Boat electrofishing survey of Lake Rotokaeo, Hamilton

CBER Contract Report 93

Client report prepared for
National Institute of Water and Atmosphere

by

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Executive summary

Lake Rotokaeo (Forest Lake) is a small (3.7 ha) lake set in suburban surroundings in the north-west of Hamilton city located at 37^{o} 46.387'S and 175^{o} 15.059'E. The lake is very shallow, with ~80% of its area <1.8 m water depth, depending on season. The bed is composed of soft sediments, and margins vary from grassed parkland to restored native wetlands and forest vegetation.

On 12 December 2008, we conducted eleven 10-min fishing shots comprising nine shoreline shots and two mid-lake shots. The shallowness of the lake precluded fishing along the western shore of the lake. All introduced fish species were removed and humanely killed, whilst all native fish species were counted, measured for length and returned to the lake. Water temperature recorded at the start of fishing was 21.3°C, and electrical conductivity was 110 µS cm^{-1} ambient and 118 µS cm^{-1} specific. The water had a distinct brownish hue, indicating tannin staining, but there was no obvious suspended sediment. The black disc measurement (horizontal water clarity) was 0.55 m. Aquatic plants present in the lake included filamentous algae, water lily (*Nymphaea* sp.), and parrot's feather (*Myriophyllum aquaticum*). *Carex* species and raupo (*Typha orientalis*) comprised the riparian and marginal vegetation.

We caught 350 fish in Lake Rotokaeo comprising a biomass of 20.6 kg in 1,810 lineal m fished (7,240 m^{2}). The fish community comprised three introduced species (goldfish, *Carassius auratus*; gambusia, *Gambusia affinis*; brown bullhead catfish, *Ameiurus nebulosus*) and the native shortfin eel (*Anguilla australis*). Goldfish and gambusia were the most abundant species caught, but numbers of gambusia and eels were almost certainly underestimated. This is because numerous small eels were entangled in vegetation, right at the water's edge, and gambusia were less affected by the electric field than the larger species making capture difficult. Fish densities were much greater at sites by edge habitats than in mid-lake habitats. Despite the large number of goldfish, fish biomass was dominated by the native shortfin eel yields. Fishing shots 1, 6, and 11 in edge habitats had the highest biomass, with 3-4 kg of fish caught at these sites (5-8 g m^{-2}). Biomasses found in mid-lake habitats only ranged from 0.01-0.41 g m^{-2}.

Lake Rotokaeo has a relatively simple fish community with shortfin eels and goldfish dominating the biomass. Catfish were present but exhibited relatively low biomasses. A positive finding of the survey is the absence of koi carp. It is possible that the outlet structure provides a barrier to upstream migration of the species, and has therefore protected the lake from invasion. The presence of a large orange goldfish may have been responsible for prior "koi carp" sightings made by the public as it can be difficult to distinguish between the two species from a distance. Given the shallow nature of Lake Rotokaeo, future boat electrofishing work should occur during high water levels as launching and navigation of the boat proved to be very difficult and only a small part of the lake is navigable even at a high water level.

1. Introduction

Small suburban lakes are surveyed relatively infrequently in New Zealand, and this is partly due to the resources required to survey the many such water bodies that exist. In shallow water bodies adjacent to parks and private houses, interference and theft of nets left to fish overnight is a common problem. Boat electrofishing, though it uses an expensive piece of equipment, 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 (e.g., Hicks at al. 2008).

The objective of this project was to survey the composition of the fish community, fish abundance and size structure of the fish species present in Lake Rotokaeo.

2. Methods

Electric fishing was undertaken using 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-kw gas-powered 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.

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 being fished with the GPP set to low range (50-500 V direct current) and a frequency of 60 pulses per second. We adjusted the GPP to 70% of range to give an applied current of 3-4 A root mean square. We assumed from past experience that an effective fishing field was developed to a depth of 2-3 m, which was the entire water column for Rotokaeo, and about 2 m either side of the centre line of the boat. We thus assumed that the boat fished a transect about 4 m wide, which 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 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.

