Boat electrofishing survey of Apata Pond and Lake McLaren

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Executive summary

We used New Zealand's first successful electrofishing boat to catch koi carp (*Cyprinus carpio haemaotopterus*; Zhou et al. 2003) and rudd (*Scardinius erythophthalmus*) at two sites in the Bay of Plenty, North Island, New Zealand. Five large koi carp were caught in a pond near Apata; shortfinned eels and adult inanga were also caught. In Lake McLaren, a small hydro-electric impoundment on the Wairoa River, two rudd were caught; longfinned eels (*Anguilla dieffenbachii*), common bullies(*Gobiomorphus cotidianus*), and brown and rainbow trout (*Salmo trutta* and *Oncorhynchus mykiss*) were also caught.

Low ambient conductivities (43-90 μS cm^{-1}) is likely to have restricted the electrofishing field and power transfer to the fish, but fish capture was still successful. Clear water compensated somewhat for the reduced effectiveness of the field.

Fish densities were low at both locations. The minimum fish density was 0.31 fish 100 m^{-2} in the pond at Apata, and 0.61 fish 100 m^{-2} in Lake McLaren. These should be regarded as minimal densities because only a single pass was conducted. All the koi carp caught in the pond at Apata were 521 to 564 mm fork length and all were 8 years old; there were two males and three females. One female was about to spawn; however, no other koi carp were found, so breeding appears to have been unsuccessful in this habitat. The two rudd from Lake McLaren were 203 and 240 mm fork length 6 and 7 years old respectively. Though no younger age classes were caught, we cannot exclude the possibility that rudd could reproduce successfully in Lake McLaren.

1. Introduction

Boat electrofishing has many advantages over conventional fish capture in lakes and rivers, primarily in extending the sampling area with limited resources. Sites need to be visited only once, rather than twice as with net setting and retrieval. Nets are very size and species selective, whereas electrofishing is less selective. The by-catch of diving birds such as shags and dabchicks can also be largely avoided. The University of Waikato commissioned New Zealand's first successful electrofishing boat in July 2003, and this report describes its use to evaluate boat electrofishing for capture and control of pest fish in two locations. Koi carp were known to be in a pond formed behind an artificial earth dam on private land near Apata (called Apata Pond informally in this report; Figures 1 and 2). Apata Pond is about 40 m wide and 160 m long, with a maximum depth of 3 m. Between January and March 2003, three similar-sized orange koi carp were removed from Apata Pond by trammel netting by Environment Bay of Plenty staff (Phil Dykzeul, pers. comm., Environment Bay of Plenty, Tauranga). Netting proved to be a time-consuming method of removing the carp, and some fish remained. Lake McLaren, a small hydro-electric impoundment in the Kaimai Ranges in the Bay of Plenty, was fished because of the suspected presence of pest fish and to survey of the fish populations. A school of 12-15 red-coloured fish was first seen in Cherry Bay (site 1 on Figure 1) in December 2003, and was seen again in February 2004 and on 5 March 2004. These fish were about 200-300 mm long (Mark Ray, Tauranga City Council, pers. comm.). In addition, tench have been found in Lake McLaren (Lake 1995).

2. Methods

The electrofishing boat, Hiko Hï Ika (translation from Mäori: electrofishing), is a 4.5-m long rigid aluminium pontoon hull with a 2-m beam, and a fishing platform at the bow. The hull has a shallow vee-shape to allow navigation in water ≥ 0.5 m deep. The boat is powered by a 50 HP four-stroke outboard motor, and is equipped with a global positioning system (GPS) and a depth sounder. The electrofishing equipment used is a 5-kilowatt gas-powered pulsator (GPP, model 5.0, Smith-Root Inc, Vancouver, Washington, USA) that is powered by a 6-kilowatt custom-wound generator. Two anode poles, each with an array of six droppers, create the fishing field at the bow (Hicks et al. 2004). The boat itself acts as the cathode, and has been authorised as an electrofishing device by the Department of Conservation.

