Water Ways Consulting

Tekapo Power Scheme: Native fish assessment of ecological effects.

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Cover photo: The Takapō River

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1. EXECUTIVE SUMMARY

Native freshwater fish surveys have been conducted in the Tekapo catchment during the summers of 2018-19 and 2019-20. In the first summer these surveys concentrated on fishing sites in the Takapō River between Lakes Takapō and Benmore. In the second summer the surveys targeted longfin eel, and the survey sites were more widespread including sites in and upstream of Lake Takapō.

The surveys found six native fish in the Takapō River, Canterbury galaxias, alpine galaxias, kōaro, common bully, upland bully and longfin eel. Canterbury galaxias and upland bully were widespread and generally common. Common bully was more restricted occurring close to Lake Benmore and in the various lakes of the catchment. Kōaro was widespread but occurred sporadically. Alpine galaxias was rare with only five individuals found at two sites in the mid-reaches of the Takapō River. A single longfin eel was found immediately downstream of the Fork Stream culvert at the upper reaches of the Takapō River.

Two species, common bully and kōaro, are benefiting from the hydro-electric power scheme developments in the Waitaki catchment. The creation of the new lakes such as Lake Benmore has created new larval fish rearing habitat for these species assisting them to extend their distribution. Kōaro, and possibly common bully have, most likely, also benefited from the reduction in longfin eel abundance as both species are prey of large longfin eels.

The longfin eel surveys of the second summer found large longfin eels but no smaller eels and elvers. These large eels were only found in a Grays River tributary and in Patterson Ponds. Other sites in Lakes Takapō, Alexandria, and McGregor and rivers and streams in the Tekapo catchment failed to find any eels. The lack of longfin eels in Takapō River tributaries that had a history of large longfin eel populations and provide good habitat for the longfin eels demonstrates the longfin eel population in the Tekapo catchment has been reduced to very few individuals by the lack of recruitment and harvesting. With regard to the Tekapo Power Scheme the reduction in flow in the Takapō River is not a cause of the absence of longfin eel from this river or the upstream lake.

The threatened native fish species in the Tekapo catchment are the upland longjaw galaxias 'Waitaki', the lowland longjaw galaxias 'Waitaki' and bignose galaxias which are all reported from the Tekapo catchment but are found in the upper reaches of tributaries of the Takapō River and Lake Takapō. These include Fork Stream, where conservation programmes partially funded by Project River Recovery (PRR) are creating predator free streams by removing salmonids and placing fish passage barriers in the streams to prevent reinvasion. The restriction of these fish to small headwater streams with long reaches of unoccupied stream between the populations and the Takapō River indicate that the downstream limits for these species are set by factors, such as salmonids, rather than the flow alteration in the Takapō River. The fish survey work also failed to locate habitat for these species along the Takapō River channel. Therefore, it is concluded that the flow changes produced by the Tekapo Power Scheme have not impacted on the fish or the availability of their habitat, rather other factors limit the distribution of these three threatened galaxiids.

The majority of native fish populations in the Takapō River appear healthy. Upland bully is common and found along the length of the river and the river provides good habitat for this species. There is a possible limitation on the abundance and distribution of alpine galaxias, but this assessment is hampered by a lack of historic data and limited knowledge of the ecological requirements of this species. The habitat assessment for alpine galaxias indicates that the Takapō River provides limited habitat, and it is of poorer quality. Therefore, the low abundance of this fish is likely to be a natural state in the Takapō River. The Canterbury galaxias is widespread along the Takapō River and is abundant in riffle habitat. This species will be being affected by the presence of didymo, salmonids and kōaro and given these negative biotic factors the limiting factor for Canterbury galaxias is not expected to the river flow created by the Tekapo Power Scheme. Longfin eel abundance is limited, not by the Takapō River flow reduction reducing available habitat rather the lack of recruitment.

Overall, the Takapō River supports the expected range of native fish, given the context of effects within the Waitaki catchment that influences the distribution and abundance of the native fish. In addition, common bully and kōaro are both more abundant in the catchment than they are expected to have been in the catchment in its pre-development state. In terms of direct negative effects on native fish the flow reduction in the Takapō River created by the Tekapo Power Scheme has reduced the available habitat for some species, e.g., longfin eel, but other factors rather than habitat are limiting their populations. For the threatened native galaxiids the present-day distributions indicate that the pre-development Takapō River was unlikely to have supported populations of these fish and scheme is unlikely to have had any direct effect on their abundance.

2. INTRODUCTION

2.1. Background

Genesis Energy Limited (Genesis) operates the Tekapo Power Scheme, an electricity generation scheme that draws water from Lake Takapō. The scheme draws water from Lake Takapō via a short pipeline to the Tekapo A power station. Once the water is discharged from the Tekapo A power station it is conveyed approximately 26 km in the Tekapo Canal to the Tekapo B power station and discharged into Lake Pukaki.

Under normal operating conditions the power scheme uses all the water being released from Lake Takapō and water is rarely discharged via the Lake George Scott Spill weir into the lower Takapō River. Water is released via the Tekapo control gates into the upper Takapō River downstream of Lake Takapō to Lake George Scott several times a week for operational purposes and recreational releases. The residual flow in the lower Takapō River is largely provided by inflowing tributaries, especially Fork Stream, Mary Burn and Grays River. Flow in the Takapō River is consequently smaller than what occurred pre-Tekapo Power Scheme.

The Tekapo Canal, as it traverses the land between Lakes Takapō and Pukaki crosses a number of streams including the Mary Burn and its major tributary Irishman's Creek. All the streams crossed by the canal run through culverts under the canal.

2.2. Waitaki Freshwater Fish

2.2.1 Waitaki River catchment freshwater fish

The Waitaki River catchment has 22 freshwater fish species present in the catchment (New Zealand Freshwater Fish Database, Dunn et al 2018, Table 1). This includes seventeen native fish taxa and five introduced species. The native fish can be grouped into two major groups the diadromous[1] (migratory) fish and the non-migratory species. Some of the diadromous can form landlocked populations where the seaward migration is replaced by a migration to and from a lake. This has allowed some diadromous species to colonise the upper Waitaki replacing their sea migration by migrating to and from the natural and hydro-electric lakes.

2.2.2 Upper Waitaki freshwater fish

The upper Waitaki River catchment has a unique native freshwater fish fauna in those three taxa; bignose galaxias (*Galaxias macronasus*); lowland longjaw galaxias 'Waitaki' (*G. cobitinis* 'Waitaki') and upland longjaw 'Waitaki' (*G. prognathus* 'Waitaki') are restricted to the Waitaki River catchment. Of these three taxa, upland longjaw galaxias 'Waitaki' are only found in the upper Waitaki. The other two taxa have populations in the upper Waitaki and the Hakataramea River catchment. For these two taxa, the majority of their populations are in the upper Waitaki catchment upstream of Lake Benmore, although historically they were likely to have been more widespread in the Waitaki catchment. Three other galaxiids; kōaro (*G. brevipinnis*), alpine galaxias (*G. paucispondylus*) and Canterbury galaxias (*G. vulgaris*) and another four native fish species; upland bully (*Gobiomorphus breviceps*) and common bully (*G. cotidianus*), longfin eel (*Anguilla dieffenbachii*) and shortfin eel (*A. australis*) are also found in the upper Waitaki. The shortfin eel,

[1] Diadromous populations must undertake migrations to and from the sea to complete their life cycle.

due to its single record in Lake Waitaki is not considered further when assessing the native fish populations of the upper Waitaki catchment.

Of the native fish present in the upper Waitaki only the two bully species are not threatened, and the rest are all considered threatened to some degree (Dunn et al 2018, Table 1). A further three species of introduced fish are also reported in the upper Waitaki; brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), and sockeye salmon (*O. nerka*).

It is important to note that for the upper Waitaki catchment species, lowland longjaw galaxias and bignose galaxias, (Table 1) their threat status has been improved by ongoing conservation management action, this being salmonid and kōaro removal operations to create and maintain predator free areas for these fish. Without this action the threat classifications for these species would be higher. On a similar note, the presence of longfin eel in the upper Waitaki catchment is provided for by the elver trap and transfer programme run by Meridian Energy and Ngāi Tahu / Waitaki Rūnanga that transfer elvers from Waitaki Dam to the upper catchment. Without this the population of longfin eels in the upper Waitaki would be declining with no recruitment.

2.3. Scope of this Report

This report provides the results of freshwater fish surveys in the Takapō River catchment to update the known distributions of freshwater fish with respect to the hydro-electric generation operations of Genesis and to assess the effects of the power scheme's operation on native fish species.

Table 1: Native fish of the Waitaki River catchment, (upper Waitaki species shaded).

Common name	Present downstream of Waitaki Dam	Present upstream of Waitaki Dam	Threat ranking	Classification qualifiers
Canterbury mudfish	Yes	No	Nationally critical	Conservation dependent, range restricted, sparse, extreme fluctuations
Lowland longjaw galaxias 'Waitaki'	Yes – Hakataramea catchment only	Yes	Nationally endangered	Conservation dependent, range restricted
Bignose galaxias	Yes – Hakataramea catchment only	Yes	Nationally vulnerable	Conservation dependent, range restricted
Upland longjaw galaxias 'Waitaki'	No	Yes	Nationally vulnerable	Data poor, range restricted, sparse
Canterbury galaxias	Yes	Yes	At risk, declining	Data poor, partial decline
Kōaro	Yes – diadromous population	Yes, landlocked populations	At risk, declining	Partial decline
Alpine galaxias	No	Yes	At risk, naturally uncommon	Data poor, range restricted, extreme fluctuations
Inanga	Yes, diadromous	No	At risk, declining	Conservation dependent, secure overseas
Longfin eel	Yes, diadromous	Yes, diadromous population	At risk declining	Conservation dependent, data poor
Shortfin eel	Yes	Yes	Not threatened	
Lamprey	Yes	No	Nationally vulnerable	Data poor, secure overseas
Common bully	Yes	Yes, landlocked populations	Not threatened	Data poor
Upland bully	Yes	Yes	Not threatened	
Bluegill bully	Yes, diadromous	No	At risk, declining	Data poor
Torrentfish	Yes, diadromous	No	At risk, declining	
Common smelt	Yes, diadromous	No	Not threatened	
Stokell's smelt	Yes, diadromous	No	At risk, naturally uncommon	Data poor, range restricted
Rainbow trout	Yes	Yes	Introduced and naturalised	
Chinook salmon	Yes, diadromous	No	Introduced and naturalised	

Common name	Present downstream of Waitaki Dam	Present upstream of Waitaki Dam	Threat ranking	Classification qualifiers
Sockeye salmon	No	Yes, landlocked population	Introduced and naturalised	
Brown trout	Yes	Yes	Introduced and naturalised	
Brook char	Yes		Introduced and naturalised	

3. METHODS

3.1. Previous Freshwater Fisheries Survey Data

To provide background information on native freshwater fish in the Takapō River catchment the New Zealand Freshwater Fish Database (NZFFD) was searched and all records for the catchment area downloaded in November 2018. A previous fisheries survey (Freshwater Solutions 2014) undertaken for Genesis was also accessed and the data mapped along with the NZFFD data. The data was mapped in a GIS and assessed to determine the known species occurrence in the catchment and their known distributions. The fisheries data was also assessed to determine where fisheries information was absent or greater than 10 years old and therefore possibly of historic value rather than representing the present-day distributions. The first year of the fish survey (January and February 2019) was designed to gather information in rivers and streams that are influenced by the Tekapo Power Scheme, the lower Takapō River, and streams crossed by the Tekapo Canal. The survey, in conjunction with a scheme-wide eel survey programme with Meridian Energy and Ngāi Tahu / Waitaki Rūnanga (Arowhenua, Waihao and Moeraki) was expanded to include tributaries of Lake Takapō in year 2 of the survey work (January 2020).

3.2. Fish Survey Summer 2019

Survey sites were selected in wadable areas of the Takapō River and its tributaries. The survey sites included an area in the upper reach of the Takapō River upstream of the Fork Stream confluence (Site 33), the mid and lower reaches of the Takapō River (Sites 1-25, 28-31) as these areas had been identified as having little fisheries data and much of the existing data was relatively old. All the survey sites were restricted to wadeable habitats as electric fishing is limited to wadable areas. Prior to selecting sampling sites, a wide area of the riverbed was walked to assess the available habitats and to check for spring fed tributaries. The range of wadeable riffle and runs present in the sample area were then electric fished. The sample area varied at each site as reflected by the area of riffle and run habitat units present at each site. The major objective of this sampling was to locate fish species by sampling a diverse array of habitats. The most frequently sampled areas were riffle habitats as riffles provide habitat for all the native fish species and this provided a consistent habitat type to survey.

Small spring fed areas are habitat that is frequently used by the lowland longjaw galaxias and bignose galaxias. Locating habitat for these species was an important objective and searching for the spring fed stream habitat was undertaken while driving the access road and while walking the riverbed. However, no spring fed tributaries were encountered along the access road, but some riverbed braids originated as subsurface water emerging from gravel/cobble river bars. These water emergence sites were sampled at the emergence site and downstream for at least 20 m when located.

It was intended to re-sample a reach of the Takapō River that had 47 fish sampling events conducted in 2010 to allow a comparison of the fish fauna of the present day with previous samples. However, upon arriving at this reach it was found that river works had been conducted by Environment Canterbury (for erosion protection reasons) in this area and the river had been diverted away from the sites previously sampled. Therefore, any comparison with the previous survey result were expected to be confounded by the channel works (Figure 1).

In total 30 sites were fished along the Takapō River, and three additional sites were fished on the Mary Burn.

Figure 1: Google Earth aerial showing river works on the Takapō River riverbed, (left) 2012 riverbed, (right) 2016 riverbed with main braid diversion.

3.2.1 Fish survey summer 2020

The 2020 fish survey targeted longfin eels and used electric fishing and fyke netting to conduct the sampling. At each electric fishing site 50 m of stream was sampled. Sampling of ponds, lagoons and lake areas was undertaken with fyke nets and Gee minnow traps. No specific trap and net sets were used as sample areas varied in size precluding the use of a standard method. However, at each site at least six unbaited fyke nets were set and the minnow traps were used more opportunistically to sample small water bodies. Survey sites had been selected from sites with historic records of eels and also sites of interest to Ngāi Tahu / Waitaki Rūnanga.

3.2.2 Data recorded

At each survey site the area was photographed, and the site location recorded by GPS. The habitat sampled was noted with data collected including water colour, periphyton cover, substrate type, width and depth of the channel being fished and riparian characteristics. All fish collected were identified to species level, measured, and returned to the water alive. A photographic record of the fish collected was also made, especially for various galaxiid species caught to provide supporting photographs if identifications needed to be confirmed.

4. RESULTS

4.1. Historic Observations

The NZFFD and previous fish survey reports provide 78 historic fish survey results from the Takapō River. Forty-eight of these sites, of which 47 were fished in 2010, are concentrated in a short section of the Takapō River (Figure 2) approximately 15 km downstream from Lake Takapō. The remaining 30 sites are scattered along the river and the mid-reaches have had very little survey effort (Figure 2).

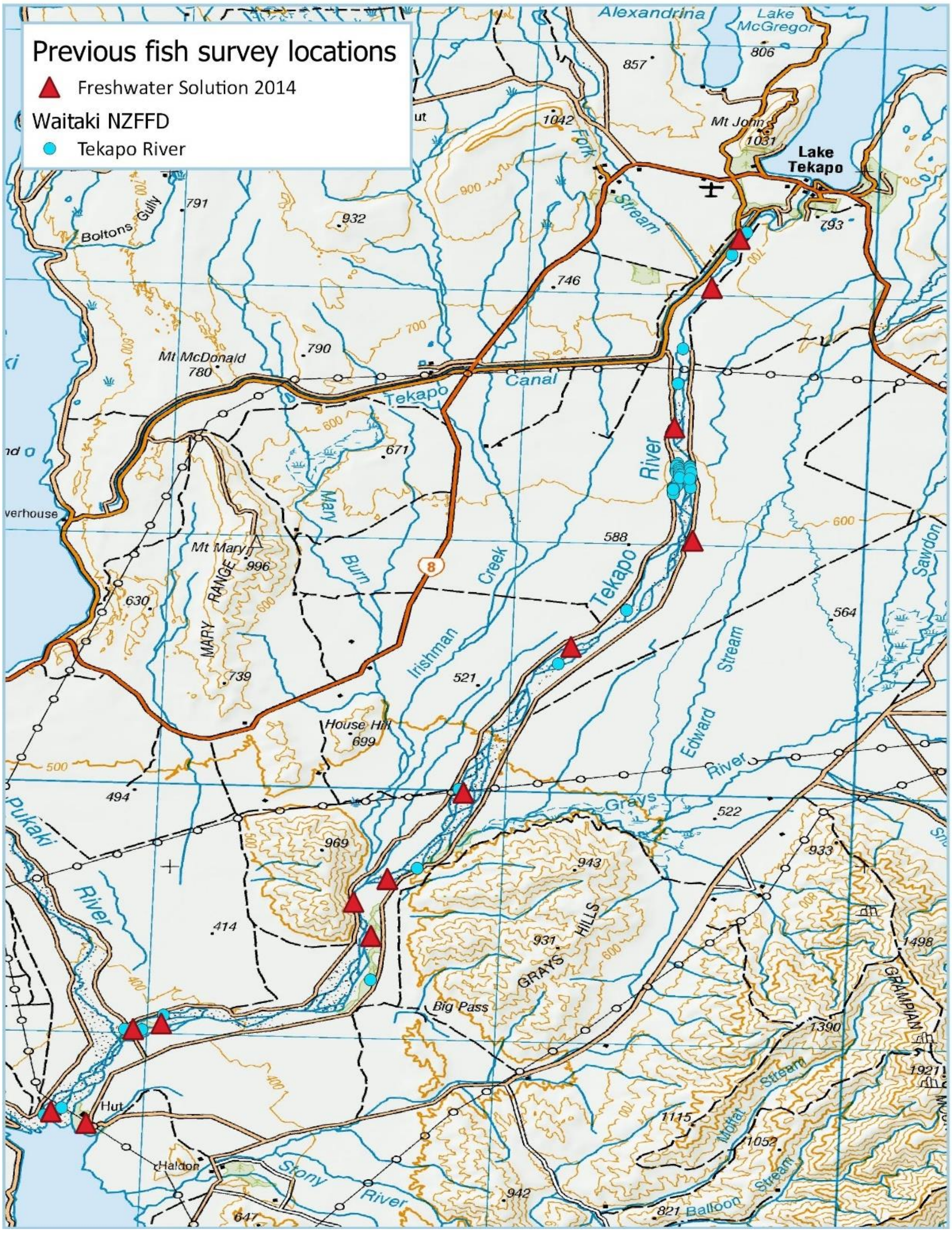

Figure 2: NZFFD and Freshwater Solutions fish survey sites in the Takapō River.

