# The Health of Freshwater Fish Communities in Tasman District 2018

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This report presents results of targeted investigations and monitoring into the freshwater fish communities of rivers and streams in Tasman District from 2011 to 2018. The purpose of the surveys varied: (1) exploratory surveys to determine species diversity, including targeting rare species; (2) surveys to determine the impact of particular stream habitat modifications or man-made in-stream structures (control-impact comparisons); (3) monitoring at set sites to track changes in the fish community over time; and (4) fish salvage associated with stream works such as gravel removal or waterway diversion operations. Although the fish surveys stand alone, together they provide insights into fish community health across the Tasman region.

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**Cover photos (left to right):**

- Inanga caught in Borck Creek by electric fishing, January 2016
- Male redfin bully
- Use of a stopnet while electric fishing at the Onekaka River, January 2018

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## Disclaimer



## Acknowledgements

Tasman District Council would like to thank all the people and organisations who have assisted in this monitoring programme. In particular, we would like to thank landowners who provided access to monitoring sites and who demonstrated an interest in the fish communities of their local streams.

Thank you to Tom Kroos, Ricky and Tim Olley of Fish & Wildlife Services for fieldwork assistance over many years and contributions to the text of this report. Thank you to Ricky Olley for helpful comments on a draft version.

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# At a Glance

Tasman District Council (TDC) has functions under the Resource Management Act to monitor and manage the life-supporting capacity and natural character of waterways. This includes wetlands, lakes, river margins, and significant habitats for indigenous fauna and introduced salmonids (trout and salmon).

The Council's Freshwater Fish monitoring programme has three broad aims:

- To compare the diversity and abundance of freshwater fish in streams of varying habitat condition modified by various activities in the stream and riparian area that alter habitat, disturb fish or interrupt migration (mostly in-stream structures).

- To assess the efficacy of stream rehabilitation projects, such as riparian plantings, and restoration of structures that present a barrier to fish migration.

- To provide baseline data from which to build a more complete picture of fish distribution and abundance patterns in the region, including rare or threatened fish species.

The fish survey results are used to identify streams of particularly high value that may require greater protection with respect to habitat disturbances. This also assists with the processing of specific resource consent applications and supports the intentions of Tasman Resource Management Plan.

This report brings together the results of fish surveys completed from 2011 to March 2018, mostly as part of the freshwater fish monitoring programme. The fish surveys were primarily carried out on lowland streams as these are areas most at risk of degradation by various human activities. If at all possible, additional reference sites on nearby streams with limited or no risk of degradation were also surveyed for comparison. The streams sampled were generally small (less than three metres wide) with varying types and degrees of habitat modification. The fish surveys were carried out using backpack electric fishing equipment or by night time spotlighting. Occasionally, various trapping techniques were employed, particularly in deep, slow-flowing streams with aquatic vegetation.

There are 20 species of indigenous freshwater fish identified within Tasman, 16 of which are diadromous (migrate to and from the sea to complete their life cycle). In addition there are three sport-fish (all salmonids), the most abundant of which is brown trout. Of the native fish species in Tasman, more than half (currently 12) are listed as At Risk or Nationally Vulnerable by the Department of Conservation. This high proportion of species with declining populations is largely due to broad-scale land use changes which has led to the degradation of fish habitat in waterways. Pest fish, such as koi carp, perch, rudd and tench, have been found in ponds on private land in Tasman and control operations appear to have achieved eradication. *Gambusia* (mosquitofish) are spreading across coastal streams in the Waimea and Moutere Inlets and are proving difficult to control.

Most native fish are sensitive to habitat degradation, particularly redfin bully, bluegill bully, torrentfish, kōaro and the three kōkopu species (banded, shortjaw and giant). These habitat-sensitive species are typically absent from streams with high loads of fine sediment or little riparian vegetation. When soil washes into waterways, the water becomes turbid (cloudy). Freshwater fish typically rely on seeing their food to catch it and the turbid water can restrict feeding. Without riparian vegetation to provide shade, water temperatures can increase. High water temperatures lead to fish stress and reduced feeding rates as well as reduce the capacity of water to hold oxygen while promoting the growth of aquatic plants. Although plants produce oxygen during the day, they consume oxygen at night, further limiting oxygen supplies for fish and invertebrates.

There was a general absence of habitat-sensitive native fish species in most streams. This was a key conclusion in the previous freshwater fish report (James & Kroos, 2011). This pattern was not as strong across the fish surveys in the present report. Of the 135 sites sampled between 2011 and 2018, 59% had at least one habitat-sensitive fish and 24% had two or more habitat-sensitive species. This seemingly positive result is most likely due to the particular set of sites surveyed, rather than an improvement in fish habitat. A greater proportion of sites surveyed in recent years have been in streams surrounded by native forest. This sampling bias stems from the sampling programme's aims. Forested catchments were often chosen for the purpose of gathering data on at-risk species or identifying streams with high biodiversity values.

Longfin eels, shortfin eels and inanga were the most frequently observed species. Between 2011 and 2018, longfin eels were observed at 72% of the sites surveyed. Shortfin eels and inanga were observed at 33% and 31% of sites (respectively) and, along with common bully, show high tolerance to poor stream habitat. Despite the high prevalence of longfin eels, there is a general absence of larger eels (greater than 600mm). Eels do not spawn until near the end of their lives, which may be 40 to 100 years. Due to the absence of larger, older individuals, the conservation status of longfin eels remains At Risk – Declining across New Zealand.

About a third of the sites surveyed were related to habitat restoration projects prior to or shortly after completion. It is premature to make conclusions about the success of these projects as it will take 10-20 years for the riparian trees to mature and for the stream biodiversity to reach its full potential.

While the climbing prowess of banded kōkopu, kōaro and tuna (eel) is well known, it was still pleasing to see that juveniles of these species made it up some several very long (up to six metres) vertical rubber aprons attached to overhanging culverts on the steep road to Totaranui. This builds on a reasonable amount of information about the effectiveness of various measures to restore fish passage. While fish passage restoration is well advanced on Council-owned in-stream structures, and monitoring for fish passage provision looks like it might be imbedded in Council roading contracts, Council is not keeping up with the number of in-stream structures being installed on private land. At present, landowners do not need to notify Council of the installation of such structures.

Rock-rip rap weirs, such as on the Wai-iti (lowest two weirs) and Moutere downstream of Old House Road, were found to be significant fish passage barriers (blocking access to large areas of catchment) for several fish species. Unfortunately, restoration of fish passage has been problematic as the rock is not stable and the river bed level is degrading downstream of the structure (probably as a result of the structure itself) leaving the concrete fish pass ramps perched at the downstream end and at risk of breaking up. The design of any new weirs will need to carefully consider fish values in the future. Fish passage remediation using baffles was tested in Reservoir Creek (Richmond) at two long culverts (almost 500m total) after fish surveys proved that very few fish apart from eels were able to get past Hill Street.

Trap and transfer of eels past fish passage barriers such as at the Kainui Dam (water supply dam in the upper Wai-iti catchment) and Waitui River (irrigation and hydro-electric scheme water take in upper Takaka) are proving successful. At the former site 1000-2000 eels have been transferred each year since transfers started in 2012.

Sampling effort targeting specific rare species such as giant kōkopu and lamprey failed to find any of these fish species at all. This indicates that these species may now be extinct in parts of our region. Historically giant kōkopu were widespread even in living memory (eg in catchments of the Moutere, Dominion Valley, ‘Arnott Stream’ and Neimann Creek) and have not been found there for some time. Investigations of other sites with ideal giant kōkopu habitat, such as Dall Creek near Rockville and an ox-bow of the Aorere River just upstream of the Dall Creek confluence also failed to find this species. There are only 43 historical records of giant kōkopu in Tasman, the last from the Onekaka River in 2011. Despite ideal habitat and anecdotal evidence of lamprey in Basin Creek in the Aorere catchment, none were found. In fact, only one dead lamprey was found (lower Wai-iti River) in any of the surveys since 2010.

Surveys at Onekaka River at Shambala Road found the highest native fish diversity of any site in Tasman (12 species). This may also be the highest native fish diversity of any site in New Zealand (Crow, 2017). There is some evidence that in the lower Parawhakaoho River (Golden Bay) trout may be impacting on native fish. However, in general there are few examples of significant predation on native fish by exotic fish in Tasman. Dwarf galaxias and brown trout seem to coexist in reasonable numbers in tributaries of catchments such as the Motupiko. Despite the catchments in the upper Motupiko River and Roundell Streams being unique in the region as have large areas of original sub-alpine bog/wetlands leading to highly stable, moss-covered streambeds, the fish community had low diversity and relatively low numbers of fish, apart from brown trout.

At a national scale, the occurrence of all native fish is declining, with particularly severe reductions in pasture and urban catchments. The longest-running quantitative fish surveys in Tasman are on the Onekaka River, Golden Bay. Here there appears to be a statistically significant decline in longfin eel and total fish numbers.

# Introduction

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Kōura (freshwater crayfish), shrimp (*Paratya*) and kakahi (freshwater mussel) are included and discussed in this report. These large invertebrates are an important component of Tasman's freshwater fauna.

## Life cycles

Many fish have very defined breeding seasons and migration patterns. Most of the migratory galaxids (giant kōkopu, banded kōkopu, shortjaw kōkopu and kōaro) spawn in late autumn-winter (April-May for kōaro and May-June for the rest), during flood events. These fish all spawn amongst leaf litter and rocks at the top of stream banks in forested streams. Inanga spawn earlier and over a greater time range (March to May peak spawning, on high tides). Juvenile inanga (whitebait) begin their upstream migration mostly in late winter-spring (August-October). Bullies and dwarf galaxias spawn mostly in spring-summer.

Spawning of eels is most likely to be outside New Zealand's territorial waters (thought to be near Samoa for longfins and near Tonga for shortfins), although this has not been witnessed and the timing is unknown. Juvenile eel first enter estuaries in spring and begin their journey up-river in summer-autumn. The downstream migration of eels (from rivers to the sea) is in summer-autumn with males heading off first. Shortfin eels begin downstream migration in February-April, ahead of the longfins in April (males) and May (females). Eels only migrate down rivers during small floods and usually in the dark.

Brown trout spawn in winter (May to September, inclusive) in smaller streams in inland waters.

NIWA have produced freshwater fish spawning and migration calendars for New Zealand freshwater fish species (Smith, 2014).

## Conservation status of freshwater fish

An expert panel led by the Department of Conservation regularly assesses the conservation status of all freshwater fish species in New Zealand. In the most recent update (Goodman, et al., 2014), 12 of the 20 native freshwater fish species found in Tasman were identified as "At Risk – Declining" or "Nationally Vulnerable" (Table 1). The criteria underpinning these classifications is available in Appendix 1.

Table 1. Native freshwater fish species found in the Tasman district with conservation status (Goodman et al. 2014). A colour code has been added for each fish species (left column). These colours are used in the catch data tables throughout this report.

| | Common Name | Scientific Name | Conservation Status | Migratory? |
|---|---|---|---|---|
| | Common bully | *Gobiomorphus cotidianus* | Not Threatened | Y |
| | Giant bully | *Gobiomorphus gobioides* | Not Threatened | Y |
| | Upland bully | *Gobiomorphus breviceps* | Not Threatened | N |
| | Redfin bully | *Gobiomorphus huttoni* | At Risk - Declining | Y |
| | Bluegill bully | *Gobiomorphus hubbsi* | At Risk - Declining | Y |
| | Longfin eel | *Anguilla dieffenbachii* | At Risk - Declining | Y |
| | Shortfin eel | *Anguilla australis* | Not Threatened | Y |
| | Northern flathead galaxias | *Galaxius "northern"* | Nationally Vulnerable | N |
| | Dwarf galaxias | *Galaxius divergens* | At Risk - Declining | N |
| | Inanga | *Galaxius maculatus* | At Risk - Declining | Y |
| | Kōaro | *Galaxius brevipinnis* | At Risk - Declining | Y |
| | Brown mudfish | *Neochanna apoda* | Declining | N |
| | Banded kōkopu | *Galaxius fasciatus* | Not Threatened | Y |
| | Giant kōkopu | *Galaxius argenteus* | At Risk - Declining | Y |
| | Shortjaw kōkopu | *Galaxius postvectis* | Nationally Vulnerable | Y |
| | Lamprey | *Geotria australis* | Nationally Vulnerable | Y |
| | Common smelt | *Retropinna retropinna* | Not Threatened | Y |
| | Torrentfish | *Cheimarrichthys fosteri* | At Risk - Declining | Y |
| | Black flounder | *Rhombosolea retiaria* | Not Threatened | Y |
| | Yelloweye mullet | *Aldrichetta forsteri* | Not Threatened | Y |

These fish species are Nationally Vulnerable: Lamprey, shortjaw kōkopu and northern flathead galaxias.

Lamprey are listed as Nationally Vulnerable in New Zealand because the total area they occupy is small (less than 1 $km^2$) and their numbers are predicted to decline. A contributing factor to this decline is a bacterial disease recently discovered in Otago and Southland which causes red lesions on the adult lamprey body. Although lamprey are widely distributed in temperate latitudes of the Southern Hemisphere, it is unclear whether populations outside New Zealand are improving or declining.

Shortjaw kōkopu are listed as Nationally Vulnerable due to a moderate population size but a high ongoing or predicted decline in numbers. They have a patchy distribution, being found in parts of the North and South Island but are largely absent from the east coast. Shortjaw kōkopu are generally found in small bouldery streams well-shaded by forest. In Tasman, there are small populations in tributaries of the Aorere River and coastal streams of Golden Bay and within Able Tasman National Park.

Northern flathead galaxias is an undescribed species (not officially named) with a restricted range, occurring predominantly in southern Marlborough. Within Tasman, they are found in the Rappahannock River and its tributaries and the upper Motueka River. Their appearance is very similar to kōaro and Canterbury galaxias (common in Canterbury rivers), to which they are extremely closely related.

Longfin eel and giant kōkopu are listed as At Risk – Declining. These two species are only found in New Zealand. They are included in New Zealand's Threatened Species Strategy - Draft for Consultation (Department of Conservation NZ, 2017), a document prioritising species for conservation efforts.

## Nation-wide Trends in Fish Populations

While trend analysis of fish species occurrence or abundance is not possible in Tasman due to limited data, trend analysis across the whole of New Zealand has produced some concerning results. Fish occurrence is reducing and this reduction is most severe in pasture (Joy, Foote, McNie, & Piria, 2018) and urban catchments (Joy M. , 2009). Increases in the extent of intensive agriculture within New Zealand is a driver of this decline. In a study of nine tributaries, for example, no trout were found in streams where dairy farms covered more than 50% of the catchment (Ramezani, Akbaripasand, Closs, & Matthaei, 2016).

An index of biological integrity (IBI) was used to assess trends in New Zealand fish communities in rivers flowing through different land use types (Joy et al 2018 and Joy 2009). The term biotic integrity is based on the concept that to function, an ecosystem must have all its component parts, thus any loss of parts is effectively lost integrity. Using the IBI approach enables comparisons between-site and between-river class as it takes into account natural elevation and distance from coast variation in fish communities caused by the largely migratory New Zealand fish fauna. It also not sensitive to different sample sizes between data sets being analysed. This approach is commonly used worldwide.

Strong relationships between fish biotic integrity scores and land-cover type were revealed using the River Environment Classifications (Figure 1). IBI scores and number of species were significantly higher at sites in native vegetation than sites in pasture or urban catchments.

The strong association between fish IBI and land use reaffirms the influence that terrestrial systems have on freshwater ecosystems. Because of a lack of consistent detail in the database on sampling intensity and fish abundance, all data used in this analysis were necessarily reduced to presence/absence. This restriction means that all results are inherently conservative. This is because any species within a fish community/population will show a gradual decline before local extirpation even with relatively sudden environmental impacts. Thus, for a reduction in IBI score, fish species must become extinct at that reach. Accordingly, the observed changes exposed in this analysis reveal the endpoints of longterm cumulative changes to fish communities (Joy M. , 2009)

The drivers of fish biodiversity declines include elevated concentrations of dissolved nutrients, deposited fine sediment, increasing macrophyte cover and water temperature, as well as decreasing water velocity (Ramezani, Akbaripasand, Closs, & Matthaei, 2016; Julian, Beurs, Owsley, Davies-Colley, & Aussiel, 2017; Lee, Simon, & Perry, 2017). Pest fish are also implicated in this decline. These include koi carp, perch, rudd and tench that have been found in ponds on private land in Tasman. Control operations on these species appear to have achieved success in eradication. *Gambusia* (mosquitofish) are currently found in coastal streams in the Waimea and Moutere Inlets and are proving difficult to control.

## Known *Gambusia* populations

Delimitation surveys over the 2016-17 and 2017-18 summers found that *Gambusia* populations are widespread throughout the coastal Tasman Bay area. *Gambusia* are present in most drains flowing into the eastern wing of the Waimea Inlet between Reservoir and Niemann creeks. *Gambusia* are present in high numbers within the coastal reaches of Borck Creek, but extend in small numbers as far upstream as Ranzau Road, four kilometres inland. *Gambusia* are also present in most drains flowing into the Moutere Inlet south of Wharf Road and in at least two north of Wharf Road. They have been found within Blue Creek two kilometres inland, and within the tidal reaches of both Tasman and Field Stream. Gambusia are also found within the lower reaches of Little Sydney Stream and two smaller drains flowing into Little Sydney Stream north of the Riwaka township.

Despite evidence that *Gambusia* are spreading within the estuary environment, surveys suggest they have not spread within the Waimea Inlet outside of the area described above, and may be restricted by the Waimea River. Surprisingly *Gambusia* are not present in any of the Stoke waterways. It is thought that *Gambusia* are not currently in Golden Bay, although surveys have been limited, and there has been an historic eradication of a population near Takaka.

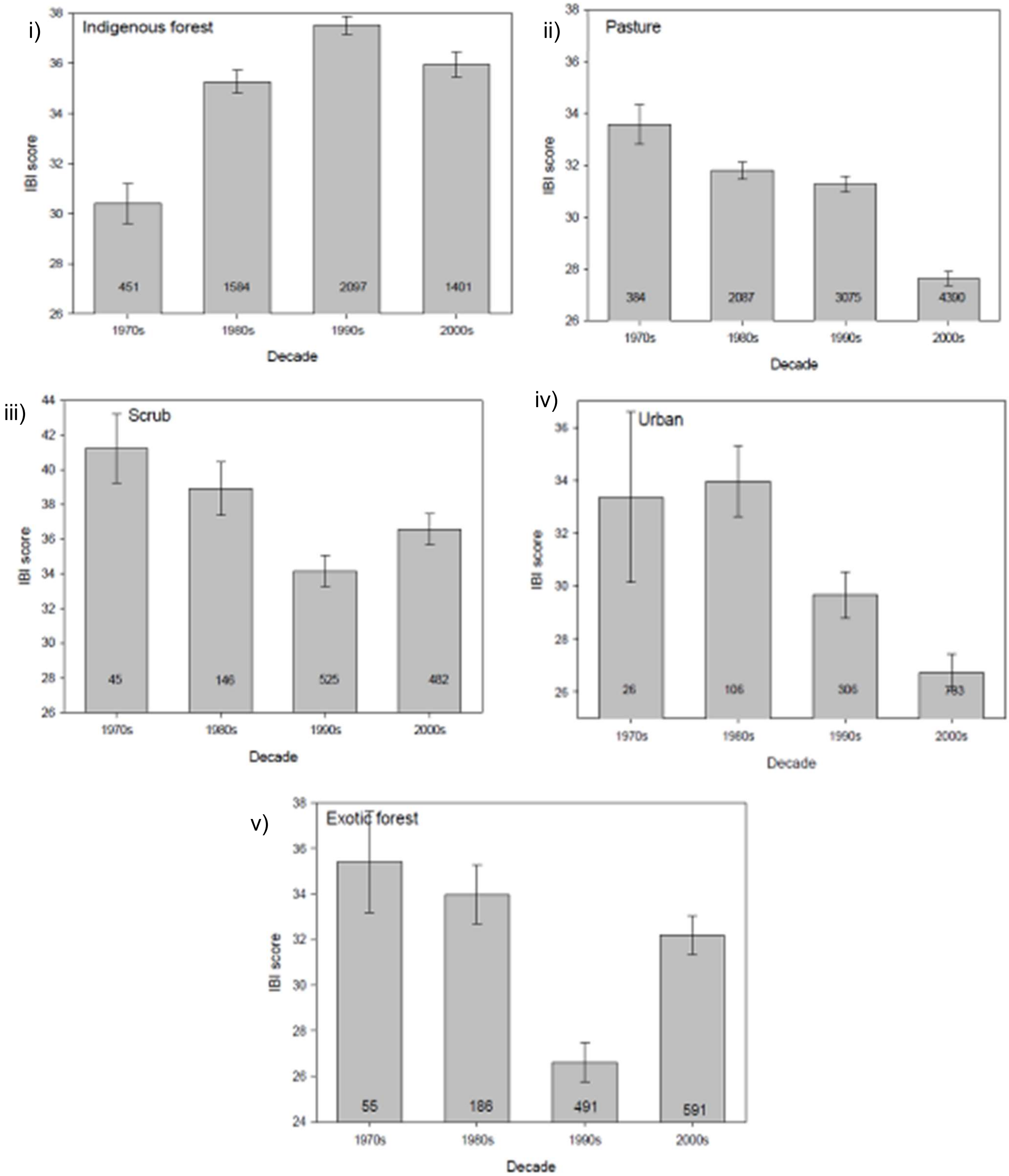
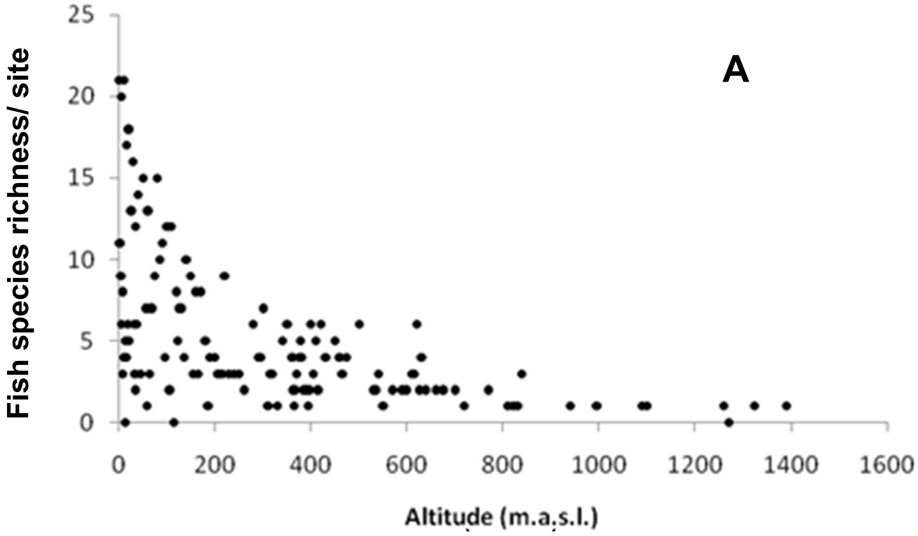



Figure 1. Average decadal IBI scores for river environment classification (REC) land cover: (i) - Indigenous forest, (ii) - Pasture, (iii) - Scrub, (iv) - Urban, (v) - Exotic forest. (Numbers per site inside bars) (from Joy et al 2009)

## Distribution of Fish Species with Altitude and Distance Inland

Records from the New Zealand Freshwater Fish Database showed that altitude (Figure 2A) and penetration inland (Figure 2B) had an important influence on fish species richness in the TDC area, showing a dramatic decrease in species richness as you move further inland and to higher altitude sites. Data about altitude and penetration inland for individual species are listed in Table 2.



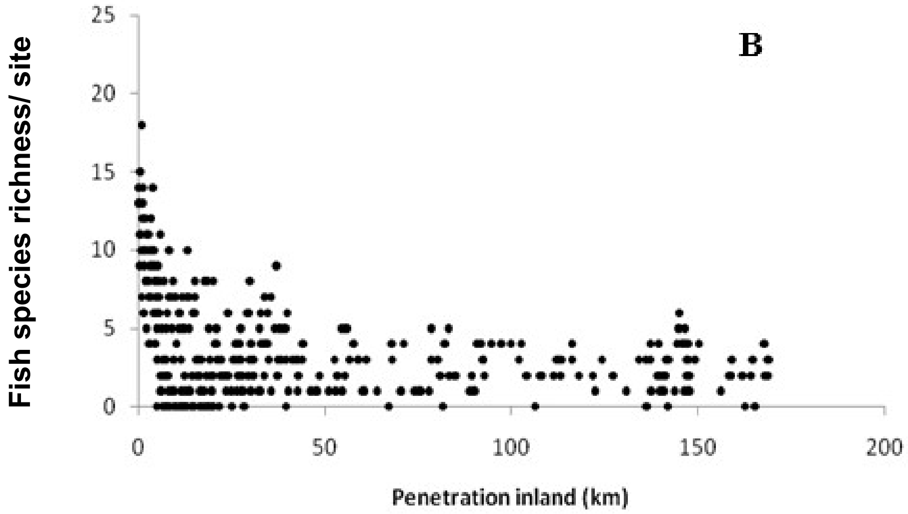




Figure 2. Number of fish species per site in respect to altitude (metres above sea level; A) and penetration inland (km; B) in the New Zealand between 1990 and 2010. Data were derived from the New Zealand Freshwater Fish Database (Crow, 2017).

Kōaro and longfin eel were found furthest inland of any native fish in Tasman (169km in the Lake Rotoiti catchment). Common and Upland Bully and shortfin eel were close behind, and northern flathead galaxias, bluegill bully, kōura and dwarf galaxias were all found at locations over 145km in the Buller catchment. Kōaro were found at the highest elevation by a long way (almost 1400m above sea level).

Table 2. Average, maximum (Max) and minimum (Min) inland penetration (km) and altitude (metres above sea level) for 27 fish species in the Tasman District between 1990 and 2010. Data were derived from the New Zealand Freshwater Fish Database (NZFFD).

| Penetration inland (km) | Average | Max | Min | Altitude (m.a.sl.) | Average | Max | Min |
|---|---|---|---|---|---|---|---|
| Flathead galaxias * | 146.6 | 146.6 | 146.6 | Rainbow trout | 830 | 840 | 820 |
| Nth flathead galaxias * | 134.1 | 146.1 | 90.2 | Flathead galaxias* | 378 | 378 | 378 |
| Dwarf galaxias * | 94.8 | 159.0 | 0.1 | Nth flathead galaxias* | 362 | 400 | 350 |
| Upland Bully * | 75.2 | 161.9 | 0.0 | Dwarf galaxias* | 303 | 535 | 0 |
| Brown trout | 61.3 | 169.0 | 0.0 | Upland Bully | 231 | 630 | 0 |
| Rainbow trout | 60.7 | 61.1 | 60.2 | Brown trout | 205 | 840 | 0 |
| Bluegill bully | 38.2 | 145.7 | 1.0 | Kōaro | 194 | 1390 | 0 |
| Longfin eel | 26.8 | 169.0 | 0.0 | Longfin eel | 108 | 770 | 0 |
| Lamprey | 24.5 | 68.1 | 0.0 | Bluegill bully | 101 | 375 | 3 |
| Kōaro | 20.1 | 169.0 | 0.0 | Freshwater crayfish | 99 | 995 | 0 |
| Torrentfish | 16.6 | 107.7 | 0.1 | Shortjaw kōkopu | 76 | 940 | 0 |
| Freshwater crayfish | 15.5 | 156.2 | 0.0 | Lamprey | 71 | 205 | 0 |
| Shortjaw kōkopu | 15.1 | 113.5 | 0.0 | Torrentfish | 43 | 210 | 0 |
| Common smelt | 11.6 | 34.2 | 0.5 | Rudd* | 41 | 100 | 0 |
| Shortfin eel | 8.4 | 167.8 | 0.0 | Redfin bully | 40 | 290 | 0 |
| Redfin bully | 8.0 | 83.2 | 0.0 | Shortfin eel | 35 | 620 | 0 |
| Common bully | 7.6 | 167.8 | 0.1 | Common smelt | 33 | 80 | 0 |
| Rudd * | 5.9 | 18.8 | 0.2 | Common bully | 29 | 620 | 0 |
| Goldfish * | 4.1 | 18.8 | 0.7 | Banded kōkopu | 28 | 220 | 0 |
| Banded kōkopu | 3.7 | 37.0 | 0.0 | Tench* | 22 | 50 | 0 |
| Giant kōkopu | 3.7 | 20.0 | 0.0 | Goldfish* | 17 | 100 | 1 |
| Tench * | 3.7 | 9.3 | 0.2 | Giant kōkopu | 17 | 80 | 0 |
| Brown mudfish * | 3.6 | 4.4 | 0.5 | Inanga | 17 | 150 | 0 |
| Inanga | 3.6 | 39.0 | 0.0 | Brown mudfish* | 14 | 15 | 10 |
| Giant bully | 2.2 | 13.2 | 0.0 | Giant bully | 7 | 31 | 0 |
| Estuarine triplefin * | 1.5 | 1.5 | 1.5 | Yelloweye mullet* | 3 | 10 | 0 |
| Yelloweye mullet * | 1.2 | 2.4 | 0.0 | Estuarine triplefin* | 0 | 0 | 0 |

* non-migratory species

# Sampling Methods

It is well recognised that multiple fish sampling methods are needed to fully characterise the fish species composition and abundance at a site. In fact, some species such as lamprey generally require highly specialised methods to locate them. These methods have only recently been developed and will be deployed in Tasman for the first time during the 2018-19 summer period. In this report, the two primary methods used for sampling the fish community of rivers and streams were backpack electric fishing and spotlighting. Deploying nets or fish-traps also occurred in a limited number of situations. The particular methods used in each investigation were chosen to best capture the composition and abundance of fish species present at that site.

