# Fish Survey of the Whangamarino Wetland 2007/2008

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# Executive Summary

The Whangamarino is a lowland wetland complex connected to the lower Waikato River. A fish survey of the Whangamarino was undertaken in 2007/2008 to gain an understanding of community composition and species distribution throughout the wetland. This was the first wide-scale survey of fish communities in the wetland since 1980. A combination of nets, traps and boat electrofishing and backpack electrofishing was used to survey sites in the main rivers, floodplain areas, and tributary streams. Nine native fish species, five exotic fish species and two native crustacean species were collected during the 2007/2008 survey. Most species found in the rivers and floodplain areas were relatively widely distributed, however, three species were only found in the small tributary streams. Each of the sampling methods had their own species specific bias, reinforcing the need to employ a suite of methods when undertaking fish surveys. Boat electrofishing caught the greatest diversity of species and was the only effective method for collecting koi (*Cyprinus carpio*). No koi were recorded in a 1980 survey of the Whangamarino but in 2007/2008 they constituted over 80% of the fish biomass in boat electrofishing samples. This suggests that ~~T~~the biomass of fish community has become dominated by exotic species. ~~No koi were recorded in the 1980 survey of the Whangamarino but in 2007/2008 they constituted over 80% of the fish biomass in boat electrofishing samples.~~ The results of the survey will be used to guide future management of the wetland including the development of ~~any~~ monitoring programmes.

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# Introduction

## 1.1 Site Description

The Whangamarino Wetland is the second largest bog and swamp complex in the North Island of New Zealand. Of the 7290 ha that makes up the wetland, 5690 ha was designated as a Ramsar site in 1989 due to its significance as habitat for wetland birds. Its ecological value, high recreational use and close proximity to large population centres in Auckland and Waikato have led to the Whangamarino being included in the Arawai Käkäriki project. This project is a Department of Conservation programme aiming to enhance the ecological restoration of three of New Zealand's foremost wetland sites.

The Whangamarino is made up of a mosaic of palustrine and riverine wetland types including young bogs, mineralised swamps and lowland rivers. While the rivers are permanent, large areas of wetland are only seasonally inundated. The wetland is a popular waterfowl hunting area and large areas are managed specifically for wildfowl hunting by Auckland/Waikato Fish & Game. Developed Fish & Game blocks contain large numbers of constructed ponds which contain water all year round.

There are two main rivers draining the Whangamarino. The Maramarua River drains a catchment of approximately 326 $km^2$, which extends into the farmland and hill country to the north-east of the Whangamarino. The Whangamarino River has a larger catchment of 460 $km^2$, which includes the Reao Stream, a small tributary draining a young bog area. The Pungarehu Canal is an artificial watercourse that links Lake Waikare to the upstream end of the Whangamarino River as part of the Lower Waikato Flood Control Scheme. Large volumes of water are spilled into the Whangamarino via the Pungarehu canal when the storage capacity of Lake Waikare is exceeded. The Maramarua and Whangamarino Rivers join together before flowing over the Whangamarino Weir and then out of the wetland. In addition to the main rivers there are also some smaller stream tributaries that flow off hill country on the eastern edge of the Whangamarino.

Water levels in the Whangamarino are controlled using three structures. The Lake Waikare outlet controls flood flows entering the Whangamarino from Lake Waikare. The Whangamarino Control Structure is located just upstream of the confluence of the

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Whangamarino and Waikato Rivers and can be used to control outflow from the wetland and backflow from the Waikato River. The Whangamarino Control Structure is only generally operated during extreme flood events. The Whangamarino Weir is found immediately downstream of the confluence of the Whangamarino and Maramarua Rivers. The purpose of the weir is to re-instate a minimum summer water level that would protect the ecological values of the wetland. The existing Whangamarino Weir was constructed in April 2000 by the Department of Conservation (DOC) and Fish and Game replacing the original structure that was built in 1993 but which failed in 1995 (Miller 2007).

The Ministry of Agriculture and Fisheries undertook a comprehensive assessment of fish communities in the Whangamarino in 1980 (Strickland 1980). Although many ad-hoc fish surveys have been conducted since, none have been on a large enough scale to allow a reassessment of fish community over the last 25 years. With an increasing focus on the Whangamarino Wetland through the Arawai Käkäriki programme the need to undertake a fish survey of the wetland was identified. The primary objective of the survey was to assess the composition and distribution of the fish community present within the Whangamarino. There were also three secondary objectives to the work. The first was to identify any barriers to the movement of fish within the wetland. The second was to trial different sampling methods to assist with the development of a methodology for surveying fish communities in New Zealand wetlands, and the third was to identify which fish species utilised floodplain habitats during periods of high water levels.

# 2 Methods

## 2.1 Netting and trapping

Netting and trapping was carried out at eight sites over two nights on the 13th and 15th of August 2007 (Figure 1). Water level at the Ropeway Monitoring Site was approximately 3.9 m above Moturiki mean sea level datum (msld) but was falling steadily at the time of sampling (Figure 2~~Figure 2~~). Two types of habitats were sampled;

1. channel sites in the main river channels flowing through the wetland, and.
2. off-channel sites in the seasonally flooded areas of the wetland.

Five of the sites sampled channel habitats while three sampled off-channel habitats.

At each site the following nets and traps were set;

- two fine mesh fyke nets with 6 mm mesh and a 2.3 m long leader,
- two coarse mesh fykes constructed with 12 mm mesh and a 4 m long leader, and
- six fine mesh (3 mm) Gee minnow traps.

Fyke nets were set in shallow water of at least 600 mm in depth while all Gee minnow traps were set at the surface. No baits were used in any of the nets or traps. Nets and traps were set during the day, left overnight and then retrieved the following day. Water temperature and pH was recorded at each site and habitat data was recorded using New Zealand Freshwater Fish Database cards.

All species caught in each net or trap were identified and counted. All fish except gambusia (*Gambusia affinis*) were measured and all large fish were weighed to the nearest gram. Fish caught in the fyke nets were anaesthetised using Aqui-S ™ to allow the eels to be measured and weighed accurately. If large numbers of a species were caught in any given net or trap a representative sub-sample of 20 fish were processed.

