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Boat electrofishing survey of fish abundance in the Ohau Channel, Rotorua, in 2017

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by

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Cover picture: Left: Kōura (59 g, 41 mm occiput-carapace length); right: 20-L pail containing 152 (17 kg) of morihana (goldfish) captured from the Ohau Channel on 5 December 2017. Photos: 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 eleventh year of sampling (2017) 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 1,110 fish and 3 kōura (18.2 kg in total) from 11 sites on 5 December 2017. The sites comprised 2,909 lineal m and 11,636 m^2 in area. Kōura (freshwater crayfish) and 6 fish species were present, with common bully the most abundant species (up to 29.6 fish 100 m^{-2} at the site 8, edge habitat). Goldfish (up to 14.2 100 m^{-2}) was the next most abundant species, with most goldfish at sites 8 and 11 in and around the side channel. Common smelt were next the most abundant species (up to 11.4 fish 100 m^{-2}). Mean density of bullies (7.8 fish 100 m^{-2}) was much higher than for smelt (1.69 fish 100 m^{-2}). Kōura had a patchy distribution with only 3 individuals were caught at two sites.

Comparing catches over the 11 years of sampling, the mean abundance of common bullies in 2017 was consistent with densities in most post-wall years (after 2007), but lower than in 2007 before wall closure (Newman-Keuls multiple range test, $P = 0.034$). 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 low BDD did not correspond with low common bully densities. In 2017, smelt abundance had recovered somewhat from the low catches from 2014 to 2016.

Goldfish biomass increased initially (2009-2010) because of targeted fishing in the side channel (site 11), which has dense macrophytes and offers good habitat for goldfish with no flow. However, the continued rise in goldfish density from 2012 on suggests a real increase in goldfish numbers. In contrast to most previous years, no eels were caught in 2017.

Analysis of fish densities before and after wall closure is hampered by the single data point before closure. However, we now have 10 years of post-wall data, and comparisons of means and standard deviations suggest that the number of bullies have been lower since 2008 with the exception of 2015, when bully densities were the same as 2007, i.e., before wall closure. The large number of small juvenile bullies (<30 mm) suggests that recruitment is taking place in the channel, so fluctuating bully abundance is likely to be controlled by factors other than wall closure.

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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 in 2017. Similar surveys using boat electrofishing had been previously carried out in each December from 2007 to 2016 (Brijs et al. 2008, 2009, 2010, Hicks et al. 2011, 2013, 2014, 2015, 2016; 2017; 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). Boat electrofishing validated the pattern of reducing smelt catches from upstream to downstream found by NIWA's seasonal trapping (Brijs et al. 2008), but because of the low number of smelt captured by a single day's boat electrofishing 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 11th year of sampling (2017) and a summary of previous surveys.

Table 1. Summary of reports describing boat electrofishing in the Ohau Channel. This report is ERI report 116.

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)
ERI report	116	2017	Hicks et al. (2018)

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 wire droppers, created the fishing field at the bow, with the boat hull acting as the cathode. A total of 11 sites in the Ohau Channel were fished in 2017 (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 habitats 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 5 December 2017.

Site	Description	Bank	Length (m)	Area (m^2)	Depth range (m)
1	Edge habitat below weir	TLB	227	908	0.7-1.3
2	Edge habitat	TLB	225	900	0.3-1.6
3	Mid-channel habitat		383	1532	0.6-1.2
4	Edge habitat	TRB	259	1036	0.4-1.3
5	Edge habitat	TRB	319	1276	0.2-2.1
6	Edge habitat	TLB	176	704	0.3-1.0
7	Mid-channel habitat		462	1848	1.2-2.2
8	Edge habitat	TLB	285	1140	0.5-1.6
9	Edge habitat	TRB	230	920	0.4-1.7
10	Edge habitat	TLB	176	704	0.4-2.6
11	Side channel	TLB	167	668	0.5-0.8
Total			2,909	11,636	

