What's lurking in the Waituna wetlands?

A freshwater fish survey – Arawai Kakariki Project

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Department of Conservation
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Summary of Findings and Recommendations

1. The Waituna catchment offers a high diversity and abundance of aquatic habitats, with tributary streams accounting for a major proportion of the available fish habitat. The presence of healthy macrophyte beds in the lagoon is significant for the fish habitat.
2. Each habitat type surveyed supported different fish assemblages where some species were either common or unique to the individual habitats.
3. In general, we recorded a low abundance and diversity of fish species in the catchment. The closed status of the lagoon at the time of sampling may account for the observed low diversity, as this restricts access to the lagoon from marine and estuarine species that would normally be expected to visit or inhabit the lagoon and the tributary streams.
4. Nine fish species were caught in the catchment; of which seven were freshwater species and two marine or estuarine species. The most abundant fish caught during the survey were; common bully, longfin eel, and giant kokopu.
5. Banded kokopu were not caught during the survey despite being previously recorded in the catchment. We suggest that further survey of their known habitat is conducted to confirm their presence in the catchment.
6. The survey has provided a 'snapshot' of the health, composition and habitat use of the fish fauna in the Waituna catchment. In order to further understand fish diversity patterns and ecosystem coupling, further survey work is required, particularly in the lagoon environment. The lagoon is regularly opened to the sea resulting in a change in fish assemblages. Further, as eels are a taonga species, a full assessment of the health of the eel populations in the catchment is recommended.
7. Little is understood about the impact of the lagoon opening on the recruitment of fish species. The presence of plenty of small fish (including giant kokopu) in the catchment suggests that recruitment is still good. In order to manage and protect the fisheries, a better understanding is needed of this unique system.

1.0 Background

The Awarua / Waituna wetland is located on the Southland coast between Bluff Harbour and the Mataura River, some 20 km south-east of Invercargill, Southland, New Zealand (see figure 1). The wetland climate is one of frequent and persistent winds, low temperatures and moderate rainfall. Mean annual values from the Invercargill airport climate station are: 1112 mm/year of rain, 9.9 °C temperature, and wind speed of 94 km/h.

The Awarua / Waituna area is on the coastal margin of a glaciofluvial plain of quartz rich gravels. These late Quaternary gravels and recent sediments overlay a thick sequence of mid-Tertiary gravels, sand, mudstone, and lignite (Department of Lands and Survey, 1984). The plains are bound by Mesozoic greywacke forming the Hokonui Hills and the Catlins. The greywacke hills are cut by the south-flowing Oreti and Mataura Rivers. Limited outgrowth of the plains is achieved by long shore drift and accumulation of beach ridges and bars. This has led to ponding and impeded drainage of the alluvial plain, and the formation of Waituna Lagoon (Department of Lands and Survey, 1984). Towards the coast a thick blanket of peat and peat bogs cover much of the gravels. Inland, lowland yellow-brown earths form the surface mantle (Riddell et al., 1988).

Figure 1. Map of the Awarua/Waituna wetland complex

2.0 Introduction

The Awarua/Waituna area is a lowland wetland / peat bog complex of large scale and high habitat diversity and complexity. It includes the New River Estuary, Awarua-Seaward Moss, Tiwai- Waituna, and Toetoes – Toetoes Estuary – Fortrose Spit areas. The wetland has been recognised internationally for its outstanding values by a RAMSAR designation. Recently (2008), the RAMSAR area was expanded to form the Awarua Wetland, an area in excess of 20,000 ha, being the largest Ramsar Wetland of International Importance in New Zealand. Part of the wetland (Waituna Lagoon and its margins) has also been recognised nationally as an important area by gaining Scientific Reserve status in 1983.

The wetland offers a diversity of aquatic habitats for fish species. Waituna Lagoon and its surrounding catchment is a network of streams, drains/channels, ponds and tarns. Waituna Creek, Moffat Creek and Currans Creek are the three lagoon tributaries; they are all single channel, slow flowing streams. There has been extensive drainage of the catchment, including: tile drains, stream channelisation and straightening for agricultural development.

Waituna Lagoon is an elongated, shallow (water depth is usually less than 2 m) coastal lake that is approximately 1850 ha. Air photography and field investigations have revealed the fact that the lagoon has been larger at some point in the past and that it used to have a drainage connection with Awarua Bay (Kirk & Lauder, 2000). Natural water levels are generally high and ocean salt content of the water body is low (water salinity was found to be near freshwater when surveyed by Stevens and Robertson (2007)). However, sea spray may contribute to the slightly brackish environment when the lagoon is closed to the sea.

The Awarua / Waituna catchments contain marine, estuarine and freshwater fish species. These include populations of: the threatened giant kokopu (*Galaxias argenteus*) (ranked as in gradual decline by the Department of Conservation threat classification system, 2004), banded kokopu (*G. fasciatus*), inanga (*G. maculatus*), short and long fin eels (*Anguilla australis* and *A. dieffenbachii*) (long finned eels threat status is in gradual decline), four species of bully (*Gobiomorphus gobioides, G. huttoni, G. hubbsi, G. cotidianus*); and other estuarine and freshwater fish such as: yellow-eye mullet (*Aldrichetta forsteri*), common smelt (*Retropinna retropinna*), estuarine triplefin (*Grahamina* sp.), yellowbelly flounder (*Rhombosolea leporina*), black flounder (*Rhombosolea retiaria*) and exotic fish such as trout (*Salmo trutta*) (see appendix 1). The brown trout fishery in Waituna Lagoon is very important in Southland, as the fish in the lagoon are larger than average due to the presence of sea run fish (Riddell et al., 1988). The Maori word “Waituna” translates into “water of eels’, and the lagoon and the streams that flow into it have traditionally been favourite fishing areas of Maori.

The lagoon is periodically opened to manage the hydrology of the surrounding farm land, generally by bulldozer. This regime makes for a unique system that switches from freshwater to estuarine, constantly changing and influencing the aquatic communities found within the system. Historically, the lagoon drained to the sea naturally when there was a combination of high water levels and strong westerlies. The strong westerlies would push the water to the east end where it would burst through the shingle bar and into the sea (Waghorn and Thomson, 1989). The highest the water level recorded in the lagoon since 1972 was 3.45 m in 1994 (Johnson and Partridge, 1998). Currently, the lagoon is opened more frequently and at lower water levels.

The artificial opening of the lagoon allows some access to and from the sea for migratory fish species, such as flounder and yellow eye mullet. The lagoon is an important habitat for many species of aquatic organisms, these include: fish, crustaceans, snails, polychaetes, aquatic insects, and macrophytes (aquatic plants). For fish, the lagoon is an important habitat for: spawning, as a nursery for juveniles (marine and freshwater), marine wanderers entering into freshwater, and for species that prefer open water and lake margin habitats. Others, such as giant kokopu, common and redfin bullies; utilise the network of freshwater systems in the rest of the catchment for the majority of their life cycle (typically in the adult form). Linkage to the lagoon or the coastal environment maybe vital for the larval stages of these fishes.