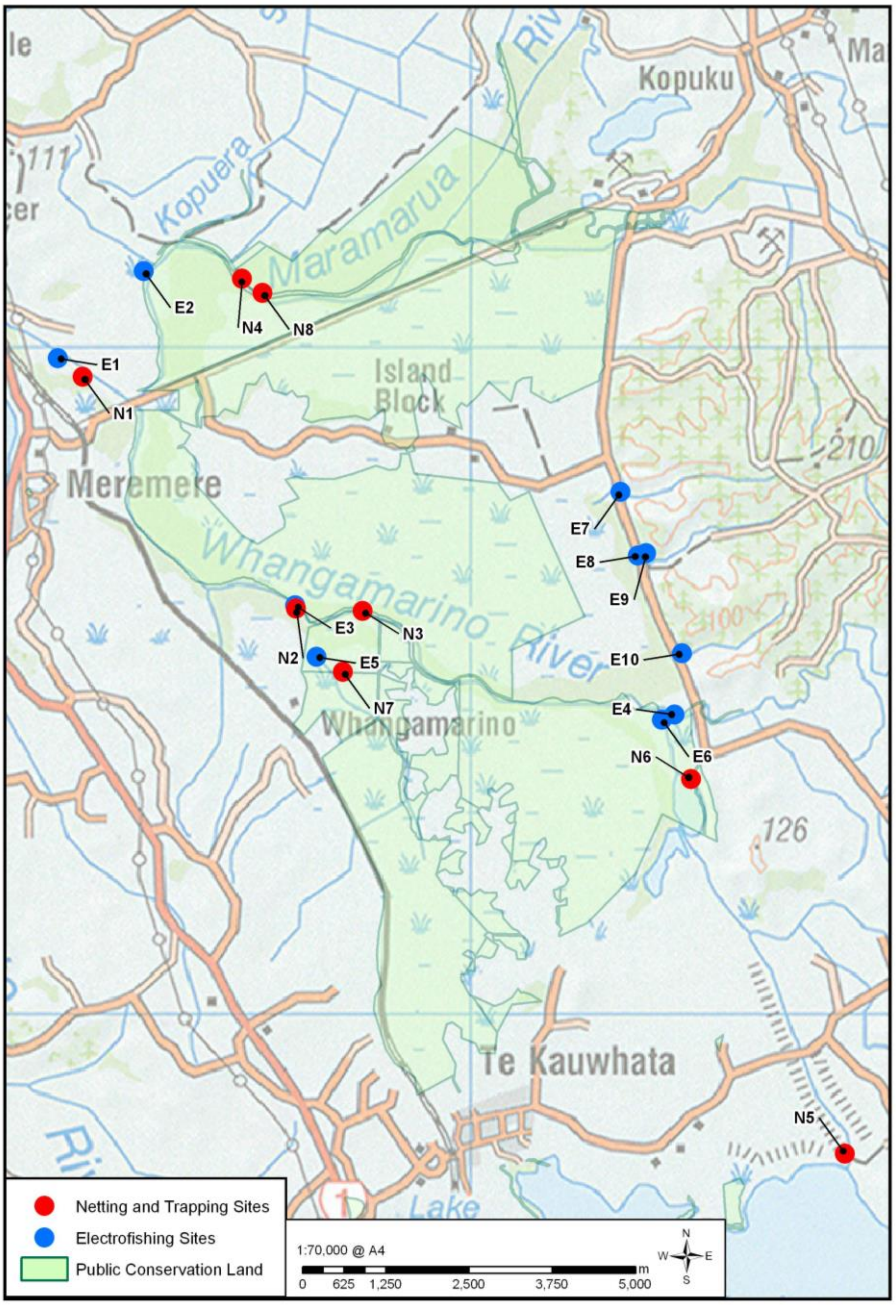


FIGURE 1 MAP SHOWING SAMPLING SITES USED IN FISH SURVEYS CARRIED OUT IN THE WHANGAMARINO WETLAND IN AUGUST 2007 AND MARCH 2008.

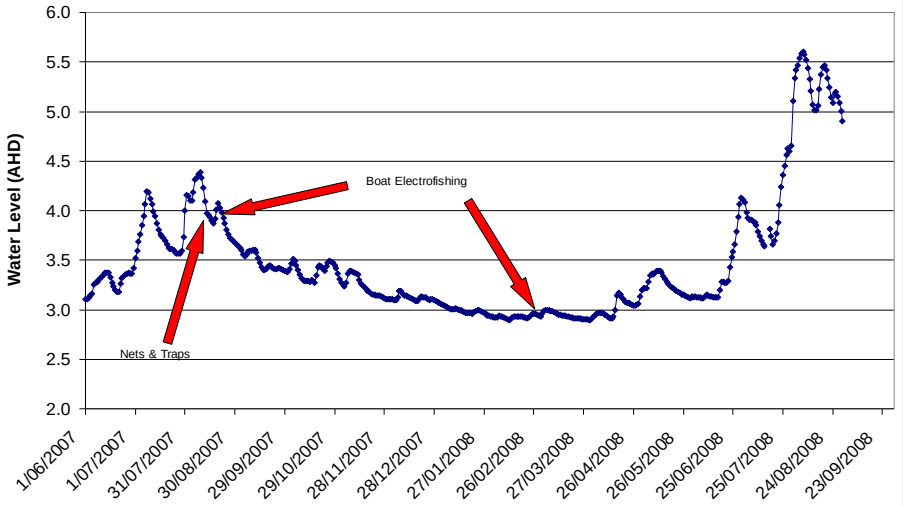


FIGURE 2 WATER LEVELS AT THE ROPEWAY WATER LEVEL MONITORING SITE AT THE TIME OF THE FISH SURVEYS CARRIED OUT IN THE WHANGAMARINO WETLAND IN AUGUST 2007 AND MARCH 2008 (DATA SUPPLIED BY ENVIRONMENT WAIKATO).

## 2.2 Boat electrofishing

Boat electrofishing was accomplished using a 4.5-m long aluminium hulled electrofishing boat with a 5-kilowatt gas-powered pulsator (GPP, model 5.0, Smith-Root Inc, Vancouver, Washington, USA) powered by a 6-kilowatt custom-wound generator. Two anode poles, each with an array of six droppers, created the fishing field at the bow, while the boat hull acted as the cathode (Hicks, B. J et al. 2006).

Electrical conductivity was measured with a YSI 3200 conductivity meter and horizontal water visibility was measured using a black disc (Davies-Colley 1988). Specific conductivity, i.e., standardised to 25$^{o}$C, ranged from 136.4 to 165.0 µS cm$^{-1}$ and so all sites (with the exception of one site which had a conductivity of 296.8 µS cm$^{-1}$) were fished with the GPP set to low range (50-500 V direct current) and a frequency of 60 pulses per second. We adjusted the percent of range setting of the GPP to between 50 and 70% to give an applied current of 3-4 A root mean square.

Six sites were fished using the electrofishing boat between 20$^{th}$ and 23$^{rd}$ of August 2007 (Table 1). Electrofishing sites were matched up with sites sampled by using nets and traps as much as access allowed. Four of the six electrofishing sites were re-surveyed between the 3$^{rd}$ and 6$^{th}$ of March 2008. Only sites located in the main river

channels could be surveyed in March 2008 because off-channel sites ~~had become exposed~~were dry.

TABLE 1. LOCATIONS (NZMG) OF ELECTROFISHING PASSES AT EACH OF THE SITES FISHED WITH THE ELECTRIC FISHING BOAT BETWEEN 20-23 AUGUST 2007 AND 3-6 MARCH 2008 IN THE WHANGAMARINO WETLAND.

| Site code | Location | Habitat type | 20-23 August 2007 | | 3-6 March 2008 | |
|---|---|---|---|---|---|---|
| | | | Easting | Northing | Easting | Northing |
| **Whangamarino River downstream of weir** | | | | | | |
| E1-01 | Main channel | Stop bank fringe | 2694816 | 6431062 | 2694811 | 6431038 |
| E1-02 | Main channel | Willow fringe | 2694507 | 6431228 | 2694518 | 6431228 |
| E1-03 | Flooded backwater/Main channel | Submerged vegetation | 2693948 | 6431557 | 2693795 | 6431734 |
| E1-04 | Flooded backwater/Main channel | Submerged vegetation | 2693939 | 6431555 | 2693630 | 6431842 |
| E1-05 | Main channel | Willow fringe | 2694008 | 6431572 | 2694009 | 6431577 |
| **Maramarua River** | | | | | | |
| E2-01 | Main channel | Willow fringe | 2695534 | 6432174 | 2695529 | 6432184 |
| E2-02 | Main channel | Stop bank fringe | 2695511 | 6432210 | 2695504 | 6432222 |
| E2-03 | Main channel | Willow fringe | 2695474 | 6432398 | 2695476 | 6432405 |
| E2-04 | Main channel | Flooded farmland | 2695947 | 6433203 | 2695954 | 6433200 |
| E2-05 | Farm inlet | Cove, farm inlet | 2695746 | 6433049 | 2695737 | 6433042 |
| **Whangamarino River downstream of Reao Stream** | | | | | | |
| E3-01 | Main channel | Glyceria river fringe | 2697883 | 6427593 | 2697876 | 6427608 |
| E3-02 | Main channel | Willow fringe | 2697751 | 6427742 | 2697771 | 6427730 |
| E3-03 | Main channel | Glyceria river fringe | 2697755 | 6427724 | 2697753 | 6427728 |
| E3-04 | Main channel | Willow fringe | 2697625 | 6427841 | 2697617 | 6427841 |
| E3-05 | Main channel | Willow fringe | 2698034 | 6427475 | 2698029 | 6427470 |
| **Whangamarino River downstream of Falls Road** | | | | | | |
| E4-01 | Main channel | Stopbank fringe | 2703675 | 6426168 | 2703674 | 6426179 |
| E4-02 | Main channel | Stopbank fringe | 2703510 | 6426075 | 2703520 | 6426079 |
| E4-03 | Main channel | Willow fringe | 2703321 | 6426104 | 2703316 | 6426105 |
| E4-04 | Main channel | Willow fringe | 2703688 | 6426206 | 2703690 | 6426214 |
| E4-05 | Main channel | Willow fringe | 2703238 | 6426249 | 2703244 | 6426260 |
| **Reao Stream** | | | | | | |
| E5-01 | Flooded backwater | Submerged vegetation | 2698021 | 6427097 | - | - |
| E5-02 | Flooded backwater | Submerged vegetation | 2698011 | 6427061 | - | - |
| E5-03 | Main channel | Stop bank fringe | 2698042 | 6427072 | - | - |
| E5-04 | Main channel | Willow fringe | 2698128 | 6426911 | - | - |
| E5-05 | Flooded wetland | Submerged vegetation | 2698241 | 6426886 | - | - |
| **Falls Road - Off channel site** | | | | | | |
| E6-01 | Flooded swamp | Swamp | 2703259 | 6426060 | - | - |
| E6-02 | Flooded swamp | Open Swamp | 2703395 | 6425903 | - | - |
| E6-03 | Flooded swamp | Swamp | 2703515 | 6425846 | - | - |
| E6-04 | Flooded swamp | Willow fringe | 2703388 | 6425811 | - | - |
| E6-05 | Flooded swamp | Swamp | 2703247 | 6426272 | - | - |

Five 10-minute long electric fishing passes were undertaken at each. Each electric fishing pass was in a different area within the site (i.e. different sides of channel, off river). The boat operators attempted to sample all of the available habitat types at each site, for example littoral areas, macrophyte beds, willow fringes.

