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# Boat electrofishing survey of fish abundance in the Ohau Channel, Rotorua, in 2014

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by

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**Cover picture**: View of the weir at the upstream end of the Ohau Channel.

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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 eighth year of sampling (2014) 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 642 fish (11.3 kg) 11 sites on 9 December 2014, which comprised 2,914 lineal m and 11,656 $m^2$ in area. Koura and 4 fish species were present, with common bully the most abundant species (up to 27 fish 100 $m^{-2}$ at the site 5, edge habitat). Goldfish (up to 5.92 g $m^{-2}$) was the next most abundant species, and was most abundant in sites 8-11 the lower channel, especially at site 11, the excavated side channel. Rainbow trout were next the most abundant species (up to 0.25 fish 100 $m^{-2}$). Mean bully biomass (5.25 g $m^{-2}$) was much higher than for smelt (0.07 g $m^{-2}$). Koura had a patchy distribution; 5 individuals were caught.

Comparing catches over the 8 years of sampling, the abundance of common bullies in 2014 was consistent with most post-wall years (after 2007), and lower than in 2013. The cause of fluctuating bully abundance is not known, and was not accounted for by water clarity expressed as black disc (BD) distance or water conductivity. Poor water clarity can reduce the efficiency of electrofishing, but BD 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.

Analysis of fish densities before and after wall closure is hampered by the single data point before closure. However, we now have 7 years of post-wall data, and comparison of means and standard deviations suggest that the number of bullies has decreased. An obvious 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 recruitment from Rotoiti is now restricted. This hypothesis is testable with otolith microchemistry.

An intriguing trend of decreasing rainbow trout densities with increasing black disc distances, a measure of both water clarity and phytoplankton abundance, has occurred following wall construction. The explanation for this is not immediately clear, but increased phytoplankton leading to increased food availability for trout is a possibility. The trend is contrary to the usual decline of catch rate by boat electrofishing with diminished water clarity.

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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). 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 which 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 eighth year of sampling (2014) and a summary of previous surveys.

## 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 11 sites in the Ohau Channel were fished in 2014 (Table 1, Figure 1).

Table 1. Habitat types and dimensions of sites that were boat electrofished in the Ohau Channel on 9 December 2014. (need to check description, depth)

| Site | Description | Length (m) | Area ($m^2$) | Depth range (m) |
|---|---|---|---|---|
| 1 | Edge habitat below weir | 329 | 1,316 | 0.8-1.2 |
| 2 | Edge habitat by net site 1 | 308 | 1,232 | 0.4-1.0 |
| 3 | Mid channel habitat by net site 1 | 405 | 1,620 | 0.6-1.8 |
| 4 | Edge habitat by net site 2 | 207 | 828 | 0.4-1.1 |
| 5 | Edge habitat by net site 3 | 251 | 1,004 | 0.6-2.1 |
| 6 | Mid channel habitat | 325 | 1,300 | 1.1-2.6 |
| 7 | Edge habitat | 225 | 900 | 0.4-1.2 |
| 8 | Edge habitat near side channel | 253 | 1,012 | 0.5-1.8 |
| 9 | Willow edge | 221 | 884 | 0.9-2.1 |
| 10 | Edge habitat by net site 4 | 227 | 908 | 0.9-2.2 |
| 11 | Side channel | 163 | 652 | 0.8-1.0 |
| Total | | 2,914 | 11,656 | |

As in previous seasons, sites 2, 4, 8 and 10 coincided with NIWA trap netting sites. Electrofishing subsequently commenced upstream of NIWA trap locations and proceeded to move downstream past them. The remaining sites were spread throughout the Ohau Channel and generally incorporated different habitat characteristics representative of the entire channel. All of the sites had a fishing effort of 10 minutes across each of the habitats (Table 5), which included littoral areas, macrophyte beds and mid-channel habitats for the specified target species.

