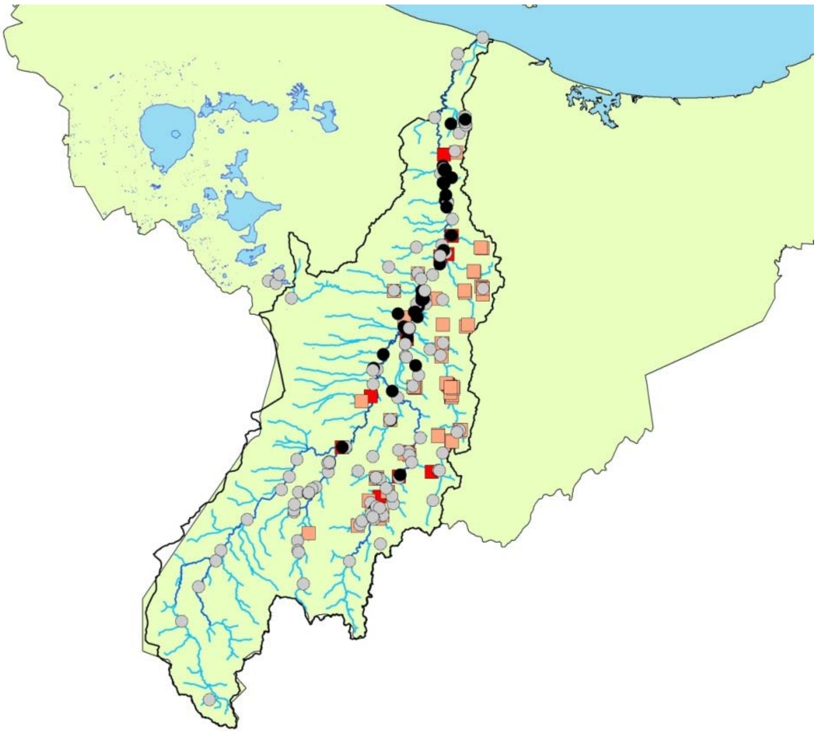


Figure 19 *Distribution of shortfin eel throughout the Rangitaiki WMA. Conventions as per Figure 12.*

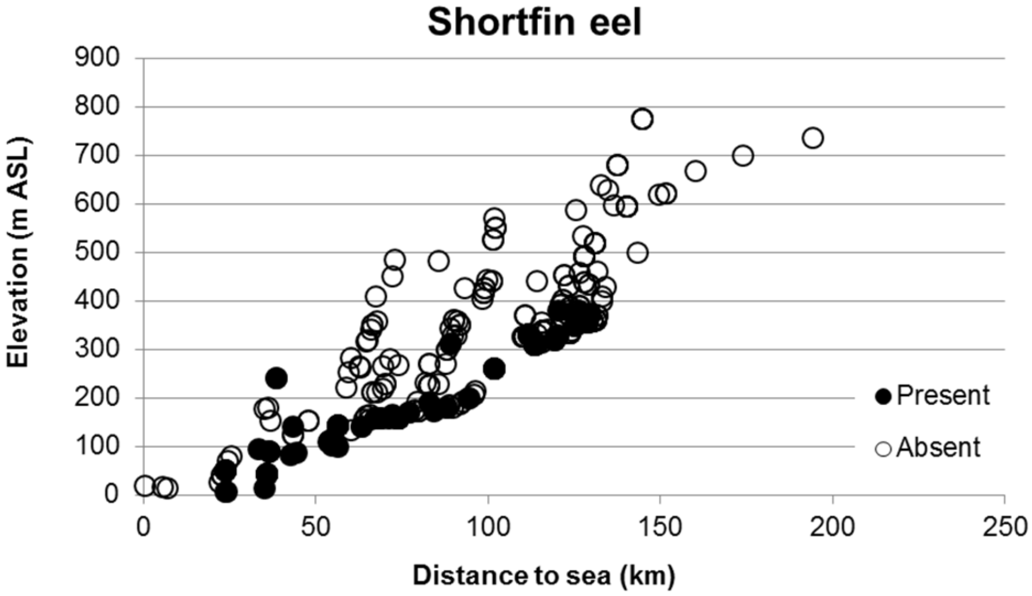


Figure 20 Distribution of shortfin eel showing its relationship to distance to sea and altitude.

Examination of the size distribution data of both eel species collected during the autumn 2014 survey revealed potentially concerning trends and patterns. Of the 138 longfin eels collected, the size classes showed a distinct lack of the smallest size class (50-100 mm, and 100-150 mm), whereas the next two size classes (150-200, and 200-250) supported far more individuals (Figure 21). This lack of small elvers in the population is of concern, as it may suggest that there is insufficient recruitment of young longfin eels throughout the catchment. A similar reduction in the frequency of small elvers was reported by Wright (2013), who suggested that it may reflect a major decline in the recruitment of the population. However, a similar pattern was also seen for shortfin eels in the Rangitāiki, and there is currently not as much concern about shortfin eel stocks as there are about longfin eel stocks. Furthermore, most elvers <100 mm would be expected to be in the river below the Matahina Dam, so their less frequent occurrence in the 2014 survey might just be an artefact of the distribution of surveyed sites, all of which were in the upper catchment.

Although the reasons for the low numbers of small eels are unknown, they are unlikely to reflect the effects of the Matahina Dam, as a similar size distribution pattern was found for both eel species throughout the Kaituna-Maketu and Pongakawa–Waitahanui Water Management Area (Figure 22). This data came from a recent (April-May 2016) survey of 58 sites in this area that were electric-fished in a similar manner as done for the Rangitaiki survey.

The low numbers of small eels may also simply reflect a reduced ability to catch these smaller individuals by electric fishing. These small individuals may live deep in the substrate and would naturally be less accessible to electric fishing than larger individuals. Finally, although the Kokopu Trust transfers over an average of 1 million elvers per year to sites upstream of the Matahina Dam (Kearney et al. 2013a), there are no studies that have examined post-transfer mortality, so there is an explicate assumption that most transferred elvers survive (Don Jellyman, NIWA Christchurch, pers comm). Given the concern of a potential for long-term recruitment failure of longfin eel (Wright 2013), it is clear that more monitoring of eel population structure throughout the Rangitaiki is warranted.

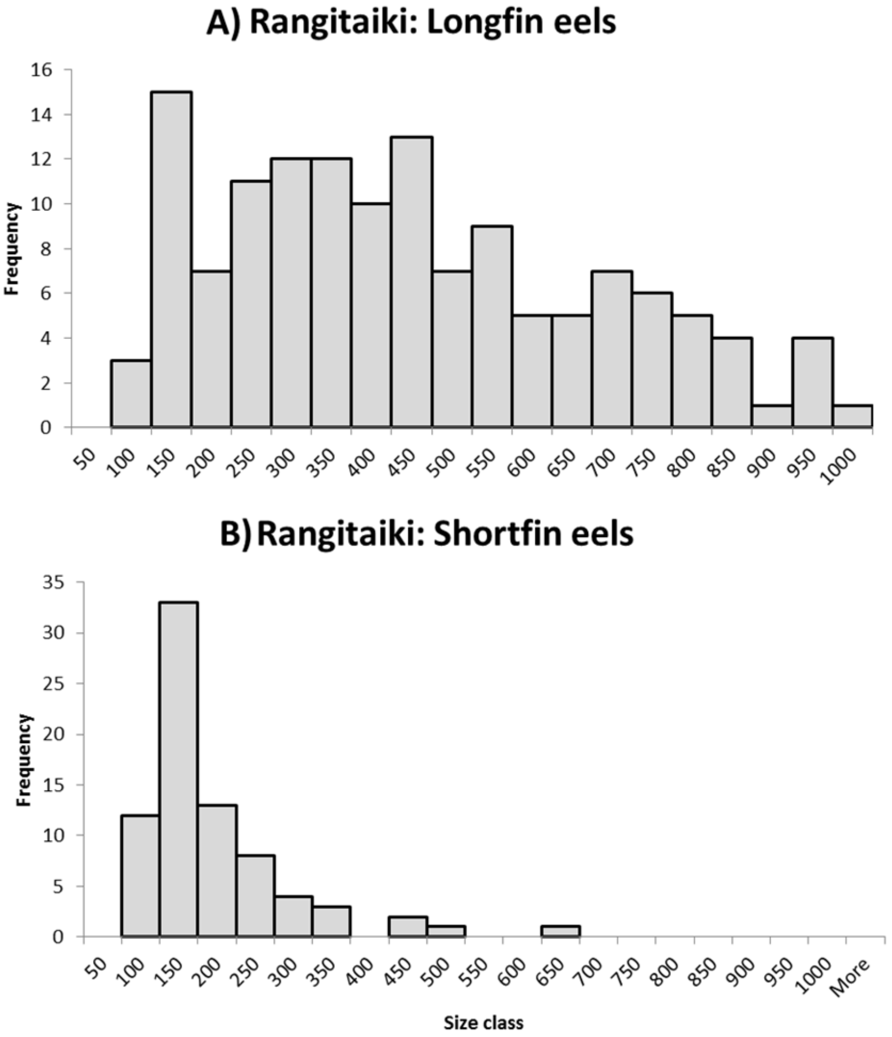


Figure 21 *Size – frequency distribution of A) longfin and B) shortfin eels at the 82 sites throughout the Rangitaiki that were electric-fished during autumn 2014, showing the lack of the smallest size classes (50 - 100 mm, and 100 - 150 mm).*

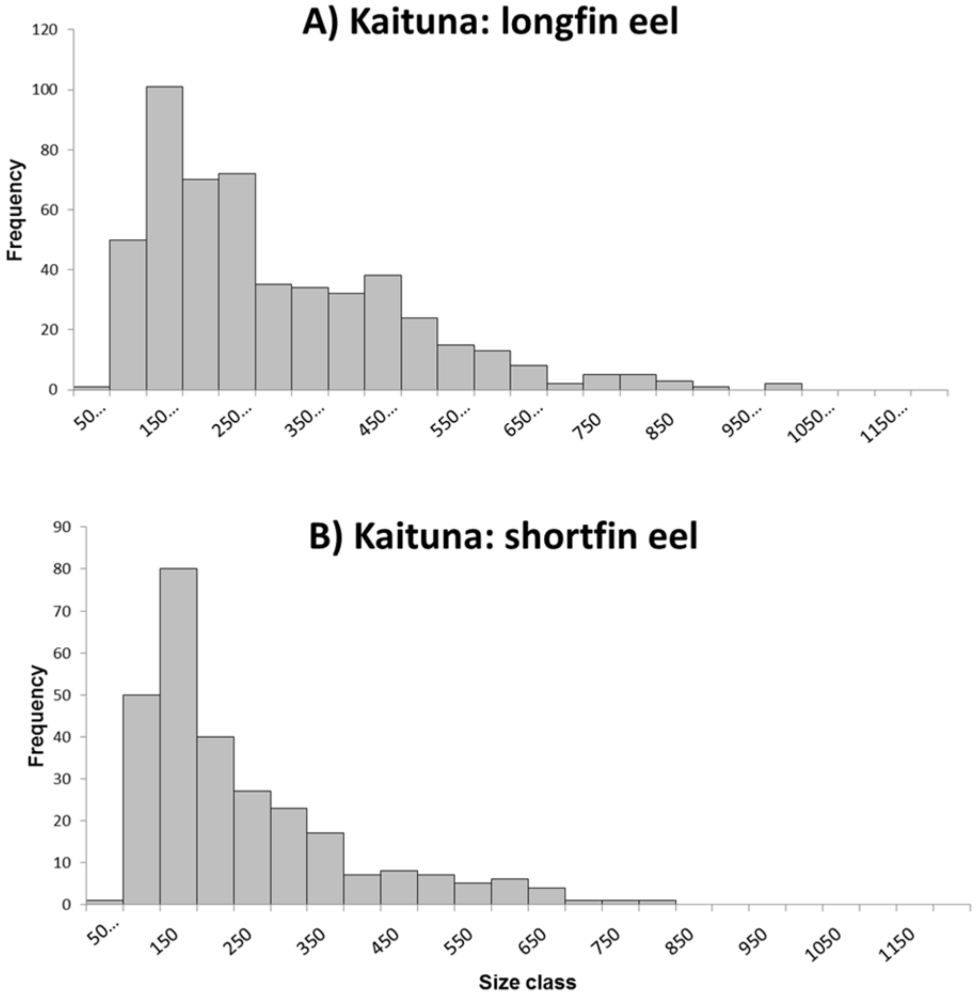


Figure 22 Size – frequency distribution of A) longfin and B) shortfin eels at 43 sites fished in autumn 2016 throughout the Kaituna-Maketu and Pongakawa-Waitahanui WMA. Note the similar lack of small size class eels (<100 mm).

Examination of the size-distribution cover of longfin eels in streams draining different land cover classes also showed some interesting patterns (Figure 23). There were significantly fewer small size class eels in streams draining catchments dominated by both agriculture and native bush, whereas streams draining catchments dominated by exotic plantation forest appeared to have a much higher frequency of small size class eels (Figure 23). The low numbers of small eels in streams draining native bush is of particular concern, as these streams would be typical of streams where longfin eel are expected to live, as they are generally relatively fast flowing and have coarse substrates. These streams did, however, have the highest number of larger longfin eels, emphasising their importance as rearing habitat for these fish.

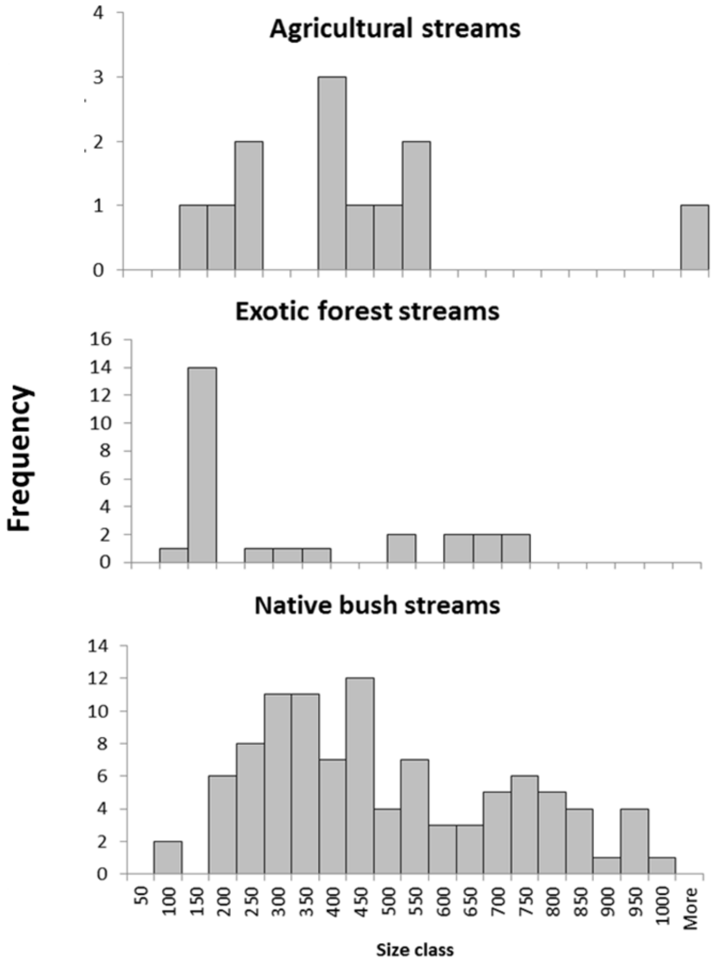


Figure 23 Size – frequency distribution of longfin eels in different land cover classes at the 82 sites throughout the Rangitaiki that were electric-fished during autumn 2014.

Despite the concern at the apparent lack of small young eels in the population structure in the Rangitaiki WMA, there may be some suggestion that eel recruitment into the upper reaches is better than it used to be. This contention comes from examination of fishing data provided by Young (2000), who surveyed a number of streams in the upper reaches of the Whirinaki catchment (Figure 24). Of the 24 longfin eels caught, 23 were large eels (>800 mm), with only a single eel being less than 200 mm. That this population was dominated only by relatively old eels suggests that there had been little recruitment of young eels into these streams. The situation found in 2014 was somewhat more encouraging (Figure 25), with seven of the 51 eels being in the smallest size class (<200 mm). Furthermore, the largest cohort (23 individuals) was in the 200 – 400 mm range, a marked difference to the situation observed by Young, where no eels of this size were found.