On 12 December 2008, we conducted eleven 10-min (nominal) fishing shots comprising nine shoreline shots (Trails 1-7, 9 and 11) and two mid-lake shots (Trails 8 and 10) between 10:30 and 14:30 h NZ Daylight Saving Time. The shallowness of the lake precluded fishing on the western side of the lake. Eleven fishing trails determined by GPS are shown in Figure 1. All introduced fish were removed and humanely killed, whereas all native fish were counted, measured for length and weight, and returned to the lake.

3. Study Site

Lake Rotokaeo (Forest Lake) is a small (3.7-ha) lake that is set in suburban surroundings located in the north-west of Hamilton city at 37° 46.387'S and 175° 15.059'E. It is very shallow, with ~80% of its area <1.8 m water depth, depending on season. The bed is composed of soft sediments, and margins vary from grassed parkland to restored native wetlands and forest vegetation. Eels and gambusia were known to be present.

The lake has park grassland to the south and east, with suburban housing also on the east (Fig. 1, Fig. 2). To the west and north, is an area of restored wetland and native shrub land.

Table 1. Physical characterisics of sites boat electrofished in Lake Rotokaeo, Hamilton, on 12 December 2008.

Trail	Time fished (min)	Distance fished (m)	Area fished (m^2)	Habitat	Aquatic macrophytes	Bank	Water depth (m)
1	10.2	136	544	Edge	Filamentous algae	Vegetated edge	0-1.0
2	10.2	165	659	Edge	Filamentous algae	Clay edge	0-1.0
3	10.0	134	537	Edge	*Myriophyllum aquaticum, Nymphaea*	Vegetated edge	0.2-1.0
4	9.9	147	588	Edge	none	Grass bank	0.3-1.0
5	10.4	143	570	Edge	*Myriophyllum aquaticum, Nymphaea*	Woody vegetation	0.3-0.7
6	10.4	156	626	Edge	none	Grass bank	0.3-0.8
7	10.4	160	641	Edge	*Myriophyllum aquaticum, Nymphaea*	Vegetation, tea tree	0.2-0.9
8	10.4	269	1074	Mid-lake	none	Not applicable	0.8-1.4
9	7.0	99	397	Edge	none	Grass bank	0.2-0.8
10	10.1	252	1008	Mid-lake	none	Not applicable	0.3-1.2
11	10.1	149	598	Edge	*Myriophyllum aquaticum*	*Carex, Baumea*	0.4-1.1
Total	109	1810	7242				