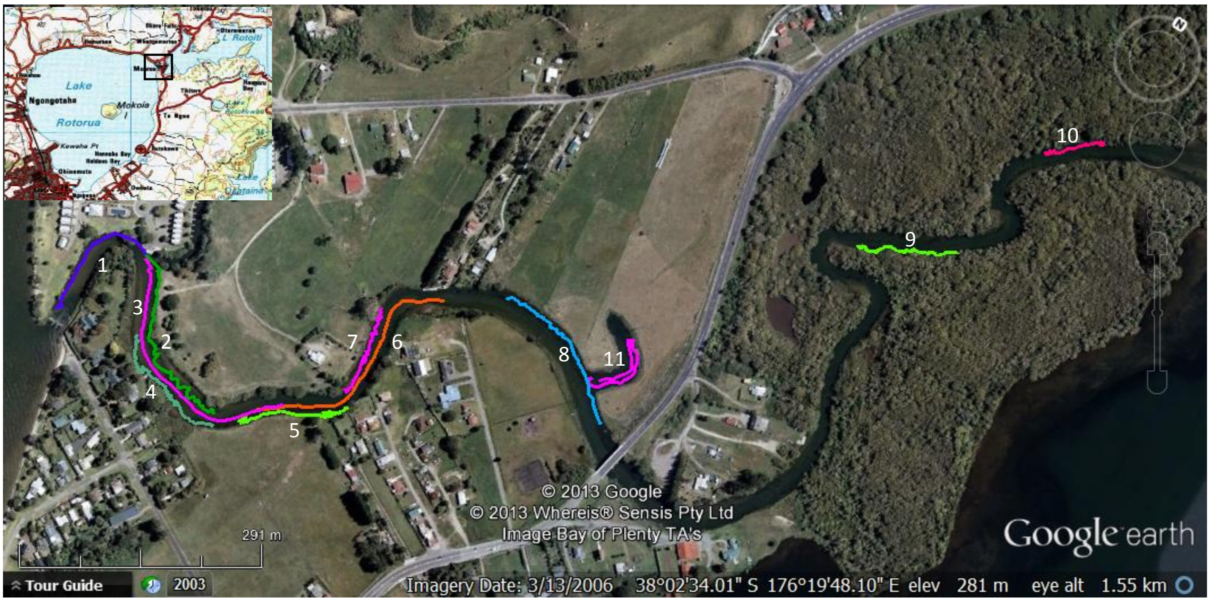


Figure 1. Fishing transects sampled on 9 December 2014 in the Ohau Channel starting from Lake Rotorua and ending at Lake Rotoiti. Site codes correspond to locations in Table 1.

Prior to fishing, electrical conductivity was measured with a YSI 3200 conductivity meter and horizontal water visibility was measured using a black disc (Davies-Colley 1988). All sites were fished with the GPP set to low range (50-500 V direct current) and a frequency of 60 pulses per second. The percent of range of the GPP 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 assumes 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 measured with the on-board GPS was multiplied by 4 m to calculate the area fished (Table 1).

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 mesh bags (4-mm mesh) that were secured in the channel at each sample station. When all sites had been fished, holding bags at each sample station 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 strong and 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 18.4$^{o}$C at 1030 h NZDST on 9 December 2014 and the fishing depth ranged between 0.4 to 2.6 m (Table 1). Specific conductivity, i.e., standardised to 25$^{o}$C, was 184.2 μS cm$^{-1}$, and ambient conductivity, which controls power transfer of the electrical field, was 163.0 μS cm$^{-1}$. The littoral zones of the Ohau Channel were much the same as in previous seasons and 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). Submerged macrophytes, such as pondweed (*Potamogeton crispus*) and parrot's feather (*Myriophyllum aquaticum*), were observed throughout the channel as well as the presence of freshwater mussels (*Echyridella menziesii*) in bare sandy areas. The black disc visibility (BD), which measures horizontal underwater visibility, was 1.45 m in 2014, which was the second highest reading, just less than 2.0 m that was measured in 2007.