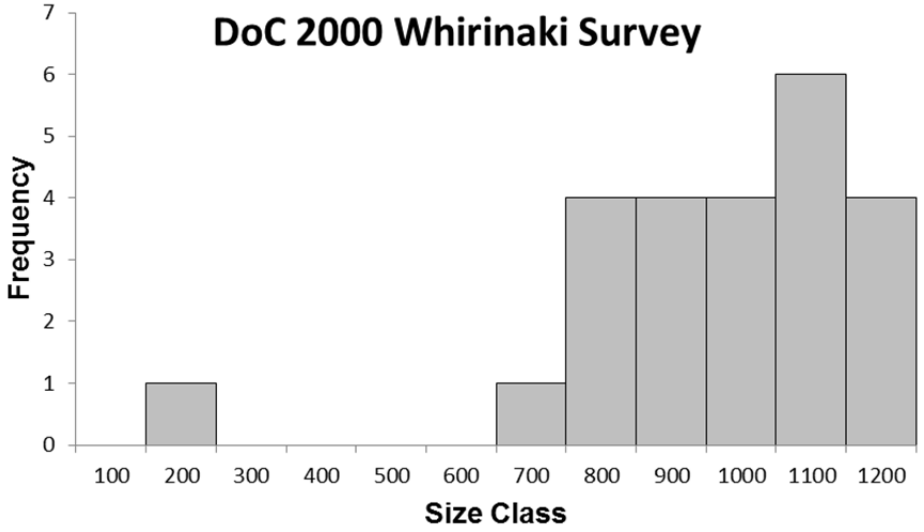


Figure 24 *Size – frequency distribution of longfin eels at nine sites throughout the Whirinaki Catchment that was surveyed by Young in 2000.*

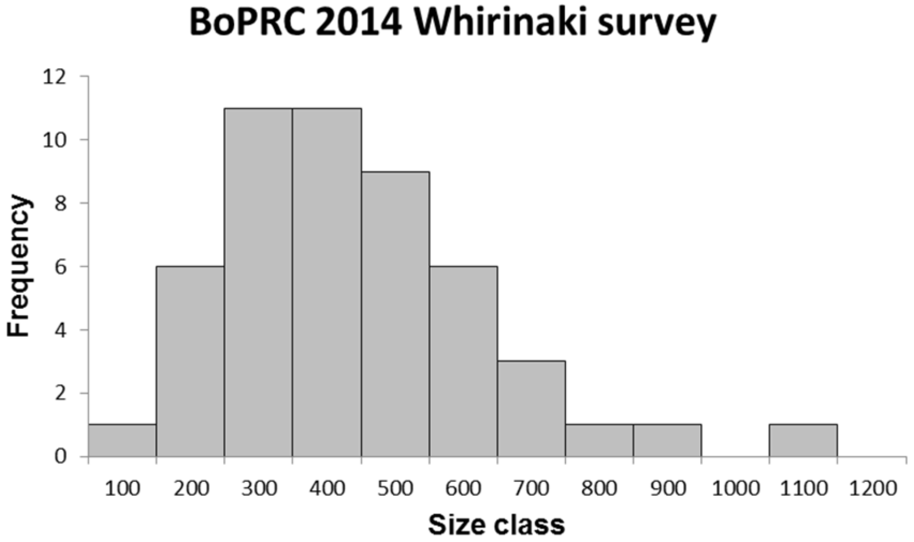


Figure 25 *Size-frequency distribution of longfin eels at 11 sites throughout the Whirinaki Catchment that were initially surveyed by Young in 2000, and resurveyed in 2014.*

Furthermore, Young also only caught five shortfin eels in her survey, form either the Minginui Stream, or Earls Road Creek. This is much less than the 44 shortfin eel caught in the 2014 survey, which were found at five sites – although the vast majority of shortfin eels (38) were caught at a single site (the Whataroa, a tributary into the Whirinaki River near Minginui).

In conclusion, while the presence of both the Matahina and Aniwhenua dams are undoubtedly barriers to the natural upstream migration of young eels, the ongoing trap and transfer work of the Kokopu Trust would be expected to go a long way to minimise these adverse effects. For example, since 1997, Bill Kerrison has translocated over 19 million elvers to areas above both the Matahina and Aniwhenua dams (Kearney et al. 2013a). It is not known what proportion of the naturally migrating eel biomass this represents, but it is likely to be a significant amount of what would have naturally migrating upstream if the dams were not there.

Although we found a reduced frequency of small elvers at sites above the Matahina Dam in the 2014 survey, this could simply be attributable to either a natural reduction in the numbers of these small elvers at sites this far inland, or an inability to collect these smaller fish with the same efficiency as larger individuals. Finally, the cautionary comments from Wright (2013) about potential evidence of recruitment failure needs to be put into context with the work by Martin et al. (2013) that examined recruitment of elvers into four main dam sites (Karapiro, Matahina, Waitaki and Arnold). They found that, while both shortfin and longfin catches at Karapiro and Matahina have declined from the maximum recorded in the 2007-2008 season, there was no indication of a medium term recruitment failure to either stock.

3.6.3 **Koaro**

Figure 26 Koaro, showing the irregular light and dark mottling pattern.

Adult koaro are characterised by having their sides and back covered in a variable pattern of highly irregular light and dark patches, or bands, that seem to “glisten” in the light (Figure 26). The juveniles have great climbing abilities and can penetrate well inland. Like giant kokopu, their whitebait can be distinguished from other whitebait species by wriggling up the sides of buckets that they are placed into. Koaro seem to prefer fast flowing, highly turbulent streams with large substrates, and are mostly restricted to streams lined with native bush. As with many galaxiids, they lay their eggs in bankside vegetation, and rely on subsequent floods to re-wet these eggs where they can hatch and the larvae are washed downstream to the sea. This reliance on bankside vegetation may explain their distribution to catchments with only well-vegetated banks.

Koaro can however also form landlocked populations within lakes, and large populations of koaro existed in the Rotorua lakes prior to European colonisation and the introduction of trout. For lake-fed populations, adults living in streams flowing into the lakes lay their eggs amongst bankside vegetation along these streams. Upon hatching, these eggs are washed into the lakes, where larvae can live and grow before returning to the rivers and streams as whitebait. Although there is evidence that self-sustaining populations of giant kokopu (Smith et al. 2007) and common bullies (Beentjes et al. 1997) may be established at Lake Matahina, it is suggested that any landlocked populations of galaxiids such as koaro or giant kokopu are unlikely to occur in Lake Aniwhenua, because the residence time within the lake is too short to allow the planktonic larval stage of life cycle to be completed successfully (Mitchell 1996).

Koaro have never before been recorded in the Rangitaiki WMA, so the finding of small populations in the Te Weramata Stream and Okahu Stream is significant (Figure 27). Both streams are in the Ikawhenua ranges and flow through unmodified catchments dominated by native bush. Both sites in the Okahu stream also supported rainbow and brown trout, so there is a potential that these fish may prey upon Koaro. In contrast, no trout were found at Te Weramata Stream, so this and other trout -free streams in the area may represent good sanctuaries for Koaro. Nevertheless, the presence of Koaro at both sites reflects the trap and transfer work undertaken by the Kokopu Trust, and also the ability of these fish species to penetrate far inland to find suitable streams where they can grow. A long-term monitoring programme is recommended to confirm the ongoing existence of Koaro throughout headwater streams within the area.

Figure 27 Distribution of koaro throughout the Rangitaiki WMA. Conventions as per Figure 12.

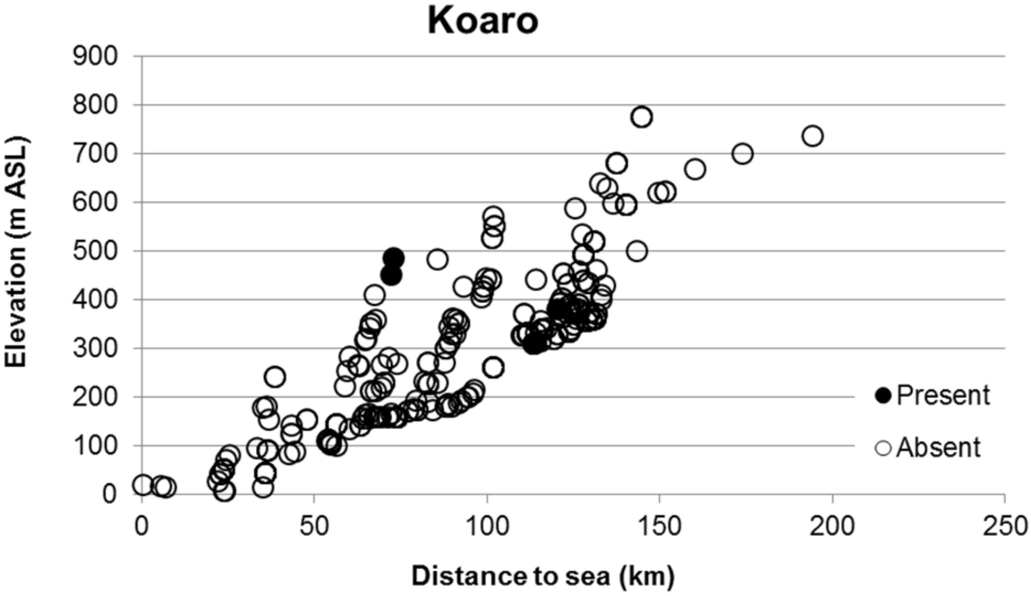


Figure 28 Distribution of koaro showing its relationship to distance to sea and altitude.

3.6.4 Dwarf galaxias

Figure 29 Dwarf galaxias (image courtesy of Stella McQueen).

The dwarf galaxias is one of the few galaxiid species that do not migrate to sea as part of their life cycle. Their whole life cycle thus occurs in fresh water. This has major implications for the long-term viability of populations, as they will not receive new individuals from outside the catchment. These small fish are amber to olive green in colour, and have dark brown blotches on their sides and back (Figure 29). They also have a silver belly. The maximum size of these fish is about 90 mm, although most adults are usually less than 70 mm in length. Aquatic larvae of mayflies and midges are the most commonly eaten foods of the dwarf galaxias.

Despite its non-migratory behaviour, dwarf galaxias are widely distributed throughout the country, although this distribution is extremely fragmented. They occur in the North Island in the headwaters of the Waihou River near Putaruru, streams flowing from the Ikawhenua Ranges into the Rangitaiki River, areas in Hawkes Bay and throughout Wellington. In the South Island, they occur in Marlborough and Nelson, and on the west coast as far south as the Hokitika River. A large part of this fragmentation throughout the central North Island has been attributed to legacy effects of volcanic activity in the area.

In particular, the last major eruption from the Lake Taupo area in 186A.D. caused vast ash showers to spread in a North East direction across the central North Island - presumably due to strong south-westerly winds at the time. This eruption would have had dramatic effects on both terrestrial and aquatic ecosystems, and is thought to still reflect the contemporary distribution of many non-migratory New Zealand fish throughout the North Island (McDowall 1996; 2006). It is likely that these small populations of dwarf galaxias in the Ikawhenua ranges represent streams which somehow avoided these otherwise devastating effects.

The preferred habitat of dwarf galaxias is gently flowing small stable foothill streams with gravelly and rocky substrates. Spawning may occur in small springs, near adult habitat. Females produce between 100-250 large eggs, approximately 2 mm in size, but the actual spawning sites remain undiscovered (McDowall 2006). There may be two peaks in spawning activity (spring and possibly autumn) by different age classes of females (McDowall 2000). Newly hatched larvae presumably remain in the same rivers as the adults. The lifespan of this species is 3-4 years, with a generation time of 2 years.

Dwarf galaxias have lost much of their original range, and their conservation status is now described as “Threatened, nationally vulnerable”. This is a very different situation to that described in McDowall (2000), where he stated that “there seems no reason for general conservation concern”. Such a dramatic change in conservation status no doubt reflects our increased knowledge of not only this fish, but also of the threats faced by native fish throughout the country.

One of the most pervasive threats to this fish (and indeed many other native fish) is the invasion of streams by trout. For example, Hopkins (1971) found dwarf galaxias only above waterfalls impassable to trout. Hopkins also reported that where trout had managed to surmount the waterfall, they were able to penetrate hundreds of metres upstream through the reach occupied by dwarf galaxias. It was noted that without the waterfall, even more trout would have colonised this upstream reach, which would have caused changes in the populations of dwarf galaxias. The association between native fish and trout were examined by Minns (1990) at a national level. He found close similarity between the distribution of dwarf galaxias and trout at a regional scale, but this similarity was not evident at a local or reach scale. These contrasts between regional and local scales were thought to have resulted from exclusion from competition and/or predation, and this was interpreted as indicating dwarf galaxias as vulnerable to invasion by brown trout.
McDowall (2006) noted that dwarf galaxias had disappeared from the location where they were originally found (in the headwaters of the Buller River), and that attempts to relocate specimens from the site of Hopkins’ 1971 study were unsuccessful. As noted in Section 3.3 above, we found a similar loss of dwarf galaxias from three streams (the Horomanga, the Kotuku uku Stream, and the Tukuhouhou Stream), where only rainbow trout were found. Further spread of these trout (either through natural processes, or by illegal movement of these game fish to new areas) has a real risk to cause further declines in distribution and abundance of dwarf galaxias.

This species is also subject to the effects of reduced water flow, arising as a result of landuse change (e.g. conversion to forestry) or of hydro schemes (Hay 2009). Habitat loss and degradation through the impacts of farming (particularly of stock) on in-stream habitat, and poor riparian management are also significant threats to this species (McDowall 2006). Fortunately, these latter threats are not applicable to the current populations of dwarf galaxias in the Rangitāiki WMA, which were found only in streams draining native forests of the Ikawhenua Ranges (Figure 31), and where they flow from the bush through the upper sections of pasture. Within the Rangitāiki, dwarf galaxias are restricted to streams less than 100 km inland, and less than 450 m in elevation (Figure 32). These altitudes are much lower than where this fish is found in other regions, where it can occur up to 1,130 m.

However, the streams where they were found did not appear to support large numbers of trout, which again emphasises the importance of keeping these streams trout-free if dwarf galaxias are to survive in the region.

Figure 30 *Electric fishing in the Ohutu Stream as if flowed from the native bush of the Ikawhenua Ranges, through pasture on the Galatea Pains. This site supported high densities of dwarf galaxias.*

Figure 31 *Distribution of dwarf galaxias throughout the Rangitaiki WMA. Conventions as per Figure 12.*

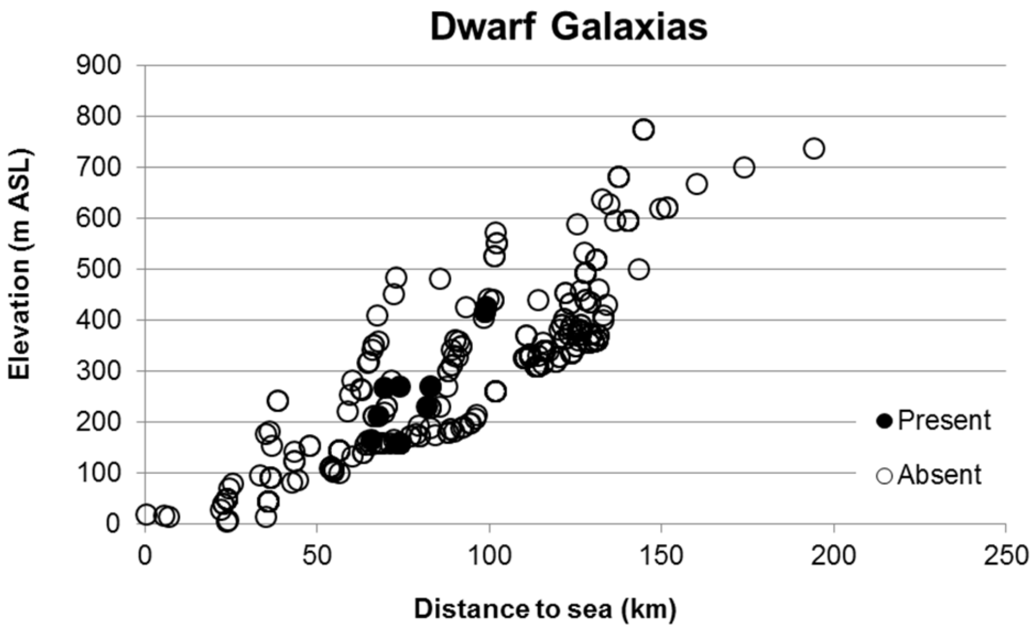


Figure 32 Distribution of dwarf galaxias showing its relationship to distance to sea and altitude.

3.6.5 Giant kokopu

Figure 33 Adult giant kokopu showing their distinct but varied pattern of golden rings, blotches and crescents (image courtesy of Stella McQueen).

The giant kokopu is the largest of all Galaxias species worldwide, and can reach a body length of nearly 600 mm and weight of 2.7 kg. However, fish in the 200 - 300 mm range are far more common. The giant kokopu was the first galaxiid to be identified and described by the early naturalists from specimens collected in the 1773 expedition of Captain James Cook. The genus name “Galaxias” refers to the giant kokopu's distinct but varied pattern of golden rings, blotches and crescents as found in the galaxy of stars (Figure 33). These patterns occur on their dark olive to brown colouring skin. As with all galaxiids, giant kokopu have no scales.

They also have a large rounded single dorsal and an anal fin that are set close to the large tail fin. These fins appear strong, and fleshy. The bodies of these fish are very broad, and can appear round or square in cross-section. Giant kokopu also have very large mouths, well suited to their behaviour as ambush predators. Juvenile fish lack the colour pattern of adults, and instead have sparse vertical bars and spots along their lateral line. Small giant kokopu may thus be confused with small banded kokopu, but as the fish grows, these markings lengthen and then fade out, and the characteristic adult markings fade in.

Giant kokopu are mostly a lowland species, commonly found in slow-flowing streams, wetlands, lakes, and lagoons. They are also usually associated with instream cover like overhanging vegetation, undercut banks, logs, or debris clusters. They are thought to lurk quietly amongst such cover awaiting their prey, which ranges from koura to terrestrial insects such as spiders and cicadas. They are mostly migratory, and juveniles form part of the "whitebait" runs. Little is known of their spawning habits, but like many galaxids, they are likely to spawn amongst bankside vegetation that has been inundated during flood events. It is thought that the adults migrate to a common spawning site, but until recently, spawning has never been observed or any eggs discovered. However, this has changed with the chance observations of giant kokopu spawning amongst vegetation in a small wetland on Wiaheke Island (see http://ourauckland.aucklandcouncil.govt.nz/articles/news/2016/07/local-waiheke-man-the-first-to-witness-giant-kokopu-spawning/). Following hatching, larvae go to sea soon after hatching in autumn, and return about four months later in late spring as small juveniles, 45 - 50 mm long. However, giant kokopu are uncommon in the whitebait catch and usually run late in the season. Like banded kokopu and koaro, giant kokopu can establish land-locked populations, where their larvae grow and develop in suitable lakes before returning to streams. Giant kokopu probably take three years to reach maturity, and may live for up to between 21 and 27 years old.

Giant kokopu are found throughout New Zealand, with records from Taranaki, the Bay of Plenty and Wellington, the Marlborough Sounds the west coast to Fiordland, and Southland. They are rare in Northland, and on the east coasts of both islands from East Cape to Otago. They are also present on Stewart Island and the Chatham Islands. Their true distribution may, however, be under-represented because these fish are often hard to catch and mainly cryptic, hiding in places difficult to observe. Although distribution records place them up to 170 km inland, they are normally a coastal species and, because they are not good climbers, do not usually penetrate inland very far. They have been recorded up to an elevation of 250 m.

In 2014, the New Zealand Department of Conservation classified the giant kokopu as "At Risk: Declining" Primary reasons for this decline include ongoing drainage of wetlands, drain clearance, and land-use changes, particularly the expansion and intensification of dairy farming.

