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Boat electrofishing survey of fish abundance in the Ohau Channel, Rotorua, in 2015

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by

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Cover picture: View of the upstream (Lake Rotorua) end of the Ohau Channel with the weir in the background. Photo: Brendan Hicks.

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Executive summary

The aim of the survey was to provide on-going monitoring of the fish communities and abundance by boat electrofishing in the Ohau Channel, especially fish species that are taonga to Maori (eels, goldfish, and koura). In the current study, we present the findings from the ninth year of sampling (2015) and a summary of previous surveys.

We used the University of Waikato's 4.5 m-long, aluminium-hulled electrofishing boat to catch a total of total of 1,198 fish and koura (18.9 kg) at 13 sites on 2 December 2015, which comprised 2,671 lineal m and 10,684 m^2 in area. Koura (freshwater crayfish) and 6 fish species were present, with common bully the most abundant species (up to 45.5 fish 100 m^{-2} at the site 6, edge habitat). Goldfish (up to 4.85 100 m^{-2}) was the next most abundant species, with most goldfish at sites 7 and 12-13 in and around the side channel. Rainbow trout densities were up to 0.28 fish 100 m^{-2}. Mean bully density (11.41 fish 100 m^{-2}) was much higher than for smelt (0.29 fish 100 m^{-2}). Koura had a patchy distribution; only 3 individuals were caught at one site.

Comparing catches over the 9 years of sampling, the mean abundance of common bullies in 2015 was consistent with densities in most post-wall years (after 2007), but lower than in 2007 before wall closure (ANOVA $P = 0.001$). The cause of fluctuating bully abundance is not known, and was not accounted for by changes in water clarity expressed as black disc distance (BDD), water temperature, or water conductivity. Poor water clarity can reduce the efficiency of electrofishing, but high BDD did not correspond with high common bully densities. In 2015, smelt abundance had recovered somewhat from the low catch in 2014.

Goldfish biomass increased initially (2009-2010) because of targeted fishing in the excavated side branch (site 11), which has dense macrophytes and offers good habitat for goldfish. The continued rise in density from 2012 on, however, suggests a real increase in goldfish numbers. In 2012 and 2013 shortfin eels were caught, but no eels were caught in 2014 and only a single longfin eel was caught in 2015.

Analysis of fish densities before and after wall closure is hampered by the single data point before closure. However, we now have 9 years of post-wall data, and comparison of means suggest that the number of bullies has been lower since 2007. An obvious cause could be interruption of bully migration into the Ohau Channel from Lake Rotoiti by the wall. This suggests that the bully population in the Ohau Channel before wall construction and closure was a mixture of fish from lakes Rotorua and Rotoiti, and that recruitment from Rotoiti is now restricted. This hypothesis is testable with otolith microchemistry.

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1. Introduction

The Bay of Plenty Regional Council (BOPRC) contracted the University of Waikato to conduct a survey of the fish abundance in the Ohau Channel. Similar surveys using boat electrofishing had been previously carried out in each December from 2007 to 2012 (Brijs et al. 2008, 2009, 2010, Hicks et al. 2011, 2013, 2014, 2015, 2016; Table 1). The original purpose of this series of surveys was to apply an independent method to estimate the densities of common smelt and bullies in the Ohau Channel at fixed points along the bank that coincided with trap netting sites used by the National Institute of Water and Atmospheric Research (NIWA). Since the low number of smelt captured by a single day's boat electrofishing became apparent compared to the numbers captured by seasonal trapping, the aim of the survey was modified to provide on-going monitoring of the fish communities and abundance in the Ohau Channel, especially fish species that are taonga to Maori (eels, goldfish, and koura). In the current study, we present the findings from the 9th year of sampling (2015) and a summary of previous surveys.

Table 1. Summary of reports describing boat electrofishing in the Ohau Channel. This report is ERI report 86.

