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Fish removal from Waikato North Head Mining Ltd's water intake pond at North Head sand mine

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by

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Cover picture: Waikato North Head Mining Ltd's sand mine water intake pond at North Head Mine, Ghezzie Road, Otaua, on the true right bank of the lower Waikato River. Photo: Caleb Sjardin.

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Executive summary

Tonkin & Taylor contracted the University of Waikato remove fish by boat electrofishing, and to estimate fish abundance, in the water intake pond of Waikato North Head Mining Ltd's sand mining site at North Head Mine, Ghezzie Road, Otaua, on the true right bank of the lower Waikato River. This removal was necessitated by failure of a screen intended to exclude fish and its repair.

The oval-shaped water intake pond is about 1.23 ha in area, 155 m long and 96 m wide, with a maximum depth of 3.2 m. Coordinates of the pond are 37°20'45.80"S, 174°44'18.51"E. The five sites fished were 316-1,161 m long (1,264-4,644 m^2 in area). Bank vegetation was primarily grass. There were no submerged macrophytes, but small patches of *Polygonum* sp., *Ludwigia* sp., *Ranunculus* sp. and *Cortaderia selloana* occurred on the pond margins.

Boat electrofishing is known to be biased towards koi carp, goldfish, and grey mullet but to be less efficient for eels and catfish. To compensate for this bias, staff from Tonkin & Taylor set 10 fyke nets and 12 Gee minnow traps for two nights (5-6 April 2016) before the boat electrofishing took place. On 7 April 2016 we electrofished with a 4.5 m-long, aluminium-hulled electrofishing boat equipped with a 5-kilowatt pulsator powered by a 6-kilowatt custom-wound Honda generator. Two anode poles, each with an array of six 1-m long stainless steel wire droppers, created the fishing field in front of the bow, with the boat hull acting as the cathode.

Fyke netting by Tonkin & Taylor caught 147 fish, caught primarily shortfin eels and common bullies. Shortfin eels and common bullies were the most common species. Boat electrofishing for 142 caught a total of 61 fish. Grey mullet were the most abundant (37 fish), and koi carp were the next most abundant species (12 fish). Relatively few eels (7 shortfin and 1 longfin), goldfish (3), and common smelt (1) were caught.

The fish biomass caught by boat electrofishing was about 150 kg because most grey mullet and koi carp were large for the respective species. Fish were not individually measured, but approximately 67% of the grey mullet were large adults in excellent condition and weighing between 2.5–5 kg each. Of the 12 koi carp, 11 were exceptionally large, exceeding 4 kg, with the largest approximately 8.5 kg. Assuming a mean weight of 2.5 kg for grey mullet, they comprised about 64% of the total fish biomass. Assuming a mean weight of 4 kg for koi carp, they comprised about 33% of the biomass. The ambient conductivity of the pond (2188 $\mu S\ cm^{-1}$), which was great than optimal for boat electrofishing, which is about 80-500 $\mu S\ cm^{-1}$.

1. Introduction

Tonkin & Taylor contracted the University of Waikato remove fish by boat electrofishing, and to estimate fish abundance, in the water intake pond of New Zealand Steel Ltd's sand mining plant at North Head Mine, Ghezzie Road, Otaua, on the true right bank of the lower Waikato River. This removal was necessitated by failure of a screen intended to exclude fish and its repair. One hundred grass carp have been previously released into the lagoon (Ministry of Primary Industries Permit Number CA040) to help control the growth of aquatic plants.

2. Study site

The oval-shaped water intake pond (Fig. 1) is about 1.23 ha in area, 155 m long and 96 m wide, with a maximum depth of 3.2 m. Coordinates of the pond are 37°20'45.80"S, 174°44'18.51"E. Sites fished were 316-1,161 m long (1,264-4,644 m^2 in area) (Table 1). Bank vegetation was primarily grass. There were no submerged macrophytes, but small patches of *Polygonum* sp., *Ludwigia* sp., *Ranunculus* sp. and *Cortaderia selloana* occurred on the pond margins. The Waikato River is tidal at the pond location, and preliminary measurements suggested that electrical conductivity in the pond was is about 300 µS cm^{-1}, well within the necessary range for boat electrofishing (about 80-500 µS cm^{-1}, Hicks unpub data).

