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Boat electrofishing survey of fish abundance in the Ohau Channel, Rotorua, in 2016

ERI Report Number 105

by

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Cover picture: Morihana (goldfish, *Carassius auratus*) from the Ohau Channel. 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 (tuna, or eels, morihana, or goldfish, and kōura, or freshwater crayfish). In the current study, we present the findings from the tenth year of sampling (2016) 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 1,340 fish (24.9 kg) at 10 sites on 28 November 2016, which comprised 2,791 lineal m and 11,164 m^2 in area. Seven fish species were present, with common bully the most abundant species (up to 72.9 fish 100 m^{-2} at site 5, which was edge habitat). Goldfish (up to 5.71 fish 100 m^{-2}) was the next most abundant species, with most goldfish at sites 5 and 8 in and around an excavated side channel. Rainbow trout were next the most abundant species (up to 0.75 fish 100 m^{-2}). Mean density for common bullies (11.71 fish 100 m^{-2}) was much higher than for common smelt (0.49 fish 100 m^{-2}). Eels and kōura were not caught in 2016.

Comparing catches over the 10 years of sampling, the mean abundance of common bullies in 2016 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 2016, smelt abundance was higher than 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.

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 decreased since 2007. A possible cause could be interruption of bully migration into the Ohau Channel from Lake Rotoiti by the wall but variable bully recruitment in the channel is also possible.

Since wall construction, decreased rainbow trout densities have been associated with increased BDD, contrary to the expected decline of catch rate by boat electrofishing with reduced water clarity. The reason for this is unclear.

Table of contents

List of tables

List of figures

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 late November or early December from 2007 to 2016 (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 (tuna, or eels; morihana, or goldfish; and kōura, or freshwater crayfish). In the current study, we present the findings from the 10th year of sampling (2016) and a summary of previous surveys.

Table 1. Summary of reports describing boat electrofishing in the Ohau Channel. This report is ERI report 105.

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)
ERI report	105	2016	Hicks et al. (2017)

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 10 sites in the Ohau Channel were fished in 2016 (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 28 November 2016.

Site	Description	Length (m)	Area (m^2)	Depth range (m)
1	Edge habitat below weir	175	700	0.3-1.5
2	Edge habitat	169	676	0.2-1.4
3	Mid-channel habitat	445	1780	0.6-1.7
4	Edge habitat	203	812	0.2-1.3
5	Edge habitat	268	1072	0.2-1.0
6	Edge habitat	186	744	0.3-1.9
7	Mid-channel habitat	462	1848	1.9
8	Side channel	92	368	0.6-1.7
9	Edge habitat	441	1764	0.4-1.9
10	Edge habitat	350	1400	0.4-1.9
Total		2,791	11,164	