2.1 AIM

Intensification of agriculture in the Awarua/Waituna wetlands has resulted in land use changes, land development and water quality issues. Human induced change in the catchment over time places pressure on the natural environment and the biota living within it. As a result of changes to the environment, the fish fauna composition, abundance, and habitat use may change. Therefore, it is important to establish baseline fish data in order to measure change across seasons and changes in the environment (both as a result of land use changes and management initiatives).

Thus, the study aims to establish baseline fish data in the Waituna catchment, including information on habitat associations, composition, relative abundance and population structure. This information will be used to guide future fish biodiversity programmes in the wetlands, as well as management options, monitoring and further field survey.

3.0 Methods

3.1 SITES

The sites selected cover stream, lagoon and tarn habitat types, as well as taking into consideration sites sampled by previous studies and the New Zealand freshwater fish database (NZFFD) records. Furthermore, sites were selected with regard to accessibility and their conduciveness with the survey methods (e.g. some sites were overgrown with macrophytes, making the methods used inappropriate).

A total of 21 sites were surveyed in the Waituna catchment (see figure 2). Sites were categorised as; stream (14 sites), tarn (3 sites) or lagoon sites (4 sites). See appendix 2 for fish survey site localities.

Figure 2. Map of fish survey sites in the Waituna catchment

3.2 DATA COLLECTION

In most instances fyke net and minnow trap survey methods were used at each site, however, in some instances only minnow traps were used. Additionally, at one site (site 21) a seine net was used (see table 1 for fishing methods used at each site). Different methods were used to catch different fish species and different size classes. The spotlighting method was also used at sites 14 and 18, but no fish were seen using this method.

TABLE 1. FISHING METHODS USED AT EACH SITE.

SITE	LOCALITY	HABITAT TYPE	FISHING METHOD
1	Currans Creek at Waghorn's bridge	Stream	4 fyke, 4 minnow
2	Currans Creek trib. at Waituna Lagoon Rd	Stream	3 fyke, 4 minnow
3	Currans Creek at Waituna Lagoon Rd	Stream	4 fyke, 4 minnow
4	Currans Creek on Cons land	Stream	2 fyke, 2 minnow
5	Currans Creek at Waituna Gorge Rd	Stream	1 fyke, 4 minnow
6	Moffat Creek at Moffat Rd	Stream	2 fyke, 4 minnow
7	Moffat Creek trib. at Hanson Rd	Stream	3 fyke, 4 minnow
8	Moffat Creek at Lawson Rd	Stream	1 fyke, 4 minnow
9	Moffat Creek at Millers Rd	Stream	4 minnow
10	Waituna Creek at Hansen Rd	Stream	4 fyke, 4 minnow
11	Waituna Creek at Birch Rd	Stream	4 minnow
12	Waituna Creek trib. at Badwit Rd	Stream	1 fyke, 4 minnow
13	Waituna Creek at Lawson Rd	Stream	1 fyke, 4 minnow
14	Waituna Creek at White pine Rd	Stream	4 fyke, 4 minnow
15	Tarn in Cons land near Currans Creek	Tarn	2 fyke, 4 minnow
16	Tarn in Cons land NW Waghorn's Rd	Tarn	2 fyke, 4 minnow
17	Tarn in Cons land - Lagoon bound spit in South	Tarn	3 fyke, 4 minnow
18	Waituna Lagoon at end of Waghorn's Rd	Lagoon	3 fyke, 4 minnow
19	Waituna Lagoon at end of Moffat Rd	Lagoon	4 fyke, 4 minnow
20	Waituna Lagoon at eastern tip	Lagoon	4 fyke, 4 minnow
21	Waituna Lagoon near opening to little lagoon	Lagoon	seine netting

3.3 FISH RECORDS

Fish caught were identified, and total length measured to the nearest millimetre before being returned to the water. Fork length (measured from the tip of the nose to the fork in the tail) was measured for any species with a forked tail, such as smelt and trout. Bullies (*Gobiomorphus* species) were not measured and counted due to the large number of fish encountered during the survey. However, relative abundance of the species was noted (e.g. rare, common, abundant).

If fish could not be confidently identified in the field, descriptive photos and measurements were taken and then the fish were returned to the water. No specimens were collected for later identification.

Fish were handled with cool wet hands to minimise stress and chance of injury. Containment and handling times were kept to a minimum to ensure fish condition.

3.4 HABITAT RECORDS

Different habitat variables were measured at each site depending on the habitat type. However, at each site a general habitat description was recorded. GPS recordings were taken at each site.

3.4.1 Streams / drains / Peat tarns

Habitat variables such as; habitat type (structure of the aquatic habitat e.g. pool, run, and riffle), substrate type (e.g. mud, sand, cobble, gravel), catchment vegetation, riparian vegetation, physical parameters (width and depth of the waterway) relative abundance of periphyton (algae) and macrophytes (aquatic plants), water chemistry (including clarity, colour, and conductivity) were measured.

3.4.2 Lagoon

The same habitat variables as measured in the streams and peat tarns were measured in the lagoon, as well as lagoon macrophyte architecture (species composition and percentage cover). Secchi disk measure of turbidity was not used, as at the time of the survey the depth of sampling was visible from the surface (~ 1.0 m).

4.0 Results and Discussion

The survey was carried out from the 27th February until the 17th April, 2008. For the duration of the survey the lagoon was closed to the sea (i.e. the gravel bar had formed over the opening to the lagoon), and had been closed to the sea for approximately six months prior to the start of the survey. The last opening occurred on the 12th July 2007 and it remained open for 41 days before closing on the 21st August 2007. The lake level over the duration of the sampling was generally low (~ 1.0 m). Lake levels are considered high when the water height reaches 2.0 m on the lagoon water level gauge at Waghorn's bridge (site 1). Over the duration of the fish survey, daytime spot water temperatures were on average 13 degrees Celsius (with a range of 10-15 °C).

4.1 HABITAT DESCRIPTION

For this survey, the Waituna catchment is classified as a network of three aquatic habitat types, they are: streams, bog tarns and the lagoon itself.

4.1.1 Stream Sites

The predominant stream habitat type was run followed by still water (see figure 3); this is partly due to habitat modification (channelisation and straightening – 12 out of 14 stream sites sampled were modified in some way, see figure 4) and partly due to the natural slow flowing and low gradient nature of the streams. Riffle habitat only made up a small portion (~ 5 %) of the habitat type available at the sites sampled.

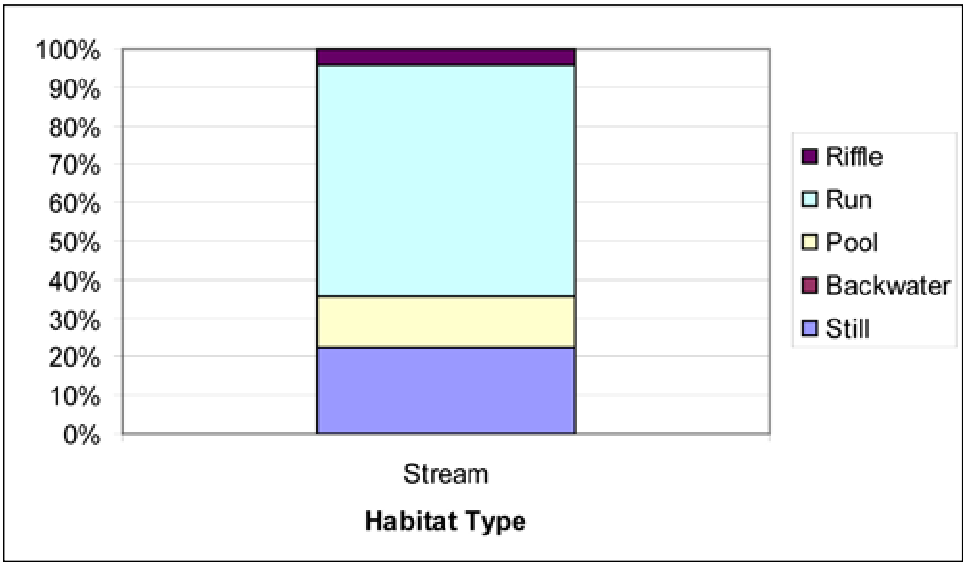


Figure 3. Habitat type composition at the stream sites sampled.