Series	Report number	Fishing year	Authors and web link
CBER report	66	2007	Brijs et al. (2008)
CBER report	97	2008	Brijs et al. (2009)
CBER report	112	2009	Brijs et al. (2010)
CBER report	124	2010	Hicks et al. (2011)
ERI report	26	2011, 2012	Hicks et al. (2013)
ERI report	47	2013	Hicks et al. (2014)
ERI report	65	2014	Hicks et al. (2015)
ERI report	86	2015	Hicks et al. (2016)

2. Methods

We used a 4.5 m-long, aluminium-hulled electrofishing boat with a 5-kilowatt pulsator (GPP, model 5.0, Smith-Root Inc, Vancouver, Washington, USA) powered by a 6-kilowatt custom-wound generator. Two anode poles, each with an array of six stainless steel droppers, created the fishing field at the bow, with the boat hull acting as the cathode. A total of 13 sites in the Ohau Channel were fished in 2015 (Table 2, Figure 1).

Electrofishing commenced immediately downstream of the concrete and gabion weir at the outlet of Lake Rotorua and proceeded to downstream towards Lake Rotoiti. The sites were spread throughout the Ohau Channel and generally incorporated different habitat characteristics representative of the entire channel. We applied a fishing effort of 10 minutes at each site, which included littoral areas, macrophyte beds and mid-channel habitats.

Table 2. Habitat types and dimensions of sites that were boat electrofished in the Ohau Channel on 2 December 2015.

Site	Description	Length (m)	Area (m^2)	Depth range (m)
1	Edge habitat below weir	212	848	0.2-1.4
2	Edge habitat	258	1032	0.4-2.0
3	Partly edge, partly mid-channel habitat	160	640	1.4-2.2
4	Mid-channel habitat	341	1364	1.4-2.3
5	Edge habitat	144	576	0.2-1.2
6	Edge habitat true left bank	168	672	0.2-1.2
7	Mid-channel habitat	303	1212	0.1-2.7
8	Edge habitat	163	652	0.2-1.6
9	Edge habitat true right bank	177	708	0.2-2.9
10	Edge habitat true left bank	242	968	1.2-2.0
11	Edge habitat	190	760	0.2-2.8
12	Side channel	196	784	0.2-1.2
13	Side channel	117	468	0.2-1.2
Total		2,671	10,684	

