# Smelt monitoring in the Ohau Channel and Lake Rotoiti: 2008-2009

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**June 2009**

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# Smelt monitoring in the Ohau Channel and Lake Rotoiti during 2008-2009

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*Prepared for*

**Environment Bay of Plenty**

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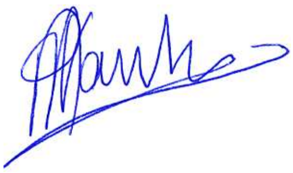

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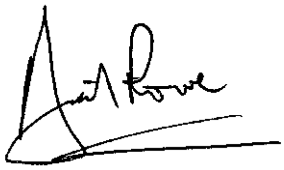

Dr David Rowe

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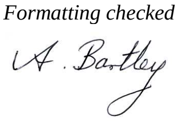

# Executive Summary

Movements of both juvenile and adult common smelt (*Retropinna retropinna*) up the Ohau Channel have been recorded on an intermittent basis as the smelt migrate from Lake Rotoiti into Lake Rotorua. These smelt were harvested by local iwi during their migration and the high concentrations of smelt that occurred below the weir near the top of the channel attracted large numbers of predators (both shags and trout). The trout that congregate around the mouth of the Ohau Channel at these times form the basis for a seasonal fishery.

Environment Bay of Plenty has constructed a diversion wall across the outlet of the Ohau Channel to stop the nutrient-rich water from Lake Rotorua entering Lake Rotoiti where it contributes to the decline in water quality and would ultimately degrade the trout fishery. Concerns were raised by Fish and Game that trout fisheries may be impacted by this wall if it restricts inter-lake fish migrations and if it results in a reduction in smelt (i.e., trout food) in Rotoiti. Concerns were also raised by local iwi that the smelt fishery in the Ohau Channel would be affected. Conditions in the resource consents therefore required monitoring of the trout fishery in Lake Rotoiti and of smelt in both the Ohau Channel and in Lake Rotoiti, before and after completion of the wall.

The wall was completed in March 2008 and this report presents the results of smelt monitoring from September 2008 to May 2009. These results are interpreted in relation to those obtained in previous years to help identify any long term and sustained change in smelt migrations in the Ohau Channel, or in smelt abundance in Lake Rotoiti. They complement monitoring of the trout fishery in Lake Rotoiti by the Eastern Fish and Game Council and studies of inter-lake movements of fish by the University of Waikato.

There was no major run of smelt up the Ohau Channel between September 2008 and May 2009. Fortnightly monitoring may have missed a small (several days long) run, but will not have missed a large one. Shag counts in the channel also showed no increase over this period reinforcing the absence of any significant smelt migration up the channel. Major runs aside, a small number of smelt (between 1 and 2 per trap per minute) were recorded moving up the channel in each month. As the wall was completed in March 2008, these results represent the first data set following its completion. They indicate no detectable difference from those obtained in 2007/2008. In this sense, there is no difference between pre- and post-wall smelt migrations, however, it will take several more years monitoring to determine whether large migrations occur or not.

A decline in smelt migration up the Ohau channel may affect smelt abundance in Lake Rotoiti. The size of the adult smelt population in Lake Rotoiti was therefore measured through an acoustic survey in September 2008 using the same methods as used in previous years. The slow decline in mean abundance noted each year from 2005 to 2007 has continued in 2008, but there was no indication of a major decline or increase.

The recruitment of smelt larvae in Lake Rotoiti was also measured in 2008/2009 and showed no difference from that measured in the previous two years.

# 1. Introduction

To control nutrient inflows into Lake Rotoiti and thereby halt the deterioration in its water quality, Environment Bay of Plenty has diverted the inflow from Lake Rotorua into Lake Rotoiti down the Kaituna River. This diversion has been achieved through the construction of a wall which channels all the Ohau Channel water along the edge of Lake Rotoiti towards the Kaituna river mouth. Concerns that the wall may restrict fish movements between these two lakes and impact on trout and smelt fisheries respectively were raised by the Eastern Fish and Game Council and local iwi respectively. Because of these concerns, resource consents were granted to Environment Bay of Plenty but with conditions requiring the pre- and post-wall monitoring of smelt and trout to determine whether an impact occurs or not.

Construction of the diversion wall in Lake Rotoiti was completed in March 2008. The results obtained in 20008/2009 therefore constitute the first post-wall data set to be compared with the pre-wall results obtained in 2006/2007 and 2007/2008. As in previous years, the movements of smelt up the Ohau Channel were monitored over summer months and the size of the smelt population in Lake Rotoiti assessed through measurement of both adult smelt abundance and larval smelt density. The results for the 2008/2009 season are compared with the pre-wall data for 2006/2007 and 2007/2008.

This smelt monitoring complements monitoring of the trout fishery and trout growth rates by the Eastern Fish and Game Council, and studies on the proportions of fish moving between the lakes by the University of Waikato. The studies on smelt were designed to firstly assess whether smelt migrations in the Ohau Channel supporting a small iwi fishery for smelt are prevented and secondly whether there is any subsequent decline in the smelt populations in Rotoiti that affects the trout fishery. The studies on trout were initiated to determine firstly whether there is significant recruitment of trout from Lake Rotorua to Lake Rotoiti and secondly whether the wall affects trout abundance in Rotoiti by reducing this recruitment.

Smelt monitoring comprises three components; (a) measurement of the number of smelt moving upstream in the Ohau Channel to detect the occurrence, relative size and frequency of large migrations, (b) measurement of the population size of adult smelt in Lake Rotoiti to determine if there is a post-wall decline and (c) an assessment of any changes in smelt recruitment in Lake Rotoiti via measurement of larval fish densities. Large changes in the smelt population of Lake Rotoiti can be expected to occur naturally in some years because of the effects of annual variations in climate on smelt recruitment. It is therefore important to monitor smelt recruitment because any decline in adult smelt abundance could be caused by a decline in natural recruitment rather than by the effects of the diversion wall.

The results of the various studies are reviewed each year by a panel of experts who advise Environment Bay of Plenty on their significance and whether mitigation measures (e.g., installation of a fish pass in the wall) are required.

# 2. Methods

## 2.1 Smelt migrations in the Ohau Channel

The four sites (2 upstream, 2 downstream) used to monitor smelt movements in the Ohau Channel in 2007/2008 were used again in 2008/2009 (Fig. 1).