## 4. Results and discussion

### *Fish density and biomass by site*

A total of 642 fish (11.3 kg) were caught at the 11 sites that were fished in 2014, which comprised 2,914 lineal m and 11,656 m$^{2}$ in area (Table 1). Koura and 4 fish species were present, with common bully the most abundant species (Table 2). Goldfish (56 fish) was the next most abundant species, and was most abundant in sites 8-11 the lower channel, especially at site 11, the excavated side channel. Rainbow trout were next the most abundant species (13 fish).

Common bullies had the highest densities of any fish species in 2014 (up to 27 fish 100 m$^{-2}$ at the site 5, edge habitat), but goldfish were very abundant than smelt at site 11 (Table 3). Mean bully biomass (5.25 g m$^{-2}$) was much higher than for smelt (0.07 g m$^{-2}$; Table 4). Koura had a patchy distribution; only 5 individuals were caught. Catch per unit effort (for time) reflected species density at each (Table 5).

Table 2. Total number of each species in the Ohau Channel collected in 10-min passes at 11 sample sites with boat electrofishing on 9 December 2014. Blank cells indicate no catch for that species.

| | Number of individuals per site | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Site | Common bully | Common smelt | Goldfish | Longfin eel | Shortfin eel | Rainbow trout | Brown trout | Koura | Total |
| 1 | 11 | | | | | 1 | | 1 | 13 |
| 2 | 10 | | | | | 3 | | | 13 |
| 3 | 6 | | | | | 4 | | | 10 |
| 4 | 7 | 1 | | | | 1 | | | 9 |
| 5 | 270 | 4 | | | | | | 3 | 277 |
| 6 | 8 | | | | | 2 | | | 10 |
| 7 | 58 | 2 | | | | | | | 60 |
| 8 | 142 | | 9 | | | | | 1 | 152 |
| 9 | 13 | | 8 | | | 1 | | | 22 |
| 10 | 3 | | 2 | | | 1 | | | 6 |
| 11 | 33 | | 37 | | | | | | 70 |
| Total | 561 | 7 | 56 | 0 | 0 | 13 | 0 | 5 | 642 |

Table 3. Density of each species in the Ohau Channel collected in 10-min passes at 11 sample sites with boat electrofishing on 9 December 2014.

| | Density (number 100 $m^{-2}$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Site | Common bully | Common smelt | Goldfish | Longfin eel | Shortfin eel | Rainbow trout | Brown trout | Koura | Total |
| 1 | 0.84 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 | 0.08 | 1.0 |
| 2 | 0.81 | 0.00 | 0.00 | 0.00 | 0.00 | 0.24 | 0.00 | 0.00 | 1.1 |
| 3 | 0.37 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 | 0.00 | 0.00 | 0.6 |
| 4 | 0.85 | 0.12 | 0.00 | 0.00 | 0.00 | 0.12 | 0.00 | 0.00 | 1.1 |
| 5 | 26.89 | 0.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.30 | 27.6 |
| 6 | 0.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.15 | 0.00 | 0.00 | 0.8 |
| 7 | 6.44 | 0.22 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.7 |
| 8 | 14.03 | 0.00 | 0.89 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 15.0 |
| 9 | 1.47 | 0.00 | 0.90 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 | 2.5 |
| 10 | 0.33 | 0.00 | 0.22 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 | 0.7 |
| 11 | 5.06 | 0.00 | 5.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 10.7 |
| Mean | 5.25 | 0.07 | 0.70 | 0.00 | 0.00 | 0.10 | 0.00 | 0.04 | 6.2 |

Table 4. Areal biomass of fish and koura in the Ohau Channel collected in 10-min passes at passes at 11 sampling sites with boat electrofishing on 9 December 2014.