This species is found only in the lower reaches of the Rangitāiki River (Figure 34). Most records come from the Ngakaroa Stream where giant kokopu have been recorded at seven locations since 1995. The stream here flows through pine forest, emphasising the importance of instream cover such as overhanging vegetation, logs, or debris clusters to giant kokopu. It is hoped that when this stream is logged, sufficient riparian vegetation is left to maintain this cover, and that the stream is not totally cleaned of any debris that falls into it.

The fact that the lower reaches of this stream flow through highly modified farm land under Paul Road, along Western Drain Road and State Highway 30, before flowing into the Rangitāiki River some 4.4 km below Te Teko suggests that (at least at the time of the surveys between 1995 and 2007), habitat conditions in this area of the stream were sufficient for young fish to successfully migrate through onto the headwaters.

The 2014 survey also found giant kokopu in the Kakahotoa Stream as it crossed Galatea ROAD, below the Matahina Dam. This finding highlights that this species is still successfully migrating up the Rangitāiki River to areas below the dam.

Records from 2007 have also shown this species is also found in Lake Matahina, as well as streams such as the Moetahanga Stream and other unnamed tributaries that flow into this lake. Juvenile giant kokopu are relatively weak climbers (unlike juvenile koaro) and are very unlikely to have surmounted the Matahina Dam by themselves. Any upstream populations might therefore be relicts from pre-dam populations that have now formed landlocked populations in Lake Matahina, or may reflect the trap and transfer work being undertaken by the Kokopu Trust. The 2007 survey also encountered fish 320 mm in length, suggesting that these fish had lived there for some time.

The most inland record of giant kokopu was found in the Waikuku Stream, a small stream that flows from the Ikawhenua Ranges and across the Galatea Road on the Waiohao Plains. This individual was only 60 mm in length, suggesting that it had either recently been liberated as part of the trap and transfer work, or it was from a land locked population of giant kokopu that now live in Lake Matahina.

Lack of these fish from sites further inland or at high elevations (Figure 35) simply reflects the effect of the Matahina Dam in preventing the natural dispersion of these fish to other areas, and the fact that they are normally only a lowland species. It is no known how far upstream these fish would have migrated prior to the Matahina Dam, but their presence in the Kakahotoa Stream suggests a natural inland dispersal of nearly 37 km, and 100 m elevation.

Figure 34 Distribution of giant kokopu throughout the Rangitaiki WMA. Conventions as per Figure 12.

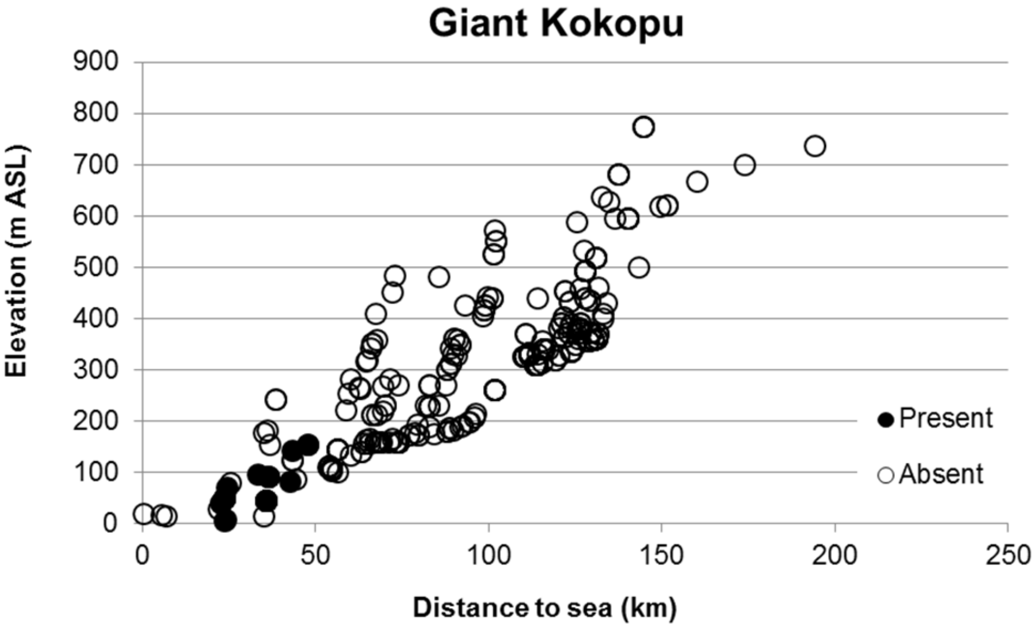


Figure 35 *Distribution of giant kokopu showing its relationship to distance to sea and altitude.*

3.6.6 Redfin bully

Figure 36 *Redfin bully (mature male, showing the characteristic red fins, and blue stripe along the top of the front dorsal fin (image courtesy of Stella McQueen).*

Redfin bullies need access to and from the sea to complete their life cycle, and do not establish land-locked populations like common bullies do (McDowall 1990). Thus, they tend to live near the coast even though they are very good climbers. Spawning takes place in fresh water and after hatching the larvae are swept out to sea. The juveniles enter fresh water in the spring and reach maturity about two years later. They are widespread throughout the country, and are one of the most common fish in the Bay of Plenty.

Male redfin bullies have bright red markings on their dorsal, anal, and tail fins, as well as the body and cheeks (Figure 36). They also have a blue-green stripe on the outer edge of the front dorsal fin. They are one of the most colourful freshwater fish, especially large individuals. Only the males have the distinctive red fins: females have the same patterns, but their fins are brown instead of red. Small individuals also lack the red colour to the fins, and in many cases look similar to common bully at first glance. However, a distinctive feature of redfin bullies is the presence of diagonal stripes along their cheeks, making for positive identification against the common bully.

These fish occur mainly in runs and pools of small, bouldery streams, and prefer habitats with a moderate flow of water with pools and riffles. Here, they feed on aquatic insects such as mayfly, caddis fly and chironomids. Because of their dependence on boulder habitats, they are more sensitive to the effects of siltation in streams than other fish species.

As with giant kokopu, this species is found only in the lower reaches of the Rangitāiki River (Figure 37). The most records also come from the Ngakaroa Stream, about 23 inland from the sea, suggesting that these fish can naturally swim this far inland up the Rangitāiki River. The 2014 survey also found 12 small - medium size redfin bully (average size = 70 mm) in the Kakahotoa Stream as it crossed Galatea Road, below the Matahina Dam. The stream here was 37 km inland, and at an elevation of 100 m. Finding redfin bullies here highlights that they are successfully being caught as part of the upstream trap and transfer programme.

Absence of redfin bullies at sites further inland from Kakahotoa Stream (Figure 38) may reflect a combination of both the reduced numbers of migrating fish being caught and transferred above the Matahina Dam, as well as the fact that these fish are normally only a lowland species. Thus, the NZFFD shows that the average distance inland for redfin bullies was only 10 km, and the maximum distance was only 59 km.

Figure 37 Distribution of redfin bully throughout the Rangitaiki WMA. Conventions as per Figure 12.

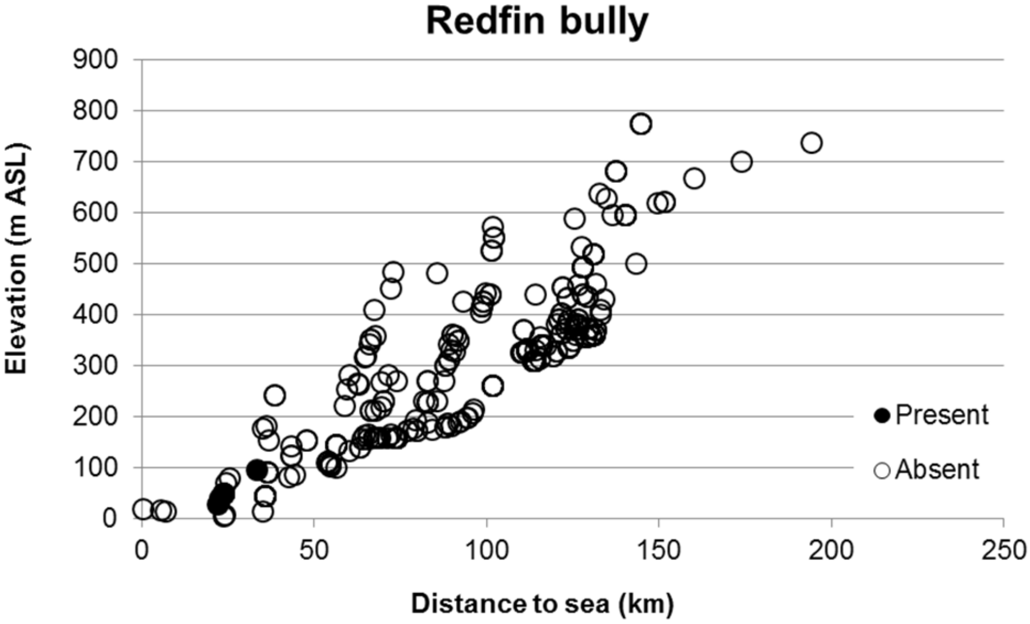


Figure 38 Distribution of redfin bully in the Rangitāiki WMA showing its relationship to distance to sea and altitude.

3.6.7 Rainbow trout

Figure 39 Rainbow trout, showing the characteristic red stripe along the side of the body in mature individuals.

Rainbow trout (Figure 39) are native to North America, where they are found in the westward draining rivers that flow into the Pacific Ocean. Trout were never naturally found in the southern hemisphere, but as with many countries, these fish were introduced into New Zealand in the early 1880s. Populations of rainbow trout, both self-sustaining and hatchery raised, are widespread throughout New Zealand. Rainbow trout are particularly valued in the Rotorua Lakes, and some of the large rivers in the Bay of Plenty such as the Rangitaiki and the Whirinaki. Although they form the backbone of this major recreational fishery, introduced trout have had a large effect on native fish species by preying on them or out-competing them for food and habitat.

Like other salmonids, the colouration of rainbow trout is variable. Lake-dwelling fish are generally uniformly silver with small, darker spots along the back, mainly above the lateral line. The backs of river dwelling fish are often more olive-green, and the red band, or rainbow, along the lateral line more prominent. When rainbow trout move into rivers and streams for spawning, this band intensifies in colour, and red slashes may occur on the cheeks and in the folds beneath the lower jaw.

Most rainbow trout migrate to their spawning grounds, with both lake and river dwelling fish moving upstream to suitable locations, often in small tributaries. Here they can congregate in large schools just prior to spawning. In lakes without suitable spawning tributaries, spawning can occur along the lakeshore. The main spawning season for rainbow trout is June and July, but the season can be extended to October in some lakes, especially those in the colder regions of the North Island.

Rainbow trout are widespread throughout the Rangitaiki WMA (Figure 40), where they were found in all the major catchments such as the Whirinaki, Whaeo, Horomanga, and throughout the mainstem Rangitaiki. The recent 2014 survey extended their distribution into the upper reaches of the Horomanga (Figure 40), which coincides with the loss of dwarf galaxiids form this stream. Rainbow trout were found throughout the longitudinal and altitudinal gradients in the WMA (Figure 41), most likely reflecting their powerful swimming ability.

However, their distribution would most likely be controlled by the dominant substrate type in streams, as these fish generally prefer streambeds with course cobbles and gravels, as opposed to fine highly mobile pumice streambed. This may explain the apparent prevalence to streams East of the Rangitaiki, and general absence from streams draining the pumice-dominated landscape of the Kaiangaroa Forest.

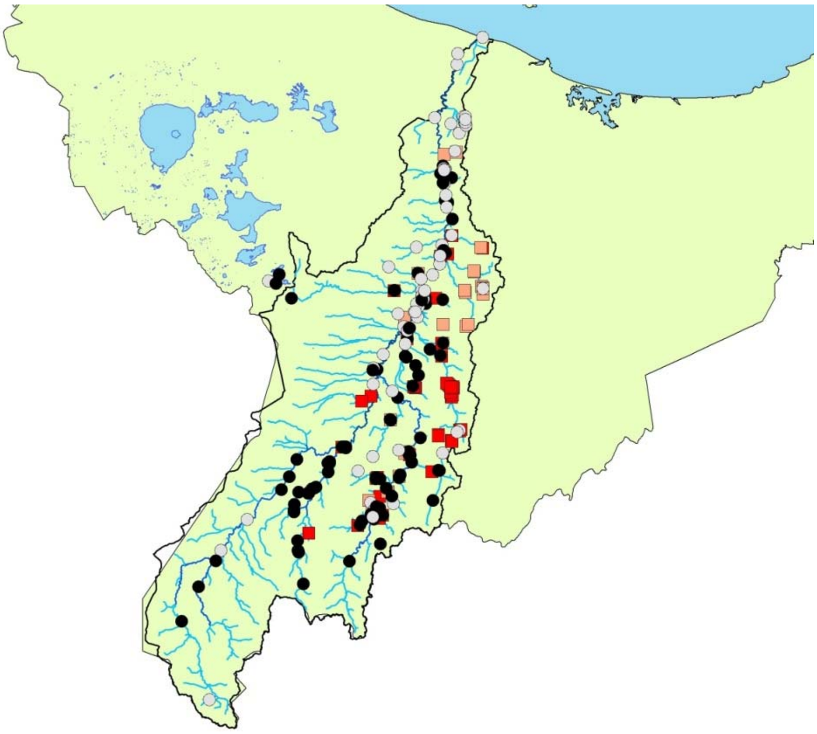


Figure 40 Distribution of rainbow trout throughout the Rangitaiki WMA. Conventions as per Figure 12.

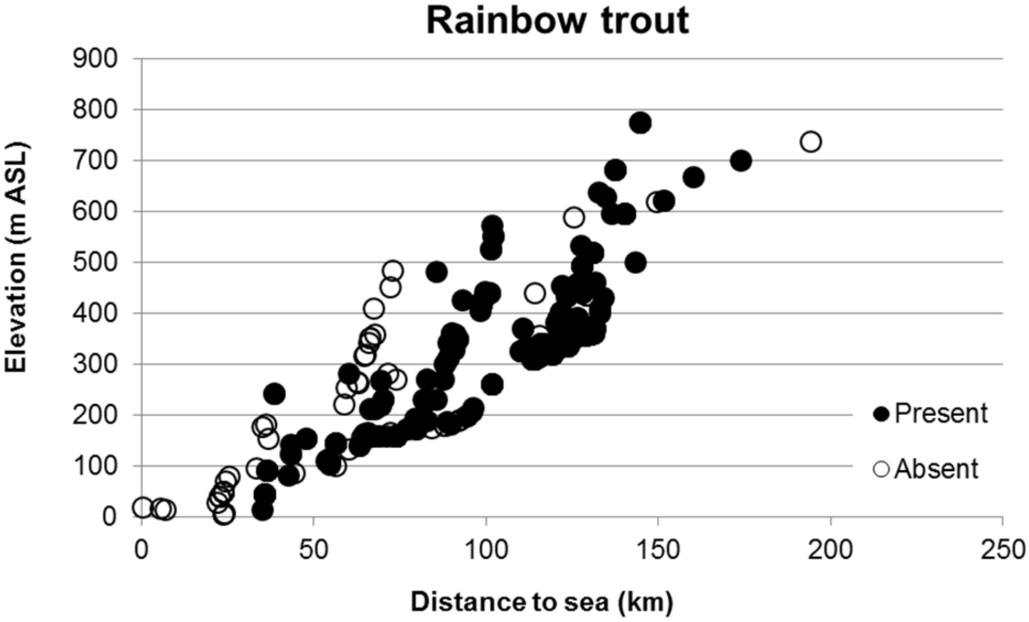


Figure 41 Distribution of rainbow trout showing its relationship to distance to sea and altitude.

3.6.8 Brown trout

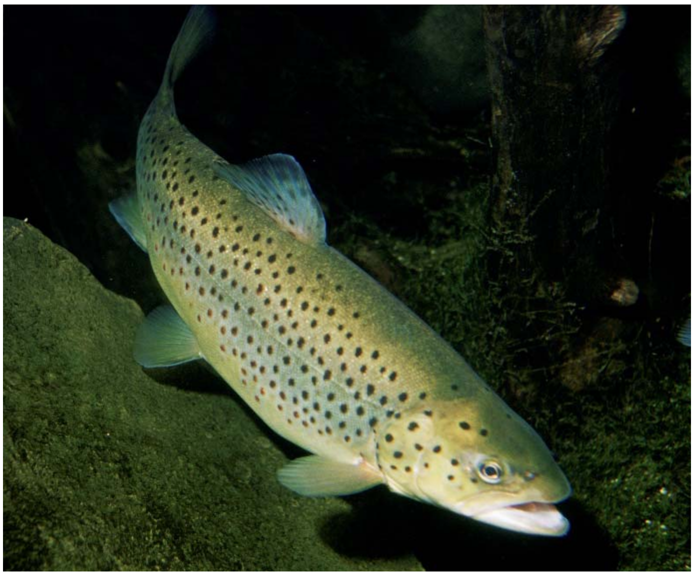


Figure 42 Brown trout, showing the characteristic black spots that are found along the side of the body.

Unlike rainbow trout, brown trout are native to Europe. They were first introduced into New Zealand in the late 1860s from British stock that had been established in Tasmania. Many subsequent introductions occurred, and brown trout established themselves rapidly where they were released – and also spread by going out to sea and swimming up other rivers. They are now the most widespread and common introduced fish in New Zealand. In the early years of their introduction, they reached very large sizes (>10 kg), but trout sizes soon dropped. Today, these fish can often reach to about 5 kilograms, although most fish caught are smaller; typically 1 - 2 kilograms.

The colour pattern of brown trout varies with their habitat, although all have black spots (Figure 42). Sea-run and lake fish tend to be silvery with brown and olive spots of varying intensity, whereas river-dwelling fish are darker with dark brown and red spots, the latter being surrounded by pale halos. These red spots are particularly prominent on small river fish. Brown trout seldom have any spots on their tails, a feature that distinguishes them from rainbow trout.

Brown trout occur throughout New Zealand south of Auckland. Populations north of here are restricted; most likely due to the warmer water temperatures, as water over 11°C will kill brown trout eggs. They are well adapted to live in fast flowing rivers. Their pectoral fins are much larger than those of rainbow trout, allowing them to use the river flow to “hug” the riverbed. Here, the current is slower, and it takes less energy to stay in the feeding position.