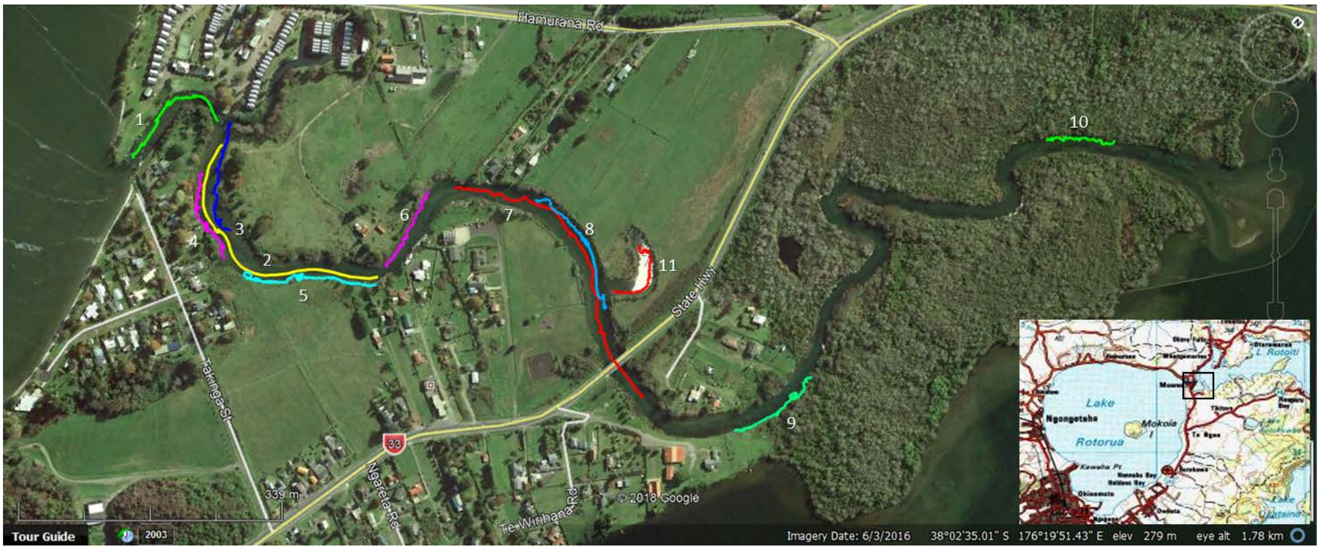


Figure 1. Fishing transects sampled on 5 December 2017 in the Ohau Channel starting from the Lake Rotorua end (site 1) down to the Lake Rotoiti end (site 10). Site numbers correspond to locations in Table 2. Inset shows the position of the Ohau Channel between lakes Rotorua and Rotoiti.

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 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 length measurement to the nearest mm in the lab. Weight was calculated using the regression parameters in Table 2, Jellyman et al. (2013) for fish and Kusabs et al. (2015) for kōura. 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. Freshwater mussels (*Echyridella menziesii*) were seen in sandy and gravelly areas 1-2 m deep in the upper part of the channel. As distance from the weir increases and the channel widens and deepens, the current slows and the extent of macrophyte beds increases. The submerged macrophytes hornwort (*Ceratophyllum demersum*), oxygenweed (*Lagarosiphon major*), curly-leafed pondweed (*Potamogeton crispus*) and parrot's feather (*Myriophyllum aquaticum*), were observed in the lower channel. The riparian zones of the Ohau Channel were mainly residential gardens and pasture in the upstream half of the channel (the Lake Rotorua end) and riparian willows and other shrubs and trees in the downstream half of the channel (near Lake Rotoiti).

Water temperature at the starting point of fishing was 20.7^{o}C at 1105 h NZDST on 5 December 2017 and the fishing depth ranged between 0.2 to 2.6 m (Table 2). Specific conductivity, i.e., standardised to 25^{o}C, was 179.4µS cm^{-1}, and ambient conductivity, which controls power transfer of the electrical field, was 164.9 µS cm^{-1}. The black disc distance (BDD), which measures horizontal underwater visibility (Davies-Colley 1988), was 1.47 m.