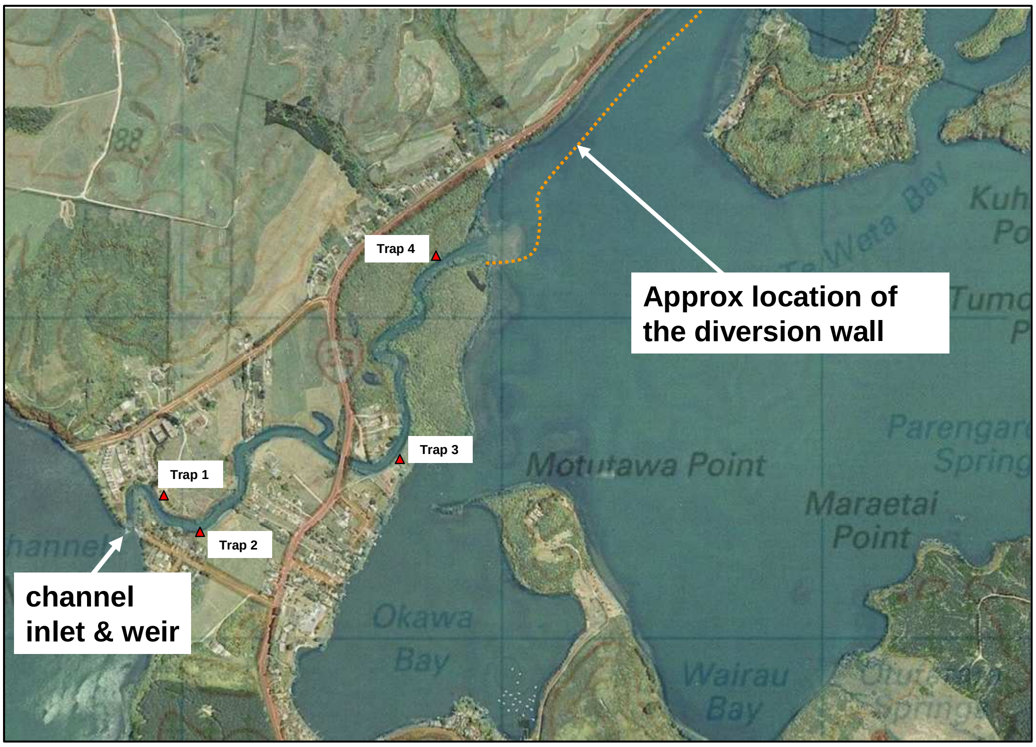


**Figure 1:** Location of smelt trapping sites (red triangles) in the Ohau Channel, 2007/2008.

Fortnightly trapping was carried out during the nine month period from 24th September 2008 until 7th May 2009. Traps were placed close to the bank at each site, facing downstream in order to capture upstream migrants. The traps were triangular with a 1 m by 0.5 m wide opening tapering to a 20 cm wide capture compartment. Mesh size was 2 mm. Traps were lifted and the catch removed every 3-4 hours from early morning until late evening. The total number of smelt caught and the time for which the traps were fishing were recorded and, depending on the number of fish present, all or a subsample were removed for processing. Both the size (under or over 45 mm total length) and coloration of smelt were used to distinguish juveniles from adults and the proportion of each in the total catch per site was determined from the subsamples. The catch per unit of effort (CPUE) for all smelt was calculated as the total catch for all four traps per day divided by the total trapping time in minutes.

Shag numbers (both on the banks and in trees lining the channel) were counted along the channel's entire length on each sampling occasion. Shags are predators of smelt and their abundance provides an additional measure to detect the presence of high densities of smelt characteristic of large runs. In addition to the smelt monitoring, water temperatures (Tidbit© data loggers), water clarity (black disc visibility), the discharge of water through the channel and the by-catch of common bullies were also recorded.

## 2.2 Adult smelt density

Acoustic surveys of adult smelt density in Lake Rotoiti have now been carried out in September 2000, 2005, 2006 and 2007. Accordingly, a further survey was carried out in September 2008 using the same transects (Figure 2) and methods as used in the previous surveys (Rowe et al. 2006, 2007).

The 2008 survey used the same SIMRAD EK60 machine operating at 120 kHz, with the transducer mounted in a towed V-fin at a depth of 2-3 m below the boat. The V-fin ensures vertical and horizontal stability of the transducer when wave action from strong winds is high and the boat pitches and rolls. Fortunately, windy conditions have not been encountered to date. The 2009 survey was carried out on 10th September but had to be repeated on 23rd September because of a fault (caused by wear and tear) in the cable from the V-fin to the echosounder. This fault introduced an error into the data that could not be removed electronically.

In the past, acoustic noise has been created by vibrations associated with one or more of the V-fin, its cable, the vessel, the motor, the propeller or water turbulence from the hull. This creates problems with data analysis but was resolvable, even though removing such false data takes time. The V-fin adds significant stability to the transducer when wave action results in rocking of the boat. However, as rough weather has not been a major factor influencing acoustic surveys in Lake Rotoiti over the past five years, we plan to dispense with the V-fin and cable and replace it with a boat mounted pole or stanchion. This will limit surveys to times when wind speeds are less than 30 km/hr, but past experience indicates that this approach is viable and will not affect the data collection or analysis.

The echosounder was calibrated *in situ* on the day of the survey and data were obtained on ambient 'noise' that could potentially confound the results. The lake was then acoustically surveyed along each transect and the data saved for later processing. This involved identification and delineation (on the echogram for each transect) of the fish layer within which the adult smelt (target strength -55dB to -45dB) occurred. This process excludes smaller juvenile smelt that are present mainly in surface waters (0-10 m) and which are not amenable to acoustic sampling.