Females lay several hundred to several thousand eggs in a small hole excavated into the streambed. These are fertilised by the male. After a month or two the eggs hatch, and the fry live in the gravel before emerging and feeding along stream margins. Adults spawn in early winter, usually in the headwaters of streams with gravel beds. Adults usually survive spawning and spawn annually. Brown trout live for 8–10 years, although individuals up to 15 years old have been recorded in New Zealand.

Brown trout are predatory fish that eat small aquatic insects and small fish. In flowing water they tend to face upstream, feeding on drifting aquatic insects. In slow-moving pools, brown trout cruise looking for food. In lakes they cruise the shallow zone close to shore, feeding on small fish such as bullies, and invertebrates such as dragonfly nymphs and snails in weed beds.

As with rainbow trout, brown trout are widespread throughout the Rangitaiki WMA (Figure 43), where they were found in all the major catchments such as the Whirinaki, Whaeo, Horomanga, and throughout the mainstem Rangitaiki. Their widespread distribution throughout the WMA (Figure 44) reflects their powerful swimming ability, but they would tend to be found only in streams dominated by course cobbles and gravels, as opposed to fine highly mobile pumice streambed. The 2014 survey extended their distribution into the upper reaches of the Hikurangi Stream in the Ikawhenua Ranges, and the Okahu Stream that flows into the Whirinaki (Figure 43). This apparent increase in range could be from natural dispersion or release of brown trout by anglers, and may have implications for the long-term survival of small native galaxids such as dwarf galaxias and koaro that live in similar streams.

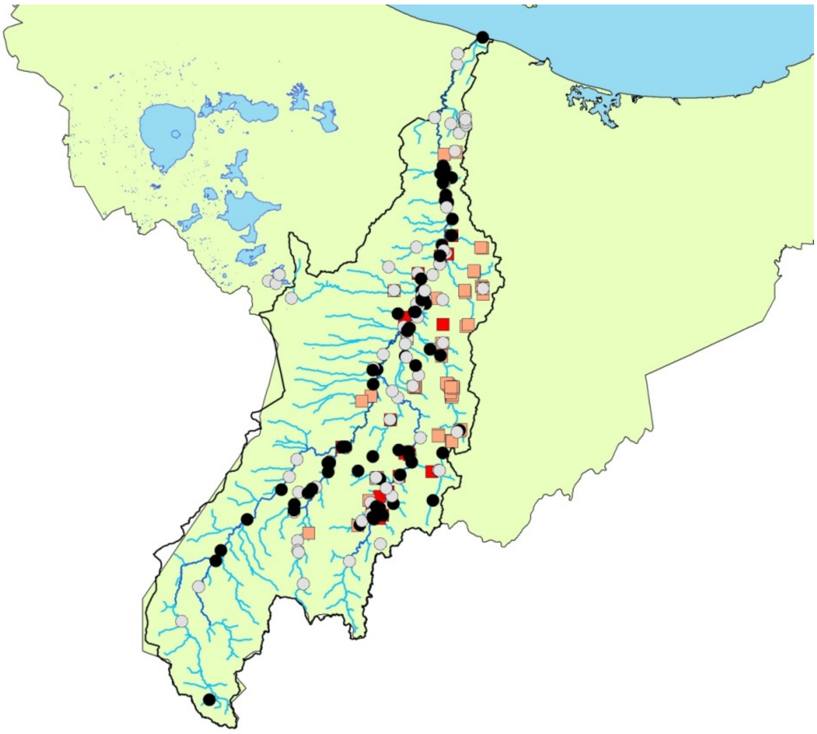


Figure 43 Distribution of brown trout throughout the Rangitaiki WMA. Conventions as per Figure 12.

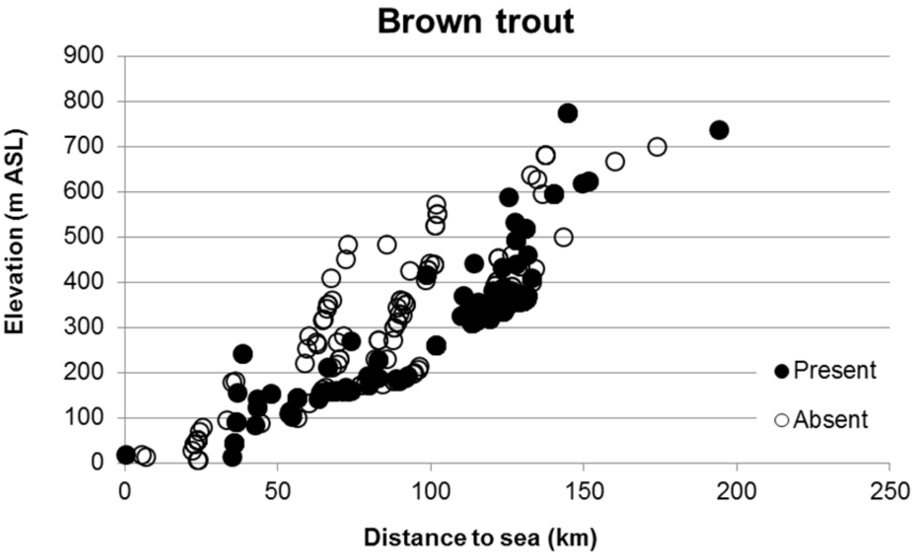


Figure 44 Distribution of brown trout showing their relationship to distance to sea and altitude.

Part 4: Discussion

The contemporary fish survey was done to fill in data gaps where previous surveys had been conducted over 16 years ago, or was targeting sites that appeared under-represented in the NZFFD. Such sites included smaller streams flowing through catchments dominated by native bush within the Rangitaiki WMA. Many of these areas were in the eastern part of the catchment in the upper reaches of the streams draining from the Ikawhenua Ranges, and which flowed across the Galatea Plains into the mainstem of the Rangitaiki River. These more recent surveys, and surveys of new areas found koaro at some sites in the catchment, and the discovery of new sites supporting dwarf galaxias. The new surveys also confirmed the abundance of rainbow and brown trout, as well as longfin and shortfin eels throughout the catchment.

The absence of dwarf galaxias from streams where they were previously recorded highlights the importance of negative interactions between native fish and trout, and suggests that such a loss of these smaller native fish could continue if trout were to spread into areas where they are currently not found. The fact that rainbow trout are already present in the three streams where dwarf galaxias were found is of concern, and raises the question of whether trout-free reaches could be created in streams where dwarf galaxias are found. This could be relatively easy in streams such as the Ohutu, as these normally dry each summer in their mid reaches. Such drying may naturally limit the upstream movement of trout to these areas. However, upstream movement of trout is likely to occur during times when the stream is flowing, leading to the possibility of creating some type of instream structure to minimise the chances of trout from colonising these streams during these times.

Although this concept may seem counter to s42 of the Freshwater Fisheries Regulations (1983) that states "no person shall construct any culvert or ford in any natural river, stream, or water in such a way that the passage of fish would be impeded", this section also has the qualification "without the written approval of the Director-General incorporating such conditions as Director-General thinks appropriate". It is assumed that such approval has been given previously throughout the country to install barriers to prevent the upstream movement of trout into areas where there are threatened native species. For example, the Department of Conservation, Fish and Game, and the Otago Regional Council are working with water user groups, landowners, iwi and the community in areas with threatened galaxias to remove trout, install barriers to prevent future trout movement (http://www.doc.govt.nz/news/media-releases/2014/otagos-native-fish-more-threatened/). Closer to home is the installation of the trout barrier in the Waitarere Stream, a small tributary that flows into the Hamurana Springs, that itself flows into Lake Rotorua. This project saw the installation of a large weir in the Waitarere Stream that was designed to prevent trout from swimming upstream into an area where koaro were found (see https://blog.doc.govt.nz/tag/hamurana-springs/). As part of this project, trout were also removed from the stream. During a two year period following the installation of the weir and trout removal, koaro numbers appear to have increased up to threefold (see http://www.rotorualakes.co.nz/vdb/document/871). Ongoing monitoring of the stream will confirm the absence of trout from there, as well as monitor koaro numbers. Consideration should be given to determine whether a similar active intervention is required for streams in the Rangitaiki where koaro are currently found. As with the Hamurana Springs and Otago examples, any such work would require close collaboration between agencies such as BOPRC, Rangitaiki River Forum, Department of Conservation and Fish and Game, as well as relevant landowners, iwi and hapu.

The new records of koaro in the Te Weramata and Okahu stream are significant. Both streams are in the Ikawhenua Ranges and flow through unmodified catchments dominated by native bush. As mentioned, the presence of these migratory fish so far inland above the Matahina Dam reflects the trap and transfer work undertaken by the Kokopu Trust, and highlights the ability of these fish species to penetrate far inland to find suitable streams where they can grow. For example, the Te Weramata Stream flows into the Mangamako Stream, which flows into the Rangitaiki above Lake Matahina. The sampling site where Koaro were found was approximately 15.5 km upstream from the Rangitaiki. The Kokopu Trust currently release elvers and galaxids at nine locations throughout the Rangitaiki above the Matahina Dam (Goldsmith and Ludgate 2016), so any Koaro found in the Te Weramata stream would have come from individuals released at the Lake Matahina boat ramp. Koaro found at the two sites in the Okahu stream could have come from release points at either the Waihora Stream at Te Whaiti Road (2.5 km and 8.3 km above this location), or from the release points at the Whirinaki River at Troutbeck Road (16.9 or 22.7 km above this location). Predictive modelling by NIWA (Leathwick et al. 2008) has shown that kaoro could be expected in many of the small headwater streams draining the Ikawhenua Ranges, including the Waikokopu, Waihua, Mangamako (including the Te Weramata where fish were observed at two locations), Kopuriki, Hikurangi, Ohutu and Horomunga (Figure 45). These predictive models, however, do not show Koaro in the Whirinaki, or head water tributaries into the Whirinaki such as the Okahu. Their continued release into the Whirinaki Catchment is probably releasing these fish into areas where they may not naturally have occurred. However, many of the locations where these fish are predicted are inaccessible for routine release of fish collected at the Matahina Dam fish trap, and other locations such as the Horomunga River and its tributaries contain large numbers of trout. Releasing newly caught migrating Koaro into these areas is problematic due to increased chances of predation by resident trout. It is recommended that discussions be initiated between relevant parties to see whether any new areas can be identified for the routine liberation of captured migrating galaxiid larvae. Further monitoring up many of the tributaries in the Ikawhenua Ranges is also recommended, in order to both ascertain the occurrence of any further koaro and dwarf galaxias populations. Such a survey may also help identify areas currently free of trout, which could be relevant in the formation of any trout-free streams in the area.

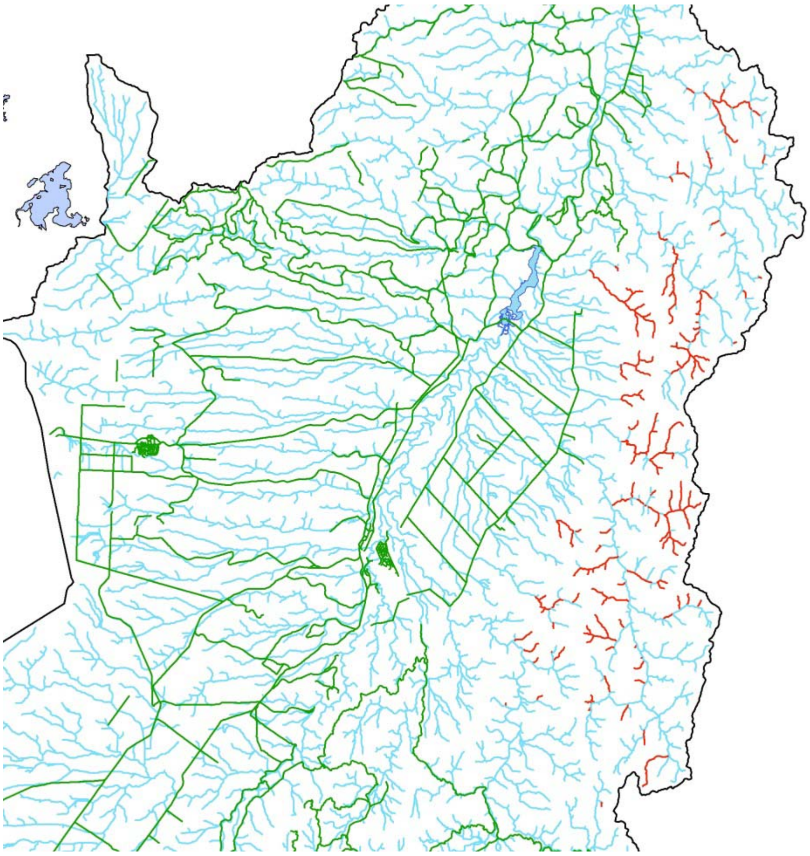


Figure 45 Map showing the predicted occurrence of koaro in small tributaries of larger streams draining the Ikawhenua Ranges.

The finding of giant kokopu and redfin bullies in Kakahotea Stream, and the presence of known populations in the upper reaches of the Ngakaroa Stream, emphasise the importance of importance of maintaining good fish access throughout waterways within the WMA to ensure that many of the migratory native fish can complete their life cycle. This means that it is also important to maintain both habitat and water quality conditions along waterways, especially in the often heavily modified lower reaches where they flow through productive farmland. The survey site in the Kakahotea Stream was only approximately 700 m from the river, and this flowed through a mix of willows, pine and scrub. This stream was most likely unmodified for much of its length. The Ngakaroa Stream in contrast has been heavily modified its lower 3.3 km where it flows from the steep hill country covered by pine forest, through productive agricultural land. The lower reaches have been straightened, and are characterised along much of their length by lack of riparian shade and presence of only long grasses along the banks. Many native fish are highly secretive, and need overhanging bank vegetation, or aquatic plants to hide amongst. These features are often conflicting with the current management of many of these lowland waterways where bank vegetation is mown, debris removed, and macrophytes weeded to maximise channel hydraulic efficiency. There is thus an obvious need for better synergies between engineering and ecological requirements with an aim to fulfil objectives for both values.

As mentioned, the existence of both the Matahina and Aniwhenua dams has huge implications on the upstream and downstream migration of all native, migratory fish in the Rangitaiki WMA. Eels are arguably the most affected by these dams. Although the upstream passage of elvers has been mitigated with the trap and transfer work being undertaken by the Kokopu Trust, it is more problematic to ensure the successful downstream migration of adult eels, especially the large, mature females. Females eels are capable of spawning many millions of eggs, so their losses can have large effects on the overall population structure. Given the fact that we cannot influence the marine life history phases of eels, the best way of ensuring sustainable stocks is to maximise the spawning escapement of adult migrating eels.

Eels usually migrate downstream during autumn, especially during times when water temperatures fall below 11°C, and when rainfall exceeds 40 mm over a three day period (Boubee et al. 2001). The Bay of Plenty Regional Council is currently working with TrustPower as part of their consent conditions to ensure that the Matahina Dam does not adversely affect the downstream migration of eels. TrustPower plan to implement a trap and transfer system, whereby migrating adults are caught at various locations throughout the catchment (including at Lakes Matahina and Aniwhenua), and are transported below the Matahina Dam. A similar trap and transfer programme has been running in Lake Manapouri in Southland for Meridian Energy (Boubee et al. 2008). Here, 50,000+ elvers are trapped at the Mararoa flow control structure on the Waiau River that diverts flow from the Mararoa River back into Lake Manapouri, and released above this structure. Migrating adult eels are also trapped using fyke nets, deployed at locations throughout Lake Manapouri. Current netting procedures enable between 200 - 400 migrating eels per year to be transferred below the control structure (Boubee et al. 2008). This, however, may only be a small proportion of the total numbers of eels migrating from Lake Manapouri, emphasising the difficulty of capturing adult migrating eels. TrustPower is also trialling other techniques, such as ceasing generation during times when the downstream migration of eels is predicted, and spilling water over the Matahina Dam spillway. The success of this is, however, unknown at present, and trials are planned to assess the survivability of eels as they pass over the spillway (Goldsmith and Ludgate 2016).

Despite the presence of these dams in the catchment, the results of the recent survey clearly show a positive effect of the upstream trap and transfer work on both the number of sites where eels were found, as well as the number of small individuals found. However, a reduction in numbers of small longfin eel was observed in both the Rangitaiki and the Kaituna-Maketū and Pongakawa-Waitahanui WMAs. This is a worrying result, especially given the absence of large dams throughout the latter area, and may reflect a general national decline in the numbers of longfin elvers migrating into New Zealand rivers (Wright, 2013). However, a similar decline in the frequency of small elvers was seen in shortfin eels in both WMAs, and this may simply reflect either a reduced ability to catch these fish using electric fishing, or the fact that smaller elvers may have been at sites lower down each catchment. More monitoring is thus needed to confirm whether there is indeed a reduction in the numbers of small elvers.

Any declines, if they are occurring, may reflect multifaceted pressures facing these long-lived species. Such pressures include land-use change and subsequent erosion and loss of stony riverbed habitat that longfin eels favour, presence of fish barriers throughout catchments, hydroelectric turbines that kill migrating fish, and commercial fishing. In addition, it was not all that long ago when large eels were assumed to prey on trout, and so acclimatisation societies promoted extermination efforts to rid rivers and streams of large eels in a misguided attempt to boost numbers of introduced salmon and trout (Wright 2013). Although eels may prey on trout, there is, however, no evidence that this predation has any harmful effects on trout populations (McDowall 1990). Furthermore, it is also unlikely that trout may significantly affect eel populations in the same way that they affect galaxids. Although trout are undoubtedly strong predators of fish such as galaxids, it is not considered likely that they would prey significantly on elvers. Trout are primarily visual feeders, taking drifting organisms that are in the water column.

Small eels, in contrast, generally live within, or close to the substrate, vegetation, overhanging banks and other areas where trout are unlikely to feed. As such, trout may not have the same adverse effects on eels as they do on other native fish.