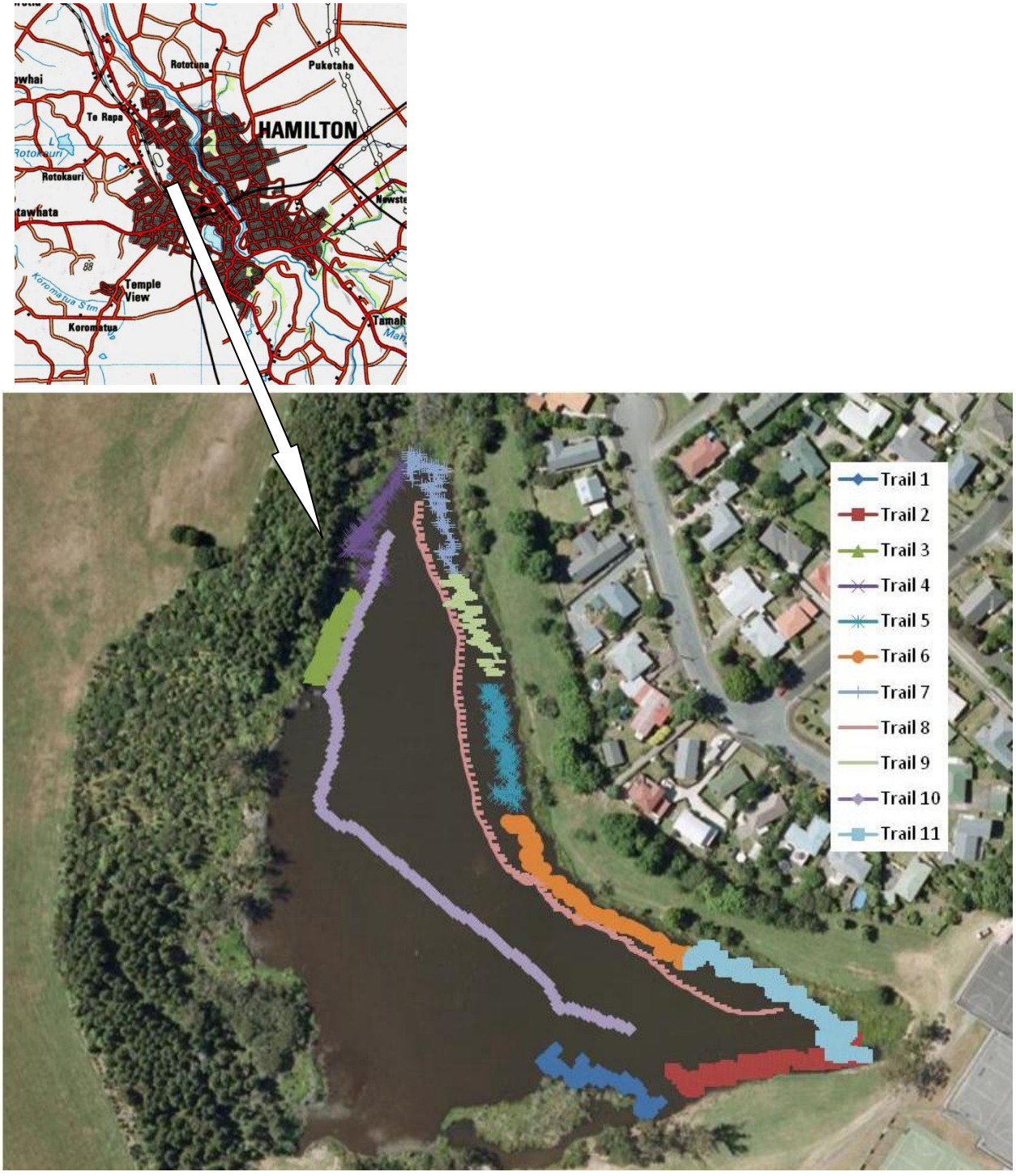

Figure 1. Location of the eleven electrofishing trails on Lake Rotokaeo, Hamilton.

Figure 2. Lake Rotokaeo, Hamilton, looking from north to south.

4. Results

Water temperature recorded at the start of fishing was 21.3°C, and electrical conductivity was 110 µS cm^{-1} ambient and 118 µS cm^{-1} specific. The water had a distinct brownish hue, indicating tannin staining, but there was no obvious suspended sediment. The black disc measurement was 0.55 m. Aquatic plants present in the lake included filamentous algae, water lily (*Nymphaea* sp.), and parrot's feather (*Myriophyllum aquaticum*). *Carex* species and raupo (*Typha orientalis*) comprised the riparian and marginal vegetation.

We caught 350 fish in Rotokaeo comprising a biomass of 20.6 kg in 1,810 lineal m fished (7,242 m^2). The fish community comprised three introduced species (goldfish, *Carassius auratus*; gambusia, *Gambusia affinis*; brown bullhead catfish, *Ameiurus nebulosus*) and the native shortfin eel (*Anguilla australis*). Goldfish and gambusia were the most abundant species caught (Tables 2 and 3), but the number of gambusia and eels were almost certainly underestimated. This is because numerous small eels were entangled in vegetation, right at the water's edge, and gambusia were less affected by the electric field than the larger species. Fish densities were much greater at sites by edge habitats than in mid-lake habitats (Table 3).