For those surveys aiming to track changes in the fish community of a site over time, we closely followed the New Zealand Freshwater Fish Sampling Protocols (Joy, David, & Lake, 2013). A 150 m length of stream was sampled (we called this method the 'Full Protocol'). For the rapid exploratory surveys, the sampling protocols were followed more loosely, particularly with respect to length of habitat sampled (we called this the 'Semi-quantitative Protocol'). For spotlighting, all available habitat was sampled over a longer distance (sometimes over 1km to maximise the chance of seeing all species.

Fish counts during salvage operations were also conducted at sites where the waterway was being diverted. This involved electric fishing prior to the stream diversion and then, once the water has been diverted, collecting stranded fish with a team of 3-5 people. A digger was often used to turn over the grass at the stream margin to enable eels to be exposed. Captured fish were transferred into containers, keeping larger eels separate so they did not have a chance to consume the smaller fish. A high proportion of the fish at a site are captured during a fish salvage, but it is very disruptive of the habitat. This method is only used in relation to major works in a waterway authorised by resource consent.

## Backpack Electric Fishing

Backpack electric fishing involves passing short pulses of electricity through the water to stun nearby fish. NIWA Kainga EFM300 backpack electric fishing machines were used. The voltage and pulse width was recorded.

For the full protocol, we sampled 150m of stream in 15 meter segments (10 per reach). Fish were captured with stopnets and dipnets. We recorded the species and length of all captured fish.

For the semi-quantitative protocol, we fished all available habitat using one or more passes and recorded the number of minutes of electric fishing.

## Spotlighting

Spotlighting is the technique of using a bright light to find and identify fish at night. The light source may be a spotlight, bright headlamp, underwater flounder light or a combination. The operator walks along the bank or along the streambed sweeping the light back and forth. This method is particularly useful for observing and counting banded kōkopu and giant kōkopu because they are large, primarily nocturnal and have conspicuous markings (Joy, David, & Lake, 2013). Smaller fish can also be caught and identified while spotlighting. This method is best applied where the water is clear and calm (without surface ripples) and can be used to identify fish even if the water is deep and difficult for electric fishing.

Spotlighting surveys were conducted at least 45 minutes after sunset. We recorded the species and visually estimated the length of all fish seen. Where possible, we took photos of the survey reach during daylight hours and recorded observations of the available habitat for fish.

### Trapping

Trapping, with fyke nets or Gee minnow traps, was also used in a limited number of situations for fish monitoring. This technique is less-often used, but is useful where the water is particularly deep, murky or where there are many aquatic plants.

### Site selection

TDC's freshwater fish monitoring programme targets a set of waterways each summer. A prioritised list of waterways is prepared annually (usually during October). Waterways are prioritised based on the following criteria:

- The fish community has high biodiversity and a moderate to high risk of degradation.
- The waterway supports a Salmonid sports fishery and has a moderate to high risk of degradation.
- The stream habitat has been modified or man-made in-stream structures may cause an adverse effect on the fish community.
- The waterway was sampled in previous years and there is a need to track changes over time.
- Fish passage barriers have been removed or remediated.
- There is a significant gap in knowledge of fish populations in that area or waterway.

The specific survey sites within each waterway are chosen to best achieve the purpose of the survey. For control-impact comparison surveys, the control and impact sites are located within a short distance of each other. The control site is usually upstream of the impact site and has similar water quality and hydraulic heterogeneity (mix of pools, riffles, runs and rapids). If an appropriate control site cannot be found upstream of the impact site, it may be located in an adjacent catchment.

It is acknowledged that this sampling design only informs us of what is happening at the sites sampled. A stratified random sampling approach would be more appropriate for monitoring fish communities at the regional level, though at significantly greater cost. Despite this limitation, the fish survey data allows us to make best-guess assumptions about fish populations in similar situations elsewhere in the region, supports the existing fish distribution maps we have from national fish distribution model work (Leathwick, Julian, Elith, & Rowe, 2008). The data is also valuable for our localised fish species distribution modelling project.

# Results and Discussion by Activity or Issue

## Fish Surveys Relation to Stream Restoration Projects

Sampling was undertaken of several streams in advance of significant restoration. Unfortunately the ecological response time is slow for all restoration projects. It is premature to make conclusions about the success of these projects as it will take 10-20 years for the riparian trees to reach a mature enough stage and therefore the stream biodiversity to reach its full potential. Sites investigated over the 2011-2018 period include: Borck Creek (Richmond), Neimann Creek (Waimea Plains), Dominion Stream (near Mapua), Supplejack Valley Stream (Upper Moutere), and Matenga Creek (Ligar Bay, Golden Bay).

The Borck Creek restoration project involved a major diversion from the straight old channel to the new meandering and ecologically-friendly new channel. This project was the largest and most comprehensive restoration project undertaken by Council and was undertaken primarily in order to increase stormwater capacity for a growing urban area with its associated impervious surface and increased quick-flow runoff. The design involved placing new cobbly-gravel that was free of fine sediment over the excavated surface of the new channel to provide habitat within the bed for fish and invertebrates. Instant cover was provided with small logs embedded in the bank and overhanging the water. Plantings included trees close to the channel to maximize shading and 'feeding' of the stream. Fish salvage from Borck Creek prior to diversion found over 1000 fish per 100m of stream. This proves how important fish recovery is in relation to major stream disturbance events. However, there can be exceptions as was discovered in the Little Sydney Stream along Swamp Road. Here during a major clean out, which included widening of both banks, on five fish (all shortfin eels) were observed in a reasonably thorough investigation of spoil material. A year after the diversion on Borck Creek the new channel is supporting abundant populations of inanga and small eels, as well as reduced numbers of larger eels and common bullies.

## Identifying fish passage barriers

Several fish passage barriers were discovered only as a result of the fish surveys. When only eels or very mature fish are found at a site, it is usually a strong indication that there is an in-stream structure causing a barrier to fish passage. Note that eels that can wriggle on wet ground around a structure and so are not particularly affected. Examples of such structures include water supply intakes (eg on Arnott Stream) and farm track/road crossings (eg Teapot Valley Stream). Follow-up surveys will be undertaken to determine the effectiveness of the measures to restore fish passage. Council has made very good progress assessing and remediating fish passage for in-stream structures it owns, and Council's roading department is looking to embed fish passage assessment in road culvert monitoring. However, the rate of in-stream structures being installed in streams on private land is high and very time-consuming to monitor. If landowners could only notify Council about the installation of such structures, it would be very helpful (currently there is no obligation to notify council, despite the high likelihood that the in-stream structure will be installed as a fish passage barrier, or become one after the first few floods). Repeated education and pleas to do so have met with very limited response (eg only three farmers responded to the big education campaign in 2014 called "Go on, show us your culvert").

### Determining the success of fish passage restoration

While the climbing prowess of banded kōkopu, kōaro and tuna (eel) are well known, it was still pleasing to see that several of these species made it up some several very long (up to six metres) vertical rubber aprons and mussel spat rope attached to overhanging culverts on the steep road to Totaranui. These aprons were installed after the December 2011 floods that closed Totaranui Road with severe washouts. These small creeks lead to even steeper headwaters that contain several waterfalls, of the type we know that these species is capable of climbing. We are not sure if these fish were climbing up the wetted margin on the rubber apron or using the spat ropes. They have been observed in other studies of climbing either. This result proves that this cost-effective option will work for providing fish passage. This is fortunate as bridging these creeks was not considered a financially viable option.

Fish passage remediation on rock-rip rap weirs (eg Wai-iti lowest two weirs and Moutere downstream Old House Road) has been problematic as the rock is not stable and the river bed level is degrading downstream of the structure (probably as a result of the structure itself). Concrete ramps constructed on these structures to create a channel away from the high degree of turbulence have each become perched at the downstream end and may start to break up in the near future. While there are consent conditions for fish passage at the Wai-iti weir (held by the Engineering Department), there is little imperative to maintain these structures for fish passage and Environment and Planning Department have taken on work to try to address the problem. The Moutere weir is no longer used for its original purpose (a flow monitoring site installed by the Ministry of Works) and the site is severely undermined. No organization or person is responsible for this structure. The best option would be to remove the structure, but that is expected to cost too much.

Fish passage remediation using flexible plastic baffles was tested in Reservoir Creek (Richmond) at two long culverts (almost 500m total) after fish surveys proved that very few fish apart from eels were able to get past Hill Street. The reason that this trial was given such a priority is that the NZ Fish Passage Guidelines (April 2018) recommend a very expensive option for spoiler baffles in culverts because that was the only option that was tested and proven to assist in getting a large proportion of fish up the culvert. We had observations of fish making it up through the flexible plastic baffles (which cost about 10% of the recommended option, including labour) but not quantitative data on the efficacy of them for fish passage. We now know that while whitebait make it up a 3% grade with baffles at 2.4m spacings, they don't make it up a 6% grade with 0.6m spacings. Installing of additional baffles is expected to result in the majority of the fish being able to make it up this steeper grade. This result reinforces the need to ensure that culverts are not set at gradients more than 5%.

### Fish Trap and Transfer

Trap and transfer of eels past fish passage barriers such as at the Kainui Dam (water supply dam in the upper Wai-iti catchment) and Waitui River (irrigation and hydro-electric scheme water take in upper Takaka) are proving successful. At the former site 1000-2000 eels have been transferred each year since transfers started in 2012. A series of surveys in the Waimea River to determine the effect of vehicle movements across riffles failed to attribute any effect on fish populations, particularly torrentfish (a relatively rare fish in Tasman). Further study with more effective experimental control is needed in this regard. No other trap and transfer operations are known in this region.

## Surveys of Rare and Threatened Fish

Sampling effort targeting specific rare species such as giant kōkopu and lamprey failed to find any of these fish species at all. This indicates that these species may now be extinct in parts of our region.

Historically giant kōkopu were widespread even in living memory (eg in catchments of the Moutere, Dominion Valley, ‘Arnott Stream’ and Neimann Creek) and have not been found there for some time. Investigations of other sites with ideal giant kōkopu habitat, such as Dall Creek near Rockville and an ox-bow of the Aorere River just upstream of the Dall Creek confluence also failed to find this species. There are only 43 historical records of giant kōkopu in Tasman, the last from the Onekaka River in 2011. Within the Moutere catchment, where there was a particularly extensive survey for giant kōkopu, high stream temperatures and low dissolved oxygen in summer are likely reasons for their absence.

Despite ideal habitat and anecdotal evidence of lamprey in Basin Creek in the Aorere catchment, none were found. In fact, only one dead lamprey was found (lower Wai-iti River) in any of the surveys since 2010. New fish survey methods using pheromone traps and environmental DNA will be employed in Tasman early in 2019 to more effectively determine the distribution of rare or threatened species.

The low occurrence of rare and threatened fish in Tasman as found in this programme concurs with the conclusions drawn from trend analysis nationally in that many species of native fish are in peril.

## Brown Trout Fishery

Brown trout, followed by eels, are the most significant freshwater fishery in the region. In the Motueka River, a popular waterway for anglers, numbers have rebounded since the mid 1990's but fluctuate from year to year depending on flooding, food supplies and water temperatures. Based on distribution patterns and abundance of native fish compared to trout, it would appear that trout and eels dominate larger waterways (over approximately 3 cumecs) and native fish appear to dominate smaller waterways that discharge directly to the coast.

Since 2001, angler effort has remained relatively consistent in Tasman with approximately 39,000 angler-days reported in the 2014/15 season (Unwin, 2016). Of the waterways where anglers spend their time, the Motueka and Buller rivers are the most popular.

### Riwaka River

The Nelson Marlborough Fish and Game Council monitor trout recruitment in the Riwaka River using electric fishing surveys. Results for the South Branch show a spike in the number of juvenile trout for December 2017 compared to the previous two surveys (Figure 1). Over the same period, the number of juvenile trout in the North Branch remained relatively flat (in the range 0.02 to 0.04 trout per m2). These survey sites were not accessible in February 2018. The next survey, scheduled for late 2018, will provide post-cyclone information on the health of this fishery.

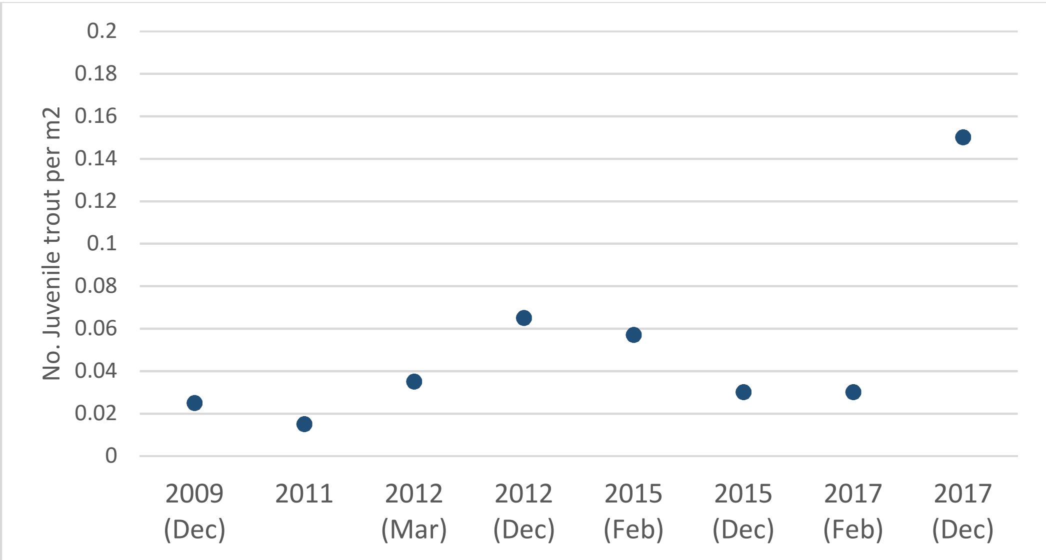



Figure 3. Number of juvenile brown trout recorded from the South Branch Riwaka River 2009 to 2017 (courtesy of Nelson Marlborough Fish and Game Council)

### Motueka River

Trout values have been recognized with a Water Conservation Order which covers much of the Motueka catchment. In many parts of the Motueka catchment, geology, vegetation cover and climate combine to create river channels and flow patterns that provide excellent habitat for trout.

Floods during the months of trout spawning (May to September) can reduce the spawning success for that year. In the Motueka River, there were few floods in 2015 or 2016. This period of relatively stable flows has led to a jump in trout numbers recorded in 2017 and 2018 (Figure 4). The most noticeable change is in the number of medium sized trout (2-3 year olds).

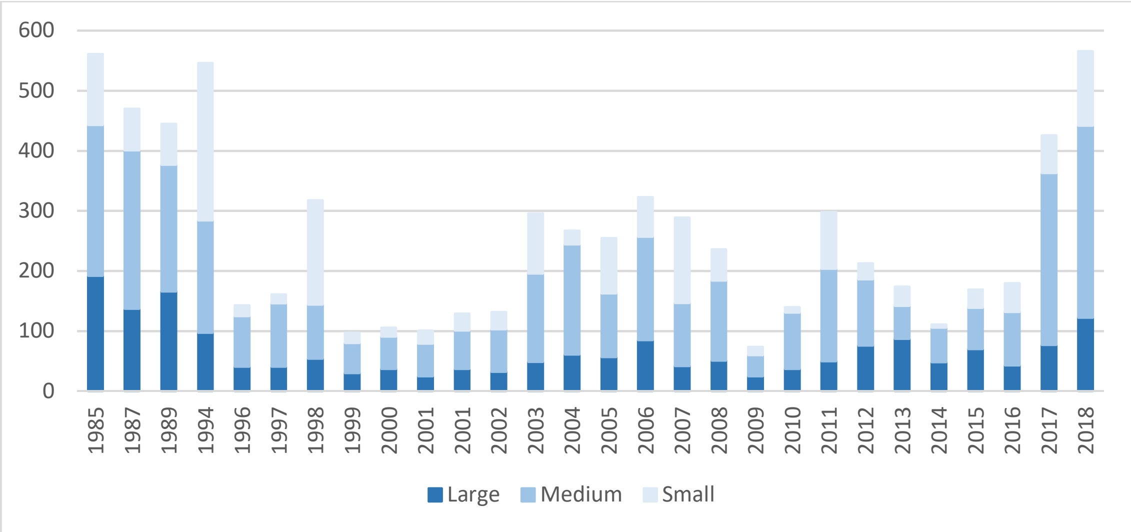



Figure 4. Number of brown trout seen by drift diving in the Motueka River at Woodstock 1985 to 2018 (courtesy of Nelson Marlborough Fish and Game Council)

In the mid-late 1990's the brown trout numbers in the Motueka River plummeted and stayed low for five years prompting concern in the fishing community. The reason for this was attributed to a series of moderate-sized floods during the early and mid 1990's.

### Buller River

The lake outlets of Rotoiti and Rotoroa provide flow and habitat conditions suitable for trout. Trout abundance has increased in recent years, after a decline in 2014.

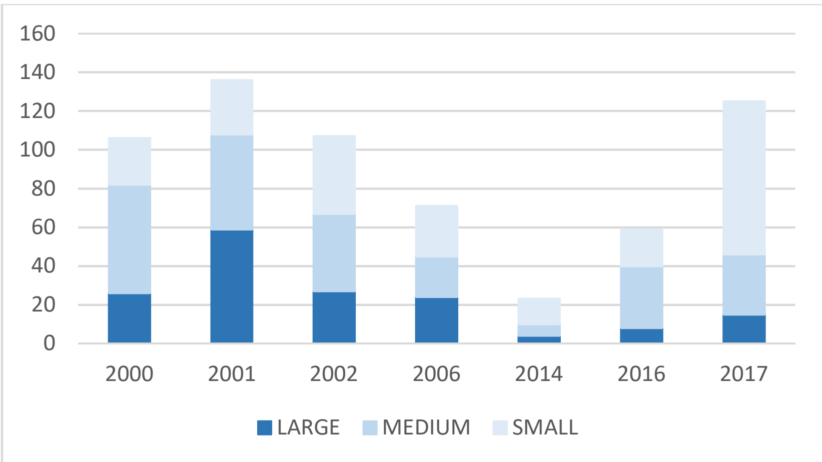



Figure 5. Number of brown trout seen by drift diving in the Buller River at Kawatiri 2000 to 2017 (courtesy of Nelson Marlborough Fish and Game Council)

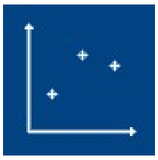
# Results and Discussion by Catchment

## Meaning of Icons

The fish surveys in this report display an icon to indicate the purpose of the work. These icons are at the top of each survey and they have the following meanings:

**Rapid exploratory survey**

Surveying streams where little or no information about the fish community has previously been recorded.



**Tracking changes over time**

Visiting the same site multiple times to track changes in the fish community.


**Control-Impact comparison**

Comparing the fish community of two or more sites to determine the impact of particular stream habitat modifications or man-made in-stream structures.


**Gathering data on threatened or at-risk species**

Describing the distribution or improving our understanding of threatened/at-risk fish populations.

**Fish salvage**

Temporarily holding or translocating fish ahead of stream works such as gravel removal or waterway diversion operations.

## Fish Abundance

Fish abundance is the number of a particular species of fish observed during a fish survey. For the fish surveys in this report, fish abundance is shown with a symbol or with a description. The symbols and descriptions used are as follows:

| Fish Abundance | Description | Symbol |
|---|---|---|
| 1 to 4 | Rare | ●○○○ |
| 5 to 10 | Occasional | ●●○○ |
| 11 to 20 | Common | ●●●○ |
| More than 20 | Abundant | ●●●● |

# Waterways of Golden Bay

## Basin Creek

‹ Threat ›

**Aim:** To search for lamprey after reported sightings by local residents.

**Summary:** Electric fishing of the creek in February 2015 did not reveal any lamprey. The fish community appeared to be in good condition with 8 species present.

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Basin Creek is almost 30 kilometres inland from the sea and is a steep, well-shaded, bouldery stream that flattens out prior to the confluence with the Aorere River. Lamprey have been sighted by local farmers in this stream and the habitat appears to meet the fish's spawning preferences (large boulders near areas of thick fine sediment). The objective for sampling this stream was to confirm the presence of lamprey in this catchment.

A 180m length of Basin Creek from the confluence with the Aorere River to Quartz Range Road was electric fished on 29 Feb 2015. The stream was 17 m wide at the confluence and narrowed to 4 m near the Quartz Range Road bridge. The habitat was mostly long, flat runs with sand/gravel/cobbles in the lower part and faster water and pools with more cobbles and larger boulders in the upper part. Overhanging tall grasses and *Carex* spp lined both banks. There was algae growth on the bed and some surface plants.

No lamprey were sighted during the survey. However, it was encouraging to see a very large female longfin eel at an estimated 1300mm long and a healthy population of redfin bullies. There were also several large shrimp (40 – 50mm), which is surprising being so far from the sea, and two kōura (40 – 70mm). Given the generally large size of the resident eels, predation of the smaller fish is likely to be high.

Left: View of Basin Creek upstream road crossing showing algae. Right: Lower section, habitat of a large female longfin eel.

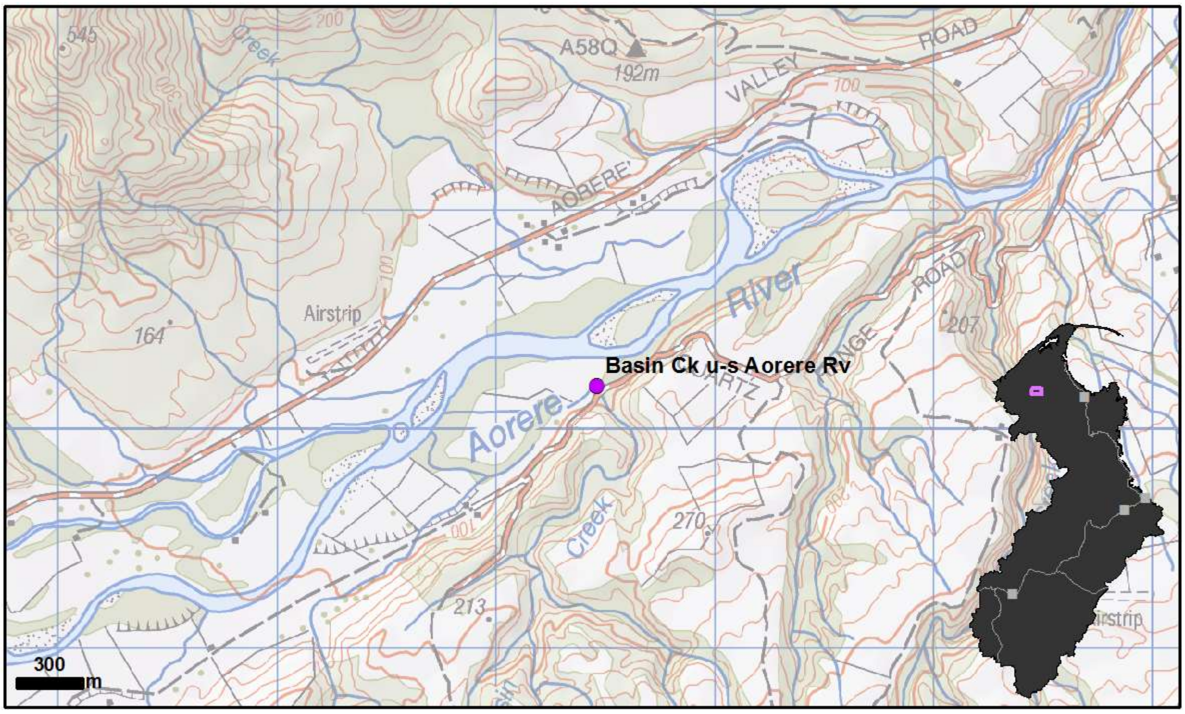


Figure 6. Basin Creek fish survey location

Table 3. Fish species and abundance at Basin Creek (●○○○ for Rare to ●●●● for Abundant).

| | Basin Ck<br>Aorere Rv to Quartz Range Rd<br>29/02/2015 |
|---|---|
| # fish species: | 6 |
| Upland bully | ●○○○ |
| Redfin bully | ●●●○ |
| Juvenile bully | ●●●● |
| Longfin eel | ●●●○ |
| Shortfin eel | ●○○○ |
| Unidentified eel | ●●●● |
| Kōaro | ●○○○ |
| Brown trout | ●●○○ |

## Dalls Lake and Dalls Creek

‹ Threat ›

**Aim:** To search for giant kōkopu. The second aim was to assess the fish values of this waterway and determine if a potential water take may affect these.

**Summary:** No giant kōkopu were found. Longfin and shortfin eels were found in both survey locations.

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Dalls Lake lies east of the Aorere River at 431 Collingwood-Bainham Rd. The lake, approximately 0.6 ha in size, formed in a historic channel of the Aorere River. The lake has woody debris (branches and logs) on the bed, good depth and overhead canopy cover along the north shoreline, all aspects associated with giant kōkopu habitat.

Dalls Creek flows into the southern end of the lake. It is a small lowland stream in a catchment dominated by dairy farming. The Dalls Creek inlet just above the lake confluence contains very good giant kōkopu habitat with deep pools and overhanging vegetation. The streambed in this section has a mix of gravels, cobbles and silt.

In February 2015, two fish survey methods were used to search for giant kōkopu. Fyke nets were set in Dalls Lake at three locations (shown below) and left overnight. Two locations were electric fished, a 30m length of stream above the lake and a 10 metre section of the south-east lakeshore.


Fyke net sites and electric fishing locations in Dalls Ck and Dalls Lake, Feb 2015. The measurements in white are water depths.

At the time of the survey, there were dense patches of aquatic vegetation (particularly willow weed) in Dalls Creek. Snails and cased caddis were abundant. No giant kōkopu were found. There were schools of inanga within the lake but none were found in the feeder creek. Longfin and shortfin eels were recorded in the creek and the lake.

On the south-eastern edge of the lake, the water was green with algae and had poor clarity. This section of the lake also had large areas of submerged algae and surface clumps of emergent aquatic vegetation.

Left:  Dalls Lake view North West to outlet. Right:  View to north shoreline

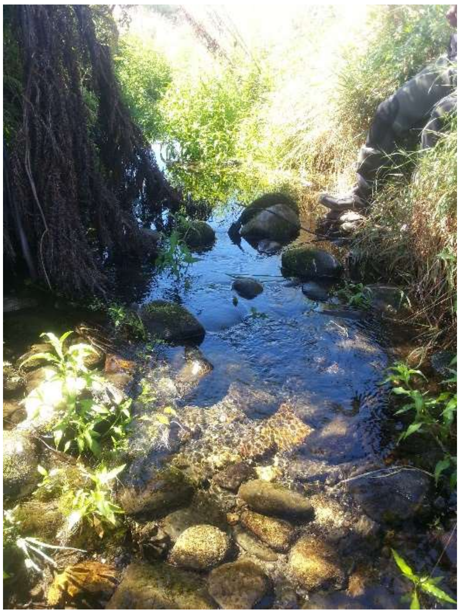
Apart from along the shoreline, the lake is too deep to set fyke nets. Any future fish survey would benefit from using the spotlighting method from a boat or kayak to search for giant kōkopu in Dalls Lake. Spotlighting would be of limited use in Dalls Creek due to the surface vegetation.

Longfin and shortfin eels were captured in fyke nets 1 and 2. No fish were captured in fyke net 3.

