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Boat electrofishing survey of the Awatapu Lagoon and lower Tarawera River

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Department of Conservation and Bay of Plenty Regional Council

by

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Cover picture: The University of Waikato's electrofishing boat on the Awatapu Lagoon, 10 December 2014.

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Executive summary

The Department of Conservation (DOC) and Bay of Plenty Regional Council contracted the University of Waikato to conduct a boat electrofishing survey of the Awatapu Lagoon, the old Rangitaiki River channel and the lower Tarawera River. This survey was in response to sightings of large orange fish at these sites by members of the public and the consequent concern that these fish might be koi carp (*Cyprinus carpio*; Pete Livingstone, DOC, Whakatane). We also recorded species of native fish to determine their relative density and biomass.

We fished the Awatapu Lagoon in October 2005 and December 2014, and we fished the old Rangitaiki River channel and the lower Tarawera River in December 2014. In the Awatapu Lagoon on 31 October 2005, we caught 260 fish, comprising 170 goldfish weighing a total of 27.5 kg, 88 shortfin eels (*Anguilla australis*), and two brown trout. In addition, common smelt (*Retropinna retropinna*), inanga (*Galaxias maculatus*) and gambusia (*Gambusia affinis*) were abundant, though their numbers were not quantitatively determined. The two adult brown trout we caught measured 450 and 460 mm fork length (FL), giving calculated weights of approximately 1.21 and 1.29 kg. Mean goldfish density was 1.70 fish 100 m^{-2}, with individuals ranging in size from 40 to 277 mm (FL) (mean FL 178 mm ± 42 mm standard deviation, SD). Mean weight of 162 g (± 97 g SD), and mean goldfish areal biomass was 1.70 g m^{-2}. Shortfin eel density was estimated as 1.87 fish 100 m^{-2} in East Lagoon, but biomass was not estimated for shortfin eels. Eels were seen in West Lagoon but not caught. No koi carp or other invasive fish species were found.

In December 2014, we caught 271 fish comprising 12 species (two introduced, and 10 native). Common bullies (*Gobiomorphus cotidianus*) and shortfin eels were the most numerous species. In the Awatapu Lagoon, we caught 102 common bullies, 64 goldfish and 22 shortfin eels. In the lower Tarawera River, we caught parore (*Girella tricuspidata*), a stargazer (*Leptoscopus macropygus*), and yelloweye mullet (*Aldrichetta forsteri*). Site T4 in the Tarawera River had the greatest species richness (7 species). We verified that the large orange cyprinids that were seen in the old Rangitaiki River channel were large goldfish and not koi carp.

As the main purpose of this fishing was to establish the identity of large orange fish seen in and round the lower Tarawera and the Awatapu Lagoon, the occurrence of goldfish was significant. From the size and colour ranges and abundance of the goldfish caught it is highly likely that any orange fish seen were large orange goldfish and not koi carp. However, before this fishing it was quite reasonable to conclude that large orange fish might be koi carp. This is similar to the Kaituna River, where goldfish were found but there were no koi carp. The high diversity of native fish species in the

lower Tarawera River is predictable from known fish distribution patterns, where the most diverse fish communities are found close to the coast. The occurrence of parore is unusual in freshwater fishing, as these are generally considered to be a marine species, but do stray into estuaries. One giant bully was found in this survey, and these are quite common in the lower reaches of large river systems. Yelloweye mullet are also common in Bay of Plenty fresh waters close to the sea. Stargazers are a relatively unusual catch, but we have found these previously in Bay of Plenty rivers and in the lower Manawatu River.

1. Introduction

The Department of Conservation (DOC) and Bay of Plenty Regional Council contracted the University of Waikato to conduct a boat electrofishing survey of the Awatapu Lagoon, the old Rangitaiki River channel and the lower Tarawera River. This survey was in response to sightings of large orange fish at these sites by members of the public and the consequent concern that these fish might be koi carp (*Cyprinus carpio*; Pete Livingstone, DOC, Whakatane). We also recorded species of native fish to determine their relative density and biomass.