Despite the large number of goldfish and gambusia, fish biomass was dominated by the native shortfin eels (Tables 4 and 5). Trails 1, 6, and 11 in edge habitats had the highest biomass, with 3-4 kg of fish caught at these sites (5-8 g m^{-2}). Mid-lake habitats only exhibited low biomasses of 0.01-0.41 g m^{-2}.

Table 2. Number of fish caught in Lake Rotokaeo, Hamilton, on 12 December 2008. Gambusia and eels were underestimated.

Trail	Habitat	Number of fish				
		Goldfish	Catfish	Shortfinned eels	Gambusia	Total
1	Edge	10	0	4	0	14
2	Edge	3	2	2	0	7
3	Edge	36	7	0	3	46
4	Edge	13	1	1	0	15
5	Edge	4	0	4	51	59
6	Edge	15	2	5	17	39
7	Edge	15	2	3	10	30
8	Mid-lake	0	0	1	0	1
9	Edge	5	2	0	38	45
10	Mid-lake	3	0	0	0	3
11	Edge	18	2	3	68	91
Total		122	18	23	187	350

Table 3. Densities of fish species caught in Lake Rotokaeo, Hamilton, on 12 December 2008. Gambusia and eels were underestimated.

Trail	Habitat	Fish density (number 100 m^{-2})				
		Goldfish	Catfish	Shortfinned eels	Gambusia	Total
1	Edge	1.84	0.00	0.74	0.00	2.6
2	Edge	0.46	0.30	0.30	0.00	1.1
3	Edge	6.70	1.30	0.00	0.56	8.6
4	Edge	2.21	0.17	0.17	0.00	2.6
5	Edge	0.70	0.00	0.70	8.95	10.4
6	Edge	2.40	0.32	0.80	2.72	6.2
7	Edge	2.34	0.31	0.47	1.56	4.7
8	Mid-lake	0.00	0.00	0.09	0.00	0.1
9	Edge	1.26	0.50	0.00	9.57	11.3
10	Mid-lake	0.30	0.00	0.00	0.00	0.3
11	Edge	3.01	0.33	0.50	11.37	15.2
Mean edge		2.32	0.36	0.41	3.86	6.95
Mean mid-lake		0.15	0.00	0.05	0.00	0.20

Table 4. Biomasses of fish species caught in Lake Rotokaeo, Hamilton, on 12 December 2008. Eels were underestimated.

Trail	Habitat	Fish biomass (g)			
		Goldfish	Catfish	Shortfinned eels	Total
1	Edge	1667	0	2548	4215
2	Edge	236	330	1326	1892
3	Edge	103	307	0	410
4	Edge	121	37	550	708
5	Edge	12	0	2401	2413
6	Edge	1096	139	3316	4551
7	Edge	39	38	1984	2061
8	Mid-lake	0	0	443	443
9	Edge	11	417	0	428
10	Mid-lake	12	0	0	12
11	Edge	1244	129	2081	3454
		4541	1397	14649	20587

Table 5. Areal biomasses of fish species caught in Lake Rotokaeo, Hamilton, on 12 December 2008. Eels were underestimated.

Trail	Habitat	Areal fish biomass (g m^{-2})			
		Goldfish	Catfish	Shortfinned eels	Total
1	Edge	3.06	0.00	4.68	7.75
2	Edge	0.36	0.50	2.01	2.87
3	Edge	0.19	0.57	0.00	0.76
4	Edge	0.21	0.06	0.94	1.20
5	Edge	0.02	0.00	4.21	4.23
6	Edge	1.75	0.22	5.30	7.27
7	Edge	0.06	0.06	3.10	3.22
8	Mid-lake	0.00	0.00	0.41	0.41
9	Edge	0.03	1.05	0.00	1.08
10	Mid-lake	0.01	0.00	0.00	0.01
11	Edge	2.08	0.22	3.48	5.78
Mean edge		0.86	0.30	2.64	3.80
Mean mid-lake		0.01	0.00	0.21	0.21

Figure 3. Large goldfish from Lake Rotokaeo, Hamilton.

