Boat electrofishing survey of the upper Turitea Reservoir, Palmerston North

CBER Contract Report 100

Client report prepared for the
Palmerston North City Council

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3 June 2009

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Executive summary

The upper Turitea Reservoir is a 12-ha reservoir that supplies water to the city of Palmerston North (Figure 1). It was constructed in 1957 and is located in the foothills of the Tararua Ranges at 40.43208^{o}S, 175.67669^{o}E. The 2,300 hectare catchment area is comprised mainly of native forest with a small section of pine forest bordering the northern end of the reservoir. The reservoir is contained by a 39-m high concrete gravity arch dam.

Water temperature during fishing ranged from 19.9 to 21.8°C, and electrical conductivity was 84-90 µS cm^{-1} ambient and 93-98 µS cm^{-1} specific (i.e., temperature corrected to 25^{o}C). The black disc distance was 0.62 m. No submerged macrophytes were observed.

At the time of fishing, the total phosphorus concentration ranged between 0.012-0.014 mg L^{-1}, and total nitrogen concentration ranged between 0.152-0.164 mg L^{-1}. Ammonium concentration was between 0.005-0.015 mg L^{-1}, and chlorophyll *a* concentration was 11.1 µg L^{-1}. Suspended sediment concentration was 1.40 mg L^{-1}, and ash-free dry weight (inorganic content of suspended sediments) was 0.20 mg L^{-1}.

The fish community was mostly comprised of European perch (*Perca fluviatilis*), with a few brown trout (*Salmo trutta*), longfin eels (*Anguilla dieffenbachia*), and freshwater crayfish (*Paranephrops planifrons*). We caught 1,129 fish in the upper Turitea Reservoir by boat electrofishing, comprising a biomass of 9.2 kg of perch in 5,867 lineal meters fished (23,462 m^{2}). The total biomass of brown trout was 3.9 kg, and the longfin eel weighed 8.3 kg

Night fishing for perch was more productive than fishing during the day. The mean density of perch caught during the day was 5.6 fish 100 m^{-2}, compared to 3.6 fish 100 m^{-2} during the night. Biomass of perch caught during the night (0.86 g m^{-2}) was also greater than the catch rate at day.

The total catch from 4 Fyke nets that were set overnight on 9 February were 2 large longfin eels (individual weights of 2.1 and 6.9 kg) and 26 perch (size ranging from 45 mm to 204 mm).

The length-frequency distribution of perch caught in the upper Turitea Reservoir shows that the population is mainly composed of age 0 fish or “young of the year”. There were very few perch of larger size classes indicating that survivorship of age 0 perch is relatively poor in the upper Turitea Reservoir.

The mean density of perch caught by electrofishing in lower Karori Reservoir was 32 fish 100 m^{-2}, compared with a mean of just 4 fish 100 m^{-2} in the upper Turitea Reservoir, this suggests that unlike the Karori Reservoir perch are unlikely to be the cause of algal blooms in the Turitea Reservoir.

1. Introduction

The upper Turitea Reservoir has had a history of algal blooms, particularly of the cyanobacteria *Anabaena circinalis* at a maximum measured density of 3,220 cells mL^{-1} (NIWA monitoring). The intention of this report is to explore the comparison with the lower Karori Reservoir, an old water supply dam that has persistent cyanobacterial blooms that have been attributed to the top-down effects of the zooplanktivorous stage of European perch (*Perca fluviatilis*) (Hicks et al., 2007; Smith and Lester, 2006; Jeppeson et al., 1990).

Boat electrofishing, while expensive, is rapid and does not require that equipment is left unattended, thus avoiding equipment loss and damage. In addition, for water bodies with wildfowl, accidental entrapment, resulting in injury or death is always a risk where nets are left to fish for an extended period. Boat electrofishing avoids these problems, and is highly effective in small shallow ponds (Hicks at al. 2008).