Data recorded for each pass included number of fish caught, length and weight of fish, presence of macrophytes, habitat characteristics and depth range of water column fished. Weights of fish were mostly derived from length-weight relationships calculated from a series of data sets (Table 2), as weighing every individual fish out in the field was impractical ~~as well as time consuming~~. If an accurate length-weight relationship for a particular fish species was not available then they were weighed. No effort was made to try and quantify the abundance or biomass of gambusia due to difficulty in successfully quantifying their abundance with the electrofishing boat.

TABLE 2. LENGTH-WEIGHT RELATIONSHIPS OF FISH SPECIES USED TO CALCULATE WEIGHT OF INDIVIDUAL FISH CAPTURED IN THE WHANGAMARINO WETLAND DURING THE SURVEY. WEIGHT OF FISH IS CALCULATED BY $W=AL^B$.

| Species | A | B | $r^2$ | N | Reference |
|---|---|---|---|---|---|
| Shortfin eel | -14.820 | 3.270 | 0.982 | 370 | Hicks unpublished data |
| Longfin eel | -15.120 | 3.353 | 0.996 | 113 | Hicks and McCaughan, 1997 |
| Grey mullet | -11.606 | 3.082 | 0.992 | 90 | Hicks unpublished data |
| Common smelt | -14.898 | 3.724 | 0.916 | 2037 | Hicks unpublished data |
| Inanga | -13.066 | 3.220 | 0.894 | 128 | Hicks unpublished data |
| Common bully | -11.708 | 3.096 | 0.976 | 115 | Hicks unpublished data |
| Koi carp | -10.949 | 3.043 | 0.966 | 2582 | Hicks unpublished data |
| Goldfish | -11.377 | 3.144 | 0.983 | 2006 | Hicks unpublished data |
| Rudd | -12.730 | 3.365 | 0.990 | 294 | Hicks unpublished data |
| Catfish | -11.049 | 2.978 | 0.956 | 281 | Hicks unpublished data |
| Gambusia | -13.147 | 3.527 | 0.960 | 100 | Amy McDonald unpublished data |

## 2.3 Backpack electrofishing

Four sites in stream tributaries, which drain directly into the Whangamarino Wetland, were sampled using a Kainga EFM 300 back-pack electrofisher (Table 3). The four sites corresponded to sites sampled by Strickland (1980). The output voltage of the machine was set at 300 V to achieve a current of 200-400 mA flowing through the circuit. This successfully caused the fish to be attracted to anode and go into a state of narcosis so that they could be captured. At each sample site 100 $m^2$ of stream was fished and the fish that were collected were identified, weighed and measured before being released back into the stream once electrofishing had been completed. Weights of fish were mostly derived from length-weight relationships calculated from a series

of data sets (Table 2), as weighing every individual fish out in the field was impractical as well as time consuming. If an accurate length-weight relationship for a particular fish species was not available then they were weighed.

TABLE 3. LOCATIONS (NZMG) AND HABITAT CHARACTERISTICS OF SITES FISHED IN THE WHANGAMARINO WETLAND BY BACKPACK ELECTROFISHING BETWEEN THE 20TH AND 23RD OF AUGUST 2007.

| Site Code | Site | Date | Habitat | Easting | Northing |
|---|---|---|---|---|---|
| E7 | Falls Road Quarry | 24/08/2007 | Open stream along the edge of a active quarry. Few native trees, pasture, quarry and rocky bottom. | 2702665 | 6429425 |
| E8 | Drake Road Farm | 3/09/2007 | Sampling reach flowed through open farmland. Pasture dominated riparian zone and silty substrate with a few rocks. | 2702925 | 6428470 |
| E9 | Drake Road Bush | 3/09/2007 | Forested stream. Native bush riparian zone, large boulders and rocky bottom | 2703045 | 6428505 |
| E10 | Falls Road | 24/08/2007 | Forested stream. Native bush riparian zone, large boulders and rocky bottom | 2703585 | 6427005 |

# 3 Results

## 3.1 Netting and trapping

Water temperature ranged between 10 and 13°C at the sites where nets and traps were used but this variation would probably have been affected by the time of the day at which temperature was measured (Table 4). The predominant substrate type found at the sites was mud and water clarity was poor. The pH at all of the sites was close to neutral and did not vary much between sites. Full descriptions of the netting and trapping sites are provided in Appendix 1.

TABLE 4. DESCRIPTION OF SITES SAMPLED USING NETS AND TRAPS IN THE WHANGAMARINO WETLAND DURING AUGUST 2007.

| Site | Description | Habitat | pH | Temperature (°C) |
|---|---|---|---|---|
| N1 | Whangamarino River downstream of weir | Channel | 7.4 | 12 |
| N2 | Whangamarino River downstream of Reao Stream | Channel | 7.4 | 12 |
| N3 | Whangamarino River upstream of Reao Stream | Channel | 7.4 | 12 |
| N4 | Maramarua River upstream of Pumping Station | Channel | 7.2 | 13 |
| N5 | Pungarehu Canal downstream of Waikare Outlet | Channel | 7.4 | 12 |
| N6 | Whangamarino in the Herb Block | Off-channel | 7.3 | 11 |
| N7 | Reao Stream | Off-channel | 7.2 | 10 |
| N8 | Maramarua River flooded margins | Off-channel | 7.2 | 10 |

The netting and trapping survey resulted in the capture of 12 different fish species from the Whangamarino (Table 5). Shortfin eels (*Anguilla australis*), common bullies (*Gobiomorphus cotidianus*), catfish (*Ameiurus nebulosus*) and gambusia were the most widely distributed fish species. Koi (*Cyprinus carpio*), inanga (*Galaxias maculatus*), rudd (*Scardinius erythrophthalmus*), common smelt (*Retropinna retropinna*) and black mudfish (*Neochanna diversus*) were relatively rare. Although widespread, common bullies were generally caught in very low numbers except for at N5, where over 2000 individuals were caught. Large numbers of freshwater shrimp (*Paratya curvirostris*) were also collected in the same sample collected from N5. The

greatest number of species was collected from N1 while the lowest number was collected from N8. Several species were quite localised in their occurrence in net and trap samples. All of the koi and most of the longfin eels (*Anguilla dieffenbachii*), inanga and grey mullet (*Mugil cephalus*) captured were from N1.

TABLE 5 TOTAL NUMBER (AND WEIGHT IN GRAMS) OF FISH CAUGHT AT EACH SITE SAMPLED IN THE WHANGAMARINO WETLAND USING NETS AND TRAPS SET ONCE OVERNIGHT AT EACH SITE DURING AUGUST 2007. TWO COARSE MESH FYKES, TWO FINE MESH FYKES AND 5 GEE MINNOW TRAPS WERE SET AT EACH SITE.

| | **N1** | **N2** | **N3** | **N4** | **N5*** | **N6** | **N7** | **N8** | **Total** |
|---|---|---|---|---|---|---|---|---|---|
| Shortfin eel | 3 (8396) | 4 (460) | 5 (599) | 26 (1948) | 4 (455) | 4 (154) | 3 (622) | 4 (191) | 89 (12825) |
| Longfin eel | 18 (4734) | | | | | | | 1(91) | 19 (4825) |
| Grey mullet | 3 (456) | | | | 1 (41) | | | | 4 (497) |
| Common smelt | 1 | | 1 | | | 9 | | | 11 |
| Black mudfish | | 5 | 2 | 2 | | | | 5 | 14 |
| Inanga | 5 | | | | | 1 | | | 6 |
| Common bully | 31 | 1 | 2 | 1 | 2054 | 8 | 1 | | 2098 |
| Koi | 5 (621) | | | | | | | | 5 (621) |
| Goldfish | | 2 (202) | 1 (66) | | | 2 (491) | 6 (887) | | 11 (1646) |
| Rudd | 1 (38) | 1 (151) | | | | | 1 (31) | | 3 (220) |
| Catfish | 19 (2406) | 8 (531) | | 6 (479) | 1 (205) | 3 (640) | 14 (1913) | | 51 (6174) |
| Gambusia | 13 | 181 | 29 | | 53 | 50 | 1 | | 327 |
| % of all species caught in nets & traps | 83 | 58 | 50 | 33 | 42 | 58 | 50 | 25 | 100 |

*only 3 fyke nets were set at this site

Shortfin eels were the dominant large bodied fish species collected in the fine and coarse mesh fyke nets, contributing nearly half of the total fish biomass caught (Figure 3). Large bodied fish were defined as those species where the average adult size was greater than 150 mm. Catfish made the next greatest contribution by weight, making up over a quarter of the fyke net samples by weight. Longfin eels made up 10

percent of fyke net samples while the remaining four large bodied species caught made relatively minor contributions to total biomass.