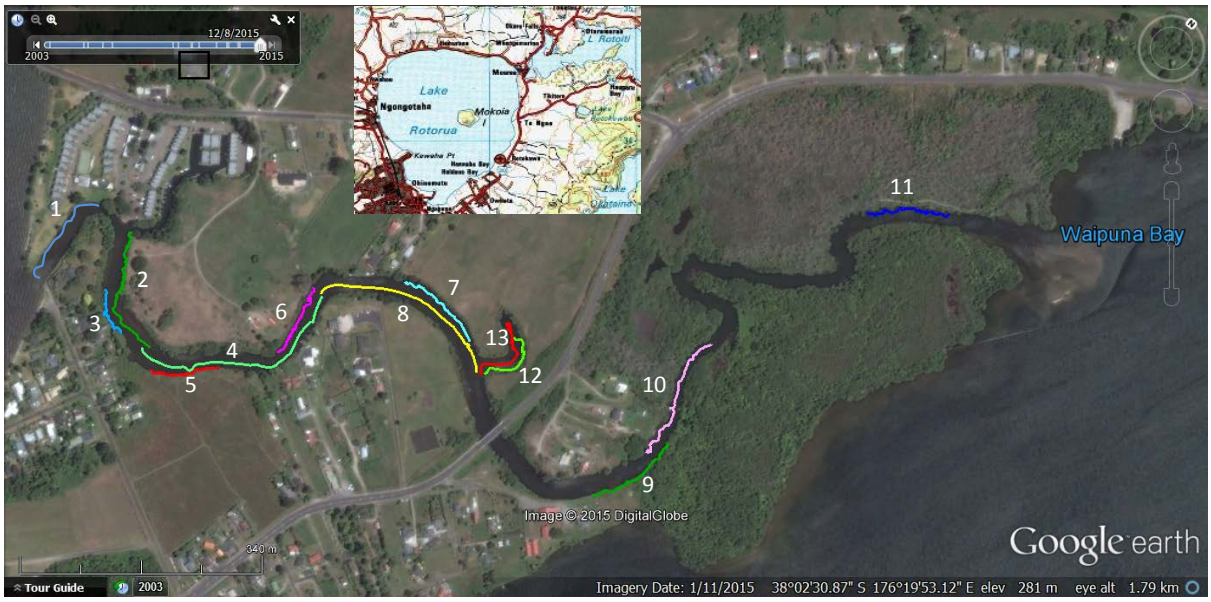

Figure 1. Fishing transects sampled on 2 December 2015 in the Ohau Channel starting from the Lake Rotorua end (site 1) down to the Lake Rotoiti end (site 11). Site numbers correspond to locations in Table 2. Inset shows the position of the Ohau Channel between lakes Rotorua and Rotoiti.

Prior to fishing, electrical conductivity was measured with a YSI 3200 conductivity meter and horizontal underwater visibility was measured using a black disc (Davies-Colley 1988). All sites were fished with the pulsator set to low range (50-500 V direct current) and a frequency of 60 pulses per second. The percent of range of the pulsator was set to 60%, which gave an applied current of 3-4 A root mean square. From past experience, an effective fishing field was noted to achieve a depth of about 2-3 m, and 2 m either side of the centre-line of the boat. This suggests that the boat fished a transect about 4-m wide, consistent with behavioural reactions of fish at the water surface, and so the linear distance fished, measured with hand-held Garmin GPSMAP 60Cx global positioning system, was multiplied by 4 m to calculate the area fished (Table 2).

All goldfish, smelt, and bullies were euthanised in benzocaine after collection then transferred into labelled bags for weighing (g) and measurement (mm) back at the lab for processing. Trout and eels were then anaesthetised in benzocaine, measured, and allowed to recover in labelled 4-mm mesh holding bags that were secured in the channel at each sample station. When all sites had been fished, holding bags at each site were recovered and the trout and eels were released at their point of capture.

3. Study site

The Ohau Channel begins below the weir that controls the outflow of Lake Rotorua; the current is relatively fast at this point. As distance from the weir increases the current slows as the channel widens and deepens and an increase in the extent of macrophyte beds occurs. At the downstream end of the Ohau Channel before it discharges into Lake Rotoiti the littoral zone is mainly dominated by willows.

Water temperature at the starting point of fishing was 17.8^{o}C at 1030 h NZDST on 2 December 2015 and the fishing depth ranged between 0.2 to 2.9 m (Table 2). Specific conductivity, i.e., standardised to 25^{o}C, was 202.9 μS cm^{-1}, and ambient conductivity, which controls power transfer of the electrical field, was 174.6 μS cm^{-1}. The riparian zones of the Ohau Channel were consisted mainly of residential gardens and pasture in the upstream half of the channel (the Lake Rotorua end) and riparian willows in the downstream half of the channel (near Lake Rotoiti). The submerged macrophytes oxygen weed (*Lagarosiphon major*), curly-leafed pondweed (*Potamogeton crispus*) and parrot's feather (*Myriophyllum aquaticum*), were observed throughout the channel as well as occasional freshwater mussels (*Echyridella menziesii*) in bare sandy areas. The black disc distance (BDD) was 1.15 m.

4. Results and discussion

Fish density and biomass by site

A total of 1,198 fish (18.9 kg) were caught at the 13 sites that were fished in 2015, which comprised 2,671 lineal m and 10,684 m^2 in area (Table 2). Koura and 6 fish species were present, with common bully the most abundant species (1,042 fish; Table 3). Goldfish (62 fish) was the next most abundant species, and was most abundant at sites 7 and 12, the excavated side channel. Common smelt were next the most abundant species (23 fish). Koura had a patchy distribution; only 3 individuals were caught at one site. Koura were seen at other sites but not caught. Rainbow trout comprised the greatest total biomass (Table 4).