Even with the large numbers of elvers being released throughout the catchment, little is known of their growth and survival rates. This is important, as one may have expected more smaller eels to be encountered that were found. The Kokopu Trust currently releases eels at nine locations throughout the catchment; of which three are in either Lakes Matahina or Lake Aniwhenua. As outlined earlier, there may be evidence to suggest that continued stocking of eels in Lakes Matahina and Aniwhenua may be leading to increased competition, and reduced growth rates. Further monitoring of eel sizes in these lakes is consequently recommended at regular intervals. The other six locations where elvers are released are in five subcatchments: 1) the Pokairoa Stream; 2) the Rangitāiki River near Murupara; 3) the Pekepeke Stream; 4) the Whirinaki River upstream of Troutbeck Road; and 5) the Waihora Stream, which also flows into the Whirinaki. While these areas undoubtedly drain a large proportion of the entire upper catchment, continued release of the many thousands of elvers into these same sites may result in an increased competition for habitat, and possible reductions in survivability. Moreover, releasing elvers into only five sub-catchments may increase their susceptibility to disturbances such as flooding, or sedimentation from slips that could affect populations in these areas. Consideration could thus be given to see if other suitable release locations for the elvers could be found, while still maintaining the requirements of ease of access and practicality.

The fate of eels throughout the Rangitaiki is of huge concern to iwi, and this has been highlighted by the Rangitaiki River Forum in their recently released Te Ara O Rangitāiki: Pathways of the Rangitaiki Document. This document clearly articulates the value of eels (tuna) to iwi, and highlights that longfin eels in particular feature in local legends as the guardian of the resource and of its people. This river document has identified the desired objective that eels within the Rangitaiki Catchment “are protected through measures including enhancement and restoration of the habitat and migration paths”. A major anticipated environmental result of this objective is to maintain a healthy eel population and structure within the Rangitaiki River so that “the tuna (eels) are fat and plentiful in the Rangitāiki River waterways”. A newer document, “Te Hekenga nui o Te Tuna” (Paul-Burke 2016) builds upon this, and presents a clear action plan to achieve these objectives. In particular, Te Hekenga Nui o Te Tuna identifies and articulates an action plan to follow to help achieve these Objectives. Such action plans include:

A and B An information gathering phase, including details on ways to restore and manage tuna migration, relevant fisheries management policies, the use of rāhui, and matauranga on the ecology, distribution and customary management practices of tuna.

C Feasibility studies and cost-benefit analysis of different fish passage options.

D Development of a Cultural Health Index for waterways throughout the Rangitaiki.

E Develop a Tuna Fisheries Management Strategy for all catches of tuna, and potentially cease the commercial take of longfin tuna in the catchment.

F Develop a community awareness strategy.

G Enact identified strategies for the protection, restoration and enhancement for the best practice management of tuna throughout the Rangitāiki.

These are clearly laudable actions and goals. However, it must be remembered that Bay of Plenty Regional Council has only limited powers in dealing with pressures that affect eel populations throughout the catchment. Such pressures include:

- barriers to migration, arising from both dams as well as smaller structures such as culverts,
- habitat loss due to land use activities, and
- loss of eels from fishing (both commercial and recreational).

Although BOPRC has a mandate to affect change to some of these pressures, it has no mandate or legal power to control other pressures facing eels throughout the Rangitāiki. These are discussed below.

Firstly, BOPRC is currently working with TrustPower to ensure the implementation of an effective upstream and downstream trap and transfer protocol. TrustPower is, however, not the only hydroelectricity generator in the catchment, and the Matahina Dam arguably has the greatest effect only on the upstream movement of eels. The Aniwhenua Dam (now operated by Southern Generation, who recently purchased this from Nova Energy) is upstream of the Matahina Dam, and so arguably has a greater effect on the downstream movement of longfin eels in the catchment. This is particularly relevant when considering the different catchment areas above each dam. Thus, the catchment above the Aniwhenua Dam (2,423 km²) is 6.7 times larger than the catchment between Lake Aniwhenua and Matahina (362 km²). Although some of this upstream area is naturally unlikely to have supported eels prior to the dams, the Aniwhenua dam still represents a major barrier to the downstream passage of migrating eels throughout the upper catchment. The Aniwhenua dam is currently operating under an existing water right, and there are no conditions in this water right to maintain downstream fish passage. Informal discussions with TrustPower have, however, indicated that they are likely to conduct a trap and transfer programme for migrating eels from above the Aniwhenua Dam as part of their consent to the Matahina Dam. It is hoped that more formal arrangements between BOPRC, TrustPower and Southern Generation can be reached to ensure a more rigorous and formal approach to the trap and transfer programme is established at sites above the Aniwhenua Dam.

Another issue where BOPRC has a mandate is to ensure that any road culverts or other structures in streams do not impede fish passage in waterways (as per Section 41 of the Freshwater Fisheries Regulations (1983)). Recent surveys of culverts throughout the Rangitaiki on public roads (i.e. maintained either by transit New Zealand or district councils) highlighted that of 299 structures identified, 49 had either perched culverts or perched aprons on their downstream ends. Analysis of those culverts draining perennial waterways showed that they were affecting approximately 60 km² of catchments. Although this is a small amount, it is often relatively easy to retrofit fish passage devices such as ramps, mussel spat ropes, or baffles in culverts, so this could be done relatively easily and cheaply in these culverts. However, as discussed above, having a perched culvert or other structure that restricts fish access to some streams (e.g. Figure 46) may actually be beneficial to fish communities if the objective is to keep predatory fish such as trout from colonising the systems. Therefore, any decision to remove potential fish barriers needs to be made with due clarification of the objectives that are to be achieved.

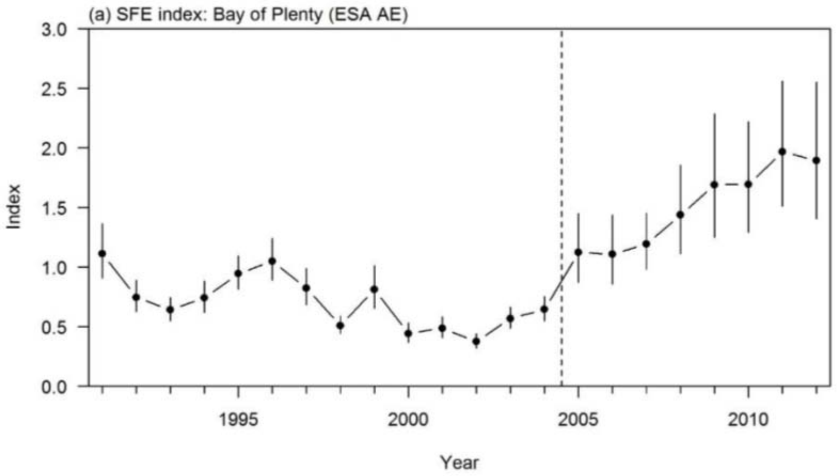
Figure 46 Example of a poorly designed road crossing that may act as a fish barrier, especially during low flows. However, such a structure may be beneficial if the stream above here is to be managed for either non-migratory species, or only for species that have good climbing abilities and which can surmount this obstacle. In this way, it may be possible to keep introduced species such as rainbow and brown trout from colonising new streams, if this is a desired outcome.

Secondly, as far as habitat loss through land-use changes goes, BOPRC has only limited powers to minimise this, and these are related mainly to implementation of rules and methods in the Regional Water and Land Plan. Such rules and methods mainly deal with riparian protection in terms of fencing and planting, and in keeping stock out of rivers and streams. However, even with these rules and methods there are many cases where stock are still found in waterways, and where streams are fenced almost to the bank, allowing for minimal riparian vegetation. Fencing streams alone and providing little or no riparian protection provides little instream benefits, and will arguably contribute little to improve instream habitat for fish such as eels. There is consequently scope for council to work more with landowners and other community groups to fence and plant more extensive riparian areas to provide shade, and overhanging vegetation cover for eels and other fish.

The third pressure facing eels in the catchment is fishing pressure, from both commercial and recreational users. The recreational bag limit is six eels per person per day, and eels can only be caught using one fyke net. Recreational fishing seems widespread, and fyke nets were occasionally found alongside streams, even far from roads (Figure 47), suggesting that people often went to relatively remote places in search of a catch. Deer and pig carcasses were also occasionally seen in some waterways during the survey, presumably to attract eels to make them easier to catch for human consumption.

Figure 47 Example of a fishing net left beside the Horomunga River (below Midway Hut) as it flowed through the Ikawhenua Ranges. Such a net could catch considerable numbers of both trout and eels.

Commercial quotas have also been introduced by the Ministry for Primary Industries. The North Island eel fishery was introduced into the Quota Management System (QMS) in 2004/2005, with initial quotas for the total allowable commercial catch (TACC) of 193 tonnes for longfin eels and 457 tonnes for shortfin eels (Beentjes and Dunn 2013). This TACC was subsequently reduced in 2007/2008 to 81 tonnes for longfin eels and 337 tonnes for shortfin eels. Both the North and South Islands are further divided into areas (called eel statistical areas, ESAs), of which there are 11 in the North Island. It is not known what the annual quota is for eels in the Bay of Plenty ESA, but a total of 284 991 tonne of shortfin eels and 118,781 tonne of longfin eels have been caught between 1991 and 2012. Analysis of the catch per unit effort (CPUE) for eels in each ESA has shown an increase in the CPUE since 2004 for shortfin eels in the Bay of Plenty, but a slight reduction in the CPUE for longfin eels since 1991, to reach a stable, but relatively low CPUE since the QMS was imposed (Figure 48). Some of these catches undoubtedly came from the Rangitāiki catchment, highlighting both that the effect of commercial harvesting for eels may be relatively large, and that there is a decrease in numbers of longfin eels in catches. BOPRC has little ability to control commercial fishing throughout the catchment, as this is regulated by MPI under the QMS. MPI have also developed customary fishing allocations in all ESA's as well. However, there may also be the ability for local iwi to implement a rāhui on the taking of eels throughout some, or the whole catchment by either commercial or recreational fishers. It is thus heartening to see that such fishing may be addressed through Actions in Te Hekenga nui o Te Tuna. However, local management plans/aspirations may have no legal standing unless they become incorporated into MPI's plans and strategies.



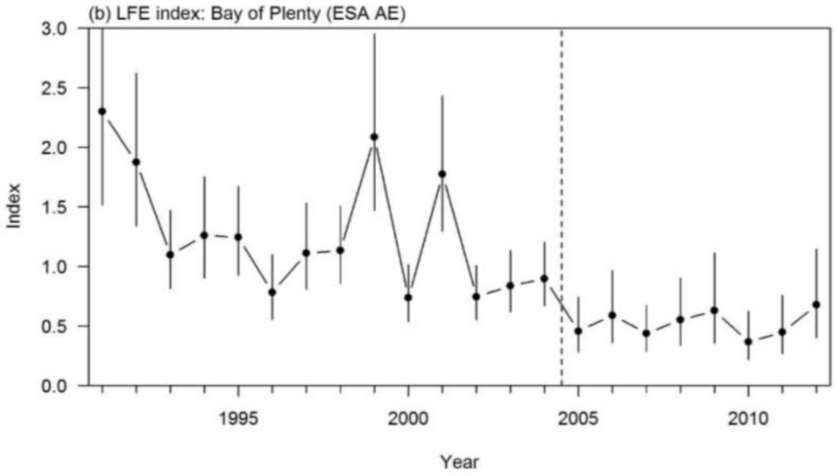


Figure 48 *Standardised CPUE indices for shortfin and longfin eels for the years 1991–2012 for the Bay of Plenty ESA. The vertical dashed line indicates introduction of the QMS in 2004/2005. Dates shown represent the end of the fishing year i.e. 1991 = 1990/1991 fishing year. (From Beentjes and Dunn 2013).*

Although the aspirations articulated by Paul-Burke (2016) are laudable, it needs to be remembered that, nationally, there appears to be a strong signal that longfin eel populations are threatened (Wright 2013), due to a reduction in the numbers of small elvers being caught. Indeed, in her report Dr Wright states that the “longfin eel was on a slow path to extinction”. She emphasised the “slow path” because of the extreme age that adults reach before migrating to sea. If the lack of small elvers is indeed a true trend (and not simply an artefact of sampling methodologies), then this means that there will be fewer females migrating out to sea to spawn in 80+ years from now to replenish eel populations. The result of this is that there will be fewer migrating elvers arriving back into catchments throughout New Zealand. A lack of very small elvers was also observed in both the Rangitāiki and Kaituna-Maketū Pongakawa-Waitahanui WMAs, so the concerns of Dr Wright may indeed be valid. However, the fact that low numbers of shortfin eel were also caught may give us hope that it may simply be an artefact of the sampling methodology, or (in the case of the Rangitāiki survey) that we sampled sites only above the Matahina Dam, and thus may have missed smaller elvers in the lower reaches of the river. More work is obviously needed to indeed confirm whether the lack of small elvers is a widespread phenomenon, as suggested by Dr Wright in her report.

Knowing this has major implications for the objectives of Te Ara Whanui o Rangitāiki, and of Te Hekenga Nui o te Tuna, as populations within the Rangitāiki may continue to decline due to the legacy effect of past national-wide pressures, despite our best efforts. One can only hope that this is not the case.

4.1 Recommendations for further work

This fish survey was initiated as a result of the gap analysis report to provide information on fish communities in sites where this information was lacking, or where the data was greater than 20 years old (Carter et al. 2015). The results of this survey have yielded some useful information, including new records of threatened fish such as koaro in the WMA, and new populations of dwarf galaxias in streams flowing from the Ikawhenua Ranges. Strong environmental gradients were identified in streams throughout the WMA, which were in part responsible for structuring fish communities found in each site. As expected for a fauna dominated by migratory species, major drivers of community structure were elevation and distance to sea. This emphasises the importance of the current trap and transfer work being undertaken by the Kokopu Trust to ensure that migrating fish can make their way past the Matahina and Aniwhenua dams, on both their upstream and downstream migrations. Results of the recent survey work in 2014 provided evidence of the clear benefits to this programme, with an increase in the numbers of small eels throughout the catchment, and the first records of the migratory koaro in some streams. Other large scale factors including catchment topography, climate and land cover were also implicated in structuring fish communities throughout the WMA, as were small-scale factors such as sediment size. While some of these factors are unaffected by human activities, other factors such as riparian vegetation, and in stream habitat have often been altered as a result of land-use activities. There is also anecdotal evidence of strong biological interactions between native fish and introduced trout as well, with the disappearance of dwarf galaxias from sites where they were previously found.

Given the large range of pressures that fish are exposed to throughout the WMA, the fact that they are highly valued by communities, and the fact that there is evidence of a potential decline in the numbers of small elvers in the upper parts of the catchment, a number of extra studies and monitoring programmes are suggested, including:

Eel monitoring

Continue monitoring eel numbers and sizes (length and weight) and catch per unit effort (kg/net/night) in lakes Matahina and Aniwhenua to assess eel growth rates in these lakes.

Continue monitoring eel population and sizes at selected sites throughout the Rangitāiki Catchment, including sites below the dam. Such downstream sites would be particularly useful to search for evidence of low recruitment of longfin eels.

Work with the Rangitāiki River Forum, the Kokopu Trust, and other relevant parties in identifying potential new sites where elvers can be liberated.

Assist where possible discussions between BOPRC, the Rangitāiki River Forum, TrustPower and Southern Generation to ensure a rigorous and formal approach to the upstream and downstream trap and transfer programme is established at sites above the Aniwhenua Dam, as well as the Matahina Dam.

It is hoped that these actions should complement those identified in Te Hekenga Nui O Te Tuna, and lead to the formation of “evidence-based, proactive strategies for the protection, restoration, enhancement and best practice management of tuna populations in the Rangitāiki Catchment” (Paul-Burke 2016).

Other fish species

Commence a long-term monitoring programme to confirm the ongoing existence of koaro throughout headwater streams within the area, as well as identify potential new populations of Dwarf Galaxids. Such a programme may also help identify areas currently free of trout, which could be relevant in the formation of any trout-free streams in the area.

Initiate discussions between relevant parties to see whether any new areas can be identified for the routine liberation of captured migrating galaxid juveniles.

Consider creating trout-free streams by installation of weirs or other devices to prevent. Monitor such sites to ensure no ingress of trout occurs.

Work with land management and landowners to, wherever possible, maximise the amount of shade and overhanging bank vegetation amongst streams. There needs to be a central database (GIS or excel etc.) that all riparian protection data can be entered, to help with future analyses as to the degree of riparian protection throughout the catchment.

Undertake repeat surveys of giant kokopu and redfin bully at sites throughout the Rangitāiki, including streams and drains below the Matahina Dam, in Lake Matahina, and streams such as the Moetahanga Stream and other tributaries that flow into this lake.

Conduct otolith microchemistry on samples of migratory fish such as koaro, banded and giant bullies caught from above the hydro dams, to see whether populations are progeny of land-locked fish, or from trap and transfer programme.

Whitebait research

Develop a better understanding of areas where inanga spawn. Although some work has been done in the Rangitāiki River to identify the location of the salt wedge, it is not known what the spawning habitat is like in this area.

Potential creation of new Inanga spawning and rearing areas. This may include investigation of placement of straw hay bales within the high tide mark of the potential spawning zone for Inanga to lay their eggs. Similar work has successfully been conducted in streams flowing through Christchurch with collaborative work by EOS Ecology, Ngi Tahu, and the University of Canterbury (See http://ngaitahu.iwi.nz/our_stories/whaka-inakacausing-whitebait-in-otautahi-rivers/ and http://www.eosecology.co.nz/Our-News/Whaka-Inaka-Causing-Whitebait.asp.

Initiate studies to determine the relative habitat values of riprap to different fish communities, and to develop and monitor the effectiveness of different bank profiles, and planting regimes to maximise potential spawning habitat along reinforced riprap banks.

It is only by obtaining further information from studies such as these can we help minimise further stressors from activities such as hydro-electric generation, land use activities, and the effects of introduced trout on native fish communities throughout the Rangitaiki WMA, and, hopefully, increase the distribution and abundance of desired fish species throughout the area.