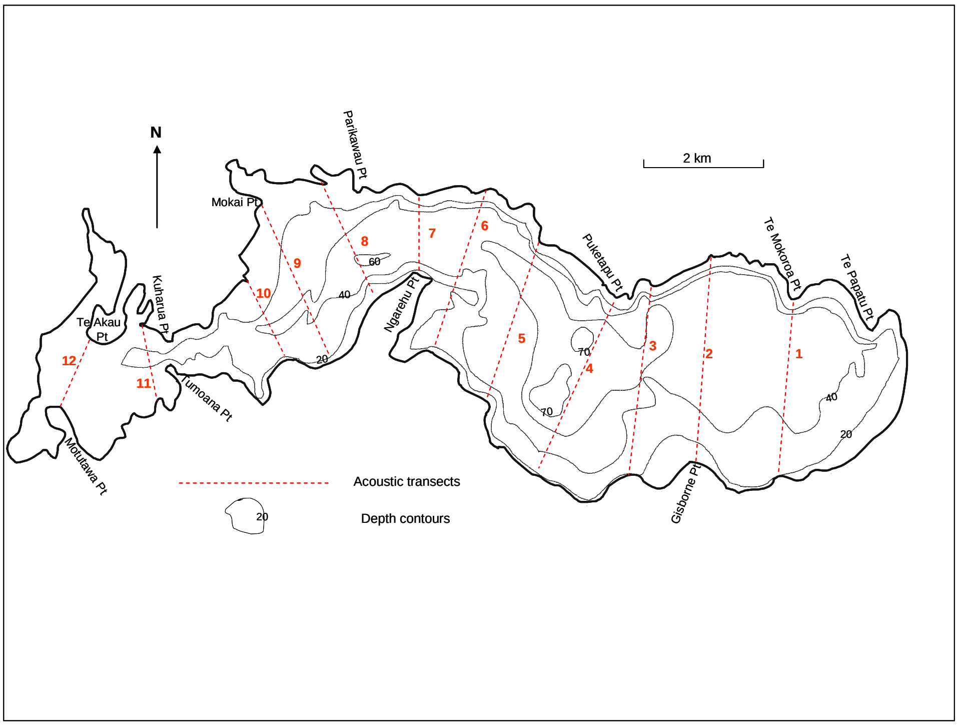


**Figure 2:** Transects (dashed red lines, labelled 1-12) used for the acoustic survey of Lake Rotoiti in September 2007.

The acoustic data present in the adult smelt regions of each transect were analysed using ESP2 (McNeil et al. 2003), which determines the total amount of acoustic backscatter from each region (i.e., a measure of the total sound energy reflected by the fish present). This process can be expected to include backscatter from adult rainbow trout present in this region of the lake, however, trout are generally present in shallower waters above the adult smelt layer (Rowe & Chisnall 1995) and smelt occupy deeper waters in lakes to avoid trout predation. Although the presence of some trout in the 'adult smelt' layer could result in an over-estimation of the acoustic backscatter from adult smelt alone, this is expected to be minor and similar each year.

The amount of backscatter for each transect was calculated per $m^2$ of lake surface area for the 2008 survey and compared with that measured in 2005, 2006 and 2007 to identify any spatial patterns in smelt abundance and any noticeable changes in these. The mean areal backscatter for adult smelt over the entire lake was then calculated and divided by the acoustic backscatter produced by a single, average-sized adult smelt to provide a measure of the mean number of adult smelt per transect for 2008. As the backscatter produced by a single, average-sized smelt may differ between years (e.g., because of differences in growth and hence size), any bias related to changes in smelt size were reduced by using the modal value for smelt in the target strength frequency distribution.

## 2.3 Larval smelt density

Smelt have an extended spawning period lasting from spring until the end of summer. Eggs are deposited on clean sand in shallow (0.5-2 m deep) waters around the lake margin as well as in shallower waters on the sandy substrate of inlet streams. The larvae hatch in 10-25 days (depending on lake water temperature) and become pelagic. Newly hatched larvae are around 6-7 mm long and are transparent. They have no air bladder so, unlike the smaller larval bullies that do possess an air bladder, they are not detected by echosounder even at high frequencies (i.e., 200 kHz). The larvae grow over summer and winter months until they reach a length of around 25 mm. After this, they become pigmented, adopt adult coloration, and form large schools in the surface waters (0-5 m) of the lake, where they become the major prey species for rainbow trout. The optimal time for spawning and hence for larval smelt density in lakes is not known, so estimates of larval smelt abundance in Lake Rotoiti are carried out in both December and April to include and slightly lag the main spawning periods (spring and summer).

In December 2007 and April 2008, drop netting was expanded to include 30 sites spread throughout the lake. The same sites were sampled in December 2008 and in April 2009. The Wisconsin drop net has a mouth area of $0.25 m^2$ and a mesh size of 250µ. It is dropped from the lake surface down to a depth of 2-3 m above the lake bottom, at which point it is throttled to prevent fish escapement and brought to the surface. Larval fish are washed out of the net, sorted into species (larval bullies and larval smelt) and counted. Lengths are measured to identify the occurrence of small larvae indicating recent recruitment. Secchi disc depth is measured as the overall number of smelt larvae in lakes has been found to co-vary with water transparency (Rowe & Taumoepeau 2004).

The mean catch of larval smelt was calculated for the 2008/2009 spawning season (i.e., December 2007 plus April 2008) and expressed in relation to secchi disc depth to reveal any change in density that is independent of changes in water clarity. The data for 2008/2009 were compared with those for previous years to determine any significant trend.

# 3. Results

## 3.1 Ohau Channel smelt

As in 2007/2008, trap one generally caught more smelt than the other traps. Exceptions occurred between September and November 2008 and again between April and May 2009 (Fig. 3).

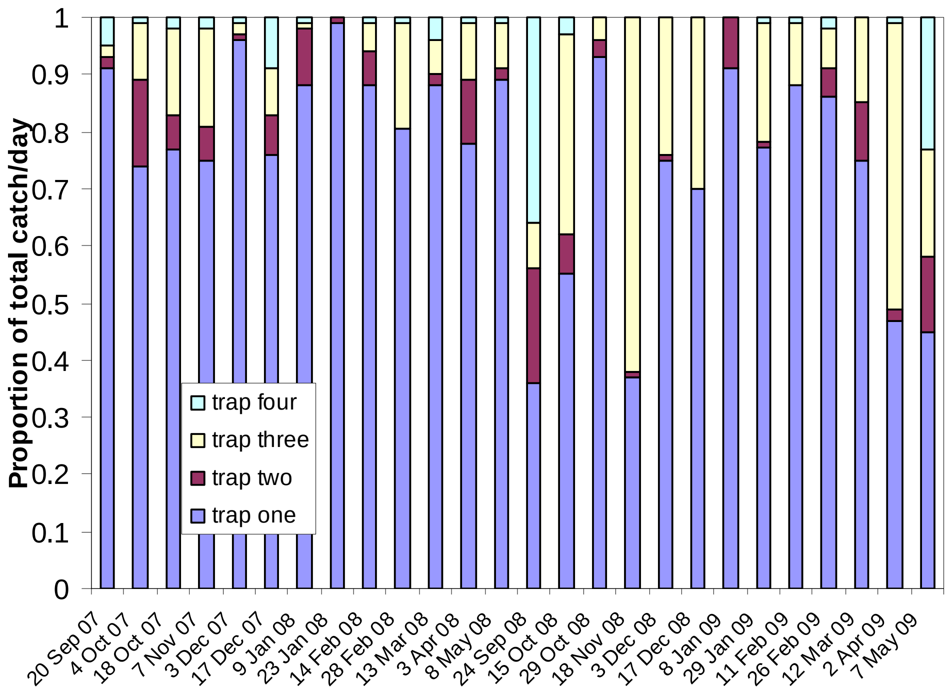


**Figure 3:** Proportions of all smelt caught by the four traps between September 2008 and May 2009 (Traps 1 and 2 are located near the top of the Ohau Channel and Traps 3 and 4 are located further downstream, just above the old outlet to Lake Rotoiti).