2. Study sites

The Awatapu Lagoon (37°57'47.26"S, 176°57'59.50"E) is part of a park reserve of the Whakatane District Council and is located within the precincts of Whakatane township (Figures 1 and 2A). It was formed when an ox-bow of the Whakatane River was isolated from the main river as part of a flood control scheme by the Bay of Plenty Catchment Commission in 1970. Plantings have been carried out over the years to enhance the reserve's terrestrial vegetation. The lagoon has a surface area of approximately 7.7 ha and a maximum depth of 2.5 m. Macrophyte species in the lagoon include hornwort (*Ceratophyllum demersum*), parrot's feather (*Myriophyllum aquaticum*) and the emergent species raupo (*Typha orientalis*). The lower Tarawera River (37°53'34.80"S, 176°47'16.01"E) was fished within 500 m of the coast, and the adjacent old Rangitaiki River channel (37°53'41.52"S, 176°47'24.69"E) was also fished. This channel is now isolated from the Tarawera River by water flow control gates, but the Rangitaiki River flowed into the Tarawera River at this point until a 1500-m cut was excavated in 1913 (BOP Regional Council 2015) that allowed the Rangitaiki River to drain directly to the sea near Thornton (37°54'34.08"S, 176°52'55.26"E).

3. Methods

To conduct the electrofishing we used a 4.5 m-long, aluminium-hulled electrofishing boat with a 5-kilowatt petrol-powered 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.

All sites were fished with the pulsator set to low range (50-500 V) with direct current, though the high conductivities of the tidal sites required adjustment of the percent of range (POR) and pulses per second (PPS) to give a consistent applied current of 3-4 amps root mean square. We assumed from past experience (Hicks et al. 2006) that an effective fishing field was developed to a depth of 2-3 m, and 2 m either side of the centre line of the boat. The boat 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.

On 31 October 2005, we boat electrofished four sites in the Awatapu Lagoon for 17-64 mins each (Table 1A), specifically searching for invasive fish species such as koi carp (*Cyprinus carpio*). For this reason only goldfish (*Carassius auratus*) and brown trout (*Salmo trutta*) had their lengths and weights recorded. We used pulsator settings of 40 POR and 60 PPS. Water temperature was 19.7-20.9^{o}C, and electrical conductivity was measured with a YSI 3200 conductivity meter and horizontal visibility through the water was measured using a black disc (Davies-Colley 1988). Ambient conductivity was 120.1-121.8 µS cm^{-1} (Table 1A); we fished for 2.5 hours and covering a distance of nearly 3,000 m (11,900 m^2).

On 10 December 2014, we fished sites T1 and T2, which had conductivities of 7,940 to 18,390 µS cm^{-1}, with 15-30 POR and 15-30 PPS (Table 1B). For sites T4-T7 and A1-A2, we used 40 POR and 60 PPS.

Sites T1 and T2 were fished in December 2014 for a total of 112 mins and sites T4-T7 and A1-A4 were fished with a consistent fishing time of 10 minutes for each site (Table 1B). We fished areas of 4,344, 3,572, and 3,348 m^2 in the old Rangitaiki River channel, lower Tarawera River, and Awatapu Lagoon respectively, surveying all fish species, including eels. Fork length (FL) was recorded for goldfish, parore and yelloweye mullet and total length (TL) was measured for all other fish to the nearest millimetre. Weight was measured to the nearest g, except for eels, for which it was calculated from length with length-weight regressions from Jellyman et al. (2013). All native fish were released after allowing recovery from the benzocaine anaesthetic. Goldfish were humanely sacrificed with an overdose of benzocaine and removed from the site for disposal.