4. Results and discussion

Fish density and biomass by site

1,110 fish and 3 kōura (18.2 kg in total) from 11 sites on 5 December 2017. The sites comprised 2,909 lineal m and 11,636 m2 in area (Table 2). Kōura and 4 fish species were present, with common bully the most abundant species (741 fish; Table 3). Common smelt were next the most abundant species (213 fish). Goldfish (152 fish) were most abundant at sites 8 in the main channel and 11, the side channel. Kōura had a patchy distribution; only 3 individuals were caught. Kōura were seen at other sites but not caught. Goldfish comprised the greatest total biomass, with 10 kg caught at site 11 (Table 4).

Common bullies had the highest densities of any fish species in 2017 (up to 29.6 fish 100 m^{-2} at the site 6, edge habitat; Table 5); common smelt were less abundant (up to 11.4 fish 100 m^{-2}). Mean bully density (7.8 fish 100 m^{-2}) was much higher than for smelt (1.7 fish 100 m^{-2}; Table 5). Goldfish had the greatest areal biomass of any species (up to 14.8 g m^{-2}; Table 6) because of the large number of individuals at site 11. Mean individual weight was greatest for goldfish and rainbow trout (Table 7). Catch per unit effort (fish min^{-1}) reflected species density at each site (Table 8).

Table 3. Total number of fish and kōura in the Ohau Channel caught by boat electrofishing in 10-min passes at 11 sample sites on 5 December 2017. Blank cells indicate no catch for that site and species.

Site	Number of individuals per site					
	Common bully	Common smelt	Kōura	Goldfish	Rainbow trout	Total
1	90					90
2	21	48			2	71
3		4			1	5
4	79	13	1			93
5	69	145				214
6	208	1				209
7					1	1
8	145			36		181
9	28	2	2			32
10	29			21		50
11	72			95		167
Total	741	213	3	152	4	1,113

Table 4. Biomass by species in the Ohau Channel caught by boat electrofishing in 10-min passes at 11 sample sites on 5 December 2017. Blank cells indicate no catch for that site and species.

Site	Biomass (g) per site					
	Common bully	Common smelt	Kōura	Goldfish	Rainbow trout	Total
1	61.8					62
2	17.9	36.2			202.0	256
3		3.2			328.0	331
4	59.4	11.0	18.2			89
5	53.2	113.8				167
6	66.9	0.0				67
7					198.5	199
8	67.2			4742.1		4,809
9	19.1	1.2	60.6			81
10	28.5			2113.3		2,142
11	99.2			9854.2		9,953
Total	473	165	79	16,710	729	18,155

Table 5. Density of fish and kōura in the Ohau Channel caught by boat electrofishing in 10-min passes at 11 sample sites on 5 December 2017.

Site	Density (number 100 m^{-2})					
	Common bully	Common smelt	Kōura	Goldfish	Rainbow trout	Total
1	9.91	0.00	0.00	0.00	0.00	9.91
2	2.33	5.33	0.00	0.00	0.22	7.89
3	0.00	0.26	0.00	0.00	0.07	0.33
4	7.63	1.25	0.10	0.00	0.00	8.98
5	5.41	11.36	0.00	0.00	0.00	16.77
6	29.55	0.14	0.00	0.00	0.00	29.69
7	0.00	0.00	0.00	0.00	0.05	0.05
8	12.72	0.00	0.00	3.16	0.00	15.88
9	3.04	0.22	0.22	0.00	0.00	3.48
10	4.12	0.00	0.00	2.98	0.00	7.10
11	10.78	0.00	0.00	14.22	0.00	25.00
Mean	7.77	1.69	0.03	1.85	0.03	11.37

Table 6. Areal biomass of fish and kōura in the Ohau Channel caught by boat electrofishing in 10-min passes at 11 sample sites on 5 December 2017.