The objective of this project was to survey the composition of the fish community, determine fish abundance and determine size structure of the fish species present in the upper Turitea Reservoir.

2. Methods

Electric fishing ensued through the use of a 4.5-m long, custom-made electric fishing boat. The boat has a rigid aluminium pontoon hull with a 2-m beam, and is equipped with a 5-kilowatt pulsator (GPP, model 5.0, Smith-Root Inc, Vancouver, Washington, USA) which is powered by a 6-kilowatt custom-wound generator. Two anode poles, each with an array of six electrode droppers, created the fishing field at the bow, with the boat hull acting as the cathode. As access to the reservoir was not possible by launch from a vehicle-towed trailer, we used a helicopter to lift the boat in and out. The cost of this helicopter service was $NZ3,975 excluding GST.

Electrical conductivity and temperature was measured with a YSI 3200 conductivity meter. The measured conductivity was then used to calculate the settings on the GPP which resulted in the lake fished with the GPP set to high range (50-1000 volts direct current) and a frequency of 60 pulses per second. We adjusted the GPP to 30% percent of range to give an applied current of 3.5-4.0 amps root mean square. We assumed from past experience that an effective fishing field was developed to a depth of 2-3 m, and about 2 m either side of the centre line of the boat. We thus assumed that the boat fished a transect approximately 4 m wide, this was generally consistent with the behavioural reactions of fish at the water surface. This assumption was used to calculate area fished from the linear distance measured with the boat's onboard global positioning system. Water clarity was measured by the black disc method (Davies-Colley 1988), where the distance is recorded at which a 3-cm diameter black disk is just visible.

Between 9 and 11 February 2009 we conducted 21 fishing shots, each of approximately 20 minutes duration (Table 1). These comprised 7 night-time shots and 14 day-time shots

(Table 2). The fishing trails determined by GPS are shown in Figure 2. All introduced fish were removed and humanely killed, whilst all native fish were counted, measured for length and returned to the lake.

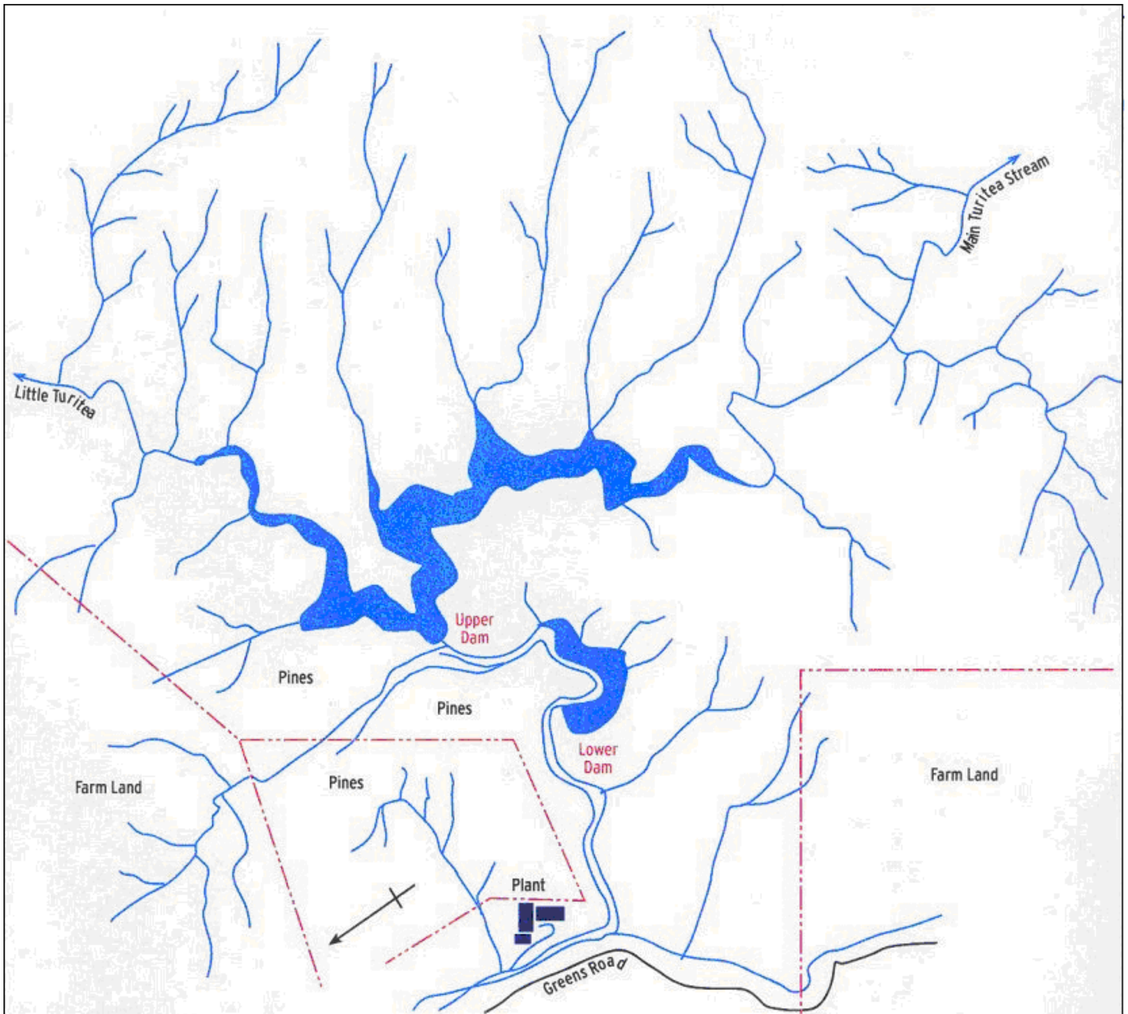
On 9 and 10 February, 4 fine-meshed fyke nets were set in the littoral zone. No gill nets were set because of the risk of entanglement in the woody debris in the reservoir.