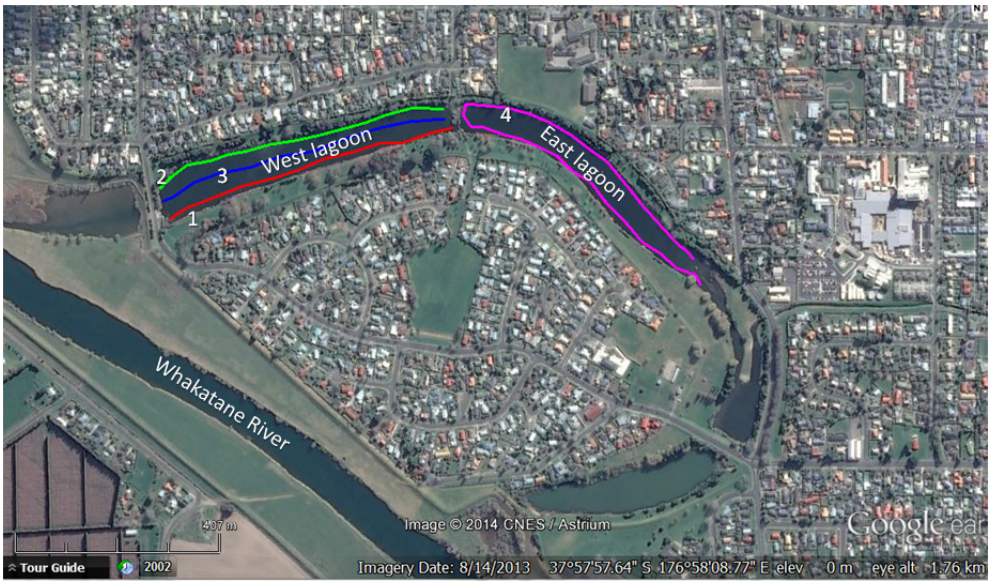

Figure 1. Locations boat electrofished in the Awatapu Lagoon, Whakatane, on 31 October 2005.

Table 1. Sites and locations boat electrofished in A. the Awatapu Lagoon, Whakatane, on 31 October 2005, and B. the old Rangitaiki River channel, the lower Tarawera River, and the Awatapu Lagoon, 10 December 2014.

A. Awatapu Lagoon, Whakatane, on 31 October 2005.

Site	Location	Length fished (m)	Area fished (m^2)	Fishing time (mins)	Ambient conductivity ($\mu S\ cm^{-1}$)	Specific conductivity ($\mu S\ cm^{-1}$)	Water temperature (^oC)
1	West lagoon TLB	587	2,348	45	121.8	135.3	19.7
2	West lagoon TRB	595	2,380	27	121.8	135.3	19.7
3	West lagoon centre	591	2,364	17	121.8	135.3	19.7
4	East lagoon	1,196	4,784	64	120.1	130.0	20.9
Total		2,969	11,876	153			

B. Old Rangitaiki River channel, lower Tarawera River, and the Awatapu Lagoon, 10 December 2014.

Site	Location	Length fished (m)	Area fished (m^2)	Fishing time (mins)	Ambient conductivity ($\mu S\ cm^{-1}$)	Specific conductivity ($\mu S\ cm^{-1}$)	Water temperature (^oC)
T1	Rangitaiki	611	2,444	63	–	7,940	20.2
T2	Rangitaiki	475	1,900	49	–	15,300	20.2
T4	Tarawera	206	824	10	320.0	367.6	18.2
T5	Tarawera	266	1,064	10	320.0	367.6	18.2
T6	Tarawera	206	824	10	320.0	367.6	18.2
T7	Tarawera	215	860	10	320.0	367.6	18.2
A1	Awatapu	183	732	10	196.3	202.7	23.2
A2	Awatapu	184	736	10	196.3	202.7	23.2
A3	Awatapu	258	1,032	10	196.3	202.7	23.2
A4	Awatapu	212	848	10	196.3	202.7	23.2
Total		2,816	11,264	192			