Common bullies had the highest densities of any fish species in 2015 (up to 46 fish 100 m^{-2} at the site 6, edge habitat; Table 5); common smelt were much less abundant (up to 1.50 fish 100 m^{-2}). Mean bully density (11.41 fish 100 m^{-2}) was much higher than for smelt (0.29 fish 100 m^{-2}; Table 5). Rainbow trout and the longfin eel had the greatest areal biomass of any species (Table 6) because of the large size of individuals (Table 7). Catch per unit effort (for time) reflected species density at each site (Table 8).

Table 3. Total number of each species in the Ohau Channel collected in 10-min passes at 13 sample sites with boat electrofishing on 2 December 2015. Blank cells indicate no catch for that species.

Site	Number of individuals per site							
	Common bully	Common smelt	Gambusia	Goldfish	Longfin eel	Rainbow trout	Koura	Total
1	155	4						159
2	33					6		39
3	72	7						79
4	3			1		2		6
5	30					1	3	34
6	306							306
7	25			12		1		38
8	127							127
9	108	5	2	2		2		119
10	118		1	2				121
11	65			3		4		72
12	36			38				74
13	12	7		4	1			24
Total	1042	23	3	62	1	16	3	1198

Table 4. Biomass by species in the Ohau Channel collected in 10-min passes at 13 sample sites with boat electrofishing on 2 December 2015. Blank cells indicate no catch for that species.

Site	Biomass (g) per site							
	Common bully	Common smelt	Gambusia	Goldfish	Longfin eel	Rainbow trout	Koura	Total
1	157.3	4.5						161.7
2	23.6					4561.4		4585.0
3	88.0	8.5						96.5
4	5.5			150.2		916.7		1072.4
5	15.6					1711.3	128.8	1726.9
6	198.6							198.6
7	18.9			2257.3		42.2		2318.4
8	93.4							93.4
9	155.5	4.8	0.2	146.7		77.9		385.1
10	43.2		0.2	342.3				385.8
11	66.9			30.0		17.2		114.1
12	48.8			3179.9				3228.7
13	10.6	6.2		126.0	4399.7			4542.6
Total	925.8	24.0	0.45	6232.4	4400	7327	128.8	18909

Table 5. Density of each species in the Ohau Channel collected in 10-min passes at 13 sample sites with boat electrofishing on 2 December 2015.

Site	Density (number 100 m^{-2})							
	Common bully	Common smelt	Gambusia	Goldfish	Longfin eel	Rainbow trout	Koura	Total
1	18.28	0.47	0.00	0.00	0.00	0.00	0.00	18.75
2	3.20	0.00	0.00	0.00	0.00	0.58	0.00	3.78
3	11.25	1.09	0.00	0.00	0.00	0.00	0.00	12.34
4	0.22	0.00	0.00	0.07	0.00	0.15	0.00	0.44
5	5.21	0.00	0.00	0.00	0.00	0.17	0.52	5.90
6	45.54	0.00	0.00	0.00	0.00	0.00	0.00	45.54
7	2.06	0.00	0.00	0.99	0.00	0.08	0.00	3.14
8	19.48	0.00	0.00	0.00	0.00	0.00	0.00	19.48
9	15.25	0.71	0.28	0.28	0.00	0.28	0.00	16.81
10	12.19	0.00	0.10	0.21	0.00	0.00	0.00	12.50
11	8.55	0.00	0.00	0.39	0.00	0.53	0.00	9.47
12	4.59	0.00	0.00	4.85	0.00	0.00	0.00	9.44
13	2.56	1.50	0.00	0.85	0.21	0.00	0.00	5.13
Mean	11.41	0.29	0.03	0.59	0.02	0.14	0.04	12.52

Table 6. Areal biomass of fish and koura in the Ohau Channel collected in 10-min passes at 13 sample sites with boat electrofishing on 2 December 2015.