On average at the sampling sites the streams were about 2.5 m wide and about 0.5 m deep. The water depths varied from about 0.2 m to 1 m at normal flows. There are no permanent water flow recorders in the Waituna catchment. However, simulated mean flows using Waihopai River records from 1980 to 2008 have estimated average flows for Waituna Creek (at Marshall Road), Currans Creek, Currans Creek tributary and Moffat Creek at 1914, 604, 177 and 447 l/sec respectively (Chris Jenkins *pers comm.*).

Figure 4. Example of habitat modification in the catchment.

Based on observations (of water clarity, smell, algal growth, and build up of sediments etc), the water quality of the Waituna catchment was generally found to be low to moderate. Often the tannin stained waters (brown coloured) in the catchment were turbid and the build up of mud on the bottom of the streams were anoxic. The only site that had high water quality was the upper reaches of Currans Creek, within conservation land. It had a healthy abundance of both macrophytes and bryophytes (mosses), and was typical of a wetland stream (see figure 5). Environment Southland monitors the water quality within the Waituna catchment on a monthly basis. A water quality report for the catchment (Environment Southland, 2005) reports that the water quality is generally poor, as the creeks feeding into the lagoon consistently have high nutrient concentrations (with the exception of the Currans Creek tributary), and ammonia concentrations that are among the highest measured in Southland (Environment Southland, 2005).

Stream substrates were dominated by peaty mud and cobbles with a small amount of sand and fine gravel (figure 6). The sediments were probably once predominantly quartz gravels (the streams are located on a glaciofluvial plain of quartz rich gravels), but with the development of the catchment for agriculture (including frequent drain maintenance); inputs of finer sediments have increased (Riddell et al. 1988; Thomson and Ryder, 2003).

A visual estimate of the surrounding land use at the stream sites sampled indicated that use was predominantly farming (~ 78 %), with a small portion of exotic forestry (~ 2 %). Only at two of the sites was the surrounding land still wetland vegetation

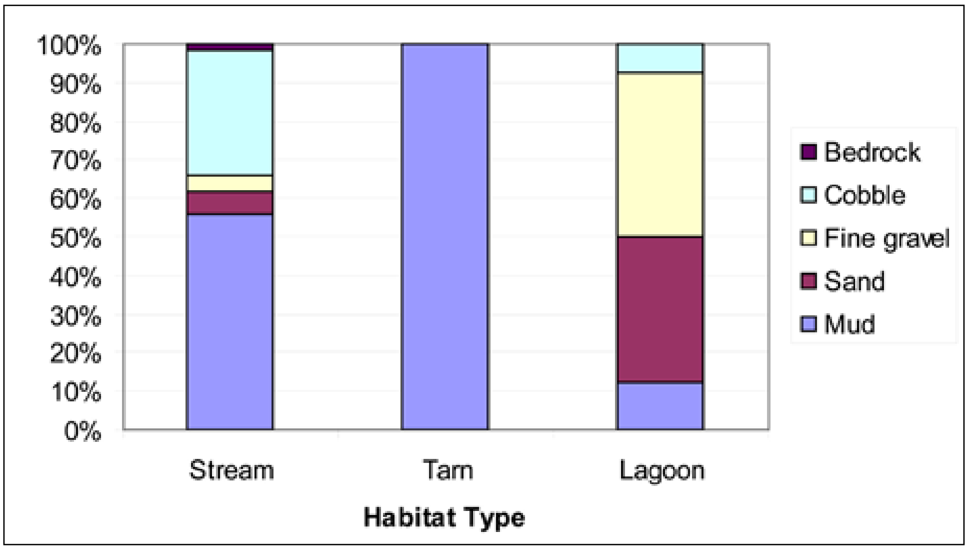
Figure 5. Currans Creek on Conservation land.

(figure 6). The riparian vegetation at the stream sites was a mixture of grass and /or tussock, and flax (figure 6). There was also a small amount of carex, rushes, weed species (gorse and broom) and manuka. Generally, flax was planted along one side of the stream with the other side planted in grass or tussock. The grass was either rank or grazed grass depending on whether or not the site was fenced. A number of the sites (33 %) were fenced in part (only one side of the stream fenced) and 10 % of the sites were fully fenced, with the other sites remaining unfenced.

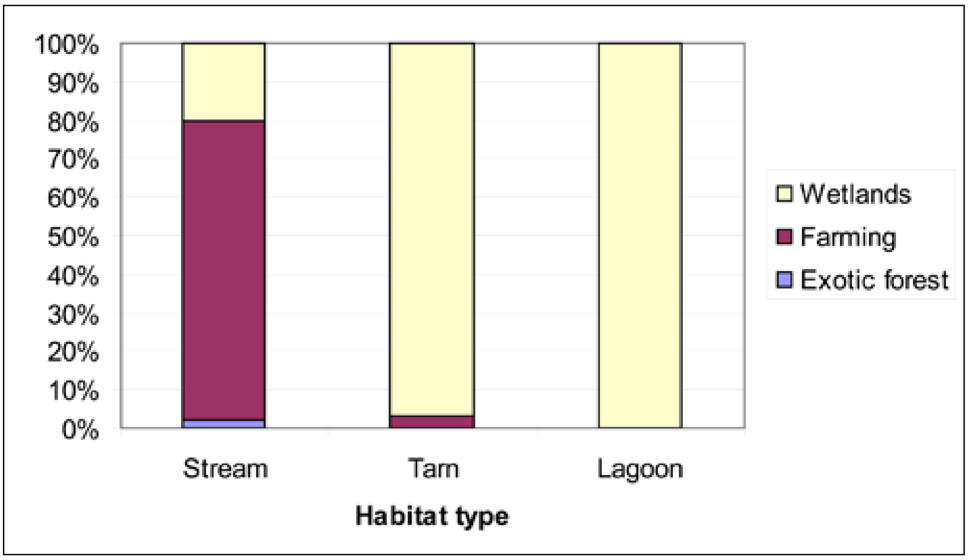
Based on observations, invertebrates at the stream sites were generally in low to moderate abundance. However, at some of the sites in the catchment shrimp (*Paratya curvirostris*) and freshwater crayfish or koura (*Paranephrops zealandicus*) were abundant. Koura were found in the Currans Creek catchment (moderate abundance) and the Waituna Creek catchment. They are expected to be present throughout the Waituna catchment. Shrimp were found in both Moffat and Currans Creek in high numbers. However, they may also have been present in Waituna Creek (the survey methods used were not suitable for the detection of shrimp). Riddell et al. (1988) discovered the presence of 16 taxa in the catchment, with the fauna being dominated by 3 groups; gastropods (*Potamopyrgus*), chironomid larvae, and annelid worms. The other benthic fauna found were; mayflies, caddisflies and dipteran taxa (fly larvae).