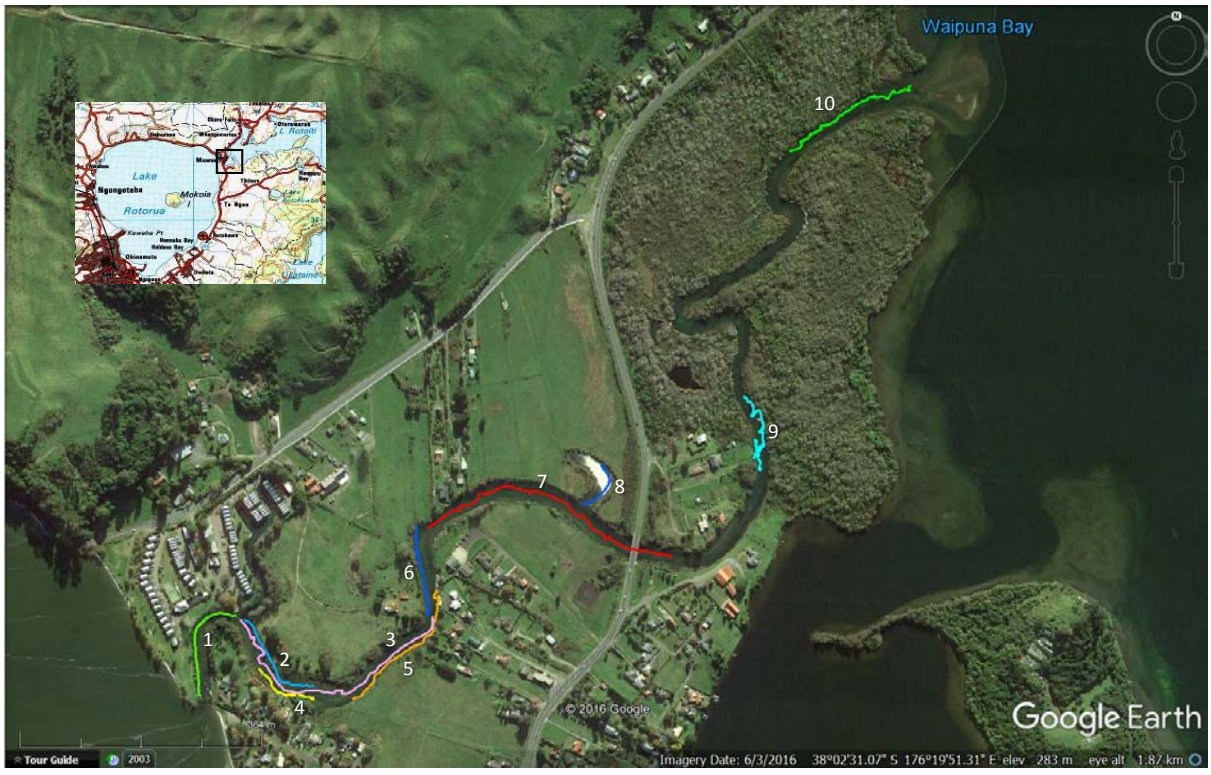

Figure 1. Fishing transects sampled on 28 November 2016 in the Ohau Channel starting from the Lake Rotorua end (site 1) down to the Lake Rotoiti end (site 10). Site numbers correspond to locations in Table 2. Inset shows the position of the Ohau Channel between lakes Rotorua and Rotoiti.

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 about 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.

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 16.0^{o}C at 1040 h New Zealand Daylight Time on 28 November 2016 and the fishing depth ranged between 0.2 to 1.9 m (Table 2). Specific conductivity, i.e., standardised to 25^{o}C, was 188.2 μS cm^{-1}, and ambient conductivity, which controls power transfer of the electrical field to fish, was 155.9 μS cm^{-1}. The riparian zones of the Ohau Channel 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), which measures horizontal underwater visibility (Davies-Colley 1988), was 0.90 m.

4. Results and discussion

Fish density and biomass by site

A total of 1,340 fish (24.7 kg) were caught at the 10 sites that were fished in 2016, which comprised 2,971 lineal m and 11,164 m^2 in area (Table 2). Five fish species were present, with common bully the most abundant species (1,162 fish; Table 3). Goldfish (78 fish) was the next most abundant species, and was most abundant at sites 5 and 8, the excavated side channel. Common smelt were next the most abundant species (62 fish). Goldfish comprised the greatest total biomass of any fish species (12.5 kg, Table 4).

Common bullies had the highest densities of any fish species in 2016 (up to 73 fish 100 m^{-2} at the site 5, edge habitat; Table 5); common smelt were much less abundant up (up to 2.5 fish 100 m^{-2}). Mean bully density (11.71 fish 100 m^{-2}) was much higher than for smelt (0.49 fish 100 m^{-2}; Table 5). Rainbow trout had the greatest areal biomass of any species (up to 1.90 g m^{-2}; Table 6) because of the large mean size of individuals (Table 7). Catch per unit effort (for time) reflected species density at each site and was greatest for bullies (Table 8).

Table 3. Total number of each species in the Ohau Channel collected in 10-min passes at 10 sample sites with boat electrofishing on 28 November 2016. Blank cells indicate no catch for that species.