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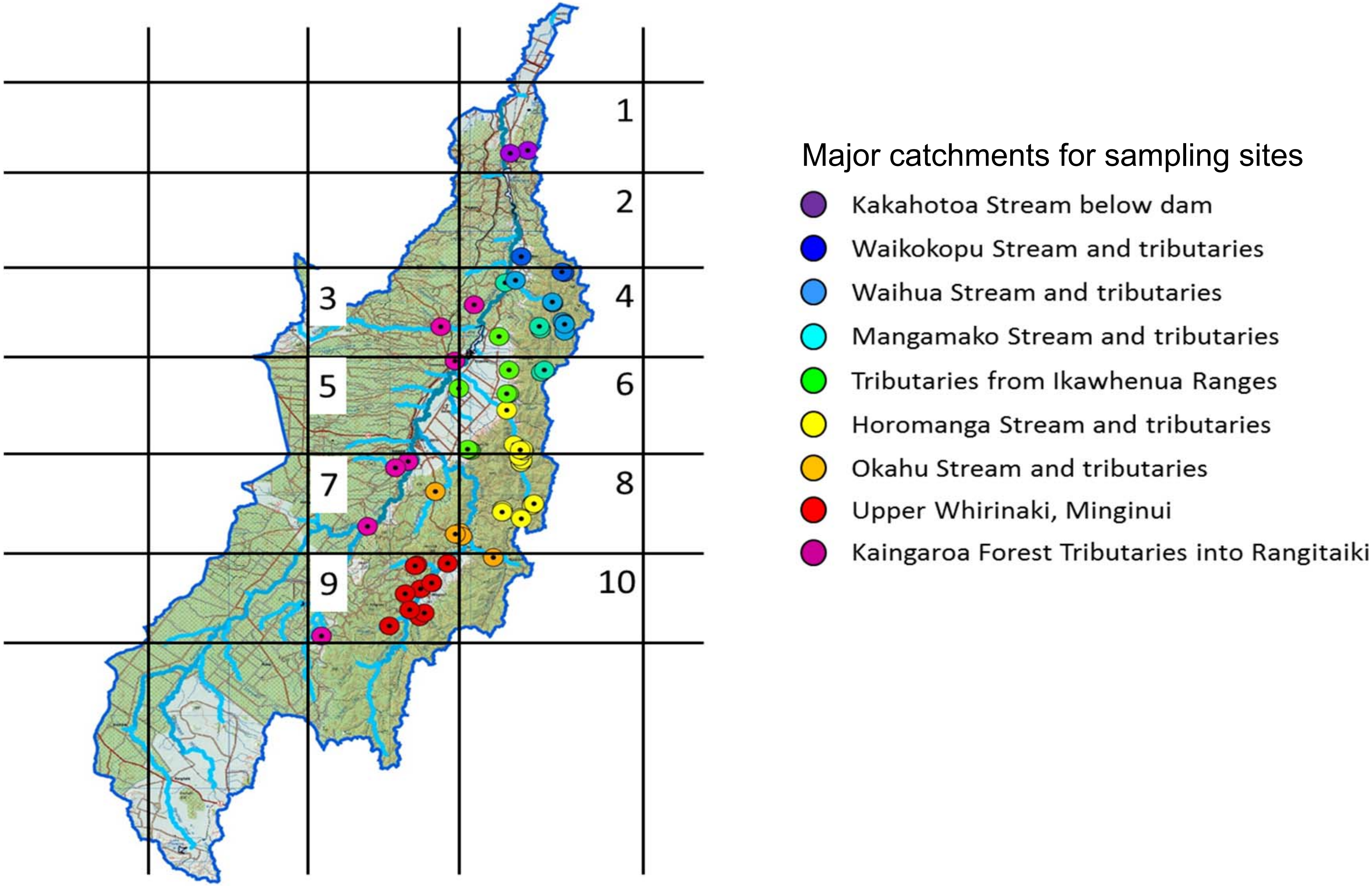
Appendices

Appendix 1 – Maps

Maps showing the location of the sites where fish communities were examined during the 2014 survey. Information contained in the following tables shows the name and location of each site (eastings and northings in NZTM), distance inland and elevation. Also shown are the different types of fish (and crayfish) collected at each site and their abundance, as well as the calculated Fish Index of Biotic Integrity (IBI) class.


1
2
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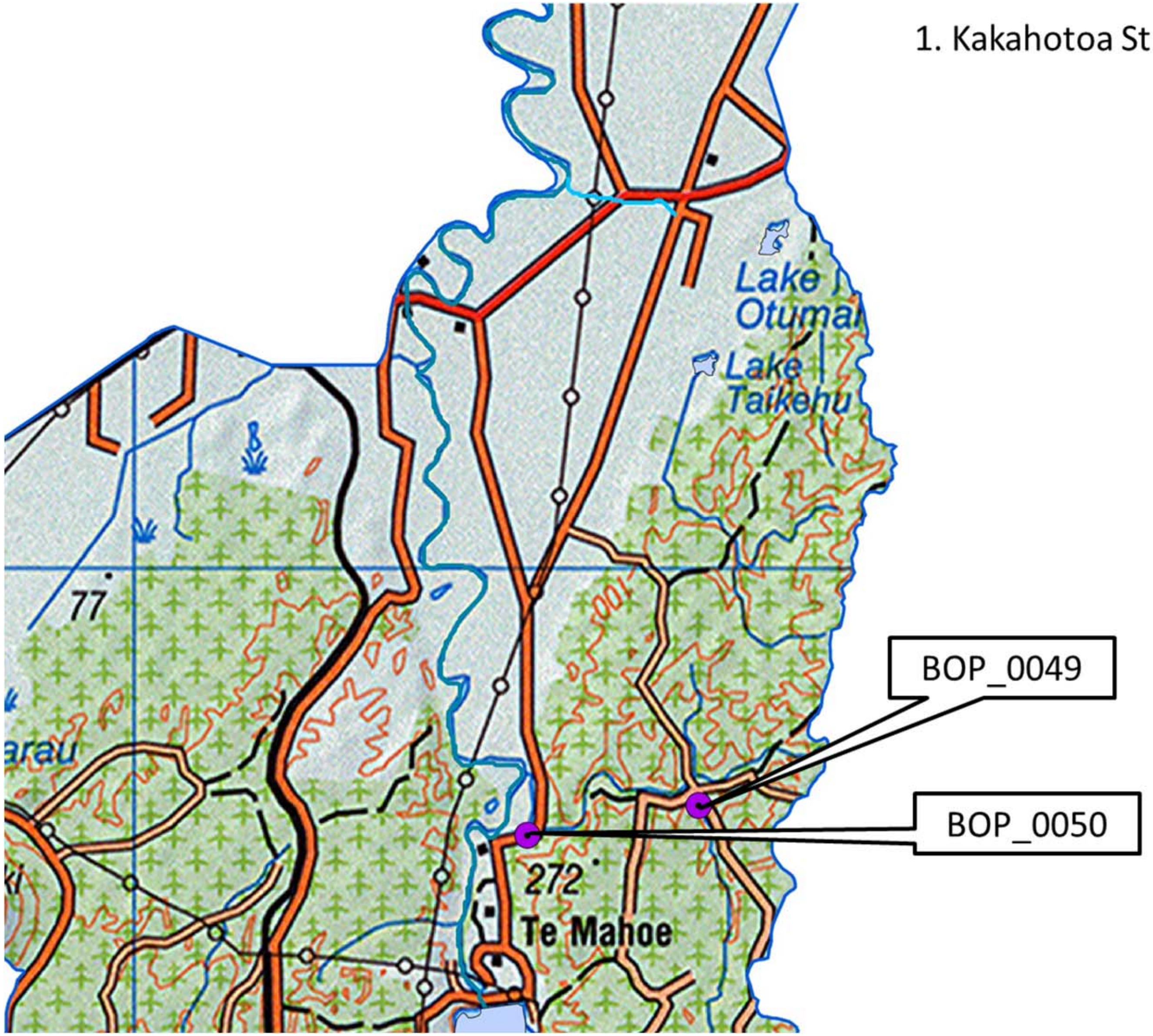
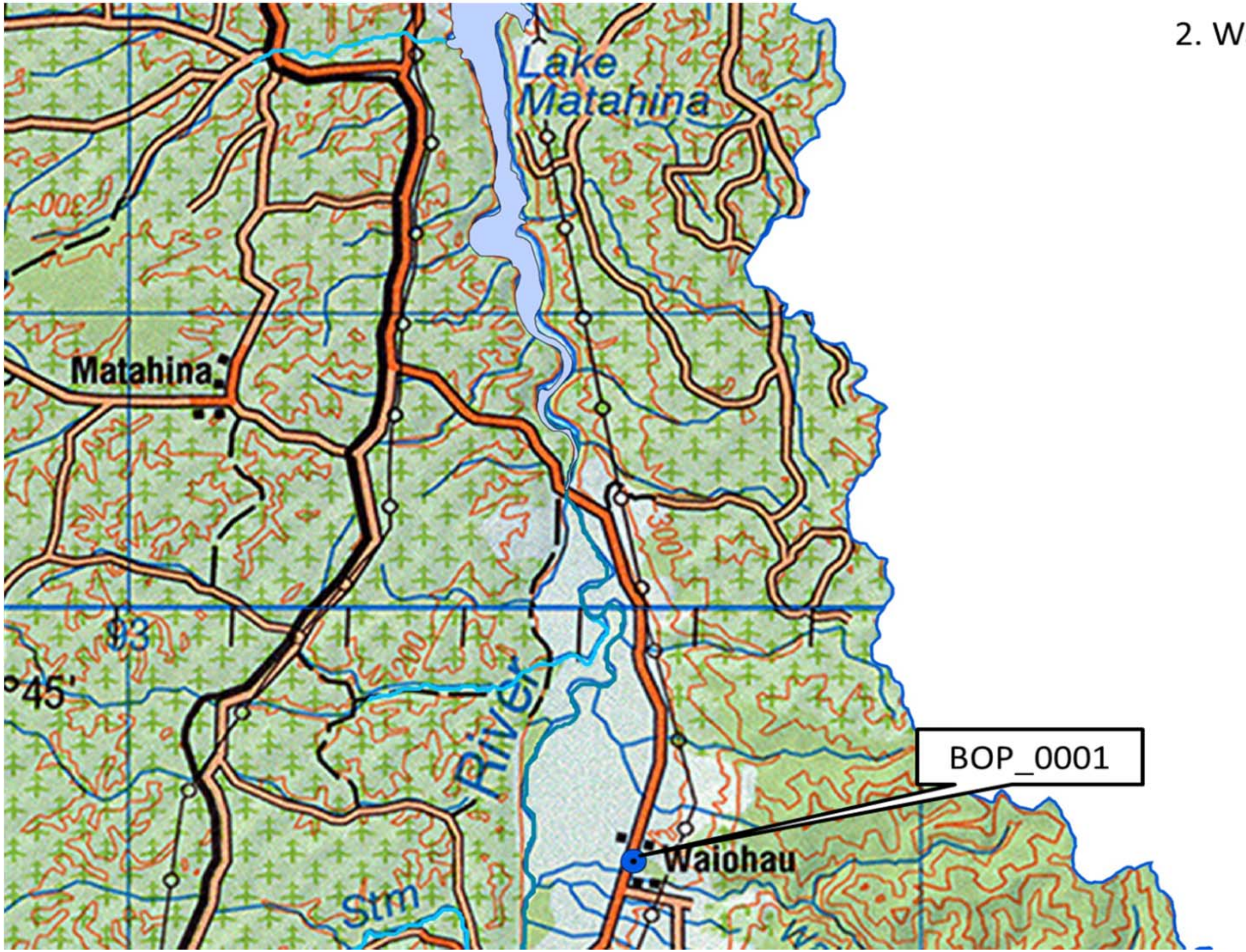
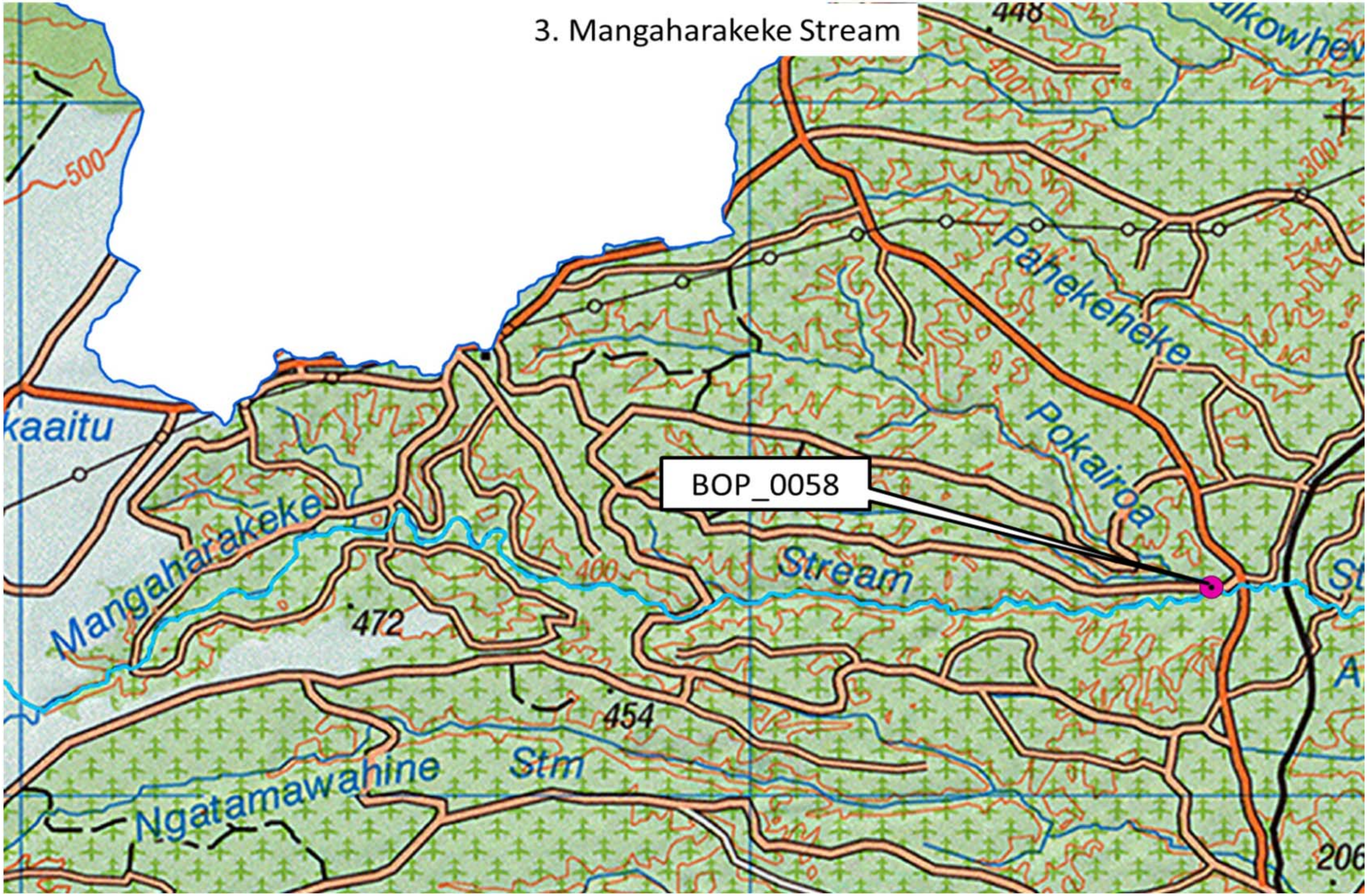
10
Major catchments for sampling sites
● Kakahotoa Stream below dam
● Waikokopu Stream and tributaries
● Waihua Stream and tributaries
● Mangamako Stream and tributaries
● Tributaries from Ikawhenua Ranges
● Horomanga Stream and tributaries
● Okahu Stream and tributaries
● Upper Whirinaki, Minginui
● Kaingaroa Forest Tributaries into Rangitaiki