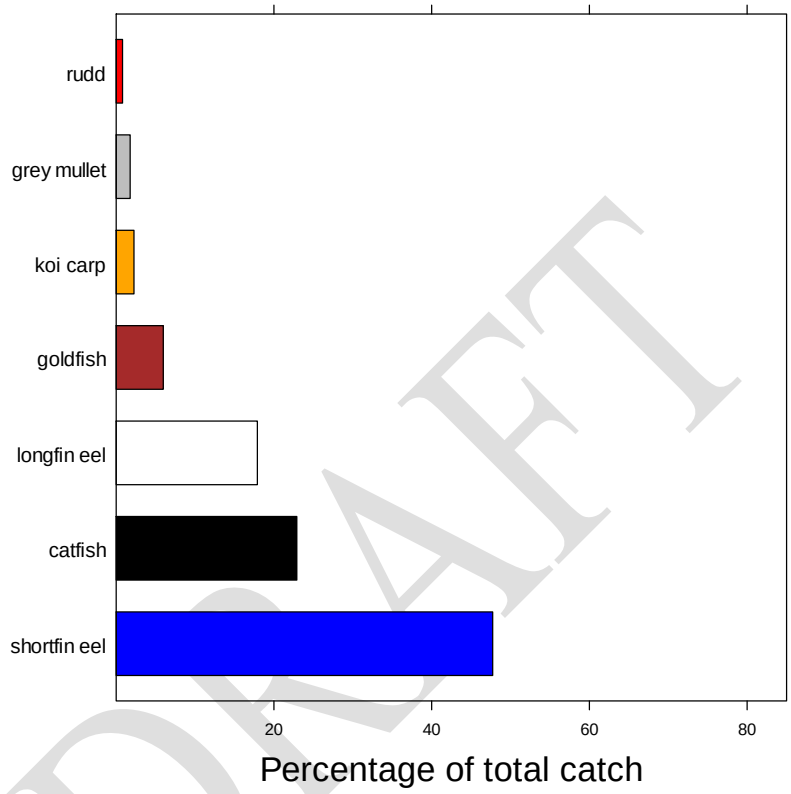


FIGURE 3 COMPOSITION BY WEIGHT OF ALL LARGE-BODIED FISH SAMPLES COLLECTED FROM THE WHANGAMARINO WETLAND IN AUGUST 2007 USING COARSE AND FINE MESH FYKE NETS. LARGE BODIED SPECIES WERE DEFINED AS THOSE WITH AN AVERAGE (ADULT LENGTH > 150 MM).

## 3.2 Boat electrofishing

Specific conductivities were moderate across all of the electrofishing sites with values ranging between 139 to 188 µS $cm^{-1}$ (Table 6). Mean water temperatures recorded at the electrofishing sites in August 2007 ranged from 10.9 to 13.9°C (Table 6). Whereas in March 2008, water temperatures were higher at around 20.7°C to 21.9°C.

TABLE 6 DESCRIPTION OF SITES SAMPLED USING AN ELECTROFISHING BOAT IN THE WHANGAMARINO DURING AUGUST 2007 AND MARCH 2008. DETAILED LOCATION INFORMATION FOR ELECTROFISHING RUNS IS PROVIDED IN APPENDIX 1.

| Site Code | Description | Month | Water temp (°C) | Mean specific conductivity (µS cm$^{-1}$) | Depth Range (m) | Distance fished (m) |
|---|---|---|---|---|---|---|
| E1 | Whangamarino River downstream of weir | August | 13.6 | 143 | 0.4 – 3.5 | 875 |
| | | March | 21.9 | 141 | 0.6 – 2.6 | 364 |
| E2 | Maramarua River | August | 13.1 | 188 | 0.4 – 3.0 | 531 |
| | | March | 20.7 | 118 | 1.0 – 2.0 | 481 |
| E3 | Whangamarino River downstream of Reao Stream | August | 12.8 | 142 | 0.4 - 3.4 | 455 |
| | | March | 20.7 | 172 | 0.3 – 2.4 | 201 |
| E4 | Whangamarino River downstream of Falls Road | August | 10.9 | 165 | 0.4 – 3.7 | 680 |
| | | March | 21.9 | 175 | 0.3 – 1.8 | 466 |
| E5 | Reao Stream | August | 13.9 | 140 | 0.4 – 1.7 | 1082 |
| E6 | Falls Road off-channel site | August | 14.1 | 139 | 0.4 – 1.2 | 1414 |

The depth of water that was fished varied depending on the habitat encountered at each site. Main channel sites in the Whangamarino and Maramarua rivers tended to be deeper, especially in August 2007 when water levels were higher. The flooded paddocks and backwaters fished at E5 in August 2007 were the shallowest environments sampled. The distance fished at each site varied considerably between 201 m and 1414 m (Table 6). At sites that were surveyed twice, sampling distances tended to be much longer in August than in March. Sites sampled in off-channel habitats in August 2007 were particularly long. Longer sample lengths are probably indicative of lower catch rates because less time is spent pausing to net fish.

A total of 1806 fish from ten fish species were caught in electrofishing samples. Six native fish species and four introduced species were caught using the electrofishing boat (

Table 7). An eleventh species, gambusia, were also observed during the electrofishing boat survey but were not collected. Gambusia were observed to be in much greater abundance during the March survey.

TABLE 7 CATCH PER UNIT EFFORT (fish 100m$^{-2}$) FOR FISH COLLECTED IN BOAT ELECTROFISHING SAMPLES FROM SITES IN THE WHANGAMARINO WETLAND IN AUGUST 2007 AND MARCH 2008. BLANKS DENOTE A CPUE OF 0 fish 100m$^{-2}$.

| **Species** | **August 2007** | | | | | | | **March 2008** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **E1** | **E2** | **E3** | **E4** | **E5** | **E6** | **Aug Total** | **E1** | **E2** | **E3** | **E4** | **March Total** |
| Shortfin eel | 0.14 | 0.56 | 0.22 | 0.18 | 0.09 | 0.05 | 1.26 | 1.72 | 1.46 | 0.87 | 0.64 | 4.69 |
| Longfin eel | | | | | | | | 0.14 | | | | 0.14 |
| Grey mullet | 0.06 | 0.05 | | | | | 0.10 | 1.17 | | | | 1.17 |
| Common smelt | | | 0.16 | 0.11 | 0.44 | 1.04 | 1.76 | 20.67 | 0.16 | 0.12 | 0.11 | 21.06 |
| Inanga | | 0.05 | | 0.04 | | | 0.08 | 1.17 | | 0.25 | 0.27 | 1.68 |
| Black mudfish | | | | | | | | | | | | |
| Common bully | 0.06 | 0.09 | 0.05 | 0.66 | | 0.04 | 0.90 | 0.27 | 0.47 | | 0.16 | 0.90 |
| Koi | 0.60 | 0.05 | 0.60 | 0.11 | 0.39 | 0.28 | 2.04 | 0.89 | 0.88 | 5.10 | 1.39 | 8.27 |
| Goldfish | 0.14 | 0.05 | 0.05 | 0.22 | 0.18 | 0.32 | 0.97 | 0.96 | 0.57 | 26.12 | 1.61 | 29.26 |
| Rudd | | | 0.05 | 0.04 | | 0.04 | 0.13 | | | 0.37 | 0.16 | 0.53 |
| Catfish | | | 0.11 | 0.04 | 0.02 | 0.11 | 0.28 | | | 1.37 | | 1.37 |
| Total | 1.00 | 0.85 | 1.26 | 1.40 | 1.13 | 1.87 | 7.51 | 26.99 | 3.53 | 34.20 | 4.35 | 69.08 |

Shortfin eels, koi, goldfish (*Carassius auratus*) were the most widely distributed fish species and were found at all sites during both the August and March boat electrofishing surveys. Common bullies and common smelt had a relatively wide distribution but were usually caught in very low numbers at each site. Inanga, rudd and catfish were usually relatively scarce and had a patchy distribution in boat electrofishing samples.