| | Biomass (g m$^{-2}$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Site | Common bully | Common smelt | Goldfish | Longfin eel | Shortfin eel | Rainbow trout | Brown trout | Koura | Total |
| 1 | 0.03 | 0.000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.04 |
| 2 | 0.01 | 0.000 | 0.00 | 0.00 | 0.00 | 1.41 | 0.00 | 0.00 | 1.42 |
| 3 | 0.01 | 0.000 | 0.00 | 0.00 | 0.00 | 0.59 | 0.00 | 0.00 | 0.59 |
| 4 | 0.04 | 0.000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 |
| 5 | 0.39 | 0.003 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.14 | 0.53 |
| 6 | 0.01 | 0.000 | 0.00 | 0.00 | 0.00 | 1.24 | 0.00 | 0.00 | 1.25 |
| 7 | 0.09 | 0.002 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 |
| 8 | 0.21 | 0.000 | 1.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 1.33 |
| 9 | 0.04 | 0.000 | 0.99 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.03 |
| 10 | 0.00 | 0.000 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 |
| 11 | 0.11 | 0.000 | 5.92 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.03 |
| Mean | 0.08 | <0.001 | 0.73 | 0.00 | 0.00 | 0.29 | 0.00 | 0.02 | 1.13 |

Table 5. Catch per unit effort of common bully, common smelt, goldfish and rainbow trout in the Ohau Channel caught at passes at 11 sample sites with boat electrofishing on 9 December 2014.

| | Time | Catch per unit effort (fish min$^{-1}$) | | | |
|---|---|---|---|---|---|
| Site | fished (min) | Common bully | Common smelt | Goldfish | Rainbow trout |
| 1 | 10 | 1.10 | 0.00 | 0.00 | 0.10 |
| 2 | 10 | 1.00 | 0.00 | 0.00 | 0.30 |
| 3 | 10 | 0.60 | 0.00 | 0.00 | 0.40 |
| 4 | 10 | 0.70 | 0.10 | 0.00 | 0.10 |
| 5 | 10 | 27.00 | 0.40 | 0.00 | 0.00 |
| 6 | 10 | 0.80 | 0.00 | 0.00 | 0.20 |
| 7 | 10 | 5.80 | 0.20 | 0.00 | 0.00 |
| 8 | 10 | 14.20 | 0.00 | 0.90 | 0.00 |
| 9 | 10 | 1.30 | 0.00 | 0.80 | 0.10 |
| 10 | 10 | 0.30 | 0.00 | 0.20 | 0.10 |
| 11 | 10 | 3.30 | 0.00 | 3.70 | 0.00 |
| Total | 110 | | | | |
| Mean | | 5.10 | 0.06 | 0.51 | 0.12 |

## *Fish abundance by year*

The abundance of common bullies in 2014 was consistent with most post-wall years (after 2007), and was lower than in 2013 (Table 6A and B). The cause of fluctuating bully abundance is not known, and was not accounted for by water clarity expressed as black disc distance (BDD) distance or water conductivity (Table 7). 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.

Table 6. A. Number of fish and koura and B. mean fish and koura densities in the Ohau Channel measured by boat electrofishing between 2007 and 2014. (Source of data: Brijs et al. 2008, 2009, 2010, Hicks et al. 2011, 2013, 2014, 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 |

B. Mean fish and koura densities

| Year | Density (individuals 100 $m^{-2}$) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total all species | Common bully | Common smelt | Goldfish | Longfin eel | Shortfin eel | Rainbow trout | Brown trout | Koura | Gambusia |
| 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 |

Analysis of fish densities before and after wall closure is hampered by the single data point before closure. However, we now have 7 years of post-wall data, and comparison of means and standard deviations suggest that the number of bullies has decreased (Figure 2). An obvious 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 recruitment from Rotoiti is now restricted. This hypothesis is testable with otolith microchemistry.