Site	Biomass (g m^{-2})							
	Common bully	Common smelt	Gambusia	Goldfish	Longfin eel	Rainbow trout	Koura	Total
1	0.19	0.01	0.00	0.00	0.00	0.00	0.00	0.19
2	0.02	0.00	0.00	0.00	0.00	4.42	0.00	4.44
3	0.14	0.01	0.00	0.00	0.00	0.00	0.00	0.15
4	0.00	0.00	0.00	0.11	0.00	0.67	0.00	0.79
5	0.03	0.00	0.00	0.00	0.00	2.97	0.22	3.22
6	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.30
7	0.02	0.00	0.00	1.86	0.00	0.03	0.00	1.91
8	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.14
9	0.22	0.01	0.00	0.21	0.00	0.11	0.00	0.54
10	0.04	0.00	0.00	0.35	0.00	0.00	0.00	0.40
11	0.09	0.00	0.00	0.04	0.00	0.02	0.00	0.15
12	0.06	0.00	0.00	4.06	0.00	0.00	0.00	4.12
13	0.02	0.01	0.00	0.27	9.40	0.00	0.00	9.71
Mean	0.10	0.00	0.00	0.53	0.72	0.63	0.02	2.00

Table 7. Mean individual weight of fish caught in Ohau Channel collected at 13 sample sites with boat electrofishing on 2 December 2015. A subsample of 30 fish were weighed where total number at a site exceeded 30.

Site	Mean individual weight (g)						
	Common bully	Common smelt	Gambusia	Goldfish	Longfin eel	Rainbow trout	Koura
1	1.0	1.1					
2	0.7					760.2	
3	1.2	1.2					
4	1.8			150.2		458.4	
5	0.5					1711.3	42.9
6	0.6						
7	0.8			188.1		42.2	
8	0.7						
9	1.4	1.0	0.1	73.4		39.0	
10	0.4		0.2	171.2			
11	1.0			10.0		4.3	
12	1.4			83.7			
13	0.9	0.9		31.5	4399.7		

Table 8. Catch per unit effort of common bully, common smelt, goldfish and rainbow trout in the Ohau Channel caught at 13 sample sites with boat electrofishing on 2 December 2015.

Site	Time fished (min)	Catch per unit effort (fish min^{-1})			
		Common bully	Common smelt	Goldfish	Rainbow trout
1	10	15.50	0.40	0.00	0.00
2	10	3.30	0.00	0.00	0.60
3	10	7.20	0.70	0.00	0.00
4	10	0.30	0.00	0.10	0.20
5	10	3.00	0.00	0.00	0.10
6	10	30.60	0.00	0.00	0.00
7	10	2.50	0.00	1.20	0.10
8	10	12.70	0.00	0.00	0.00
9	10	10.80	0.50	0.20	0.20
10	10	11.80	0.00	0.20	0.00
11	10	6.50	0.00	0.30	0.40
12	10	3.60	0.00	3.80	0.00
13	8	1.50	0.88	0.50	0.00
Total	128				
Mean		8.41	0.19	0.48	0.12

Fish abundance by year

Comparing catches over the 9 years of sampling, the abundance of all species combined in 2015 (1,198 fish, comprising 1,042 common bullies, and 3 koura) was greater than all other post-wall closure catches (Table 9A). However, the area fished was also greater than in the first two fishing years, so densities (12.5 fish and koura 100 m^{-2}) was about half the pre-wall catch (Table 9B). The cause of fluctuating bully abundance is not known, and was not accounted for by changes in water clarity expressed as black disc distance (BDD), water temperature, or water conductivity (Table 11). Poor water clarity can reduce the efficiency of electrofishing, but BDD was greater in 2012 than in 2011 when common bully densities were lower. In 2014, smelt catches were extremely low.

Goldfish biomass increased initially (2009-2010) because of targeted fishing in the excavated side branch (site 11), which has dense macrophytes and offers good habitat for goldfish. The continued rise in density from 2012 on suggests a real increase in goldfish numbers. In 2012 and 2013 shortfin eels were caught, but no eels were caught in 2014. One longfin eel was caught in 2015.

Table 9. A. Number of fish and koura and B. mean fish and koura densities in the Ohau Channel measured by boat electrofishing between 2007 and 2015. (Source of data: Brijs et al. 2008, 2009, 2010, Hicks et al. 2011, 2013, 2014, 2015, and this survey).