Catches in Trap 2 and Trap 4 were positively correlated ($r = 0.64$) but the daily catch rate for Trap 1 was negatively correlated with the daily catch in all other traps (Table 1). The correlation coefficients indicate that when Trap 1 was catching high numbers of smelt, the other traps were catching relatively low numbers, and vice versa. Such site-specific differences in catchability will most likely be related to the interaction between smelt distribution in the channel and localised conditions such as water velocity, water depth, bank slope and distance from the shore.

**Table 1:** Correlations between smelt catch per trap.

| | Trap 1 | Trap 2 | Trap 3 | Trap 4 |
|---|---|---|---|---|
| Trap 1 | 1.00 | | | |
| Trap 2 | **-0.40** | 1.00 | | |
| Trap 3 | **-0.73** | -0.24 | 1.00 | |
| Trap 4 | **-0.56** | **0.64** | -0.09 | 1.00 |

Water velocities varied markedly among the sites and over time in both 2007/2008 and 2008/2009 (Fig. 4). They were generally highest at the Trap 1 site in 2008/2009, with exceptions occurring during May 2008 when velocities at Site 3 were higher and in December 2008 when they were the same. The data for the two years combined indicates that water velocities at Site 3 may be higher than at Site 1 over winter months (June-September), when flows in the channel are higher (Fig. 5).

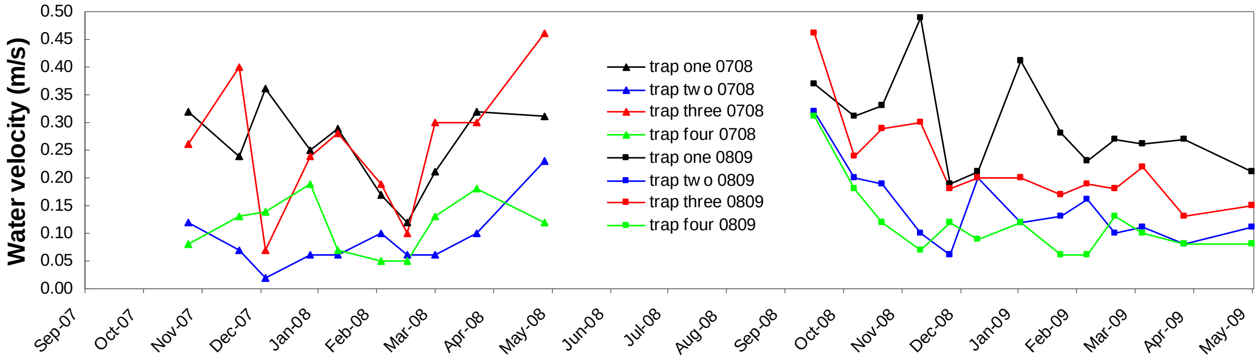


**Figure 4:** Variations in water velocity at the four trap sites over time.

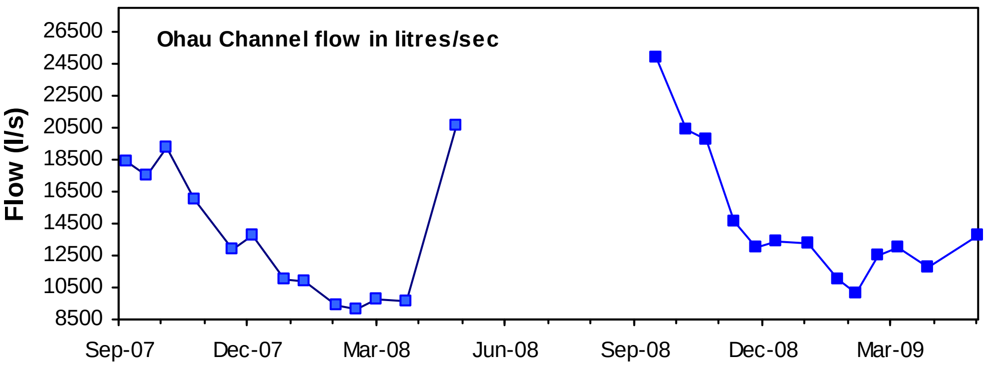


**Figure 5:** Flows through the Ohau Channel September 2007 to May 2009.

The daily catch rate of smelt for the four traps combined remained below 2 fish $min^{-1}$ throughout 2008 and 2009 (Fig. 6). Catch rates tended to decline throughout the summer season and there were no prolonged spring or summer runs up the Ohau Channel, as recorded in 2006, when catch rates were 4.5 and 35.4 fish $min^{-1}$ respectively. However, a small run is likely to have occurred in early May 2009 just after sampling ceased. A local angler (Bert Robinson, web communication) reported that "*the Ohau Channel was not producing fish consistently with some of the fish being in poor condition, but there was a very good run of smelt up the channel the night before last which could improve things*". A small increase in shags was observed by a local in the first week of May (local communication to John Holst, EBOP). Inspection of the channel on 13th May 2009 indicated that some adult smelt were present but shag numbers were no longer elevated. Collectively, these observations indicate that a small run probably occurred on an intermittent basis over several days in early May. Such small runs will not be detected by fortnightly sampling unless the run happens to coincide with the sampling.