Table 4. Fish species and abundance at Dall Creek and Dall Lake at 431 Collingwood-Bainham Road (●○○○ for Rare to ●●●● for Abundant). Note:  Kōura (freshwater crayfish) were abundant in Dall Creek.

| | Dall Creek 29/02/2015 | Dall Lake 29/02/2015 |
|---|---|---|
| # fish species: | 2 | 3 |
| Longfin eel | ●●○○ | ●●○○ |
| Shortfin eel | ●○○○ | ●●●○ |
| Unidentified eel | ●●●● | |
| Inanga | | ●●●● |

**Dalls Creek.** Below: 50m upstream from Dall Lake and downstream of the cattle race. Electric Fishing started here and worked upstream. Right: 110m upstream Dall Lake.



## Aorere Oxbow


**Aim:** To search for giant kōkopu in the Aorere Oxbow by electric fishing. To assess the fish values of this waterway and assess the potential for a water take to affect these.

**Summary:** Shortfin eels and inanga were found but no giant kōkopu.

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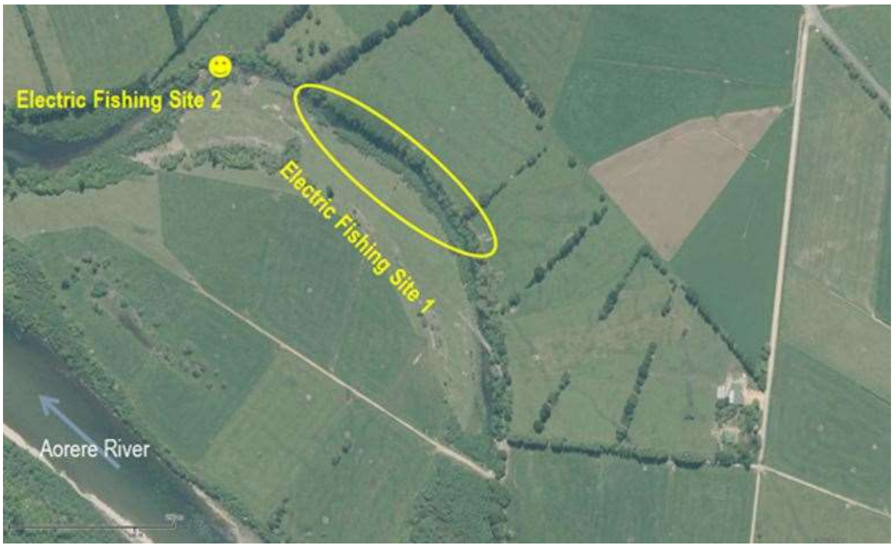
The Aorere Oxbow is an old channel of the Aorere River downstream of Pah Road North. Along its length (1.8km), the oxbow contains numerous pools, overhanging branches and large amounts of woody debris. It was thought that giant kōkopu may be found in the oxbow because of these habitat features.

Electric fishing of the oxbow was carried out in February 2015. At that time, a water take from this area was in the application stage (consent subsequently granted). The fish survey was carried out in two pools towards the western end of the oxbow. At site 1, 300m of the oxbow was fished while at site 2, a 'look and see' approach was used.




Aorere Oxbow at 42 Pah Road North, Feb 2015

Table 5. Aorere Oxbow electric fishing site characteristics

| | Aorere Oxbow Site 1 | Aorere Oxbow Site 2 |
|---|---|---|
| Temperature (°C) | 25 | 28 |
| Conductivity (µS/cm) | 110 - 130 | 120 |
| Maximum width (m) | 10 | - |
| Depth (m) | 1 – 1.5 | - |
| Flow | none | none |

There was no water flow through the oxbow at the time of the survey. The last time the Aorere river flowed into the oxbow was likely two months earlier, on December 31, when the river rose approximately four metres.

At site 1, there was a strong sulphur odour emitted when walking in the water due to rotting organic matter. There was a large amount of weed growth and the water was green with algae. The true left bank was lined with small willow trees and the true right bank was elevated with a mature tree canopy. Shortfin eels and inanga were abundant here.

Site 2 had poor water clarity (less than 1m) and a large amount of wood and branches piled on the bed with some pools in between. The occasional shortfin eel was observed, but no other fish.

Left: Aorere Oxbow electric fishing site 1. Right: Site 2

The fish species observed (shortfin eels and inanga) are the most tolerant of the poor water clarity and large amount of weed growth present. The log cover and overhanging tree branches would provide shelter for giant kōkopu, but the poor water quality is likely to be a limiting factor.

There may be improved native fish habitat within the oxbow after a flushing event from the Aorere River.

Table 6. Fish species and abundance at Aorere Oxbow (●○○○ for Rare to ●●●● for Abundant).

| | Aorere Rv Oxbow site 1 29/2/2015 | Aorere Rv Oxbow site 2 29/2/2015 |
|---|---|---|
| Shortfin eel | ●●●● | ●●○○ |
| Inanga | ●●●● | |

## Burton Ale Creek

**Aim:** To record the diversity and abundance of fish species in Burton Ale Creek and establish a baseline for determining the benefits of riparian planting.

**Summary:** Longfin eel, shortfin eel, inanga and banded kōkopu were found by spotlighting and electric fishing. Banded kōkopu were abundant at the site 200m upstream of Win Ck. Shortjaw kōkopu were present but rare in Win Creek.

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Burton Ale Creek, and the neighbouring James Cutting Creek, are unique in that their catchments are dominated by farmland on pakihi soils. Phosphorus retention in these soils is extremely low (1%) leading to high rates of leaching of this nutrient (James & Mullis, 2014). As a consequence, filamentous green algae cover is high at times during summer. In the lower part of the catchment, very low dissolved oxygen levels have been recorded (daily minimum of 40% saturation during a 3-day deployment in March 2015).

The total area of this catchment is 802 ha with 247 ha in sheep and beef, 450 ha in dairy farming and about 65 ha in scrub and forest. The flow in this creek can be as little as 5 L/sec in the driest summers. Dense gorse cover was present over the stream at Burton Ale Creek at 200m upstream of Win Creek.

Riparian planting was carried out in the lower reaches of this waterway (upstream and downstream of Collingwood-Bainham Rd) starting from 2005.

Left: Burton Ale Creek 200m upstream of Win Creek. Right: At Collingwood-Bainham Rd

Spotlighting surveys of this creek were carried out after stable flows in 2011 immediately below Collingwood-Bainham Road and on Win Creek. Electric fishing was also completed at two sites further up in the catchment, upstream of the Win Ck confluence.

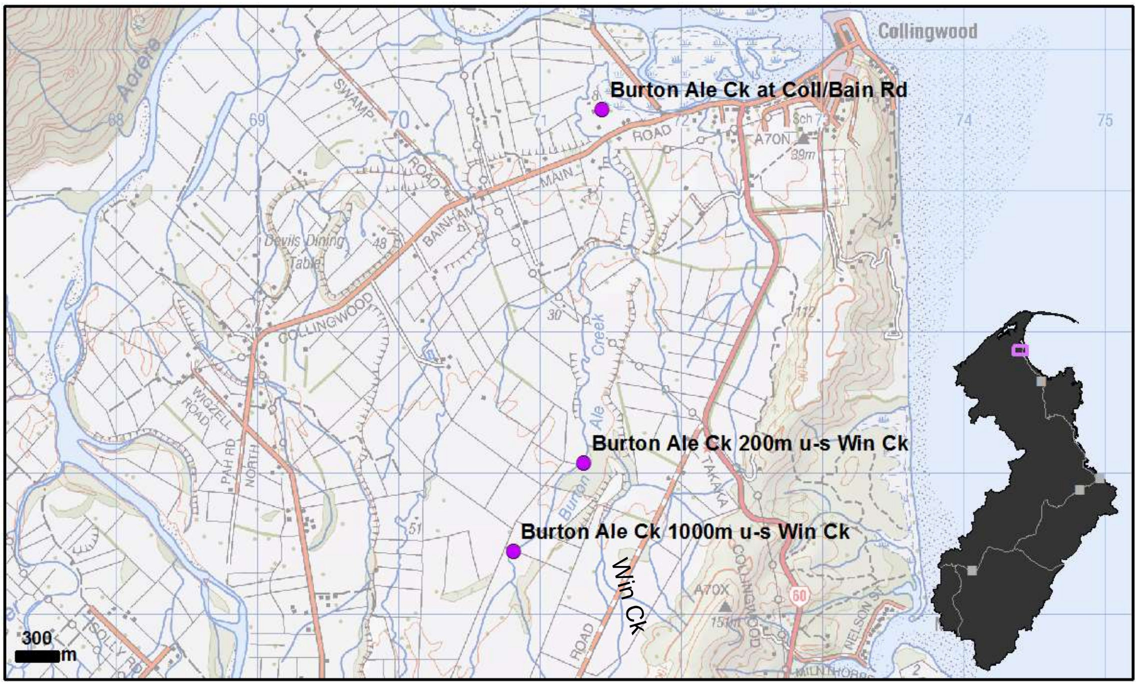


Figure 7. Burton Ale Creek fish survey locations

Few fish were seen by spotlighting at the Collingwood-Bainham Rd site. This may be because the high coverage of filamentous green algae (occasionally over 90%) obscured the fish from view. Electric fishing 200m upstream of Win Ck revealed a greater diversity and abundance of fish species. At this site, riparian scrub overhangs the stream, there is a variety of water depths and a natural meander. Banded kōkopu were abundant in the deeper pools. At the furthest upstream site, there was less riparian shading but still a good variety of water depths. In this habitat, shortfin eels were abundant but banded kōkopu were rare.

Table 7. Fish species and abundance at Burton Ale Creek (●○○○ for Rare to ●●●● for Abundant). Note: Kōura (freshwater crayfish) were common at all sites except at Collingwood-Bainham Road.

| | Burton Ale Ck at Coll/Bain Rd Oct 2011 Spotlighting | Burton Ale Ck 1000m u-s Win Ck Nov 2011 E-Fishing | Burton Ale Ck 200m u-s Win Ck Nov 2011 E-Fishing | Win Ck u-s Burton Ale Jan 2012 Spotlighting |
|---|---|---|---|---|
| # fish species: | 2 | 4 | 4 | 5 |
| Redfin bully | | | | ●○○○ |
| Longfin eel | | ●●●○ | ●●●● | ●●●● |
| Shortfin eel | | ●●●○ | ●○○○ | |
| Inanga | ●●○○ | ●●●● | ●●●● | ●●●● |
| Banded kōkopu | ●○○○ | ●○○○ | ●●●● | ●●○○ |
| Shortjaw kōkopu | | | | ●○○○ |

# Onekaka River

**Aim:** To track changes in the diversity and abundance of fish in the lower Onekaka River.

**Summary:** Electric fishing and spotlighting surveys upstream and downstream of the Shambala Road Ford revealed 13 fish species in 2011, the highest number of species so far found in Tasman. The longest-running quantitative fish monitoring in Tasman, at three sites upstream of Shambala Road Ford, shows a decline in eel densities and a decline in total fish densities from 2003 to 2018.

The Onekaka River, between Takaka and Collingwood, has a large proportion of native forest in its catchment (40%). A hydro-electric power scheme operates on the river, using a 10.7 m high dam, built in 1928, which is located four kilometres upstream of Shambala Road. Other than the hydro scheme, there is only one other water take from this river, at a point near the Otere-Onekaka River confluence.

Council carries out long-term water quality and a river ecology monitoring on the Onekaka River at Shambala Ford. Water quality monitoring, since 2000, shows generally good water quality for ecological health. The macroinvertebrate community is diverse (Macroinvertebrate Community Index 115-130) and is dominated by mayflies, stoneflies and caddisflies.

The longest-running quantitative electric fishing surveys conducted in Tasman District are on the Onekaka River associated with the Electric Waters Ltd (EWL) Hydro Electric Power Scheme. This scheme began operation in November 2003 on the site of an earlier scheme built for an historic iron ore mine. As part of resource consent requirements for damming and taking water from the river, fish surveys were carried out annually from 2003 to 2008 then 5-yearly (totaling eight fish surveys to date) by NIWA and Stark Environmental (Stark, 2018). There are two Electric Waters Ltd fish survey sites downstream of the power station tailrace and one upstream (all three sites are downstream of the dam). The distance from Shambala Ford to the lowest Electric Waters Ltd survey site is approximately 2.2 km (

Figure 8).

Shambala Road Ford, Onekaka River (December 2018)

Council surveyed the fish community at Shambala Ford in October 2011 and January 2018 using both electric fishing and spotlighting methods. In these surveys, two 150 m long reaches were fished, one immediately upstream of the Shambala Rd ford and one immediately below (total 300 m).

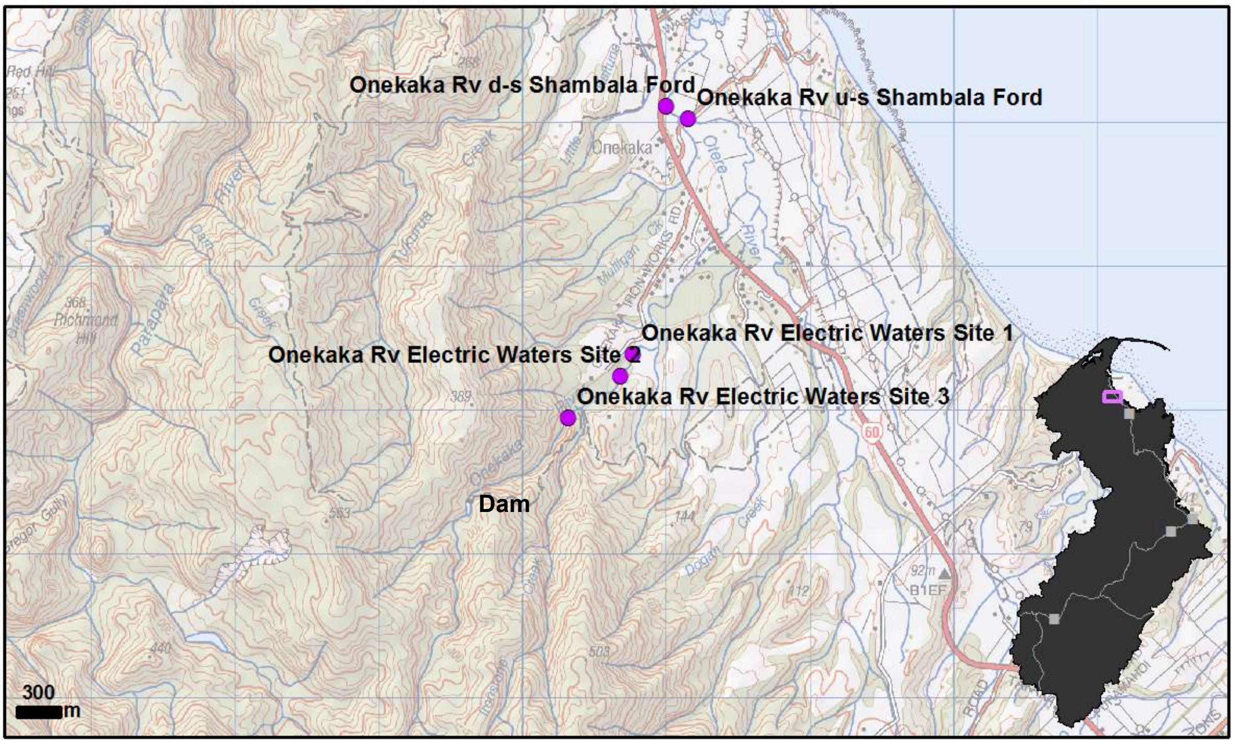


Figure 8. Onekaka River fish survey locations

Onekaka River looking downstream from Shambala Road Ford in 2013

Electric Waters Ltd fish survey site 1 on the Onekaka River (lower site)

Electric Waters Ltd fish survey site 2 on the Onekaka River (60 m below the power station tailrace)

Electric Waters Ltd fish survey site 3 on the Onekaka River (upstream Ironstone Creek and 260 m upstream of the power station tailrace)

At the three Electric Waters Ltd monitoring sites, a total of six fish species have been found: longfin eel, redfin bully, kōaro, shortjaw kōkopu, brown trout and torrentfish. In terms of fish density, eels show a statistically significant decline across the three sites (Kendal tau -0.786, p-value 0.007). Total fish densities also show a decline. However, lack of control data from other unimpacted streams in the area, and only one survey prior to commissioning the power scheme, make it difficult to attribute any impact from the scheme. The effects of floods may also explain these fish community changes.

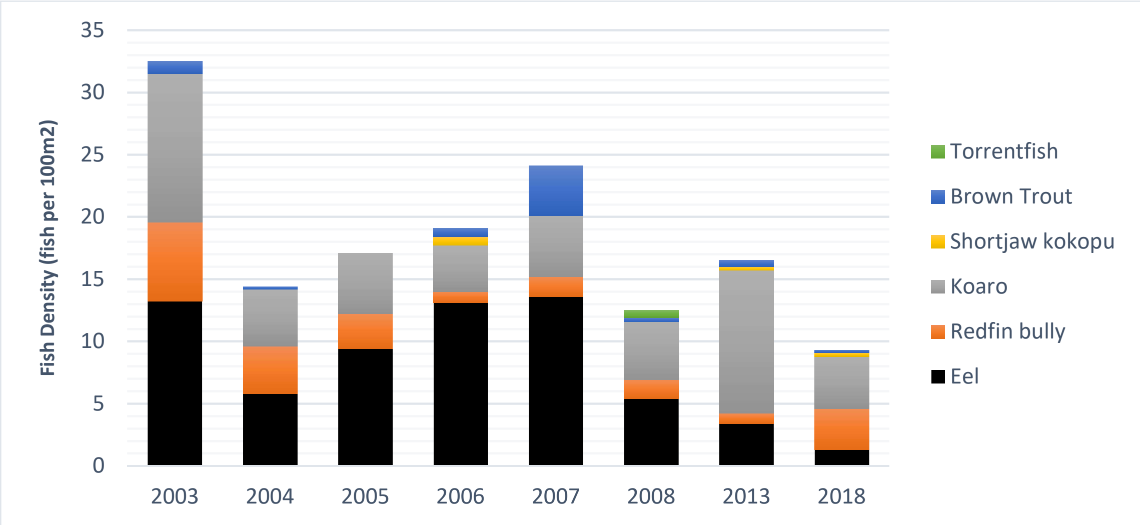


Figure 9. Estimated fish density (average fish per 100m2) in the Onekaka River for the three Electric Waters Ltd monitoring sites sites combined, 2003-2018 (data supplied by EWL).

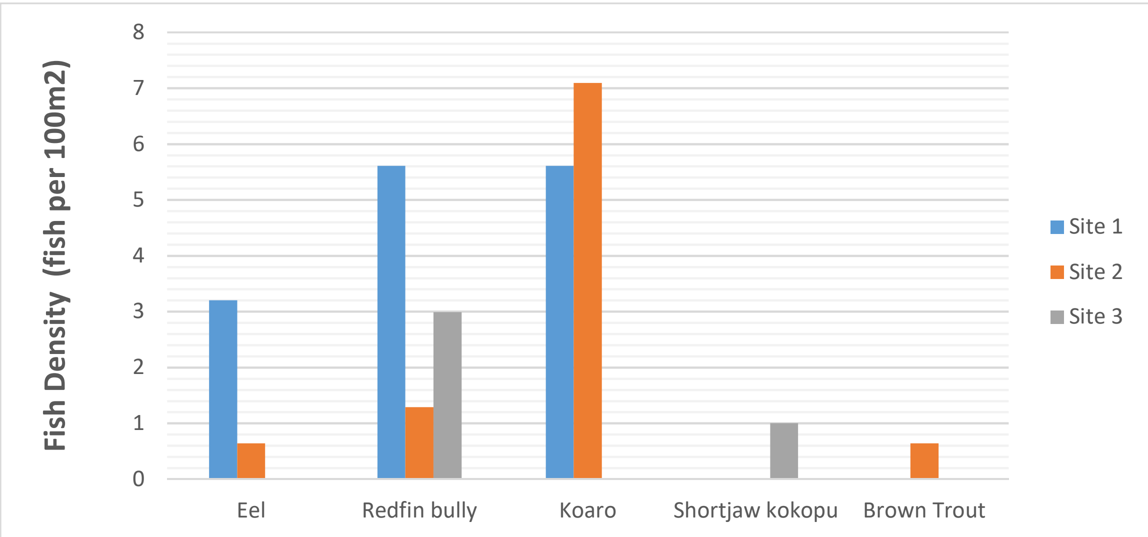


Figure 10. Estimated fish density (average fish per 100m2) from electric fishing on April 24 2018 for the three Electric Waters Ltd monitoring sites on the Onekaka River (data supplied by EWL).

From Council's fish monitoring at Shambala Ford, there were differences in the fish community between 2011 and 2018 (Table 8 and Table 9, overleaf). In 2011, a total of 13 fish species were captured, 12 native species plus brown trout. This is the highest species richness for a particular reach known in the district. In 2018, seven native species were observed, plus brown trout.

The 2018 survey found no banded kōkopu or kōaro and no bluegill bully either downstream or upstream of the ford.  However, only very low numbers of bluegill bully were found in 2011. This could be a reflection of the different time of year, with the 2018 survey occurring well after the spring upstream migration period. Large numbers of small bullies (20-30mm) were found at both sites in 2018, as well as a greater abundance of redfin bully adults. In the same year, three juvenile (amocoete) lamprey and a freshwater mussel were found upstream of the ford. Torrentfish were found in similar numbers in 2011 and 2018 but were found upstream of the ford for the first time in 2018. The moderate number of inanga (about 40) observed upstream of the ford in 2018 show that there are access opportunities for these fish over the ford at some times of the year. Giant bullies were missing from the 2018 survey, possibly due to the pool infilling.

The bed and channel characteristics downstream of the ford do not appear to have changed much between 2011 and 2018 with good run-riffle-pool habitat remaining. Upstream of the ford, however, the habitat has changed with fewer pools and reduced depth in some of the existing pools. Between the survey years, much of the dense riparian vegetation was removed by flooding and bank erosion following the poisoning and then rotting of the willows that held the banks. At the time of the 2018 survey, the pools had a layer of fine sediment covering the gravel substrate.

To assist with the interpretation of future fish survey data collected from the Onekaka River, long-term monitoring at a control site (Tukurua Stream, Pariwhakaoho River or another nearby site) needs serious consideration. Fish surveys of the control site should occur at a similar time to the Electric Waters Ltd fish surveys.

Table 8. Onekaka River fish survey results on **31 October 2011** for upstream (u-s) and downstream (d-s) Shambala Ford (●○○○ for Rare to ●●●● for Abundant). Note: Kōura (freshwater crayfish) present at both sites.

| | Onekaka Rv d-s Ford **Electric fishing** | Onekaka Rv d-s Ford **Spotlighting** | Onekaka Rv u-s Ford **Electric fishing** | Onekaka Rv u-s Ford **Spotlighting** |
|---|---|---|---|---|
| **# fish species:** | **10** | **12** | **8** | **11** |
| Common bully | ●●●● | ●●●○ | | ●●○○ |
| Giant bully | | ●○○○ | | ●○○○ |
| Redfin bully | ●●●● | ●●○○ | ●●●● | ●●●○ |
| Bluegill bully | ●●○○ | ●○○○ | ●○○○ | ●○○○ |
| Longfin eel | ●●●● | ●●●● | ●●●● | ●●●● |
| Shortfin eel | ●○○○ | ●○○○ | | |
| Unidentified galaxiid | | ●○○○ | | |
| Inanga | ●●●● | ●●●● | ●○○○ | ●○○○ |
| Inanga (jv) | ●●●● | | | |
| Kōaro | ●●●● | ●●●○ | ●●●○ | ●●○○ |
| Kōaro (jv) | ●●●● | | ●●●○ | |
| Banded kōkopu | ●○○○ | ●○○○ | | ●○○○ |
| Giant kōkopu | | | | ●●●○ |
| Shortjaw kōkopu | | ●○○○ | ●○○○ | ●○○○ |
| Torrentfish | ●●○○ | ●●○○ | | |
| Brown trout | ●○○○ | ●○○○ | ●○○○ | ●○○○ |

Table 9. Onekaka River fish survey results on **31 January 2018** for upstream (u-s) and downstream (d-s) Shambala Ford (●○○○ for Rare to ●●●● for Abundant). Note: Kōura (freshwater crayfish) present at both sites.

| | Onekaka Rv d-s Ford **Electric fishing** | Onekaka Rv d-s Ford **Spotlighting** | Onekaka Rv u-s Ford **Electric fishing** | Onekaka Rv u-s Ford **Spotlighting** |
|---|---|---|---|---|
| **# fish species:** | **5** | **7** | **6** | **5** |
| Common bully | | ●○○○ | ●●○○ | |
| Redfin bully | ●●●● | ●●●● | ●●●● | ●●●● |
| Unidentified bully | ●●●● | ●○○○ | ●●●● | |
| Longfin eel | ●●○○ | ●●●○ | ●●●● | ●●●○ |
| Shortfin eel | | | ●○○○ | |
| Unidentified eel | ●●●● | ●●●○ | ●●●● | ●●○○ |
| Unidentified galaxiid | | ●●○○ | ●○○○ | ●○○○ |
| Inanga | ●○○○ | ●●●○ | ●○○○ | ●●●● |
| Lamprey | | | ●○○○ | |
| Torrentfish | ●●○○ | ●●○○ | | ●○○○ |
| Brown trout | | ●○○○ | | |

# Pariwhakaoho River

**Aim:** To record the diversity and abundance of fish species in the lower reaches of the Pariwhakaoho River.

**Summary:** Nine species were recorded in the survey, between the river mouth and 1200m upstream. Much lower abundance of redfin bully, common bully, inanga and banded kōkopu were found compared to expected, possibly due to trout predation.

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One of the numerous rivers crossed by State Highway 60 between Takaka and Collingwood, the Pariwhakaoho River enters Golden Bay one kilometre north of Patons Rock. Experienced hikers walk along the top of the Pariwhakaoho catchment to reach Parapara Peak. The catchment is steep, descending 1249 m from Parapara Peak to the mouth over only ten kilometres. The upper half of the catchment is native forest and the lower half is a patchwork of farms, rural residential sections and forest remnants.

A spotlighting survey of the river in February 2015 focused on the lower part of the catchment. The diversity and abundance of fish species was recorded from two study reaches within 1200 m of the river mouth.

The furthest downstream reach consisted of 180m of run habitat beginning at the river mouth. The dominant substrate in this reach was coarse gravel and small cobbles. The channel was wide and shallow (average width 20m, average depth 0.15m) with undercut banks. In this reach, smelt were abundant, there was an occasional longfin eel and bully species were rare. Two trout were observed (120 and 350mm in length).

Left: Pariwhakaoho River mouth. Right: 1200m u-s river mouth

The second reach was 600m upstream of the river mouth and consisted of a run, a riffle and several small pools with dense willow growing on the banks and willow branches extending across the channel. The substrate was predominantly course gravel and cobbles with some fine gravel and sand. Banded kōkopu, torrentfish and kōura were seen in low numbers. These three species were not seen in the first survey reach. Three trout were present (110 to 400 mm).

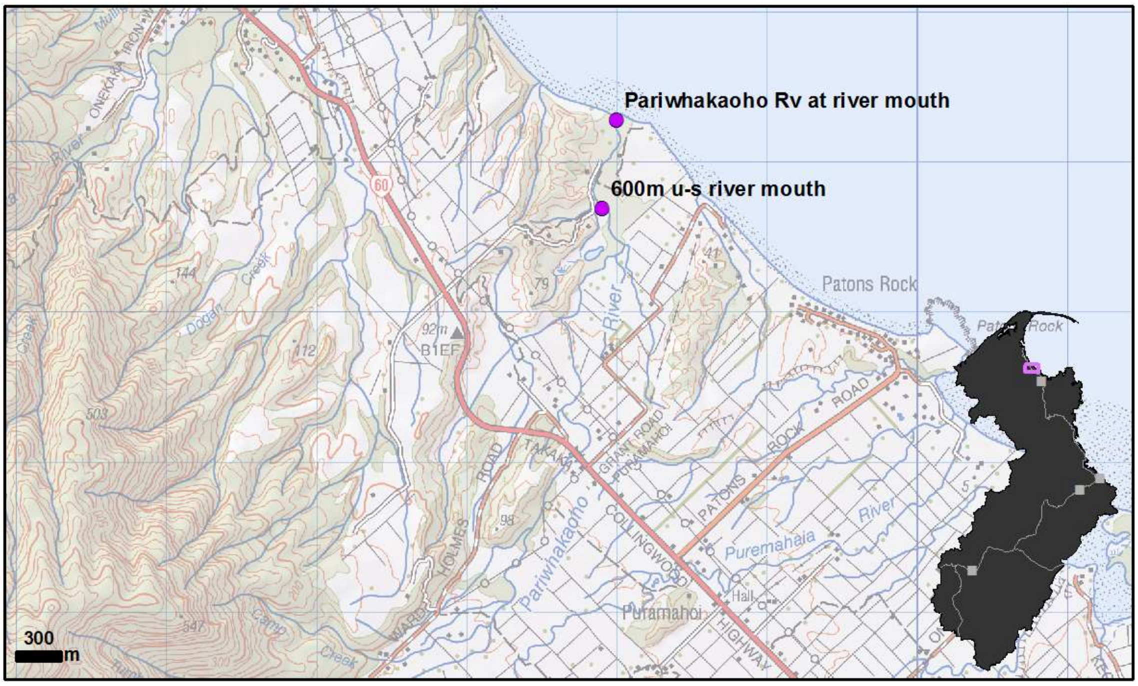


Figure 11. Pariwhakaoho River fish survey locations

Of the trout recorded across the two survey reaches, two were greater than 300 mm in length - large enough to put considerable predation pressure on smaller native fish (McIntosh, 2000). We expected to find higher numbers of inanga and redfin bully, as was found in the nearby Onekaka River. The low numbers seen may be partly attributable to trout predation in this river.