3. Methods

Boat electrofishing is known to be biased towards koi carp, goldfish, and grey mullet but to be less efficient for eels and catfish (Hicks et al. 2015a, b). To compensate for this bias, staff from Tonkin & Taylor set ten fyke nets (mesh size of 17 mm by 7 mm) and twelve Gee minnow traps (mesh size of 3 mm by 3 mm) for two nights (5-6 April 2016) before the boat electrofishing took place. On 7 April 2016, immediately prior to the boat electrofishing, we measured the physical conditions in the pond. Horizontal visibility through the water was measured using a black disc (Davies-Colley 1988); black disc distance was 0.50 m. Water temperature, electrical conductivity and salinity were measured with a YSI 3200 conductivity meter; at 1045 h surface water temperature was 18.8°C, ambient conductivity was 2188 µS cm^{-1}, specific conductivity was 2481 µS cm^{-1}, and salinity was 1.30 ppt.

We electrofished with a 4.5 m-long, aluminium-hulled electrofishing boat equipped with a 5-kilowatt fishing pulsator (GPP model 5.0, Smith-Root Inc, Vancouver, Washington, USA) powered by a 6-kilowatt custom-wound Honda generator. Two anode poles, each with an array of six 1-m long

stainless steel wire droppers, created the fishing field in front of the bow, with the boat hull acting as the cathode. We fished with the fishing pulsator on low range (50-500 V), direct current, and a frequency of 60 pulses per second and 40% of low range, which gave an applied current of about 10-12 amps root mean square.

We assumed from past experience (Hicks et al. 2006) that an effective fishing field was developed to a depth of about 3 m, and about 2 m either side of the centre line of the boat. We therefore fished a transect 4 m wide, which was generally consistent with behavioural reactions of fish at the water surface. This assumption was used to calculate the area fished from the linear distance measured with a hand-held Garmin GPSMAP 60Cx global positioning system.

All sites where fished on 7 April 2016 with a fishing time of 22-45 minutes; sites fished were 316-1,161 m long (1,264-4,644 m^2 in area) (Table 1). Fish were returned to shore, species were determined and counted, grey mullet, goldfish and koi carp were provided for disposal by Waikato North Head Mining, and eels were released into the Waikato River.

