Taihoro Nukurangi

Smelt monitoring in the Ohau Channel and Lake Rotoiti: 2009-2010

NIWA Client Report: HAM2010-064
June 2010

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Smelt monitoring in the Ohau Channel and Lake Rotoiti during 2009-2010

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Contents

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Executive Summary

In June 2008, a wall to divert the nutrient-rich water from Lake Rotorua around the edge of Lake Rotoiti and into the Kaituna River was completed. To determine any effect of this diversion wall on the migrations of smelt between Lake Rotoiti and Lake Rotorua via the Ohau Channel, annual monitoring of smelt runs in the Ohau Channel and smelt abundance in Lake Rotoiti have been carried out since 2006. Prior to June 2008, smelt monitoring provided a pre-diversion baseline and, as it takes at least a year for fish population dynamics to respond to a change in their environment, monitoring over 2008/2009 was not expected to reveal any major change. Monitoring during 2009/2010 therefore provides the first real opportunity to detect any impact of the diversion wall on smelt migrations in the Ohau Channel and smelt abundance in Lake Rotoiti.

As in previous years, the upstream migration of smelt was trapped at four sites in the Ohau Channel at 2-3 weekly intervals from August 2009 until June 2010. A high catch rate of adult smelt occurred in October 2009 and the concurrent increase in the abundance of shags indicated that a ‘run’ or migration of smelt was occurring in the Channel at this time. Near daily observations of birds, fish, and anglers made by a local angler near the top of the Ohau Channel indicated that runs of adult smelt were likely to have occurred on a number of days between September 2009 and February 2010, including the day on which the trapping occurred in October 2009. Collectively these results and observations indicate that the diversion wall has not stopped the migration of adult smelt into the channel to spawn. No runs of juvenile smelt were detected in spring or autumn, but they may either not occur on an annual basis or now only occur in winter months (i.e., outside the monitoring period). This aside, runs of adult smelt into the Ohau Channel occur with the diversion wall in place and provide opportunities for shags and gulls to feed, allow local iwi to harvest smelt in the channel, and facilitate the catch of trout by anglers.

Monitoring of larval smelt abundance in the lake indicated that larval densities over the 2009/2010 summer period were more than double those measured during the previous three summers. This may represent a generalised increase (i.e., smelt recruitment increased in all lakes because of similar weather conditions in 2009/2010) or it may be a lake-specific response, related to the increased water clarity in Lake Rotoiti and/or the absence of blue-green algal blooms. Further monitoring is required to determine whether smelt recruitment increases next year indicating a trend and reflecting lake restoration, or whether it was related to natural variability. The adult smelt population in Lake Rotoiti was estimated by acoustic surveys. The 2009 survey confirmed that the smelt population was the same as that recorded in 2008. The annual decline in overall mean abundance recorded between 2000 and 2007 has therefore been halted, and the increased survival of larval smelt in 2009/2010 may increase adult abundance in 2010/2011. We therefore recommend that monitoring continue for another year to determine whether the encouraging results obtained during the 2009/2010 season represent a trend or are simply a consequence of natural variation related to interannual variations in weather conditions.

1. Introduction

To reduce nutrient inflows from Lake Rotorua into Lake Rotoiti and thereby improve water quality in Lake Rotoiti, Environment Bay of Plenty diverted the inflow of water from Lake Rotorua into Lake Rotoiti. This diversion was achieved by the construction of a wall that diverts the water flowing down the Ohau Channel from Lake Rotorua around the edge of Lake Rotoiti towards the Kaituna River mouth.

Concerns that this wall may restrict fish movements between these two lakes and impact on trout and smelt fisheries were raised by the Eastern Fish and Game Council and local iwi respectively. This was because, firstly, migrations of adult smelt up the Ohau Channel occurred in spring and supported a small iwi fishery in the Channel as well as a seasonal trout fishery there. Migrations of juvenile smelt have also occurred up the Channel during summer/autumn months, but are not regular, annual events. Secondly, a decline in the smelt population in Lake Rotoiti could affect the trout fishery there. Because of these concerns, conditions requiring pre- and post-wall monitoring of smelt in both the Ohau Channel and Lake Rotoiti were attached to the resource consents granted to Environment Bay of Plenty. The intent of these conditions was to determine whether the wall affected smelt migrations in the Channel and/or smelt abundance in Lake Rotoiti.