Aquatic macrophytes were generally abundant (*Potamogeton* spp were the dominant species), and were present at all the sites. Bryophytes on the other hand

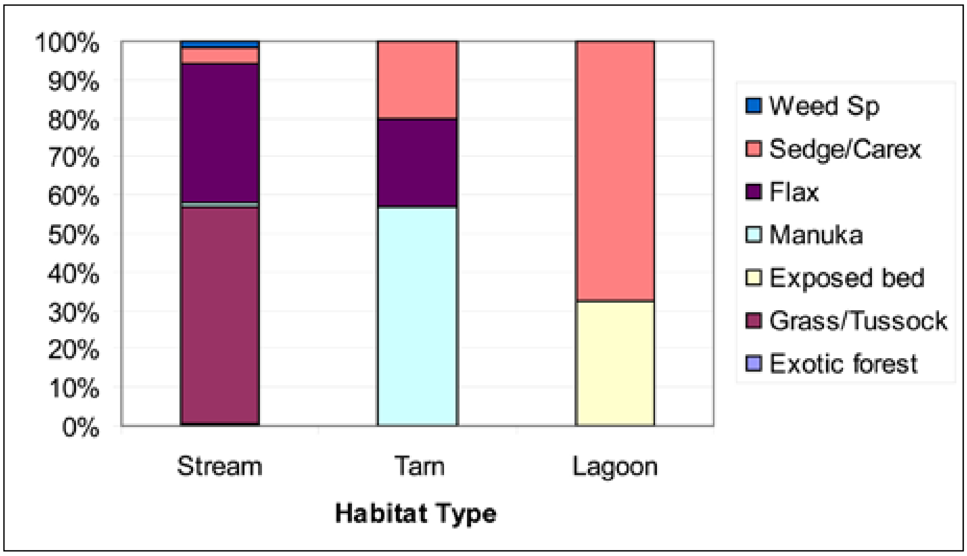
Figure 6. Substrate composition, dominant land use and riparian vegetation at the different habitat sites sampled.



PERCENTAGE SUBSTRATE COMPOSITION AT THE DIFFERENT HABITAT SITES SAMPLED.



PERCENTAGE CATCHMENT VEGETATION/LAND USE AT THE SITES SAMPLED.



PERCENTAGE RIPARIAN VEGETATION COMPOSITION AT THE DIFFERENT HABITAT TYPE SITES SAMPLED were generally rare, and were only found at two of the sites, where they were found to be common. Bryophytes were dense in Currans Creek within the conservation land, as well as common in a tributary to Currans Creek on Waituna Lagoon road. Filamentous algae, were also very common in the stream sites, and were found at all the sites except for the ones with deep, turbid waters with low clarity i.e. the Currans Creek sites. Filamentous algae were the most common in the Moffat Creek and Waituna Creek catchments.

Cover at the stream sites was generally good with an abundance of riparian vegetation overhang, overhanging banks, and an abundance of instream macrophytes.

4.1.2 Waituna Lagoon

Waituna Lagoon receives contaminants from the stream and drain inflows, including increased sediment loading, due to existing land use. The poor water quality of the inflows and sedimentation are the main threats to the lagoon. Nutrient and chlorophyll *a* levels have been known to be high at times, resulting in algal blooms during summer months. At the time of sampling there was a moderate abundance of filamentous algae suggesting that there was a reasonable level of nutrients in the lagoon. Another significant influence on the lagoon health is the artificial opening; it is thought that the opening of the lagoon lowers the levels of nutrients and bacteria. At the time of sampling the lagoon was closed, so it is expected that the nutrient levels could be high. The water colour was tannin stained and clear (at all the sites sampled the bed of the lake was visible).

The lagoon bed is predominantly pea gravel or quartz pebble. Sandy substrates occur in a few places, particularly near the lagoon opening site where there are low lines of old sand dunes (Johnson & Partridge, 1998). Peaty substrates are dominant at the eastern end near the Currans Creek outlet, or 'little Waituna' (Riddell et al. 1988). The substrate at the sites sampled around the periphery of the lagoon was predominantly fine gravel and sand (figure 6). However, peaty mud and cobble substrate was also noted to be present at some of the sites. Peaty muds were mostly detected around the outlet of Currans Creek and 'little Waituna'.

The catchment vegetation around the lagoon is entirely wetland vegetation (figure 6) as it is within the Waituna Scientific Reserve (Department of Conservation administered land). Wetland vegetation includes extensive bog, along with areas of fen, swamp, salt marsh, shallow water and ephemeral wetland classes. Vegetation associated with these classes is diverse and complex and includes; wire rush and manuka shrubland associations etc. The riparian vegetation at the sites sampled was generally sedge (figure 6 and 7). However, due to the low levels of the lagoon at the time of sampling there was also a large amount of exposed bed (figure 6).

Waituna Lagoon has been described as unique because of its intact horse's mane weed (*Ruppia* spp) dominated macrophyte communities (Johnson & Partridge, 1998). Other species previously noted as present are; water milfoil (*Myriophyllum triphyllum*), *Glossostigma elatinoides, Lilaeopsis novae-zelandiae* and *Selliera radicans*. At the lagoon sites sampled, *Ruppia* were the dominant macrophyte species found, except at site 18 where water milfoil contributed to about 50 % of the macrophyte cover. Macrophyte cover in general was very low, often as low as 1 %, with an average cover of 29 %. Recently, a survey carried out by Stevens and Robertson (2007) found that the *Ruppia* beds are overall, still in good condition. This is important as *Ruppia* are keystone species in Waituna Lagoon due to their

Figure 7. Waituna Lagoon at the end of Moffat Road.

importance as being both a habitat forming species and a food source for aquatic communities, and also for their role in regulating water quality (Schallenberg & Tyrell, 2006).

It has been noted by Schallenberg & Tyrell (2006) that species such as *Potamogeton pectinatus, Lepilaena bilocularis, and Zannichellia palustris* are missing from the lagoon, potentially as a result of the extreme salinity variations of the lagoon. During the survey, *Potamogeton* species were found in the tributary streams draining into the lagoon, so it is likely that salinity variations are a factor driving the distribution of macrophytes within the lagoon.

During the sampling period, filamentous algae were common at the lagoon sites. Low lagoon water levels, high light penetration and the closed status of the lagoon at the time of sampling may have been contributing factors.

Observed invertebrate abundance in the lagoon at the time of sampling was low, however, shrimp species were noted in large numbers. Mud crabs were also observed to be present, although all the specimens sighted were dead. Aquatic invertebrates have not been well studied in the lagoon, but they are likely to be limited by salinity variations (Schallenberg & Tyrell, 2006). Riddell et al. (1998) surveyed Waituna Lagoon for invertebrates, and found a total of nine taxa from three sites. Amphipods (crustacean) were found to be the dominant taxa, followed by; gastropods (snails), annelids (worms), platyhelminthes (flat worms) and the isopod *Austridotea annectans* (crustacean). Further, caddisflies were identified at the confluence of Waituna Creek.