Apata Pond was fished on 18 February, and truck with a Palfinger telescopic, hydraulic lifting arm was used to lift the boat in and out of the water. Lake McLaren was fished on 19 February, 2004 (Table 1). Electrical conductivity was measured with a YSI conductivity meter, and the GPP output was optimised to maximise the applied peak voltage. Both locations had relatively low ambient electrical conductivity (43-90 μS cm^{-1}), necessitating high machine settings. We fished Apata Pond with an applied voltage that was 100% of the low-range setting (50-500 V direct current) and a frequency of 60 pulses per second. The applied voltage was 60% of range at the low-range setting (50-500 V direct current), resulting in an applied current of 2-3 amps root mean square. For

Lake McLaren, we fished with an applied voltage that was 80% of the high-range setting (50-1000 V direct current) and a frequency of 60 pulses per second, resulting in an applied current of 2-3 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. Thus the boat fished a transect about 4 m wide. This assumption was used to calculate area fished from length fished measured with the GPS.

Table 1. Latitude and longitude of start and finishing points taken during fishing in Apata Pond and Lake McLaren with the electrofishing boat of the University of Waikato on 18 and 19 February 2004.

			Start location		Finishing location	
Site no.	Site name	Date	Longitude start (°W)	Latitude start (°S)	Longitude stop (°W)	Latitude stop (°S)
	Apata Pond	18-Feb-04	175.994333	37.650778	175.993556	37.651944
1	Lake McLaren	19-Feb-04	176.045500	37.811917	176.043139	37.812750
2	Lake McLaren	19-Feb-04	176.041194	37.811389	176.042583	37.811444
3	Lake McLaren	19-Feb-04	176.043000	37.812417	176.042750	37.812917
4	Lake McLaren	19-Feb-04	176.042750	37.812917	176.040583	37.813972
5	Lake McLaren	19-Feb-04	176.039528	37.815444	176.038167	37.817917
6	Lake McLaren	19-Feb-04	176.040611	37.814667	176.041361	37.814667
7	Lake McLaren	19-Feb-04	176.042417	37.810250	176.044222	37.808972
8	Lake McLaren	19-Feb-04	176.044861	37.808194	176.045917	37.806889
9	Lake McLaren	19-Feb-04	176.045639	37.807639	176.045222	37.808111