Site	Number of individuals per site					
	Common bully	Common smelt	Goldfish	Rainbow trout	Brown trout	Total
1	41	1				42
2	14	3		4	1	22
3	2			10	1	13
4				1		1
5	782	7	55	8		852
6	113	2				115
7	98	2	1			101
8	42	3	21			66
9	54	44		5		103
10	16		1	7	1	25
Total	1,162	62	78	35		1,340

Table 4. Biomass by species in the Ohau Channel collected in 10-min passes at 10 sample sites with boat electrofishing on 28 November 2016.

Site	Biomass (g) per site					
	Common bully	Common smelt	Goldfish	Rainbow trout	Brown trout	Total
1	45.7	1.3	0.0	0.0	0.0	47.0
2	14.0	3.9	0.0	1286.6	99.8	1404.3
3	1.2	0.0	0.0	2094.9	2589.1	4685.2
4	0.0	0.0	0.0	272.7	0.0	272.7
5	651.7	12.8	10543.6	760.5	0.0	11968.6
6	76.8	3.7	0.0	0.0	0.0	80.5
7	124.5	1.9	72.6	0.0	0.0	199.0
8	31.3	3.5	1863.3	0.0	0.0	1898.1
9	23.7	36.4	0.0	31.0	0.0	91.1
10	11.9	0.0	53.4	3534.8	433.8	4033.9
Total	981	64	12,533	7,980	3,123	24,680

Table 5. Density of each species in the Ohau Channel collected in 10-min passes at 10 sample sites with boat electrofishing on 28 November 2016.

Site	Density (number 100 m^{-2})					
	Common bully	Common smelt	Goldfish	Rainbow trout	Brown trout	Total
1	5.86	0.14	0.00	0.00	0.00	6.00
2	2.07	0.44	0.00	0.59	0.15	3.25
3	0.11	0.00	0.00	0.56	0.06	0.73
4	0.00	0.00	0.00	0.12	0.00	0.12
5	72.95	0.65	5.13	0.75	0.00	79.48
6	15.19	0.27	0.00	0.00	0.00	15.46
7	5.30	0.11	0.05	0.00	0.00	5.47
8	11.41	0.82	5.71	0.00	0.00	17.93
9	3.06	2.49	0.00	0.28	0.00	5.84
10	1.14	0.00	0.07	0.50	0.07	1.79
Mean	11.71	0.49	1.10	0.28	0.03	13.61

Table 6. Areal biomass of fish in the Ohau Channel collected in 10-min passes at 10 sample sites with boat electrofishing on 28 November 2016.

Site	Biomass (g m^{-2})					
	Common bully	Common smelt	Goldfish	Rainbow trout	Brown trout	Total
1	0.07	0.00	0.00	0.00	0.00	0.07
2	0.02	0.01	0.00	1.90	0.15	2.08
3	0.00	0.00	0.00	1.18	1.45	2.63
4	0.00	0.00	0.00	0.34	0.00	0.34
5	0.61	0.01	9.84	0.71	0.00	11.16
6	0.10	0.00	0.00	0.00	0.00	0.11
7	0.07	0.00	0.04	0.00	0.00	0.11
8	0.09	0.01	5.06	0.00	0.00	5.16
9	0.01	0.02	0.00	0.02	0.00	0.05
10	0.01	0.00	0.04	2.52	0.31	2.88
Mean	0.10	0.01	1.50	0.67	0.19	2.46

Table 7. Mean individual weight of fish caught in Ohau Channel collected at 10 sample sites with boat electrofishing on 28 November 2016. A subsample of 30 fish were weighed where total number at a site exceeded 30. Blank cells indicate no data for that species.

Site	Mean individual weight (g)				
	Common bully	Common smelt	Goldfish	Rainbow trout	Brown trout
1	1.1	1.3			
2	1.0	1.3		321.7	99.8
3	0.6			209.5	2589.1
4				272.7	
5	0.8	1.8	191.7	95.1	
6	0.7	1.9			
7	1.3	1.0	72.6		
8	0.7	1.2	88.7		
9	0.4	0.8		6.2	
10	0.7		53.4	505.0	433.8

Table 8. Catch per unit effort of common bully, common smelt, goldfish and rainbow trout in the Ohau Channel caught at 10 sample sites with boat electrofishing on 28 November 2016.