4.1.3 Bog Tarns

The bog tarns that were sampled on public conservation lands were all small to medium sized tarns (no larger than 300 m^2). The tarns were all closed to fish passage (i.e. there were no stream outlets), although in general, there were other bog tarns or nearby streams at each site. The tarns were on average 0.5 m deep with the deepest sampling in any of the tarns occurring at 1 m. The substrate of all three bog tarn

Figure 8. Natural state bog tarn on the Waituna Lagoon bound spit.

sites as peaty mud (figure 6), and the catchment being wetland vegetation (figure 6). Riparian vegetation at the sites was a mixture of manuka, flax, and sedge (figure 6), with other plant species being wire rush, bog pine (site 15) and gorse.

The water quality in the bog tarns varied from moderate to high. Two of the sites had a high visitation of water fowl, which resulted in turbid and heavily silted waters. However, at one site (bog tarn on the lagoon bound spit) there was little evidence of pollution, as the tannin stained water was clear (see figure 8).

The only invertebrates observed in the bog tarns were dragon fly larvae and beetles.

4.2 FISH COMMUNITIES

Previous surveys have revealed the presence of 18 fish species in the Waituna catchment (see appendix 1). The fish fauna consists of native, introduced and marine or estuarine species. Known fish to have been found in the catchment include; nine freshwater fish that are diadromous (migrate between freshwater and the sea at some stage in their life cycle), two species that are marine fish and spawn in freshwater, six species of marine wanderers and one introduced fish. A total of nine fish species (see table 2) were found in the Waituna catchment over the duration of the current survey. Of these species, seven are considered freshwater and the other two as marine or estuarine species. Further, one introduced fish (brown trout) was caught. The lack of marine fish caught was potentially due to the status of the lagoon with it being closed to the sea for the entirety of the survey. During previous fish surveys carried out by Riddell et al. (1988) and Chesterfield (2005), the lagoon was open for varying periods during the survey allowing access to the lagoon for marine species such as triplefin, yellow eyed mullet and estuarine stargazer. Generally, these species would only be expected to be found if the lagoon was open to the sea. Further, no banded kokopu were caught in the current survey even though they have been observed in the catchment in the past.

The most abundant fish species caught in the catchment were; common bully, longfin eel and giant kokopu. Common bullies were found at 52 % of the sites sampled and in large numbers. Longfin eels were found at 33 % of the sites sampled and were generally found in the stream sites. The eel species that were caught in the lagoon were predominantly shortfin eels (see figure 9). Giant kokopu were found at 62 % of the sites and was also the only fish species to be found in the bog tarns. Riddell et al. (1988) only found koura (freshwater crayfish) at the bog tarn sites they visited.

TABLE 2. FISH SPECIES CAPTURED IN THE WAITUNA CATCHMENT SURVEY, AND THEIR RELATIVE ABUNDANCE IN SAMPLES DURING FEBRUARY-APRIL 2008.

COMMON NAME	LATIN NAME	ABUNDANCE
Longfin eel	*Anguilla dieffenbachii*	Abundant
Shortfin eel	*Anguilla australis*	Occasional
Common bully	*Gobiomorphus cotidianus*	Abundant
Redfin bully	*Gobiomorphus huttoni*	Occasional
Giant kokopu	*Galaxias argenteus*	Abundant
Inanga	*Galaxias maculatus*	Rare
Common smelt	*Retropinna retropinna*	Rare
Flounder species	*Rhombosolea spp.*	Rare
Brown trout	*Salmo trutta*	Occasional

Figure 9. Shortfin eel caught in the lagoon.

The nine species caught showed variable habitat preference. That is, some species were found in a variety of the habitat types sampled, whereas others tended to be only found in one of the habitat types (see table 3 for species found at each survey site). This is expected, as different species have different habitat requirements and similar results have been found by Riddell et al. (1988). Of particular interest is the result of the lagoon survey. Overall, the diversity of fish captured in the lagoon during the survey was low (five species), and the species that were captured (with the exception of common bully) were caught in low numbers. The sites that were sampled in the lagoon typically had very little cover (low abundance of macrophytes and no overhanging vegetation or instream debris); this may have been a contributing factor to the low fish diversity and biomass observed at the lagoon sites sampled. However, with further survey work in the lagoon, it would be expected that more species would be caught and that high abundances would be observed.

TABLE 3. FISH SPECIES CAPTURED AT EACH LOCALITY (SEE FIGURE 2 FOR MAP OF SAMPLING LOCALITIES).

SITE	LOCALITY	SPECIES PRESENT
1	Currans Creek at Waghorn's bridge	Inanga, common bully
2	Currans Creek trib. at Waituna Lagoon Rd	Longfin eel, giant kokopu
3	Currans Creek at Waituna Lagoon Rd	Longfin eel, giant kokopu, common bully, redfin bully
4	Currans Creek on Cons land	Shortfin eel, giant kokopu
5	Currans Creek at Waituna Gorge Rd	Longfin eel, giant kokopu
6	Moffat Creek at Moffat Rd	Longfin eel, Inanga, common bully, redfin bully,
7	Moffat Creek trib. at Hanson Rd	Longfin eel, giant kokopu
8	Moffat Creek at Lawson Rd	Giant kokopu, common bully
9	Moffat Creek at Millers Rd	Giant kokopu, common bully
10	Waituna Creek at Hansen Rd	Longfin eel, giant kokopu, inanga, common bully, redfin bully
11	Waituna Creek at Birch Rd	Giant kokopu, brown trout
12	Waituna Creek trib. at Badwit Rd	Giant kokopu, brown trout
13	Waituna Creek at Lawson Rd	Giant kokopu, common bully
14	Waituna Creek at White pine Rd	Longfin eel, giant kokopu, galaxiid, common bully
15	Tarn in Cons land near Currans Creek	No fish
16	Tarn in Cons land NW Waghorn's Rd	No fish
17	Tarn in Cons land - Lagoon bound spit in South	Giant kokopu
18	Waituna Lagoon at end of Waghorn's Rd	Shortfin eel, common bully, flounder
19	Waituna Lagoon at end of Moffat Rd	Shortfin eel, common bully
20	Waituna Lagoon at eastern tip	Common bully, brown trout
21	Waituna Lagoon near opening to little lagoon	Common smelt, flounder

4.2.1 Longfin eel (*Anguilla dieffenbachii*)

Life history – diadromous *Freshwater Species*

Mature longfin eels migrate out to sea in autumn and travel to subtropical Pacific Ocean to spawn before dying. On average mature males migrate at 23 years old, while females migrate at 34 years old (Jellyman and Todd, 1982). The larvae hatch and return to New Zealand via ocean currents, before entering freshwater as glass eels. They then change colour (become darker) and migrate inland as elvers (McDowall, 2000).