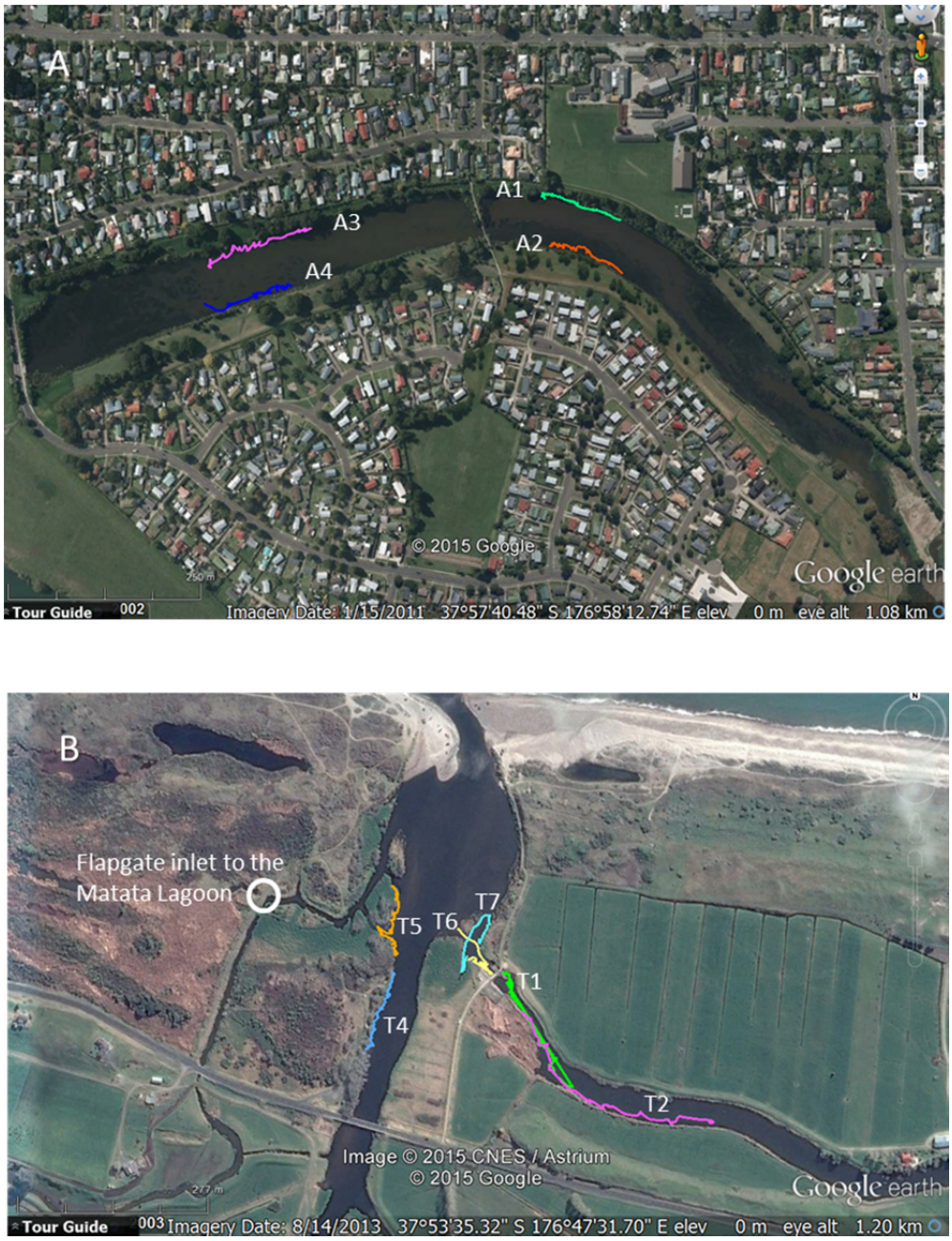

Figure 2. Locations boat electrofished on 10 December 2014 in the A. Awatapu Lagoon (A1-A4), Whakatane, and B. old Rangitaiki River channel (T1 and T2) and the lower Tarawera River (T4-T7).