The dates of the surveys in the NZFFD ranged from 1979 to 2010 and there was some additional sampling conducted by Freshwater Solutions (2014) in 2014. There is no sampling reported from prior to the construction and start of the operation of the Tekapo power scheme. The sample records detected up to eight fish species: longfin eel, alpine galaxias, canterbury galaxias, kōaro, common bully, upland bully, rainbow trout and brown trout (Table 2). None of these records report either of the longjaw galaxias species or bignose galaxias in the Takapō River. Some caution must be taken with the lack of bignose records as the species was only recognised and described in 2003

(McDowall & Waters 2003) and fish survey records from before this year would have reported bignose galaxias as a different galaxiid or an unidentified galaxiid.

Table 2: Number of records for fish species from 1979 to 2014.

Species	Number of records	Year range	Takapō River locations
Longfin eel	5	1979-2014	Full river length
Alpine galaxias	9	1981-2014	Full river length
Canterbury galaxias	24	1981-2014	Full river length
Kōaro	11	1981-2014	Lower and mid river reaches
Common bully	5	1981-2014	Lower and mid river reaches
Upland bully	40	1979-2014	Full river length
Brown trout	35	1979-2014	Full river length
Rainbow trout	19	1979-2014	Full river length
No fish present	9	2010	Intensely fished river section

4.2. Summer 2019 Survey Results

4.2.1 Summary results

The January 2019 fish survey concentrated on the Takapō River and the very lower reaches of Fork Stream downstream of the Tekapo Canal culvert with 30 sites fished and three sites in the Mary Burn also fished (Figure 4 -5). The surveys concentrated on riffle and run habitat of wadable depths and sampled both minor and major braids of the Takapō River (Figure 7Figure 8). Upland bully was the most common fish species collected and was present at 28 of the 30 sites fished. Canterbury galaxias, brown trout and rainbow trout were the next most common fish species, found at twenty-one, twenty and twenty-one sites each. The other four species collected were longfin eel, alpine galaxias, common bully and kōaro which occurred at eight or fewer sites (Table 3). All 30 sites had fish and the maximum number of fish species at a site was six.

Table 3: Summary data for fish catches in the Takapō River and lower Fork Stream, January 2019.

Species	Number of sites	Total number collected	Takapō River location
Longfin eel	1	1	Fork stream culvert
Alpine galaxias	2	5	Mid river reach
Canterbury galaxias	20	73	Full river length
Kōaro	9	46	Full river length
Common bully	8	27	Lower river reach
Upland bully	28	178	Full river length
Brown trout	20	82	Full river length
Rainbow trout	21	137	Full river length

4.2.2 Longfin eel

A single longfin eel, 200 mm long was collected at Site 28, immediately downstream of the Fork Stream culvert (Figure 3).

Figure 3: The Fork Stream culvert under the Tekapo Canal.

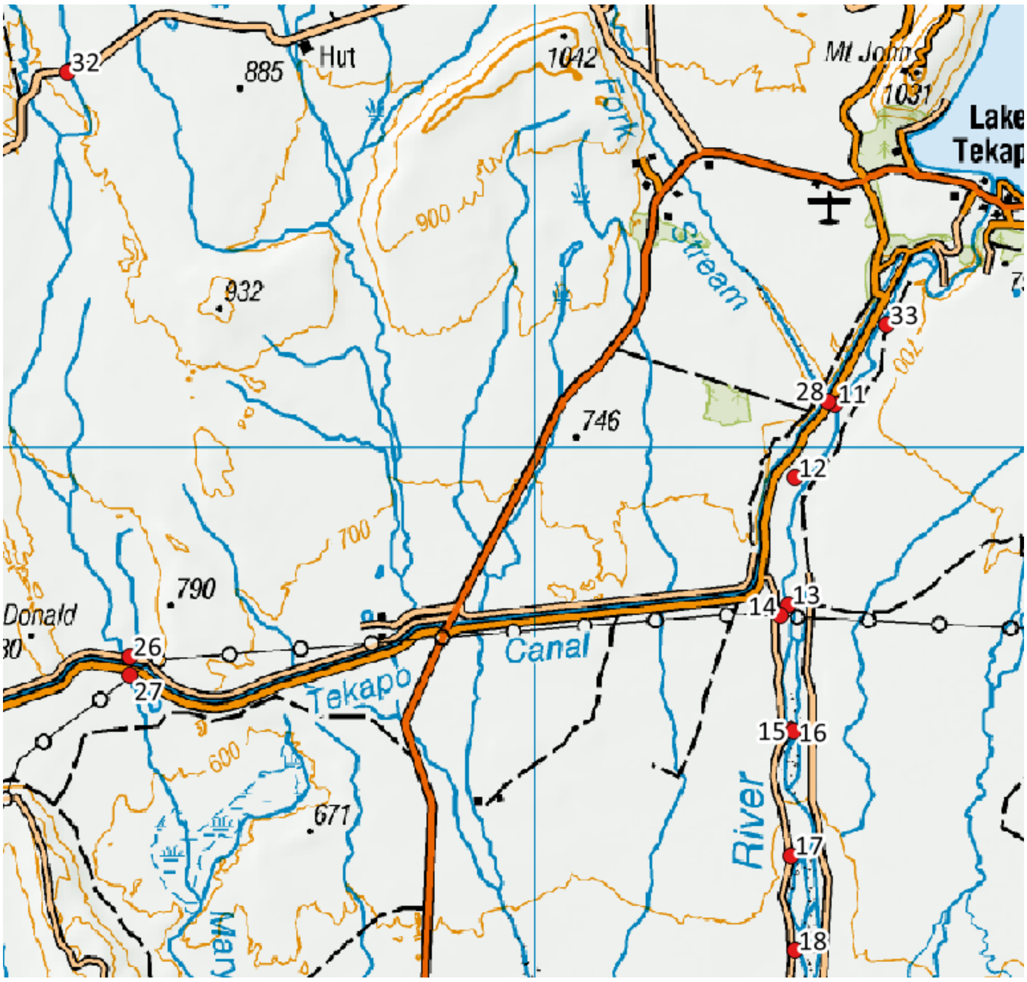

Figure 4: Summer 2019 upper Takapō River and tributary fish survey sites.

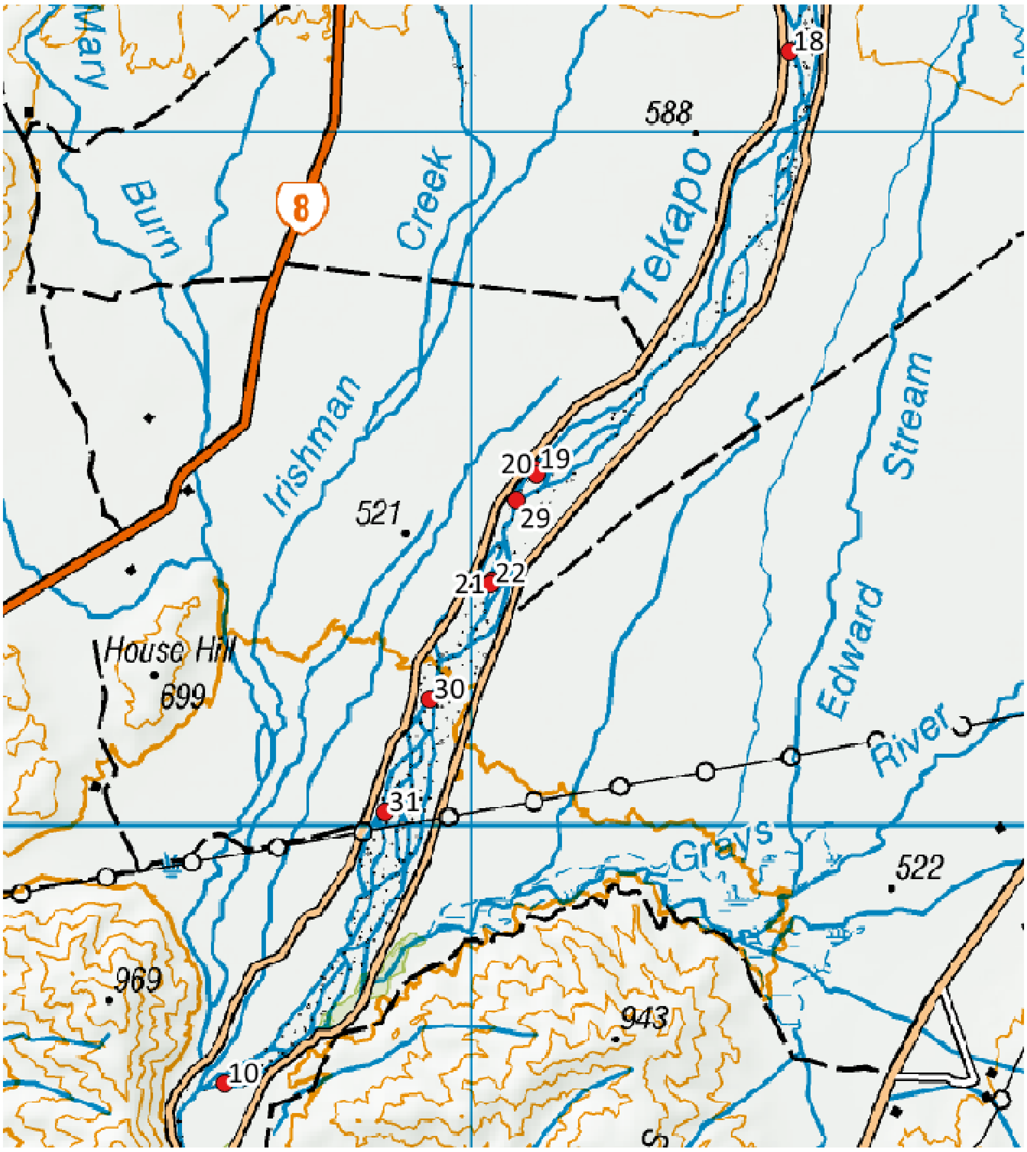

Figure 5: Summer 2019 mid Takapō River fish survey sites.

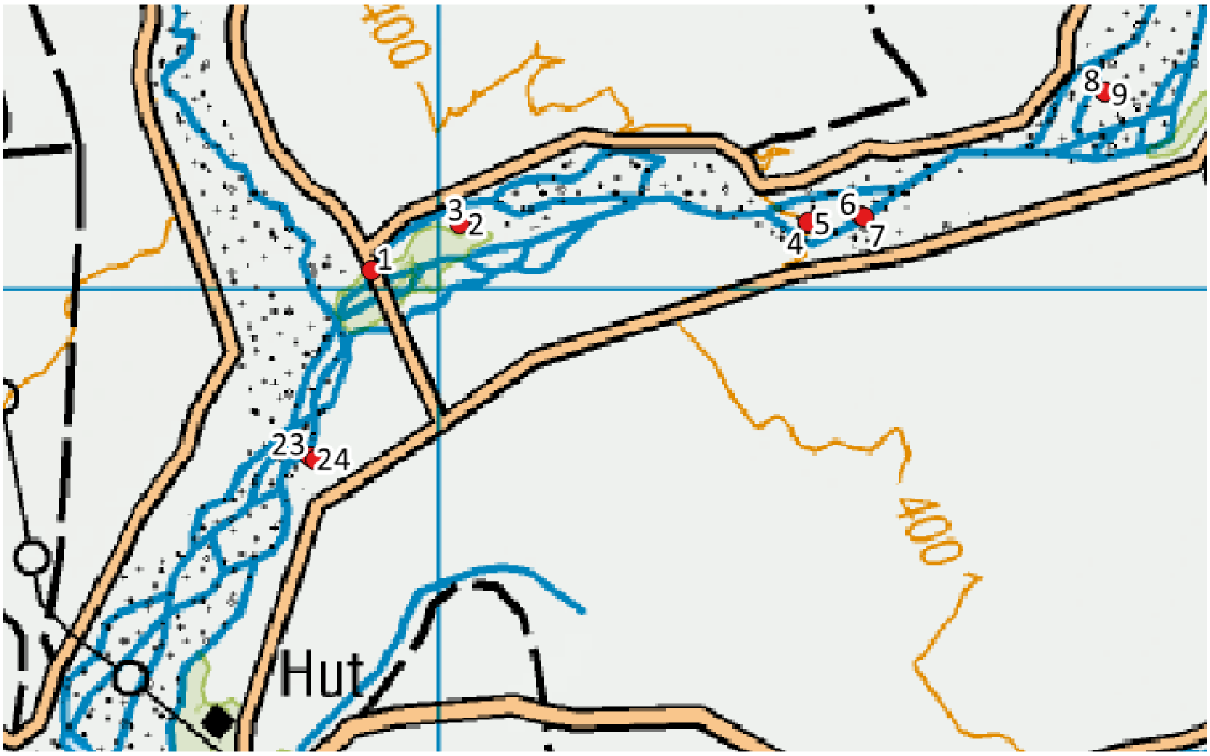

Figure 6: Summer 2019 lower Takapō River fish survey sites

Figure 7: Site 12, run habitat in a minor braid of the Takapō River.

4.2.3 Alpine galaxias

Alpine galaxias was caught at two sites in close proximity to each other (Figure A2). Site 20 (30 m^2, Figure 9) was fished during the early January survey week and two alpine galaxias (60 mm and 65 mm) were collected. The second site, Site 29 (50 m^2) was fished on the late January survey trip and three alpine galaxias (43mm, 46 mm and 48 mm) were caught. The size range indicates juvenile and small adult fish were present but in low densities.

Figure 8: Site 18, fast riffle habitat in a major Takapō River braid.

Figure 9: Site 20, riffle habitat where alpine galaxias were collected.

4.2.4 Canterbury galaxias

The Canterbury galaxias was one of the most widespread and common fish species collected. A total of 73 individuals were collected from the 20 survey sites it occurred at. It was present in the very upper reaches of the Takapō River where the flow is provided by ground water seepage all the way downstream to Lake Benmore (Figure A3). It was common in riffle and run habitat amongst boulder, cobble and gravel substrates that provide cover for the fish. The fish ranged in size from 35 mm to 106 mm (Figure 10) and there was a distinct cohort between 34 mm and 48 mm that are likely to be young of the year fish and then a range of larger adult fish were present.

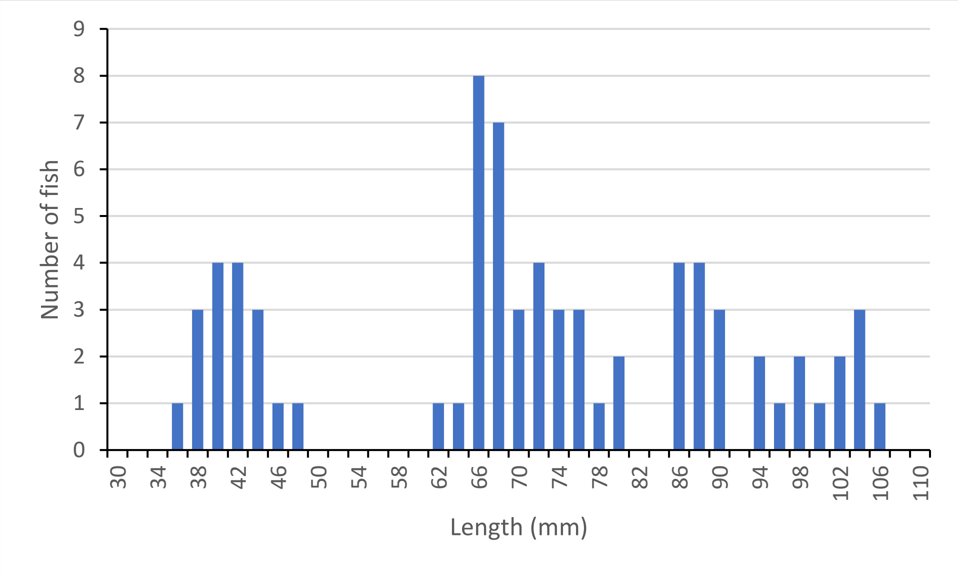

Figure 10: Length frequency for the Canterbury galaxias collected from the Takapō River.

4.2.5 Kōaro

Kōaro were found at nine sites and these sites were scattered along the Takapō River from the Fork Stream culvert to the lower river near Lake Benmore (Figure A4). A total of 46 individuals were collected and they ranged in length from 41 mm to 132 mm (Figure 11). The length range and life history stages of kōaro at sites varied along the river. In the lower river at Site 24 whitebait individuals (Figure 12) were collected together with ripe male fish.

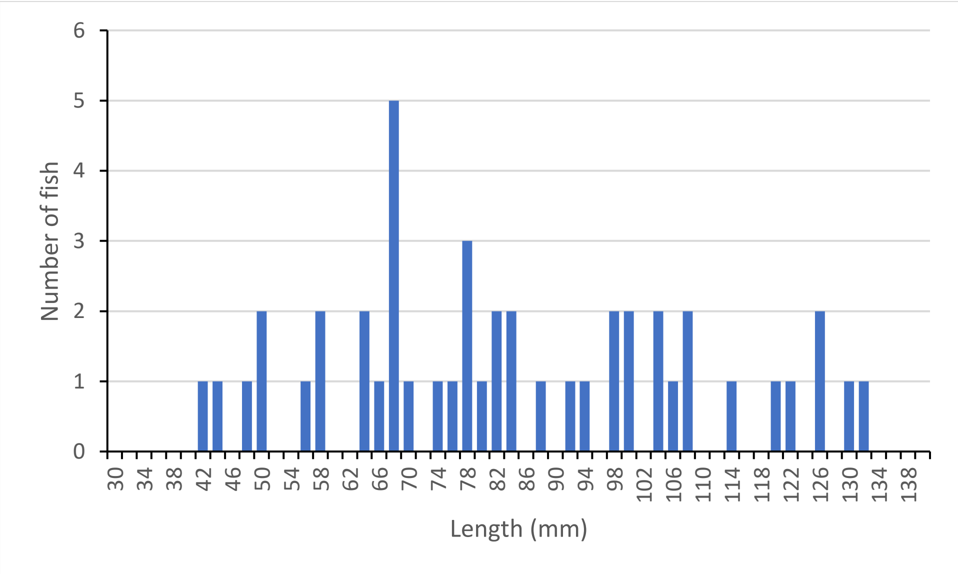

Figure 11: Length frequency for the kōaro collected from the Takapō River.