Longfin eel are classified by the Department of Conservation as being in decline nationally (Hitchmough et al., 2005). This species was abundant in the wetlands as has been found by Riddell et al. (1988). However, at the lagoon sites sampled, only shortfin eels were caught. Riddell et al. (1988) caught longfin eels at their lagoon sites, but only in small numbers. This result could be due to a number of reasons including: preferential stream habitat selection, net bias (i.e. eel species may respond differently to trapping efforts), or historic harvest selectively removing one species over the other.

Longfin eels caught were a range of sizes (figure 10), suggesting that the eel

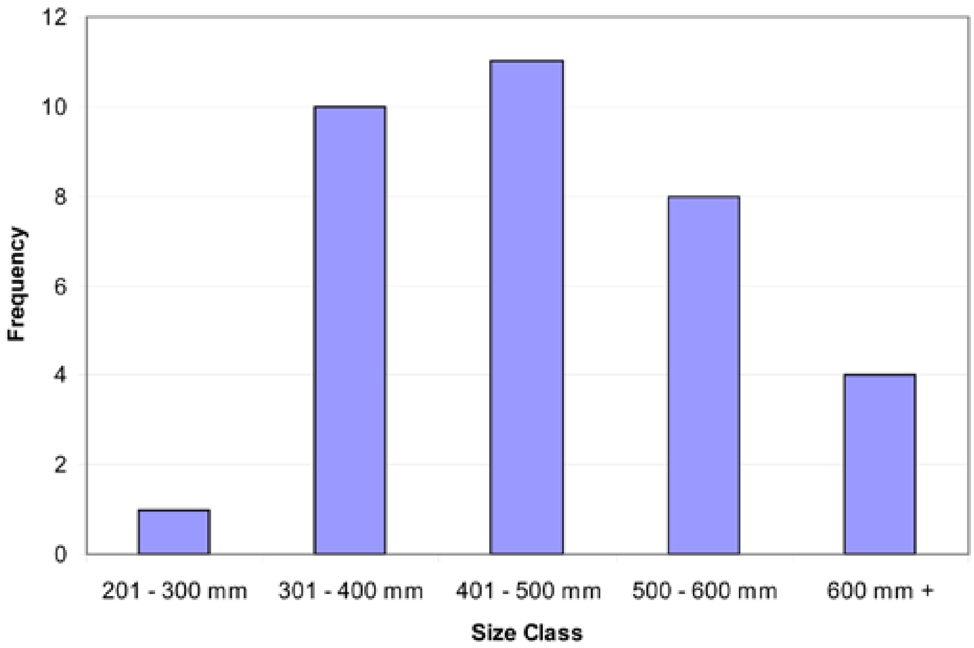


Figure 10. Longfin eel size frequency (*n* =127) in Waituna catchment.

population is stable (normal distribution). There was a notable absence of small elvers (100 mm size class) caught during the survey. This is likely due to the fishing techniques being used not being appropriate for catching this smaller size class. During a stream cleaning exercise on Currans Creek (March 2008), large numbers of small (100 mm) elvers were observed, so recruitment of elvers is occurring.

4.2.2 Shortfin eel (*Anguilla australis*)

Life history – diadromous *Freshwater Species*

Shortfin eels have a similar life history to longfin eels, except it is expected that they spawn between Fiji and Tahiti rather than Tonga like the longfin eel (McDowall, 2000). Female shortfins average 22 years when they migrate to sea (Jellyman and Todd, 1892).

Shortfin eels were only caught at one of the stream sites and two of the lagoon sites although they are expected to be abundant throughout the catchment. Riddell et al. (1988) only caught short fin eels in Waituna Lagoon and in low numbers. Further, Chesterfield (2005) found that shortfin eels were common in the lagoon and that longfin eels were rarer in the lagoon (they only caught 6 individuals in comparison to 25 shortfin eels). Shortfin eels were not recorded in Waituna Creek or Moffat Creek although they are expected to be present in both systems. Overall, shortfin eels were common, but not abundant in the samples at the sites surveyed.

4.2.3 Common bully (*Gobiomorphus cotidianus*)

Life history – diadromous *Freshwater Species*

Common bullies spawn from spring through to summer. The male establishes a territory either in amongst aquatic vegetation or under a large rock in their freshwater habitat. After spawning the males guard the nests until they hatch. The larvae go to sea and return to freshwater after three or four months.

Common bullies were widespread in the catchment (caught at 52 % of the sites) and in large numbers. They were particularly abundant in Waituna Lagoon. Although fish lengths were not measured, a full range of sizes was observed.

4.2.4 Redfin bully (*Gobiomorphus huttoni*)

Life history – diadromous *Freshwater Species*

Spawning for redfin bullies occurs in spring, where like the common bully; the male guards the nest and the larvae go out to sea for several months.

Redfin bullies were only found occasionally in the catchment. They were caught in the stream sites and usually in low numbers. None were caught in the lagoon. Riddell et al. (1988) only caught redfin bullies in the most coastal sections of the Waituna tributaries, whereas in the current survey they were found in all three main tributary streams; in locations both coastal and further inland.

Redfin bullies are most often found in cobble / boulder streams, and usually in moderately swift flows. They are not common in unstable, gravelly streams and sandy, weedy streams (McDowall, 1990). The stream sites where redfin bullies were found varied from wide slow flowing waters with muddy bottoms to waters with a little bit of riffle habitat (preferred habitat of redfin bullies).

4.2.5 Giant kokopu (*Galaxias argenteus*)

Life history – diadromous *Freshwater Species*

Giant kokopu spawn in autumn and winter in freshwater (it is unknown where spawning sites are, but there may be a downstream migration). After hatching larvae go out to sea and return as whitebait in spring (generally around November) (McDowall, 2000). However, giant kokopu are known to form land-locked populations where the larvae rear within the freshwater environment. Giant kokopu are in gradual decline nationally.

Giant kokopu is found in variable habitats; often in swamps, swampy creeks, forest streams, lakes and gravelly streams. They are found where there is plenty of cover for them to take refuge, such as logs, tree roots, overhanging banks and flax bushes (McDowall, 1990). Site suitability for giant kokopu in the Waituna catchment is high as most of the waterways are deep, slow flowing and offer plenty of fish cover (flaxes and overhanging banks etc). Locally, giant kokopu are abundant in the Waituna catchment (127 individuals were caught). They were found in all the