Table 10. Fish recorded by spotlighting on the Pariwhakaoho River, 25 January 2015 (●○○○ for Rare to ●●●● for Abundant).

| | Pariwhakaoho Rv River mouth to 180m u-s 25/02/2015 | Pariwhakaoho Rv 600m u-s river mouth 25/02/2015 |
|---|---|---|
| # species: | 6 | 5 |
| Common bully | ●○○○ | |
| Redfin bully | ●○○○ | |
| Longfin eel | ●●○○ | ●●○○ |
| Inanga | ●○○○ | ●○○○ |
| Banded kōkopu | | ●○○○ |
| Common smelt | ●●●● | |
| Torrentfish | | ●○○○ |
| Brown trout | ●○○○ | ●○○○ |

## Matenga Creek, Ligar Bay

**Aim:** To record the fish community downstream of Matenga Road before restoration planting that is proposed as part of a subdivision as well as upstream and downstream of a perched culvert (on a private property upstream of Matenga Road).

**Summary:** The culvert at 57 Matenga Rd was acting as a barrier to all fish species apart from eels. Inanga and longfin eels were abundant downstream of Matenga Road, despite poor habitat (uniform channel shape, limited meander, limited in-stream cover and no riparian tree cover.

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The Matenga Creek catchment is all within highly erodible Separation Point Granite geology with the upper half of the catchment being steep. High rates of erosion occurred in December 2011 and again after logging of pine forest in the catchment in 2015-16.

Electric fishing surveys were completed upstream and downstream of culverts in January 2018.

The culvert at 57 Matenga Road is scheduled for fish passage remediation. Ligar Bay Developments Ltd applied for subdivision consent and will go to a hearing in late 2018. Setbacks of 5m from the top of the bank have been provided for along with riparian tree planting.

Left: Matenga Creek downstream of Matenga Rd view downstream. Right: Steep country above Ligar Bay about a year after forest harvest.

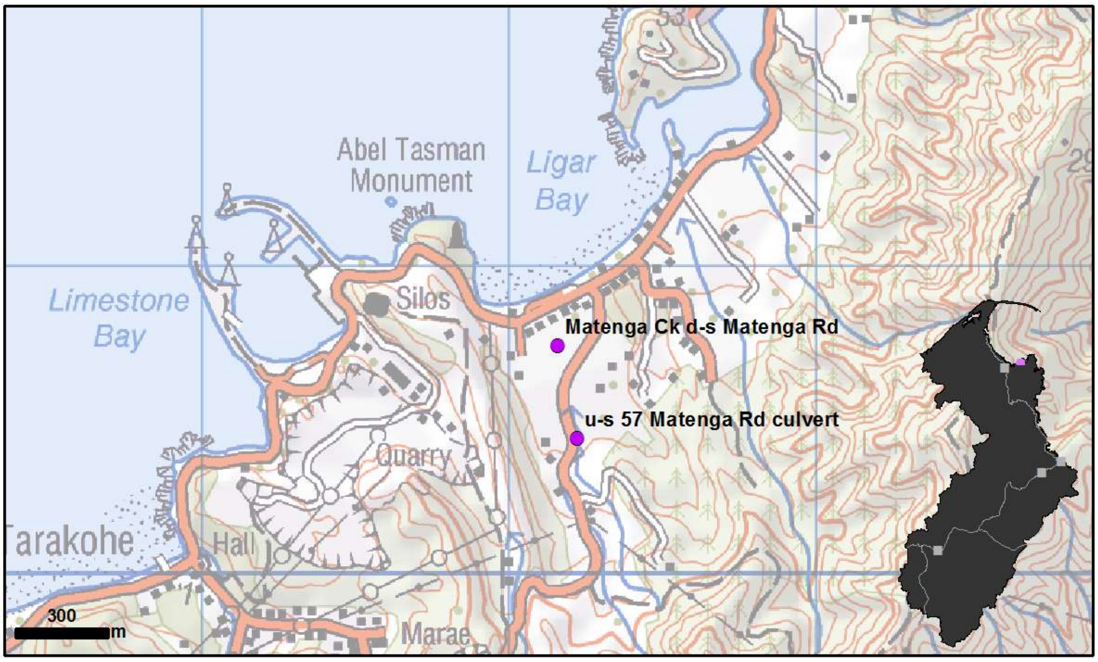



Figure 12. Matenga Creek fish survey locations

Table 11. Fish species and abundance at Matenga Creek (●○○○ for Rare to ●●●● for Abundant) from electric fishing surveys in January 2018

| | Matenga Ck d-s Matenga Rd | Matenga Ck u-s 57 Matenga Rd culvert |
|---|---|---|
| # fish species: | 5 | 4 |
| Common bully | ●○○○ | |
| Redfin bully | ●●○○ | |
| Unidentified bully | ●●○○ | |
| Longfin eel | ●●●● | ●○○○ |
| Unidentified eel | ●●●● | ●●●● |
| Inanga | ●●●● | ●●○○ |
| Kōaro | | ●○○○ |
| Banded kōkopu | ●○○○ | ●○○○ |

Left: Redfin Bully from Matenga Creek. Right: Electric fishing

## Totaranui and Awaroa Road Streams, Golden Bay

**Aim:** To record the fish community upstream and downstream of culverts (where the stream flows under the road) along Totaranui and Awaroa Roads and assess whether the rubber aprons placed on the outlet of the culverts provide fish passage for climbing fish species.

**Summary:** At three of the four culverts, kōaro were recorded upstream and downstream. This suggests they were able to climb the long rubber aprons (up to six metres). No fish were sighted at the fourth culvert in either year.

The road to Totaranui in Abel Tasman National Park is steep and windy; storms in December 2011 gave it a hammering and every culvert crossing washed out, many forming deep chasms. The cost of reinstating the road had several officials questioning whether restoring the road was worth the investment. While bridges were considered for the stream crossings, they were deemed too expensive (to the point that the road could not have been reopened) and so culverts were installed. The road was reopened in late 2012.

Culverts were installed to overhang the rock rip rap that was placed to stabilise the embankments. The streams flowed out of the culverts and into space, free-falling several metres to the stream below and forming an extreme type of barrier to fish migration. Upstream of these culvers, a reasonable amount of good quality stream habitat exists, albeit very steep with many waterfalls. Even downstream of these culverts there are numerous waterfalls. The catchment upstream and downstream is mostly covered in mature native bush. The Separation Point geology provides reasonable groundwater storage and supports higher stream flows during dry periods that in catchments with most other geologies.

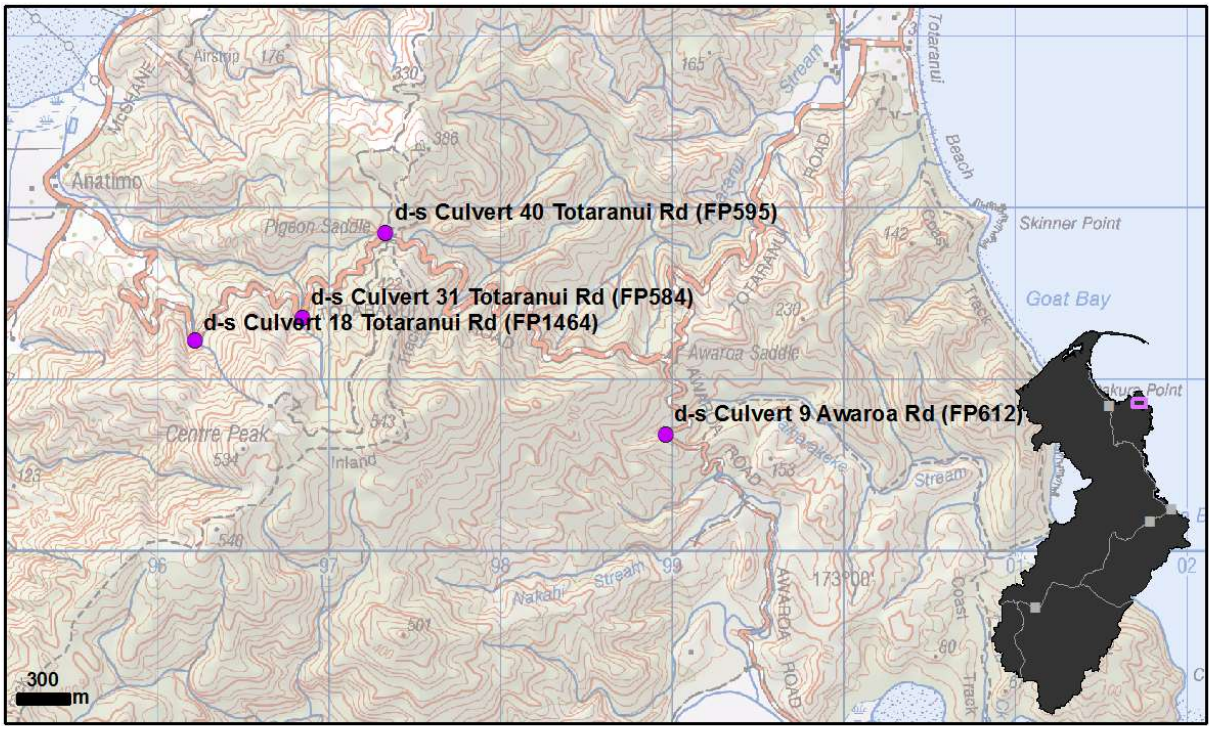



Figure 13. Totaranui Rd and Awaroa Rd fish survey locations

In February 2013, the culverts were retrofitted with spat rope and rubber aprons to allow fish to get up. These are the highest drops of any culverts remediated with this system in Tasman District to date (up to six metres). Hairy mussel spat rope was attached at the inlet end of the culvert, through the culvert barrel and down to the stream below. The aprons were attached to the outlet of the culvert.

Two spotlighting surveys were carried out; one on 16 January 2014 and another on 25 February 2015, upstream and downstream of four culverts to determine whether fish were making it up above the road.

Spotlighting was completed upstream and downstream of the culverts as far as possible, up to 150m. For most culverts, the surveyed stream length was much shorter than this (20 to 80m) due to the difficult terrain which included very steep, slippery inclines, dense vegetation and fallen branches over the streams. Being small, steep headwater streams, low numbers of fish were expected.

### Totaranui Rd Culvert 18

The rubber apron on this culvert spanned a height of six metres. In both years (2014 and 2015) kōaro were rare upstream and downstream of culvert 18. Only one kōaro was seen upstream of the culvert in 2015.

Table 12. Catch data for Totaranui Rd Culvert 18 (FP1464)

| | Downstream | | Upstream | |
|---|---|---|---|---|
| Survey date | Jan 2014 | Feb 2015 | Jan 2014 | Feb 2015 |
| Stream length (m) | 20 | 30 | 20 | 50 |
| UnID Galaxid | | | 1 | |
| Freshwater crayfish | | 2 | | |
| Kōaro | 4 | 2 | 3 | 1 |
| Kōaro size range (mm) | 50 – 100 | 60 – 80 | 80 – 100 | 80 |

Left: Totaranui Rd Culvert 18 before a rubber apron and mussel spat rope were attached to encourage fish passage (Dec 2012). Right: With rubber apron attached to the culvert outlet (Jan 2014).

### Totaranui Rd Culvert 31

The rubber apron on this culvert spanned a height of 2.5 metres. Kōaro were sighted upstream and downstream of this culvert in both years. Although more kōaro were found upstream of the culvert in Feb 2015 compared to the year before, the distance surveyed was two times larger.

Table 13. Catch data for Totaranui Rd Culvert 31 (FP584)

| | Downstream | | Upstream | |
|---|---|---|---|---|
| Survey date | Jan 2014 | Feb 2015 | Jan 2014 | Feb 2015 |
| Stream length (m) | 20 | 80 | 20 | 40 |
| Freshwater crayfish | | 1 | | |
| Longfin Eel | | | | 1 |
| Kōaro | 11 | 8 | 6 | 21 |
| Kōaro size range (mm) | 50 - 110 | 80 - 110 | 60 - 80 | 60 - 110 |

Totaranui Rd Culvert 31 with rubber apron and mussel spat rope attached to the outlet to encourage fish passage (Dec 2012).

### Totaranui Rd Culvert 40

The rubber apron on this culvert spanned a height of three metres. In both 2014 and 2015, only a short distance was accessible for survey (20m upstream and 20m downstream).

In the 2014 survey, two freshwater crayfish were seen upstream of the culvert. Excluding these large invertebrates (35 and 80 mm), no fish were recorded upstream of the culvert in either the 2014 or the 2015 spotlighting surveys.

### Awaroa Rd Culvert 9

A rubber apron was not attached to this culvert as there was no overhang at the outlet. However, two mussel spat ropes were added to the inside of the culvert to help slow down the water, with minimal impact on the culvert capacity in higher flows. From the spotlighting surveys, Kōaro were rare upstream and downstream and no fish were seen upstream of the culvert in 2015.

Table 14. Catch data for Totaranui Rd Culvert 9 (FP612)

| | Downstream | | Upstream | |
|---|---|---|---|---|
| Survey date | Jan 2014 | Feb 2015 | Jan 2014 | Feb 2015 |
| Stream length (m) | 20 | 20 | 20 | 50 |
| Freshwater crayfish | 8 | | | 7 |
| Kōaro | 1 | 2 | 1 | |
| Kōaro size range (mm) | 50 | 50 | 70 | |

Inlet of Awaroa Rd Culvert 9, Jan 2014. Mussel spat ropes on the inside of the pipe slow down the water to allow better fish passage.

### Discussion and conclusion

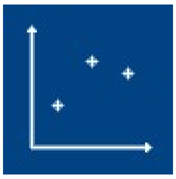
Combining the results from the 2014 and 2015 surveys, kōaro were found upstream at three out of the four culverts. All the kōaro recorded upstream of the culverts were greater than 50 mm in length, indicating they were least a year old.

It is likely that most of the fish we observed upstream of the culverts used the rubber aprons and mussel spat rope to work their way up. We cannot be certain how many used these structures because some fish may have been resident above the culverts before the rubber aprons were installed. Although there were several years between the culvert installation and the fish surveys, it is possible that kōaro grow slowly in these small headwater streams.

Nevertheless, these results provide the first indications that the rubber aprons and mussel spat rope installed in culverts along Totaranui and Awaroa roads provide fish passage for climbing species. The completion of a third spotlighting survey will help to confirm fish passage of juvenile kōaro at these culverts.

# Waterways of the Riuwaka - Motueka

## Wai-Atua and Arnott Streams



**Aims:** (1) To repeat a survey on Wai-Atua Stream to determine variability over time; (2) To compare an impacted site (lower reaches are straightened and have little or no riparian tree cover) with sites in close to reference condition (upper reaches are in native forest) and (3) to determine if any fish passage barriers or impedences exist in the catchment.

**Summary:** All three bully species and banded kōkopu that were found in 2013 at the lower site on Wai-Atua Stream were absent in 2017, possibly due to a succession of large floods. The upper site in climax native podocarp forest contained kōaro, but no banded kōkopu. Natural waterfalls impeding passage for some fish species located downstream of the upper site may be the reason for no banded kōkopu. Fewer kōaro were found at the upper site in the 2017 survey.

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Wai-Atua and its tributary 'Arnott' stream are lowland streams in Separation Point Granite geology. This highly erodible granite results in a sandy mobile stream bed, particularly in the lower catchment. Wai-Atua Stream was diverted (probably a century ago) to follow a course almost parallel to Riuwaka-Kaiteriteri Road to the mouth of the Riuwaka River.

The catchment area of Wai-Atua Stream is about 220ha, the upper sampling site of which makes up 110ha. The land use in the lower reaches is pastoral farming and horticulture while the upper reaches have native forest (10ha), scrub and lifestyle blocks (50ha) and plantation forest (50ha). At a quarter of the size of the Wai-Atua stream catchment, Arnott Stream has approximately 25ha in scrub and native forest, 20ha in farmland and 5ha of plantation forest.

### Lower Wai-atua Stream at Hickmott

On February 20, 2017, the fish populations of the upper and lower reaches of Wai-Atua stream were evaluated by electric fishing. The upper reach was at Riuwaka-Kaiteriteri Road and the lower reach was at Riuwaka-Sandy Bay Road. The same locations were surveyed by electric fishing four years previously, in January 2013.

The lower survey reach flowed through unfenced farmland and had little hydraulic heterogeneity, signs of bank erosion and no riparian canopy tree cover. The stream bed comprised mostly of sand and gravel, notably more than the last visit to the site in 2013. Eels (less than 200mm in length) and inanga populations were abundant in this section. However, we did not find the diversity in bully species that was observed in a similar survey conducted in February, 2013. In that survey, common and redfin bullies were present and giant bullies were rare. Only two unidentified juvenile bullies were found in the current 2017 survey.

The reduced diversity and abundance of bullies could be due to large floods in the Riuwaka Valley following the January 2013 survey. In the 4 years between surveys, there were two 5-

year floods, two 10-year floods and a 50-year flood. This contrasts with the five years prior to Jan 2013 survey in which there was a single 5 year flood (and that was in 2008).

Table 15. Fish species and abundance at **lower Wai-atua Stream** (●○○○ for Rare to ●●●● for Abundant) from electric fishing surveys.

| | **January 2013** | **February 2017** |
|---|---|---|
| # fish species: | 7 | 4 |
| Common bully | ●●○○ | |
| Giant bully | ●○○○ | |
| Redfin bully | ●○○○ | |
| Unidentified bully | | ●○○○ |
| Shortfin eel | ●●●○ | ●○○○ |
| Longfin eel | ●●●● | ●●●○ |
| Unidentified eel | ●●○○ | ●●●● |
| Inanga | ●●●● | ●●●● |
| Banded kōkopu | ●○○○ | |

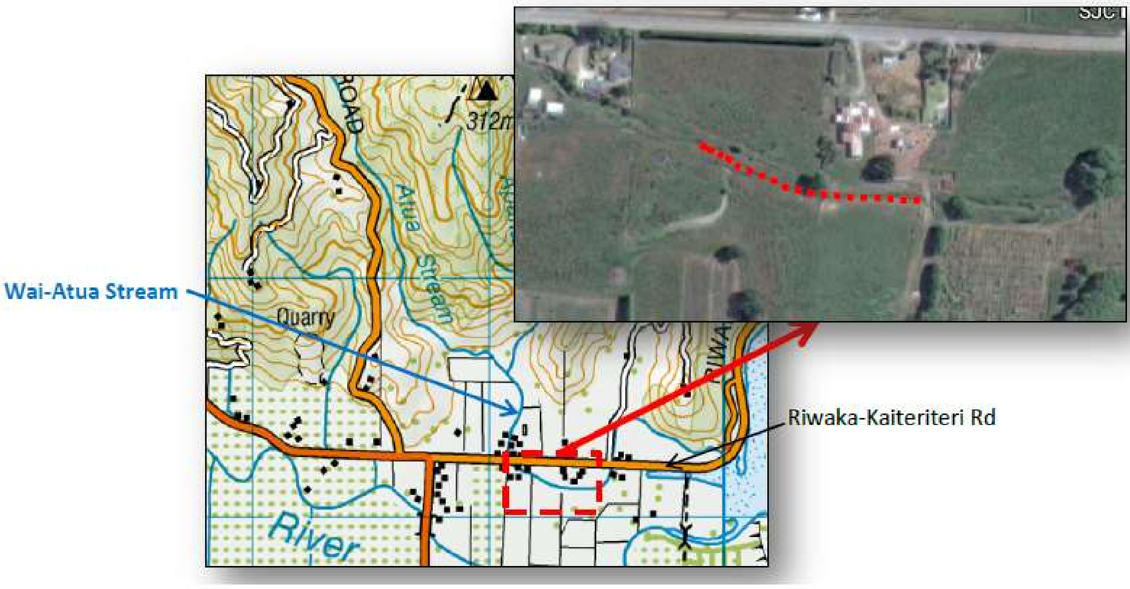



Figure 14. 150m length of stream electric fished on the lower Wai-Atua Stream (Olley, 2017)

## Upper Wai-atua Stream at Sandy Bay Rd (Pine Gully)

The upper survey reach in Wai-Atua Stream runs through regenerating native bush and offered good habitat for fish and invertebrate species. The stream had boulder cascades and a large riparian width either side of the bed. Kōaro, longfin eels, eels (less than 200mm in length) and crayfish numbers were low compared to the 2013 survey, and no banded kōkopu were found.

Table 16. Fish abundance for upper Wai-atua Stream at Sandy Bay Rd from electric fishing surveys. Note: Kōura (freshwater crayfish) were present on both sampling dates.

| | January 2013 | February 2017 |
|---|---|---|
| # fish species: | 3 | 2 |
| Longfin eel | ●●○○ | ●●○○ |
| Unidentified eel | | ●○○○ |
| Banded kōkopu | ●○○○ | |
| Kōaro | ●●●○ | ●●○○ |

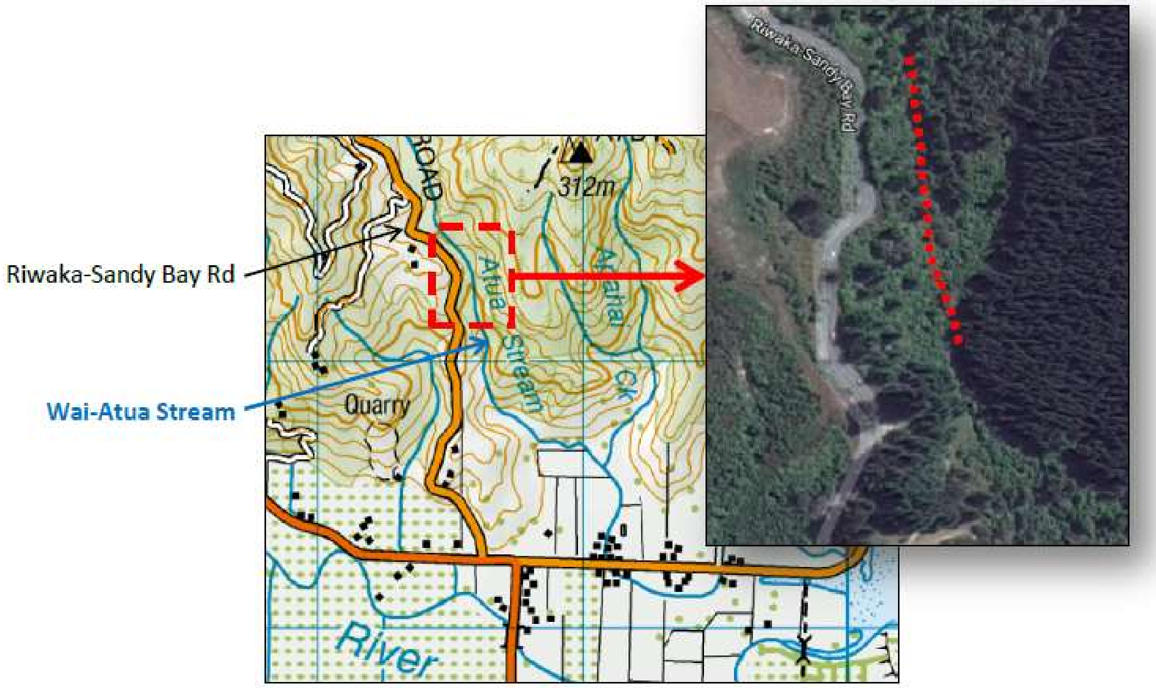



Figure 15. 150m length of stream electric fished on the lower Wai-Atua Stream (Olley, 2017)

Two potential fish passage barriers in Wai-Atua Stream were assessed after consulting the landowner (Hickmott). The first was a man-made rock weir located on the Hickmotts farm upstream of Riuwaka-Kaiteriteri Rd. In its current state the rock weir appears to provide passage for most fish species. The second barrier was located 50m downstream of the upper survey reach and is a series of one metre high natural waterfalls/cascades. Poorer swimming fish species, like inanga, would struggle to navigate this natural feature, however, the presence of juvenile eels and kōaro upstream suggest it may only be a partial fish barrier. Fish passage remediation on such a feature would be difficult to implement and generally not carried out on natural features.

Because of these natural impedances to fish passage, we could not assess how effective improving habitat by riparian planting will be. We recommend surveying sites upstream and downstream of this rock weir in future to assess the effect of this natural barrier.

Upper Wai-Atua Stream, Feb 2017

### Arnott Stream, Riuwaka

On April 10, 2017, two full protocol spotlight surveys were performed along Arnott Stream. Fish populations were evaluated by surveying the lower reaches that are in farmland, followed by an upper reach in native bush. Potential fish passage concerns were identified by a stream walk and in consultation with the land owner.

A healthy breeding population of freshwater crayfish was observed in upper Arnott Stream. Banded kōkopu were present with both juvenile and adult fish surveyed. The lower reach had a series of deep pools and undercut banks which provide good cover for fish species. Large schools of inanga were observed, but banded kōkopu and longfin eels were rare. Common bullies were present, with some adult fish reaching 130 mm in length. The relatively low fish numbers and diversity observed in lower Arnott Stream may be due to a combination of poor water quality (particularly high water temperatures and low dissolved oxygen) and the amount of unfishable water encountered. This unfishable water was a result of dense aquatic plant growth which impeded the spotlight. Modifications to a water take scheme located in the upper survey reach were recommended to better provide for fish passage.