1. Kakahotoa Stream below dam

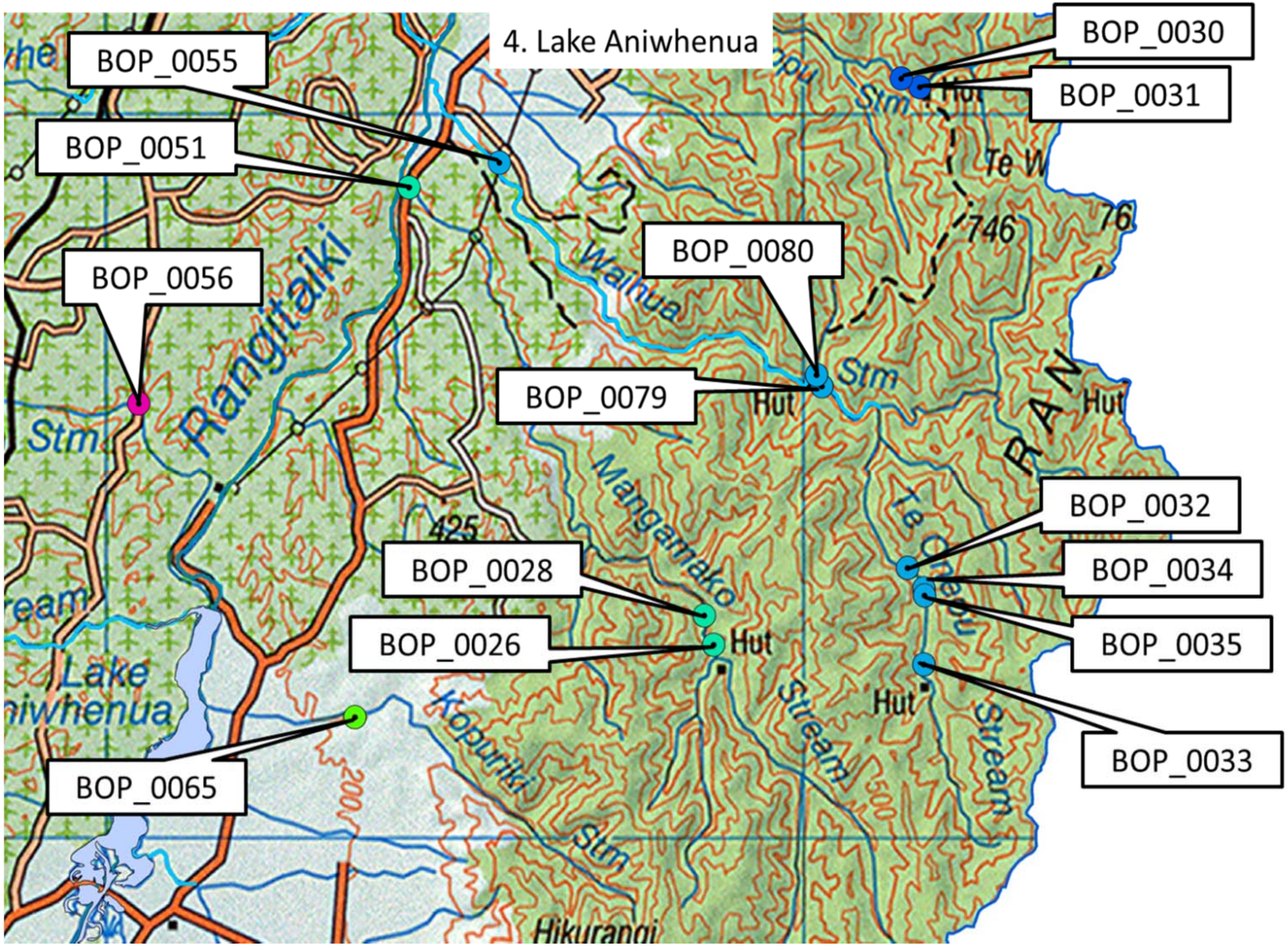


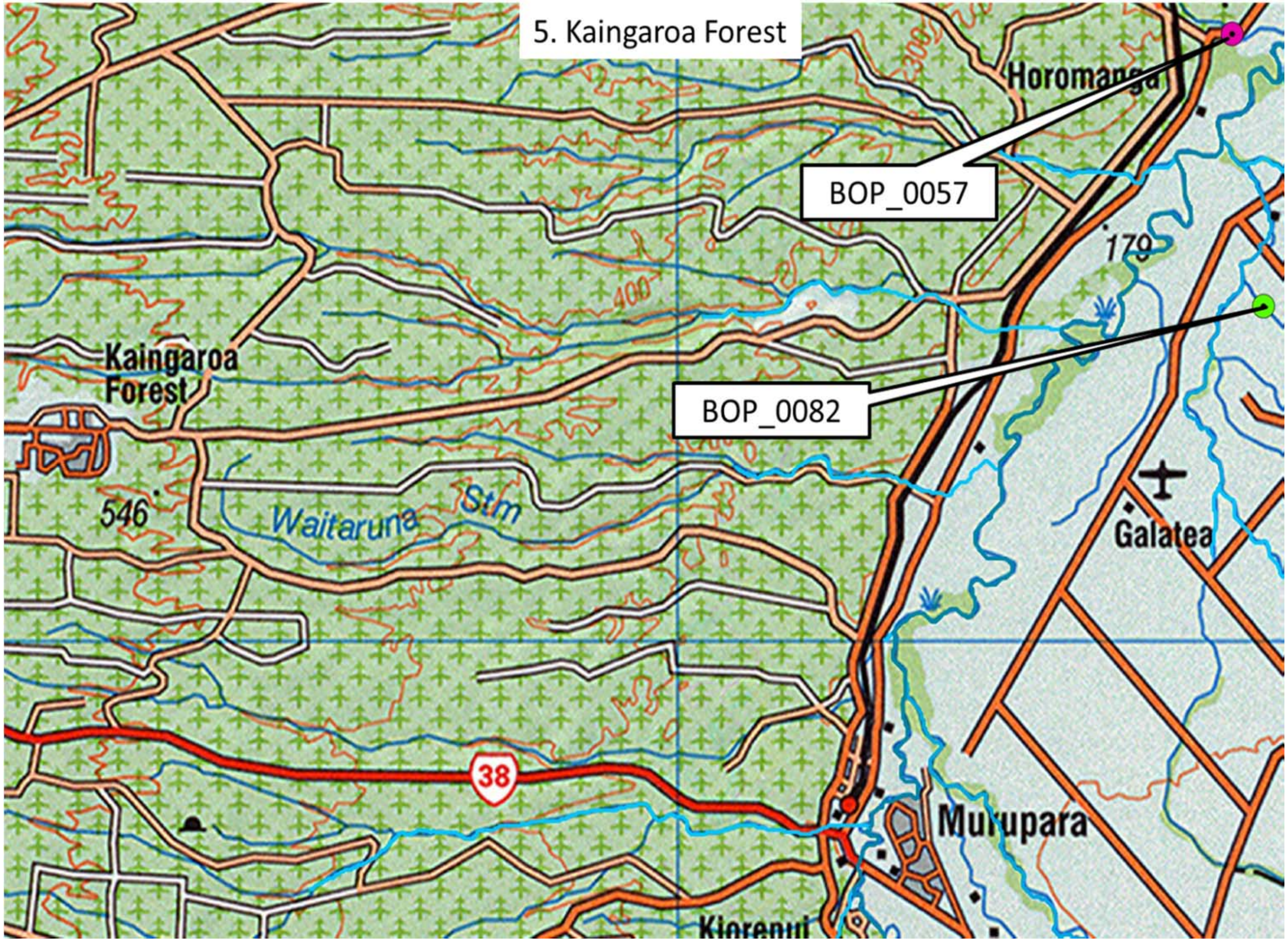
2. Waiohau


Lake Matahina
Matahina
300
93
45'
River
200
Stm
Waiohau
BOP_0001

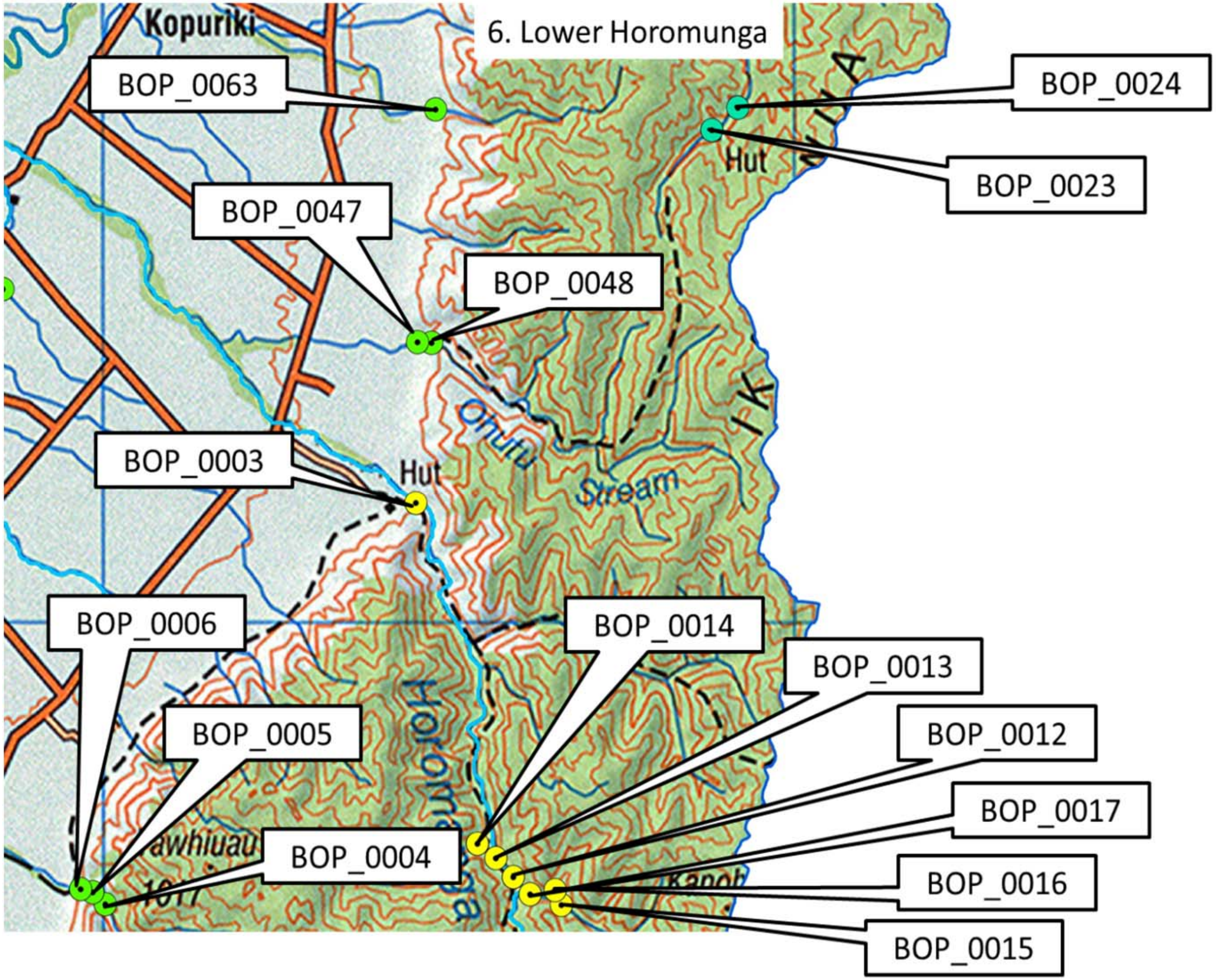


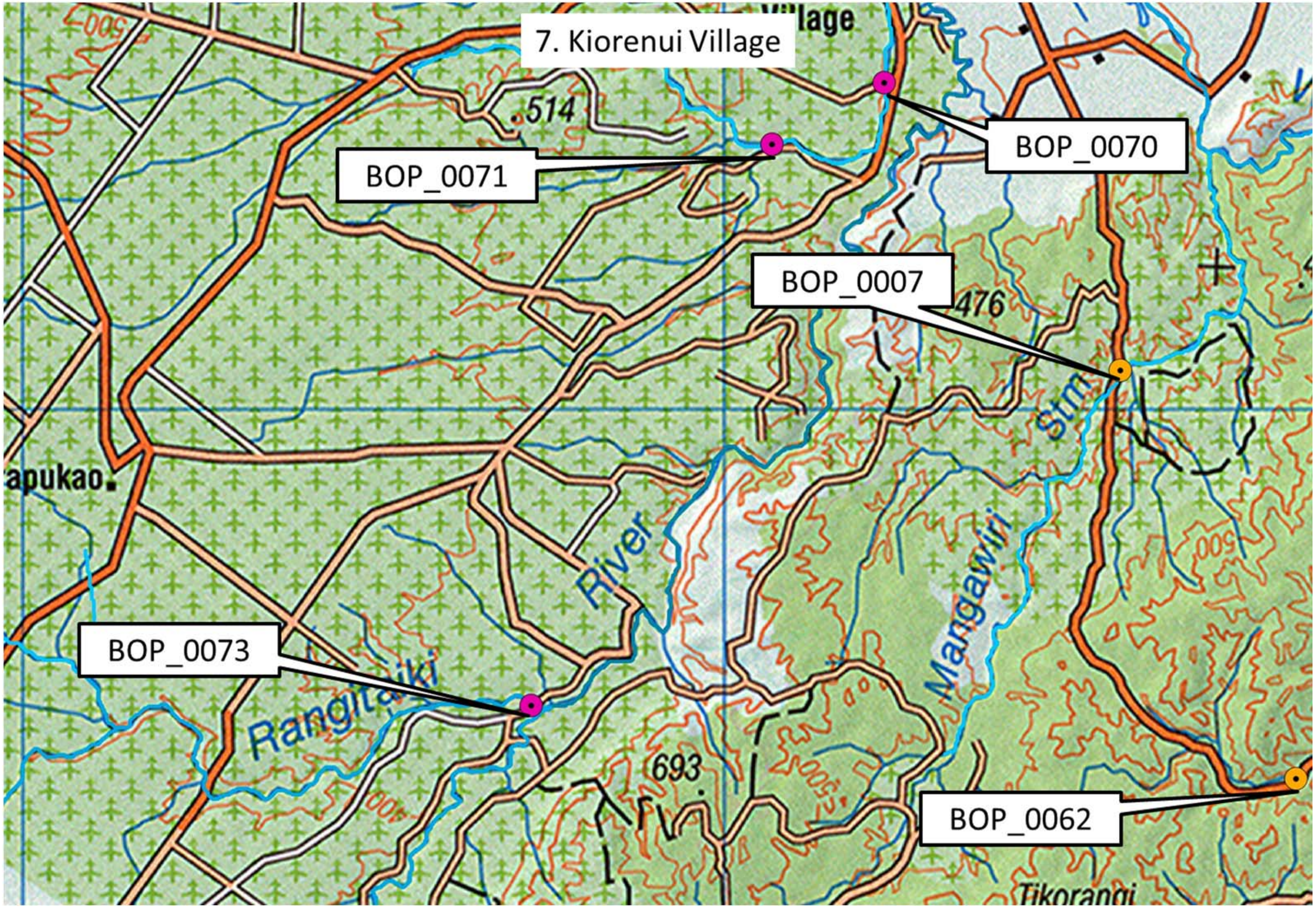
3. Mangaharakeke Stream

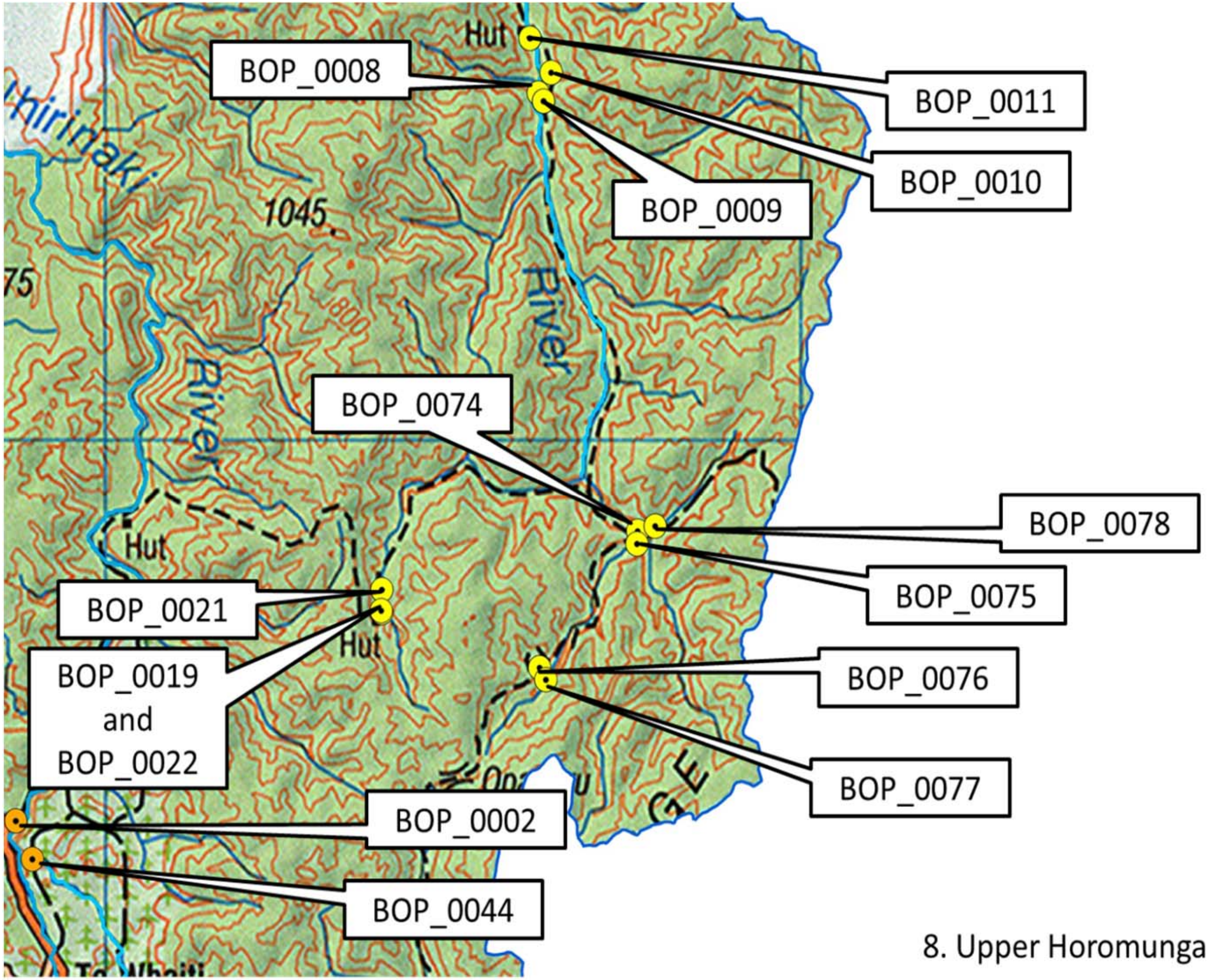

4. Lake Aniwhenua
BOP_0055
BOP_0051
BOP_0056
BOP_0030
BOP_0031
BOP_0080
BOP_0079
BOP_0032
BOP_0034
BOP_0035
BOP_0033
BOP_0028
BOP_0026
BOP_0065
Rangitaiki
Waihua
Stm
Mangamako
Stream
Te Onepu
Kopuriki Stm
Lake Aniwhenua
Hut
Hikurangi
425
746
200