3. Study Site

The upper Turitea Reservoir is a 12-ha reservoir that supplies water to the city of Palmerston North (Figure 1). It was constructed in 1957 and is located in the foothills of the Tararua Ranges at 40.43208^{o}S, 175.67669^{o}E. The 2,300 hectare catchment area is comprised mainly of native forest with a small section of pine forest bordering the northern end of the reservoir. The reservoir is contained by a 39-m high concrete gravity arch dam (Figure 2).

Table 1. Physical characteristics of the sites boat electrofished in the upper Turitea Reservoir, Palmerston North, 9-11 February 2009.

Site	Date	Start point NZMG N (m)	Start point NZMG E (m)	Stop point NZMG N (m)	Stop point NZMG E (m)	Distance fished (m)	Area fished (m^2)	Time fished (min)
371A	9-Feb-09	6082322	2737002	6082403	2736955	239	955	24
371B	9-Feb-09	6082223	2737202	6082265	2737089	235	941	20
371C	9-Feb-09	6082610	2737199	6082616	2737128	298	1193	20
371D	9-Feb-09	6082540	2737029	6082558	2736875	313	1252	22
372A	10-Feb-09	6082915	2737416	6082914	2737296	273	1092	20
372B	10-Feb-09	6082896	2737326	6082889	2737414	352	1407	20
372C	10-Feb-09	-	-	-	-	-	-	21
372D	10-Feb-09	6082974	2737012	6082908	2736974	222	886	21
372E	10-Feb-09	6082753	2736991	6082835	2737003	244	975	21
373A	11-Feb-09	6081807	2736790	6081928	2736711	309	1236	21
373B	11-Feb-09	6082021	2736770	6081961	2736864	295	1181	20
373C	11-Feb-09	6082059	2736927	6082114	2736966	339	1356	20
373D	11-Feb-09	6082223	2736936	6082120	2736903	273	1091	20
373E	11-Feb-09	6082203	2737016	6082116	2736963	277	1108	21
373F	11-Feb-09	6082207	2737064	6082207	2737186	235	941	20
373G	11-Feb-09	6082597	2737223	6082663	2737103	298	1192	20
373H	11-Feb-09	6082532	2737007	6082570	2736847	313	1251	21
373I	11-Feb-09	6082925	2737368	6082870	2737471	348	1391	20
373J	11-Feb-09	6082981	2737034	6082832	2737096	326	1303	19
373K	11-Feb-09	6082039	2736745	6082023	2736871	329	1314	20
373L	11-Feb-09	6082420	2736950	6082532	2737006	349	1397	19
Total						5867	23462	430
Total for Karori 2007						1848	7392	532.7