Figure 4. Large ~300-mm fork length goldfish from Lake Rotokaeo, Hamilton, showing damage to caudal fin probably from eel bites.

Figure 5. Large orange 320-mm fork length goldfish from Lake Rotokaeo, Hamilton, showing damage to caudal fin probably from eel bites.

Figure 6. Young-of-the-year goldfish (32-68 mm FL) from Lake Rotokaeo, Hamilton.

Figure 7. Structure at the downstream outlet of Lake Rotokaeo, Hamilton, that is most probably a barrier to upstream migration of fish species other than eels.

There was a large range in the sizes of goldfish caught in Lake Rotokaeo with fork lengths ranging from 32 to 310 mm. The length-frequency distribution (Figure 8) shows that there is an abundance of juvenile goldfish indicating that breeding is occurring in the lake. However, a relatively small number of adults suggests that the mortality rate of juvenile goldfish is high. Figure 9 shows the length-frequency distribution of gambusia in Lake Rotokaeo and it also shows that recruitment is occurring. As well as breeding more than once a year, the male and female gambusia grow to different sizes making it extremely difficult to determine the different generations. The length of shortfin eels captured in the lake ranged from 500-865 mm with a mean of 675 mm. No juvenile shortfin eels were captured, but some (several dozen) were seen in the margins at trails 3 and 4 that were too shallow to be boat electrofished effectively. Thus boat electrofishing has most likely underestimated the abundance of juvenile eels (<250 mm total length). Similarly, gambusia are more numerous than estimates in this report indicate.

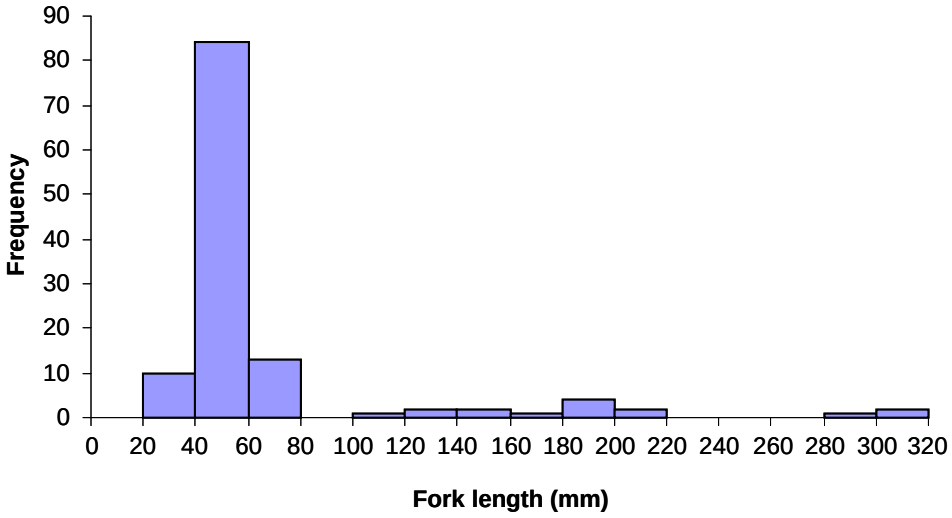

Figure 8. Length-frequency distribution of goldfish caught by boat electrofishing on Lake Rotokaeo on 12 December 2008. *N* = 122.