Site	Time fished (min)	Catch per unit effort (fish min^{-1})		
		Common bully	Goldfish	Rainbow trout
1	10	4.10	0.00	0.00
2	10	1.40	0.00	0.40
3	10	0.20	0.00	1.00
4	10	0.00	0.00	0.10
5	10	78.20	5.50	0.80
6	10	11.30	0.00	0.00
7	10	9.80	0.10	0.00
8	10	4.20	2.10	0.00
9	10	5.40	0.00	0.50
10	10	1.60	0.10	0.70
Total	100			
Mean		11.62	0.78	0.35

Fish abundance by year

Comparing catches over the 10 years of sampling, the abundance of all species combined in 2016 (1,340 fish, comprising 1,162 common bullies) 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 mean total density (13.6 fish 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 8). 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. The large proportion of juveniles (<35 mm) in the bully catch suggests that recruitment is occurring in the channel (Figure 2).

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 and 2016.

Analysis of fish densities before and after wall closure is hampered by the single data point before closure. However, we now have 1 year of pre-wall data and 9 years of post-wall data. Comparison of means and standard deviations for each fishing year suggests that the catch of bullies was low between 2008 and 2014 (ANOVA $P = 0.007$; Figure 3). A multiple means comparison suggests that bully numbers have since recovered as means in 2015 and 2016 were not different from the mean in 2007 (Table 10).

Table 9. A. Number of fish and kōura and B. mean fish and kōura densities in the Ohau Channel measured by boat electrofishing between 2007 and 2016. (Source of data: Brijs et al. 2008, 2009, 2010, Hicks et al. 2011, 2013, 2014, 2015, 2016, and this survey).

A. Number of fish and kōura

Year	Date	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	13-Dec-07	1,267	1,099	140	9	2	0	17	0	0	0	82	1,582	6,328
2008	11-Dec-08	774	429	311	2	1	0	31	0	0	0	100	2,033	8,133
2009	7-Dec-09	353	149	152	8	1	0	43	0	0	0	101	2,721	10,884
2010	7-Dec-10	921	604	206	18	1	0	92	0	0	0	112	3,488	13,952
2011	5-Dec-11	399	298	39	28	4	0	25	2	1	2	129	2,721	10,884
2012	4-Dec-12	301	117	131	33	1	1	15	1	0	2	115	3,625	14,500
2013	27-Nov-13	1,025	583	373	42	1	1	23	1	0	1	112	2,871	11,484
2014	9-Dec-14	642	561	7	56	0	0	13	0	0	5	106	2,914	11,656
2015	2-Dec-15	1,198	1,042	23	62	1	0	16	0	3	3	128	2,671	10,684
2016	28-Nov-15	1,340	1,162	62	78	0	0	35	3	0	0	100	2,791	11,164

B. Mean fish and kōura densities

	Mean 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	26.15	22.28	3.30	0.14	0.03	0.00	0.41	0.00	0.00	0.00
2008	10.52	6.14	4.12	0.03	0.01	0.00	0.22	0.00	0.00	0.00
2009	3.34	1.45	1.46	0.07	0.01	0.00	0.36	0.00	0.00	0.00
2010	6.70	4.34	1.65	0.16	0.01	0.00	0.53	0.00	0.00	0.01
2011	3.76	2.76	0.32	0.31	0.04	0.00	0.27	0.03	0.01	0.02
2012	2.34	0.86	0.99	0.33	0.01	0.01	0.12	0.01	0.00	0.02
2013	10.25	5.56	3.97	0.53	0.01	0.01	0.16	0.01	0.00	0.01
2014	6.15	5.25	0.07	0.70	0.00	0.00	0.10	0.00	0.00	0.04
2015	12.52	11.41	0.29	0.59	0.02	0.00	0.14	0.00	0.03	0.04
2016	13.61	11.71	0.49	1.10	0.00	0.00	0.28	0.03	0.00	0.00