Table 2. Conductivity of the old Rangitaiki River channel, moving from west (left, T1 start) to east (right, T2 end). Note change in units from Table 1.

	Depth (m)	Specific conductivity (mS cm^{-1})		
		T1 start	T1 end	T2 end
Surface	0.0	7.49	8.54	15.3
Midwater	0.5	15.71	17.88	–
Bottom	0.9-1.0	16.62	18.39	16.5

4. Results

On 31 October 2005, we caught 260 fish (Table 3A), comprising 170 goldfish weighing a total of 27.5 kg, 88 shortfin eels (*Anguilla australis*), two brown trout. In addition, common smelt (*Retropinna retropinna*), inanga (*Galaxias maculatus*) and gambusia (*Gambusia affinis*) were abundant, though their numbers were not quantitatively determined. The two adult brown trout we caught measured 450 and 460 mm fork length (FL), giving calculated weights of approximately 1.21 and 1.29 kg. Mean goldfish density was 1.70 fish 100 m^{-2}, with individuals ranging in size from 40 to 277 mm (FL) (mean FL 178 mm ± 42 mm standard deviation, SD). Mean weight of 162 g (± 97 g SD), and mean goldfish areal biomass was 1.70 g m^{-2} (Table 3D). Shortfin eel density was estimated as 1.87 fish 100 m^{-2} in East Lagoon, but biomass was not estimated for shortfin eels. Eels were seen in West Lagoon but not caught. No koi carp or other invasive fish species were found.

The modal size of the goldfish was about 200 mm FL, and two distinct size classes were evident (Fig. 3). Though most goldfish were bronze in colour, typical of wild goldfish, a few larger specimens were orange (Figure 4), and could easily have been mistaken for koi carp. These results suggest that it is possible that the earlier reports of koi carp in the Awatapu Lagoon were in fact large goldfish.

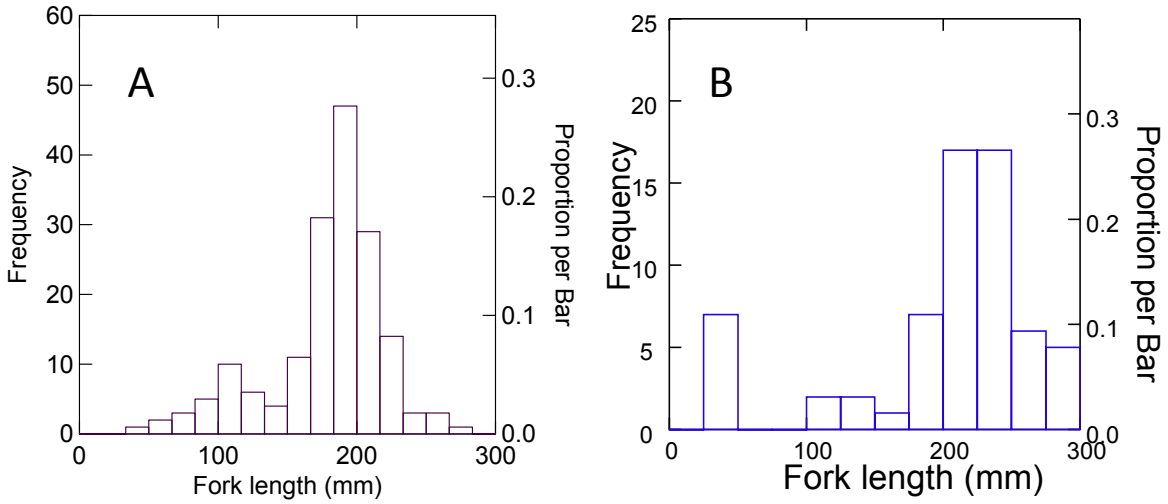

Figure 3. Length frequency of goldfish caught by boat electrofishing in the Awatapu Lagoon, Whakatane River, on A. 31 October 2005 (*N* = 170) and B. 10 December 2014 (*N* = 67).