Several species were quite restricted in their distribution in boat electrofishing samples. Longfin eels were only caught at E1 below the weir during the March 2008 survey. Except for a single individual caught at E2 all of the grey mullet captured using the electrofishing boat were caught downstream of the weir at E1.

The total catch rate for all species combined was considerably higher in March 2008 (69.08 fish 100 m$^{-2}$) compared with that in August 2007 (7.51 fish 100 m$^{-2}$). Much of this increase is attributable to very high catches of smelt at E1 and goldfish at E3 during the March 2008 survey. The total catch rates for all species increased between August 2007 and March 2008 and this increase was consistent across almost all of the sites.

Koi carp made up 83.2% by weight of electrofishing samples for large bodied fish species (Figure 4). Goldfish made the next greatest proportion of boat electrofishing

samples by weight, contributing 9.8% of samples. Shortfin eels had the greatest proportion by weight for a native species but still only made up 3.9 % of the samples. Other large bodied species made up only a minor component of electrofishing samples.

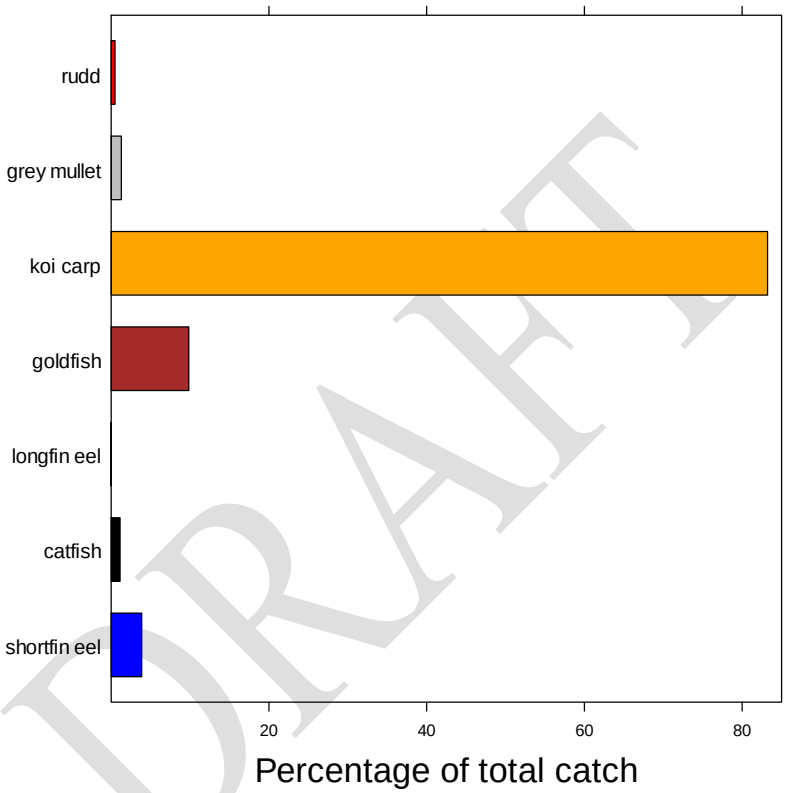


FIGURE 4 COMPOSITION BY WEIGHT OF ALL LARGE-BODIED FISH (> 150 MM) COLLECTED FROM THE WHANGAMARINO WETLAND IN AUGUST 2007 AND MARCH 2008 BY BOAT ELECTROFISHING.

## 3.3 Backpack electrofishing

Four sites were sampled at three streams using a backpack electrofishing machine (Table 8). Site E7 was bordered by pasture on the left and a gravel quarry on the right. The substrate type present in the stream consisted of gravel and rocks (diameter of less than 10 mm). The riparian margin consisted of a mixture of native trees, pasture and open sections. This stream had a very high specific conductivity of 456

µS $cm^{-1}$, which was probably due to turbid runoff from the nearby quarry. Water temperatures ranged between 8.5 and 11.8 °C. These water temperatures were slightly cooler than those encountered in the wetland during the boat electrofishing survey conducted around the same time.

TABLE 8 DESCRIPTION OF SITES SAMPLED USING A BACKPACK ELECTROFISHER BOAT IN THREE TRIBUTARY STREAMS OF THE WHANGAMARINO DURING AUGUST 2007.

| Site Code | Site | Date sampled | Specific conductivity (µS $cm^{-1}$) | Water temp. (ºC) | Distance fished (m) | Area fished ($m^2$) |
|---|---|---|---|---|---|---|
| E7 | Falls Road Quarry | 24/08/2007 | 456 | 11.8 | 75 | 100 |
| E8 | Drake Road Farm | 03/09/2007 | 163 | 10.5 | 100 | 100 |
| E9 | Drake Road Bush | 03/09/2007 | 163 | 10.5 | 50 | 100 |
| E10 | Falls Road | 24/08/2007 | 203 | 8.5 | 50 | 100 |

The unnamed stream next to Drake Road flowed through native bush, then pasture and finally into the wetland proper. Site E8 was located in open pasture and had a degraded riparian margin consisting of mainly pasture grasses with a few sedges, rushes and sometimes reed sweetgrass (*Glyceria maxima*). Substrate at this site was predominantly composed of mud. Site E9 was located a little further upstream in the same stream where it flowed through dense native bush and contained some moderately deep pools as well as shallow riffles but with no emergent vegetation. Substrate at this site consisted of bedrock as well as a variety of different sized boulders larger than 200 mm in width. Site E10 was very similar to E9 and also flowed through dense native bush and contained a mix of both pool and riffle habitat with a similar substrate type but in general the size of the boulders were smaller (ranging from 50 mm to 200 mm in width) .

A total of 402 fish were caught from the three tributary streams using the backpack electrofishing machine (Table 9~~Table 9~~). All of the six species captured in the stream surveys were native and three of them, shortfin eel, longfin eel, and common bullies, were also found in the trap, net and boat electrofishing samples in the Whangamarino. Three additional species, redfin bullies (*Gobiomorphus huttoni*) banded kokopu (*Galaxias fasciatus*) and koura or freshwater crayfish (*Paranephrops planifrons*) were found in the tributary streams but not the wetland itself. Shortfin eels were found at all sites and were the only species found at E7. Banded kokopu were only found at E8 and E9. The most abundance species recorded in backpack electrofishing samples

were common bullies followed by shortfin eels and koura. The highest catch rates for all species except for banded kokopu were recorded at E8.

TABLE 9. CATCH PER UNIT EFFORT (fish $100m^{-2}$) FOR FISH AND CRAYFISH SPECIES CAUGHT BY BACKPACK ELECTROFISHING IN STREAMS FLOWING INTO THE WHANGAMARINO WETLAND ON 24 AUGUST AND 3 SEPTEMBER 2007.

| Site Number | Common bully | Redfin bully | Longfin eel | Shortfin eel | Banded Kokopu | Koura | Grand Total |
|---|---|---|---|---|---|---|---|
| E7 | 0 | 0 | 0 | 12 | 0 | 0 | 12 |
| E8 | 98 | 14 | 20 | 69 | 1 | 39 | 241 |
| E9 | 10 | 1 | 6 | 1 | 0 | 19 | 37 |
| E10 | 66 | 5 | 1 | 10 | 4 | 26 | 112 |
| Mean | 44 | 5 | 7 | 23 | 1 | 21 | 101 |

## 3.4 Population structure of shortfin eels

The length frequency distributions for shortfin eels caught using fyke nets and the electrofishing boat were compared and found to be very similar (Figure 5~~Figure 5~~). Relatively few shortfin eels were caught using the electrofishing boat in August 2007 compared with March 2008, however, the length frequency distributions were not obviously different.

Only 27 out of the 190 measured eels caught in the wetland using fyke nets and boat electrofishing were large enough to be taken by commercial fishers (>220 g). None of the eels caught in either the wetland or tributary streams were heavier than the 4 kg maximum takeable size for commercial fishers.