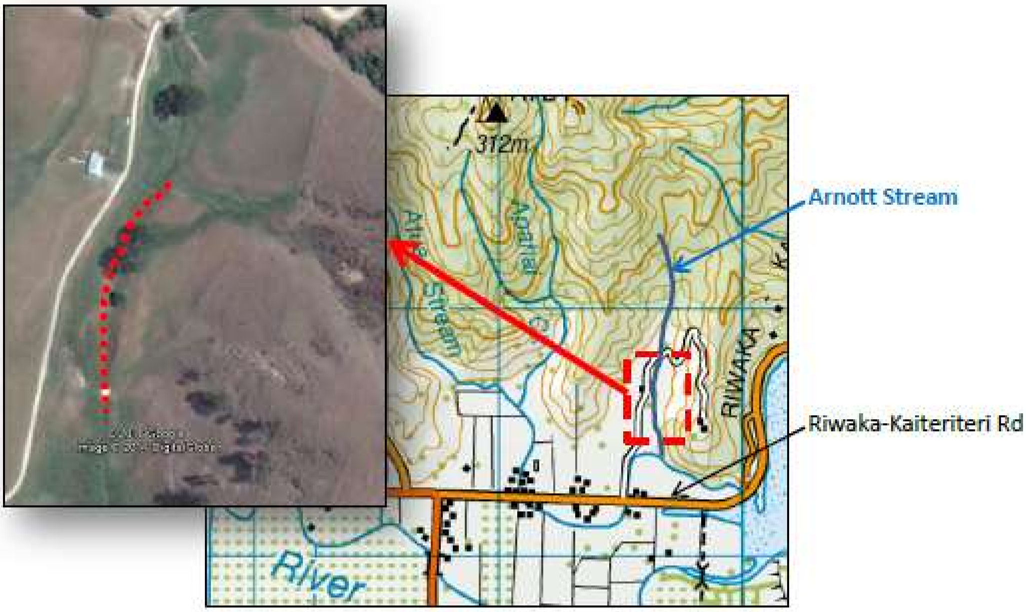



Figure 16. 150m length of stream spotlight surveyed on lower Arnott Stream (Olley, 2017)

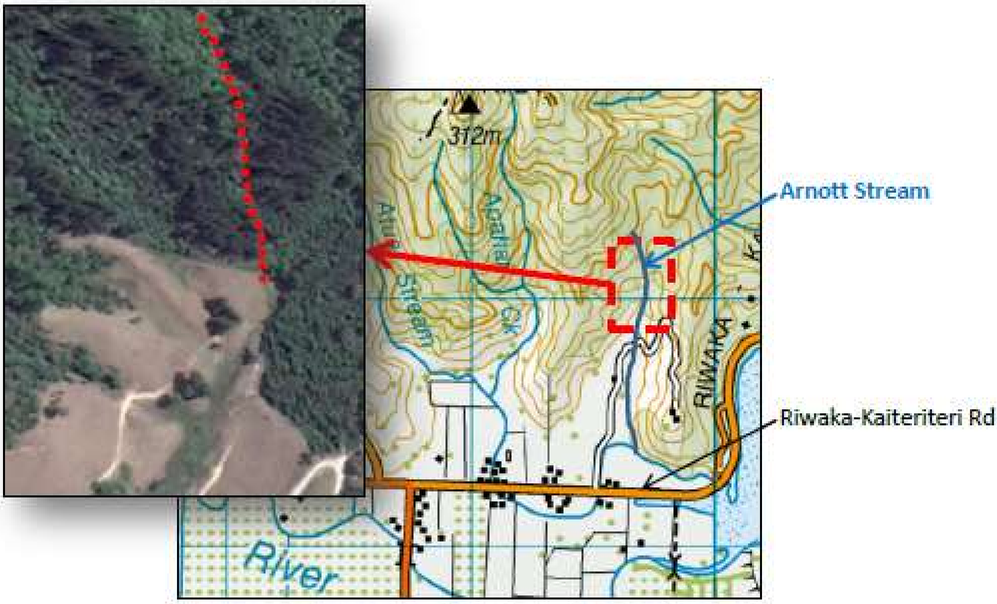



Figure 17. 150m length of stream spotlight surveyed on upper Arnott Stream (Olley, 2017)

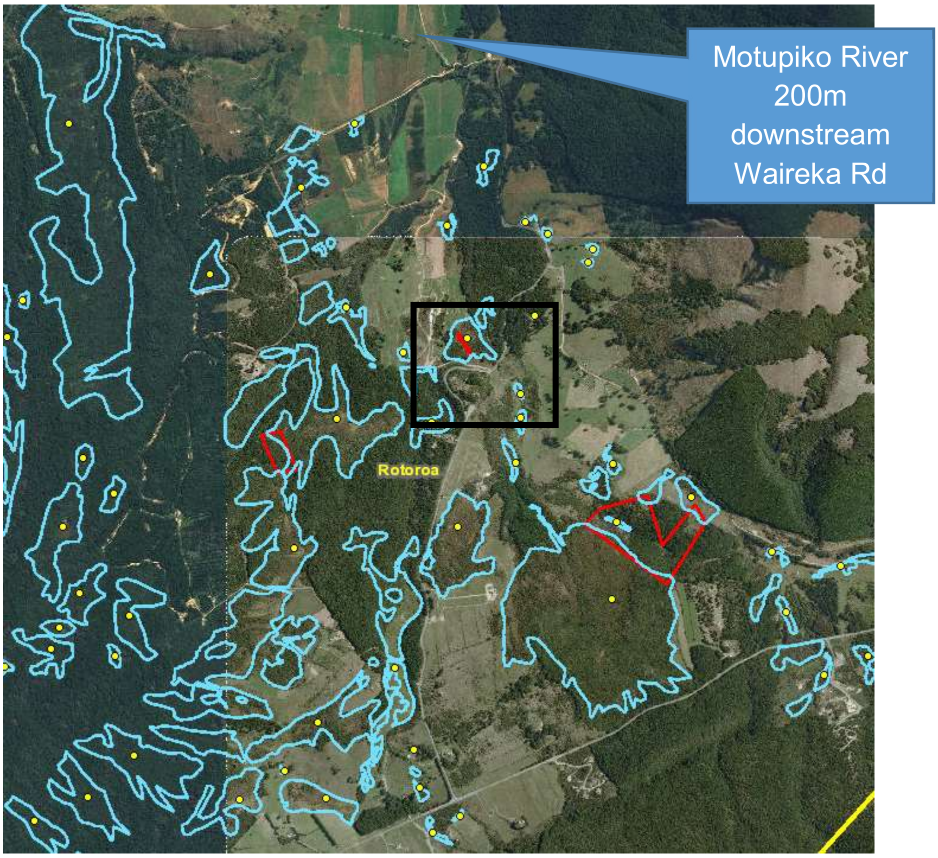
## Upper Motupiko, Tophouse

**Aim:** To record the diversity and abundance of fish species in the Motupiko River and its tributary Roundell Creek. These waterways are unusual in Tasman District as they have about 10% or more of original wetlands remaining.

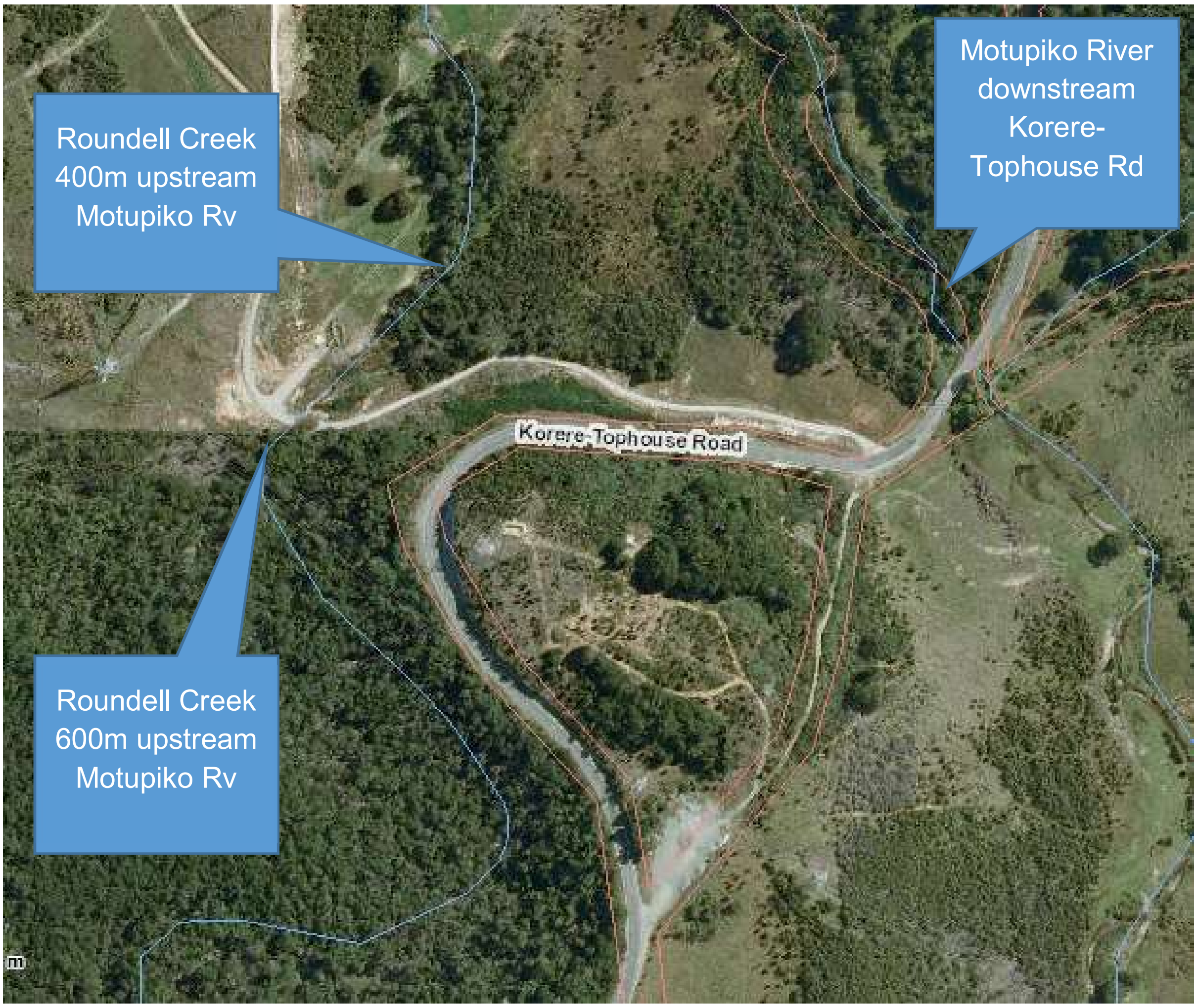
**Summary:** Juvenile brown trout dominated fish communities in the upper Motupiko. Dwarf galaxias was not found in the upper sites near Tophouse but were present in the slower-flowing riffles at Waireka and Desception Roads.

---

The upper reaches of the Motupiko River (above Waireka Road) have a high proportion of original wetlands remaining compared to lower in the catchment. Approximately 10% of the upper catchment land cover is wetlands. These wetlands are mostly montaine bogs (acidic and low in nutrients) on the flatter areas and fens (pH neutral or alkaline) on the gentle hillslopes. The wetland influence results in high dissolved organic carbon concentrations in the river which encourages biofilm development on the stream bed, providing food for invertebrates and, in turn, fish.




Aerial photo of the upper Motupiko catchment showing areas of wetland (blue lines). The red lines indicate areas that may contain additional wetlands. The black frame marks the area shown in the aerial photo over page.




Aerial photo of the upper Motupiko catchment the locations of the two Roundell Creek survey sites and the upper most Motupiko River site downstream of Korere Tophouse Road.

Roundell Creek and the Upper Motupiko River were surveyed on 20 March 2018 using electric fishing methods. Two sites on Roundell Creek were sampled one upstream and one downstream a culvert that has become perched and therefore posed a potential barrer to fish. These two sites have about 15% of their upstream catchment in montaine fens and bogs (75 ha out of 507 ha). Three sites were also surveyed on the Motupiko River, one downstream of Korere Tophouse Rd, one downstream of Waireka Rd and one downstream of Deception Road. The site on the Motupiko River downstream of Korere-Tophouse Road has almost 10% of the catchment in wetlands (107 ha out of 1100 ha; mostly montaine bog). The site on the Motupiko River downstream of Waireka Rd also has almost 10% of the catchment in montaine bog and fen wetlands (242 ha out of 2490 ha).

Roundell Creek at Tophouse, showing perched culvert outlet (creating a short waterfall and potential barrier to fish passage).

Left: Roundell Creek downstream of culvert. Right: Upstream of culvert, showing the riparian margin of beech forest.

Left:  Motupiko River downstream Korere-Tophouse Road, March 2018. Right: Motupiko downstream Waireka Road.

Left: Adult dwarf galaxias habitat at Motupiko River downstream Deception Road, March 2018. Right: sampling juvenile dwarf galaxids.

Adult dwarf galaxias caught in the upper Motupiko River

**Results**

Generally all sites surveyed had good habitat. A high cover of moss and a high abundance and diversity of inverterbrates was particularly notable within Roundell Creek.

No dwarf galaxias were found within Roundell Creek or within the Motupiko River downstream of Korere Tophouse Road, but they were relatively common at the two lower Motupiko sites. However, dwarf galaxias distribution within these sites was patchy and appeared strongly accociated with habitat. Generally, dwarf galaxias were found in the slower flowing riffles with smaller substrate size (80% small cobbles, 10% gravel and 10% large cobbles). The shallow nature of these parts of the stream could naturally exclude trout and therefore allow dwarf galaxias to survive. Smaller dwarf galaxias were found in the smaller substrate, particularly in spring-fed channels. There did not appear to be an assocation with a particular type of overhead cover, with dwarf galaxias found below beech, willow and open streams.

Upland bullies were rare throughout all sites surveyed. They were absent from the two furthest downstream sites on the Motupiko River and only found downstream of the Roundell Creek culvert.

Table 17. Fish species and abundance in the upper Motupiko catchment (●○○○ for Rare to ●●●● for Abundant). Data from electric fishing surveys conducted on 20 March 2018.

| | Roundell Ck 400m u-s Motupiko Rv | Roundell Ck 600m u-s Motupiko Rv | Motupiko Rv d-s Korere-Tophouse Rd | Motupiko Rv 200m d-s Waireka Rd | Motupiko Rv 250m d-s Deception Rd |
|---|---|---|---|---|---|
| # fish species: | 3 | 2 | 2 | 3 | 3 |
| Upland bully | ●○○○ | | ●○○○ | | |
| Longfin eel | ●○○○ | ●○○○ | | ●○○○ | ●○○○ |
| Unidentified eel | ●○○○ | ●○○○ | | ●○○○ | ●○○○ |
| Dwarf galaxias | | | | ●●○○ | ●●●○ |
| Brown trout | ●●●○ | ●●●○ | ●●●○ | ●●●○ | ●●●○ |

Generally the number of longfin eels at all sites was low, and only one large individual exceeding 400mm in length was found.

Brown trout were present in moderate to high numbers and were the most abundant species present at almost all sites. Most were year 0+ or 1+ individuals in good condition suggesting a high level of recruitment over the past few years. Although these trout were probably too small to put much predation pressure on native galaxiid fishes, they may out-compete these species for food and habitat. This could explain the low diversity and abundance of native fish at most sites in the upper Motupiko catchment.

Kōura were surprisingly absent at all sites given the high cover of native forest and woody debris in the stream (particularly Roundell Creek). It is possible that, despite the buffering of flows by wetlands, the rainfall in this area still produces fast, flashy flows which limit fish numbers and account for the absence of kōura. However, the high numbers of juvenile trout present would suggest that this has not been the case for at least the last couple of years.

Fish abundance increased between the Tophouse sites and further downstream. Even though these sites had very good habitat and a high percentage of wetlands in the catchment, fish diversity and abundance was relatively low. Kōura were surprisingly absent given the high cover of native forest and woody debris in the stream (particularly Roundell Creek). It is possible that despite the buffering of flows by wetlands and a very low percentage of the catchment extenting above the treeline (40 ha in alpine tussocklands) that the rainfall in this area still produce such flashy flows limit fish numbers and account for the absence of kōura.

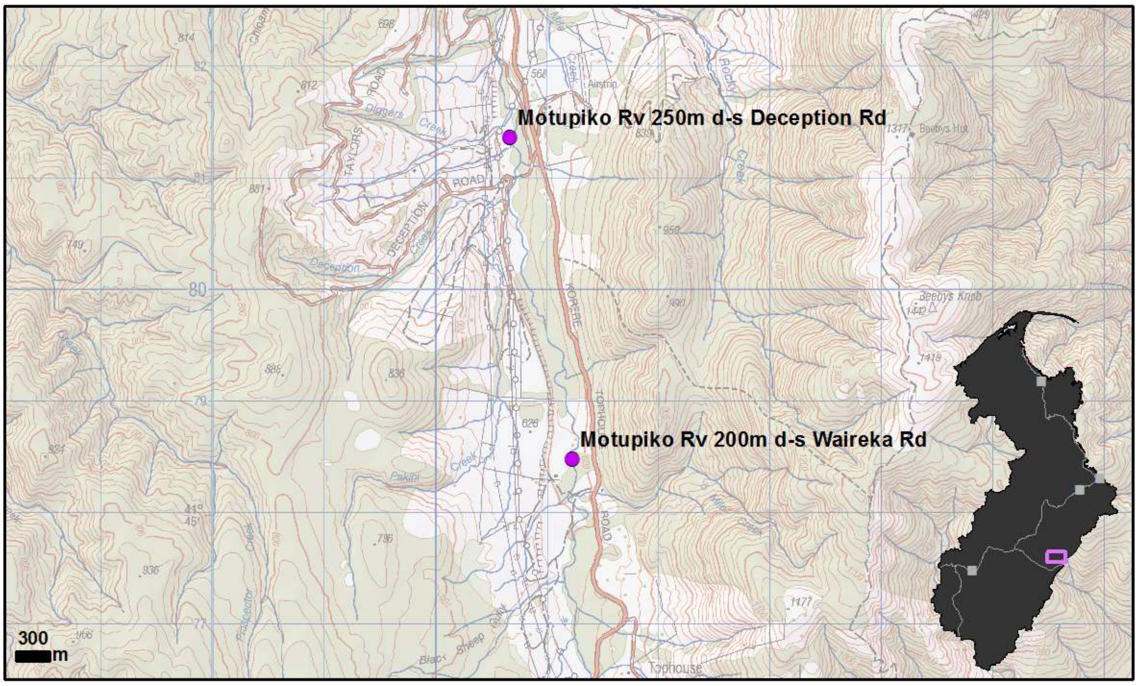



Figure 18. Upper Motupiko River fish survey locations downstream of Waireka Rd

# Waterways of the Moutere Inlet

## Supplejack Valley Stream Tributary

**Aim:** To establish a baseline fish community prior to riparian planting.

**Summary:** Shortfin eel and upland bullies were abundant at both sites with juvenile kōura throughout. Longfin eels were found only at the downstream site. A single adult kōaro (no juveniles) was found at the upstream site.

In January 2014, two sites were surveyed, one at 200 Supplejack Valley Rd (downstream site) and one on the adjacent property belonging to Arnold and Janice Heine (upstream site). Electric fishing of approximately 150m of stream length was completed at both sites.

The downstream section was shaded by willows and contained longfin eels, shortfin eels and upland bullies. The upstream section was unshaded and had shortfin eels, upland bullies and one kōaro. Riparian planting along the unshaded section may provide improved habitat for longfin eels in the future. An old hydrology weir at Old House Road has been acting as a fish passage barrier for some time and reducing fish community diversity for a large part of the Moutere catchment.

Perhaps longfin eels were not found in the upstream reaches due to a lack of shading from riparian vegetation. Alternatively, the prolific macrophytes (in-stream plants) at the upstream site may have provided hiding places for the eels, preventing them from being caught.

Supplejack Valley Stream at 200 Supplejack Valley Rd

Supplejack Valley Stream at upstream site

Table 18. Fish species and abundance at Supplejack Valley Stream (●○○○ for Rare to ●●●● for Abundant) from electric fishing surveys. Note: Kōura (freshwater crayfish) were abundant at both sites.

| | Downstream site 200 Supplejack Valley Rd 15/01/2014 | Upstream site Arnold and Janice Heine property 15/01/2014 |
|---|---|---|
| # fish species: | 3 | 3 |
| Upland bully | ●●●● | ●●●● |
| Longfin eel | ●●●○ | |
| Shortfin eel | ●●●● | ●●●● |
| Kōaro | | ●○○○ |

A concrete ramp was installed on the weir downstream of Old House Road in March 2010 to provide fish passage. However, this site subsequently returned to being a fish passage barrier after floods degraded the bed level within a year or so afterwards. In 2018 water was observed for the first time as flowing under the weir. This risks undermining the whole structure. A plan to produce a more long-lasting fish passage solution and arrest the downstream bed degradation is being worked on with Council river engineers.

## Tasman Valley Stream

‹ Threat ›

**Aim:** To determine fish diversity and abundance at representative sites on the main stem of Tasman Valley Stream and Tto search for giant kōkopu in Tasman Valley Stream and the wetland at Potter's Bush, a covenanted site under the QEII National Trust site.

**Summary:** Spotlighting revealed high densities of banded kōkopu in the small creek flowing out of Potter's Bush wetland, but no giant kōkopu. High numbers of inanga were found upstream and downstream of Aporo Rd. Short fin eel have been found in high abundance at this site on occasion too.

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This small stream has several reaches with natural meander and small remnant riparian forest patches, both important characteristics of good fish habitat. A few landowners have, or are in the process of planting native trees along the stream and new natural-like wetlands have been created to restore what was removed a century or more ago.

One of the wetlands, Potter's Bush, is now a QEII National Trust site. The southern side contains a swamp lined with *Carex secta* and *Carex virgata* sedges with a stand of young kahikatea. Sighting of the nationally *at risk* giant kōkopu have been reported here.

Parts of the stream are in a degraded state. On Tasman Valley Stream, immediately upstream of the Jester House café, there is a long-term river water quality monitoring site. At this location, the water quality is poor, with high water temperatures over summer, low dissolved oxygen concentrations, high concentrations of disease-causing organisms and moderately high nutrient concentrations.

Tasman Valley Stream upstream of Jester House, July 2017

In January 2014, a spotlighting survey of Tasman Valley Stream at Jester House and at Potter's Bush Creek was completed. Tasman Valley Stream upstream of Jester House, the stream had a silty bed and was slow-flowing. There was slight bank damage by cattle, but in 2017 this stream was fully fenced. The stream contained abundant smelt (40 to 60mm), occasional kōaro (120 to 180mm), occasional long-fin eels (200 to 400mm) and banded kōkopu, but not shortfin eel or bullies. Fish surveys less than 700m upstream at the Aporo Rd bridge, in 2006 and 2008, recorded common bully, longfin eel, shortfin eel, inanga and banded kōkopu. Over a dozen large longfin eel reside at Jester House as part of a tourist attraction.

Potter's Bush had a healthy community of banded kōkopu in the range 120 to 250mm. Six banded kōkopu at the higher end of this range were seen, with one at 250mm which is close to the maximum size recorded for this species (260mm). These densities and sizes of banded kōkopu are not uncommon in these narrow channels (only 300-400mm wide), and show the importance of looking after even the smallest of streams. No giant kōkopu were seen, although the channels through well-shaded swamp provides suitable habitat. There may be a barrier downstream that is preventing giant kōkopu (the least capable swimmer of the whitebait species) from accessing the site.

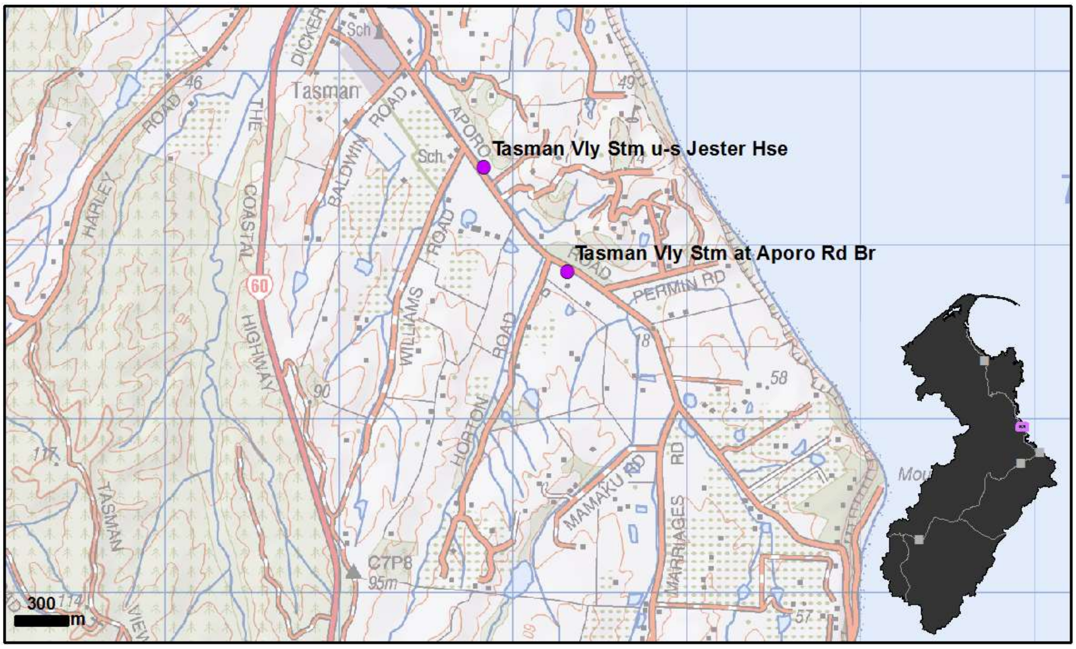


Figure 19. Tasman Valley Stream fish survey locations

Table 19. Fish species and abundance at Tasman Valley Stream (●○○○ for Rare to ●●●● for Abundant).

| | Tasman Vly Stm at Aporo Rd Br 1/11/2006 | Tasman Vly Stm at Aporo Rd Br 22/02/2008 | Tasman Vly Stm u/s Jester Hse 23/01/2014 |
|---|---|---|---|
| # fish species: | 4 | 5 | 4 |
| Common bully | ●○○○ | | |
| Giant bully | | ●○○○ | |
| Longfin eel | ●●○○ | ●○○○ | ●●○○ |
| Shortfin eel | ●●●○ | ●○○○ | |
| Inanga | ●●●● | ●●●● | |
| Inanga (jv) | ●●●● | | |
| Kōaro | | | ●●○○ |
| Banded kōkopu | | ●○○○ | ●●○○ |
| Common smelt | | | ●●●● |

# Tasman Valley Stream Tributaries


**Aim:** To search for giant kōkopu in the Williams Road Stream wetland and along Horton Road Stream by spotlighting

**Summary:** No giant kōkopu were conclusively identified. There was one tentative sighting of a giant kōkopu in Horton Road Stream (unconfirmed). Banded kōkopu were found in both streams.

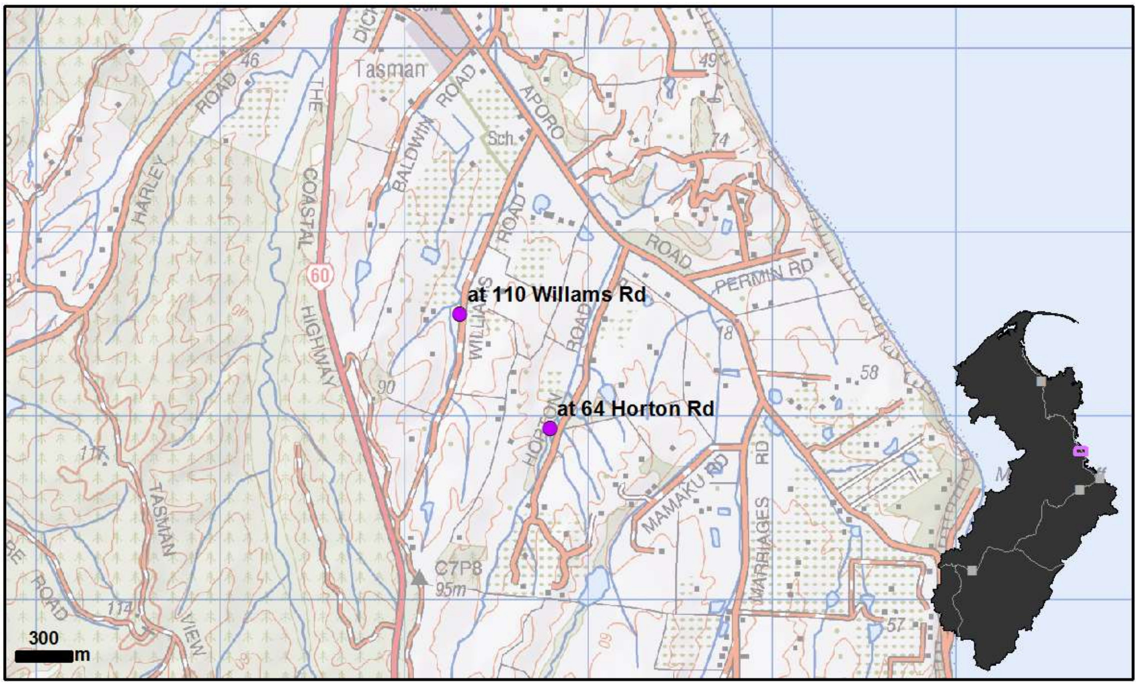


Figure 20. Tasman Stream Tributaries

In this report the two unnamed tributaries of Tasman Valley Stream are refered to by the nearest road name.

**Williams Road Stream:**

We searched for giant kōkopu by spotlighting on 27/03/2014 in the two main pools within the wetland, one adjacent to the driveway at the northern end of the property (at 110 Williams Rd), the other 200m upstream. We spotlighted for 30min in total and, in that time, saw 20 banded kōkopu (60-180mm) but no other fish and no giant kōkopu.

The water clarity was very poor - a few centimetres in places but approximately 20cm overall - due to suspended and dissolved organic matter. There were patches up to several metres across of orange, slightly gelatinous iron bacteria growth.

**Horton Road Stream:**

We spotlighted along approximately 150m of the stream downstream from the 108 Horton Valley Rd accessway in March 2014. Juvenile banded kōkopu (less than 80mm) were common, larger banded kōkopu were occasional (120-160mm). Shortfin eels in the range 400 to 500mm were common. On previous spotlight surveys, there was a very brief sighting of what could have been a giant kōkopu. Such a 'ghost-sighting' occurred during this survey in a pool about 30m downstream of the driveway. To make a confident identification, netting would be required.