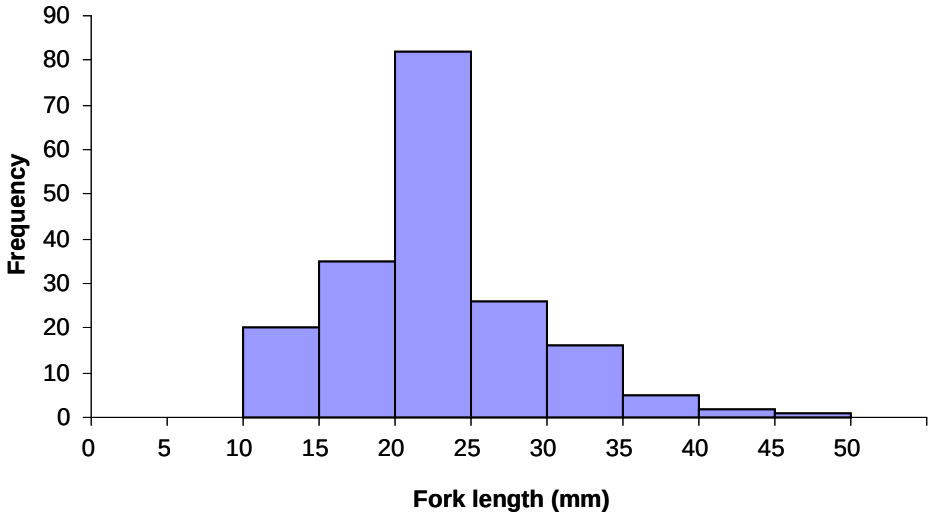

Figure 9. Length-frequency distribution of gambusia caught by boat electrofishing on Lake Rotokaeo on 12 December 2008. *N* = 187.

5. Discussion

Lake Rotokaeo has a relatively simple fish community dominated in biomass by shortfin eels (maximum biomass 4.68 g m^{-2}) and goldfish (maximum biomass 3.06 g m^{-2}). Catfish, although present, contributed much less biomass (up to 1.05 g m^{-2}). By

comparison, the Waikato River has a maximum catfish biomass of 1.6 g m^{-2}, and Lake Mangahia a maximum biomass of 10.1 g m^{-2} (Hicks, unpubl. data).

A positive finding of the survey is the absence of koi carp. It is possible that the outlet structure provides a barrier to upstream migration of this species, and has therefore protected the lake from invasion. "Koi carp" sightings by the public may continue to occur in the future for Lake Rotokaeo given the presence of large orange goldfish which are easily coonfused with koi carp. Given the shallow nature of Lake Rotokaeo, it is important that any future fishing is conducted at high water level as we had difficulty launching the boat and could not electrofish the western side of the lake. Less than half of the lake is navigable even at high water level.

Boat electrofishing has most likely underestimated the abundance of juvenile eels (<250 mm total length), and gambusia are more numerous than estimates in this report indicate. Although no juvenile eels were caught, some that were out of capture range were seen in the margins, so recruitment is occurring. In addition, the southwestern side of the lake was too shallow to electrofish with the boat, and may have contained juvenile eels. However, this survey has revealed a comprehensive view of the fish community composition in the deeper littoral zones.

6. Acknowledgements

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7. References

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Hicks, B. J., Brijs, J., Heaphy, J., and Bell, D. G. 2008. The use of boat electrofishing for koi carp (*Cyprinus carpio*) removal in the Kauri Point catchment. *CBER Contract Report No. 69*. Client report prepared for Department of Conservation. Centre for Biodiversity and Ecology Research, Department of Biological Sciences, The University of Waikato, Hamilton.

8. Appendix 1. Site photographs.

Trail 1 (site 368A), Lake Rotokaeo, 12 December 2008.

Trail 2 (site 368B), Lake Rotokaeo, 12 December 2008.

Trail 3 (site 368C), Lake Rotokaeo, 12 December 2008.

Trail 4 (site 368D), Lake Rotokaeo, 12 December 2008.

Trail 5 (site 368E), Lake Rotokaeo, 12 December 2008.

Trail 6 (site 368F), Lake Rotokaeo, 12 December 2008.

Trail 7 (site 368G), Lake Rotokaeo, 12 December 2008.

Trail 9 (site 368I), Lake Rotokaeo, 12 December 2008.

Trail 10 (site 368J), Lake Rotokaeo, 12 December 2008.

Trail 11 (site 368K), Lake Rotokaeo, 12 December 2008.