At the Fork Stream culvert (Site 28) six juvenile kōaro were collected. At Site 17 which was in the mid-reaches of the Takapō River the largest adult kōaro were collected (132 mm, Figure 13). Site 17 was unusual in that this braid had no upstream exit so fish migrating upstream into this braid could not move further upstream.

Figure 12: Fish collected at Site 24 including kōaro whitebait (centre of picture).

Figure 13: Adult kōaro collected at Site 17.

The Site 17 was also notable for the large didymo mats that covered the top of rocks in the riffle habitat where the kōaro are found. Despite these large algal mats, the kōaro were present and using the didymo covered rocks as cover (Figure 14).

Figure 14: Didymo covered riffle areas at Site 17 where kōaro were found.

4.2.6 Common Bully

Common bullies were collected from eight sites in the lower Takapō River (Figure A5) and were not common with a total of 27 caught. They ranged in length from 38 mm to 68 mm.

4.2.7 Upland bully

Upland bullies were collected at twenty-eight of the thirty Takapō River sites (Figure A6) and were found along the whole length of the river from the upper most Site 33 to the most downstream sites, Sites 23, 24. The upland bullies were regularly abundant at sites and not all these bullies seen were collected. However, 178 were collected and measured and the lengths ranged from 22 mm to 82 mm. Small upland bullies less than 30 mm long (recently hatched bully fry) were common in still water areas along the river margins (Figure 15).

Figure 15: Upland bully fry.

4.3. Summer 2019 – Mary Burn

The Mary Burn was fished immediately upstream and downstream of the Tekapo Canal culvert. Upstream of the culvert Canterbury galaxias (16 caught) and upland bully (12 caught) were both common. Downstream of the culvert brown trout, Canterbury galaxias, upland bully and one longfin eel were caught. The longfin eel was estimated to be 800 mm long but was not measured.

A small tributary of the Mary Burn was fished where it is crossed by Braemar Road and juvenile Canterbury galaxias were caught.

4.4. Summer 2020 Longfin Eel Survey

4.4.1 Fyke netting

The longfin eel survey sampled Lakes Alexandria, McGregor and Tekapo, Rapuwai Lagoon and Patterson Ponds using large fine mesh fyke nets (Figure 16). A total of 59 fyke net sets were made in the Tekapo catchment. Longfin eel were caught in two of these fyke nets, both of which were set in Patterson Ponds. The lengths of the four longfin eels were 570 mm, 790 mm, 920 mm, and 1155 mm. The fyke nets caught 1000s of common bullies which were abundant at almost all the sites fyke netted. Fyke nets in the three lakes also caught adult kōaro and they were common in Lakes Alexandrina and McGregor but rarely caught in Lake Takapō.

4.4.2 Electric fishing

Electric fishing sampled another fifteen sites in the lower and upper Takapō River, Grays River, spring fed streams in the Godley/Macaulay delta, Mary Burn and Irishmans Creek (Figure 17). One longfin eel 1114 mm long was caught in the lower Grays River and two other longfin eels approximately 1000 mm long escaped at this site. Electric fishing caught no other eels.

Bignose galaxiids were caught at three sites in the Grays River catchment only being absent from the lower most site in this subcatchment. Kōaro were caught in the Lake Takapō tributaries. Upland bullies were collected at all sites.

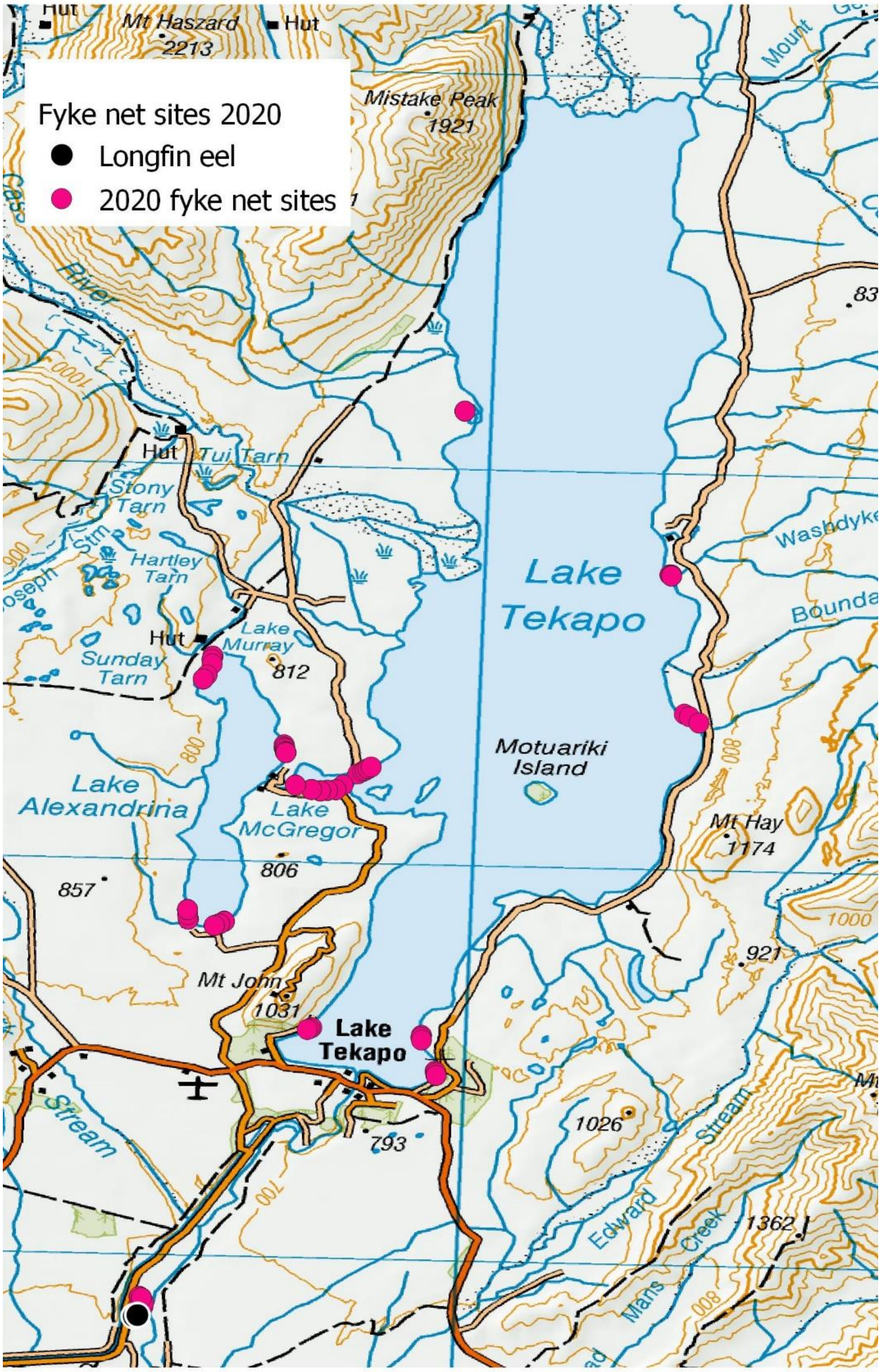

Figure 16: Longfin eel fyke net fishing locations and locations where longfin eels were caught.

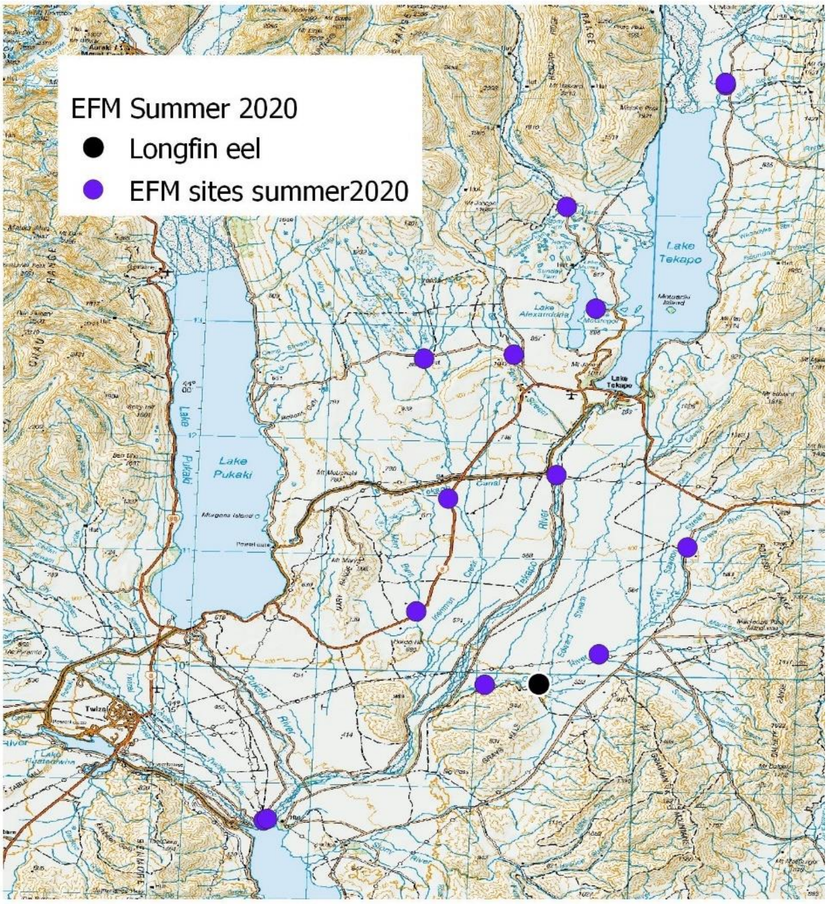

Figure 17: Electric fishing locations and locations where longfin eels were caught.

5. DISCUSSION

5.1. Threatened Fish Species

The Department of Conservation (Townsend et al 2008) has three categories of threatened fish; *Nationally critical, Nationally endangered* and *Nationally vulnerable*. In the upper Waitaki there are three fish classified as threatened – upland longjaw galaxias 'Waitaki', lowland longjaw galaxias 'Waitaki' and bignose galaxias (Dunn et al 2018). Bignose galaxias was found during this survey work, but only in the Grays River at sites unaffected by the Tekapo power scheme operations. It is also reported from Fork Stream, Edwards Stream, Irishmans Creek and the Mary Burn, but has not been reported at any survey site in the Takapō River. There are populations of upland longjaw galaxias 'Waitaki' in the upper reaches of Fork Stream, but these populations are approximately 25 km upstream of the Fork Stream culvert under the Tekapo Canal. Edwards Stream, a tributary of the Grays River has a population of lowland longjaw galaxias 'Waitaki' and this population occurs upstream of State Highway 8 at least 20 km upstream of the Takapō River. Given the distribution of the threatened fish in the Tekapo catchment the power scheme does not impact on them.

The fish surveys along the Takapō River in summer 2019 looked for spring fed streams that are habitat used by the threatened galaxiids, but no spring fed streams were found. There were some braided channels at the margins of the riverbed that were fed by water seeping through the riverbed gravels. This habitat did not appear highly suitable for the threatened galaxiids but was sampled and none were caught. Rather at these sites only upland bullies and brown trout were caught.

5.2. At Risk Declining Fish Species

Canterbury galaxias, kōaro, and longfin eel are all classified as *At Risk-declining* fish species (Dunn et al 2018). In the Tekapo catchment longfin eel are very rare and almost all individuals now found are large old eels. The single 200 mm eel collected at the Fork Stream culvert was a young eel and is likely to have been transferred above the three downstream hydro-electric dams as part of the Meridian Energy and Ngāi Tahu / Waitaki Rūnanga elver trap and transfer programme. If longfin eels are to become common in the Takapō River catchment transfers of elvers will be required. At this time, the majority of elvers are released around Omarama and few will migrate around Lake Benmore to the Takapō River. If elvers are transferred into the Tekapo catchment there is abundant habitat for them in the lakes, lagoons, rivers and wetlands. Aside from transferring them into the catchment, no management action is required to increase the number of longfin eel. Downstream fish passage for the large eels will remain a potential management issue and the capture and transfer of downstream migrant eels will be required so that they can pass the downstream dams without suffering turbine mortalities.

Canterbury galaxias is relatively widespread in the Takapō River and also occurs in the Mary Burn and Fork Stream. The present Takapō River provides good and abundant riffle habitat for this fish. However, the individuals caught did not include large individuals (this fish is known to reach a length of 170 mm). The limitation on growth and longevity may be related to the threats this fish faces. The major threat to Canterbury galaxias is considered to be salmonids via predation (McDowall 2006). During this survey larger salmonids were not seen in the Takapō River upstream of the Mary Burn and Grays River confluences, so the impact of salmonids maybe limited by their low occurrence. The reduced size of the Takapō River upstream of the Mary Burn and Grays River confluences may limit the presence of large salmonids, and it also provides abundant shallow riffle habitat for Canterbury galaxiids. It is also possible two additional impacts are occurring, didymo may be altering the macroinvertebrate food resource (Kilroy et al 2009, Jellyman & Harding 2016) and kōaro may also be a competitor and predator (e.g., McDowall & Allibone 1994). The pre-development state of the Canterbury galaxias population is unknown, but these three recognised or potential threats are possible limiting factors. In addition, Canterbury galaxias are generally uncommon in unstable large river systems in Canterbury and are more abundant in more stable tributary habitat as long as salmonids are absent. Therefore, their abundance prior to the construction of the Tekapo power scheme would most likely have been controlled by the flood regime of the Takapō River and the outflow from Lake Takapō.

The threat classification for kōaro is *At Risk declining* and the classification has an additional qualifier of partial decline (PD). This indicates that in some areas of New Zealand kōaro is not considered threatened and in the case of the upper Waitaki kōaro is expected to be expanding its range. Lake Benmore has provided a new lake where pelagic larval kōaro can rear before migrating back upstream to the Takapō River and its tributaries. The presence of kōaro whitebait in the lower Takapō River supports the use of Lake Benmore as rearing habitat. The presence of kōaro juveniles at the Fork Stream culvert also demonstrates that kōaro are migrating well upstream from Lake Benmore and into tributaries of the Takapō River. However, kōaro are not numerous in the Takapō River and they often occurred near to impediments to upstream fish migration. Therefore, while the population is expanding due to new rearing habitat in Lake Benmore kōaro have not become a dominant fish species in the Takapō River.

5.3. At Risk Naturally Uncommon Fish Species

Alpine galaxiid is considered a naturally uncommon fish due to its limited range in the upper reaches of rivers in Canterbury (Dunn et al 2018). In the Takapō River there are infrequent records of the fish, and these records are spread along the whole river length. In streams upstream of Lake Takapō alpine galaxiids are far more common and in the upper reaches of tributaries such as Edwards Stream alpine galaxiids are also common. The reasons for its rarity in the Takapō River are unknown. This survey did find juvenile fish, and this indicates that a small reproducing population is present in the Takapō River. The historic reports of the fish also indicate while it is rare it continues to persist along the full length of the Takapō River. In other Canterbury Rivers (e.g., the Rangitata and Rakaia rivers) alpine galaxias becomes increasingly rare in a downstream direction, eventually becoming absent. In the Waitaki catchment the Takapō River population may be a population of alpine galaxiid near the species' downstream distribution limit.

5.4. Bully Species

Upland bully is common in the Takapō River and also in the tributaries. Upland bully is often an abundant fish in braided rivers, especially in the stable braids and tributaries. The stable flow of the Takapō River and the riparian planting in the lower reaches create excellent habitat for this bully.

Common bully is generally associated with lakes and ponds as it requires these still water bodies for its larval life history phase. The fish is also not a strong upstream migrant and its limited penetration upstream from Lake Benmore represents its natural limited upstream movement. Common bully in the upper reaches of the Takapō River is likely to be dispersing downstream from Lake Takapō rather than migrating the length of the Takapō River. The catches in fyke nets in Lakes Alexandrina and McGregor and in Rapuwai Lagoon indicate that the common bully populations are abundant in some parts of the Tekapo catchment. It is also reported to be extremely common in the canal system so has benefited from the hydro-electric development more so than any other native fish.

6. ASSESSMENT OF EFFECTS OF THE TEKAPO POWER SCHEME

6.1. Potential Effects

The potential effects of the Tekapo Power Scheme on native fish in the Tekapo catchment arise because the scheme diverts water away from the Takapō River and the canal system crosses a number of tributaries. These effects include:

- Change in riverine habitat in the Takapō River with the reduced flows altering habitat availability leading to changes in the fish community and/or abundance;
- Impedance of fish passage from the Takapō River to Lake Takapō;
- Reduction in habitat quality in the Takapō River due to lack of flushing flows; and
- Fish passage barriers at the culverts where streams flow under the Tekapo Canal.

In addition, there is the potential for the Tekapo Power Scheme to have positive effects:

- The flow reduction in the Takapō River:
    - provides more suitable habitat for native fish species that prefer low water velocities and shallow water habitats. This includes the bully and galaxiid species present in the Takapō River; and

    - upstream of the Mary Burn and Grays River confluences may limit the presence of large salmonids; and
- A reduction in flood disturbance thereby a reduction in flood related mortality; and
- The Tekapo Canal provides new habitat for native fish.

One caveat when describing the native fish fauna in the Takapō River catchment is that there is no published information on the native fish fauna of the Takapō River prior to the Tekapo Power Scheme being constructed. Therefore, existing distributions and information regarding native fish habitat use and distributions from other rivers have to be used when assessing possible effects of the Tekapo Power Scheme. In this respect, other Canterbury rivers, both within the Mackenzie Basin, and also the Rangitata and Rakaia rivers can provide useful information.

6.2. Separating Multiple Effects in the Tekapo Catchment

The lack of data on the native fish community in the Tekapo catchment prior to the development of the Tekapo power scheme means there is no baseline condition to compare the present-day native fish community to. Any assessment is further complicated by other changes to the aquatic environment provided in the Takapō River including:

- The introduction of salmonids and the effects of their predatory and competitive interactions on the native fish;
- The effects of didymo on invertebrate communities leading to food web alterations;
- River works and the riparian planting programme in the lower Takapō River altering riverine habitat;
- An expected increase in the abundance and distribution of kōaro now Lake Benmore provides additional rearing habitat for larval kōaro; and
- The reduction in the longfin eel population due to the fish passage impediment at Waitaki Dam reducing recruitment and commercial eel harvesting removing longfin eels from the upper Waitaki.