UPPER DAM SPECIFICATIONS

Type:	Concrete arch with gravity concrete abutments
Constructed:	1957
Structural height:	39 metres
Hydraulic height:	30 metres
Mass concrete in dam:	9120 cubic metres
Catchment area:	2300 hectares
Reservoir area:	12 hectares
Reservoir capacity:	1,682,000,000 litres
Spillway capacity:	500 year flood
Earthquake capacity:	Maximum Credible Earthquake

LOWER DAM SPECIFICATIONS

Type:	Concrete faced Rockfill Dam
Constructed:	1907, 1912, 1996
Structural Height:	20 metres
Rockfill Volume:	37,000 cubic metres
Reservoir capacity:	280,000,000 litres
Spillway capacity:	Probable maximum flood
Earthquake capacity:	Maximum Credible Earthquake

Figure 1. Specifications of the upper and lower Turitea Reservoirs, Palmerston North. Source: Palmerston North City Council.

Figure 2. The 30-m high concrete gravity arch dam that forms the upper Turitea Reservoir, Palmerston North. Photo: Nicholas Ling.

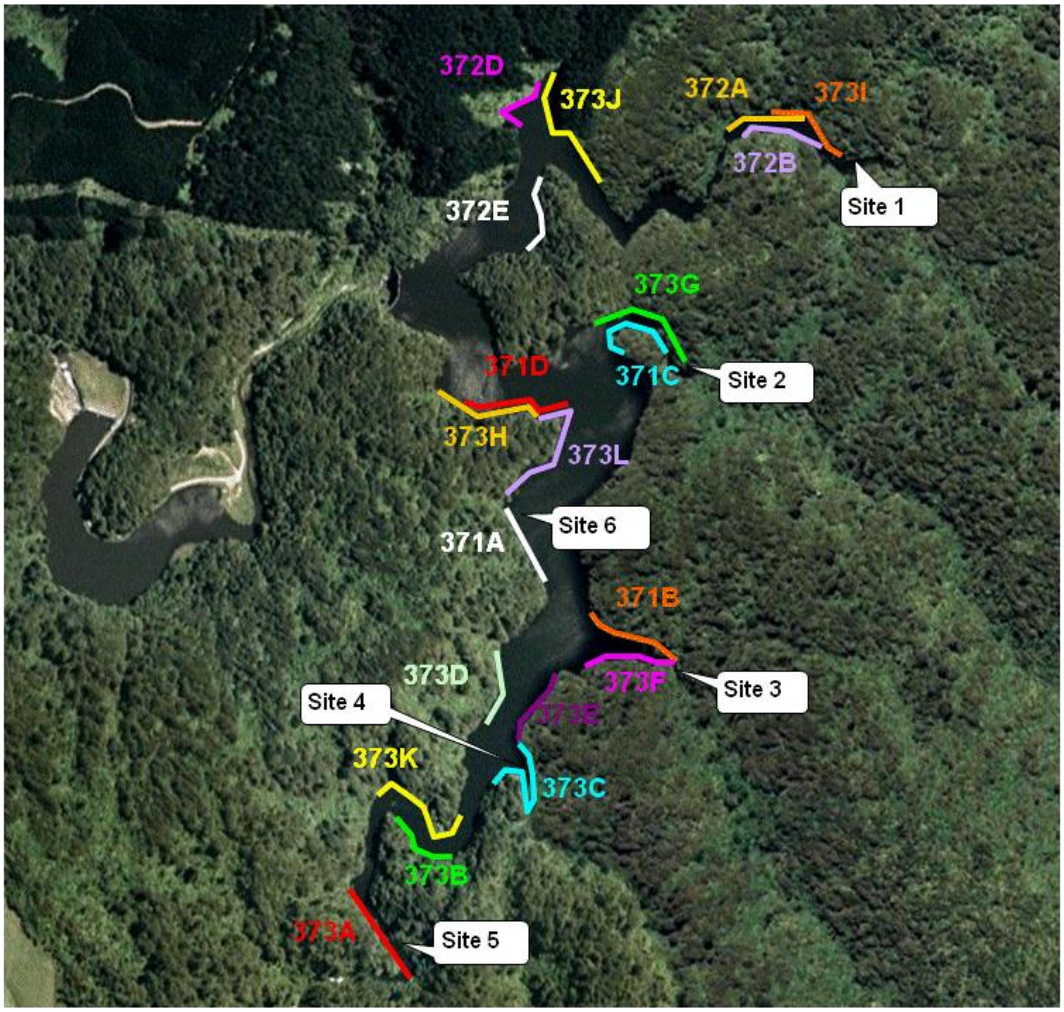


Figure 3. Tracks followed by the electrofishing boat from 9 to 11 February 2009 in the upper Turitea Reservoir, Palmerston North. Photo: Google Earth.

4. Results

Water temperature during fishing ranged from 19.9 to 21.8°C, and electrical conductivity was 84-90 µS cm^{-1} ambient and 93-98 µS cm^{-1} specific (i.e., temperature corrected to 25^{o}C). The black disc distance was 0.62 m. No submerged macrophytes were observed.

At the time of fishing, the total phosphorus concentration ranged between 0.012-0.014 mg L^{-1}, and total nitrogen concentration ranged between 0.152-0.164 mg L^{-1}. Ammonium concentration ranged between 0.005-0.015 mg L^{-1}, and chlorophyll *a* concentration was 11.1 µg L^{-1}. Suspended sediment concentration was 1.40 mg L^{-1}, and ash-free dry weight (inorganic content of suspended sediments) was 0.20 mg L^{-1}.