Table 3. Fish caught at four sites in the Awatapu Lagoon, Whakatane River, on 31 October 2005 by boat electrofishing. A. Number, B. density, C. biomass per site, and D. areal biomass. –, eels seen but not caught; blank cells indicate no catch.

A. Number of fish

		Number of fish per site			
Site	Location	Brown trout	Goldfish	Shortfin eels	Total
1	West lagoon TLB		122	–	122
2	West lagoon TRB	1	23	–	24
3	West lagoon centre	1	5	–	6
4	East lagoon		20	88	108
Total		2	170	88	260

B. Density of fish

		Density (fish 100 m^{-2})			
Site	Location	Brown trout	Goldfish	Shortfin eels	Total
1	West lagoon TLB		5.20	–	5.20
2	West lagoon TRB	0.04	0.97	–	1.01
3	West lagoon centre	0.04	0.21	–	0.25
4	East lagoon		0.42	1.84	0.42

C. Fish biomass per site

		Biomass per fishing shot (g)		
Site	Location	Brown trout	Goldfish	Total
1	West lagoon TLB		17,593	17,593
2	West lagoon TRB	1,215	5,061	6,276
3	West lagoon centre	1,291	779	2,070
4	East lagoon		4,121	4,121
Total		2,506	27,554	30,060

D. Areal fish biomass

		Areal fish biomass (g m^{-2})		
Site	Location	Brown trout	Goldfish	Total
1	West lagoon TLB		7.49	7.49
2	West lagoon TRB	0.51	2.13	2.64
3	West lagoon centre	0.55	0.33	0.88
4	East lagoon		0.86	0.86
Mean		0.26	2.70	2.97

In December 2014, we caught 271 fish comprising 12 species (two introduced, and 10 native; Table 4A). Common bullies (*Gobiomorphus cotidianus*) and shortfin eels were the most numerous species. In the Awatapu Lagoon, we caught 102 common bullies, 64 goldfish and 22 shortfin eels. In the lower Tarawera River, we caught parore (black bream, *Girella tricuspidata*, Family Kyphosidae; Figure 5), a stargazer (*Leptoscopus macropygus*; Figure 6), and yelloweye mullet (*Aldrichetta forsteri*; Figure 7). Site T4 in the Tarawera River had the greatest species richness (7 species). We verified that the large orange cyprinids that were seen in the old Rangitaiki River channel were probably large goldfish and not koi carp.

Table 4. Fish caught at 11 sites in the old Rangitaiki River channel, lower Tarawera River, and Awatapu Lagoon on 10 December 2014 by boat electrofishing. A. Number, B. density, C. biomass per site, and D. areal biomass. Blank cells indicate no catch.

A. Number of fish

		Number of fish per 10-min shot												
Site	Water body	Gambusia	Goldfish	Common bully	Giant bully	Redfin bully	Inanga	Common smelt	Longfin eel	Shortfin eel	Parore	Stargazer	Yelloweye mullet	Total
T1	Rangitaiki		1											1
T2	Rangitaiki		2							1				3
T4	Tarawera			4		1	2		2	5	1		3	18
T5	Tarawera			1						12	1			14
T6	Tarawera							1		5	4			10
T7	Tarawera			2						15		1	7	25
A1	Awatapu	6	2	95	1					7				111
A2	Awatapu						1			6				7
A3	Awatapu		25	7			4			6				42
A4	Awatapu		37							3				40
Total		6	67	109	1	1	7	1	2	60	6	1	10	271