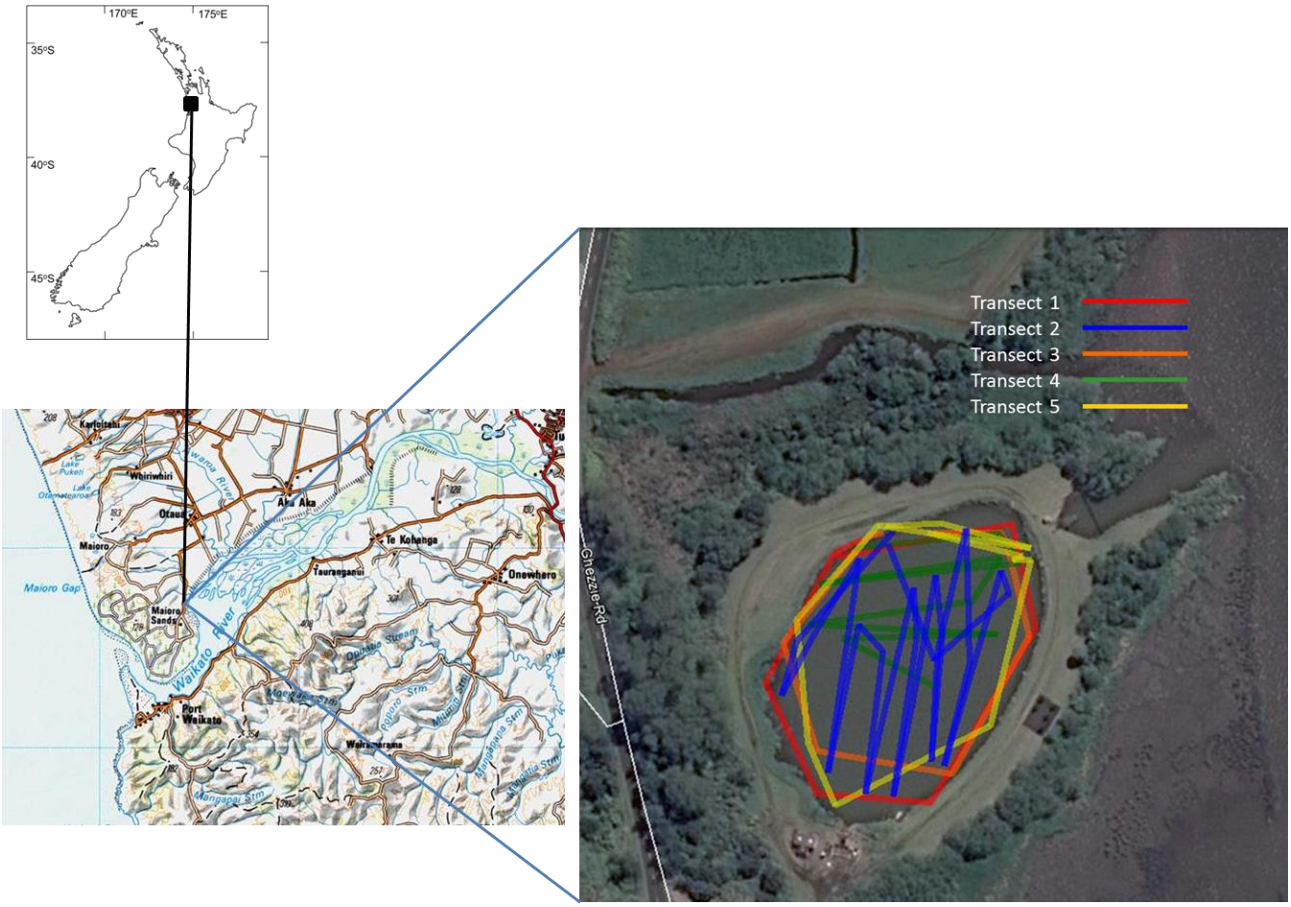

Figure 1. Location of the five transects that were boat electrofished in Waikato North Head Mining Ltd's sand mining water intake pond on 7 April 2016.

Table 1. Lengths, areas, depths of five transects that were boat electrofished in Waikato North Head Mining Ltd's sand mining water intake pond at North Head Mine, Ghezzie Road, Otaua on 7 April 2016.

Transect	Distance fished (m)	Area fished (m^2)	Time fished (minutes)	Depth range (m)
1	388	1,552	22	0.6-2.3
2	1,161	4,644	45	1.6-3.2
3	316	1,264	25	0.6-2.0
4	521	2,084	22	1.2-2.7
5	467	1,868	28	1.6-2.3
Total	2,853	11,412	142	

4. Results

Fyke netting by Tonkin & Taylor caught 147 fish, caught primarily shortfin eels and common bullies (Table 2). Shortfin eels and common bullies were the most common species.

Table 2. Fish and shrimp caught by fyke netting in Waikato North Head Mining l Ltd's sand mining water intake pond at North Head Mine, Ghezzie Road, Otaua on 5-6 April 2016.

	Number of fish caught			Length ranges (mm)	
Species	5 Apr 2016	6 Apr 2016	Total	5 Apr 2016	6 Apr 2016
Shortfin eel	47	4	51	300 - 900	350 - 600
Longfin eel	3	5	8	250 - 350	150 - 400
Common bully	47	24	71	25 - 70	25 - 70
Inanga	4	8	12	50 - 70	55 - 80
Common smelt	0	1	1	-	70
Shrimp	1	3	4	-	-
Total	101	42	143		

We boat electrofished 2,853 m in length and an area of 11,412 m^2 at a total of five sites, in which we caught a total of 61 fish. Grey mullet were the most abundant (37 fish), and koi carp were the next most abundant species (12 fish). Relatively few eels (7 shortfin and 1 longfin), goldfish (3), and common smelt (1) were caught (Table 2).

The fish biomass caught was about 150 kg because most grey mullet and koi carp were large for the respective species. Fish were not individually measured, but approximately 67% of the grey

mullet were large adults in excellent condition and weighing between 2.5–5 kg each. Of the 12 koi carp, 11 were exceptionally large, exceeding 4 kg, with the largest approximately 8.5 kg. The single smaller koi carp was about 0.5 kg and was likely to have been less than 2 years old. The carp were all in good condition with no evidence of recent spawning. The single longfin eel was approximately 1 kg and in good condition. The shortfin eels were smaller ranging from approximately 0.2–0.4 kg. The three goldfish were small, less than 60 mm in length. Assuming a mean weight of 2.5 kg for grey mullet, they comprised about 64% of the total fish biomass. Assuming a mean weight of 4 kg for koi carp, they comprised about 33% of the biomass.