The water clarity of the stream was 50 to 100cm and the pools were developing macrophyte beds on the margins. There was also good riparian cover (more than 50% cover along most of the stream) and woody debris present, particularly in the lower 50m.

Table 20. Fish species and abundance at Horton Road Stream, below 108 Horton Valley Rd accessway, from spotlighting surveys (●○○○ for Rare to ●●●● for Abundant).

| | 4/11/2006 | 13/03/2008 | 20/11/2008 | 27/03/2014 |
|---|---|---|---|---|
| # fish species: | 2 | 2 | 1 | 2 |
| Shortfin eel | | ●●○○ | | ●●●○ |
| Longfin eel | ●○○○ | | | |
| Unidentified galaxiid | ●○○○ | ●○○○ | | |
| Banded kōkopu | ●○○○ | ●●●○ | ●●●○ | ●●○○ |
| Banded kōkopu (jv) | | | ●○○○ | ●●●○ |

# Waterways of the Waimea Inlet

## Dominion Stream, near Mapua

**Aim:** To assess changes in the fish community as the riparian plants at Dominion Flats mature. This is intended to be a long term fish monitoring site.

**Summary:** Fish surveys in summer 2012/13 identified seven fish species. Longfin eels, inanga and juvenile banded kōkopu were abundant. Repeat surveys in 2016/17 found a similar species composition, with early indications of increased habitat for adult banded kōkopu.

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With a small catchment (230 ha), Dominion Stream flows from the eastern edge of the Moutere Hills into the Waimea Inlet. Extensive plantings at Dominion Flats, at the lower reaches of the stream downstream of SH60, were progressively planted from 2012 to 2017. The high proportion of the stream covered with *Carex geminata* (see photo below), will certainly improve habitat. However, to achieve the greatest fish abundance and diversity there needs to be a variety of riparian vegetation to provide for dietary needs. At this stage the tree plantings in this area are still too immature to realise any significant change to fish communities.

Dominion Stream 25m upstream Mapua Drive showing *Carex geminata* cover over the channel (Feb 2014)

Fish surveys in 2008-09 found a giant kōkopu in the reach downstream of the Chaytor Road wetland.

In summer 2012/13, a stream reach immediately upstream of SH60 (also known as the Mamaku Road or the Coastal Highway) was surveyed by electric fishing and a reach downstream of SH60 was surveyed by spotlighting (January 2013). The electric fishing and spotlighting was repeated in summer 2016/17 to assess changes in the fish community.

Between the two survey periods, the stream below the highway has developed deep stable pools connected by deep runs and a small amount of shallow riffle. The riparian plantings have begun to form a canopy, providing shade. Directly adjacent to the stream, *Carex* grasses and young trees form a dense margin overhanging the stream, up to one metre in places.

Upstream of the highway, the stream gradient increases slightly, with more shallow riffle habitat which is preferred by kōaro and red fin bully. Deep pools were still present however, often associated with mature willows. Riparian restoration is likely to occur upstream of SH60 and this is likely to include willow removal. No riparian planting has occurred in this section as yet and the riparian vegetation was restricted to weedy species eg broom and rank pasture grasses, providing modest shading.


Figure 21. Dominion Stream fish survey locations

**Comparison Between Sites**

At both sites, the amount of deposited sediment on the bed was about 20%, not unusual for a lowland stream of this size in the Moutere Hills.

Although greater species diversity was found upstream, this was probably due to greater diversity of habitat occurring, particularly better quality riffles and pools.

Table 21. Fish species and abundance at Dominion Stream (●○○○ for Rare to ●●●● for Abundant).

| | E-fishing u-s SH60 21/12/2012 | Spotlighting d-s SH60 11/01/2013 | E-fishing u-s SH60 20/12/2016 | Spotlighting u-s SH60 23/03/2017 | Spotlighting d-s SH60 23/03/2017 |
|---|---|---|---|---|---|
| # fish species: | 7 | 3 | 5 | 5 | 4 |
| Common bully | ●○○○ | | | ●○○○ | ●●●○ |
| Redfin bully | ●●○○ | | ●●●○ | ●○○○ | |
| Longfin eel | ●●●● | ●●○○ | ●●○○ | ●●○○ | ●○○○ |
| Shortfin eel | ●○○○ | | | | |
| Unidentified eel | | | ●●●● | | |
| Unidentified galaxiid | | ●●○○ | ●●●● | | |
| Inanga | ●●●● | ●●●● | ●●●● | ●●●● | ●●●● |
| Kōaro (jv) | ●○○○ | | | | |
| Kōaro | | | ●○○○ | | |
| Banded kōkopu | ●○○○ | | | ●○○○ | ●○○○ |
| Banded kōkopu (jv) | ●●●● | ●○○○ | ●○○○ | | |

**Comparison over time**

**Downstream of SH60**: In 2017 the fish community was characterised by large numbers of inanga with the odd banded kōkopu and large longfin eel. Compared with the 2012 survey, the 2017 results showed more common bullies and a similar number of inanga. There were fewer eels in 2017, though of a larger size. The most recent survey is also the first time adult banded kōkopu have been seen within this reach.

These changes probably reflect habitat changes as restoration efforts mature, particularly the development of overhanging vegetation along the banks and a diversity of pool and run habitats. With time it should be hoped that giant kōkopu may, once again, be found within this reach.

**Upstream of SH60:** Similar to the downstream site, the upstream 2017 fish community contained large schools of inanga, in similar numbers to 2012. Redfin bullies were common, probably as a result of the greater riffle habitat in the upstream reach. There were moderate numbers of small eels, with a few adult longfin eels ranging in size from 200 to 700mm in length. The numbers of adult banded kōkopu and kōaro, as well as common bullies were low, and similar to 2012. The main difference within this reach between 2016/17 and 2012/13 was the recent decline in numbers of juvenile banded kōkopu which were found in especially high numbers in 2012. This probably reflects variability in returning juveniles among years, as a similar decline in numbers was also seen in comparative surveys performed on Saxton Creek in 2012 and 2017.

## Kainui Stream and Quail Valley Stream

**Aim:** To determine any effects on the fish community as a result of the Kainui Dam.

**Summary:** Longfin eels dominated the fish community.

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Kainui and Quail Valley Streams are adjacent catchments within the wider upper Wai-iti Valley. The Kainui Community Dam ('Kainui Dam') was constructed in May 2006 within a reach of the Kainui Stream upstream of Eighty Eight Valley Road. As part of the consent application process, Fish and Game Nelson Marlborough performed surveys of the fish communities upstream and downstream of the proposed dam location (Davey & Deans, 2002). Since then, following the conditions outlined within the Kainui Dam operating consent, further fish surveys in similar locations have been completed. In addition, an annual transfer operation moves juvenile eels from beneath the dam wall into the dam itself.

Quail Valley Stream was considered as an additional extraction site to feed into the proposed dam, but this never eventuated. However, fish surveys of Quail Valley Stream completed prior to the construction of the dam can be compared to more recent surveys. This provides a comparison of two streams in adjacent catchments, before and after dam construction. This summary report aims to examine these fish surveys to determine any effects the Kainui Dam has had on the fish community of Kainui Stream since its construction.

### Fish surveys and transfers to date

In 2002 Davey and Deans surveyed three sites within Kainui Stream:

- Upstream of the rail embankment accessed of Swamp Road.
- Upstream of Eighty Eight Valley Rd Bridge immediately downstream of the then proposed Kainui Dam.
- Within farmland at a site upstream of the then proposed Kainui Dam.

Since then, a site downstream of Wai-iti Valley Road within the Redstone golf park has been surveyed in 2013, 2015, 2016 and 2018. A site upstream of the most southerly road culvert along Swamp Road was surveyed in 2017, and a full wetland survey including both tributaries draining into Kainui Dam was completed in 2017.

In addition to these surveys, a salvage and transfer of eels into Kainui Dam from below the discharge pipe has occurred in each year since 2012.

In 2002 Davey and Deans surveyed five sites within the Quail Valley Stream catchment:

- At Quail Valley Road Bridge.
- Within the North Branch of Quail Valley Stream upstream of Eighty Eight Valley Road.

- Within the South branch of Quail Valley Stream upstream of Eighty Eight Valley Road.
- And at two sites near the boundary of the pasture with the forested hill side, at the time this was the proposed intake location.

Since then full protocol surveys have occurred within the mid catchment along Quail Valley Rd in 2017 and at the upper site near to the original Davey and Deans location in 2018.

Quail Valley Stream about 1.4km upstream Eighty-Eight Valley Road

**Results**

Davey and Deans concluded following their surveys of Quail Valley Stream in 2002 that fish abundance and diversity was relatively low despite apparently ideal habitat. Generally, this remains the case with patterns of fish diversity and abundance similar in 2017/18 to what they were in 2002 (Figures 1 and 2). The exception being, in 2018, brown trout and crayfish were more common within the upper reaches. However, crayfish numbers were still low with only 1-2 individuals per 15 metre reach.

Davey and Deans postulated that summer low flows, particularly in the lower reaches are likely to be exhibiting some stress on the fish populations present. In their report they present data that suggests at the lower valley site, summer flows are often reduced to 20-50Lsec with temperatures recorded up to 21.1°C. They suggest that at least where trout are concerned the upper reaches, where bedrock is closer to the surface, would offer a refuge against seasonal drying and high water temperatures thus explaining the higher numbers of trout there. This conclusion is supported by the 2018 survey data. Upland bullies, only ever present in the lower most survey site, would likely be more tolerant of summer low flows; however this doesn't explain their absence from the upper reaches. Their distribution is perhaps more likely to be a reflection of their preferred substrate and riffle structure being more abundant within the lower reaches. Eel and crayfish numbers appear to be relatively stable but are probably seasonally variable especially as juveniles. Predation of bullies by trout is unlikely as generally the trout present are not of a size to be piscivorous.

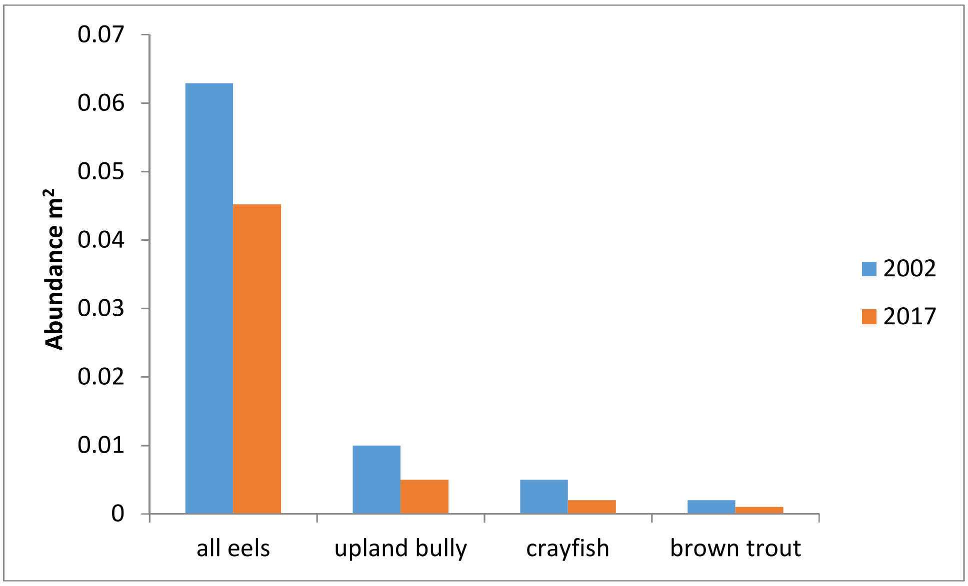


Figure 22. The results of fish surveys in 2002 and 2017 within Quail Valley Stream at a lower Valley site near Quail Valley Rd Bridge. Note that that abundance values have been adjusted to reflect the area fished during each survey.

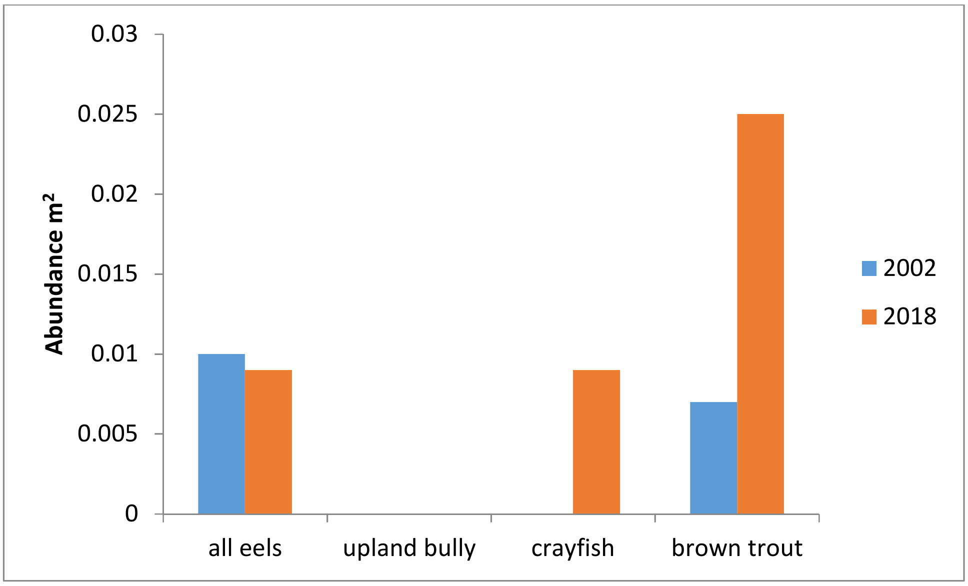


Figure 23. The results of fish surveys in 2002 and 2017 within Quail Valley Stream at an Upper Valley site near the boundary of the pasture with the forested hill side. Note that that abundance values have been adjusted to reflect the area fished during each survey.

### Kainui Stream

In 2002 Davey and Deans concluded the following from their Kainui Stream surveys. “Kainui Stream was virtually devoid of all freshwater fish life, with a total of only seven short finned and long finned eels found at three sites surveyed. Five crayfish were also found but only within the lower and upper reaches. Habitat for much of Kainui Stream was limiting for many species, either due to insufficient flow/water depth, muddy/fine substrate or lacking food. Habitat appeared to be best within the lower reaches of Kainui Stream due to increased flow with deeper pools and a higher percentage of course gravel and cobbles present, although habitat was still limited for many species. Invertebrate numbers throughout the length of Kainui Stream were also low, with snails being the dominant species present. Mayflies were only found in the upper reaches with some caddis found in the lower reaches.”

In January 2017 a survey was completed within the wetland at the head of the Kainui Dam and within the upper tributaries draining into the Kainui Dam, at similar locations to which Davey and Deans surveyed in 2002. Within the wetland a healthy population of eels, some very large, were observed. Longfin eels dominated the catch; however large shortfin eels (up to 400mm) were also present. Within the upper tributaries, in contrast to the Davey and Deans surveys, eels were much more abundant in 2017 than in 2002. Shortfin eels dominated the assemblage, where only longfins were present in 2002 in low numbers. The crayfish population within the upper tributaries appears to be stable. Habitat was noted to be similarly degraded in both 2002 and 2017 with notable stock damage causing sedimentation.

Within the mid Swamp Gully reach of Kainui Stream three eels were observed in 2002 ranging in size from 170 to 300mm in length. By comparison in 2017 four eels were observed within a similar length of stream. A notable difference was the presence of a large 700mm long longfin eel in 2017. No crayfish were seen in 2002, while in 2017 seven were present with at least one large individual 100mm in length.

Unfortunately, the lower most site surveyed by Davey and Deans in 2002 is not directly comparable to the site downstream of Wai-iti Valley Road, now known as the golf course site, that has been regularly monitored since the creation of the Kainui Dam. The site surveyed in 2002 was within the forest above the old railway embankment and thus above at least two potential fish passage barriers. Regardless, within this reach in 2002 Deans and Davey found one shortfin eel, one longfin eel and three crayfish. The results of four surveys over a similar length of stream at the golf course site are displayed in Figure 3. In general, the abundance of species present has been quite variable. At first glance, the number of juvenile eels present appears to have declined over time. However the number of juvenile eels present in a given year is more likely to be a result of variable survey times, and reflective of the eel migration peaking in December and declining as the summer progresses. The numbers of adult longfin eels is likely to be stable, while shortfin eels may have declined slightly. The population of upland bullies appears to be seasonally variable, but generally stable, and roughly mirrors that of crayfish. In April of 2015 for instance, large numbers of juveniles of both species were present, perhaps indicating a good breeding season for both species. Within this reach of Kainui Stream upland bullies and crayfish appear to favour similar habitat. Pleasingly, in May of 2018, both a juvenile galaxiid (probably either kōaro or banded kōkopu; pers com T. Kroos) and two brown trout were identified for the first time within the Kainui Stream catchment since records began.

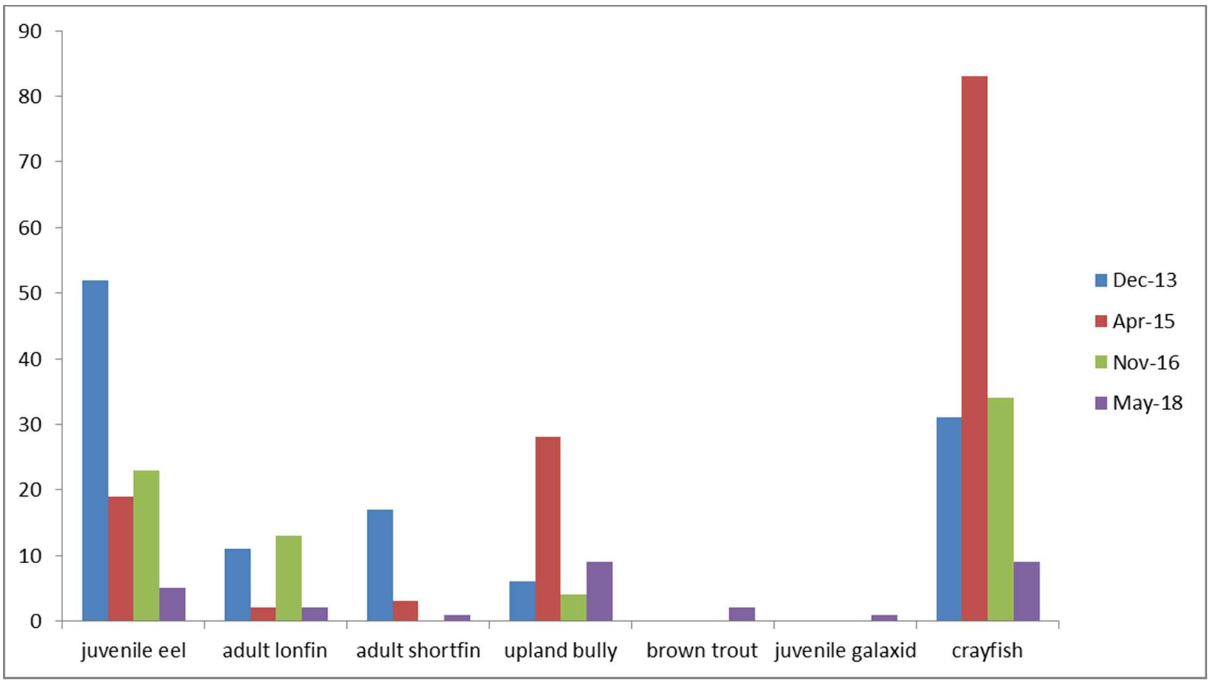


Figure 24. The results of fish surveys with the golf course reach of Kainui Stream, downstream of Wai-iti Valley Road, from 2013 to 2018.

In 2002, Davey and Deans recommended provision of eel passage over the dam wall. This has become an important aspect of the Kainui Dam operating procedure. Since the creation of the Kainui Dam, eight transfer operations have relocated 8278 eels over the dam wall, and into the dam above. The breakdown of these transfers can be seen in Figure 4.

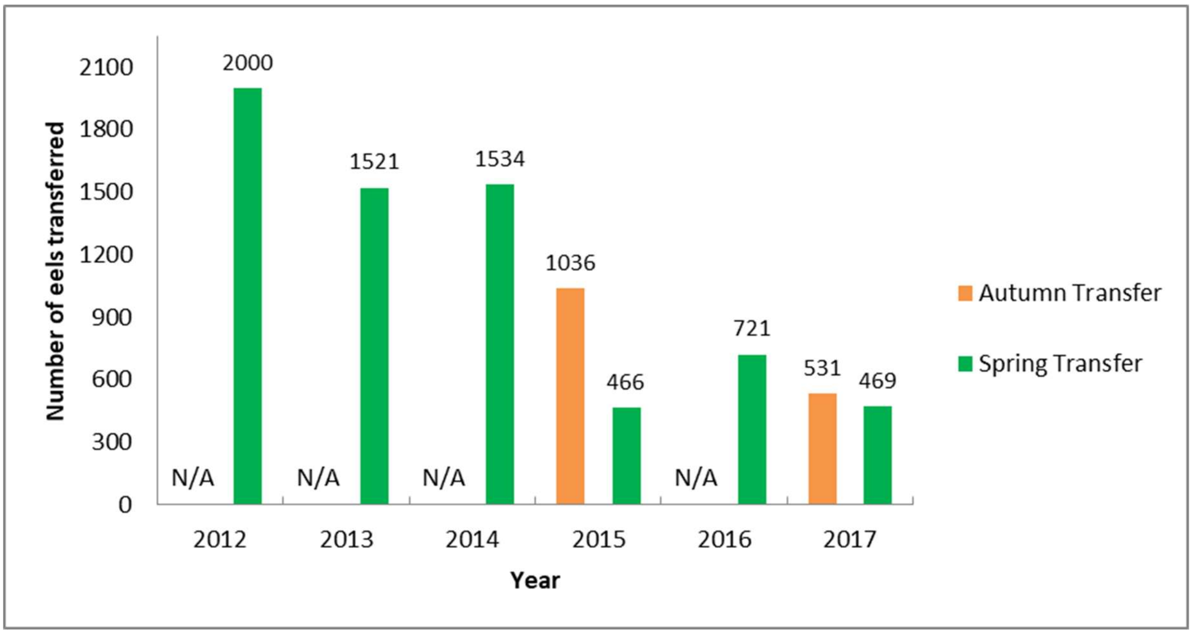


Figure 25. Juvenile eel transfers into Kainui Dam.

Total numbers of eels transferred each year remained fairly stable up until 2015, but numbers have trended down over recent years. Regardless at least 1000 eels are normally transferred each year. Wetland and upper tributary surveys in 2017 suggest good numbers of eels, in keeping with the habitat available, suggesting the eels transfer is a successful operation.

### General discussion

There is no evidence to suggest that Kainui Stream has been negatively affected by the creation of the Kainui Dam. To the contrary rather, fish populations may have improved, or at worst remain stable. In 2002 Davey and Deans suggested that both Quail Valley and Kainui Streams may be compromised by low flows. In Quail Valley Stream, where summer flows presumably have not changed, fish populations are similar in 2018 to what they were in 2002, with the exception of an increase in brown trout and crayfish numbers within the upper reaches. Within Kainui Stream, generally fish abundance and diversity has improved. Downstream of the dam, this may be a result of higher than natural summer flows resulting from dam releases during times of low flow. Upstream of the Dam eel numbers may be boosted by the dam acting as a reservoir for juveniles. Generally speaking the species present in Kainui Stream are as would be expected. Encouragingly, 2018 saw the first trout and galixiids recorded within the catchment. Comparisons with Quail Valley Stream suggest trout may be able to remain resident in low numbers as juveniles within Kainui Stream so long as flow allows, and presumably some spawning may occur within the lower reaches downstream of Wai-iti Valley Road during the winter months. Galaxiids were not recorded in any of the Quail Valley survey sites, so it seems they are present only at low numbers within the wider Wai-iti catchment.  Regardless, it is not beyond belief that, overtime, a population of banded kōkopu could establish within suitable habitat throughout the Swamp Gully reach of Kainui Stream.

In 2002 Davey and Dean were concerned by the effect fish passage barriers may have on the fish population of Kainui Stream. They postulated that, “the lack of fish numbers and diversity in Kainui Stream could be related to fish passage issues, as there are a number of debris dams, culverts and a v-notch weir in the lower reaches”. Survey data for upland bullies since then seem to confirm this concern. Only once during an eel salvage directly below the dam wall has an upland bully been located upstream of the Wai-iti Valley Road, despite an apparently robust population downstream. Further surveys within the reach of Kainiu Stream upstream of Wai-iti Valley Road, and an examination of fish barriers along the length of Swamp Gully, although technically difficult due to physical and administrative access constraints, could help clarify this possibility. It should be noted however, that as a comparison, upland bullies were also only found in the lower reaches of Quail Valley Stream indicating that the lowland distribution of upland bullies within these two streams may be a natural phenomenon.

## Teapot Valley Stream tributary, South-west of Brightwater

**Aim:** To establish a baseline fish community prior to harvesting of exotic forest in the upstream catchment.

**Summary:** Longfin eels dominated the fish community. Two undercut and overhanging culverts were likely to be acting as fish passage barriers downstream of the sample site are likely preventing access to this reach for most species.

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Teapot Valley Stream and its tributaries, flow from the Moutere hills to the Wai-iti River. The tributary targeted for this survey has a catchment of approximately 470 hectares, a large proportion of which is used for exotic forestry (80 to 90%). There is also dairy farming in the catchment. Forest harvesting is due in the coming decade and the purpose of the survey was to establish a baseline fish community prior to the start of harvesting.

A 150m reach of the tributary, beginning 900m upstream of the confluence of Teapot Valley Stream was surveyed using the electric fishing method on 20/01/2014. In the two weeks prior to the survey, there was 6mm of rainfall (Wai-iti at Birds rain gauge).

In total, three fish species were caught: upland bully, longfin eels and shortfin eels. Kōura were common. Longfin eels were the most abundant. We noted that all species caught are considered to be good climbers. Following the fish survey, two fish passage barriers were identified downstream and these were likely to be preventing access to this reach for non-climbing species.

Notable positive stream health attributes of the Teapot Valley Stream Tributary are that the water temperature was low and there was minimal fine sediment. The low temperatures are important for fish survival and are related to the good riparian cover of the stream. Grasses lined the banks and shrubby willow trees provided additional cover. Some resuspendable fine-sediment was present, but at lower levels than other streams of similar stream order in the region (such as Redwood Valley stream). This reflects the dense riparian buffer around the stream and fencing to prevent cattle access.

The two perched culverts downstream of the sample site were remediated with conveyor belt flaps attached to the outlet in November 2014. It would be useful to repeat this survey to check that other species expected to be upstream of these culvers are now present. A similar fish survey should also be conducted once forest harvesting upstream of the site has been completed (due in the coming decade).


Teapot Valley Stream 1.1 km upstream confluence of Wai-iti River prior to fish passage remediation May 2014


Teapot Valley Stream 1.1 km upstream confluence of Wai-iti River following fish passage remediation May 2014

## Lower Wai-iti River Weirs, Brightwater

**Aim:** To assess whether the lower two gravel retention weirs on the Wai-iti River are fish passage barriers. We were also interested to find out if the concrete ramp on the weir 100m downstream Waimea West Rd (Weir 2) has improved fish passage.

**Summary:** Two visual surveys were carried out on the lower two weirs, in 2012 and 2015. The riverbed was dry downstream of a point at about 1.1km d-s Waimea West Rd (Weir 1) during both surveys, leaving fish confined to residual pools. Weir 2 appeared to be a severe fish passage barrier in 2012 . At this stage, we cannot be sure that the concrete ramp installed in 2013 on Weir 2 has improved fish passage since neither smelt or inanga have been found downstream or upstream since. A spotlighting survey at a similar time of year would provide stronger evidence either way.

---

Three gravel retention weirs sit on the lowest four kilometres of the Wai-iti River, upstream the Waimea River. The weirs were constructed from 2000 to 2008 in response to lowering water tables in the Waimea plains due to many years of gravel extraction from the Wai-iti and Waimea Rivers. By raising the river level in times of low flow, the weirs increase the quantity of water recharging the Appleby Gravel Unconfined and Upper Confined aquifers.

The three weirs, constructed using rock riprap (boulders), have spaces between the rocks where water ‘sieves’ through creating highly turbulent conditions. We expected the fast water velocities and turbulence created by these sieves to prevent non-climbing galaxids (whitebait species) and smelt from migrating upstream.

The furthest downstream section of the Wai-iti River (upstream of the confluence with the Waimea River) dries up progressively from the downstream to upstream in most years.