Site	Biomass (g m^{-2})					
	Common bully	Common smelt	Kōura	Goldfish	Rainbow trout	Total
1	0.07	0.00	0.00	0.00	0.00	0.07
2	0.02	0.04	0.00	0.00	0.22	0.28
3	0.00	0.00	0.00	0.00	0.21	0.22
4	0.06	0.01	0.02	0.00	0.00	0.09
5	0.04	0.09	0.00	0.00	0.00	0.13
6	0.09	0.00	0.00	0.00	0.00	0.09
7	0.00	0.00	0.00	0.00	0.11	0.11
8	0.06	0.00	0.00	4.16	0.00	4.22
9	0.02	0.00	0.07	0.00	0.00	0.09
10	0.04	0.00	0.00	3.00	0.00	3.04
11	0.15	0.00	0.00	14.75	0.00	14.90
Mean	0.05	0.01	0.01	1.99	0.05	2.11

Table 7. Mean individual weight of fish and kōura caught by boat electrofishing in Ohau Channel at 11 sample sites on 5 December 2017. Weight was calculated using the regression parameters from Jellyman et al. (2013) for fish and Kusabs et al. (2015) for kōura. Blank cells indicate no catch for that site and species.

Site	Mean individual weight (g)				
	Common bully	Common smelt	Kōura	Goldfish	Rainbow trout
1	0.7				
2	0.9	0.8			101.0
3		0.8			328.0
4	0.8	0.8	18.2		
5	0.8	0.8			
6	0.3	0.0			
7					198.5
8	0.5			131.7	
9	0.7	0.6	30.3		
10	1.0			100.6	
11	1.4			103.7	

Table 8. Catch per unit effort of common bully, common smelt, goldfish and rainbow trout caught by boat electrofishing in Ohau Channel at 11 sample sites on 5 December 2017.

Site	Time fished (min)	Catch per unit effort (fish min^{-1})			
		Common bully	Common smelt	Goldfish	Rainbow trout
1	10	9.00	0.00	0.00	0.00
2	10	2.10	4.80	0.00	0.20
3	10	0.00	0.40	0.00	0.10
4	10	7.90	1.30	0.00	0.00
5	10	6.90	14.50	0.00	0.00
6	10	20.80	0.10	0.00	0.00
7	10	0.00	0.00	0.00	0.10
8	10	14.50	0.00	3.60	0.00
9	10	2.80	0.20	0.00	0.00
10	10	2.90	0.00	2.10	0.00
11	10	7.20	0.00	9.50	0.00
Total	110				
Mean		6.74	1.94	1.38	0.04

Fish abundance by year

Comparing catches over the 11 years of sampling, the abundance of all species combined in 2017 (1,113 individuals, comprising 741 common bullies, 213 common smelt and 3 kōura) was less than in 2016 (Table 9A). The densities of fish and kōura in 2017 were lower than in 2015 and 2016 (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 10). Poor water clarity can reduce the efficiency of electrofishing, but BDD was greater in 2017 than for any year except 2007.

Analysis of fish densities before and after wall closure is hampered by the single data point (2007) before closure. However, we now have 10 years of post-wall data (2008-2017), and comparison of means and standard deviations suggest that the number of bullies was initially lower (ANOVA $P = 0.008$; Figure 2) but seems to have increased somewhat in 2015 and 2016. A multiple means comparison shows that the mean density in 2007 was still greater than any other year except 2015 (Table 11). The number of juvenile bullies <30 mm total length (Figure 3A), which comprised 43% of the total bully catch of 741 fish in 2017, suggests that recruitment is taking place in the channel, so fluctuating bully abundance is likely to be controlled by factors other than wall closure. Common smelt were mostly adults (98%; Figure 3B) according to the criterion of Rowe et al. (2008), who considered that smelt <44 mm in length were juveniles.

Goldfish biomass continued the recent trend of increasing abundance (Figure 4). In contrast to most previous years, no eels were caught in 2017.