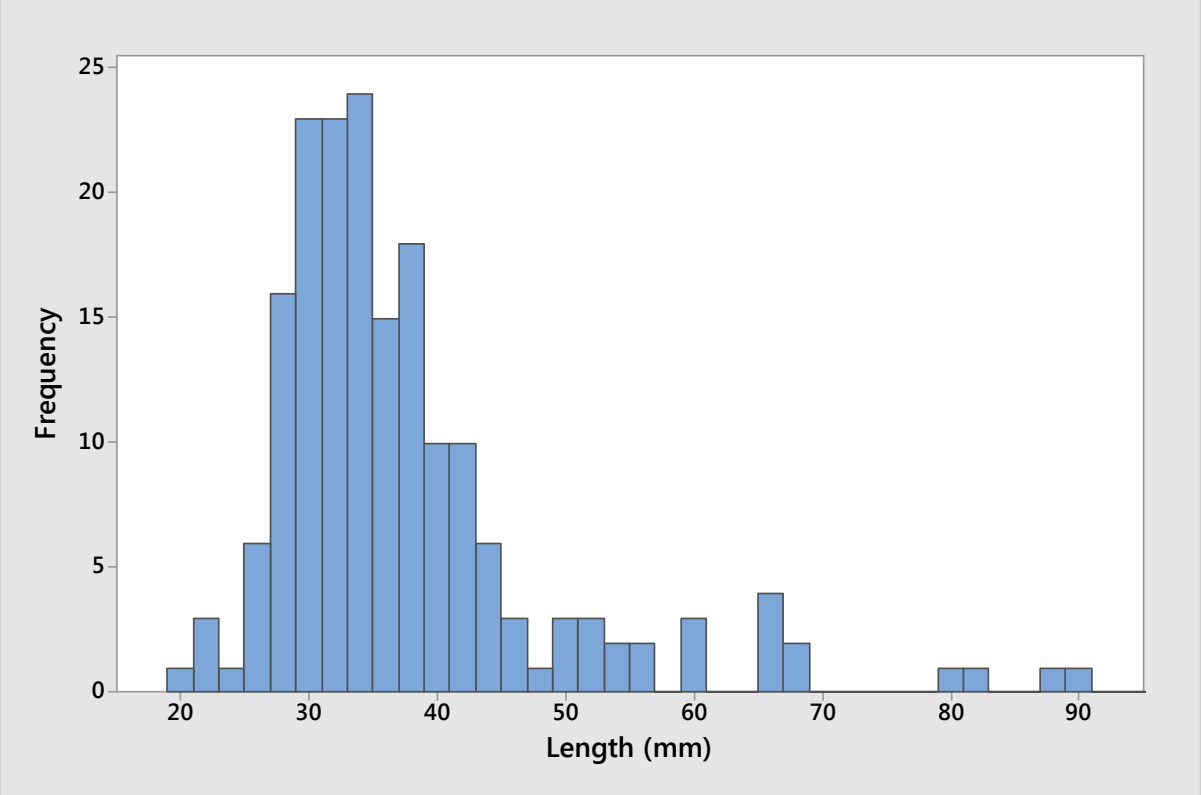

Figure 2. Length frequency of common bullies in the Ohau Channel caught by boat electrofishing on 28 Nov 2016.