The expected effect of salmonids and the increase in kōaro is that small native fish, particularly non-migratory galaxiids are now subject to much greater predation and competition for food. The effects of these predatory species are evident at the trout and kōaro removal sites that the Department of Conservation have instigated, and which is partially funded by PRR. Once the salmonids and kōaro are removed bignose and lowland longjaw galaxias (e.g., at Fraser Spring) increase in abundance. With respect to the effects of salmonids these impacts would have begun in the late 1800s as salmonids were spread around New Zealand and the effects have been present for over 100 years. For kōaro the changes in abundance would have been possible once Lake Benmore was filled in 1964 creating a new larval kōaro rearing habitat. The ability of Lake Benmore to provide a pelagic food chain that supports larval kōaro is unknown and as the trophic status of Lake Benmore varies the productivity of the pelagic food chain and kōaro production is also likely to vary. However, the combination of the salmonid introduction and the much later addition of more kōaro have led to a combination of changes in the fish community and its dynamics over the last 130 years.

The direct effects of didymo on the growth and abundance of native fish is uncertain. Jellyman & Harding (2016) report changes to the invertebrate food resources on riverbeds as didymo becomes the predominate algae present, and especially when it forms large blooms. They note didymo blooms are often most prevalent downstream of lakes and in this investigation didymo was very abundant in the riffle areas of the upper Takapō River (Figure 14). Jellyman & Harding (2016) also found that where didymo was highly prevalent that the impact of the change in invertebrate communities was most apparent on salmonids with more empty guts found and trout being absent from some area where they had been present prior to didymo becoming established. Therefore, it is reasonable to expect that the Takapō River fish communities are subject to invertebrate communities that have been significantly altered since didymo was first observed in New Zealand in 2004 and subsequently spread to South Island rivers including the Takapō River. In addition, it is possible the didymo driven changes to invertebrate communities has impacted more on salmonids and has led to a reduction in predatory interactions with native fish.

Another ongoing effect is the river works that has been undertaken by Environment Canterbury. Localised channel works to protect the access road along the river has altered the channel form in some areas. This effect is relatively localised and a minor issue. However, the tree planting in the lower Takapō River has stabilised the river channel and created stable river braids that provide habitat that is likely to be different to that of the natural river system. What effects this has had on the fish community is unknown due to the lack of fish surveys prior to the works being conducted.

Impacts on the longfin eel population could have commenced when the Waitaki Dam was completed in 1934. A fish pass for salmonids was constructed at the Waitaki Dam that could have provided passage for elvers, but his was removed during a power station upgrade in the 1950s and after that whether passage was possible for the elvers over the dam in unknown. The dam to this day is regularly overtopped by the Waitaki River and elvers may be able to climb the wetted dam face. However, the subsequent construction of the Aviemore and Benmore dams will have halted upstream elver migrations leading to the loss of eel recruitment in the upper Waitaki including the Takapō River catchment. While the dams have restricted elver recruitment commercial harvest continued for many years and this reduced the population of resident eels upstream of Lake Benmore faster than the decline via loss of recruitment would have otherwise been. At present, as shown during this investigation, the longfin eel population in the Tekapo catchment is very small. The reduction in the abundance of large longfin eels from the upper Waitaki will have reduced the effect this large native fish predator had on the aquatic ecosystem. Of relevance is the effect of longfin eels on kōaro. In near pristine Stewart Island streams (Chadderton & Allibone 2000) found presence of longfin eels and kokopu restricted kōaro to riffle habitats but in the absence of these species kōaro occupied riffle, run and pool habitat. Applying this finding to the upper Waitaki it would suggest the reduction in longfin eels would have released competition and/or predation pressure on kōaro at the same time as new rearing habitat in Lake Benmore became available to kōaro. The trap and transfer operation now being conducted by Meridian Energy and Ngāi Tahu / Waitaki Rūnanga will slowly restore the longfin eel population but for the time being the fish communities are structured without significant interactions with longfin eels.

The construction and operation of the Tekapo Power Scheme began in 1938 and the Tekapo A Power Station was completed and commissioned in 1951. This was the first flow change in the Takapō River. Subsequently the Tekapo Canal and Tekapo B Power Station were constructed in the 1970s and Tekapo B Power Station was commissioned in 1978. At this stage the effects of the present Tekapo Power Scheme would have begun and at which time all the above impacts and interactions among these effects would have already been occurring and altering the native freshwater fish community of the Tekapo catchment. Therefore, the effect of the Tekapo Power Scheme is determined after the effects of the pre-existing changes to the upper Waitaki fish community and habitat had already occurred and has to also account for the ongoing effects of river and fisheries management in the Tekapo catchment.

This range of ongoing activities and their effects, together with the lack of baseline information on the native fish present in the Tekapo catchment means this assessment of effects is limited to describing the present native fish community and assessing the effects of the Tekapo Power Scheme as it operates today on the native fish rather than the effects on an unknown historic state.

6.3. Assessment of Effects.

6.3.1 Non-migratory native fish

The pre-development native fish fauna of the Takapō River and its tributaries is expected to have consisted of the same species that are currently present. There are no obvious non-migratory fish species absent from the Tekapo catchment that are present in other parts of the Waitaki River catchment or other Canterbury rivers. The two longjaw galaxias and bignose galaxias are restricted to the Waitaki catchment and as such are not found elsewhere. However, similar upland and lowland longjaws are present elsewhere and generally occupy inland braided rivers and some spring fed tributary streams. The three species are all found in tributaries of the Takapō River and Lake Takapō so are not absent from this part of the catchment. The downstream limits of the populations of upland longjaw 'Waitaki' in Fork Stream and lowland longjaw 'Waitaki' in Edwards Stream are both well upstream of the Takapō River indicating that their range is restricted to headwater areas of these tributaries.

Three different alpine galaxias (Dunn et al 2018) are found in inland areas from Southland to Marlborough. In the Tekapo catchment they are common in Lake Takapō tributaries and present, albeit rarely, in the Takapō River. This fish is the least common non-migratory fish in the Takapō River, and the fisheries records indicate it is the most sporadically distributed fish in the Takapō River downstream of Lake Takapō. The reasons for the sporadic occurrence are uncertain. However, alpine galaxias can be the first inland non-migratory galaxiid to reach a downstream range limit. Therefore, the present distribution is likely to be due to habitat limitation and similar to the historic limitation.

The more common Canterbury galaxias and upland bully are present in all the flowing reaches of Takapō River from Lake Benmore to the upper reach upstream of the Fork Stream confluence. Both species are also present in some of the tributaries and are widespread in the Tekapo catchment. Upland bully are also abundant in the Tekapo Canal (Gabrielsson 2013)

Therefore, the present day Takapō River has three native non-migratory fish present, Canterbury galaxias, alpine galaxias, upland bully, and the tributaries also have upland bully, Canterbury galaxias, alpine galaxias, upland longjaw galaxias, lowland longjaw galaxias and bignose galaxias. Comparisons with other Canterbury rivers indicate that no non-migratory native fish are absent.

The non-migratory galaxiids and upland bully present in the Tekapo catchment are all considered to be shallow water resident fish species and habitat preferences developed by Jowett & Richardson (2008) display these preferences (see Appendix B). They are common in riffles and shallow water areas close to the channel banks. The Takapō River still provides an abundant amount of shallow water habitat amongst the various braids and channel edges. However, native fish densities are not high in the shallow water areas and riffles indicating that habitat is not the factor limiting these fish populations. Other limiting factors are potentially related to the effects noted above, interactions with salmonids, the effects of didymo on the invertebrates and food resources for native fish, and possibly naturally low recruitment rates.

The lack of longjaw galaxias either lowland or upland and bignose galaxias from the main river is expected and most likely due to the lack of stable spring habitat and presence of predators such as salmonids and kōaro. While determining the pre-development populations is not possible the present-day distribution indicates the fish are limited to small headwater streams such as the headwater tributaries of Fork Stream. If flow changes in the Takapō River had led to the elimination of these galaxiids it would be reasonable to expect they would still be present more widely in the tributaries and occupy these streams downstream to their confluences with the Takapō River. It is possible the fish were more widespread prior to the introduction of salmonids and their range has been now restricted to the headwater tributaries by the salmonids. If this is the case, then this effect predates the construction of the Tekapo Power Scheme 50-70 years and as such the Tekapo Power Scheme cannot have contributed to the range reduction for these threatened galaxiids. However, it is also possible that these small galaxiids have never been present in the Takapō River rather they have resided in the tributaries.

It is possible to compare the upland longjaw distribution with that found in other Canterbury rivers (noting these are not upland longjaw galaxias 'Waitaki'). In the Rakaia River the largest population is known from a salmonid free spring fed tributary of the Mathias River (Water Ways Consulting 2015). Other records of the fish from the braided river channels of the Rakaia and Wilberforce rivers (NZFFD, Allibone pers. obs.) found occasional individuals rather than dense upland longjaw populations. In the Rangitata River, upland longjaws where abundant in some edge braids of the Rangitata River near Mesopotamia Station, but other areas of the braided river had few or no upland longjaw galaxias (Water Ways Consulting 2020). In both these river systems there is also a natural downstream limit near the upper reaches of the Rakaia and Rangitata gorges. What forms the downstream limiting factors is unknown but when assessing the Takapō River that the river maybe at or below the natural downstream limit cannot be forgotten. These surveys in other rivers do indicate that at times the braids can provide habitat for upland longjaw galaxias, but not all braided river areas do. In the Tekapo catchment the presence of upland longjaws only in tributaries well upstream of the Takapō River indicates that other factors are preventing their populations from spreading downstream towards the Takapō River and therefore the Tekapo Power Scheme cannot be restricting their present-day distribution.

Lowland longjaw galaxias 'Waitaki' is limited to small water ways in the Waitaki catchment, and the most abundant populations are generally in the trout free Department of Conservation managed streams. This distribution in small stream streams and the negative effect of salmonids indicates that the Takapō River was highly unlikely to support lowland longjaw galaxias in its pre-development flow state.

For bignose galaxias, there are no possible comparison with other river systems available as bignose galaxias is restricted to the Waitaki catchment. The present-day distribution of bignose galaxias is small spring fed streams in which it can often be highly abundant, e.g., small spring fed tributaries of the Grays River. The lack of this habitat along the Takapō River main channel would appear to be a straightforward limiting factor and this is not a result of the Tekapo Power Scheme.

6.3.2 Migratory fish and fish passage

Migratory fish are largely absent from the Takapō River, and this is due to the barriers further downstream on the Waitaki River blocking fish passage for migrant species capable of long inland migrations. This lack of migratory fish is not an effect of the Tekapo Power Scheme. However, the Tekapo Power Scheme will prevent fish passage from the Takapō River to Lake Takapō and back downstream. If longfin eel transfers occur to Lake Takapō and upstream areas the downstream passage for adult migrant eels would need to be provided.

The pre-existing stock of longfin eels in the Takapō River catchment is unknown. However, local residents recall large eels being common or abundant 30-40 years ago in the Takapō River tributaries such as the Grays River. It is unlikely the eels were abundant in the Takapō River if it had an open braided gravel riverbed as this does not provide good cover for large longfin eels unless there are logjams, macrophyte beds and stable side braids to reside in. Fish surveys in the upper reaches of the Rangitata River (e.g., Water Ways Consulting, 2020) and Rakaia River (Allibone pers. obs.) failed to find any longfin eels in the main braided river channels and only a few in stable side streams in the upper Rakaia catchment. This indicates that the lack of longfin eels in upper catchment braided river areas is common in the large Canterbury braided rivers. The present lower Takapō River, downstream of the Mary Range, does provide this habitat but no longfin eels were located at sampling sites there. The presence of suitable habitat without longfin eels demonstrates the longfin eel population has been reduced to a very small proportion of its historical size leaving large areas of suitable habitat in the lower Takapō River and the Takapō River tributaries unoccupied. However, abundant habitat would be available if elvers are transferred into the catchment, especially in the Takapō River tributaries.

It is also important to consider the available habitat in the Takapō River tributaries that still support small eel populations. This tributary habitat has good eel cover and is being used preferentially by the eels when compared to the Takapō River. It is reasonable to expect that regardless of flows in the Takapō River, the tributary habitat will still be the preferred habitat and the Takapō River eel population will remain small or non-existent.

Kōaro resident in Lake Takapō can conduct their natural migration to and from the lake and its upstream tributaries. However, larval kōaro in the Takapō River migrate downstream to Lake Benmore. Lake Benmore has provided new rearing habitat for the pelagic kōaro larvae and the adult population is expected to be increasing in the Tekapo catchment downstream of Lake Takapō. Therefore, the population in the Takapō River is considered to be predominately an artifact of Lake Benmore providing larval kōaro rearing habitat for the Takapō River population and it is self-sustaining. Upstream of Lake Takapō natural populations of this fish are abundant (Allibone pers. obs.) and are present in major river tributaries (e.g., Cass and Godley rivers) and smaller tributaries. It is unlikely the management of water levels in Lake Takapō has contributed to any noticeable change (increase or decrease) in abundance of kōaro.

Landlocked populations of common bully are present in all the upper Waitaki Lakes including Lake Takapō. The populations are abundant and the distributions of adult common bullies in the lower reaches of lake tributaries is also normal. The presence of common bully in the Tekapo Canal also indicate the bully has benefited from the construction of the canal (Gabrielsson 2013).

6.3.3 Fish entrainment from Takapō to the hydroelectric canal

Recent fish surveys in Lakes Takapō, Alexandrina and McGregor and Lake Takapō tributaries have reported two native fish: common bully and kōaro, but longfin eels that have previously been reported were not detected.

Most common bullies reside in the lake where they can complete their whole life cycle. Individuals may also move short distances upstream into lake tributaries, especially low gradient systems. Larval fish that hatch from eggs laid in the tributaries move downstream to Lake Takapō. Larval common bullies that hatch from eggs laid in Lake Takapō remain in the lake. The larval bullies are initially pelagic feeders and become more benthic in habit when they are 15-20 mm long. While the fish are pelagic there is potential for some of them to be entrained in the outflow and pass through the Tekapo A power station into the Tekapo Canal. There is some potential for larval fish mortality from pressure changes during passage through the turbines. However, the presence of a very large common bully population in the Tekapo Canal indicates that survival has been sufficient to establish and possibly help maintain this large common bully population. The impact of any loss of larval fish from the lake on the lake and lake tributary populations of common bully are not expected to be evident.

Kōaro have adult populations in the lakes and larval kōaro occur as pelagic fish in the lakes. The larval kōaro become benthic and migrate to adult habitat in the tributaries or the lake bottom when about 50 mm long. While the fish are pelagic there is potential for them to be entrained in the outflow and pass through the Tekapo A power station into the Tekapo Canal. There is some potential for larval fish mortality from pressure changes during passage through the turbines. Research on larval kōaro behaviour in Lake Wakatipu (Augspurger 2017) found that the pelagic larval kōaro did not disperse randomly around the lake. Rather they were concentrated in the inflow plumes of the lake tributaries. For Lake Takapō this means that the pelagic kōaro are likely to be concentrated near the major inflows, the Cass and Godley Rivers, both of which have large adult kōaro populations and are distant to the scheme intake. It is expected given this behavioural trait that few larval kōaro will encounter the power scheme intake. The larval kōaro are also known to exhibit rheotaxic behaviour and resist moving downstream with the current and rather swim in an upstream direction. Therefore, they will actively resist being entrained in the scheme intake.

Furthermore, given the size of the lake by far the majority of the larval bullies and kōaro will never encounter the Tekapo intake. Also prior to the development of the hydro-electric scheme the natural lake outflow to the Takapō River would have entrained larval bullies and kōaro in similar proportions as likely to occur today as the natural outflow is a similar size to the scheme intake inflow.

Adult longfin eels are the only native fish that would actively seek to move downstream into the intake as they undertake their migration to sea to spawn. However, no monitoring of downstream migration by adult longfin eel has been undertaken. This is part due to the lack of longfin eels left in Lake Takapō catchment. The longfin eel survey conducted in 2019 failed to catch any longfin eel in Lakes Takapō, Alexandrina and McGregor or their tributaries. and as such there is little chance of detecting any downstream migrating longfin eels with any monitoring. Therefore, while entrainment and possible mortality of longfin eel can occur as their population has now fallen to below detection levels actual out migration and any associated mortality is expected to be very low and will be declining further. The Tekapo Canal is also a significant recreational fishery and if longfin eel mortalities were occurring due to passage through Tekapo A power station this would have been observed and reported on at least some occasions. The absence of such reports at least anecdotally indicates there is no obvious eel mortality

Therefore, any effect of the intake and power station passage on present native fish populations in Lake Takapō is expected to be undetectable. The longfin eel population in the lake is too small for the scheme to have an effect. The effect on larval fish is expected to be very small because they can either survive turbine passage (bullies) or actively avoid entrainment in the intake (kōaro). Adult populations of common bully and kōaro occur upstream of the intake and are unaffected by any larval fish entrainment.

6.3.4 Fish passage at the Tekapo Canal culverts

The Mary Burn, Irishmans Creek and Fork Stream are the major streams that flow under the Tekapo Canal. All three streams flow through culverts and these have the potential to be fish passage barriers.

Fork Stream culvert has a downstream concrete apron with an approximately 1 m fall that will impede fish passage. A small fish ladder has been constructed to assist trout passage over the concrete apron. This fish ladder has been damaged and partially infilled with gravel. Kōaro and elvers can still ascend the 1 m fall as these small fish can both climb the vertical face of the concrete apron and also still use the fish ladder as a small flow suitable for their passage still flows down the fish ladder. Other native fish such as upland bully and Canterbury galaxias will struggle to gain upstream fish passage at this culvert. However, neither species needs to migrate upstream and there are resident populations of both species upstream of the culvert. The present restriction on salmonid passage by this culvert is beneficial to native fish in the upper reaches of Fork Stream as it may be limiting salmonid abundance and reducing predation. Therefore, the present limitation of fish passage at Fork Stream is most likely either neutral or a benefit to native fish in Fork Stream.