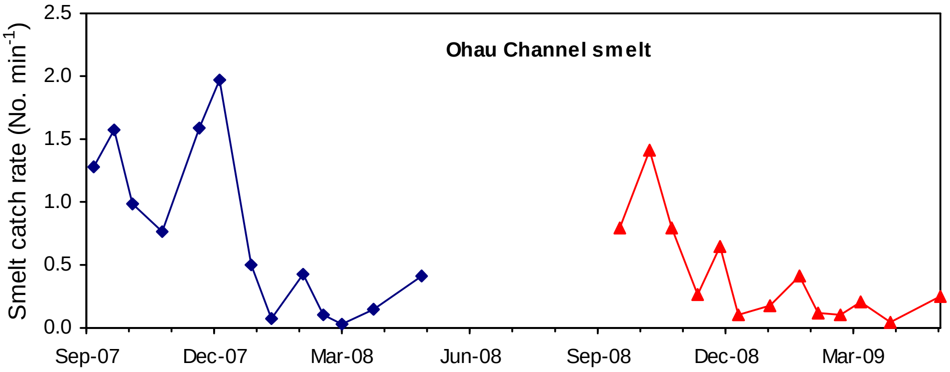


**Figure 6:** Daily catch rate for smelt in the Ohau Channel from September 2007 to May 2009.

Even though there was no marked increase in smelt in the channel in 2007, 2008 or 2009, the seasonal timing of adults and juvenile fish remained much the same, with juveniles dominating the catch over the warmer, summer months and adults at other times (Fig. 7). Juveniles dominated from January 2007 to April 2008, and from November 2008 to April 2009 indicating some variation in the seasonal timing of their upstream summer movement.

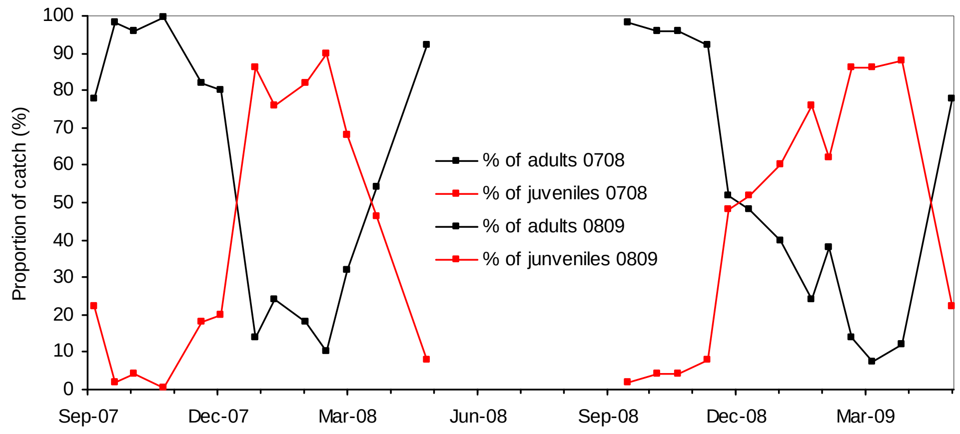


**Figure 7:** Proportions of adult and juvenile smelt in the Ohau Channel trap catches from September 2007 to May 2009.

The total smelt catch per day was positively correlated (r = 0.5) with flow rate (Table 2). Other studies with traps in rivers have indicated that this also occurs for whitebait and is caused by fish swimming closer to the banks when flows are higher.

The smelt catch was also correlated with counts of shags (r = 0.43) (Table 2), indicating that shag numbers increase when smelt numbers increase. The relatively high correlation between shag number and flow rate indicates that shags accumulate in the channel at times of high flow. This may be because smelt are more abundant or easier to feed on at times of high flow, but this is speculative.

**Table 2:** Correlations between the variables measured between 2007 and 2009.

| | Smelt catch (No/min) | Bully catch (No/min) | Shags (No.) | Black disc (m) | Flow (L/s) |
|---|---|---|---|---|---|
| Smelt catch | 1.00 | | | | |
| Bully catch | 0.37 | 1.00 | | | |
| Shags | **0.43** | 0.14 | 1.00 | | |
| Black disc | 0.35 | 0.37 | -0.06 | 1.00 | |
| Flow | **0.50** | 0.24 | **0.59** | -0.09 | 1.00 |

Shag numbers showed no marked increase throughout the 2008/2009 sampling period compared with the previous year (Fig. 8). The by-catch of other fish in 2008-2009 included bullies (Fig. 9), koaro (Fig. 10) and a few juvenile trout (3).