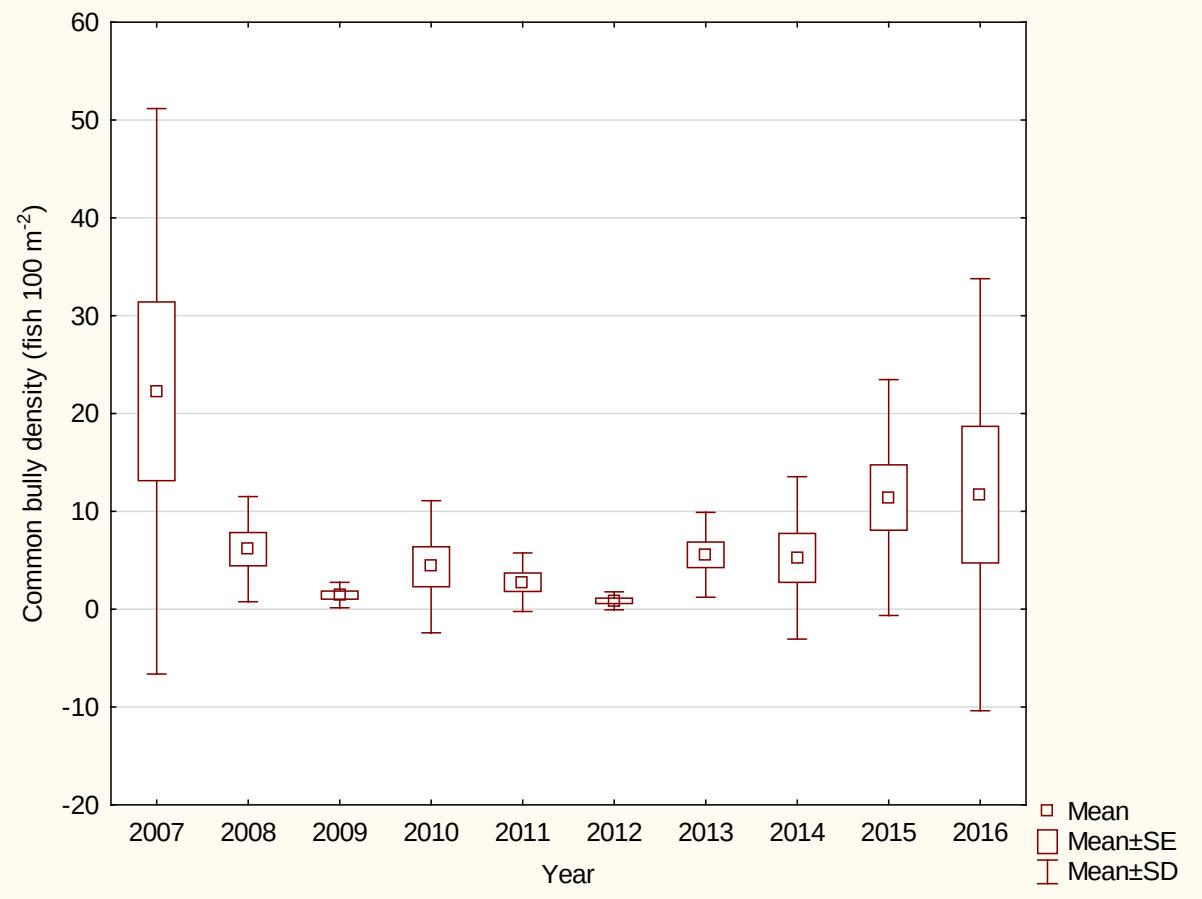

Figure 3. Comparison of common bully densities in the Ohau Channel before wall closure (2007) compared to after wall closure (2008-2016). Error bars are 1 standard deviation, boxes are 1 standard error.

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 2008-2016 after wall closure. Values in red italics are significant at $p < 0.05$.

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
2007		*0.024*	*0.006*	*0.022*	*0.011*	*0.005*	*0.025*	*0.028*	0.106	*0.049*
2008	*0.024*		0.949	0.987	0.969	0.954	0.913	0.984	0.582	0.720
2009	*0.006*	0.949		0.848	0.805	0.913	0.937	0.890	0.567	0.591
2010	*0.022*	0.987	0.848		0.766	0.913	0.971	0.865	0.766	0.806
2011	*0.011*	0.969	0.805	0.766		0.932	0.952	0.886	0.662	0.695
2012	*0.005*	0.954	0.913	0.913	0.932		0.949	0.922	0.553	0.569
2013	*0.025*	0.913	0.937	0.971	0.952	0.949		0.952	0.688	0.774
2014	*0.028*	0.984	0.890	0.865	0.886	0.922	0.952		0.772	0.827
2015	0.106	0.582	0.567	0.766	0.662	0.553	0.688	0.772		0.956
2016	*0.049*	0.720	0.591	0.806	0.695	0.569	0.774	0.827	0.956	

A possible cause could be interruption of bully migration 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 bully recruitment from Lake Rotoiti added to the population in the Ohau Channel but that this source of recruitment is now restricted by the wall. Given the high proportion of small juvenile bullies in the Ohau Channel it is possible that changes in bully recruitment in the channel is the cause of the variable densities. This hypothesis is testable with otolith microchemistry.