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 2015. (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	Total all species	Common bully	Common smelt	Goldfish	Longfin eel	Shortfin eel	Rainbow trout	Brown trout	Gambusia	Kōura	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
2016	1,340	1,162	62	78	0	0	35	3	0	0	100	2,791	11,164
2017	1,113	741	213	152	0	0	4	0	0	3	110	2,909	11,636

B. Mean fish and kōura densities

Year	Density (individuals 100 m^{-2})									
	Total all species	Common bully	Common smelt	Goldfish	Longfin eel	Shortfin eel	Rainbow trout	Brown trout	Gambusia	Kōura
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
2017	11.00	7.66	1.44	1.85	0.00	0.00	0.02	0.00	0.00	0.03

Table 10. 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, 2016, 2017 and this survey).

Year	Date	Time (h NZDT)	Water temperature (°C)	Ambient conductivity (μS cm^{-1})	Specific conductivity (μS cm^{-1})	Black disc distance (m)
2007	13-Dec-07	1015	18.8	159.3	180.9	2.00
2008	11-Dec-08	1030	20.4	167.8	183.7	0.80
2009	7-Dec-09	1045	19.4	172.4	193.4	0.65
2010	7-Dec-10	1100	20.1	169.7	187.4	0.50
2011	5-Dec-11	1030	17.8	148.5	173.5	0.85
2012	4-Dec-12	0900	17.4	144.1	169.4	1.30
2013	27-Nov-13	1100	20.9	169.3	183.5	0.80
2014	9-Dec-14	1030	18.4	163.0	184.2	1.45
2015	2-Dec-15	1042	17.8	174.6	202.9	1.15
2016	28-Nov-16	1040	16.0	155.9	188.2	0.90
2017	5-Dec-17	1105	20.7	164.9	179.4	1.47

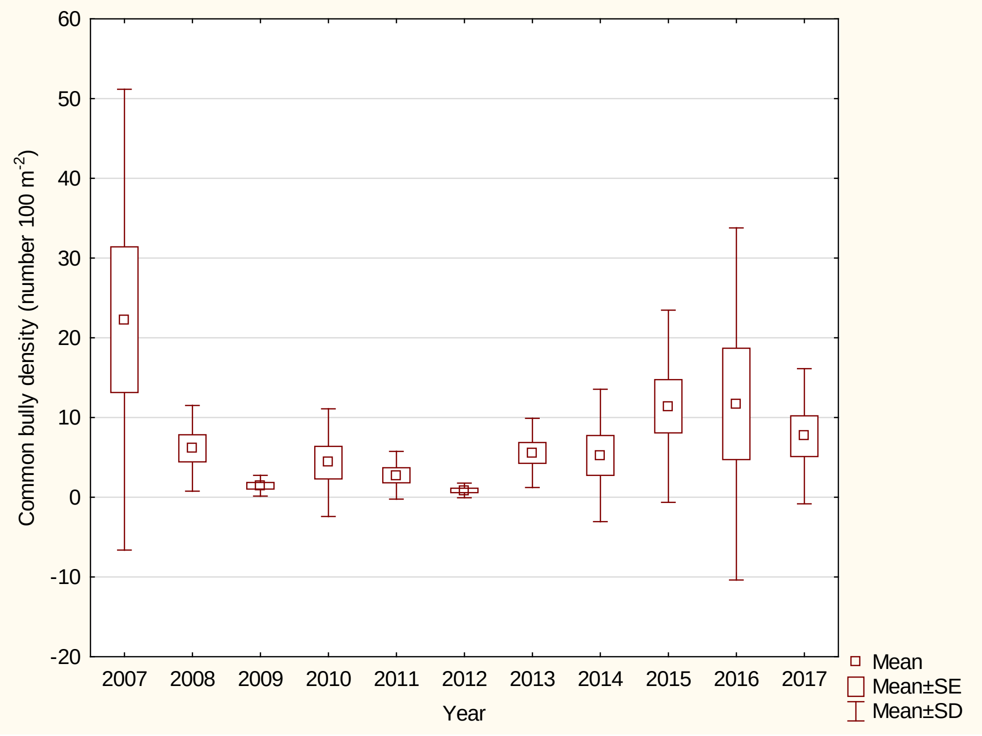
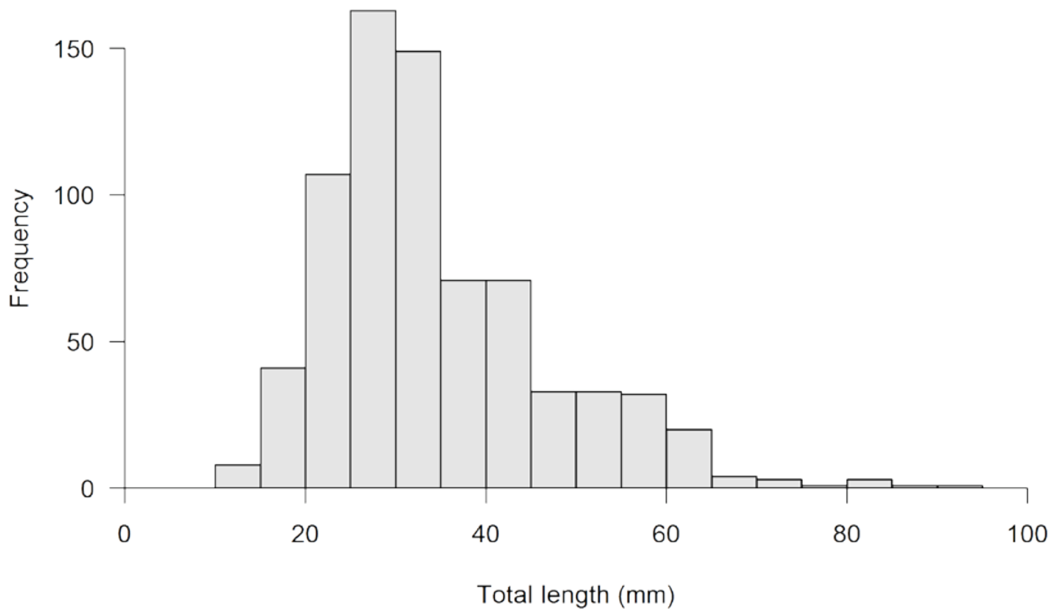