The fish community comprised mostly European perch, with a few brown trout, *Salmo trutta* (Figure 4), longfin eels, *Anguilla dieffenbachii* (Figure 5), and freshwater crayfish, *Paranephrops planifrons* (Table 1). We caught 1,129 fish in the upper Turitea Reservoir by boat electrofishing, comprising a biomass of 9.2 kg of perch in 5,867 lineal meters fished (23,462 m^2). The total biomass of brown trout was 3.9 kg, and the longfin eel weighed 8.3 kg

Night fishing for perch was more productive than fishing during the day. The mean density of perch caught during the day was 5.6 fish 100 m^{-2}, compared to 3.6 fish 100 m^{-2} during the night (Mann-Whitney *U* test, $p = 0.029$). Biomass of perch caught during the night (0.86 g m^{-2}) was also greater than the catch rate at day (0.17 g m^{-2}; Mann-Whitney *U* test, $p = 0.001$). One large school of juvenile perch caught at site 373J skewed the daytime results (Table 1).

The total catch from 4 fyke nets that were set overnight on 9 February were 2 large longfin eels (individual weights of 2.1 and 6.9 kg) and 26 perch (size ranging from 45 mm to 204 mm). A flash flood overnight on 10 February made the nets difficult to retrieve as they were inundated with sediment, and had no fish in them.

Figure 4. Brown trout caught by boat electrofishing the upper Turitea Reservoir, Palmerston North, 9-11 February 2009.

Figure 5. An 8.3-kg longfin eel caught by boat electrofishing the upper Turitea Reservoir, Palmerston North, 9-11 February 2009.