Since wall construction, decreased rainbow trout densities have been associated with increased BDD (Figure 4), contrary to the expected decline of catch rate by boat electrofishing with reduced water clarity. The reason for this is unclear.

Table 11. Conductivity and black disc distance measured in the in the Ohau Channel at the time of boat electrofishing surveys between 2007 and 2016. 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, 2016 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
28-Nov-16	1130	16.0	155.9	188.2	0.90

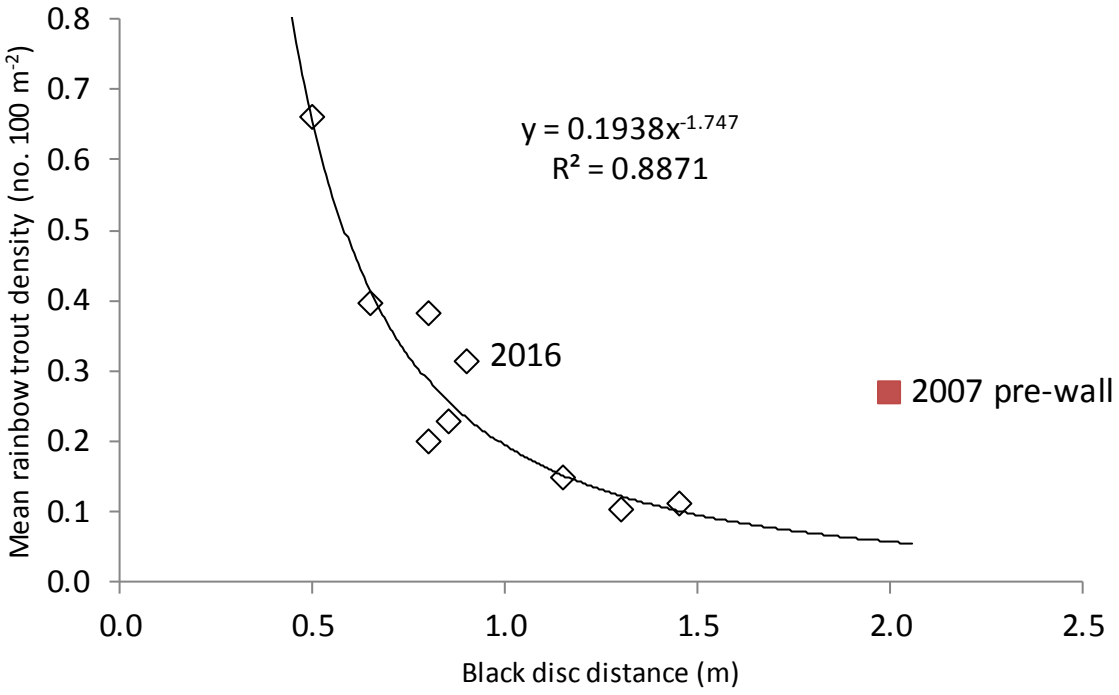

Figure 4. Relationship of rainbow trout density to black disc distance in the Ohau Channel between 2008 and 2016 following wall construction, excluding 2007 data before wall closure.

It is possible that westerly winds create turbulence and suspended material that drifts down the Ohau Channel, possibly increasing foods supply for smelt that in turn causes more trout to enter the channel. A strong westerly was blowing on 28 Nov 2016.

6. Acknowledgements

This research was funded by Bay of Plenty Regional Council. We thank Rob Donald of the Bay of Plenty Regional Council for his review.

7. References

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