At Irishmans Creek there is no evidence that the culvert is a fish passage barrier with fish survey data upstream of the culvert showing all species are passing through the culvert.

The Mary Burn culvert has records of upland bully and Canterbury galaxias upstream of the culvert in recent years (this survey and Freshwater Solutions 2014) but no salmonids have been reported since 2001. However, fish surveys in this catchment are very limited and evidence of a fish passage obstruction at this culvert is limited to the recent failure to find salmonids. If this fish passage blockage does exist, it could be protecting a native fish only community upstream of the Tekapo Canal. However, further assessment is required before reaching a conclusion on fish passage at this culvert.

6.3.5 Lake Takapō lake level fluctuations

When considering the potential impact of lake level fluctuations, a rising lake level is not considered to present a risk to the fish populations. A falling lake level does present a risk of stranding of fish or eggs. However, this risk exists naturally as the lake level rises and falls. Therefore, the risk associated with the hydroelectric scheme is only present when the scheme causes lake lowering to occur at a faster rate than naturally occurs. Of the three native fish potentially present in Lakes Takapō, Alexandrina and McGregor (common bully, kōaro, and possibly longfin eels), the fish most exposed to any of the lake level fluctuations is the common bully as the bully's habitat includes, but is not limited to, the shallow lake margins. The bullies living around the lake margins are already exposed to lake level fluctuations and to substantial wave action driven shoreline disturbance. However, the presence of common bully catches in fyke nets set along or near the shoreline indicates that despite this disturbance common bullies survive in good numbers around Lakes Takapō, Alexandrina and McGregor. Under the current lake level regime, the bullies maintain a healthy population. The outflow from the lake into the Tekapo PS mimics the natural outflow and given the area of Lakes Takapō, Alexandrina and McGregor it is extremely unlikely that lake levels can drawn down fast enough to cause fish stranding. The risk of stranding is further mitigated by the nature of the lake shore, the shallow lake area and shoreline is sloped with little chance of forming isolated pools as the lake level falls. Therefore, stranding of bullies on the lake shore is considered to be a very low risk.

Common bully spawning sites with eggs, if laid very near the lake shore, may be at risk of being stranded by a lake level fall. Spawning near the lake shore is considered to be unlikely as the disturbance caused by wave action makes the shallow water habitat unsuitable for spawning. Also, the risk of egg stranding is already present due to the present lake level fluctuations and the risk can only be increased in the future if, as noted, the rate at which the lake level falls occur faster than today, and this can only happen if the outflow volume is increased. Stranding of eggs is not considered a risk when the lake is falling after a flood event. It is extremely unlikely that bullies will spawn on the flooded lake shore as this will not have suitable spawning habitat and bullies will not have sufficient time to select nest sites and for the males to undertake courtship behaviours to attract females to spawn. The potential impact of egg loss on the bully population is also further mitigated by the bully reproductive strategy. Female bullies can spawn multiple batches of eggs each year and if some are lost subsequent spawning activity can provide the common bully reproductive requirements.

Kōaro, when present in the lake, are either pelagic larval fish residing in the water column or benthic adult fish that are expected to live in deeper water below the littoral zone. Neither of these life history stages is expected to be directly affected by lake level fluctuations.

No effect is expected on longfin eel due to the lack of eels in Lake Takapō and connected waters. If eels were present, they are unlikely to strand as large eels will remain in water deep enough to avoid stranding and small eels and elvers are likely to wriggle downslope and escape isolated pools rather than be stranded.

7. CLIMATE CHANGE

7.1. Introduction

Climate change is an acknowledged effect on global ecosystems and is expected to impact on ecosystems in the next century. The actual level of warming is unknown, and many scenarios exists that predict a wide range of outcomes. The wide range of potential climate change outcomes means that assessing the effect of climate change on an ecosystem is dependent on the scenario(s) being assessed. An assessment also requires detailed knowledge on the tolerances of species to the ecosystem changes that will be driven by climate change.

In relation to freshwater ecology effects of climate change can be categorised into two types. Flood and drought events that are acute events that cause large scale disturbance, habitat restriction and mortality. These events can be considered acute effects as the impacts occur over a short duration of a few days (floods) to months (droughts). With climate change the magnitude and frequency of floods and droughts is expected to increase so their impacts become more frequent and severe. Other climate change freshwater related effects are more chronic and result from the increase in temperatures due to climate change warming effects. These temperature related effects create slow cumulative change to the environment. For example, this may lead, over time, to water temperatures outside the range tolerated by species or their prey, or changes the timing of temperature related environmental cues (e.g., spawning or migration) or changes to water quality (e.g., dissolved oxygen levels). They can be considered chronic effects as environmental stressors until such time as lethal limits are reached.

7.2. Acute climate change effects in the Takapō River

The major acute effect that will affect the Takapō River native fish fauna is flood events. The vulnerability of the native fish to flood events is difficult to determine as the effects will reflect the magnitude and frequency of the events and the amount of riverbed disturbance that occurs during the flood. The expectation is that with climate change the magnitude and frequency of flood events will increase and therefore cause greater and more frequent harm to aquatic communities.

The impact of flood events on native fish include:

- direct mortality as fish are killed by materials (rocks, logs etc) that are mobilised by the flood;
- mortality of fish stranded on the flood plain as flood water recede;
- the destruction of spawning sites;
- downstream displacement of fish; and
- loss of invertebrate prey communities.

As flood events become more frequent and severe the ability of native fish populations to recover decreases and populations may be lost either due to a single extreme event or multiple events with insufficient recovery time between events. If or when this occurs is inherently unpredictable as the scale of future flood events, the magnitude of their effects and the vulnerability of the native fish are not known. However, rarity does provide an indicator of risk. The very low numbers of alpine galaxias detected in the various fish surveys in the Takapō River indicates that this species is most at risk. For other native fish the populations are large and populations of these fish that are present in tributaries also provide resilience and refuge populations so floods may cause significant declines, but populations loss is less likely.

In the Takapō River there is some scope to moderate flood effects as Lake Takapō can buffer the downstream flood events by storing water in the lake and attenuating the flood event. There are flood management rules in place for Lake Takapō with the aim of reducing flood damage effects in the Waitaki catchment and these can/may reduce the impact of flood events.

Drought events are less likely to cause large scale native fish losses as the river will continue to provide habitat until it is completely dry both in the main river and its tributaries. Species such as upland bully and Canterbury galaxias are also common in small streams so tolerate low flow conditions. It is possible that increased water temperatures and low dissolved oxygen levels that can accompany droughts will be more lethal than the loss of habitat.

7.3. Chronic climate change effects in the Takapō River

In the Takapō River climate change can be expected to increase water temperature leading to increases in mean and maximum water temperatures and warmer water temperatures throughout the year. Direct deleterious effects on the fish themselves occurs as the water temperature rises to levels above the tolerances of the fish. High water temperatures will initially have chronic effects such as reduced growth rates and changes in behaviour as fish seek temperature refuges. Further temperature increases can lead to direct mortality and the absence of fish from the warmest areas of the river.

Olsen et al (2012) reviewed the available temperature tolerance data for native fish and invertebrates. Of the native fish species in the Takapō River, there is temperature tolerance data available for longfin eel, kōaro, upland bully and common bully. This data comes in two forms:

- lethal temperature 50 (LT_{50}) which is the water temperature that is lethal to a fish species and kills 50 % of the fish in a trial in a set time period; and
- critical thermal maximum (CTM) is the water temperature at which a fish's movements become disorientated, and the fish is unable to escape the high temperature area.

The actual tolerance of fish (and other organisms) to temperature change does vary depending on the temperature they are experiencing at the start of a test and also the rate of temperature increase (Desforges et al 2023). Therefore, direct comparisons of laboratory tests to the in-river situation are not possible as the river situation is only very rarely going to match any experimental setup. In addition, water temperature varies through the day and high and potentially deleterious water temperatures may only be reached for short periods and not sustained for long enough to have noticeable effects.

For native fish in the Takapō River the following assessments have been made (Olsen et al 2012):

- longfin eels there are LT_{50}s available for elvers and adult eels of 34.8°C and 37.3°C respectively;
- Common bully, an LT_{50} of 34.0°C and a CTM of 32.7°C;
- Upland bully a CTM of 32.8°C
- Kōaro juveniles a CTM of 28.0°C and a LT_{50} of 27.0°C.

This indicates that kōaro are the most sensitive of the fish tested that are present in the Takapō River. Recent water temperature measurements (Young et al 2025) found spot water temperatures vary along the Takapō River with the highest temperatures reported in the reach 10 km reach upstream of the Grays River confluence. However, this water temperature was measured in mid-afternoon, a likely time period for high water temperatures, whereas the water temperatures were measured at cooler times of day at other sites. The maximum water temperature measured was 23.4°C in March 2019. This is below the CTMs and LT_{50} of the native fish in the Takapō River. However, it is unlikely to be the warmest water temperature in the river as it is unlikely a spot measurement in March was taken during the peak water temperature that will be summer. Therefore, it is unknown how close the Takapō River water temperature comes to the temperature limitations of the various native fish. Nor is it known if or when water temperatures may exceed the temperature tolerances of native fish as this will depend on the rate of climate warming that occurs in the future.

There are a second group of indirect effects where the water temperature increases affect other species the native fish interact with, either their prey or their predators. Salmonids, a major predator and competitor of native fish is expected to be more susceptible to the detrimental effects of temperature increases and also the lower dissolved oxygen levels that accompany higher water temperatures. If this leads to a decline in salmonids, either in abundance or areas they occupy in the Takapō River then the native fish may benefit from the reduction in predation and competition if this offsets any temperature related effects the native fish are experiencing. Temperature effects may also lead to a decrease in the abundance of the native fish's prey, insects such as *Deleatidium* and chironomids. This has the potential reduce food supply to fish. Olsen et al (2012) showed the LT_{50}s for *Deleatidium* range from 21.9°C to 26.9°C depending on the experimental setup and that this key prey species is one of the most vulnerable to invertebrate prey species to temperature increases. As other invertebrate taxa are less sensitive to warm temperatures fish may either become prey limited (food limited) or they make begin prey switching and feeding on invertebrates that are still common in the Takapō River.

7.4. Climate Change Summary

Predicting the effects of climate change on the native fish in the Takapō River is problematic as there is little or no information available on the temperature tolerances of the native fish and differences in possible effects for different species (native fish, their prey and their predators/competitors) means that a simple assessment of climate change cannot be conducted.

Acute flood and drought events will become more problematic as their frequency and magnitude increase. The chronic effects of warmer water temperature are also likely and will impact on the less tolerant species first. The actual outcomes for native fish depend, for each species, on the direct and indirect effect of acute and chronic effects. This outcome will reflect the actual level of climate change and warming experienced in the future that at this time is unknown.

8. SIGNIFICANT NATURAL AREA ASSESSMENT

8.1. Introduction

The Canterbury Regional Policy Statement (CRPS)(Appendix D) has a requirement to assess areas for their significance. Policy 9.3.1 states:

> *1. Significance, with respect to ecosystems and indigenous biodiversity, will be determined by assessing areas and habitats against the following matters:*
>
> *a. Representativeness*
> *b. Rarity or distinctive features*
> *c. Diversity and pattern*
> *d. Ecological context*
> *The assessment of each matter will be made using the criteria listed in Appendix 3.*
>
> *2. Areas or habitats are considered to be significant if they meet one or more of the criteria in Appendix 3.*
>
> *3. Areas identified as significant will be protected to ensure no net loss of indigenous biodiversity or indigenous biodiversity values as a result of land use activities.*

For this assessment the native fish assemblage in Takapō River has to be placed within an ecological setting that allows it to be assessed against the criteria in the CRPS. For that purpose, the Takapō River is a large lake outflow braided river that flows through the dry MacKenzie Basin. It is distinct from large, braided rivers such as the Rakaia and Rangitata in that its source of flow is a lake rather than mountain rainfall and snow melt. Lake Takapō provides a buffer on high and low flow events creating a flow regime that differs from large braided rivers fed directly by runoff from the Southern Alps. Therefore, for the native freshwater fish are less frequently affected by flood flows and drought events. It differs from other rivers in the MacKenzie Basin such as the Ahuriri, Cass and Godley rivers, as they also derive their flow from rainfall and snow melt from the Southern Alps. There are two rivers, the Pukaki and Ohau rivers that are also large lake fed braided rivers that flow across the MacKenzie Basin and experience similar climatic, flow source and geologic settings within which the native fish assemblages could be compared to determine the relative state of the Takapō River native fish fauna.

As noted in this report the MacKenzie Basin has a distinct native fish fauna with bignose galaxias, the lowland galaxias 'Waitaki' and upland longjaw galaxias 'Waitaki' that are unique to the catchment. This local endemic fauna also restricts the assessment, with respect to the native fish to the Waitaki catchment as no other river system has all the fish species that are features of the Waitaki catchment.

Therefore, when considering the CRPS criteria for significance comparisons to the Pukaki and Ohau rivers are considered appropriate. Rivers outside of the Waitaki catchment are not considered as appropriate for inclusion in the assessment. Furthermore, the small streams within the MacKenzie Basin are not considered as appropriate for any comparison with the native fish fauna of the Takapō River due to their small size and flow sources.

The use of the Pukaki, and Ohau rivers as the only other examples of similar habitat is problematic in that both these rivers are highly modified and the natural state of these rivers and their native fish faunas are unknown. Most of the Pukaki River is a dry riverbed with flow only present when Lake Pukaki overflows at the lake level control structure. As such the Pukaki River provides no information on the natural state of the large lake fed MacKenzie basin rivers and their fish fauna. The Ohau River has a minimum flow of 8 m^3/s for the reach from Lake Ohau to Lake Ruataniwha, but downstream of Lake Ruataniwha no minimum flow applies and the Ohau River is an intermittent river with dry sections and the river flow is provided by ground water seepage and small spring fed tributaries. Therefore, the Ohau River provides limited habitat for native fish, that are residing in a highly modified environment and fish passage is not available along the full length of the river.

8.2. Representativeness

The Takapō River's flow connection with its lake source is now via a hydro-electric power scheme control structure and the natural outflow and flow character has been lost. The Takapō River flow is also highly modified as the lake outflow is diverted to the Tekapo Canal and the source of the flow for the Takapō River is now its upper most tributary, Fork Stream. Fork Stream is a rain and snow melt fed stream. Additional inflows to the Takapō River are the Mary Burn, and Grays River, also both rainfed stream systems. Therefore, the flow character of the Takapō River is now a rain/snow melt river system rather than a lake source system. This change in flow source will have modified the ecosystem function in several ways:

- Loss of lake seston food resources (planktonic lake production) that provides food resources to filter feeding invertebrates and then to fish in the downstream river;
- Water quality in the river now reflects the stream drainage from agricultural and reserve land with varying degrees of modification with the associated agricultural runoff character to the water quality;
- Water temperature regimes that are buffered, at least in the upper river areas, by the lake sourced water have been lost and replaced with the more variable rain fed stream temperature regimes;
- Alteration to fish passage opportunities.

The first three alterations to the Takapō River ecosystem are general effects on the freshwater ecosystem. The effects of these changes on the native fish fauna are unknown, if present at all. Comparisons with Pukaki and Ohau rivers cannot provide any examples of unmodified systems. With respect to native fish the creation of the Lake Takapō intake and Tekapo Canal has created a fish passage barrier. Downstream movement from Lake Takapō lead fish into the power scheme canal and upstream movement from the Takapō River to Lake Takapō is prevented by a lack of connection between the river and the lake. The lack of fish passage also occurs in the Pukaki and Ohau rivers so none of the rivers are representative of the pre-hydro-electric state for fish passage.

Therefore, none of the three rivers is representative of large lake fed braided river for fish passage. Unlike the Pukaki and Ohau rivers, the Takapō River while highly modified, does provide native fish habitat for almost its entire length and fish passage up to the Fork Stream culvert. Under the CRPS criteria (representativeness (1)) the Takapō River, while degraded is the least modified remaining large lake fed braided river ecosystem. However, the river is heavily modified by:

- The very reduced in flow;
- The presence of salmonids;
- Increases abundance of kōaro and reduction in eels;
- The effects of didymo;
- River channel works; and
- Riparian planting

And the representativeness of the native freshwater fish fauna is uncertain. The diversity of native fish species present appears correct, in part due to the few fish species that can occupy the river. However, there is considerable uncertainty with regard to the abundance and distribution of fish and this raises some doubts as to how representative, aside from in terms of general diversity, the native fish fauna is of this type of river.

8.3. Rarity/Distinctiveness

The MacKenzie Basin has three threatened native fish, upland longjaw galaxias 'Waitaki', lowland longjaw galaxias 'Waitaki' and bignose galaxias, but none of these species are found in the Takapō River. Therefore, the Takapō River does not trigger the rarity criteria for threatened species.

Three declining species, longfin eel, Canterbury galaxias, and kōaro, are found in the Takapō River.

For longfin eel habitat is available both in the Takapō River and in the wider MacKenzie Basin and habitat is not considered to be limiting the abundance and distribution of longfin eel. Rather fish passage further downstream in the Waitaki catchment limits longfin eel recruitment and fishing of the eel stocks in the MacKenzie Basin has further reduced the abundance of the eel. The loss of habitat is not considered to be such that less than 20 % of the longfin eel habitat exists in the MacKenzie Basin.

Canterbury galaxias is present in the Takapō River, but it is unknown if the modifications to the river has increased or decreased the available habitat in the river. The reduction in flow would have reduced the total area of the river, but much of the pre-modification habitat would have been too deep and too fast to be occupied by Canterbury galaxias and the present river provides good shallow water habitat in riffle and run areas and it is unknown how much the present-day area differs from the natural state. Comparisons to the Pukaki and Ohau rivers are not possible. The assessment of the state of the habitat also needs to consider the effects of the river channel work, both mechanical channel maintenance and tree planting programmes conducted by ECan on the habitat available for Canterbury galaxias. However, these effects are also unknown. The fish survey data does show Canterbury galaxias occupies the Takapō River from upstream of the Fork Stream confluence to Lake Benmore so Canterbury galaxias occupies the full length of the river. It would seem unlikely that the natural river would have provided 80% or more habitat than is present today so a reduction in habitat available to less than 20% of the habitat available pre-power scheme development is considered unlikely.