Restoration of fish passage at the weir located just downstream of Waimea West Road was undertaken in 2015 by creating a concrete ramp on a lower gradient from the crest of the weir across to the true right. This ramp should be extended as the bed has been undermined at the downstream end. The integrity of this ramp is in question due to movement of the rock it is founded on.

The furthest downstream weir does not have as high water velocities as the Waimea West Rd weir and it provides for passage of smelt some years. However, it may still present an impedence to inanga and smelt movement and further surveys are recommended.

There is a fourth gravel retention weir upstream of Arnold Lane. This weir is not as steep as others downstream, and therefore provides areas of lower water velocity for fish to pass through.

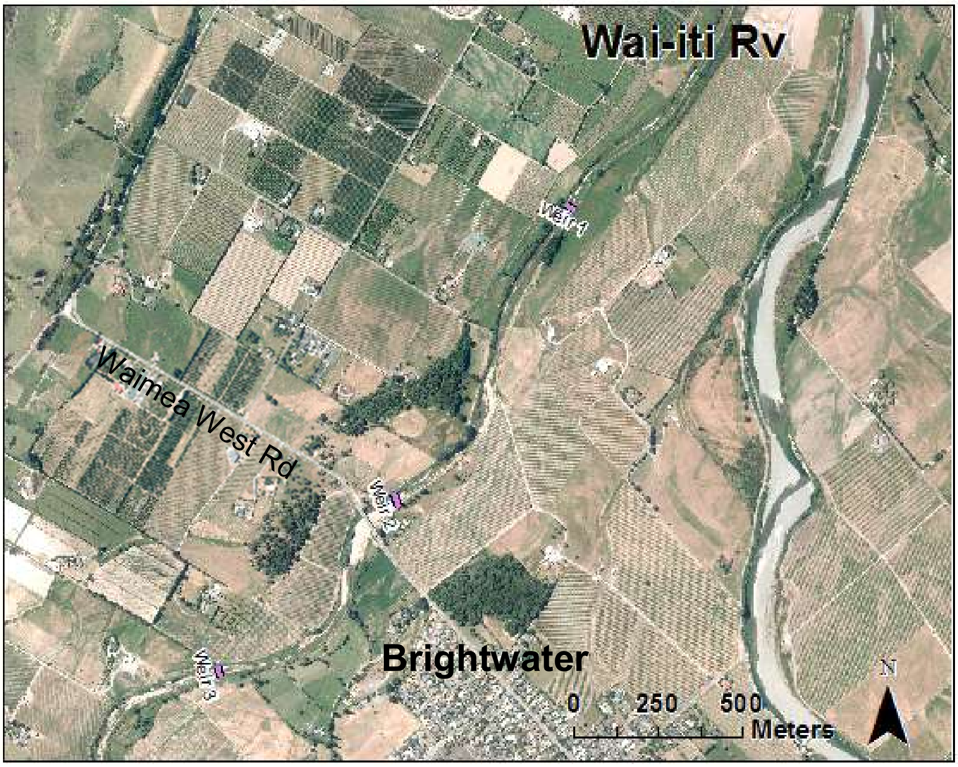


Figure 26. Location of Wai-iti River Gravel Retention Weirs

Wai-iti River at lowest weir, view upstream showing dry riverbed, 23 December 2015

Visual surveys of the fish above and below weirs 1 and 2 were carried out in December 2012 and again in December 2015. For the 2012 survey, spotlighting was completed several hundred metres above and below Weir 2. For the 2015 survey, weirs 1 and 2 were inspected during the day to record the number of fish schooling immediately downstream, if any.

In both the 2012 and 2015 surveys, the Wai-iti River was dry above and below Weir 1. In both cases there had been less than 40 mm of rain in the previous four weeks (Wai-iti at Birds rain gauge). In 2012, the lowest 500 metres of the river had dried up. In December 2015, the river was dry from approximately 100m above to 200m below Weir 1. No moving water was visible within the weir itself but there were several small pools. The pool below the weir contained a school of several hundred smelt (see photo below). An effort was made to rescue some of the fish trapped in the remaining pools. In all, six trout, 26 eels and one crayfish were salvaged from pools within the weir and immediately upstream of the weir. A lamprey was found dead within the boulders of the weir.

Wai-iti River at lowest weir, view upstream showing dry riverbed and school of smelt below the lowest weir (December 2015)

There was good flow in the river at Weir 2 at the time of the 2012 survey (200 – 300 L/s) and the 2015 survey (60 to 80 L/s).

In the 2012 survey, Weir 2 appeared to be a severe barrier to passage for smelt. Only six smelt were found upstream with many hundred downstream despite good deep pools found at both sites (refer Table below). A very thorough search for smelt and inanga was undertaken upstream of the upstream weir (in addition to the two electric fished reaches, four people searched upstream for about 500m). The downstream weir was a lesser barrier but thousands of smelt were found downstream of this structure indicating a slight impedence.

Inanga were missing at all sites sampled in 2012 despite some good habitat being present (including some deep backwater habitat).

A concrete ramp was constructed on Weir 2 during low flows in March 2014. No schools of inanga or smelt were seen above or below Weir 2 in December 2015, nor during other inspections in 2017 and early 2018. Without more information it is unclear whether the concrete ramp is providing improved fish passage. A spotlighting survey, which covers habitat further upstream of the Weir, would provide a better comparison with the 2012 results.

Table 22. Results of spotlighting surveys above and below the Wai-iti River weir d-s Waimea West Rd (Weir2) (●○○○ for Rare to ●●●● for Abundant). Note: Kōura (freshwater crayfish) were present in low numbers upstream and downstream of the weir.

| | Wai-iti Rv<br>Waimea West Rd, u-s weir<br>20/12/2012 | Wai-iti Rv<br>Waimea West Rd, d-s weir<br>20/12/2012 |
|---|---|---|
| # fish species: | 5 | 6 |
| Common bully | ●○○○ | ●●●● |
| Upland bully | ●○○○ | ●○○○ |
| Longfin eel | ●●●● | ●●●○ |
| Common smelt | ●●○○ | ●●●● |
| Torrentfish | | ●○○○ |
| Brown trout | ●○○○ | ●○○○ |

Since the concreting work was completed on Weir 2 the bed level has degraded on the downstream side causing it to become a fish passage barrier again. To further improve fish passage in the Wai-iti river, a similar concrete ramp should be constructed on Weir 1. This work is a lower priority, however, as the impedence of fish passage at Weir 1 was not nearly as high as Weir 2.

Wai-iti Weir 2 about 100m downstream of Waimea West Rd in November 2017. Note the concreted ramp (circled) provides a channel with lower water velocities and less turbulent flow. This ramp now needs to be extended across to the true right (towards the foreground of the photo).

## Waimea River Riffles

< Threat >

**Aim:** To compare the abundance of torrentfish in riffles on the Waimea River with the density of vehicle tracks in the riffles. We expected to find fewer torrentfish in riffles with more vehicle tracks. To assess the fish community generally and determine if blue gill bullies are present.

**Summary:** Torrentfish abundance was moderate to high at most sites on the Waimea River. We found no obvious relationship between vehicle track density and torrentfish abundance. This may be due to the survey's focus on vehicle tracks rather than the frequency of vehicle crossings. We suggest improvements to the study design to address this limitation.

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The Waimea River is a lowland river with a catchment area of 780 km$^2$. The river runs from the confluence of the Wai-iti and Wairoa rivers to the Waimea Inlet, a distance of only 7km. The riverbed is used as a road by an increasing number of 4WD vehicles. Vehicle tracks extend from about 500m downstream to 2km upstream of SH60 and further upstream on the Wai-iti River beds. The fish community is likely to be adversely affected by the potentially high number of vehicle movements on the riverbed each year. Most of the vehicle tracks are concentrated around riffles where torrentfish are known to live.

All electric fishing was completed on 23 December 2015, after 10 days of low flows in the river (less than 4 m$^3$/sec). Nine riffles were surveyed along a 3km stretch of river between SSH60 and the Wai-iti River confluence using single-pass electric fishing. As the riffles were wide (10 to 40 m), they were fished in sections, working from the right bank to the left bank. At each riffle, the percentage cover of vehicle tracks across the area fished was estimated.

Electric Fishing at 300m upstream Challies Rd (riffle 7 in map below)

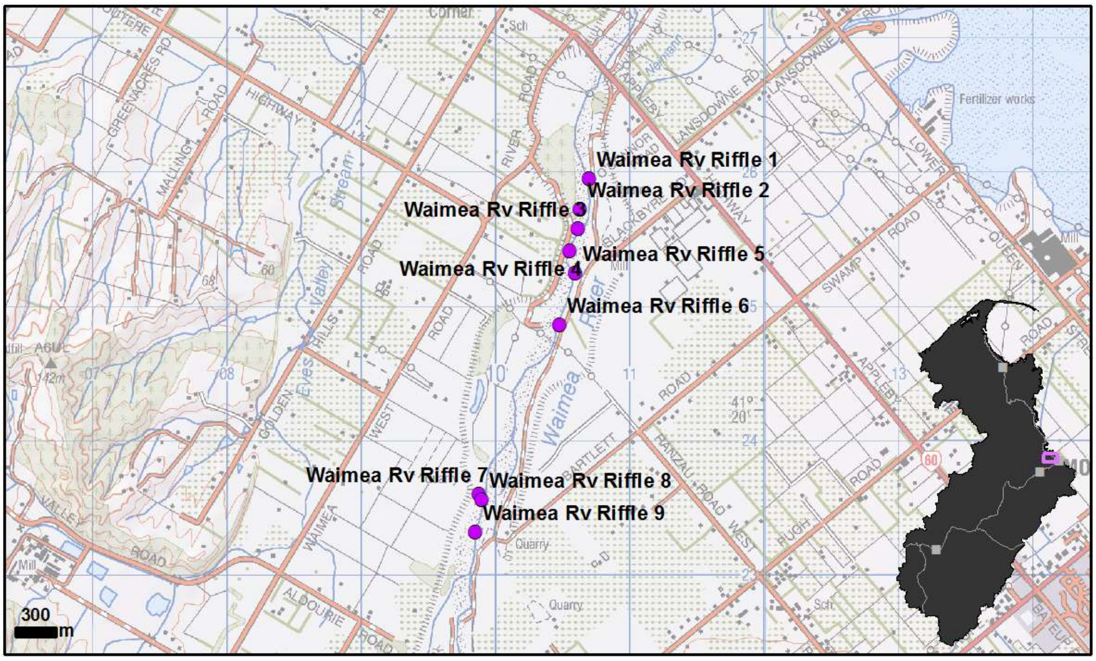


Figure 27. Waimea River fish survey locations, 23 December 2015

Vehicle track coverage of the bed, across the nine riffles fished, ranged from 0 to 70%. All the riffles sampled had a substratum dominated by small and large cobbles (60 to 250 mm). The cobbles were predominantly covered in thin algal films. There was no overhanging vegetation at any site except for several willow trees at the downstream end of riffle 1.

Water velocities in the riffles ranges from approximately 0.5 to 2 m/s. The total shock time ranged from 2 to 5 min depending on the area of the riffle fished (45 to 120 m2).

During the survey, seven fish species were caught. They were, in order of abundance, torrentfish (n = 70), short/longfin elver (56), common bully (38), longfin eel (14), common smelt (14), upland bully (4) and inanga (1). No blue-gill bullies were caught despite having a similar habitat preference to torrentfish. Blue-gill bullies have been found in the nearby Lee and Matai rivers, although at low abundance. Common smelt and inanga are likely to be present in higher abundance than found in this survey as they tend to school in the deeper pool habitat, rather than riffles.

Table 23. Fish species and abundance results for two representative riffles along the lower Waimea River (●○○○ for Rare to ●●●● for Abundant) from electric fishing on 23 Dec 2015.

| | Waimea River 800m u-s SH60 | Waimea River 1.1km u-s SH60 |
|---|---|---|
| # species: | 6 | 4 |
| Common bully | ●●●○ | ●●○○ |
| Upland bully | ●○○○ | |
| Longfin eel | ●○○○ | ●○○○ |
| Unidentified eel | ●●●○ | ●○○○ |
| Unidentified galaxiid | ●○○○ | |
| Common smelt | ●○○○ | ●●○○ |
| Torrentfish | ●●●● | ●●○○ |

Across the nine riffles fished, there was no obvious relationship between vehicle track density and the abundance of torrentfish (Figure 1). To account for differences in the total electric fishing time at each riffle, we report the number of torrent fish caught per shock minute.

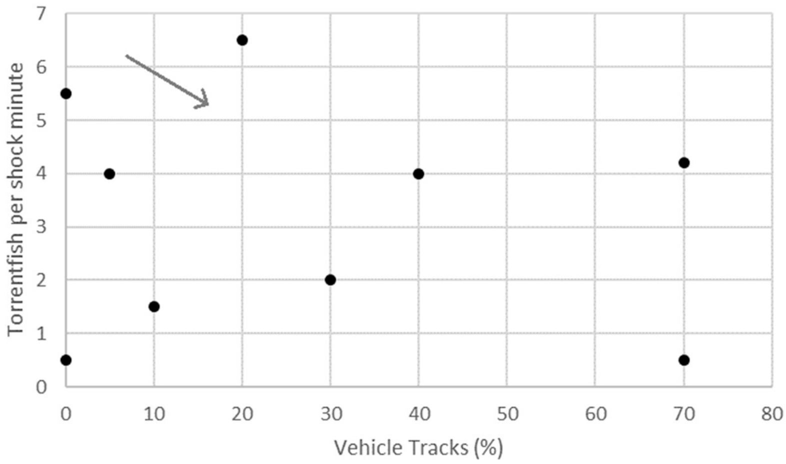


Figure 28. Torrentfish per shock minute against vehicle track density (%) in riffles on the Waimea River. The arrow indicates the direction of relationship expected.

The abundance of torrentfish in riffle habitats depends on water depth, water velocity and substrate size (Jowett & Richardson, 1995), with higher numbers found in deep, fast-flowing riffles with small cobbles. Although riffle depth was not recorded in this survey, data on the average water velocity and substrate size distribution were collected. The average water velocity was swift in each riffle (0.5m/sec or higher), and the percentage cover of small cobbles ranged from 20 to 60 percent. However, we did not find a clear relationship between either habitat parameter and torrentfish abundance in this survey.

From this survey, we cannot draw firm conclusions about the impact of vehicle crossings on torrentfish abundance in riffles. There are two main reasons for this:

First, it became obvious during the survey that vehicle tracks leave only a shallow mark in small cobbles and gravels. Given that most of the riffles had a high proportion of these substrate classes, we could easily have underestimated the vehicle track densities by 20% or more. To exclude this possibility, a future survey should include several control riffles. This could be done by roping off one bank of each control riffle two weeks before the survey. Depending on the cooperation of the vehicle drivers, a more substantial barrier may be required.

Second, we do not know if the percentage cover of vehicle tracks provides a reasonable indication of vehicle crossing frequency and therefore an accurate measure of pressure on riffle-dwelling fish. Many vehicles may cross along the same path. In that case, the frequency of vehicle crossings would increase without an increase in vehicle tracks. To address this, a more direct measure of vehicle crossing frequency should be included. One approach would be to use a camera (a webcam or camera trap would be suitable) trained on a set of riffles. By recording details of where and when vehicles crossed the river in the two weeks before conducting the survey, estimates of vehicle crossing frequency could be made.

## Neimann Ck

**Aim:** To establish the state of the freshwater fish community of Neimann Creek prior to the implementation of a restoration and management plan.

**Summary:** From the fyke nets and gee-minnow traps set overnight, shortfin eels, common bullies, inanga and one longfin eel were caught. Shortfin eel and inanga were found in abundance and longfin and common bully common in the sediment removal project in January 2018. No giant kōkopu have been found.

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Neimann Ck is a former channel of the Waimea River and is now a lowland spring-fed stream in the Waimea plains, similar to Pearl Creek on the opposite (north-west side of the Waimea River). Its source is a shallow aquifer in horticultural and pastoral land and it drains into the Waimea Inlet east of the Waimea River (length approximately 3km). Giant kōkopu were found in the stream several decades ago (Todd, pers.com.).

Neimann Ck Spring Source looking downstream (Dec 2015)

A major issue for Neimann Ck is the presence of thick deposits of fine sediment on the streambed, averaging 500mm in the upper reaches. This thick sediment layer reduces the available habitat for macro-invertebrates and fish. A restoration and management plan was produced for Neimann Creek in 2015 (Lindsay, 2015) and the removal of fine sediment from the creek was carried out in January 2018 using a digger and willowcontrol in winter 2017. The main riparian planting operation will occur in winter 2018.

Dissolved oxygen in the creek is low (daily minimum around 20% saturation) and is likely to be affecting fish communities. Given that daily fluctuations correlate with photosynthetic activity, it is most likely that it is the excessive growth of aquatic plants that are the main cause. Shading the stream with riparian tree cover is the best solution for this.

In anticipation of stream restoration work being conducted, a fish survey was conducted in Neimann Ck to establish the pre-restoration state of the fish community.

Setting fyke nets in Neimann Ck, 29 March 2016

Three fyke nets and six gee-minnow traps were set at 4pm on 29 March and collected at 9am on 30 March. The nets were arranged such that two gee-minnow traps were in close proximity to each fyke net (approximately 3m upstream and 3m downstream). The location of the fyke nets are shown below. Species and length were recorded for all fish caught.

A spotlighting survey was carried out in January 2012 from 20m d-s Landsdowne Road to up past the speedway to the upstream boundary of the Todd's property.


Figure 29. Location of fyke nets in Neimann Ck, 29 March 2016

In 1988 there was a record of brown trout but they have not been found in any survey since. It is possible that this is due to water quality degradation.

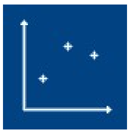
The 2012 survey found inanga in schools of up to about 100 fish (averaging about 50-70mm long), shortfin eel were common (300-800mm long), longfin eel in low numbers (600-800mm long) and common and giant bully in low numbers and only downstream Landsdowne Rd. Paratya shrimp were abundant and kōura were rare.

During the 2016 survey the flow in Neimann Ck was approximately 50L/sec, the water was clear and the water temperature was approximately 16°C.Inanga and common bully were caught in the gee-minnow traps. One longfin eel and 26 shortfin eels were caught in the fyke nets.

Table 24. Fish species and abundance at Neimann Creek 600m u-s Lansdowne Rd (●○○○ for Rare to ●●●● for Abundant).

| | Neimann Ck 600m u-s Lansdowne Rd 30/03/2016 |
|---|---|
| Common bully | ●●○○ |
| Longfin eel | ●○○○ |
| Shortfin eel | ●●●● |
| Inanga | ●●●● |

## Borck Creek, Richmond



**Aim:** To compare the diversity and abundance of fish before and after stream restoration.

**Summary:** Eels, common bullies and inanga were abundant. Fish salvage operations found over 1000 fish per 100m of stream length. Schools of Gambusia (Mosquitofish) were found at two sites. Although none of these pest fish were seen in the 2016 survey, they are likely still present.

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Borck Creek is located on the Waimea Plains close to Richmond and drains into the Waimea Inlet. The whole area was a wetland prior to the 1800's, but was drained and the straight channel of Borck Creek was dug. It is fed from tributaries flowing off the Barnicoat Range. During summer the mid reaches (from downstream of Paton Road to about 1.5km upstream from lower Queen St) go dry. This is due to high permeability of the stream bed and consequent loss of stream water to groundwater. The water re-emerges in a spring about 1.5km upstream of lower Queen St. Analysis of the spring water shows that it is very young and is a mix of groundwater from the Hope Unconfined Aquifer and surface water fed from the Barnicoat Range.

In 2015, the creek was diverted into a newly constructed channel from approximately 300m above to 400m below Lower Queen St, Richmond. The primary driver for this diversion was to cater for increased floodwater from expanding urban development (with the resultant increase in proportion of land cover with impervious surface). The new channel was designed to include a greater range of habitats for aquatic life than the old channel. While the old channel was straight, with little variation in water width and depth, the new channel has a natural meander with more width variation. Logs have also been embedded into the banks to provide instant cover for fish and about 300mm depth of clean cobble-dominated gravels placed on top of the new channel base to create habitat for fish and invertebrates. Wetland areas were created adjacent to the channel with swales dug to connect the wetlands to the main channel during high flows. Riparian trees and grasses were planted in July-August 2016 on elongated 'islands' adjacent to the channel. The islands help to keep the tree roots above the waterlogged soil. In time, the trees are anticipated to result in about 60% shading of the stream and should reduce the proliferation of filamentous algae.

The main water quality issues in Borck Creek are high nutrient concentrations, low dissolved oxygen levels in summer, and fine sediment deposits in the stream (James & McCallum, River Water Quality in Tasman District 2015, 2015). The creek has elevated nitrate-N concentrations (2017 annual median nitrate-N = 5.3 g/m$^3$). This is mostly an issue for fueling the excessive filamentous green algae growth (the highest coverage in Tasman District). When the hardness of the water is considered, however, this elevated nitrate is well below toxicity levels for native fish (Hickey, 2015).

Flow in the stream was approximately 30 L/sec. There was very high coverage of filamentous green algae along the full length of the surveyed reach (approximately 90%, image below). Near both banks, the filamentous green algae mats were particularly thick and there were patches of macrophytes. It is difficult to estimate the number of fish hidden by the algal mats and macrophytes during the survey (it is likely that less than half the number of eels present in the stream were recorded).


Left: Borck Creek about 400m downstream of Lower Queen St viewed upstream (January 2009). Right: Borck Creek 200m downstream of Lower Queen St (June 2017). Note the meander, the log in the foreground for instant fish cover and the *Carex* grasses and trees planted on the banks.

On 27 January 2016, after the stream diversion work was complete, a 150m reach from 350m d-s Lower Queen St to 200m d-s Lower Queen St was surveyed using a backpack electric fishing machine.


Figure 30. Borck Creek fish survey location (2018 Aerial Imagery)

Borck Ck 350m d-s Lower Queen St, view u-s in 2017 (the stormwater drain from the TNL yard is on the right)

Filamentous green algae in Borck Creek while electric fishing (January 2016)

Several schools of inanga were caught as well as common bully, shortfin eel and longfin eel. There were also a large number of elvers.

Two fish salvage operations were conducted, in March and May 2015, prior to filling in the old channel. These found over 1000 fish per 100m of stream. *Gambusia* were found in the stormwater drain near the TNL yard and the main stem approximately 30 metres upstream of the confluence (R. Olley, pers. comm.). As *Gambusia* are able to tolerate a wide range of conditions, it is surprising that none were sighted in the 2016 survey.

In the old channel, six giant bullies were caught (90 to 140mm in length) but they were not caught in the new channel. We also expected to see redfin bullies in the lower reaches of Borck Ck but they were absent in both the salvage and the present survey. Riparian planting may help to provide more suitable habitat for these species, as well as the increase in amount of riffle habitat, as well as increase the abundance of inanga, common bully and longfin eel.

Table 25. Fish species and abundance at Borck Ck below Queen St (●○○○ for Rare to ●●●● for Abundant). Freshwater crayfish were seen by spotlighting in October 2008.

| | Spotlighting Oct 2008 | E-Fishing Feb 2010 | Fish salvage March 2015 | Fish salvage May 2015 | E-Fishing Jan 2016 |
|---|---|---|---|---|---|
| # fish species: | | | 5 | 4 | 4 |
| Common bully | | ●○○○ | ●●●● | ●●●● | ●●○○ |
| Giant bully | | | ●●○○ | ●●●○ | |
| Longfin eel | ●●●● | ●○○○ | ●●●● | | ●●○○ |
| Shortfin eel | ●●●● | | ●●●● | | ●●●○ |
| Unidentified eel | | | ●●●● | ●●●● | ●●●● |
| Inanga | ●●●○ | ●●●● | ●●●● | ●●●● | ●●●● |
| Inanga (jv) | ●●●○ | ●●●● | | | |
| Common smelt | | ●○○○ | | | |

Determining the effectiveness of the restoration on ecological health of this stream before and after the new meandering channel of Borck Ck (diversion from the old straight channel) is limited by the riparian planting taking at least a decade to grow to a point of making a difference for fish. The fish monitoring site on the lower reach is a long-term monitoring site.

## Borck Creek Tributary, Richmond

**Aim:** To record the diversity and abundance of fish species in the residual pools of a Borck Creek tributary using a spotlighting survey.

**Summary:** Only 5 eels and 8 banded kōkopu remained in the residual pools along 150m of stream length.

Borck Creek is fed from tributaries originating in the Barnicoat Range. One of these tributaries runs west of Hart Rd, Richmond. It drains a small catchment (less than 0.5 $km^2$) including the Sunview Heights residential area and a mix of pastoral and horticultural land. After long periods with no rain, this tributary stops flowing leaving only residual pools for fish to live in.

A spotlighting survey of this tributary was carried out on 5 March 2015, towards the end of an unusually dry summer. The survey was conducted from the NW boundary of 42 Hart Rd (property owner Angus Malcolm) to a point 150m upstream.

The residual pools in the survey reach were between 0.5 and 2 m wide. The substratum was muddy (40% cover) with some fine gravel and coarse gravel (20% each). Most of the reach had undercut banks with grass overhanging the channel. Riparian planting had been completed along both banks but these were too young to provide shading at the time of the survey.

In total, 5 shortfin eels (200 to 500mm) and 8 banded kōkopu (80 to 200mm) were seen in the residual pools. Common bullies were not seen, although they are tolerant of still water.

These results provide an indication of the fish community that remains in the low flow residual pools of the Borck Ck tributaries. By conducting similar spotlighting surveys in other Borck Ck tributaries, the fish community could be better characterised.

Residual pool in Borck Creek Trib at 42 Hart Road

# Reservoir Creek, Richmond

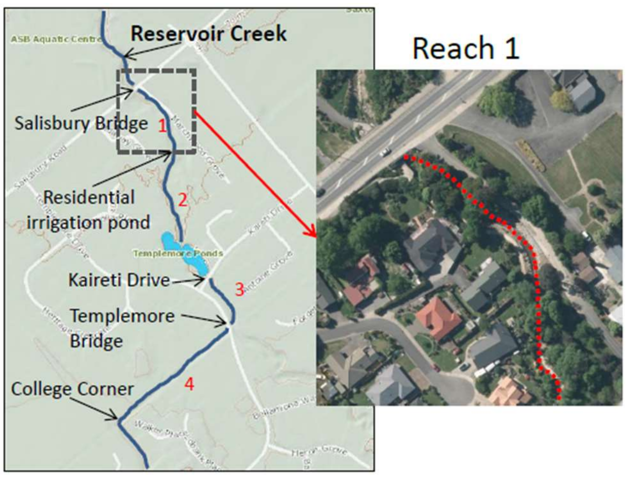
**Aim:** To assess changes in the fish community of Reservoir Ck between 2006 and 2016.

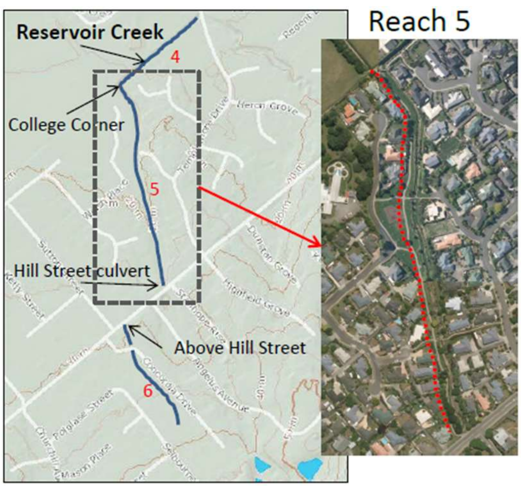
**Summary:** A very similar pattern of fish abundance and distribution was found over the years (2006, 2008 and 2016). Eels and inanga were abundant in the lower reaches but, above Hill Street, few fish species were observed. One likely reason is that the long culverts at Hill Street and downstream of Easby Park are causing high water velocity therefore and restricting fish passage .

Reservoir Creek was named for the old water supply reservoir built in the creek in its upper reaches in the early 1890's. This structure was a fish passage barrier up until 2014 when an elaborate fish pass/spillway was constructed. The creek begins in the Barnicoat Range and ends at the Waimea Estuary at a point near the edge of Richmond, bordering Stoke. Below the old reservoir, two sections of the creek are piped (470 m total length). Above the old reservoir, the riparian zone (the land on both banks) contains steep but highly diverse habitat with a riparian zone comprised of numerous old-growth native trees.