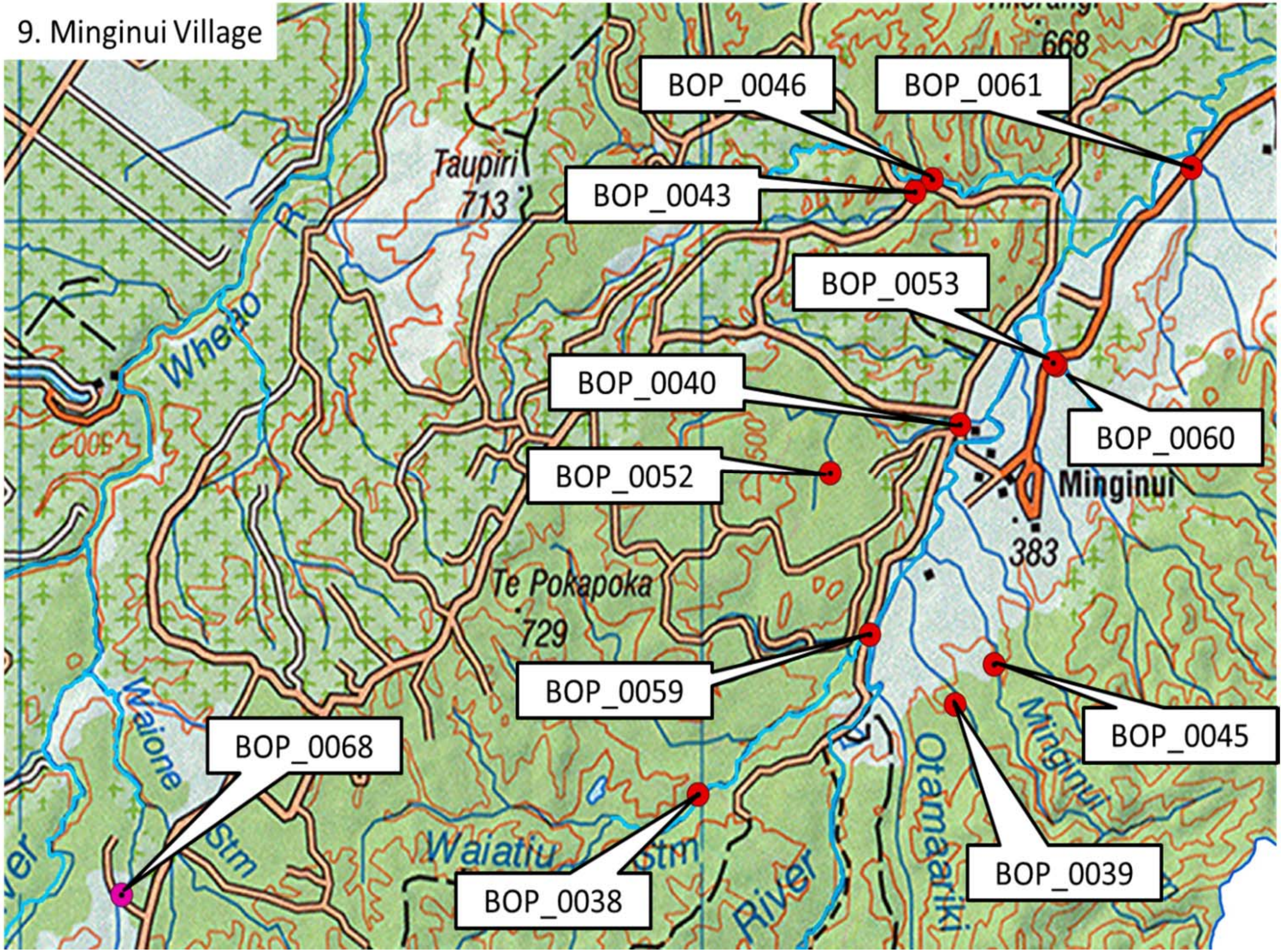
5. Kaingaroa Forest


6. Lower Horomunga
Kopuriki
BOP_0063
BOP_0024
BOP_0023
Hut
BOP_0047
BOP_0048
Onutu
Stream
BOP_0003
Hut
BOP_0006
BOP_0014
BOP_0013
BOP_0005
Horomunga
BOP_0012
BOP_0017
BOP_0004
awhiuau
1017
BOP_0016
BOP_0015

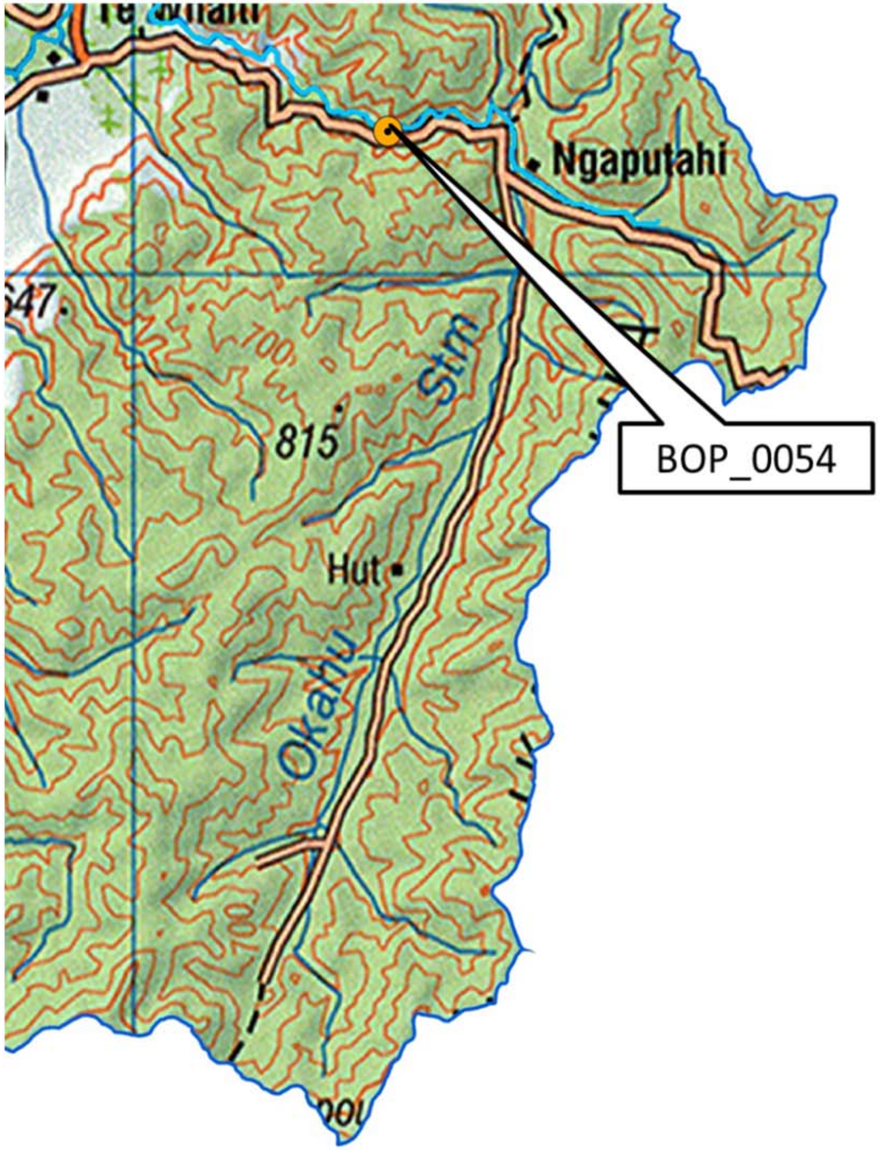

7. Kiorenui Village
Village
BOP_0070
BOP_0071
BOP_0007
BOP_0073
BOP_0062
514
476
693
apukao
River
Rangitaiki
Mangawiri
Stm
Tikorangi



8. Upper Horomunga


9. Minginui Village

10. Upper Okahu Stream



Map Number	Site Name	Site_ID	East_TM	North_TM	Elevation (m ASL)	Distance to Sea (km)	Richness	Fish_IBI	Species Found	Number
1	Kakahotoa Stream in Forestry Block	BOP_0049	1937151	5777053	180.7	36.1	1	Poor	Longfin	2
1	Kakahotoa Stream at Galatea Road	BOP_0050	1934984	5776678	94.7	33.5	4	Excellent	Giant_Kokopu Longfin Redfin bully Shortfin	2 18 12 2
2	Waikokopu above Galatea Road Bridge	BOP_0001	1936374	5762564	112.5	53.9	4	Good	Brown Longfin Rainbow Shortfin	16 2 5 1
4	Mangamako Stream below hut	BOP_0026	1938716	5752653	317.8	65.1	1	Moderate	Longfin	2
4	First tributary into Mangamako Stream on true right below hut	BOP_0028	1938584	5753058	316.2	64.8	1	Moderate	Longfin	1
4	Waikokopu Stream near Waikokopu Hut	BOP_0030	1941673	5760364	281.6	60.4	2	Moderate	Longfin Rainbow	2 1
4	Waikokopu Stream downstream of Waikokopu Hut	BOP_0031	1941409	5760482	252.9	59.6	1	Poor	Longfin	6
4	Te Inepa Stream, 1.5 km downstream of Casino Hut	BOP_0032	1941498	5753714	340.7	66.2	1	Moderate	Longfin	6
4	Te Inepa Stream, downstream of Casino Hut	BOP_0033	1941730	5752381	358.6	67.8	1	Moderate	Longfin	4

Map Number	Site Name	Site_ID	East_TM	North_TM	Elevation (m ASL)	Distance to Sea (km)	Richness	Fish_IBI	Species Found	Number
4	Te Inepa Stream, close to Casino Hut	BOP_0034	1941731	5753431	349.8	66.6	1	Moderate	Longfin	1
4	Tributary into Te Inepa Stream	BOP_0035	1941742	5753334	408.7	67.5	1	Moderate	Longfin	1
4	Mangamako Stream at Galatea Road Bridge	BOP_0051	1934348	5758975	143.0	56.5	4	Good	Brown Longfin Rainbow Shortfin	6 1 4 1
4	Wainua Stream below gauging station	BOP_0055	1935644	5759321	106.6	54.9	4	Good	Brown Longfin Rainbow Shortfin	1 1 4 1
4	Pahekeheke Stream at Pokairoa Road Bridge	BOP_0056	1930475	5755990	210.5	66.5	2	Moderate	Brown Longfin	22 1
4	Kopuriki Stream above fertiliser bin in Blacks farm	BOP_0065	1933572	5751652	211.0	67.7	3	Good	Dwarf_Galaxias Longfin Rainbow	42 1 1
4	Waihua Stream just upstream from Waihua Hut	BOP_0079	1940270	5756230	261.7	62.9	1	Moderate	Longfin	1
4	Tributary on true right below Waihua Hut into Waihua Stream	BOP_0080	1940195	5756386	265.9	62.6	1	Poor	Longfin	2
5	Ngatamawahine Stream at Kopuriki Road Bridge	BOP_0057	1928109	5748329	158.4	71.2	2	Moderate	Brown Longfin	7 2

Map Number	Site Name	Site_ID	East_TM	North_TM	Elevation (m ASL)	Distance to Sea (km)	Richness	Fish_IBI	Species Found	Number
5	Upper Maungaharakeke Stream tributary	BOP_0058	1926340	5752996	229.1	70.2	1	Poor	Rainbow	6
5	Mangakotukutuku Stream	BOP_0082	1928567	5744588	170.9	77.1	3	Good	Longfin Rainbow Shortfin	4 1 23
6	Horomunga at end of dirt road	BOP_0003	1934541	5741629	227.2	82.8	1	Poor	Rainbow	7
6	Mangamate - upper	BOP_0004	1930048	5736070	299.9	88.1	1	Poor	Rainbow	7
6	Mangamate - mid	BOP_0005	1929869	5736236	299.9	88.1	1	Poor	Rainbow	7
6	Mangamate - lower	BOP_0006	1929691	5736280	270.2	87.7	1	Poor	Rainbow	9
6	Horomunga River below Midway Hut	BOP_0012	1935948	5736446	310.5	89.1	2	Good	Longfin Rainbow	6 3
6	Horomunga River above Horokaka Stream	BOP_0013	1935700	5736707	310.5	89.1	3	Good	Longfin Rainbow Shortfin	3 13 1
6	Horokaka Stream - tributary into Horomunga	BOP_0014	1935432	5736907	342.4	89.0	2	Good	Longfin Rainbow	1 9
6	Upper Oohenu Stream	BOP_0015	1936646	5736062	359.4	90.3	1	Poor	Rainbow	29
6	Tributary into Oohenu Stream on true right	BOP_0016	1936555	5736267	360.0	90.1	1	Poor	Rainbow	6

Map Number	Site Name	Site_ID	East_TM	North_TM	Elevation (m ASL)	Distance to Sea (km)	Richness	Fish_IBI	Species Found	Number
6	Ooheno Stream above confluence with Horomunga	BOP_0017	1936194	5736209	328.9	89.7	1	Poor	Rainbow	25
6	Te Weramata Stream, 50 m below Duckville Hut	BOP_0023	1938820	5746789	483.5	73.1	2	Good	Koaro Longfin	5 2
6	Te Weramata Stream, 200 m below Duckville Hut	BOP_0024	1939200	5747100	451.2	72.2	2	Good	Koaro Longfin	5 1
6	Ohutu Stream - upper site in bush edge	BOP_0047	1934770	5743845	270.6	83.0	2	Good	Dwarf_Galaxias Longfin	46 1
6	Ohutu Stream - lower site opposite pasture	BOP_0048	1934565	5743855	230.0	81.8	2	Moderate	Dwarf_Galaxias Rainbow	34 1
6	Hikurangi Stream near Ikawhenua Ranges in park	BOP_0063	1934826	5747078	268.6	73.9	3	Good	Brown Dwarf_Galaxias Longfin	14 1 1
7	Mangawiri at Road Bridge	BOP_0007	1925678	5730538	260.0	101.9	1	Poor	Brown	3
7	Kopikopiko Stream on Te Whaiti road side	BOP_0062	1928181	5724722	330.6	114.3	2	Good	Brown Longfin	21 2
7	Pekepeke Stream on Marys Road	BOP_0070	1922307	5734630	198.1	94.5	3	Good	Longfin Rainbow Shortfin	1 3 1
7	Pekepeke Stream on forestry track off Kiorenui Road	BOP_0071	1920708	5733757	212.8	96.3	2	Moderate	Longfin Rainbow	2 5

Map Number	Site Name	Site_ID	East_TM	North_TM	Elevation (m ASL)	Distance to Sea (km)	Richness	Fish_IBI	Species Found	Number
7	Rangitaiki River above raft launching site on road to Ngahunga Crossing	BOP_0073	1917276	5725766	332.0	111.9	3	Moderate	Brown Rainbow Shortfin	3 3 3
7	Horomanga River mainstem in upper Ikawhenua Ranges	BOP_0074	1937677	5728770	404.8	98.4	2	Good	Longfin Rainbow	1 94
8	Opaheru Stream at ford	BOP_0002	1928740	5724950	309.5	113.4	3	Good	Brown Longfin Shortfin	36 2 2
8	Raropo - near confluence with Horomumga	BOP_0008	1936247	5734554	349.7	92.0	2	Good	Longfin Rainbow	1 15
8	Raropo - 100 m u/s of confluence with Horomumga	BOP_0009	1936327	5734448	349.7	92.0	1	Poor	Rainbow	44
8	Tunupa Stream, 50 m upstream of confluence to Horomunga	BOP_0010	1936434	5734822	358.5	91.3	2	Good	Longfin Rainbow	1 13
8	Side braid of Horomunga above Midway Hut	BOP_0011	1936131	5735278	327.6	90.7	1	Poor	Rainbow	10
8	Arowhaia Stream 30 m above hut	BOP_0019	1934000	5727700	550.1	102.2	1	Moderate	Rainbow	3
8	Arowhaia Stream 250 m below Mangapouri Hut	BOP_0021	1934000	5728000	525.1	101.5	2	Excellent	Longfin Rainbow	1 23

Map Number	Site Name	Site_ID	East_TM	North_TM	Elevation (m ASL)	Distance to Sea (km)	Richness	Fish_IBI	Species Found	Number
8	Arowhaia Stream 500 m below Mangapouri Hut	BOP_0022	1933990	5727721	550.1	102.2	2	Excellent	Longfin Rainbow	4 14
8	Okahu Stream on Te Whaiti Road	BOP_0044	1928977	5724446	310.2	114.4	4	Excellent	Brown Koaro Longfin Rainbow	4 1 3 5
8	Kotuku uku Stream, in upper Horomunga River	BOP_0075	1937669	5728605	426.2	99.2	2	Good	Longfin Rainbow	1 25
8	Oirakino Stream - tributary into Kutu uku Stream at road bend	BOP_0076	1936266	5726972	570.6	101.7	1	Moderate	Rainbow	8
8	Kotuku uku Stream, just above confluence with Oirakino Stream	BOP_0077	1936357	5726814	524.7	101.4	1	Moderate	Rainbow	33
8	Kohangaweka Stream from junction of Horomunga	BOP_0078	1937931	5728839	416.6	98.9	2	Good	Longfin Rainbow	2 58
9	Waiatua Stream below foot bridge	BOP_0038	1919981	5712179	429.0	134.2	1	Moderate	Rainbow	30
9	Otamaariki Stream at confluence with Whirinaki	BOP_0039	1923750	5713400	460.1	131.9	3	Excellent	Brown Longfin Rainbow	5 6 20

Map Number	Site Name	Site_ID	East_TM	North_TM	Elevation (m ASL)	Distance to Sea (km)	Richness	Fish_IBI	Species Found	Number
9	Waiakaka Stream at bridge	BOP_0040	1923823	5717209	378.0	127.0	4	Good	Brown	8
									Longfin	10
									Rainbow	4
									Shortfin	1
9	Upper Okahu Stream	BOP_0043	1923420	5720539	378.7	125.8	1	Moderate	Rainbow	17
9	Minginui Stream at picnic site - road end	BOP_0045	1924323	5713947	371.5	129.8	3	Excellent	Brown	8
									Longfin	1
									Rainbow	25
9	Tributary into Upper Okahu Stream on Loop Road	BOP_0046	1923159	5720370	390.6	126.6	1	Moderate	Rainbow	25
9	Tauranga Stream - Whirinaki Mountain Bike Track	BOP_0052	1921920	5716546	433.8	129.5	1	Good	Longfin	4
9	Parewharangi Stream - Whirinaki, above main Road	BOP_0053	1925238	5718019	349.1	125.0	4	Good	Brown	17
									Longfin	4
									Rainbow	1
									Shortfin	2
9	Waiparera Stream by River Road Bridge	BOP_0059	1922501	5714351	357.2	130.3	1	Moderate	Brown	1
9	Parewharangi Stream - Whirinaki, above main Road	BOP_0060	1925189	5718046	349.1	125.0	1	Poor	Brown	1
9	Whataroa Stream just above road	BOP_0061	1927217	5720700	328.5	120.3	3	Good	Brown	1
									Longfin	8
									Shortfin	38

Map Number	Site Name	Site_ID	East_TM	North_TM	Elevation (m ASL)	Distance to Sea (km)	Richness	Fish_IBI	Species Found	Number
9	Otupoka Stream	BOP_0068	1911522	5710816	637.3	132.8	1	Good	Rainbow	17
10	Okahu Stream into Whirinaki	BOP_0054	1932896	5721532	380.7	120.3	4	Excellent	Brown	4
									Longfin	11
									Rainbow	4
									Shortfin	1