Kōaro are present in the Takapō River and are recruiting from the larval rearing habitat created in Lake Benmore. They are also considered to be increasing in abundance in the Takapō River as a result of the additional rearing habitat in Lake Benmore. Therefore, while classified as a declining species, (and the classification notes this is a partial decline (Dunn et al 2018)), the Mackenzie Basin population of kōaro is considered to be increasing in range and abundance. Therefore, changes to the flow in the Takapō River are not leading to a reduction in kōaro abundance and the fish is becoming more common in the MacKenzie Basin.

Alpine galaxias is classified as a naturally uncommon species. Its occurrence in the Takapō River is sporadic and it is neither widespread nor abundant in the river. It is absent from the Pukaki River and fish surveys in the Ohau River have also failed to locate this fish. The sparse state of the Takapō River population indicates that there are habitat limitations for alpine galaxias that the other native fish in the Takapō River are not subject to. What the limitations are and whether they existed prior to ecosystem modification commencing or whether they are due to the hydro-electric scheme alterations or other effects are unknown. Given the lack of knowledge with regard to the present-day distribution and the habitat use requirements of alpine galaxias the natural distribution it is not possible to determine nor are any changes to their habitat. As such determining if the population is representative or not is not possible.

With respect to geographic ranges of the native fish, with the exception of the Waitaki endemic galaxiids, none of the populations of native fish species present in the Takapō River or the MacKenzie Basin are at geographic extreme of the species' geographic range. While the Waitaki catchment is the only catchment with upland longjaw galaxias 'Waitaki', lowland longjaw galaxias 'Waitaki' and bignose galaxias, none of these species have been located in the Takapō River. Therefore, the Takapō River is not at a distributional limit for any native fish.

8.4. Diversity and Pattern

The Takapō River is limited in terms of habitat diversity. The braided river channel provides riffle, run and pool habitat that is common in braided and non-braided gravel/cobble bed rivers. The lower third of the Takapō River has some stable well vegetated channels, but the vegetation has often been planted as part of the river channel control programme conducted by ECan. As such some of the lower river habitat diversity is artificial, rather than natural and not part of the natural diversity and pattern of a braided river.

The native freshwater fish fauna is composed of relatively common fish species that occupy inland braided river areas of Canterbury and this reflects the natural low habitat diversity system the Takapō River provides. The Takapō River is not considered to provide any unique diversity that would be recognised as significant.

8.5. Ecological Context

The Takapō River provides habitat for all the non-migratory native fish present in the river as they all complete all their life cycle in the river. However, this is no different from any other water body in which non-migratory fish live. There is no feature of the river that is ecological unique or that supports an important part of the life cycle that is not supported in other water bodies with non-migratory native fish.

For the longfin eel, when present, the river provides feeding habitat for eels as they grow to adulthood, but this is not restricted to the Takapō River.

The Takapō River provides feeding and spawning habitat for kōaro, but this habitat is found in any water body with riffle and/or cascade habitat.

When compared to the other large lake fed braided rivers – Ohau and Pukaki, the Takapō River does provide more habitat that the other rivers, but as all the fish species in the Takapō River are not restricted to the Takapō River (or Pukaki and Ohau rivers) there are no important ecological features of the Takapō River that provide for native fish that are not provided in other rivers.

8.6. Summary

The assessment of the Takapō River for significant habitat for native fish indicates that the populations of native fish, with exception of representativeness, do not trigger the provisions of Policy 9.3.1 of the CRPS using the assessment criteria in Appendix 3.

It is noted that the Takapō River is the least modified of the three lake-fed, large, braided rivers, the other two being Pukaki and Ohau rivers. The Takapō River retains habitat for native fish that the other two rivers do not. However, the extend of the modifications on habitat and by the flow regime change coupled with the impacts of introduced species and alterations caused by river channel and riparian management means determining the effects of the Tekapo hydro-electric scheme on the native fish fauna is problematic. The assessment protocol does state in the representative assessment that even degraded examples can be significant if they are some of the best remaining. The Takapō River in its present state is considered significant for representativeness.

9. FRESHWATER FISH CONSERVATION MANAGEMENT IN THE UPPER WAITAKI

9.1. Regional Issues

The Waitaki catchment has three non-migratory galaxiid taxa, bignose galaxias, upland longjaw 'Waitaki' and lowland longjaw 'Waitaki' restricted to the catchment with the majority of the populations of these species occurring upstream of Lake Benmore in small tributaries of the Twizel, Ahuriri and Takapō Rivers and in rivers and streams upstream of Lakes Takapō, Pukaki and Ohau. The three fish together with Canterbury galaxias and alpine galaxias form a suite of galaxiids that are in decline due to the impacts of salmonids and habitat loss. An additional impact is now the increase in kōaro, a larger native fish, that preys upon the smaller galaxiids and possibly competes for space and food with Canterbury galaxias.

9.2. Conservation Management

To improve the conservation status of these threatened and declining galaxiids the Department of Conservation, Environment Canterbury and iwi are undertaking predatory fish exclusion and removal projects.

For the lowland longjaw galaxias barriers to upstream movement by salmonids have been established on streams in the Omarama Stream catchment and Fraser River near Twizel. The Fraser River site, Fraser Spring, has an active trout and kōaro removal programme that catches these fish and removes them from the spring and first 200 m of stream downstream from the spring. A weir barrier prevents reinvasion by the trout and kōaro.

The tributaries of Fork Stream are another active trout removal area with removal operations being conducted about 25 km upstream of the Tekapo Canal culvert. The upper reaches of Fork Stream that are within NZ Army land and private land have a number of tributaries where bignose galaxias and upland longjaw galaxias are present (Figure 18). The Department of Conservation and Environment Canterbury are cooperating on two trout removal projects in tributaries at the downstream end of the area with bignose and longjaw galaxias populations. No kōaro or longfin eel have been recorded in these upper Fork Stream tributaries, so the conservation management only has to remove salmonids. The first removal site is a tributary on the true left of Fork Stream on NZ Army land. Here a trout barrier has been placed in the lower reaches of the tributary and an annual trout removal operation is conducted. This well-established project removed seven brown trout in the February 2020 fishing indicating removal is nearly complete. The second more recently established trout removal project is on private land in a true right bank tributary of Fork Stream. This is a larger stream and in the early stages of the removal process so relatively large numbers of trout are being removal during the annual removal operations. Following the completion of trout removal in these streams there will be a requirement to check on the barrier status and monitoring for any reinvasion.

Both the present removal projects are in tributaries of Fork Stream at the downstream end of the area occupied by bignose galaxias and upland longjaw galaxias and it is possible further exclusion sites can be developed in other tributaries further upstream in the Fork Stream catchment.

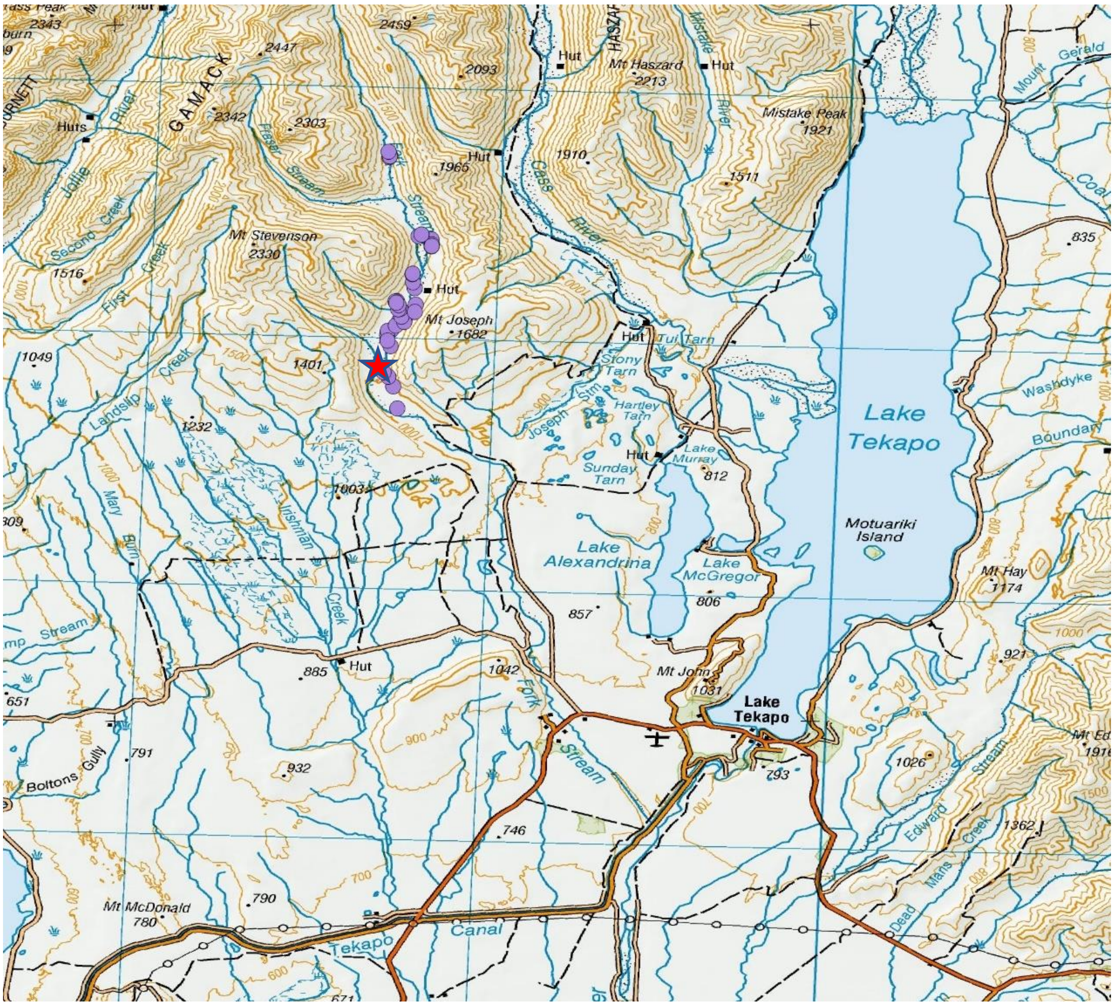

Figure 18: Fork Stream upland longjaw sites and location of trout removal projects (red star).

The Department of Conservation also monitors the large population of lowland longjaw galaxias in Edwards Stream. This population occupies the upper reaches of Edwards Stream upstream of State Highway 8 (Figure 19) on Sawdon and Mount Hay stations. The stream is also occupied by rainbow trout. At present there are no conservation actions at Edwards Stream aside from monitoring but there are possible trout removal options for Edwards Stream tributaries.

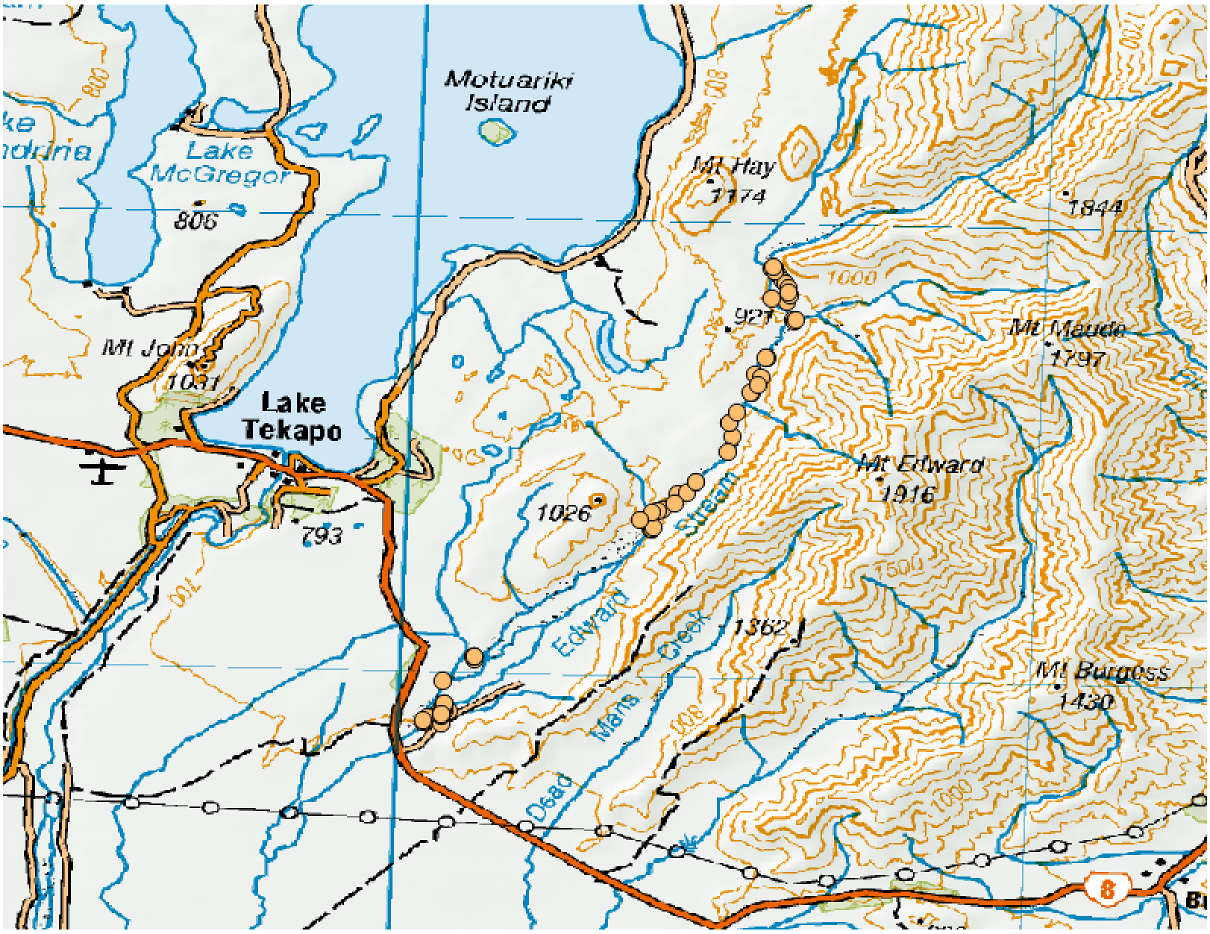

Figure 19: Edwards Stream and the lowland longjaw galaxias records.

Further conservation projects may be found in the upper reaches of Mary Burn and Irishmans Creek. Mary Burn has not been surveyed upstream of Braemar Road and the native fish values are poorly understood for this stream. Aerial photographs indicate the habitat is unmodified and potential suitable for bignose galaxias but its potential to be habitat for either of the longjaw galaxias cannot be determined from these photographs. Irishmans Creek, while having had some survey work upstream of Braemar Road, has had limited survey effort but this limited survey has found bignose galaxiids at three locations indicating at least one of the rarer galaxiids are present in the catchment. The presence of abundant brown trout in Irishmans Creek at Braemar Road means any conservation management for threatened galaxiids is likely to only possible upstream of Braemar Road (in NZ Army land) in tributaries of Irishmans Creek.

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APPENDIX A THREATENED GALAXIIDS

Pencil galaxiids

The pencil galaxiids are a group of slender bodied non-migratory galaxiids that are called pencil galaxiids as their body is long and slender and often about as thin as a pencil. The group is comprised of the two longjaw galaxiids, the alpine galaxiids, bignose galaxiid and dwarf galaxiids. Four of these taxa, the lowland longjaw galaxias 'Waitaki', the upland longjaw 'Waitaki', alpine galaxiid and bignose galaxiid are found in the Waitaki catchment.

Longjaw galaxiids

The upland longjaw galaxias is a very slender bodied galaxiid with an upturned lower jaw with a maximum length of 85 mm (Figure A1, A2). The key difference between upland and lowland longjaws is the placement of the dorsal fin which is in front of the anal fin in upland longjaws and straight above or behind the anal fin in lowland longjaws. The principal caudal fine ray counts also distinguish the two longjaw galaxiids with upland longjaws usually having 16 principal caudal fin rays and lowland longjaws having 15.

Figure A1: Upland longjaw galaxias

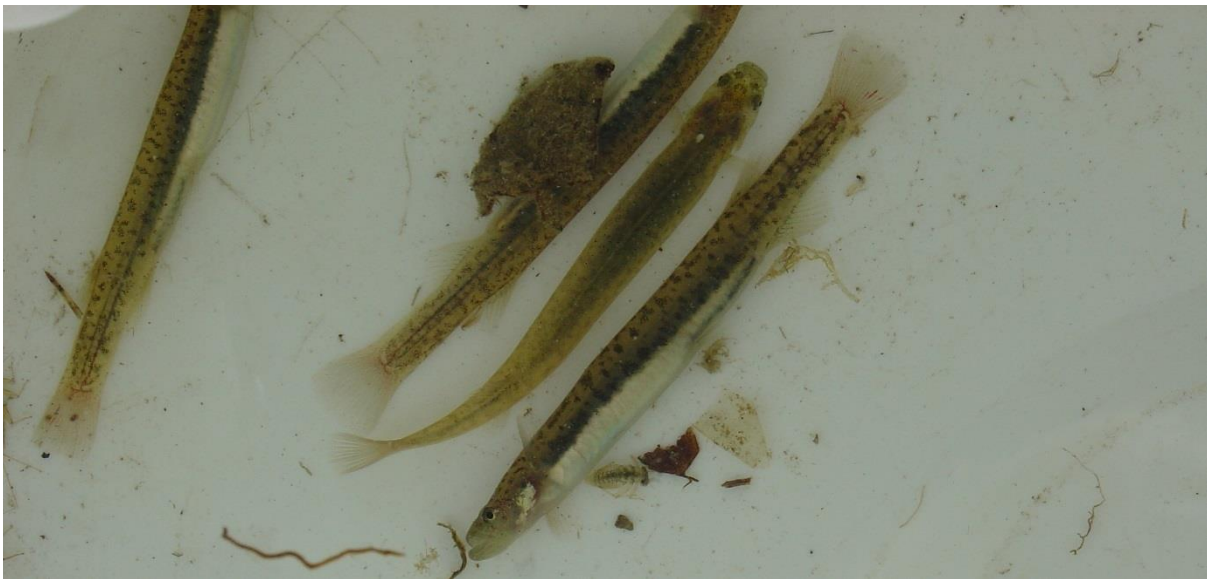


Figure A2: Lowland longjaw galaxias

Bignose galaxiid

Bignose galaxias is s slender bodied galaxiid that rarely exceeds 80 mm in length. The equal length upper and lower jaws distinguish it from longjaw galaxiids. It is similar to the alpine galaxias but has a more slender body and does not reach the larger lengths alpine galaxias can attain. Bignose galaxias lack the dorsal chevron that alpine galaxias has and has a rounded snout (Figure A3) Bignose galaxiids also have a low principal caudal fin ray count with fish usually having 14 or 15 rays.