The entire length  of Reservoir Creek was electric fished, from upstream of the estuary to upstream Hill St (along Concordia Lane), on 18 March 2016. The electric fishing was followed by a spotlighting survey over the same section one week later. In addition, electric fishing was conducted above and below the Reservoir creek spillway in upper Reservoir Creek over three days in March to determine whether the spillway was a barrier to native fish passage. Two detailed reports on the investigation are available, one for the lower reaches (Olley, 2016a) and one for the upper reaches (Olley, 2016b). Here we provide a summary of findings from these reports.

The 2016 fish surveys are a repeat of similar surveys conducted in 2006 (lower reaches) and 2008 (upper reaches).



**Lower reaches surveyed on Reservoir Creek by electric fishing and spotlighting, March 2016, with detailed inset maps for reaches 1 and 5.**

The stream habitat varied widely between the six reaches surveyed. Reach 1 and 2 had deep pools well shaded by riparian plants. Reach 3 and 4 were rock armoured to protect from bank erosion whilst maintaining storm water capacity. This creates relatively uniform cross-section and longitudinal depth profile (thalweg), providing lower quality fish habitat.

Although habitat in some reaches was good, several fish species we expected to see, such as banded kōkopu and kōaro, were not observed in any of the reaches below Hill Street. These species require the presence of tree cover and space between the cobbles of the stream bed, more than the other fish found in this survey. The likely limiting factors for kōkopu and kōaro numbers include degraded stream habitat, high levels of fine sediment deposited in the stream and potentially predation from other fish species (predominantly eels) at the spillway/fish pass on the old reservoir.

In 2016 both species of eels and inanga were abundant throughout lower Reservoir Creek (below Hill Stream; reaches 1 to 5), and very abundant at some locations. Above Hill Street, even though some of the habitat was fish friendly, only eels and one common bully were observed. One juvenile banded kōkopu was observed at Easby Park shortly after the survey.

The Hill Street culvert and the rock work and geotextile filter cloth at the upstream end, were identified as a major fish passage barrier (see photo below). Whilst the geotextile filter cloth was partially cleared to create fish passage, the Hill Street culvert remains a barrier to inanga and bullies.

Reservoir Creek about 10m upstream of Hill St, March 2016.

Eels are able swim or climb up the culvert and even wriggle on land around obstacles. Eels (both adult and juvenile shortfin and longfin) were the only fish found at the top of the survey site. Because eel numbers were much lower in comparison to downstream reaches, it is considered very likely that the culverts are acting as a significant impedance to fish passage.

Overall, there was a very similar pattern of fish abundance and distribution in the 2016 surveys compared to the 2006 and 2008 surveys.

**Comparison over time**

In the electric fishing survey below the spillway of the Reservoir (see photo to the right), only eels and one juvenile galaxiid were observed (in Easby Park). The absence of other species was surprising because there are pools and riparian cover in this part of the stream. Limiting factors may be the high levels of fine sediment and fish passage barriers through the middle of Reservoir Creek (Hill St to Easby Park as discussed above). During the spotlighting survey on the spillway, eels were found lying on the upstream side of about half the baffles. These baffles are attached like rungs of a ladder to the invert of the spillway and most are made of plastic, hollow and have an entry hole in the top. It is likely that the eels are residing inside these plastic baffles during the day and coming out at night to feed.

The spillway/fish pass on Reservoir Creek 2016

Further fish passage restoration on Reservoir Creek:: baffles were installed in spring 2018 through the Hill Street and Easby-Concordia culverts (with the associated trash rack). Baffles are considered the best option to reduce the high water velocity which is the most likely reason preventing fish passage.

A floating ramp was installed on the outlet of the Tower Road culvert after the conveyor belt apron was found to fold back under the culvert and therefore create an overhang and therefore not allow for fish passage.

Left: Tower Road culvert with a rubber apron (February 2014). Right: With a floating ramp and baffles within the culvert (November 2016).

Once these interventions have been implemented, follow up fish surveys and a mark-recapture study will be conducted above and below the Hill Street and Easby-Concordia culverts to determine whether fish passage for native fish has been achieved.

## Saxton Creek, Richmond

**Aims:** To assess the abundance and diversity of fish in Saxton Ck upstream of Champion Rd and in the lower reaches.

**Summary:** In the upstream reach, above Champion Rd, the number of large eels and juvenile galaxiids appeared to decline between 2012 and 2017. There was a high diversity and abundance of fish in the lower reaches of Saxton Creek. Inanga and banded kōkopu were abundant.

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Saxton Creek flows between Richmond and Stoke, from the headwaters in the Barnicoat Range to the Waimea Inlet. The lower part of the catchment is suburban and the upper part is in forestry. Parts of the upper reaches of Saxton Creek run dry during low summer flows due to loss of water to groundwater. Sediment discharges and direct disturbance of the stream bed by beef stock has been ongoing for decades in this section of waterway from about 300m upstream of Champion Road.

**Upper reach:**

A 150m reach located about 1.3km above Champion Rd (**upper reach**) was surveyed by backpack electric fishing and spotlighting. Replicate surveys were carried out in December 2012 and January/February 2017.

In the 10 days prior to the surveys, both 2012 and 2017, there was less than 5 mm of rainfall and the stream was in low flow.

Saxton Creek at this location runs through an area of exotic scrub and sparse native vegetation. The stream is well shaded and flows through an unmodified pattern of run riffle and pool.

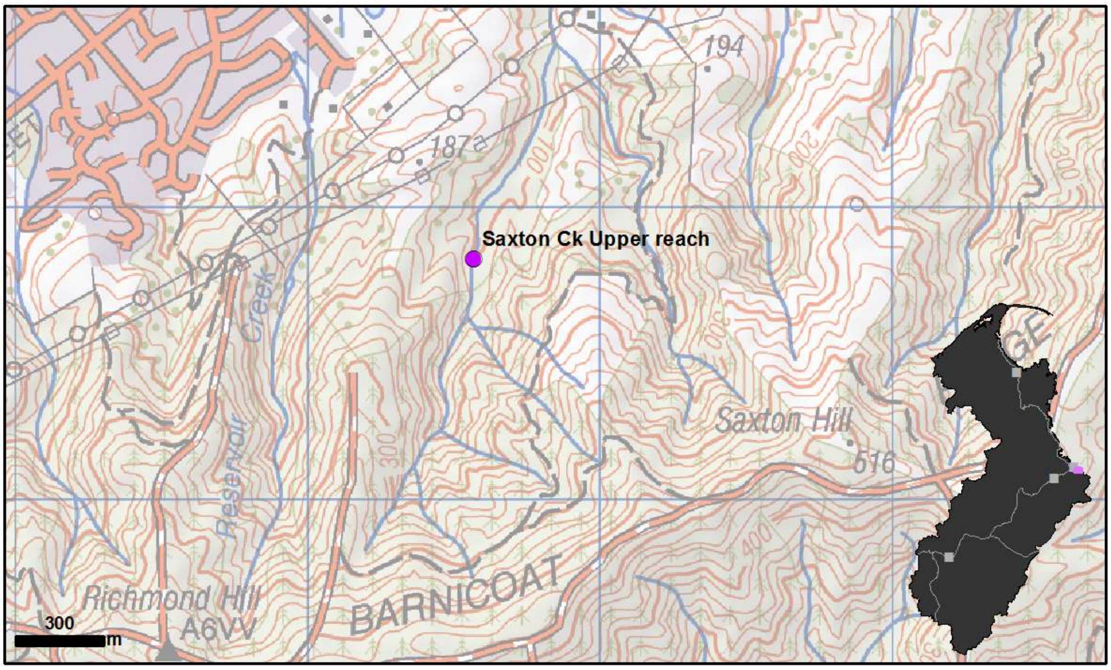


Figure 31. Saxton Creek fish survey location (upper reach)

There are low numbers of upland bullies present throughout Saxton Creek and large numbers of diadromous species of bullies within its lower reaches. Given that, it is difficult to explain the lack of bullies in the upper reach. The stream habitat did not change noticeably between surveys and there were no significant barriers to good climbers such as redfin bullies. If bullies are present here, then they are likely to be in very low numbers.

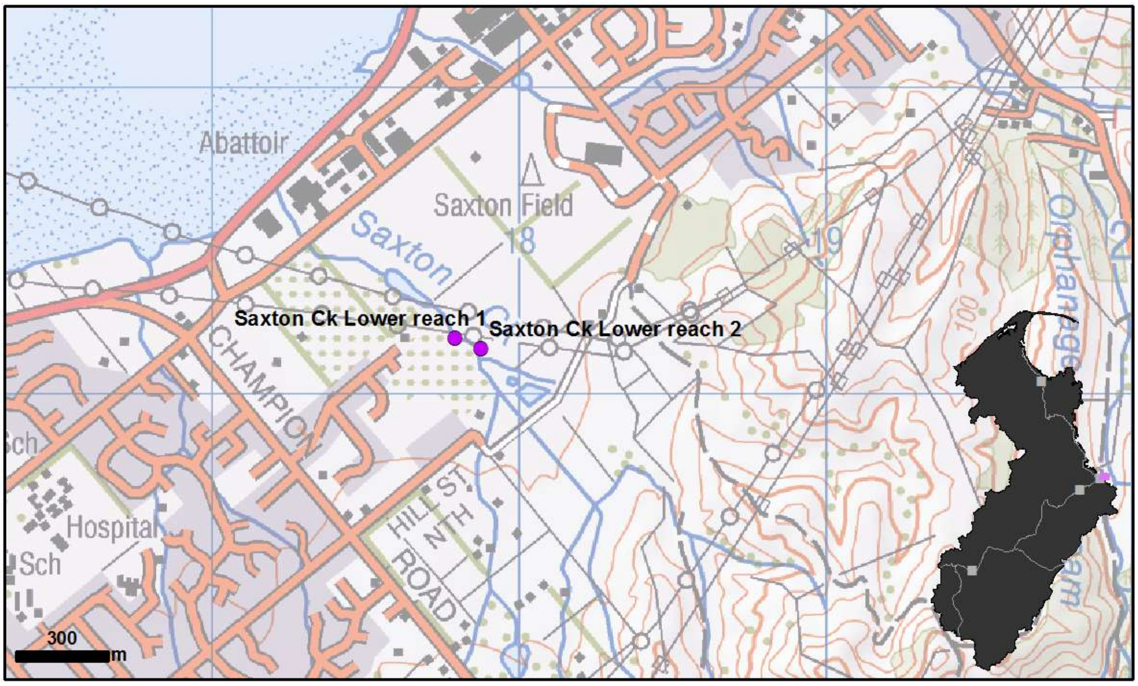


Figure 32. Saxton Creek fish survey locations (lower reaches)

**Lower reaches:**

Exploratory spotlighting and electric fishing surveys were conducted along two lower reaches, near Saxton Oval, in December 2012 (**lower reach 1** and **lower reach 2**). The spotlighting surveys were completed in the evening of the same day as the electric fishing surveys.

The fish community in **lower reach 2** was surprisingly diverse and abundant given the muddy bottom through much of the reach, and collapsing banks due to damage by cattle. This is most likely due to the good meander, variety of depth and width and occasional over-hanging trees. Present in this reach were schools of large numbers of inanga, reasonable numbers of eels and some banded kōkopu (Table 27).

**Lower reach 1** had fewer fish than **lower reach 2**. This reach was straightened (perhaps decades ago) and now has very little variation in bank shape, water depth or width. Most of the fish recorded from this reach were found below the solitary willow tree providing shade to the top end of the reach.

**Comparison over time:**

In 2017, the numbers of large eels found in the upper reaches was much lower than that found in 2012 (from 25 to 5), while the number of juvenile galaxiid reduced from 20 to zero. The numbers of small eels, adult galaxiid and crayfish were similar in both years.

The reduction in large eel numbers in the upper reaches seems unlikely to be a result of any changes in habitat, as no significant changes were observed. Instead, it could be a result of individuals moving out of the reach later in summer in response to a longer period of stream drying. The lack of juvenile galaxiids is unlikely to be seasonal, as at least some would likely still be present in the months following the peak run in late spring. More likely is that the considerable engineering re-alignment work that occurred within the lower reaches of Saxton Creek throughout 2016 and 17 has disrupted the migration in 2017, or that 2017 saw a poor run of this species (as could have been the case at Dominion Stream also).

Table 26. Fish species and abundance at Saxton Creek upper reach (●○○○ for Rare to ●●●● for Abundant) from electric fishing and spotlighting surveys in 2012 and 2017. Note: Kōura (freshwater crayfish) were present in low numbers on both sampling events.

| | Upper reach Electric Fishing **19/12/2012** | Upper reach Spotlighting **19/12/2012** | Upper reach Electric Fishing **17/01/2017** | Upper reach Spotlighting **20/02/2017** |
|---|---|---|---|---|
| # fish species: | 4 | 3 | 3 | 2 |
| Longfin eel | ●●○○ | ●●○○ | ●○○○ | |
| Unidentified eel | ●○○○ | | ●●●● | ●○○○ |
| Shortfin eel | | | | ●○○○ |
| Unidentified galaxiid | ●●○○ | ●○○○ | ●○○○ | |
| Kōaro | ●○○○ | | | |
| Banded kōkopu (jv) | ●●○○ | | | |
| Banded kōkopu | | ●○○○ | ●○○○ | ●○○○ |

Saxton Creek upstream Champion Road

Table 27. Fish species and abundance at Saxton Creek lower reaches (●○○○ for Rare to ●●●● for Abundant) from electric fishing and spotlighting surveys in 2012. Note: Kōura (freshwater crayfish) were present in lower reach 2 but not lower reach 1.

| | **Lower reach 1**<br>Electric Fishing<br>19/12/2012 | **Lower reach 2**<br>Electric Fishing<br>19/12/2012 | **Lower reach 2**<br>Spotlighting<br>19/12/2012 |
|---|---|---|---|
| # fish species: | 5 | 5 | 4 |
| Redfin bully | ●○○○ | | |
| Longfin eel | ●○○○ | ●●●○ | ●○○○ |
| Shortfin eel | ●●○○ | ●●●○ | ●●○○ |
| Unidentified eel | | ●●○○ | |
| Unidentified galaxiid | | ●●○○ | ●●●● |
| Inanga | ●○○○ | ●●●○ | ●●●○ |
| Inanga (jv) | | ●●●○ | ●●●● |
| Kōaro (jv) | | ●●○○ | |
| Banded kōkopu (jv) | ●●●● | ●●●● | ●●●● |
| Banded kōkopu | | | ●○○○ |

# Waterways of the Buller

## Station Creek and Tributaries, Kawatiri

**Aim:** To track changes in the diversity and abundance of fish, including trout, in Station Creek and its tributaries.

**Summary:** Electric fishing in March 2010 and January 2013 found low species diversity typical of upper Buller and Upper Motueka catchments.

Three weeks prior to sampling (January 2013), there was a flood of 50 to 100 times base flow in the stream. The debris line from this flood was visible roughly 1.5 m above the water level on the day of sampling. According to the landowner, there were very low flows prior to this flood with the stream 'almost drying up' at the end of December.

Pools in Station Creek were much deeper than when sampled previously in 2010 (Tom Kroos, *pers comm*). High numbers of invertebrates were seen, indicating that the low flows had not dried up the creek.

There were very low numbers of trout (or none in the case of Fraser Gully). This could be due to the lack of spawning adults in the Buller River ((Fish and Game data) and a series of medium-high flow events from July-September 2012 (most of the spawning season).

Station Creek upstream Fraser Gully – upland bully and dwarf galaxias were very abundant (near carrying capacity) in the sample reach despite no riparian trees to provide shade. Bare earth from cattle trampling along the stream banks was only evident along <5% of the stream. Bank collapse was most likely due to under-mining from floods rather than stock.

In Long Gully and Station Creek below Station Creek road had much lower numbers of fish despite much better tree and bush cover and in-stream cover (woody debris and boulders). Trout were present in low numbers at these lower two sites.

Table 28. Fish species and abundance at Station Creek (●○○○ for Rare to ●●●● for Abundant).

| | Station Ck u/s Fraser Gully 12/03/2010 | Station Ck d/s Long Gully 12/03/2010 | Station Ck d/s Higgins Rd Br 29/01/2013 |
|---|---|---|---|
| # species: | 4 | 4 | 4 |
| Upland bully | ●●●● | ●●●● | ●●●● |
| Longfin eel | ●●○○ | ●●○○ | ●●○○ |
| Dwarf galaxias | ●●○○ | ●●●○ | ●●●● |
| Brown trout | ●●○○ | ●●●● | ●●○○ |

## Black Valley Stream

**Aim:** To characterise the fish community of Black Valley Stream and to record the abundance of trout.

**Summary:** High abundance of brown trout and low abundance of longfin eel and upland bully.

Black Valley Stream flows through the St Arnaud township into Lake Rotoiti. Electric fishing of a reach parallel to Bridge Street was conducted in January 2013.

Very good water quality has been found for the lower reaches of this waterway over the 15 years of record in TDC's water quality monitoring programme. The macroinvertebrate community was "excellent" or close to "excellent" (MCI over 120) over this period, but is showing signs of declining, possibly due to increasing urbanisation.

High numbers of trout were found in this stream despite approximately 30% cover of filamentous green algae. Such algae when it gets over about 30% reduces the ability of trout to sight their prey and takes up space within the water column that trout like to occupy. In addition, it can clog gills and reduce the quality of the invertebrates available to trout.

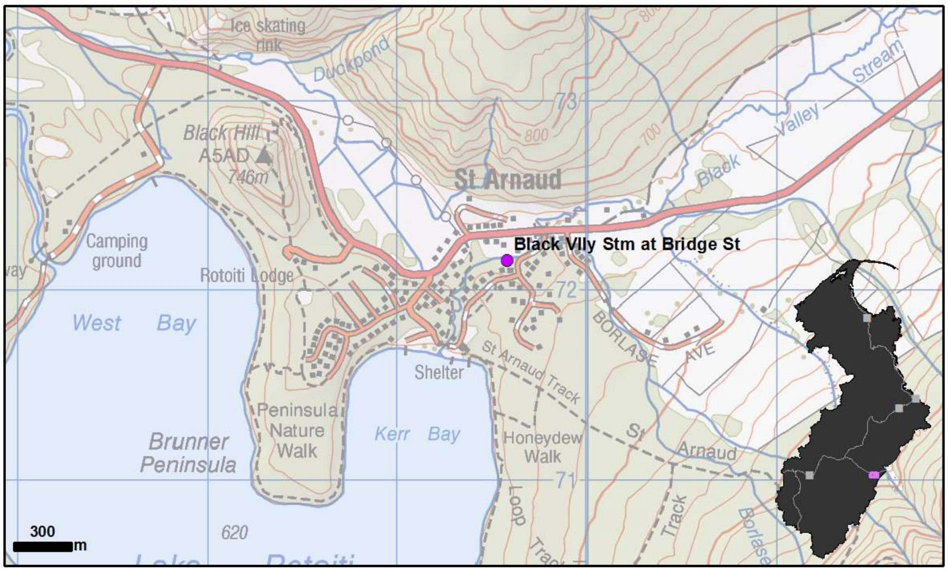


Figure 33. Black Valley Stream fish survey location

Table 29. Fish species and abundance at Black Valley Stream (●○○○ for Rare to ●●●● for Abundant).

| | Black Valley Stm Bridge Street foot Br 29/01/2013 |
|---|---|
| Upland bully | ●○○○ |
| Longfin eel | ●●○○ |
| Brown trout | ●●●● |

# Recommendations for Future Monitoring

With increased funding for the Tasman Freshwater Fish Monitoring Programme (from $10,000 to $25,000 per year), there is an opportunity to develop the programme to better provide for trend information, alongside information provided by impact monitoring (the dominant aim to date). A suggestion is to allow 50% of budget for trend sites to be sampled every two years. An application for Envirolink funding to provide for expert advice on the design of the monitoring programme should be made.

Candidates for long-term trend sites include:

- Small creeks between Pakawau and Puponga.
- Burton Ale catchment: representative of a small low-gradient creek impacted by intensive pastoral farming. Sample both good and poor habitat sites. Repeat the sites sampled in 2011.
- Onekaka catchment: The Shambala Road site is a good contender being low in the catchment and having a particularly high fish diversity and abundance (sampled in 2011 and 2018). However, monitoring at this site needs to be integrated with monitoring at the three sites sampled as part of the Electric Waters Ltd resource consent. An additional site to the four described above is probably needed to act as an appropriate control for the potential effect caused by EWL.
- Horton Road Stream: pastoral catchment with remnant wetlands
- Dominion Stream: representative of hill country streams of the Waimea Inlet.
- Borck Creek: representative of a catchment undergoing increasing urbanisation.
- Neimann or Pearl Creek: representative of spring-fed streams of the Waimea.

Further impact monitoring:

- Repeat sampling at Teapot Valley following fish passage restoration downstream.
- Totaranui Road culverts for the third time to be convinced that young kōaro and banded kōkopu are using the rubber aprons.
- Matakitaki Station following dairy land use intensification

Sampling of restoration projects:

- Borck Creek, Waimea
- Neimann Creek, Waimea
- Dominion Stream, Waimea
- Supplejack Valley Stream, Moutere
- Tasman Vly Stm upstream Horton Rd
- Waiatua Stream at Hickmotts (pending restoration)
- Matenga Creek, Ligar Bay
- James Cutting Creek d-s Collingwood-Bainham Road

Methods:

- Consider rolling out the use of eDNA and pheromone traps following the trial in January 2019.
- Undertake an assessment of natural meander and riparian tree cover using GIS methods (currently underway using Morphum Ltd)

# References

Crow, S. (2017). *New Zealand Freshwater Fish Database. Version 1.2.* The National Institute of Water and Atmospheric Research (NIWA). Retrieved from https://doi.org/10.15468/ms5iqu

Davey, L., & Deans, N. (2002). *Freshwater Fisheries and Invertebrate Survey of Kainui Stream and Quail Valley Stream for the Proposed Wai-iti Water Augmentation Scheme.* Nelson Marlborough Fish and Game Council.

Department of Conservation NZ. (2017). *New Zealand's Threatened Species Strategy - Draft for Consultation.* New Zealand Government.

Goodman, J. M., Dunn, N. R., Ravenscroft, P. J., Allibone, R. M., Boubee, J. A., David, B. O., . . . Rolfe, J. R. (2014). *Conservation status of New Zealand freshwater fish, 2013.* New Zealand Department of Conservation.

Harding, J. S., Young, R. G., Hayes, J. W., Shearer, K. A., & Stark, J. D. (1999). Changes in agricultural intensity and river health along a river continuum gradient. *Freshwater Biology*, 345-357.

Hickey, C. (2015). *Hardness and Nitrate toxicity – site-specific guidelines for spring-fed streams in the Waimea and Motupipi river catchments and Waikoropupu Springs.* NIWA.

James, T., & Kroos, T. (2011). *The Health of Freshwater Fish Communities in Tasman District 2011.* Tasman District Council.

James, T., & McCallum, J. (2015). *River Water Quality in Tasman District 2015.* Tasman District Council.

James, T., & Mullis, K. (2014). *Water Quality and Aquatic Ecology of Burton Ale Creek.* Tasman District Council.

Jowett, I. G., & Richardson, J. (1995). Habitat preferences of common, riverine New Zealand native fishes and implications for flow management. *New Zealand Journal of Marine and Freshwater Research, 29*, 13-23.

Joy, M. (2009). *Temporal and land-cover trends in freshwater fish communities in New Zealand's rivers: an analysis of data from the New Zealand Freshwater Fish Database 1970 - 2007.* Massey University.

Joy, M. K., Foote, K. J., McNie, P., & Piria, M. (2018). Decline in New Zealand's freshwater fish fauna: effect of land use. *Marine and Freshwater Research*. doi:10.1071/MF18028

Joy, M., David, B., & Lake, M. (2013). *New Zealand Freshwater Fish Sampling Protocols.* Palmerston North: Massey University.

Julian, J. P., Beurs, K. M., Owsley, B., Davies-Colley, R. J., & Aussiel, A.-G. E. (2017). River water quality changes in New Zealand over 26 years: response to land use intensity. *Hydrology and Earth System Sciences*, 1149-1171.

Leathwick, J., Julian, K., Elith, J., & Rowe, D. (2008). *Predicting the distribution of freshwater fish species for all New Zealand's rivers and streams.* NIWA Client Report HAM2008-005.

Lee, F., Simon, K., & Perry, G. (2017). Increasing agricultural land use is associated with the spread of an invasive fish (Gambusia affinis). *Science of the Total Environment*, 1113-1123.

Lindsay, H. (2015). *Neimann Creek Restoration & Management Plan.* Department of Conservation.

McIntosh, A. R. (2000). Habitat- and size-related variations in exotic trout impacts on native galaxiid fishes in New Zealand streams. *Can. J. Fish. Aquat. Sci*, Vol 57.

Olley, T. (2016a). *An ecological fish survey of Reservoir Creek to determine fish passage barriers, and recommendations for improved fish passage in these problem areas.* Tom Kroos Fish and Wildlife Services Ltd.

Olley, T. (2016b). *Fish Survey of Reservoir Creek, RM100464V1 Condition 6 - Fish Passage.*

Olley, T. (2017). *An ecological fish survey on Wai-Atua Stream and Arnott Stream; Exploring the evidence for fish passage concerns.* Fish & Wildlife Services.

Ramezani, J., Akbaripasand, A., Closs, G. P., & Matthaei, C. D. (2016). In-stream water quality, invertebrate and fish community health across a gradient of dairy farming prevalence in a New Zealand river catchment. *Limnologica, 61*, 14-28.

Smith, J. (2014). *Freshwater Fish Spawning and Migration Periods.* NIWA Client Report HAM2014-101.

Stark, J. D. (2018). *Onekaka River Biomonitoring.* Stark Environmental Report 2018-03.

Townsend, A. J., de Lange, P. J., Duffy, C. A., Miskelly, C. M., Molloy, J., & Norton, D. A. (2008). *New Zealand Threat Classification System manual.* Wellington: Science and Technical Publishing, Department of Conservation.

Unwin, M. J. (2016). *Angler usage of New Zealand lake and river fisheries.* Christchurch: National Institute of Water & Atmospheric Research.

# Appendix 1: Conservation status criteria

The Department of Conservation assesses the conservation status of freshwater fish using the New Zealand Threat Classification System manual (Townsend, et al., 2008).

## Nationally Vulnerable

Any one of these criteria trigger Nationally Vulnerable:

**A—small, increasing population (unnatural)**
A1: 250–1000 mature individuals, predicted increase greater than 10%
A2: 5 or fewer subpopulations, 300 or fewer mature individuals in the largest subpopulation, predicted increase greater than 10%
A3: Total area of occupancy of 10 ha (0.1 km2) or less, predicted increase greater than 10%

**B—moderate, stable population (unnatural)**
B1: 1000–5000 mature individuals, stable population
B2: 15 or fewer subpopulations, 500 or fewer mature individuals in the largest subpopulation, stable population
B3: Total area of occupancy 100 ha (1 km2) or less, stable population

**C—moderate population, with population trend that is declining**
C1: 1000–5000 mature individuals, predicted decline 10–50%
C2: 15 or fewer subpopulations, 500 or fewer mature individuals in the largest subpopulation, predicted decline 10–50%
C3: Total area of occupancy 100 ha (1 km2) or less, predicted decline 10–50%

**D—moderate to large population, and moderate to high ongoing or predicted decline.**
D1: 5000–20 000 mature individuals, predicted decline 30–70%
D2: 15 or fewer subpopulations and 1000 or fewer mature individuals in the largest subpopulation, predicted decline 30–70%
D3: Total area of occupancy 1000 ha (10 km2) or less, predicted decline 30–70%

**E—large population, and high ongoing or predicted decline.**
E1: 20 000–100 000 mature individuals, predicted decline 50–70%
E2: Total area of occupancy ≤ 10 000 ha (100 km2), predicted decline 50–70%

## At Risk – Declining

Taxa that do not qualify as Nationally Critical, Nationally Endangered or Nationally Vulnerable because they are buffered by large population size and/or a slower rate of decline than the trigger points.

Any one of these criteria trigger At Risk - Declining:

**A—moderate to large population and low ongoing or predicted decline**

A1: 5000–20 000 mature individuals, predicted decline 10–30%

A2: Total area of occupancy 1000 ha (10 km2) or less, predicted decline 10–30%

**B—large population and low to moderate ongoing or predicted decline**

B1: 20 000–100 000 mature individuals, predicted decline 10–50%

B2: Total area of occupancy 10 000 ha (100 km2) or less, predicted decline 10–50%

**C—very large population and low to high ongoing or predicted decline**

C1: More than 100 000 mature individuals, predicted decline 10–70%

C2: Total area of occupancy greater than 10 000 ha (100 km2), predicted decline 10–70%