B. Density of fish

		Denisty of fish per 10-min shot (number 100 m^{-2})												
Site	Water body	Gambusia	Goldfish	Common bully	Giant bully	Redfin bully	Inanga	Common smelt	Longfin eel	Shortfin eel	Parore	Stargazer	Yelloweye mullet	Total
T1	Rangitaiki		0.04											0.04
T2	Rangitaiki		0.11							0.05				0.16
T4	Tarawera			0.49		0.12	0.24		0.24	0.61	0.12		0.36	2.18
T5	Tarawera			0.09						1.13	0.09			1.32
T6	Tarawera							0.12		0.61	0.49			1.21
T7	Tarawera			0.23						1.74		0.12	0.81	2.91
A1	Awatapu	0.82	0.27	12.98	0.14					0.96				15.16
A2	Awatapu						0.14			0.82				0.95
A3	Awatapu		2.42	0.68			0.39			0.58				4.07
A4	Awatapu		4.36							0.35				4.72

Table 4. (continued)

C. Biomass per shot

		Biomass of fish per 10-min shot (g)												
Site	Water body	Gambusia	Goldfish	Common bully	Giant bully	Redfin bully	Inanga	Common smelt	Longfin eel	Shortfin eel	Parore	Stargazer	Yelloweye mullet	Total
T1	Rangitaiki		1,120											1,120
T2	Rangitaiki		4,297							170				4,467
T4	Tarawera			13		6	13		516	1,333	36		570	2,487
T5	Tarawera			2						2,700	122			2,824
T6	Tarawera							0		829	484			1,313
T7	Tarawera			2						1,736		38	3,910	5,686
A1	Awatapu	3	642	72	53					1,654				2,424
A2	Awatapu						3			1,580				1,583
A3	Awatapu		5,841	6			5			720				6,571
A4	Awatapu		10,218							1,350				11,569
Total		3	22,118	94	53	6	21	0	516	12,072	642	38	4,480	36,138

D. Areal biomass

		Biomass of fish (g m^{-2})												
Site	Water body	Gambusia	Goldfish	Common bully	Giant bully	Redfin bully	Inanga	Common smelt	Longfin eel	Shortfin eel	Parore	Stargazer	Yelloweye mullet	Total
T1	Rangitaiki		0.458											0.00
T2	Rangitaiki		2.262							0.089				0.09
T4	Tarawera			0.015		0.007	0.016		0.626	1.617	0.044		0.692	3.02
T5	Tarawera			0.002						2.538	0.115			2.65
T6	Tarawera							0.000		1.006	0.587			1.59
T7	Tarawera			0.002						2.019		0.044	4.546	6.61
A1	Awatapu	0.004	0.877	0.098	0.073					2.260				2.43
A2	Awatapu						0.004			2.147				2.15
A3	Awatapu		5.660	0.006			0.005			0.698				0.71
A4	Awatapu		12.050							1.592				1.59

Figure 4. Large orange-coloured wild goldfish (277-mm FL) with smaller bronze-coloured goldfish from the Awatapu Lagoon, Whakatane River, 31 October 2005.

Figure 5. Parore (131 mm fork length, 36 g) from the lower Tarawera River.

Figure 6. Stargazer (159 mm fork length, 38 g) from the lower Tarawera River.