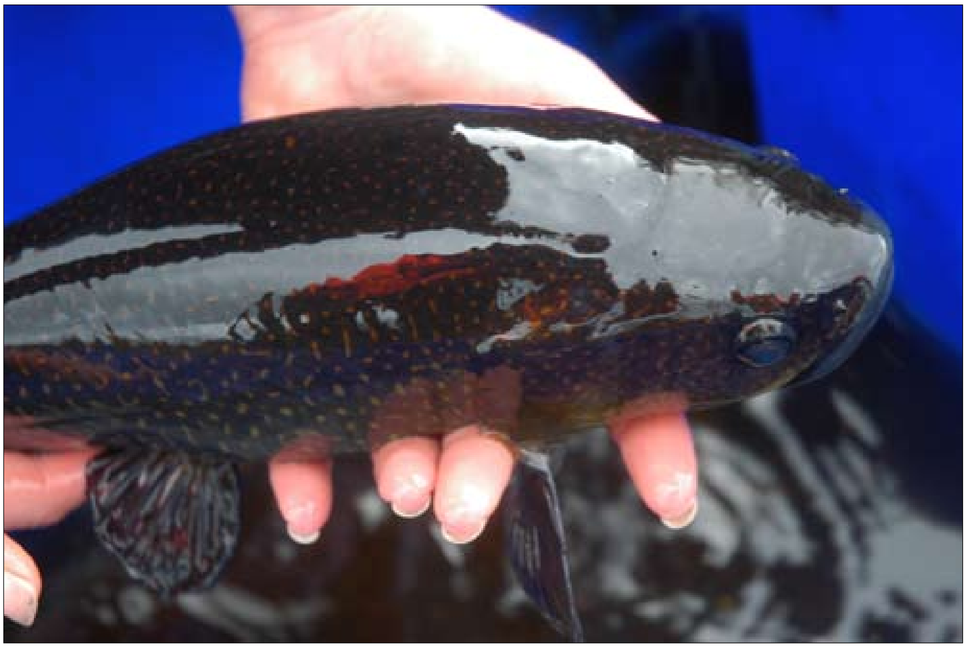


Figure 11. large giant kokopu caught in the lagoon bound spit bog tarn.

main tributaries that flow into Waituna Lagoon and were only absent from two of the stream sites sampled. Adult fish were not caught in Waituna Lagoon; this was expected as there was very little cover at the sites sampled. Riddell et al. (1988) also found that they were absent from the lagoon. Giant kokopu were the only fish species found in the bog tarns with all three adult fish caught being large (~ 400 mm) and likely to be as old as 20 years (see figure 11).

Giant kokopu caught were a range of sizes (figure 12). However, most of the fish were of a small size class (41-80 mm), with few large fish being caught. The large pulse of fish in the 41 to 80 mm size class (figure 12) were probably from the whitebait run in the spring before the sampling period – giant kokopu return to freshwater as 45-50 mm whitebait (McDowall, 2000). The large number of whitebait in the catchment suggests that recruitment for giant kokopu in Waituna catchment is not limiting.

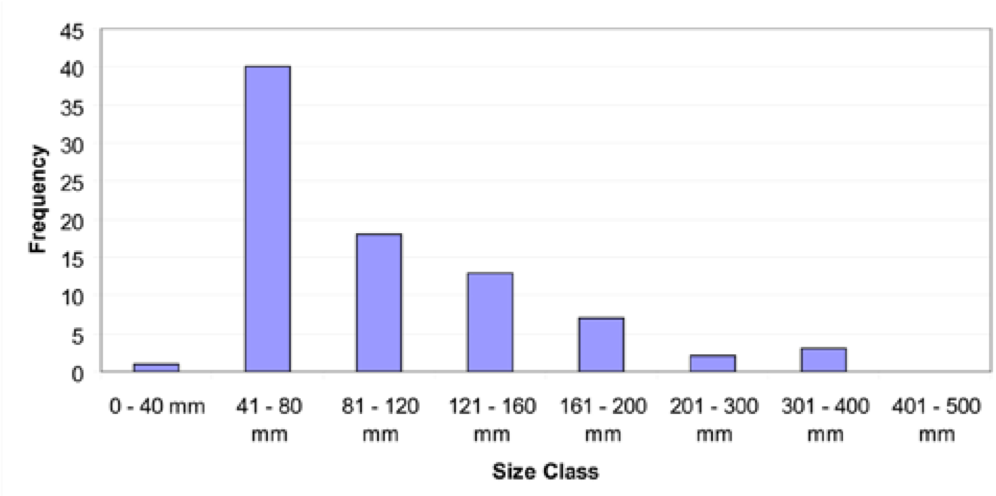


Figure 12. Giant kokopu size frequency (*n* =127) in the Waituna catchment.

Little is known of the importance of Waituna Lagoon for the recruitment of indigenous fish species. It has been noted in Riddell et al. 1988 that the survival of giant kokopu in the catchment requires freedom for the juveniles to return from sea to freshwater during spring as part of the whitebait run. Recent studies looking at otoliths (fish ear bone) has revealed that some giant kokopu (and other galaxiid fish) populations become non-diadromous even when they have free access to the sea (A. Hicks *pers comm.*, 2008). The presence of whitebait-of-the-year in the current survey further emphasises the importance of the lagoon for recruitment, as the lagoon was shut to the sea during the previous whitebait run period.

4.2.6 Inanga (*Galaxias maculatus*)

Life history – diadromous *Freshwater Species*

Inanga matures usually at one year, and in autumn migrates downstream to estuaries to spawn. They generally spawn when spring tides cover marginal estuary vegetation; the eggs then hatch in a later tide. The larvae go to sea for about 21-23 weeks before returning to freshwater as whitebait.

Inanga favour gently flowing and still water in: estuaries, lowland lakes, lagoons, wetlands and backwaters, and they are often found in shoals in large water bodies around the margins. Much of Waituna catchment provides ideal habitat for inanga. Over the sampling period, inanga were only caught at three sites, their overall abundance at the sites sampled was rare. This may have been due to the timing of the survey (end of February to end of April), as this is generally when inanga are spawning. In fact, two of the inanga caught in Moffat Creek were spent fish (had already spawned) (see figure 13). Inanga were caught in all three tributary systems, but were not caught in the lagoon. Riddell et al (1988), however, found inanga to be common in the catchment where they tended to be the dominant species and were found in all the water types. Chesterfield (2005) did not capture inanga in the survey of the lagoon.

Figure 13. Spent inanga caught in Moffat Creek.

4.2.7 Common smelt (*Retropinna retropinna*)

Life History – diadromous *Marine Species*

Smelt mature at the age one or two and spawn in the lower reaches of rivers in summer and autumn. The adults die after spawning. The larvae go out to sea, some return as juveniles but most as adults. Smelt spend most of their life at sea (McDowall, 2000).

Smelt occur in large shoals in estuaries and lowland rivers; usually in still slow flowing, open waters and around lake margins (McDowall, 2000). Thus, Waituna Lagoon provides suitable habitat for smelt. During this survey smelt were only caught once in the lagoon with a seine net (a total of two adult individuals). It is unknown how the connection between the sea and Waituna Lagoon influences juvenile and adult smelt abundance in the lagoon. Both Riddell et al. (1988) and Chesterfield (2005) caught a large abundance of smelt in Waituna Lagoon.

4.2.8 Flounder (*Rhombosolea* spp)

Life History - Spawns at sea *Freshwater Species or Marine Wanderers*

Over the duration of the survey only two small flounder were caught that were too small to positively identify (see figure 14). Previously, three species of flounder have been identified in the lagoon; black flounder, yellowbelly flounder and sand flounder. Black flounder are generally observed in river estuaries, lowland lakes or in quietly flowing lowland rivers (McDowall, 2000). They migrate to sea to spawn (probably in winter), and juveniles enter freshwater at the length of about 10-15 mm during spring. The flounder caught in the survey were 81-120 mm in length.

Figure 14. Juvenilre flounder caught in the lagoon.

Flounder are common in lowland and coastal lakes, and provide important commercial fisheries in some areas such as Lake Ellesmere. Waituna Lagoon offers an ideal habitat for flounder species in an area where commercial fishing is prohibited.