Figure 2. Comparison of common bully densities in the Ohau Channel before wall closure (2007) compared to after wall closure (2008-2017). Error bars are 1 standard deviation and boxes are 1 standard error.

Table 11. Newman-Keuls multiple range test of mean common bully densities in the Ohau Channel estimated by boat electrofishing between 2007 (before wall closure) and 2008-2017 after wall closure. Values in red are significant at $p < 0.05$.

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
2007		*0.024*	*0.006*	*0.022*	*0.011*	*0.005*	*0.025*	*0.028*	0.106	*0.049*	*0.034*
2008	*0.024*		0.949	0.987	0.969	0.954	0.914	0.984	0.583	0.721	0.775
2009	*0.006*	0.949		0.849	0.805	0.913	0.937	0.891	0.569	0.592	0.903
2010	*0.022*	0.987	0.849		0.766	0.913	0.971	0.865	0.766	0.807	0.971
2011	*0.011*	0.969	0.805	0.766		0.932	0.952	0.886	0.663	0.696	0.940
2012	*0.005*	0.954	0.913	0.913	0.932		0.949	0.922	0.555	0.570	0.904
2013	*0.025*	0.914	0.937	0.971	0.952	0.949		0.952	0.689	0.775	0.918
2014	*0.028*	0.984	0.891	0.865	0.886	0.922	0.952		0.773	0.827	0.969
2015	0.106	0.583	0.569	0.766	0.663	0.555	0.689	0.773		0.956	0.481
2016	*0.049*	0.721	0.592	0.807	0.696	0.570	0.775	0.827	0.956		0.727
2017	*0.034*	0.775	0.903	0.971	0.940	0.904	0.918	0.969	0.481	0.727	