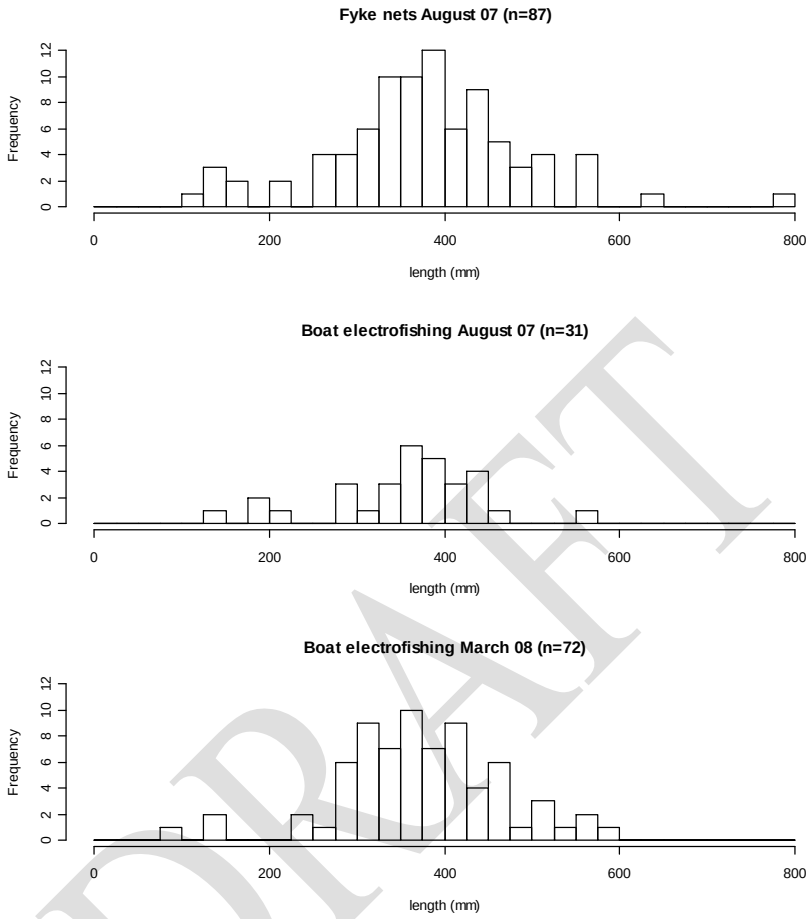


FIGURE 5 LENGTH FREQUENCY DISTRIBUTION FOR SHORTFIN EELS COLLECTED USING FYKE NETS AND BOAT ELECTROFISHING FROM THE WHANGAMARINO DURING SURVEYS IN AUGUST 2007 AND MARCH 2008.

## 3.5 Comparison of methods

The greatest number of species recorded using a single sampling method were caught using the electrofishing boat (Table 10). Most of the koi and goldfish collected during the surveys were caught in boat electrofishing samples. The only species that was not caught using the electrofishing boat were black mudfish.

Gee minnow traps caught the lowest number of species and only caught small bodied species and juvenile shortfin eels. Gee minnow traps did not catch any fish species that was not collected using one of the other methods.

TABLE 10 TOTAL NUMBERS OF FISH CAUGHT IN THE WHANGAMARINO WETLAND DURING SURVEYS CONDUCTED IN AUGUST 2007 AND MARCH 2008 USING FOUR DIFFERENT TYPES OF SAMPLING GEAR.

| | **Gee Minnow traps** | **Fine-mesh fykes** | **Coarse-mesh fykes** | **Boat electrofishing** | |
|---|---|---|---|---|---|
| Sample Month | August | August | August | August | March |
| Effort | 40 traps | 16 nets | 15 nets | 5037 metres | 1512 metres |
| Shortfin eel | 2 | 39 | 48 | 33 | 72 |
| Longfin eel | | 12 | 7 | | 2 |
| Grey mullet | | | 4 | 3 | 17 |
| Common smelt | | 11 | | 84 | 307 |
| Black mudfish | 6 | 8 | | | |
| Inanga | | 6 | | 2 | 24 |
| Common bully | 1450 | 646 | 2 | 25 | 16 |
| Koi | | | 5 | 69 | 97 |
| Goldfish | | 3 | 8 | 39 | 265 |
| Rudd | | | 3 | 4 | 6 |
| Catfish | | 15 | 36 | 10 | 11 |
| Gambusia | 316 | 11 | | observed | observed |
| Total number of species recorded | 4 | 9 | 8 | 10 | 11 |

Fine-mesh and coarse-mesh fykes tended to catch a slightly different range of fish species but combined together accounted for all of the fish species recorded from channel and off-channel sites. Fine-mesh fykes caught more small bodied species such as black mudfish, inanga and common bullies but did not catch any large-bodied species such as koi, rudd or grey mullet.

Very large numbers of common bullies were caught in Gee minnow traps and fine meshed fykes. Nearly all of these common bullies (98%) were caught from the same site at N5 where the electrofishing boat could not be used.

Koi were rarely caught in fyke nets and no koi were caught in Gee minnow traps. The five koi that were caught in fyke nets were all found at the same site (E1) and were all less than 184 mm. Rudd were not caught in any great number using any of the sampling methods used.

# 4 Discussion

## 4.1 Fish community

Fourteen fish species and two freshwater crustacean species were recorded during the surveys carried out in August 2007 and March 2008. While tributary streams were found to contain only native species, the channel and off-channel habitats within the wetland itself were dominated by introduced species, particularly koi.

**Commented [DW3]:** Only seen mention of paratya?assume second spp was mysids????

There was no clear differentiation between the species composition found in channel habitats compared with off-channel habitats. This suggests that all of the species found within the wetland are able to utilise the floodplain during periods of inundation. It should be noted, however, that the surveys were only conducted at relatively discreet points on the hydrograph. More frequent surveys which include sampling on the rising and falling hydrograph may elucidate any related movement patterns by some species.

The tributary streams contained a different type of fish community to that found in the channel and off-channel sites. Redfin bullies, koura, and banded kokopu were only found in the tributary streams. Common bullies and longfin eels were also more abundant in the tributary streams than in the wetland sites although this may be explained by the different sampling method used in the streams (ie. backpack electrofishing). Another feature of the tributary stream fish communities is that they contained no exotic species.

The differences observed between the fish communities found in the tributary streams and those found within the wetland can be largely attributed to differences in habitat. The tributary streams provided completely different habitat types to those in the channel and off-channel sites within the Whangamarino Wetland itself. Tributary streams were narrow, shallow, fast flowing and generally had larger substrate types.

Greater catch rates were achieved using the electrofishing boat in March 2008 compared with August 2007. Whilst this increase was observed at most sites, the accumulation of koi and other species below the weir and goldfish downstream of Raeo Stream certainly contributed a great deal to the higher catch rates in March 2008. Experience with the electrofishing boat has shown that catch rates appear to increase during summer compared to winter (Hicks unpublished data). The warmer

water temperatures encountered in late summer may therefore account for this increase in catch rates. Another possible explanation is that fish populations became more concentrated at low water levels as fish became confined to channel habitats.

There were some differences in the list of fish species recorded by Strickland (Strickland 1980) and the current survey. Native redfin bullies and introduced koi were not reported by Strickland (1980) but were present in the 2007/2008 survey. Six species reported by Strickland (1980) as being present in the Whangamarino Wetland were not found during the 2007/2008 survey. These included three native species giant kokopu (*Galaxias argenteus*), torrentfish (*Cheimarrichthys fosteri*) and lamprey (*Geotria australis*), and three introduced species, tench (*Tinca tinca*), brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*). Neither giant kokopu, lamprey or either of the two trout species were physically collected during Strickland's 1980 survey but were reported as being present by eel fishers (Strickland 1980). While these species may occur in the wetland when conditions allow or during migration periods they are likely to be very rare and therefore only detected by people who frequently fish there. The reasons for the presence/absence of these species in either survey is explained in the species sections below.

**Koi**

Between the 1980 survey and the 2007/2008 survey, koi have invaded the Whangamarino and are now the dominant fish species. Koi carp do not appear to have been present in the Whangamarino in 1980 (Strickland 1980), and the earliest records for the species in the wetland are from 1984 (NZFFDB 2008). The results of the electrofishing surveys in 2007/2008 indicate that the biomass of koi now constitutes over 80% of the whole fish community present in the wetland although they were rarely caught in fyke nets and never found in Gee minnow traps.

While koi were the dominant fish species found in the wetland during the 2007/2008 survey they were found to be absent from the tributary streams. The tributary streams are unlikely to provide much suitable habitat for koi carp because they are cool, fast flowing, shallow and lack fine substrates.