Table 2. Number of fish caught in the upper Turitea Reservoir, Palmerston North, 9-11 February 2009.

Site	Day or night fishing	Number of individuals caught by electrofishing			
		Perch	Brown trout	Longfin eels	Crayfish
371A	Night	37	1	0	1
371B	Night	28	1	0	2
371C	Night	135	2	0	1
371D	Night	63	4	0	0
372A	Day	130	0	0	1
372B	Day	69	0	0	0
372C	Night	113	0	0	0
372D	Night	62	0	0	0
372E	Night	36	0	0	1
373A	Day	1	1	0	0
373B	Day	0	0	1	0
373C	Day	2	1	0	0
373D	Day	5	0	0	0
373E	Day	0	0	0	0
373F	Day	5	3	0	0
373G	Day	0	0	0	0
373H	Day	1	1	0	0
373I	Day	3	0	0	0
373J	Day	391	1	0	0
373K	Day	2	0	0	0
373L	Day	23	1	0	0
Total		1106	16	1	6
Total for Karori 2007		2280	1	2	1

Table 3. Densities of fish species caught in the upper Turitea Reservoir, Palmerston North, 9-11 February 2009.

Site	Day or night fishing	Perch density (fish 100 m^{-2})	Perch biomass (g)	Perch biomass (g m^{-2})
371A	Night	3.87	723	0.76
371B	Night	2.98	525	0.56
371C	Night	11.32	1386	1.16
371D	Night	5.03	1296	1.04
372A	Day	11.90	318	0.29
372B	Day	4.90	171	0.12
372C	Night	-	830	-
372D	Night	7.00	943	1.06
372E	Night	3.69	580	0.59
373A	Day	0.08	52	0.04
373B	Day	0.00	0	0.00
373C	Day	0.15	49	0.04
373D	Day	0.46	169	0.15
373E	Day	0.00	0	0.00
373F	Day	0.53	169	0.18
373G	Day	0.00	0	0.00
373H	Day	0.08	13	0.01
373I	Day	0.22	396	0.28
373J	Day	30.01	1006	0.77
373K	Day	0.15	72	0.05
373L	Day	1.65	637	0.46
Average		4.20	445	0.38
Average for Karori 2007		35.02	2569	4.97

The length-frequency distribution of perch caught in the upper Turitea Reservoir (Figure 6) shows that the population is primarily composed of age 0 fish or “young of the year”. There were very few perch of larger size classes indicating that survivorship of age 0 perch is relatively poor. The size of perch present in the reservoir ranged from 30 mm to a maximum of 210 mm with a modal size of 50 mm.