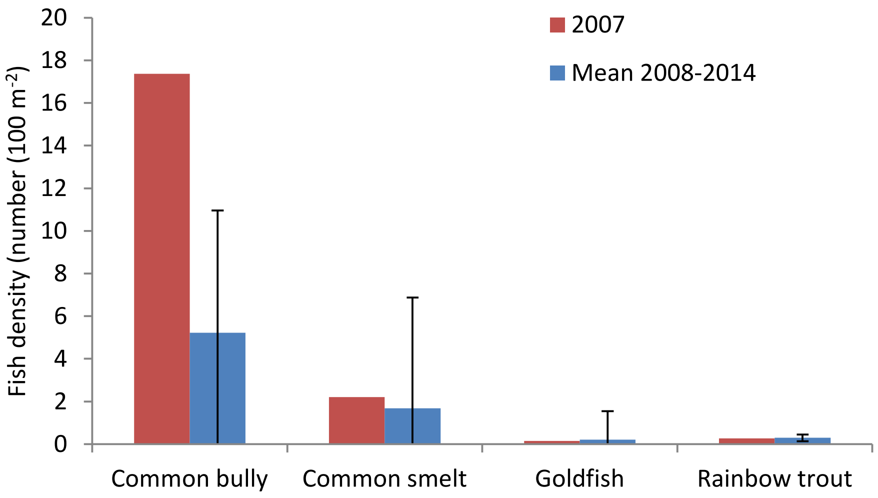


Figure 2. Comparison of fish densities in the Ohau Channel before wall closure (2007) compared to after wall closure (2008-2014). Error bars are 1 standard deviation.

An intriguing trend of decreasing rainbow trout densities with increasing black disc distances, a measure of both water clarity and phytoplankton abundance, has occurred following wall construction (Figure 3). The explanation for this is not immediately clear, but increased phytoplankton could have lead to increased food availability for trout is a possibility. The trend is contrary to the usual decline of catch rate by boat electrofishing with diminished water clarity.

Table 7. Specific conductivity and black disc distance measured in the in the Ohau Channel at the time of boat electrofishing surveys between 2007 and 2014. 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, 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 |

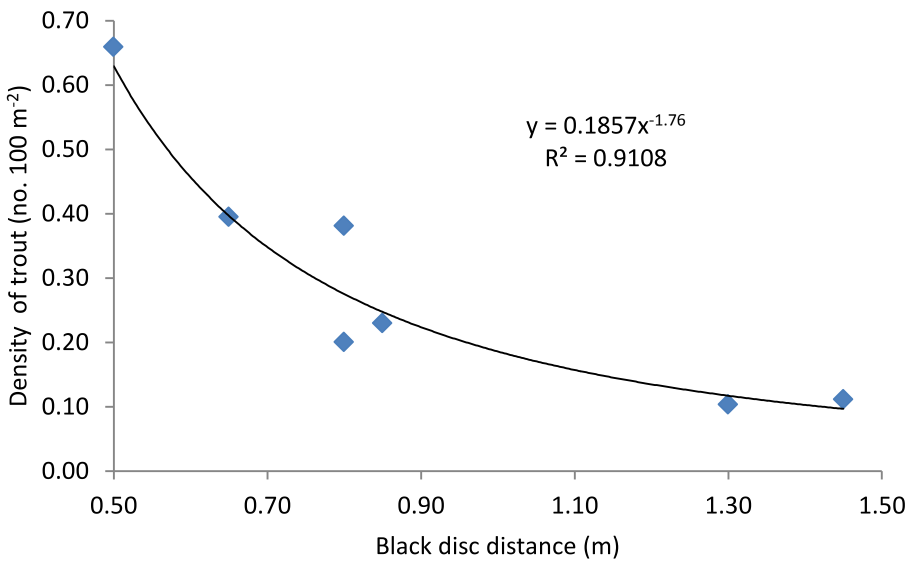


Figure 3. Relationship of rainbow trout density to black disc distance in the Ohau Channel between 2008 and 2014 following wall construction, excluding 2007 data before wall closure.

## 6. Acknowledgements

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