`The deleterious effects of carp on aquatic environments is well documented overseas (Koehn et al. 2000) and given their high biomass in the Whangamarino they are highly likely to be having some impact on the ecology of the wetland.

Koi were found in off-channel habitats during high water levels in August 2007. It is unknown whether koi were actively seeking out recently flooded areas or were just passively spreading out as more habitat became available. Koi carp have been shown to undertake wide ranging movements up and down the Waikato River and also between the river and connected floodplain environments (Daniel 2009). Flooded off-channel habitats may provide significant seasonal food sources for koi as well as ideal spawning habitat during the warmer months of the year.

**Goldfish**

Goldfish were found to be widespread in channel and off-channel habitats within the wetland, but as with koi were absent from the small tributary streams. Goldfish biomass made a minor contribution to fish biomass in both fyke net and electrofishing samples and they were never caught in Gee minnow traps. Strickland (1980) caught goldfish at a few sites using a backpack electrofishing machine but observed that large numbers of goldfish were caught in fyke nets. Based on the information provided by (Strickland 1980) it is not possible to establish whether goldfish numbers have increased since 1980.

Very high densities of goldfish (26.12 fish 100 $m^{-2}$) were caught by the electrofishing boat at E3 in the Whangamarino River downstream of Reao Stream during the March 2008 electrofishing survey. The high density encountered at this site suggests that an aggregation of goldfish had formed there. The reason for this aggregation of this species is unknown, but it is possible that flow from the Reao Stream provided some sort of attraction.

The potential for goldfish to impact on freshwater ecosystems has been recognised and the species is now listed in the Waikato Regional Pest Management Strategy (Environment Waikato 2009). The species should be regarded as an undesirable component of the fish community in the Whangamarino.

**Tench**

No tench were caught during the 2007/2008 survey and there are few records for the species in the lower Waikato in general. Tench were reported by both eel fishers and Acclimatisation staff in the 1980 survey report (Strickland 1980) but were not collected by the author. They were considered to occur in low numbers and mainly within the Whangamarino River. It is possible that tench were displaced by koi when

the latter invaded the habitat during the 1970s and 80s. The commercial fishery for tench in the Murray River is thought to have declined after the invasion of common carp (Brumley 1996) and the same phenomenon may have occurred in the Whangamarino following the invasion of koi.

**Catfish**

In Strickland (1980), commercial eel fishers reported that catches of catfish far exceeded those of eel species in the Whangamarino. Catfish were not found to dominate any samples collected during the 2007/2008 survey although they did make up 28% of net and trap samples. Catfish were relatively scarce in electrofishing samples and it appears that this species may not be particularly susceptible to this sampling method (Hicks unpublished data). There are two possible explanations for the apparent reduction in catfish numbers between the 1980 and 2007/2008 survey. The first is that the methods used in the 2007/2008 survey did not target catfish as effectively as those used in the 1980 survey or by commercial eel fishers around that time. Unfortunately it is not possible to compare fishing effort because this information was not documented in the 1980 report. A second possible explanation is that the invasion of koi carp has had a negative impact on catfish populations. Koi carp and catfish are both benthic omnivores and could potentially compete for food resources.

**Torrentfish**

No torrentfish were collected during the current survey. Strickland (1980) collected torrentfish from at least some catchment drainage sites, however, it is not clear exactly where they were collected or in what numbers. It also is possible that Strickland (1980) collected torrentfish from streams flowing into Lake Waikare as these were included in his survey although not indicated on the sampling site map. Torrentfish prefer fast flowing riffle habitats with rocky substrates (McDowall 2000) and so are highly unlikely to be found in the channel and off-channel habitats within the wetland itself. Further sampling of higher elevation tributary streams within the Whangamarino catchment may reveal the presence of torrentfish.

**Shortfin eels**

Shortfin eels were the most widespread and numerous native species caught during the 2007/2008 survey and were caught at every site sample. They also made up the

greatest biomass of any native species in fyke net and electrofishing samples. Strickland (1980) made similar observations about the distribution and abundance of shortfin eels and identified them as a highly significant fishery resource.

The eel population in the Whangamarino is dominated by shortfin eels and appears to be skewed towards smaller individuals. The population structure of shortfin eels found in 2007/2008 was similar to that found in 1980 (Strickland 1980). Commercial fishing has been shown to reduce the average size of eels (Chisnall & Kemp 2000) and this activity may explain the lack of large shortfin eels caught in the both surveys. It is difficult to assess whether the population structure of eels in the Whangamarino has been affected by commercial fishing pressure as there is currently a lack of comparable data on unexploited eel populations to use as a reference.

**Longfin eels**

Longfin eels were much less abundant than shortfin eels during the 2007/2008 survey. The species was quite common in samples collected from the tributary stream habitats and several were collected at E1 below the weir in fyke nets. Only one longfin eel was caught upstream of the weir within the wetland itself.

**Commented [DW4]:** Compared to 1980 survey also??

The absence of longfin eels from off-channel habitats can be explained by the habitat preferences of the species. Longfin eels, unlike shortfin eels, are not regarded as a wetland species and tend to prefer river and stream habitats (Taylor & Main 1987). The channel habitats in the Whangamarino and Maramarua Rivers should provide ideal habitat for longfin eels and the absence of this species from these sites was unexpected. Hicks et. al. (2005) collected relatively few longfin eels compared to shortfin eels in the lower Waikato River and this may be a common pattern throughout the lower Waikato River catchment. There is evidence that longfin eels are preferentially removed from the eel fishery over shortfin eels (Beentjes et al. 2006).

Longfin eels are ranked as chronically threatened and in slow decline (Hitchmough et al. 2007). A significant factor in the decline of the species has been identified as commercial overfishing (Jellyman et al. 2000). Unfortunately it is not currently possible to protect longfin eels from commercial fishing in the Whangamarino because the Whangamarino and Maramarua Rivers are not included within the reserve boundaries.

**Grey mullet**

Grey mullet made up only a very minor component of fish samples collected during the 2007/2008 survey. Most fish were collected below the Whangamarino weir at E1, including a number of very small individuals around 30 mm in length. These findings suggest that the Whangamarino weir may be limiting the upstream movement of grey mullet.

Grey mullet were collected by Strickland (1980) and were presumably caught in fyke nets although no detail was provided in his report. Strickland (1980) referred to a small commercial fishery for the species in the Whangamarino once they started running into the wetland in early summer. If the Whangamarino weir is restricting upstream movement of grey mullet then this fishery is likely to have declined since the construction of the weir.

**Commented [DW5]:** Were grey mullet recorded in L. Waikare fishway monitoring?what about other species movement through fishway quite relevant to weir discussion and movement through Whangamarino….

**Common bullies**

Common bullies were one of the most widespread native fish species found in the Whangamarino and tributary streams. Common bullies were the most abundant species in samples collected from the tributary streams, however, they were typically only recorded in relatively low numbers in the channel and off-channel sites. The exception was at N5 where over 2000 common bullies were caught using nets and traps. Site N5 was located in the Pungarehu canal immediately downstream of the Lake Waikare outlet. During the time that the nets and traps were set the water level at the site dropped considerably and the sampling gear became exposed.

Strickland (1980) reported that common bullies were common in electrofishing samples from Catchment Drainage and Swamp Drainage sites but it appears that they were absent from Swamp Proper sites. These findings are broadly consistent with those of the 2007/2008 survey.

**Redfin bullies**

Redfin bullies were only collected from tributary stream sites. They were caught in reasonable numbers but were never very abundant. Redfin bullies would not be expected to occur in the channel and off-channel sites within the Whangamarino because the species prefers small cobbly streams with good riparian shading (Leathwick et al. 2008). No redfin bullies were recorded by Strickland (1980) and

this may be due to either their low abundance or possibly misidentification with common bullies which are similar in appearance when small.

**Common smelt**

This species was frequently caught using the electrofishing boat but was rarely found in net and trap samples. Very high abundances of common smelt (20.67 fish 100 $m^{-2}$) were recorded below the Whangamarino Weir at E1 during the survey in March 2008. At that time of year the Whangamarino Weir would have prevented any upstream movement of swimming species such as common smelt. Common smelt were probably accumulating below the weir as they attempted to migrate upstream and this would have resulted in the high number of fish that were caught.

No common smelt were caught in any of the tributary streams and this is probably due to their preference for larger, lower gradient streams with low levels of riparian shading. Common smelt were reportedly captured during the 1980 survey but were not discussed in detail by Strickland (1980), possibly because they were relatively rare.