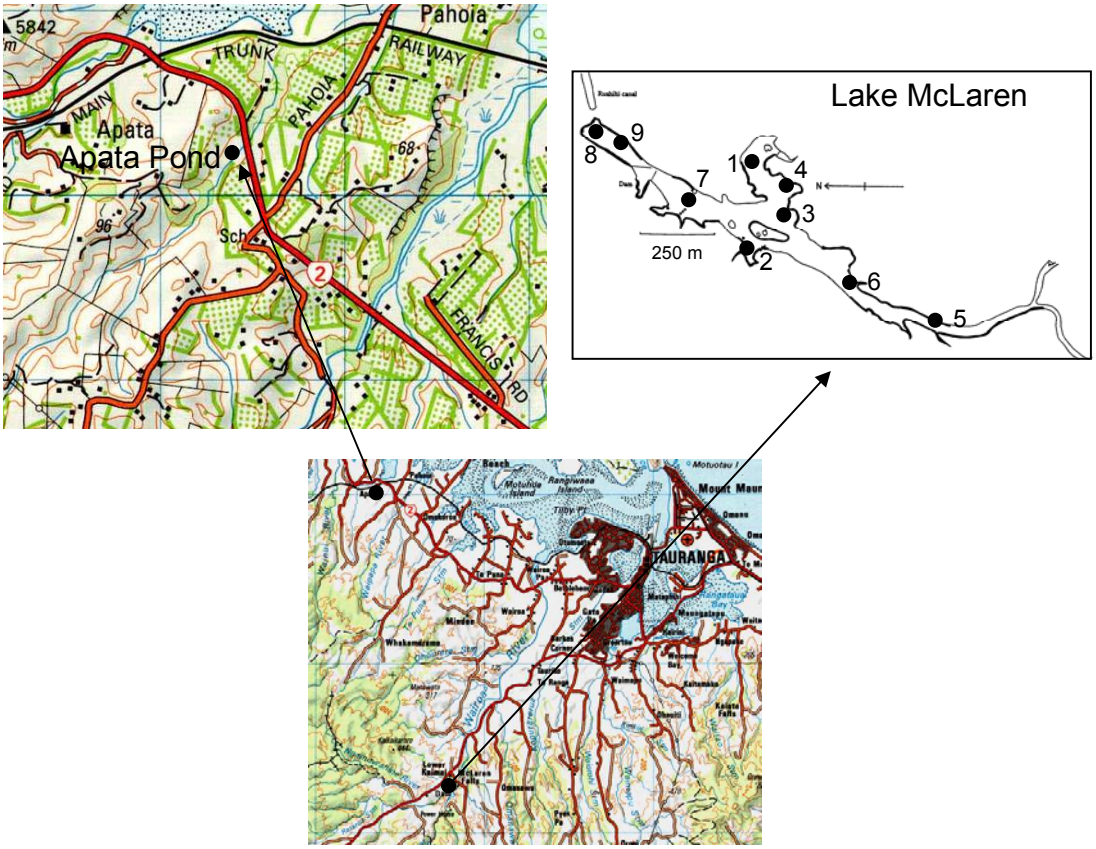

Figure 1. Sites fished in Apata Pond and Lake McLaren with the electrofishing boat of the University of Waikato on 18 and 19 February 2004 (original map scale: 1:50,000, NZMS 260). Numbers in bold refer to the sites in Table 1. Sources: MapWorld TopoMap NZ 2.0 and Lake (1995).

3. Results

Ambient conductivities were low in this study, especially in Lake McLaren (Table 2), and these conductivities probably restricted the range of the electric field. Water temperature was also low in Lake McLaren. In Apata Pond, shortfinned eels, inanga, and koi carp were attracted to the anodes. The large koi carp were observed from the electrofishing boat, but escaped from the electrofishing field, probably sensing it before entering the range of galvanotaxis (greater than about 1 volt cm^{-1}). However, the carp could be approached by the boat with the field switched off, and were easily captured by suddenly energising the field when the carp were within 0.5 m of the anodes. Five large koi carp (all the fish seen from the boat) were caught in this manner (Table 3). These carp ranged in length from 521 to 564 mm fork length, and 3.27 to 4.33 kg (total biomass 19.0 kg), and were all 8 years old (Table 4). There were 2 males and 3 females, and the white-

coloured female (Figure 3) was about to spawn. One of the three koi carp removed by EBOP staff in 2003 was about 525 mm fork length and weighed 2.55 kg (Phil Dykzeul, pers. comm., Environment Bay of Plenty, Tauranga; Figure 3). Fyke netting by EBOP staff showed that eels were more numerous than the boat electrofishing indicated. Peter Guy, the landowner of Apata Pond, has looked for koi carp in the pond since the removal on 18 Feb 2004, but has seen no further fish to this point (3 March 2004).

A large, orange carp-like fish that was previously observed in a pond downstream of Apata Pond was captured by Environment Bay Of Plenty staff, and was later identified as a gravid, 7 year-old, female goldfish (Table 4, Figure 4).

In Lake McLaren, longfinned eels, bullies, rudd, brown trout, and rainbow trout were attracted to the anodes. Most longfinned eels were large (up to 1 m in length), and were not brought on board. The bullies and trout were netted and measured, and all except one brown trout and one rainbow trout were returned to the water. The rudd were kept and killed for age and sex determination. There was one male and one female, and they were small for their ages (6 and 7 years; Table 4).

One rainbow trout (540 mm fork length) and one brown trout (525 mm fork length) from site 1 were caught with a frequency of 120 pulses per second, and these fish appeared not to recover well from the effects of electrofishing, and were sacrificed. On later examination, however, no spinal damage or internal haemorrhaging was observed. The stomach of the rainbow trout was almost empty, but had about ten aquatic snails (*Physa acuta*). The hind gut was very full of fragments of aquatic macrophytes and snails. The stomach of the brown trout was full, and had approximately equal volumes of snails, the backswimmer (*Anisops* sp.), red damselflies (*Xanthocnemis zealandica*). There was also one bully in the stomach. The other 20 trout were caught with a frequency of 60 pulses per second; these recovered rapidly from the effects of electronarcosis and were released back into the lake.

The water temperature in Lake McLaren was cold for the time of year (14.9^{o}C, Table 2), and had a diverse community of submerged macrophytes. The submerged vegetation at sites 1 and 8 were dominated by *Egeria densa* and *Elodea candensis*. *Myriophyllum propinquum* was found on a low turf community at site 7, and scattered plants of *Potamogeton ochreatus* and *Nitella hookeri* were found at other sites.

Table 2. Sites and physical conditions Apata Pond and Lake McLaren fished on 18 and 19 February 2004 with the electrofishing boat of the University of Waikato.