A. Number of fish and koura

Year	Total all species	Common bully	Common smelt	Goldfish	Longfin eel	Shortfin eel	Rainbow trout	Brown trout	Gambusia	Koura	Time fished (min)	Distance fished (m)	Area fished (m^2)
2007	1,267	1,099	140	9	2	0	17	0	0	0	82	1,582	6,328
2008	774	429	311	2	1	0	31	0	0	0	100	2,033	8,133
2009	353	149	152	8	1	0	43	0	0	0	101	2,721	10,884
2010	921	604	206	18	1	0	92	0	0	0	112	3,488	13,952
2011	399	298	39	28	4	0	25	2	1	2	129	2,721	10,884
2012	301	117	131	33	1	1	15	1	0	2	115	3,625	14,500
2013	1,025	583	373	42	1	1	23	1	0	1	112	2,871	11,484
2014	642	561	7	56	0	0	13	0	0	5	106	2,914	11,656
2015	1,198	1,042	23	62	1	0	16	0	3	3	128	2,671	10,684

B. Mean fish and koura densities

	Density (individuals 100 m^{-2})									
Year	Total all species	Common bully	Common smelt	Goldfish	Longfin eel	Shortfin eel	Rainbow trout	Brown trout	Gambusia	Koura
2007	20.02	17.37	2.21	0.14	0.03	0.00	0.27	0.00	0.00	0.00
2008	9.52	5.27	3.82	0.02	0.01	0.00	0.38	0.00	0.00	0.00
2009	3.24	1.37	1.40	0.07	0.01	0.00	0.40	0.00	0.00	0.00
2010	6.60	4.33	1.48	0.13	0.01	0.00	0.66	0.00	0.00	0.00
2011	3.67	2.74	0.36	0.26	0.04	0.00	0.23	0.02	0.01	0.02
2012	2.08	0.81	0.90	0.23	0.01	0.01	0.10	0.01	0.00	0.01
2013	8.93	5.08	3.25	0.37	0.01	0.01	0.20	0.01	0.00	0.01
2014	5.51	4.81	0.06	0.48	0.00	0.00	0.11	0.00	0.00	0.04
2015	11.21	9.75	0.22	0.58	0.01	0.00	0.15	0.00	0.03	0.03

Analysis of fish densities before and after wall closure is hampered by the single data point before closure. However, we now have 9 years of post-wall data, and comparison of means and standard deviations suggest that the number of bullies has decreased (ANOVA P = 0.001; Figure 2). A multiple means comparison shows that the mean density in 2007 was greater than any other year (Table 10).

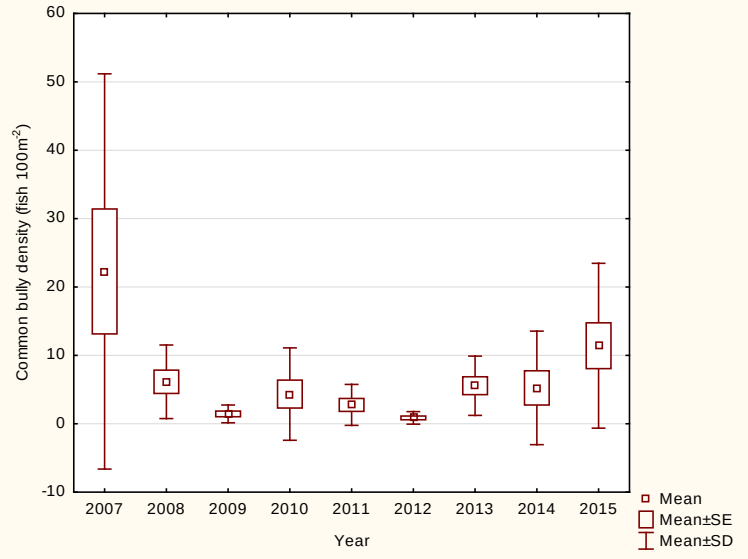

Figure 2. Comparison of common bully densities in the Ohau Channel before wall closure (2007) compared to after wall closure (2008-2015). Error bars are 1 standard deviation, boxes are 1 standard error.