4.2.9 Brown trout (*Salmo trutta*)

Life History – diadromous and non-diadromous *Freshwater & Marine Species*

The current population of brown trout in the Waituna catchment is a mixture of sea-run and freshwater fish (Thompson & Ryder, 2003). The brown trout population spawns in reeds in the tributary streams of the lagoon.

Brown trout were caught in low numbers (five individuals) at the sites sampled. They were caught in Waituna creek at two sites and in the lagoon (see figure 15).

Figure 15. Brown trout caught in the lagoon being released.

Their overall abundance in samples during the survey was rare. Riddell et al. (1988) found them to be abundant in the catchment, particularly in Waituna Creek where they were the dominant species at two of the sites. It would be expected that if electric fishing was carried out in Waituna Creek more trout would be captured. Further, according to locals there are plenty of fish around the mouth of Waituna creek and in some of the western parts of the lagoon. None of these areas were fished due to accessibility (boat access required).

5.0 Conclusions

The Waituna Wetlands offer a significant diversity and abundance of aquatic habitats for aquatic organisms, and in particular fish. Each habitat supports different fish assemblages (with some species common or unique to the different habitats). The tributary streams (Waituna Creek, Moffat Creek and Currans Creek) provide a considerable area of the available habitat for fish species in the catchment. There is plenty of cover for fish with an abundance of riparian vegetation overhang, overhanging banks, and instream macrophytes. The availability of fish habitat in the lagoon relies on the presence of healthy macrophyte beds.

Abundance and diversity of fish species discovered in the lagoon was generally low. The highest abundance of fish was found in the tributary streams, indicating that tributaries are an important habitat for the life stages of a number of native fish species. It remains unclear what changing land use, both historically and currently, may be having on these important fish habitats. The closed status of the lagoon at the time of sampling may be a contributing factor to the low diversity of fish species found in the catchment during this survey. However, with further sampling effort and the use of more sampling techniques; a greater diversity and abundance of fish species would be expected in the catchment.

6.0 Recommendations and priorities for future management

1. The current survey has achieved a 'snapshot' of the health, composition and habitat use of the fish fauna in the Waituna catchment, given the time of the year and the closed status of the lagoon. Further baseline information is required on the fish fauna in the catchment to further establish the health of populations (particularly eels as they are a taonga species), fish assemblages and habitat use in the lagoon. A full understanding of the fish fauna in the catchment will aid the department and the community to make decisions when considering management options.

   Therefore, it is suggested that further fish survey work is carried out in the wetlands that includes:

   - Fish survey of the lagoon when it is open to the sea in order to establish fish assemblages under different environmental conditions. Extend the survey sites to cover a greater extent of the lagoon.
   - Establish the health of the eel population in the lagoon and tributary streams.
   - Further use of seine nets, both at night and during the day.
   - Electric fish sites in all three stream catchments where possible.
   - Re-fish sites where banded kokopu have been caught historically to establish if they are still present in the wetlands.
   - Carryout further spotlight work in both the lagoon and Currans Creek as many fish species are nocturnal.
   - Sample more bog tarns for giant kokopu populations.
   - Sample Muddy Creek for fish populations as a comparable site where there is a continuous connection with the sea and an intact catchment.

2. The current management of the water levels in the lagoon is primarily aimed at improving drainage of the surrounding farms. The artificial opening of the lagoon and its timing has a strong influence on the fish assemblages found in the lagoon and on larval recruitment of native fish.

   Therefore, to better understand how the lagoon opening impacts on the recruitment of native fish it is suggested that research is carried out using a number of methods, including: larval light traps, otolith microchemistry, trawling of pelagic larval fishes, and examining the seasonality of fishes.

3. Giant kokopu have been identified as being in gradual decline by the department's threat ranking classification system (Hitchmough et al., 2007). The fish survey suggested that there are healthy populations of giant kokopu in the Waituna catchment. There are a number of management initiatives in the wetlands that include: the clean stream accord (Moffat Creek), fencing programmes, nutrient budgeting etc, that have been set up in order to improve the health of the waterways. One of the ways that the changes can be monitored is through biological monitoring.

   Therefore, it is suggested that a giant kokopu monitoring site is established on Currans Creek as a way of measuring changes in water health. Further, the information from the monitoring will allow detailed examination of population structure and recruitment of giant kokopu at that site.

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Appendix 1: Fish species previously recorded in the Waituna catchment

COMMON NAME	LATIN NAME	LAST RECORDED IN THE CATCHMENT
Giant kokopu	*Galaxias argenteus*	This survey
Banded Kokopu	*Galaxias fasciatus*	Riddell (1988)
Longfin eel	*Anguilla dieffenbachii*	This survey
Shortfin eel	*Anguilla australis*	This survey
Lamprey	*Geotria australis*	Riddell (1988)
Inanga	*Galaxias maculatus*	This survey
Common Bully	*Gobiomorphus cotidianus*	This survey
Redfin Bully	*Gobiomorphus huttoni*	This survey Chesterfield (2005)
Giant Bully	*Gobiomorphus gobioides*	This survey
Common Smelt	*Retropinna retropinna*	This survey
Brown Trout	*Salmo trutta*	Chesterfield (2005)
Yelloweye Mullet	*Aldrichetta forsteri*	Chesterfield (2005)
Yellowbelly Flounder	*Rhombosolea leporina*	This survey (?)
Black Flounder	*Rhombosolea retiaria*	Riddell (1988)
Sand Flounder	*Rhombosolea plebeia*	Chesterfield (2005)
Estuarine Stargazer	*Leptoscopus macropysus*	Riddell (1988)
Cockabully	*Grahamina nigripenne*	Riddell (1988)
Kahawai	*Arripis trutta*	

Appendix 2: Fish survey site localities

SITE	LOCALITY	GPS COORDINATES **EASTING**	**NORTHING**
1	Currans Creek at Waghorn's bridge	2177141	5395699
2	Currans Creek trib. at Waituna Lagoon Rd	2176782	5397804
3	Currans Creek at Waituna Lagoon Rd	2176268	5398399
4	Currans Creek on Cons land	2178664	5401882
5	Currans Creek at Waituna Gorge Rd	2176354	5403200
6	Moffat Creek at Moffat Rd	2170070	5398367
7	Moffat Creek trib. at Hanson Rd	2171759	5399328
8	Moffat Creek at Lawson Rd	2170505	5399442
9	Moffat Creek at Millers Rd	2172618	5400714
10	Waituna Creek at Hansen Rd	2170656	5407451
11	Waituna Creek at Birch Rd	2174244	5409649
12	Waituna Creek trib. at Badwit Rd	2174114	5412384
13	Waituna Creek at Lawson Rd	2170323	5402692
14	Waituna Creek at White pine Rd	2167563	5398321
15	Tarn in Cons land near Currans Creek	2179086	5401403
16	Tarn in Cons land NW Waghorn's Rd	2175000	5396590
17	Tarn in Cons land - Lagoon bound spit in South	2173070	5394333
18	Waituna Lagoon at end of Waghorn's Rd	2175548	5396182
19	Waituna Lagoon at end of Moffat Rd	2170240	5396369
20	Waituna Lagoon at eastern tip	2178020	5395603
21	Waituna Lagoon near opening to little lagoon	2177146	5395679