Site no.	Site name	Submerged macrophytes	Bank and substrate	Ambient conductivity (µS cm^{-1})	Specific conductivity (µS cm^{-1})	Water temperature (^oC)
	Apata Pond	None	*Paspalum distichum, Nymphaea*	89.9	98.3	20.6
1	Lake McLaren	*Egeria, Elodea*		42.5	52.7	14.9
2	Lake McLaren	*Potamogeton ochreatus*		42.5	52.7	14.9
3	Lake McLaren			42.5	52.7	14.9
4	Lake McLaren			42.5	52.7	14.9
5	Lake McLaren			42.5	52.7	14.9
6	Lake McLaren			42.5	52.7	14.9
7	Lake McLaren	*Myriophyllum propinquum*		42.5	52.7	14.9
8	Lake McLaren	*Egeria, Elodea*		42.5	52.7	14.9
9	Lake McLaren			42.5	52.7	14.9

Table 3. Fish species caught or immobilised in Apata Pond and Lake McLaren by the University of Waikato electrofishing boat on 18 February.

Site no.	Elapsed time (hh:mm:ss)	Distance fished (m)	Area fished (m^2)	Depth (m)	Number of fish seen or caught									Fish density (fish 100 m^{-2})
					Shortfinned eels	Longfinned eels	Inanga	Bullies	Koi carp	Rudd	Brown trout	Rainbow trout	Total	
Apata Pond														
	3:04:00	700	2800	0.5-3	8		4		5				17	0.61
Lake McLaren														
1	01:09:00	1137	4546	0.5-1.5		3					3	1	7	0.15
2	00:14:00	296	1184	0.5-1.5				1			1		2	0.17
3	00:11:00	60	239	2							3	1	4	1.68
4	00:15:00	224	896								3	2	5	0.56
5	00:12:00	300	1198					2			4	1	7	0.58
6	00:36:00	132	528								1		1	0.19
7	00:21:00	459	1837			4					1		5	0.27
8	00:23:00	344	1377	1-2.5		3				2	1		6	0.44
9	00:05:00	64	256	0.5-1									0	0.00
Total	3:26:00	3015	12061		0	10	0	3	0	2	17	5	37	0.31

Table 4. Lengths, weights, sex, and ages of fish caught in Apata Pond and Lake McLaren on 18 and 19 February 2004 by the University of Waikato electrofishing boat.

Site	Species	Length (mm)	Weight (g)	Sex	Reproductive condition	Age (years)
Apata Pond						
	Koi carp	564	3911	Female	Post-spawning	8
	Koi carp	556	4167	Female	Post-spawning	8
	Koi carp	548	4329	Female	About to spawn	8
	Koi carp	537	3329	Male	Unripe	8
	Koi carp	521	3266	Male	Unripe	8
Downstream of Apata Pond						
	Goldfish	275	1174	Female	Ripe	7
Lake McLaren						
1	Brown trout	430		Female		
1	Brown trout	525		Male		
1	Brown trout	520		Male		
1	Rainbow trout	540		Female		
2	Brown trout	405		Female		
2	Common bully	72				
3	Brown trout	480		Male		
3	Brown trout	360		Female		
3	Brown trout	480		Male		
3	Rainbow trout	470		Female		
4	Brown trout	400		Female		
4	Brown trout	410		Male		
4	Brown trout	410		Male		
4	Rainbow trout	420		Female		
4	Rainbow trout	350		Female		
5	Brown trout	540				
5	Brown trout	90				
5	Brown trout	110				
5	Brown trout	90				
5	Rainbow trout	240				
5	Common bully	62				
5	Common bully	79				
6	Brown trout	405				
7	Brown trout	345				
8	Brown trout	510				
8	Brown trout					
8	Rudd	240	273.7	Female	Unripe	7
8	Rudd	203	174.9	Male	Unripe	6

Figure 2. Apata Pond in the Bay of Plenty on 18 February 2004 before the removal of five large koi carp. Photo: Brendan Hicks.

Figure 3. Koi carp caught by the University of Waikato electrofishing boat in Apata Pond on 18 February. The carp ranged in length from 521 to 564 mm fork length, and 3.27 to 4.33 kg (total biomass 19.0 kg). Photo: Brendan Hicks.

Figure 4. Large, female goldfish captured downstream of Apata Pond on 18 February 2004 by Environment Bay of Plenty staff. Fork length was 275 mm, and weight was 1174 g. Photo: Brendan Hicks.