Table 10. Newman-Keuls multiple range test of mean common bully densities in the Ohau Channel estimated by boat electrofishing between 2007 (before wall closure) and 2008-2015 after wall closure. Values in red are significant at $p < 0.05$.

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015
2007		0.004	0.001	0.005	0.002	0.001	0.005	0.006	0.027
2008	0.004		0.925	0.982	0.956	0.928	0.905	0.981	0.277
2009	0.001	0.925		0.820	0.786	0.904	0.913	0.860	0.381
2010	0.005	0.982	0.820		0.743	0.888	0.965	0.852	0.587
2011	0.002	0.956	0.786	0.743		0.918	0.937	0.864	0.475
2012	0.001	0.928	0.904	0.888	0.918		0.925	0.893	0.369
2013	0.005	0.905	0.913	0.965	0.937	0.925		0.948	0.449
2014	0.006	0.981	0.860	0.852	0.864	0.893	0.948		0.579
2015	0.027	0.277	0.381	0.587	0.475	0.369	0.449	0.579	

It is not clear whether the reduced abundance of bullies since wall closure is a result of changes of recruitment from Lake Rotoiti or in-channel recruitment.

An intriguing trend of decreasing rainbow trout densities with increasing BDD, which is a measure of both water clarity and phytoplankton abundance, has occurred following wall construction (Figure 3). The trend of decreasing fish capture with increasing water clarity is

contrary to the usual trend where catch rates increase with increasing water clarity. The explanation for this is not immediately clear, but increased phytoplankton abundance leading to increased food availability for trout is a possibility.

Table 11. Conductivity and black disc distance measured in the in the Ohau Channel at the time of boat electrofishing surveys between 2007 and 2015. NZDST = New Zealand daylight saving time, i.e., UTC+13 h. UTC = Universal time coordinated. (Source of data: Brijs et al. 2008, 2009, 2010, Hicks et al. 2011, 2013, 2014, 2015, and this survey).

Date	Time (h NZDT)	Water temperature (°C)	Ambient conductivity (µS cm^{-1})	Specific conductivity (µS cm^{-1})	Black disc distance (m)
13-Dec-07	1015	18.8	159.3	180.9	2.00
11-Dec-08	1030	20.4	167.8	183.7	0.80
7-Dec-09	1045	19.4	172.4	193.4	0.65
7-Dec-10	1100	20.1	169.7	187.4	0.50
5-Dec-11	1030	17.8	148.5	173.5	0.85
4-Dec-12	0900	17.4	144.1	169.4	1.30
27-Nov-13	1100	20.9	169.3	183.5	0.80
9-Dec-14	1030	18.4	163.0	184.2	1.45
2-Dec-15	1042	17.8	174.6	202.9	1.15

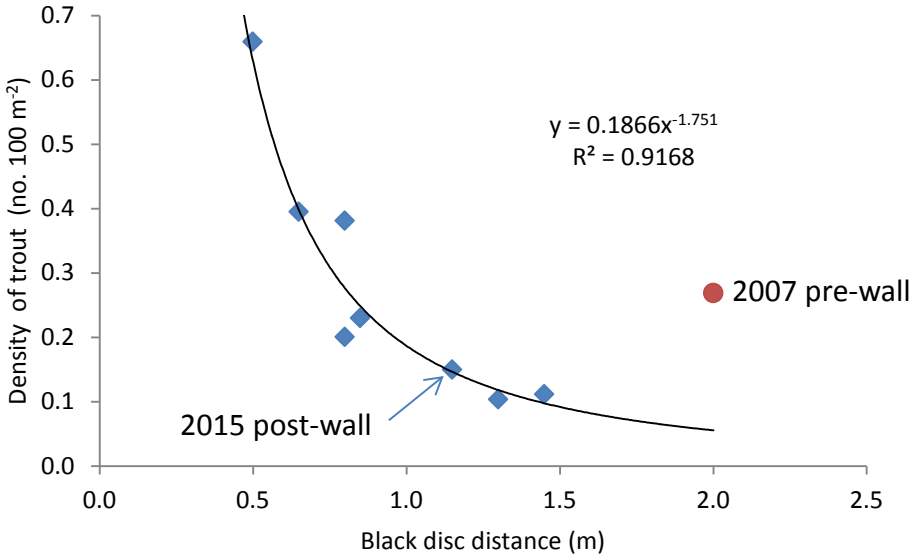

Figure 3. Relationship of rainbow trout density to black disc distance in the Ohau Channel between 2008 and 2015 following wall construction, excluding 2007 data before wall closure.