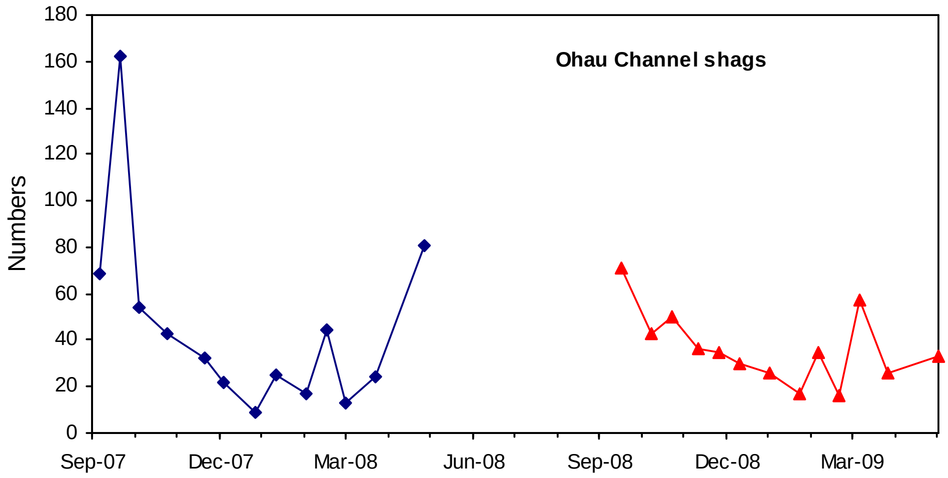


**Figure 8:** Counts of shags along the side of the Ohau Channel from September 2007 to May 2009.

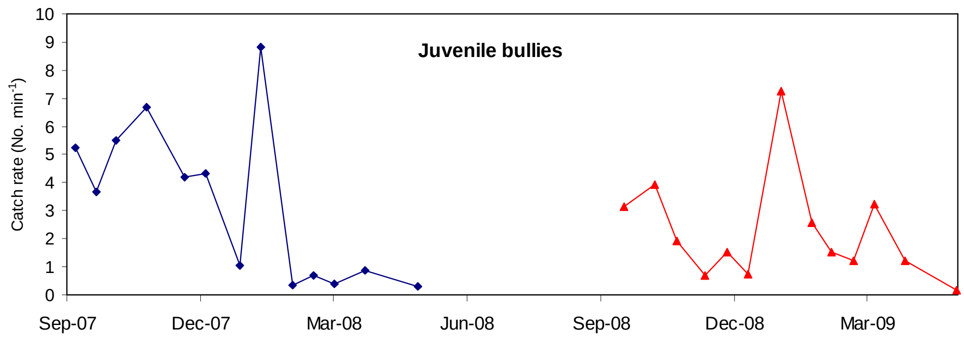


**Figure 9:** Total daily catch rate for bullies in the Ohau Channel.

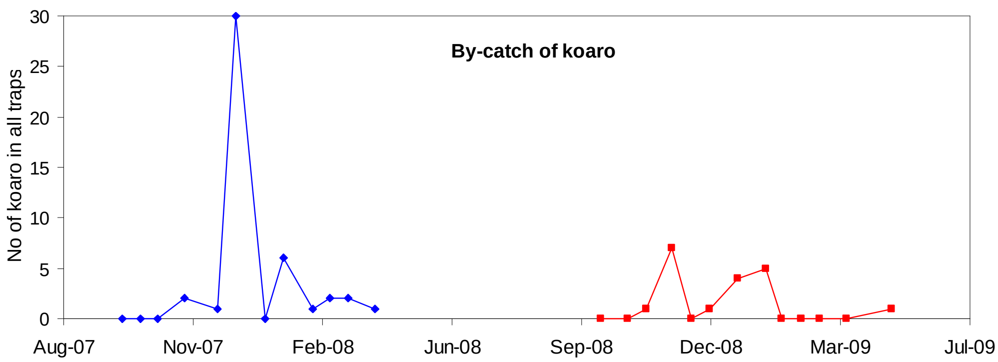


**Figure 10:** Total daily catch rate for koaro in the Ohau Channel.

Water temperature in the Ohau Channel ranged from 11ºC in winter to 27ºC in summer (Fig.11). There was a marked decline over a period of 6-7 days in both mid-January and mid-February 2009 and a brief spell of pronounced warming in early February.

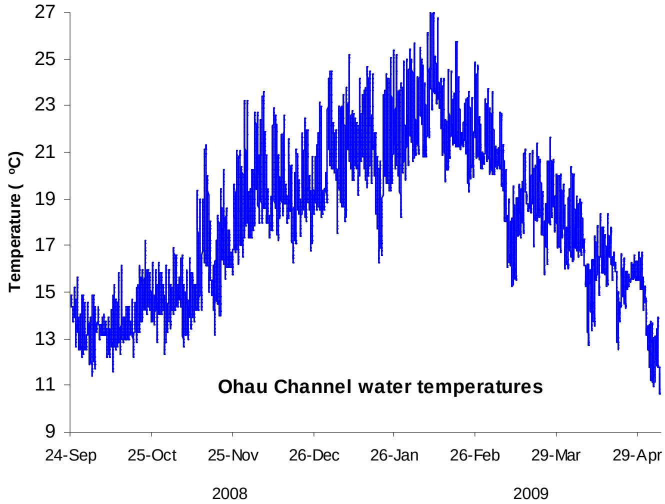


**Figure 11:** Water temperature in the Ohau Channel over the sampling period.

Water quality (as measured by black disc transparency) ranged from 0.5 to 2.5 m over the sampling period (Fig. 12). In general, water transparency in the Channel has tended to decrease during the 2008/2009 season compared with the 2007/2008 one. The prolonged drops in water transparency are related mainly to algal blooms in Lake Rotorua.

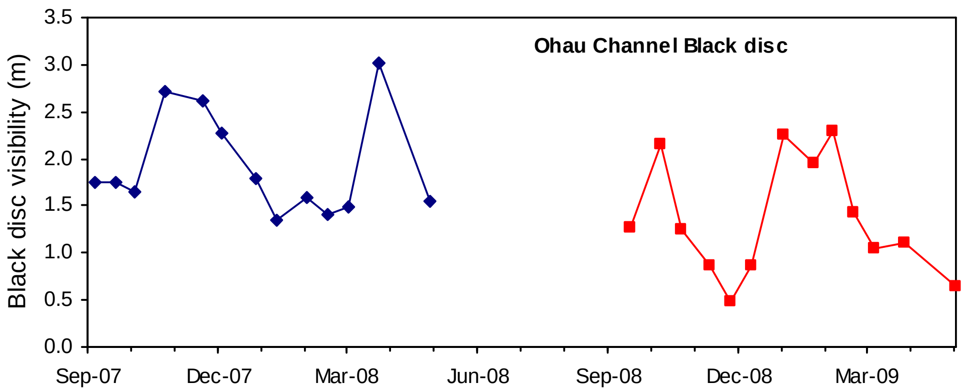


**Figure 12:** Water transparency in the Ohau Channel from September 2007 to May 2009.

### 3.2 Adult smelt density

In September 2008, adult smelt were much less abundant in the relatively deep, eastern basin of the lake (transects 1-7) than in previous years (Fig. 13).

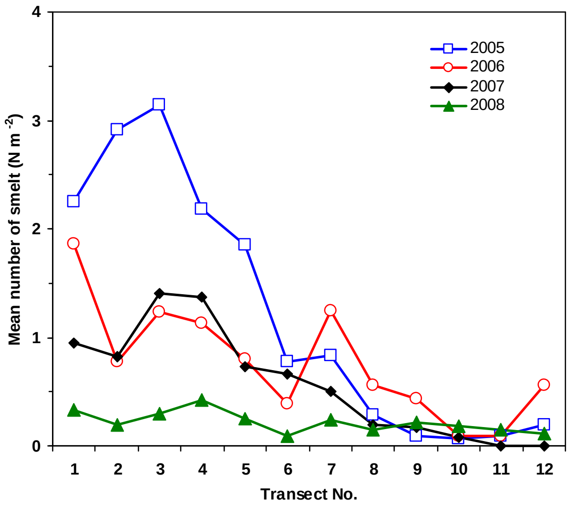


**Figure 13:** Mean number of adult smelt (N $m^{-2}$) per transect for each of the acoustic transects in Lake Rotoiti between September 2005 and September 2008.