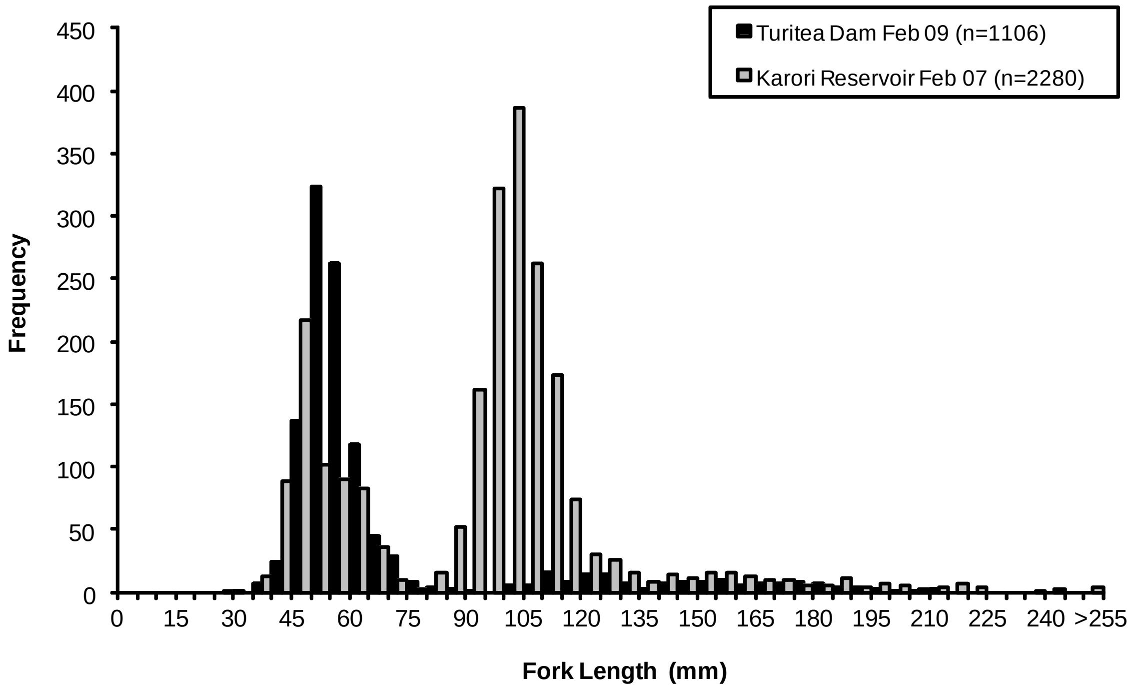


Figure 6. Length-frequency distribution of perch caught by boat electrofishing in the upper Turitea Reservoir, Palmerston North, 9-11 February 2009 and the Karori reservoir February 2007.

5. Discussion

The fish community of the upper Turitea Reservoir had comparatively few species present. This is most likely due to the barrier to upstream migration caused by the dam. There may be landlocked galaxiids upstream of the dam; however, they were not detected during this survey. This lack of species diversity was also present in the lower Karori Reservoir. Our comparisons with the perch population in the lower Karori Reservoir show that there are far fewer perch in the upper Turitea Reservoir. Survival to age 1 appears to be much poorer in the upper Turitea Reservoir. The age 0 perch (45-75 mm in length; Figure 6) had a larger modal size (50 mm) than age 0 perch in the lower Karori Reservoir when they were first fished in February 2007 (45 mm), which is consistent with the lower overall juvenile density in the upper Turitea Reservoir. The mean density of perch caught by electrofishing in lower Karori Reservoir was significantly greater (32 fish 100 m^{-2}) when compared with a mean of 4 fish 100 m^{-2} in the upper Turitea Reservoir.

The upper Turitea Reservoir is larger and more complex as a habitat than the lower Karori Reservoir, so this result should be treated with some caution. However, the obvious implication is that perch are less likely to be the cause of the algal blooms than appears to be the case in the lower Karori Reservoir. Also, given the habitat complexity, size of the reservoir, and the fact that its primary purpose is water supply, eradication of perch in the upper Turitea Reservoir appears to be an unlikely prospect. The typical method for fish eradication is the application of toxin such as rotenone, which would be unacceptable for use in a water supply reservoir.

The size distribution of longfin eels suggests that recruitment is limited. The addition of juvenile longfin eels to the reservoir would provide an unfished population that would add to natural recruitment of this threatened species, and may also further reduce the perch population.

Nutrient concentrations did not appear especially high at the time of fishing. Given that perch removal does not appear to be an option for control of the algal blooms, artificially breaking the stratification might be an option. Solar powered pumps can be used to draw water from the hypolimnion to the surface, replacing the bottom waters with oxygenated surface waters. This has the dual effect of breaking stratification and reducing nutrient release from the bottom sediments that occurs under deoxygenated conditions.

6. Acknowledgements

This study was funded by a contract from the Palmerston North City Council. We gratefully acknowledge the assistance of Helipro Helicopters, Palmerston North, for their help with launching the boat, and Palmerston North City Council for funding this service. We would also like to thank Bruce Lawrence and his team at the treatment station for providing us with additional assistance during the project.

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