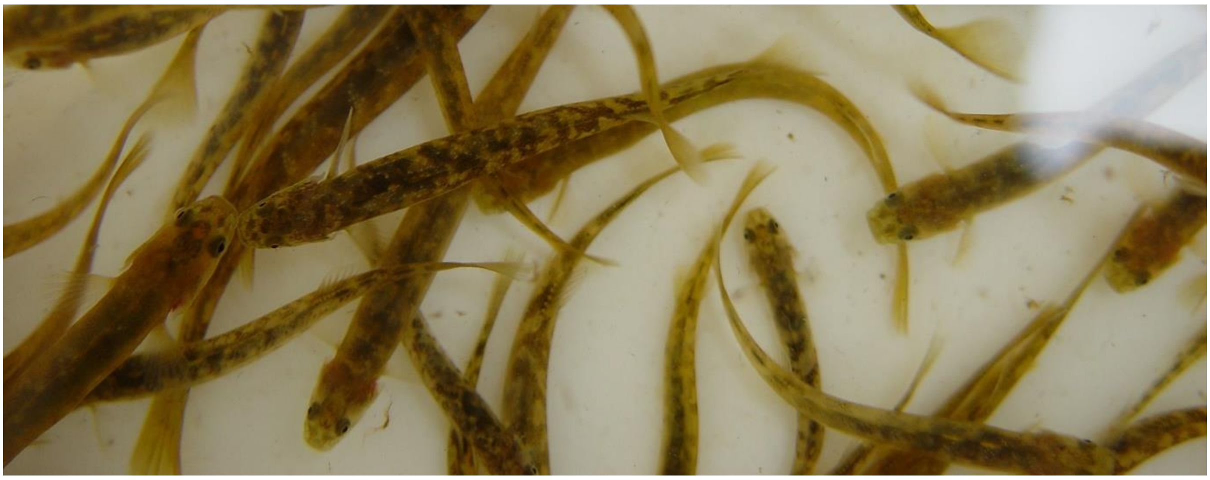


Figure A3 Bignose galaxias

Alpine galaxias

The alpine galaxias is the largest of the pencil galaxiids and can reach a length of 150 mm. It has a white chevron in front of the dorsal fin that distinguishes it from other galaxiids in the upper Waitaki. The snout also has a protruding upper jaw and an abrupt change angle when the head is viewed from above (Figure A4). Alpine galaxiids have 16 principal caudal fin rays

Figure A4 Alpine galaxias, showing blunt snout (top), a large individual (middle) and white dorsal chevrons (bottom).

Canterbury galaxias

The Canterbury galaxiid (Figure A5) is stout bodied non-migratory galaxiid and is generally distinguished from the pencil galaxiids by its large body size for any length. The maximum length for a canterbury galaxiid in 170 mm but individuals are rarely over 130 mm. It lacks the blunt snout and dorsal chevron of the alpine galaxiid and does not have the long upturned lower jaw the longjaw galaxiids. It has 16 principal caudal fin rays, and this will distinguish smaller Canterbury galaxiids from bignose galaxiids.

Figure A5: The Canterbury galaxias.

Kōaro

Kōaro are a migratory galaxiid and in the upper Waitaki larval fish rearing in the natural lakes and hydro-electric reservoirs. Adult fish can be found in lakes, rivers and streams. The life history provides some identification cues as kōaro whitebait are captured at some times of year and this 50-60 mm transparent whitebait are not found in any of the non-migratory galaxiids that all are fully pigmented at lengths of 2-300 mm. Kōaro can be distinguished from Canterbury galaxiids by the head shape and pectoral fin shape. Kōaro have a head the slopes downwards towards the snout and the head tapers inwards from the operculum to the snout (Figure A6). The pectoral fins on kōaro are more triangular in shape than the rounded pectoral of Canterbury galaxias (Figure A7) The large size of kōaro with individuals up to 250 mm found in the upper Waitaki makes them the largest galaxiid present in the catchment.

Figure A6: Kōaro.

Comparison among the galaxiids

Figure A7 Kōaro (horizontal fish) and Canterbury galaxias (vertical fish) showing head and fin shape differences.

The body dimensions of galaxiids are a useful comparative identification feature (Figure A8) with the fish of the same lengths more or less slender than one another.

Figure A8: Canterbury galaxias, alpine galaxias and upland longjaw galaxias

APPENDIX B FISH DISTRIBUTION MAPS

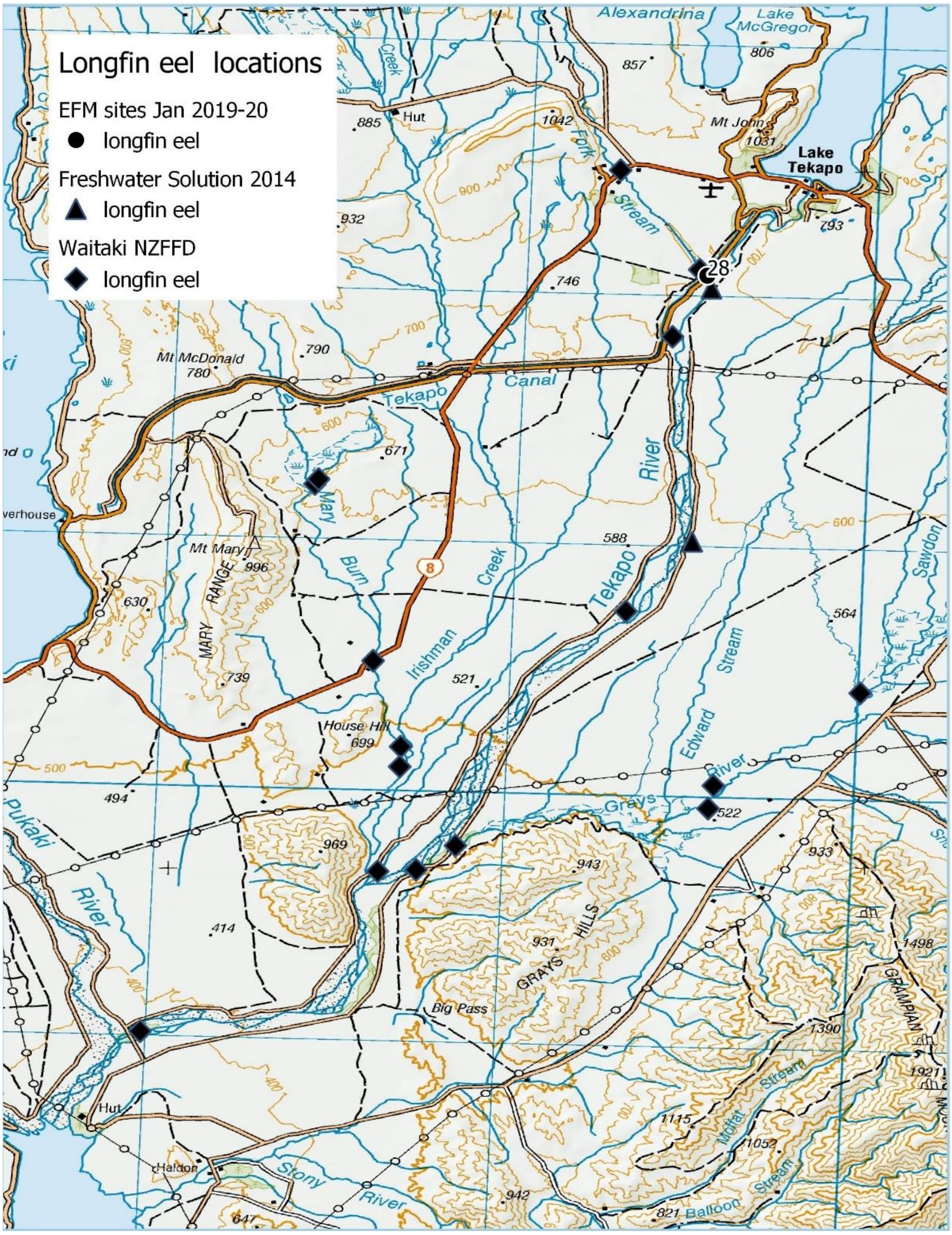


Figure B1: Longfin eel records from all sources for the Takapō River.

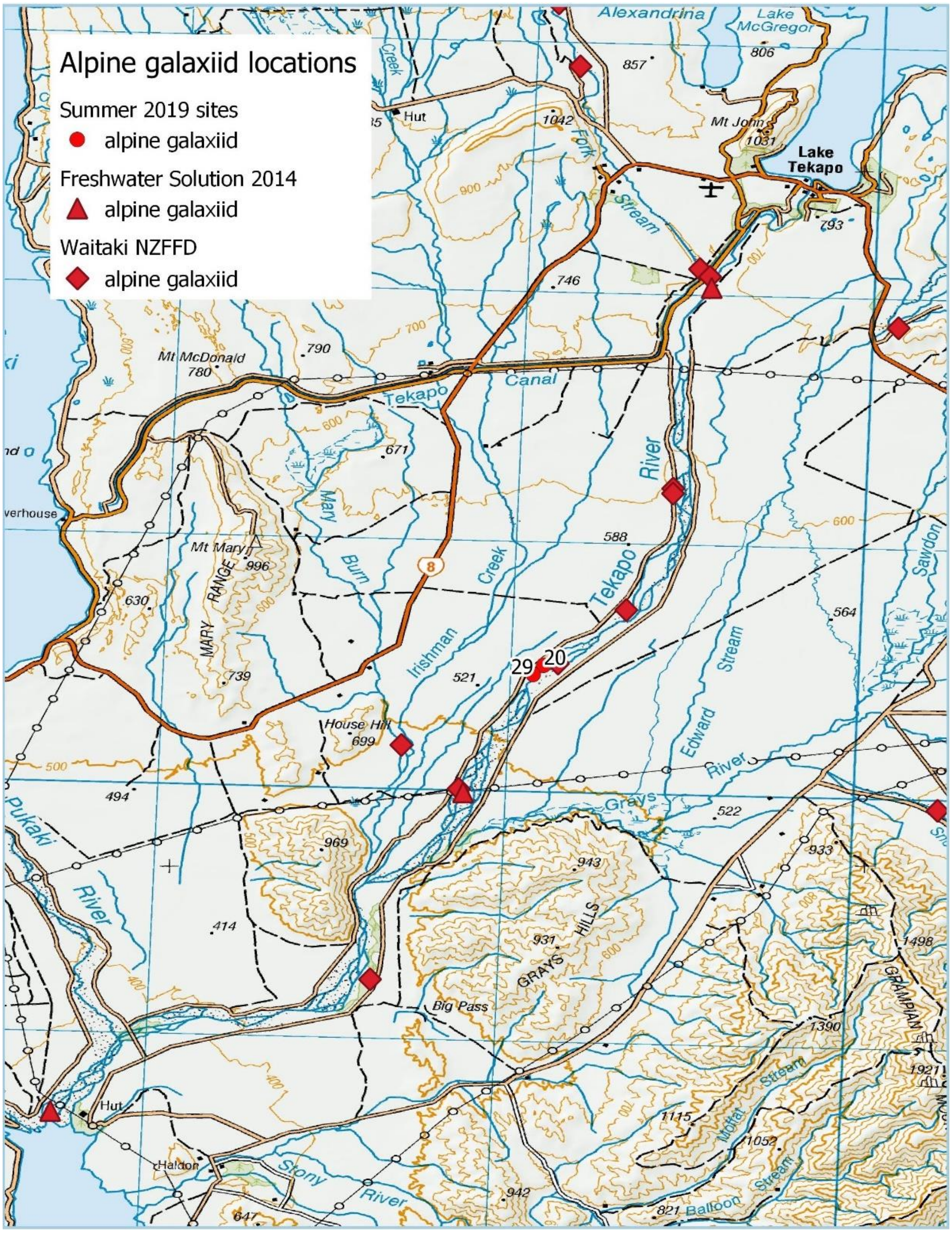


Figure B2: Alpine galaxiid records from all sources for the Takapō River.

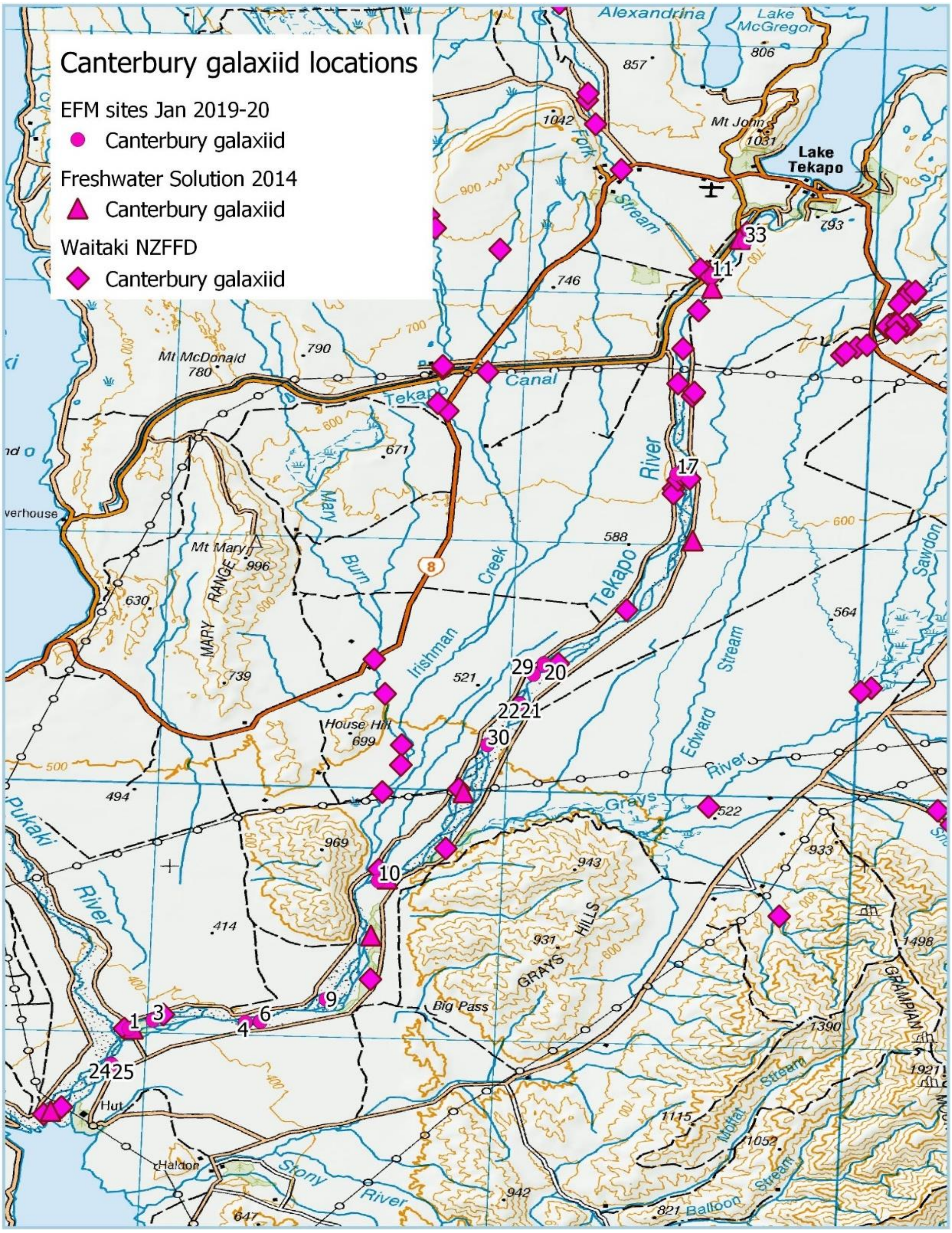


Figure B3: Canterbury galaxiid records from all sources for the Takapō River.