The 2008 target strength (TS) frequency distribution of 'individual' echoes (i.e., from individual organisms and not from two or more organisms in close proximity) revealed three distinct modes, as in previous years, reflecting zooplankton, larval bullies and smelt respectively. In 2008, the modal TS for these organisms were all shifted to the left suggesting a lower TS for each taxa (Fig. 14). However, natural variations in TS of this order can be expected because of the measurement methods and because the mean size of these organisms will vary from year to year, more so for smelt than for larval bullies and especially zooplankton. A bias in TS could potentially be caused by a small tilt in the transducer plane (relative to the lake surface) and this may have occurred following repair of its cable in 2009. Because it is not possible to identify the exact cause of this slight drop in TS value for 2008 and it is within the limits for natural variation, we assumed that smelt size was actually lower in 2008 than in 2007. Smelt size in 2008 was more similar to that indicated by the TS frequency distribution for 2005 and 2006, than that for 2007, so this assumption seems reasonable. If the assumption is wrong, the estimate of mean adult smelt density presented for 2008 would be slightly higher.

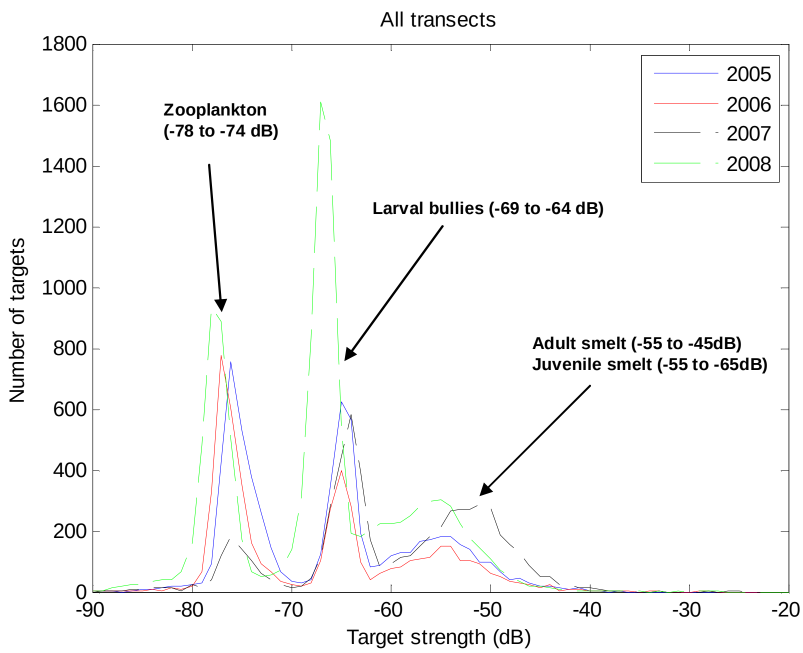


**Figure 14:** Frequency distributions for 'individual' echoes in Lake Rotoiti 2005 to 2008.

The mean density of adult smelt across all transects provides a comparable measure of the adult smelt population in Lake Rotoiti and is shown in Figure 15 for the years 2000, 2005, 2006, 2007 and 2008.

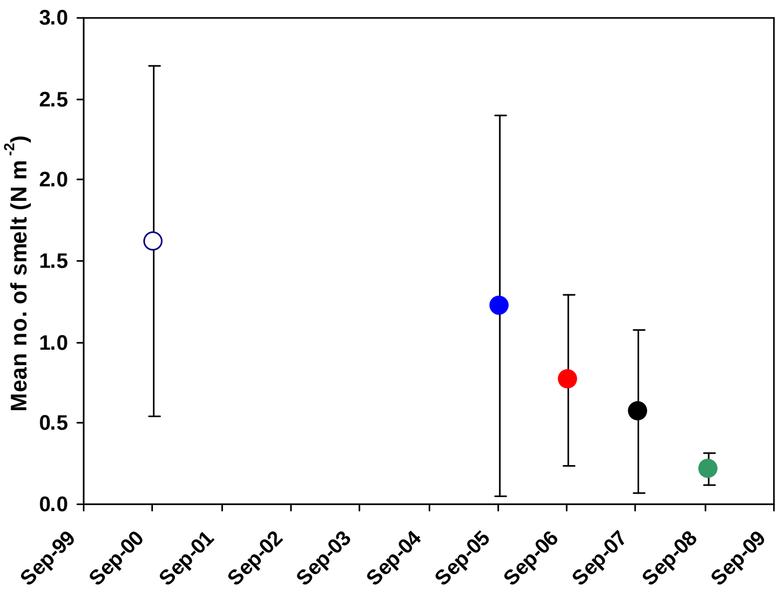


**Figure 15:** Mean density (±SD) of adult smelt in Lake Rotoiti per year for 2000 and 2005 to 2008.

The lower mean density for adult smelt in Lake Rotoiti in 2008 was accompanied by a much smaller standard deviation than in previous years, reflecting the lower variation in smelt density among the transects compared with previous years (see Fig. 13). Between 2005 and 2008, the mean density of smelt has dropped steadily from 1.2 to 0.2 smelt $m^{-2}$.

### 3.3 Larval smelt density

Mean catch rates of larval smelt, reflecting areal densities through the water column are shown in Table 3. Catch rates were higher in December 2008 than in previous years but were lower in April.

**Table 3** Mean catch rates (±SD) for larval smelt throughout Lake Rotoiti between 2005 and 2009.

| Summer season (hauls) | Mean catch rate (No. net-haul$^{-1}$) ± SD | |
|---|---|---|
| | December | April |
| 2005/2006 (n = 15) | 0.60 ± 0.74 | 0.47 ± 0.52 |
| 2007/2008 (n = 30) | 0.65 ± 1.28 | 0.94 ± 1.15 |
| 2008/2009 (n = 30) | 1.00 ± 1.34 | 0.42 ± 0.76 |

The density of smelt larvae in lakes decreases as the lake becomes more eutrophic and water transparency (i.e., secchi disc depth) declines (Rowe & Taumoepeau 2004). Larval smelt density in lakes therefore needs to be standardised for changes in lake water transparency reflecting changes in lake trophic status. The mean smelt CPUE for the 2008/2009 summer period is shown relative to other years and to other Rotorua lakes in Figure 16. The density of larval smelt over the 2008/2009 summer period was no different to that recorded in the 2005/2006 or 2007/2008 summer periods. There is therefore no evidence for any large change in larval smelt density in this lake over these years.