**Black mudfish**

Black mudfish were only collected in Gee minnow traps and fine mesh fyke nets from four sites within the Whangamarino. Black mudfish are typically found in well vegetated wetland habitats, particularly if associated with peat soils. They have very specific habitat requirements for very shallow water levels, which for short periods, may temporarily drop below ground level (O'Brien & Dunn 2007). They have been found to be associated with three main variables, low water levels, low turbidity, and low levels of anthropogenic disturbance (Barrier 1993; Hicks, B. & Barrier 1996).

The fact that black mudfish were caught in flooded channel sites is unusual as these are not considered to be a preferred habitat type for this species. It is likely that the black mudfish captured at these sites had been flushed out of more preferred habitats in and around the peat areas.

Black mudfish were found throughout the Whangamarino by Strickland (1980) but adults were only caught by electrofishing in a few sites located in Swamp Proper habitats. The techniques for successfully sampling black mudfish populations had not yet been developed in 1980 and this would explain Strickland's lack of success in capturing adults. Mudfish surveys require the use of Gee minnow traps set in very

shallow water. Mudfish surveys conducted since 1980 by the University of Waikato and Department of Conservation indicate that black mudfish are quite widespread in the Whangamarino, but are restricted to seasonally inundated areas in or around the young peat bog zones (NZFFDB 2008). Black mudfish are considered threatened and in slow decline (Hitchmough et al. 2007).

**Inanga**

Inanga made up only a minor component of the fish community observed during the 2007/2008 survey. Only eight inanga were caught in October 2007 using nets, traps and by boat electrofishing. Greater numbers were caught using the electrofishing boat in March 2008 when 26 inanga were caught. As was observed for grey mullet and common smelt, the greatest number of inanga were found at E1 immediately downstream of the Whangamarino Weir. The weir may therefore also restrict upstream migration for inanga during low water level conditions.

## 4.2 Comparison of methods

It is difficult to directly compare the numbers of fish caught using different sampling gear because catch effort cannot be readily standardised. However, boat electrofishing caught the greatest diversity of fish species and was clearly more effective for catching koi carp and goldfish than netting and trapping.

Fyke nets were effective at catching a wide range of species provided both fine mesh and coarse mesh fykes were used. Small bodied species were not caught in coarse mesh fykes but these nets appear to be more effective at catching some larger bodied species. While reasonable numbers of eels and catfish were caught using the electrofishing boat, fyke nets are probably still the most efficient method for sampling these species. Much higher catches of eels would be expected if the nets and traps had been baited, or if they had been set across channels between floodplains and the main rivers as the commercial fishers do.

One of the drawbacks of using any passive fishing method such as nets and traps in floodplain wetlands is that they may become exposed or completely inundated if water levels change during the time they are set. This may not only result in lost gear or fish kills but will also confound results because samples are collected from a range of water level conditions. Care must be taken when setting nets or traps during periodic flooding to avoid falling water levels.

Gill nets were not used in the 2007/2008 survey because of concerns for non-target species within the wetland. Fish caught in gill nets can be heavily scavenged by eels, particularly if left overnight, which can make species identification and catch rates difficult to determine accurately. Fine mesh gill nets are an effective method for catching rudd (Neilson et al. 2004) and the use of these nets in the 2007/2008 survey may have shown that greater numbers of rudd were present in the Whangamarino. If the risks of catching non-target species can be managed then gill nets would complement other techniques used in wetland fish surveys. The different biases of the various sampling gear used in the current survey reinforces the need to use a suite of techniques in order to fully sample the range of fish species.

### 4.2.1 Knowledge Gaps

Although the current fish survey attempted to sample as many habitats as possible there were a number of habitats that were omitted from the sampling programme. The Kopuera Stream, which flows into the Maramarua just upstream from the confluence with the Whangamarino River was not sampled. This stream has been converted into a system of drains which draw off water from the peat soils to the north of the Whangamarino. This system is known to be highly peat influenced and may contain an unusual assemblage of species including black mudfish but there are no records in the NZFFDB that it has been surveyed. Permanent pool habitats created by duck pond development were also not assessed in the 2007/2008 fish survey. These habitats are common in the Whangamarino and there is ongoing pressure to develop further areas of the wetland for waterfowl hunting. An understanding of which fish species use existing duck ponds would help assess the values that these habitats support in the Whangamarino.

An assessment of fish passage over the original Whangamarino Weir, built in 1994, was undertaken in that same year (Barrier et al. 1995). The authors concluded that at the time of their survey smelt, inanga and elvers were able to negotiate the weir. However, Barrier et al. (1995) recommended further monitoring during high water differentials as well as a netting survey during summer to assess the effect of the weir on mullet. The original Whangamarino Weir failed in 1995 and was replaced with the current structure in 2000 (Miller 2007). The current structure is due to be repaired in the summer of 2009/2010.

The current Whangamarino Weir appears to be affecting the upstream migration of some fish species. Some species, notably common smelt and grey mullet, appear to be prevented from migrating to suitable habitat upstream. It should be noted, however, that the March 2008 electrofishing survey coincided with an extended drought period and that at the time the Whangamarino Weir was leaking. These two factors may have exacerbated fish passage issues by increasing the head difference over the weir and reducing the length of time over which the weir was spilling.

### 4.2.2 Recommendations

The following recommendations are made in response to the findings of the 2007/2008 fish survey of the Whangamarino;

1. An assessment of fish passage at the Whangamarino Weir should be undertaken once the structure has been repaired. The assessment should focus on the ability of grey mullet, inanga and smelt to navigate the weir during peak migration periods.
2. Undertake additional survey of fish communities in the Kopuera Stream catchment.
3. Undertake additional surveys of duck pond habitats in the Whangamarino to assess any values that they may support.
4. A range of different sampling techniques should be used to compensate for different gear bias when undertaking fish community inventories in wetlands.

# 5 Acknowledgements

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# Appendix 1 - Net and trap survey site descriptions

**N1 – Whangamarino River downstream of the weir (E2694582 N6431168).**

Nets and traps were set along the true left bank of the river between two willow trees. Instream cover consisted of flooded grasses and herbs. The gear was retrieved on August 14, 2007.

**N2 – Whangamarino River downstream of Reao Stream (E2697784 N6427685).**

Nets and traps were set along the flooded bank of the river amongst exotic wetland grasses (*Glyceria maxima* and *Phalaris arundinacea*) with a willow canopy. The water was turbid and brown at the time of sampling. The gear was retrieved on August 14, 2007.

**N3 – Whangamarino River upstream of Reao Stream (E2698786 N6427650).**

Similar habitat characteristics to N2. Gear set amongst wetland grasses and under a willow canopy. Nets and traps were retrieved on August 14, 2007.

**N4 – Maramarua River upstream of the pumping station (E2696978 N6432634).**

Nets and traps were set along the flooded bank of the river which was lined with collapsed dead willows. Instream habitat consisted of flooded *G. maxima*. Nets and traps were retrieved on the August 14, 2007.

**N5 – Pungarehu Canal downstream of the Lake Waikare Outlet (E2706018 N6419506).**

Fishing gear was set along the banks of the canal amongst flooded terrestrial grasses. The Lake Waikare Outlet was shut while the gear was set and there was a significant drop in water level which left the nets and traps almost completely exposed. Large numbers of (*Paratya curvirostris*) shrimp were caught in the Gee minnow traps. Nets and traps were retrieved on August 16, 2007.

**N6 – Herb Block (E2703715 N6425125).**

Nets and traps were set along the water line in the seasonally flooded area of the wetland. Instream habitat was dominated by flooded wetland grasses and herbs such as *Persicaria* spp. and *Bidens* spp. Closure of the Lake Waikare Outlet resulted in water level drops overnight that left the fishing gear partially exposed. Nets and traps were retrieved on August 16, 2007.

**N7 – Reao Stream (E2698490 N6426740).**

Fishing gear was set amongst flooded vegetation and fallen willow trees approximately 100 m from the main channel. Water levels dropped by around 400 mm overnight due to closure of the Lake Waikare Outlet. Nets and traps were retrieved on August 16, 2007.

**N8 – Maramarua River flooded margins (E2697290 N6432420).**

Nets were set approximately 30 m from the main Maramarua River channel amongst thick beds of *Glyceria maxima*. Water levels dropped by approximately 300 mm overnight partly exposing the fishing gear. Nets and traps were retrieved on August 16, 2007.