A. Common bullies (*N* = 714)



B. Common smelt (*N* = 213)

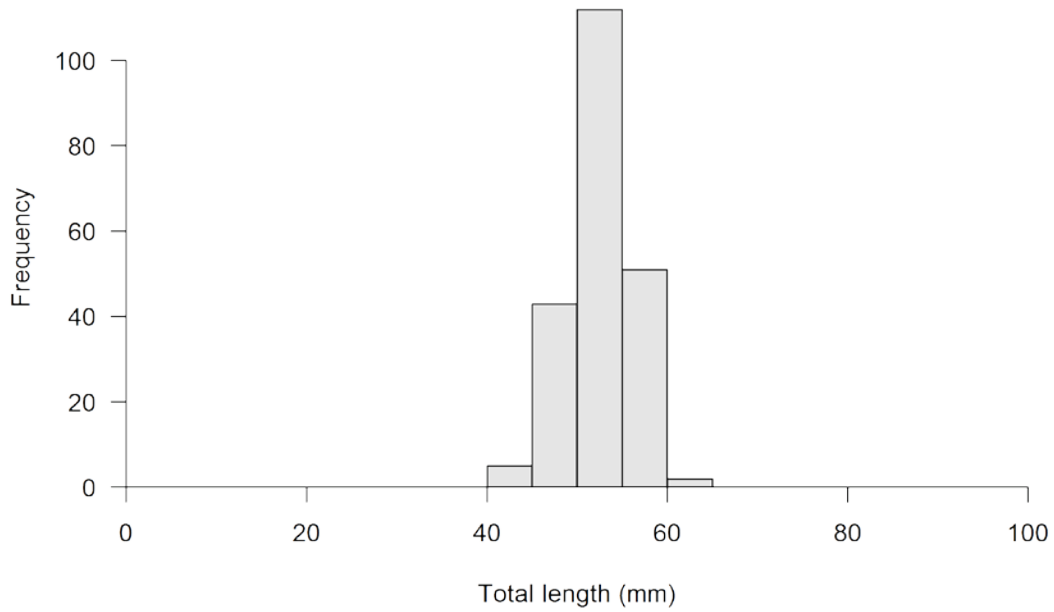


Figure 3. Length frequency of A. common bullies and B. common smelt caught by boat electrofishing in the Ohau Channel on 5 December 2017.

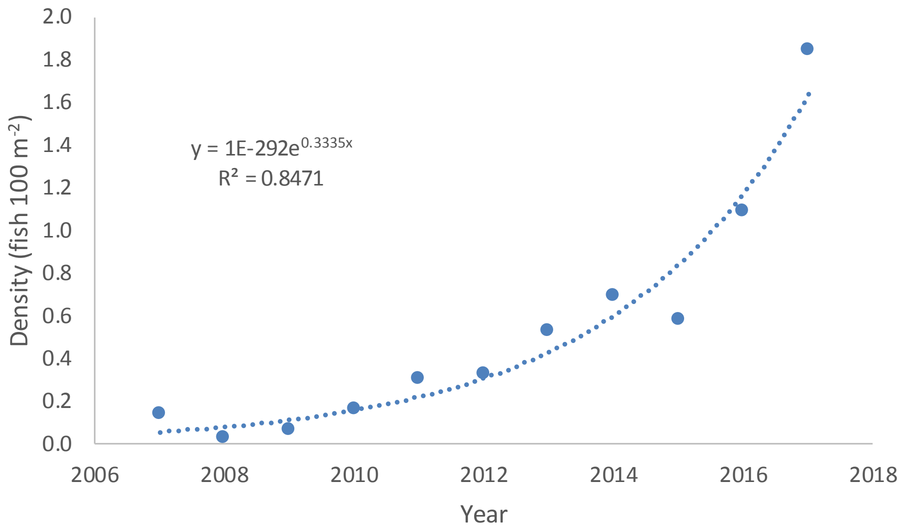


Figure 4. Mean goldfish density in the Ohau Channel from 2007 to 2017 estimated by boat electrofishing.

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