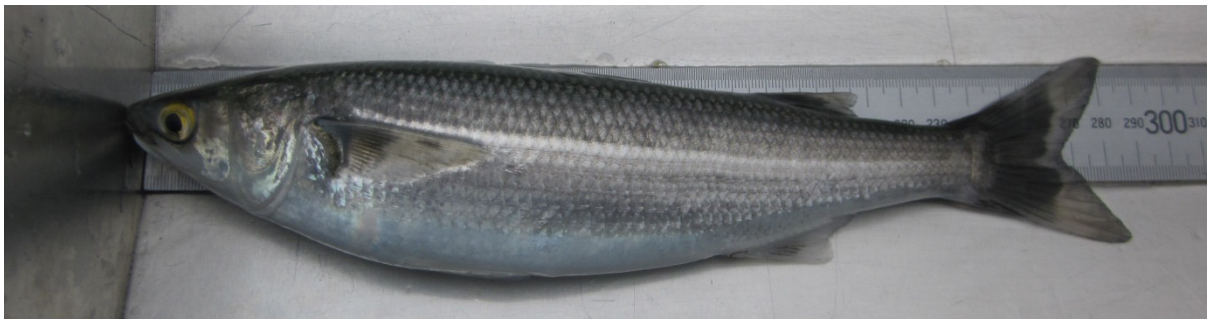

Figure 7. Yelloweye mullet (265 mm fork length, 222 g) from the lower Tarawera River

Figure 8. Large goldfish (432 mm fork length, 2,778 g) from the old Rangitaiki River channel.

5. Discussion

As the main purpose of this fishing was to establish the identity of large orange fish seen in and round the lower Tarawera and the Awatapu Lagoon, the occurrence of goldfish was significant. From the size and colour ranges and abundance of the goldfish caught it is highly likely that any orange fish seen were large orange goldfish and not koi carp. However, before this fishing it was quite reasonable to conclude that large orange fish might be koi carp. This is similar to the Kaituna River, where goldfish were found but there were no koi carp (Hicks et al. 2014). The high diversity of native fish species in the lower Tarawera River (e.g., 7 species at site T4) is predictable from known fish distribution patterns, where the most diverse fish communities are found close to the coast (Hicks et al. 2005a, Jowett and Richardson 1996). The occurrence of parore is unusual in freshwater, as these are generally considered to be a marine species, but do stray into estuaries (Ayling and Cox 1982); parore have not been recorded in the NZ Freshwater Fish Database, and McDowall (1990, 2000) does not record them as a freshwater species, despite including yelloweye mullet and stargazers as fish known to inhabit fresh waters. Parore could be a regular inhabitant of coastal fresh waters of the Bay of Plenty as they were also observed downstream of the flapgate inlet to the Matata Lagoon (Figure 2B, -37 53' 33.15" S, 176 47' 7.04" E) about 10 years ago (pers. comm., Rob Donald, Bay of Plenty Regional Council). One giant bully was found in this survey, and these are quite common in the lower reaches of large river systems (Hicks et al. 2005b). Yelloweye mullet are also common in Bay of Plenty fresh waters close to the sea (Hicks et al. 2005b). Stargazers are a relatively unusual catch, but we have found these previously in Bay of Plenty rivers and in the lower Manawatu River (Hicks et al. 2003, Hicks et al. 2005b).

In 2005 we concluded that the Awatapu Lagoon appeared to have good stocks of native fish species including shortfin eels, inanga, and common smelt. Despite the lack of quantitative estimates in 2005 except for eels at one site, it is probable that the abundance of common smelt and inanga was lower in 2014. The abundance of common bullies was greater in 2014, however, and giant and redfin bullies were found in 2014 but not in 2005. Shortfin eels were moderately abundant in the Tarawera River and Awatapu Lagoon in 2014, but were more abundant in 2005 at the one site where they were enumerated (East Lagoon, 1.87 eels 100 m^{-2}), compared to the range of 0.35-0.96 eels 100 m^{-2} at four sites in 2014. It is possible that there has been a reduction in recruitment of diadromous fish since 2005.

Fish abundance estimates referred to in this report are all derived from single-pass boat electrofishing, so are the estimates of relative abundance are robust but these are not estimates of absolute abundance, which can be derived from removal electrofishing (Hicks et al. 2006). It is most likely that the abundance of eels was underestimated in this survey because previous boat electrofishing has shown that first-pass estimates can be as low as 5-19% of the population estimate form shortfin eels (Hicks et al. 2006; Hicks, unpublished data).

6. Acknowledgements

We thank Peter Livingstone from the Department of Conservation, Whakatane, for research assistance. The study was funded by the Department of Conservation and the Bay of Plenty Regional Council. All photos were taken by Brendan Hicks.

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