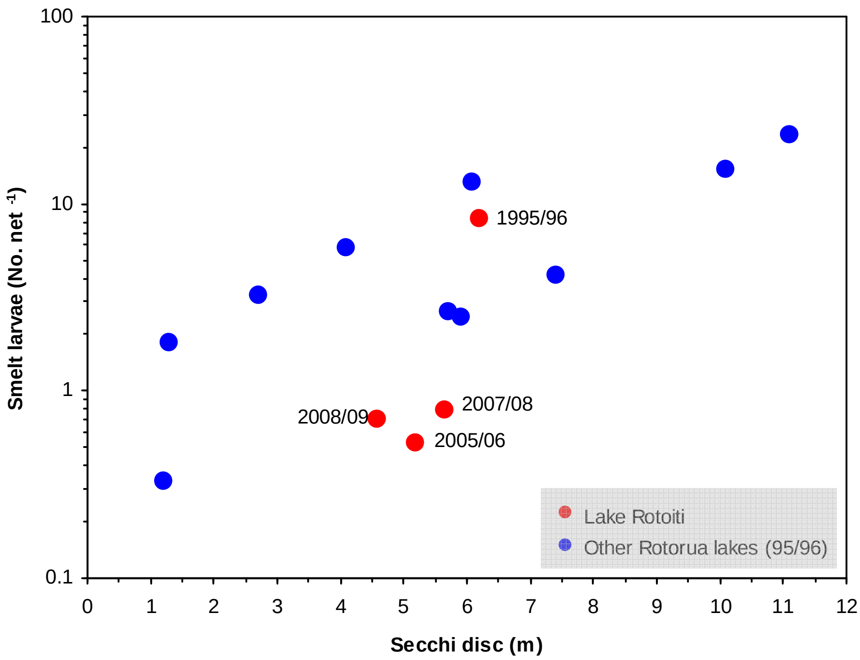


**Figure 16:** Relationship between mean larval smelt CPUE (No. net-haul$^{-1}$) for each spawning season (i.e., December plus April data combined) and water transparency among 11 Rotorua lakes (blue markers), showing changes in the relative density of larval smelt in Lake Rotoiti (red markers) over seasons.

The total length of larval smelt sampled ranged from 6-21 mm in December 2008 and from 7-16 mm in April 2009 (Table 4). The presence of small larvae (TL 4-8 mm) in each month sampled since December 2005, coupled with the presence of a wide range of larger smelt (TL 10-20 mm), indicates that smelt spawning is not restricted to early or late summer, but occurs over a wide range of summer months.

**Table 4:** Size range of larval smelt in Lake Rotoiti (December 2005- April 2009).

| Month and year sampled | Size range (TL mm) |
|---|---|
| December 2005 | 8-12 |
| April 2006 | 6-16 |
| December 2007 | 7-21 |
| April 2008 | 4-19 |
| December 2008 | 6-21 |
| April 2009 | 7-16 |

# 4. Discussion

Comparison of the Ohau Channel trap data for 2008 and 2009 with that for previous years (Fig. 17) showed that there were no extensive runs of smelt (as occurred in 2005/2006) into the Channel between 23rd September 2008 and 7th May 2009. However, short runs (over several days vs. several weeks) may well have occurred between the fortnightly sampling periods.

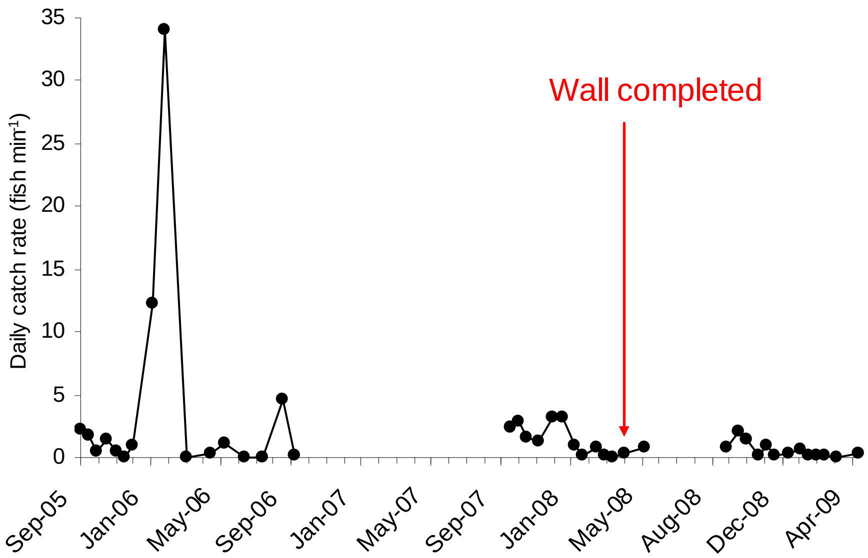


**Figure 17:** Long-term changes in the CPUE of smelt in the Ohau Channel.

A small run was reported by anglers in early May 2009 and this observation was supported by several observations of increased shag foraging activity in the channel. The trap results indicate that small numbers of smelt continue to move up-channel and that the seasonal change from juveniles to adults and back again still occurs. Collectively these results indicate that some smelt are moving up the channel despite the diversion of its entrance. Large runs, as occurred in 2005/2006, have not been recorded in the channel to date, but may not have occurred every year in the past. The abundance of smelt moving up the channel may increase in time as these fish adapt to the new channel configuration, but whether large runs will occur is unknown. Although the channel extension does not create a physical barrier to smelt migration upstream, its power to draw smelt from the far regions of Lake Rotoiti may be reduced because the flow from Lake Rotorua no longer travels deep and far into Lake Rotoiti, thereby providing a gradient of temperature, flow and/or planktonic food to attract the smelt.

There was a marked decline in the abundance of adult smelt in the eastern end of Lake Rotoiti in September 2008 compared with previous years. This contributed to the small drop in overall adult smelt abundance in 2008 compared with 2007. However, there was no evidence of a ‘crash’ in smelt in 2008 that would indicate a major impact of the diversion wall or of some other factor (e.g., increased trout predation) on smelt abundance in Lake Rotoiti. However, as the wall was completed in March 2008, it would not be expected to affect smelt recruitment until the 2008/2009 summer period and adult density until 2009/2010.

There was no indication that the recruitment of smelt larvae into Lake Rotoiti dropped between the 2007/2008 and 2008/2009 spawning seasons (i.e., post wall construction). Smelt recruitment as indicated by mean larval density varies by three orders of magnitude in the Rotorua lakes depending on their trophic status and, over the past 50 years, reduced water quality from increased eutrophication has steadily reduced smelt abundance in these lakes, probably by increasing egg mortality (Rowe & Taumoepeau 2004). In the decade between 1995/96 and 2005/2006, smelt recruitment declined by an order of magnitude in Lake Rotoiti. Since 2005/2006, smelt recruitment has remained static and dropped no further.

## 5. Acknowledgments

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# 6. References

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