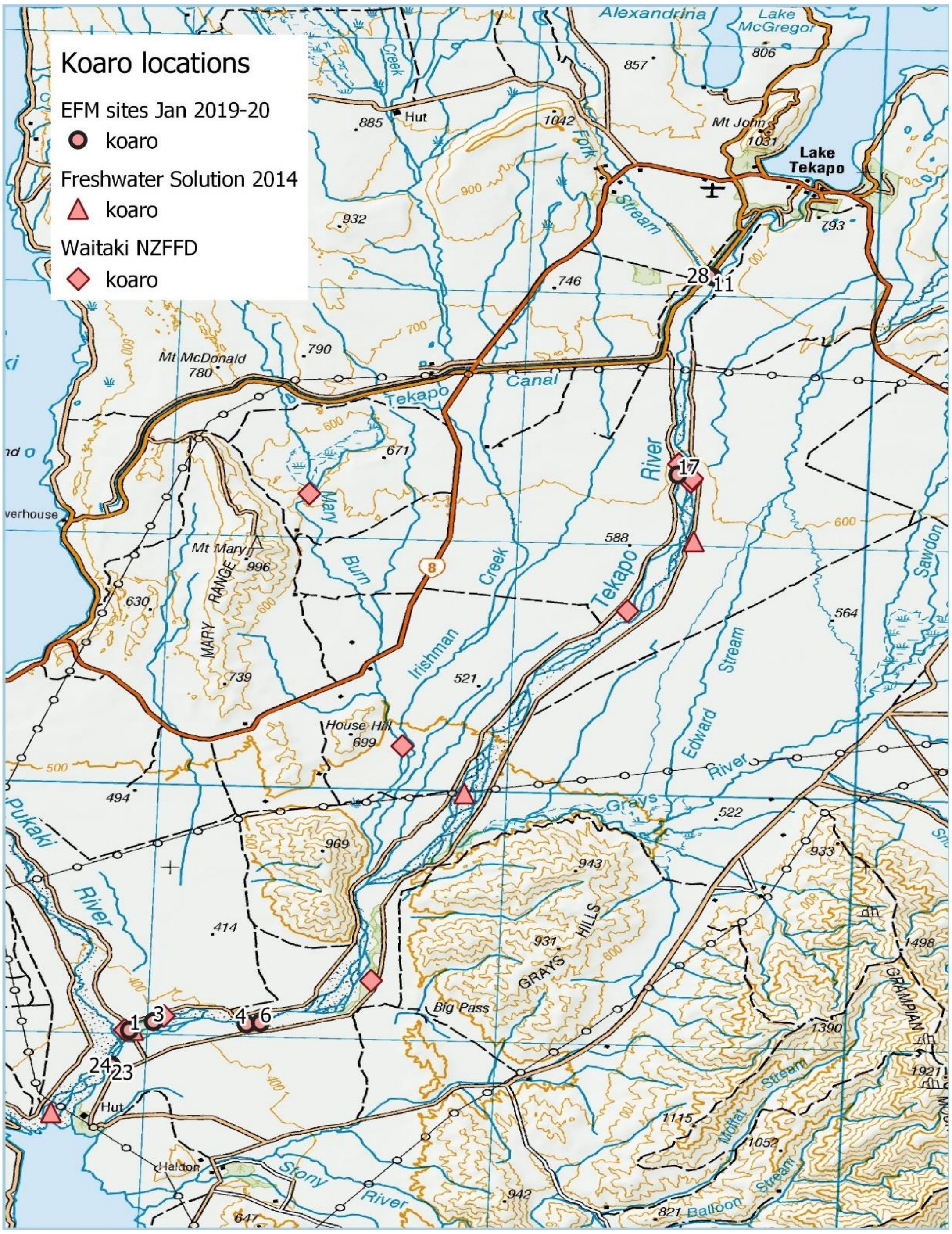


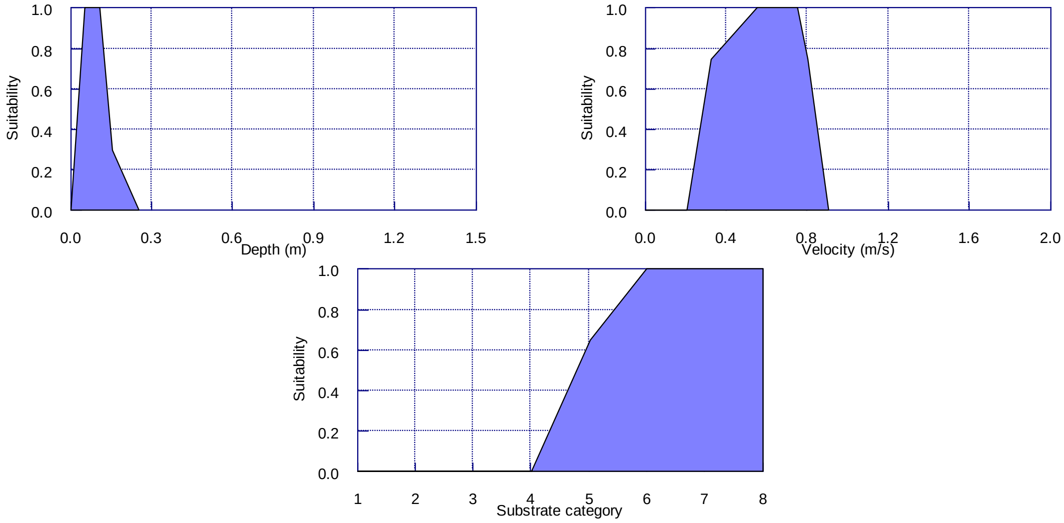
Figure B4: Kōaro records from all sources for the Takapō River.

Figure B5: Common bully records from all sources for the Takapō River.

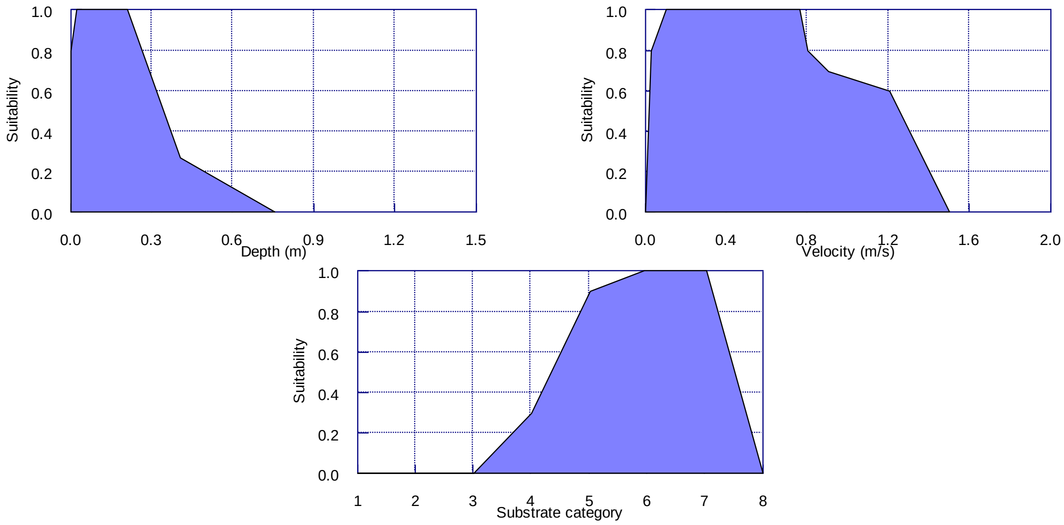
Figure B6: Upland bully records from all sources for the Takapō River.

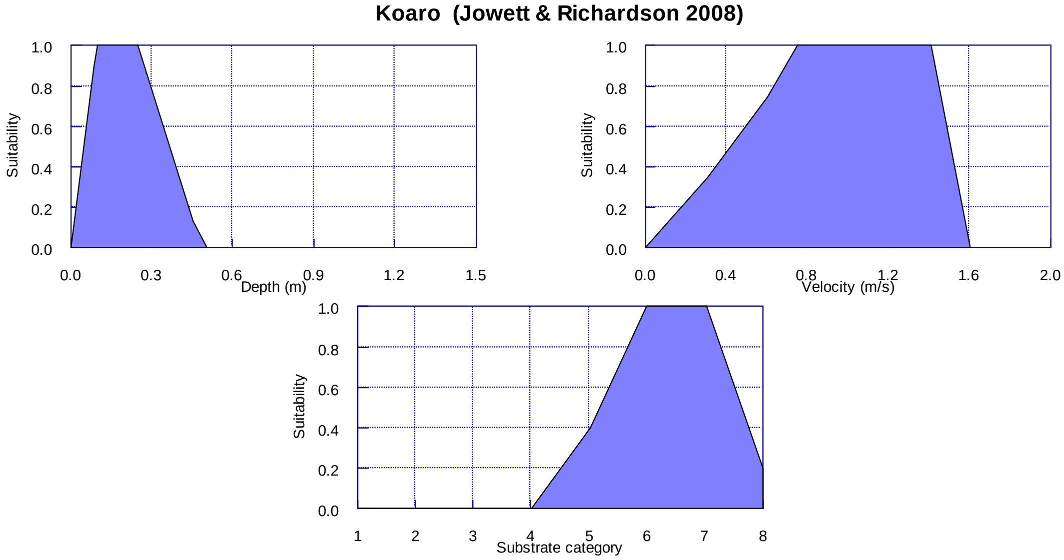
APPENDIX C HABITAT PREFERENCES CURVES FOR NATIVE FISH IN THE TAKAPŌ RIVER.

Alpine galaxias (Jowett & Richardson 2008)

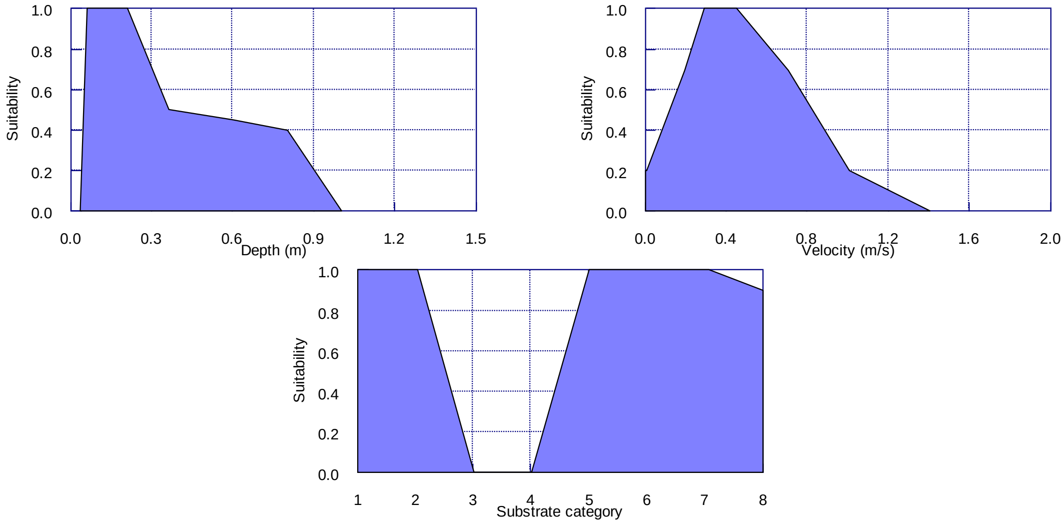


Canterbury galaxias (Jowett & Richardson 2008)

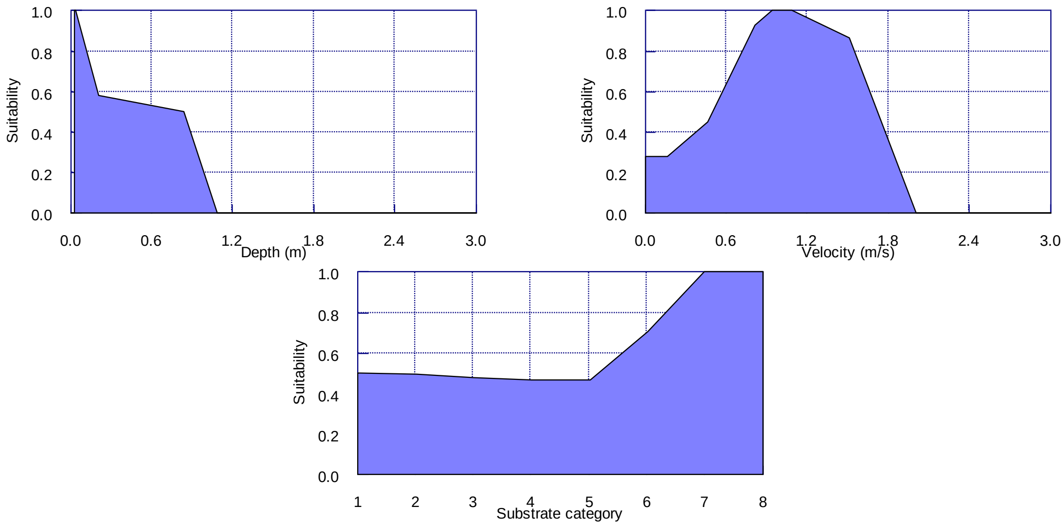



Koaro (Jowett & Richardson 2008)
Suitability
Depth (m)
Velocity (m/s)
Substrate category
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.3
0.6
0.9
1.2
1.5
0.4
0.8
1.6
2.0
1
2
3
4
5
6
7
8

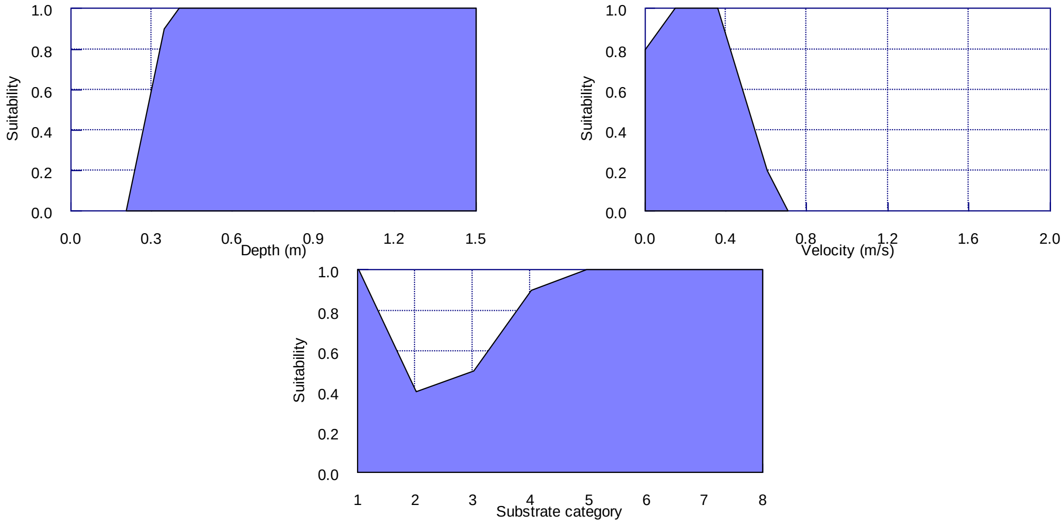
Longfin eel < 300mm (Jowett & Richardson 2008)



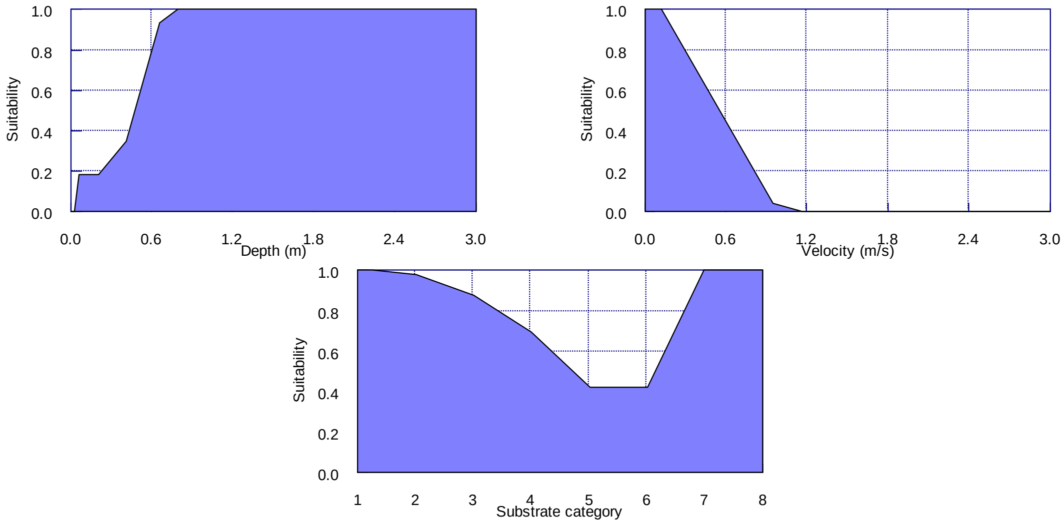
Longfin eel <300 mm (Jellyman et al. 2003)



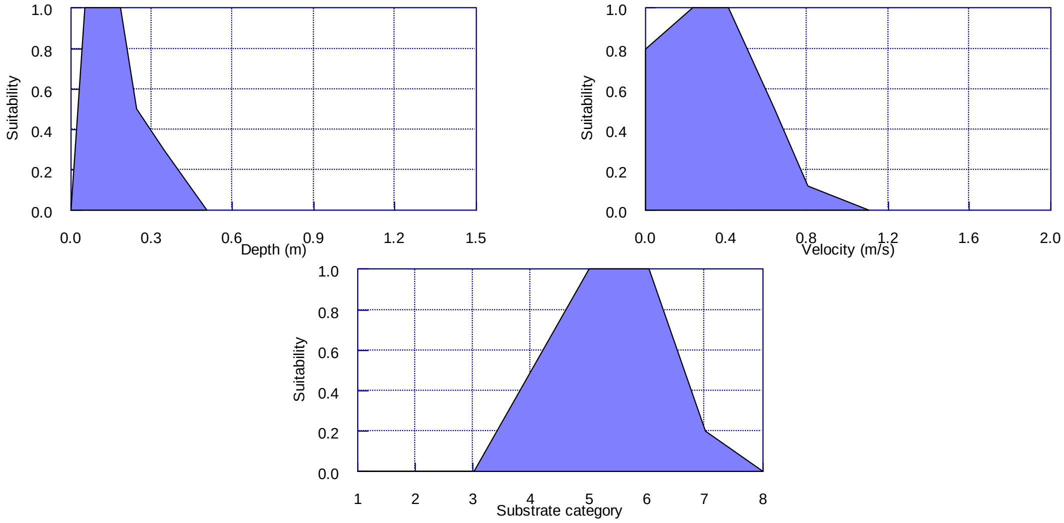
Longfin eel > 300mm (Jowett & Richardson 2008)



Longfin eel >300 mm (Jellyman et al. 2003)



Upland bully (Jowett & Richardson 2008)



APPENDIX D ECAN RPS: CRITERIA FOR DETERMINING SIGNIFICANT INDIGENOUS VEGETATION AND SIGNIFICANT HABITAT OF INDIGENOUS BIODIVERSITY

Representativeness

1. Indigenous vegetation or habitat of indigenous fauna that is representative, typical or characteristic of the natural diversity of the relevant ecological district. This can include degraded examples where they are some of the best remaining examples of their type, or represent all that remains of indigenous biodiversity in some areas.

2. Indigenous vegetation or habitat of indigenous fauna that is a relatively large example of its type within the relevant ecological district.

Rarity/Distinctiveness

3. Indigenous vegetation or habitat of indigenous fauna that has been reduced to less than 20% of its former extent in the region, or relevant land environment, ecological district, or freshwater environment.

4. Indigenous vegetation or habitat of indigenous fauna that supports an indigenous species that is threatened, at risk, or uncommon, nationally or within the relevant ecological district.

5. The site contains indigenous vegetation or an indigenous species at its distribution limit within Canterbury Region or nationally.

6. Indigenous vegetation or an association of indigenous species that is distinctive, of restricted occurrence, occurs within an originally rare ecosystem, or has developed as a result of an unusual environmental factor or combinations of factors.

Diversity and Pattern

7. Indigenous vegetation or habitat of indigenous fauna that contains a high diversity of indigenous ecosystem or habitat types, indigenous taxa, or has changes in species composition reflecting the existence of diverse natural features or ecological gradients.

Ecological Context

8. Vegetation or habitat of indigenous fauna that provides or contributes to an important ecological linkage or network, or provides an important buffering function.

9. A wetland which plays an important hydrological, biological or ecological role in the natural functioning of a river or coastal system.

10. Indigenous vegetation or habitat of indigenous fauna that provides important habitat (including refuges from predation, or key habitat for feeding, breeding, or resting) for indigenous species, either seasonally or permanently