4. Conclusions

Despite the low conductivities, electrofishing in both Apata Pond and Lake McLaren was effective. It is encouraging that in Apata Pond, from where large mature koi carp were removed, no small koi carp were caught or seen, suggesting that no successful breeding had taken place. All the carp were the same age (8 years old), suggesting that they were released as an even-aged cohort in 1998 or later. The 525 mm koi carp removed by EBOP in April 2003 was almost certainly from the same cohort (Figure 5). The bright orange or white colouration of the carp is typical of aquarium stock of the Asian strain of koi carp (*Cyprinus carpio haemopterus*; Zhou et al. 2003).

Figure 5. Koi carp (about 525 mm fork length; 2.55 kg) removed by netting by Environment Bay of Plenty in April 2003. Photo: Glenn Ayo, EBOP.

The capture of rudd in Lake McLaren was disappointing but not surprising, because there have been previous reports of a school of red-coloured fish (Mark Ray, Tauranga City Council, pers. comm.). No tench were caught in Lake McLaren, even though areas in which they were most abundant in 1995 were fished intensively. In 1995, six mature tench 420-461 mm fork length were caught at locations corresponding to sites 2 and 7 in this survey. The tench weighed between 1195 and 2026 g. The absence of any tench in the current survey suggests that the tench have failed to reproduce successfully in Lake McLaren, possibly because of its low water temperatures.

Previous fishing with the electrofishing boat in the North Island, NZ, in similar conductivities and habitats, and with similar machine settings, has caught eels, rudd, brown bullhead catfish, perch, tench, and koi carp. The low conductivity of Lake McLaren probably restricted the field somewhat; power transfer from the water to the fish would have been impeded by the measured ambient conductivity (43 µS cm^{-1}), which was less than the presumed conductivity of the fish. Goldfish have effective conductivities of about 100-160 µS cm^{-1} (Kolz and Reynolds 1989).

Boat electrofishing generally provides a good picture of the range of fish species present, especially on water depths of 0.5-2 m. Fish densities in Lake Rotoiti ranged from 2.3 to 11.7 fish 100 m^{-2}. Fishing with this electrofishing boat in the Waikato region caught a wide range of fish species in water with similar conductivities. For instance, single-pass fishing in July 2003 in a weedy side channel of the Waikato River at 10.3^{o}C with an ambient conductivity of 114 µS cm^{-1} caught 464 fish in 75 mins in a fished distance of about 1000 m (4,000 m^2), implying a minimum density of 11.6 fish 100 m^{-2}. The catch included 24 koi carp, 2 rudd, 2 goldfish, 10 shortfinned eels, 1 catfish, 400 smelt, and 25 grey mullet. Fishing in August 2003 in Lake Rotoroa (Hamilton Lake) at 11.0^{o}C and ambient conductivity of 79 µS cm^{-1} caught 80 fish in 65 mins in a fished distance of 600 m (2,400 m^2), or a minimum density of 3.3 fish 100 m^{-2}. The catch included 10 tench, 10 rudd, 20 perch, 17 shortfinned eels, and 23 catfish. In the shallow margins of Lake Whangape, Waikato, 24 koi carp weighing a total of 87 kg were caught in about 400 m^2, to give a minimum biomass of about 2,200 kg ha^{-1}. Population estimates of koi carp made from two-pass fishing in 915 m^2 of the Kimihi Wetland outlet on 29 January 2004 were 14.3 fish 100 m^{-2}, or about 2,140 kg ha^{-1} (Hicks, unpubl. data). Minimum fish densities in Lake Rotoiti estimated by electrofishing with the University of Waikato's boat were 2.3-11.7 fish 100 m^{-2} (Hicks and Ring 2004). Thus fish densities in both Lake McLaren and Apata Pond were relatively low.

5. Acknowledgements

We gratefully acknowledge the efforts of Kim Young, Bay of Plenty Conservancy, and John Heaphy and Alan Jones of the Tauranga Area Office, Department of Conservation (DOC). Phil Dykzeul of Environment Bay of Plenty (EBOP) assisted with fishing in Apata Pond, and caught the goldfish from downstream. Brian Clement (EBOP) and Ian Rogerson, a DOC volunteer, also assisted with the field work. We appreciate the willingness of Peter Guy and his family to grant access to their property to make the fishing possible. The survey was funded by DOC and EBOP.

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