6. Acknowledgements

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7. References

Brijs, J., Hicks, B. J. and Bell, D. G. (2008). Boat electrofishing survey of common smelt and common bullies in the Ohau Channel. *CBER Contract Report No. 66.* Client report prepared for Environment Bay of Plenty. Centre for Biodiversity and Ecology Research, Department of Biological Sciences, The University of Waikato, Hamilton.

Brijs, J., Hicks, B. J. and Bell, D. G. (2009). Boat electrofishing survey of common smelt and common bullies in the Ohau Channel. *CBER Contract Report No. 97.* Client report prepared for Environment Bay of Plenty. Centre for Biodiversity and Ecology Research, Department of Biological Sciences, The University of Waikato, Hamilton.

Brijs, J., B.J. Hicks, and D.G. Bell. 2010. Boat electrofishing survey of common smelt and common bully in the Ohau Channel in December 2009. *CBER Contract Report No. 112.* Prepared for Environment Bay of Plenty. Centre for Biodiversity and Ecology Research, Department of Biological Sciences, School of Science and Engineering, The University of Waikato, Hamilton.

Davies-Colley, R. J. 1988. Measuring water clarity with a black disk. *Limnology and Oceanography 33*: 616-623.

Hicks, B.J., Bell, D.G. and Powrie, W. 2014. Boat electrofishing survey of fish abundance in the Ohau Channel, Rotorua, in 2013. ERI Report No. 47. Client report prepared for Bay of Plenty Regional Council. Environmental Research Institute, Faculty of Science and Engineering, University of Waikato, Hamilton, New Zealand.

Hicks, B.J., Bell, D.G. and Powrie, W. 2015. Boat electrofishing survey of fish abundance in the Ohau Channel, Rotorua, in 2014. ERI Report No. 65. Client report prepared for Bay of Plenty Regional Council. Environmental Research Institute, Faculty of Science and Engineering, University of Waikato, Hamilton, New Zealand.

Hicks, B. J., Ling, N., Osborne, M. W., Bell, D. G., and Ring, C. A. (2005). Boat electrofishing survey of the lower Waikato River and its tributaries. *CBER Contract Report No. 39*. Client report prepared for Environment Waikato. Centre for Biodiversity and Ecology Research, Department of Biological Sciences, The University of Waikato, Hamilton.

Hicks, B.J., Tana, R. and Bell, D.G. 2011. Boat electrofishing survey of fish populations in the Ohau Channel in December 2010. CBER Contract Report No. 124. Prepared for Bay of Plenty Regional Council. Centre for Biodiversity and Ecology Research, Department of Biological Sciences, Faculty of Science and Engineering, The University of Waikato, Hamilton.

Hicks B. J., Tana R., and Bell D. G. 2013. Boat electrofishing surveys of fish populations in the Ohau Channel in 2011 and 2012. *ERI Report No. 26*. Client report prepared for Bay of Plenty Regional Council. Environmental Research Institute, Faculty of Science and Engineering, University of Waikato, Hamilton, New Zealand.

Rowe, D.K., Bowman, E., Dunford, A. and Smith, J. (2008). Smelt in Lake Rotoiti and the Ohau Channel, 2007-2008. *NIWA Client Report: HAM2008-081*. Client report prepared for Environment Bay of Plenty. National Institute of Water & Atmospheric Research Ltd, Hamilton.

Rowe, D.K., Bowman, E., Dunford, A. and Smith, J. (2008). Smelt in Lake Rotoiti and the Ohau Channel, 2008-2009. *NIWA Client Report: HAM2009-077*. Client report prepared for Environment Bay of Plenty. National Institute of Water & Atmospheric Research Ltd, Hamilton.