Figure 2. Large koi carp (710 mm fork length, 8.5 kg) caught by boat electrofishing in the Waikato North Head Mining Ltd's sand mining water intake pond on 7 April 2016. Box lid is 650 mm long.

5. Discussion

The bias of fyke netting for eels and common bullies, and of subsequent boat electrofishing for grey mullet and koi carp, is clear from Table 3, which also shows the synergy of combining both techniques.

Table 3. Scientific names and combined totals of numbers of fish and shrimps caught by fyke netting and boat electrofishing in the Waikato North Head Mining Ltd's sand mining water intake pond on 7 April 2016.

Common name	Scientific name	Status	Total number of fish	
			Fyke netting	Boat electrofishing
Shortfin eel	*Anguilla australis*	Native	51	7
Longfin eel	*Anguilla australis*	Native	8	1
Common bully	*Gobiomorphus cotidianus*	Native	71	0
Inanga	*Galaxias maculatus*	Native	12	0
Common smelt	*Retropinna retropinna*	Native	1	1
Grey mullet	*Mugil cephalus*	Native	0	37
Goldfish	*Carassius auratus*	Introduced	0	3
Koi carp	*Cyprinus carpio*	Introduced	0	12
Shrimp	*Paratya curvirostris*	Native	4	0
Total			147	61

An important constraint on electrofishing is the electrical conductivity of the water. Electrofishing is assumed to be most effective when maximal power transfer occurs to the fish, which happens when the water is about the same electrical conductivity as the immersed fish (Kolz 2006). Conductivity for immersed goldfish of 90-95 mm length has been measured at 72-204 µS cm^{-1} (Kolz 2006), and higher and lower water conductivities can compromise the efficiency of electrofishing, especially for small fish.

Ambient conductivity in the pond was higher on the day of fishing (2188 µS cm^{-1}) than the original measurement of 300 µS cm^{-1}, suggesting that the tidal influence in the Waikato River causes variable salinity of the intake water. The high ambient conductivity of the pond water at the time of fishing is most likely is the reason that we did not catch inanga or common bullies, small fish that fyke netting and minor trapping confirmed were present in the pond. High conductivity would also have lowered capture efficiency for large fish such as grey mullet and koi carp, which is most likely why the catches did not decline with successive fishing passes. This is unusual in boat electrofishing

for carp in a closed water body in our experience (e.g., Hicks et al. 2005a). Despite this, the areal biomasses of koi carp (~4.2 g m^{-2}) and grey mullet (~8.1 g m^{-2}) in the Waikato North Head Mining pond were similar to the highest biomasses for lakes Whangape and Hakanoa (Hicks et al. 2016). Grey mullet biomass in the pond far exceeded biomasses in these lakes (up to 1.7 g m^{-2}; Hicks et al. 2016) and were similar to the highest biomasses the Waikato River between Lake Karapiro and Mercer (4.9-10.5 g m^{-2}; Hicks et al. 2005b). Fish abundance estimated in this report is relative rather than absolute abundance because complete population estimates from removal methods require that numbers caught decline between successive fish removals (e.g., Hicks et al. 2006).

Fish abundance estimates referred to in this report are derived from single-pass boat electrofishing, so are robust estimates of relative abundance but are not absolute abundance (Hicks et al. 2006). Boat electrofishing is a useful survey tool but like all fishing methods it has its own biases. Despite the fact that 59 eels were removed by fyke netting before the boat electrofishing it is likely that the abundance of eels determined by boat electrofishing was an underestimate. First-pass estimates of eels by boat electrofishing can be as low as 5-19% of the population estimate (Hicks et al. 2006; Hicks, unpublished data). Comparison of fishing methods show that capture efficiency for boat electrofishing in Lake Kaituna was 22% for koi carp and 13% for goldfish but only 6% for shortfin eels (Hicks et al. 2015b; p127). Overall, however, the combination of fyke netting and boat electrofishing achieved its objective of removing a large amount of fish biomass from the pond. Grass carp, if still present, were at low abundance.

6. Acknowledgements

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