Construction of the diversion wall was completed in June 2008 and monitoring was carried out in 2005/2006 and 2007/2008 to provide a pre-wall baseline. As there can be a delay of a year or more before fish populations respond to changes in their environment, monitoring in 2008/2009 was not expected to provide a true post-wall comparison. Monitoring in 2009/2010 therefore provides the first valid opportunity to detect any impact of the wall on smelt.

As in previous years, the movements of smelt up the Ohau Channel were monitored by trapping, and the size of the smelt population in Lake Rotoiti was assessed through the acoustic measurement of adult smelt abundance, together with the measurement of larval smelt density in this lake. Methods used have not changed between monitoring seasons, so that the results for 2009/2010 can be directly compared with the results from previous years.

2. Methods

2.1 Smelt migrations in the Ohau Channel

The location of the four sites (2 upstream, 2 downstream) used to monitor smelt movements in the Ohau Channel are shown in Figure 1.

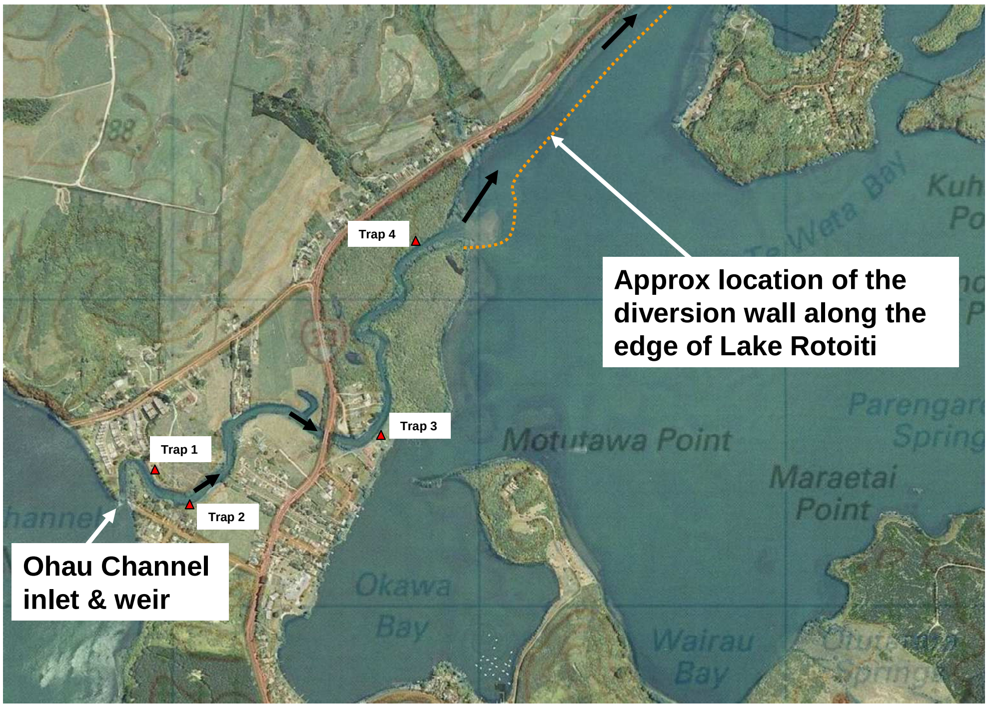

Figure 1: Location of smelt trapping sites (red triangles) in the Ohau Channel. Black arrows indicate direction of flow.

Trapping was carried out at two to three week intervals during the nine month period from 7th September 2009 until 8th June 2010. 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 usually set close to daybreak and the catch removed every 3-4 hours until late evening. The total number of smelt caught per trap 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 determining the proportion of juveniles to adults. Both the length (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 the high densities of smelt that are characteristic of large migrations (commonly termed runs). In addition to the smelt monitoring, water temperatures (Tidbit© data loggers), water clarity (black disc visibility), water velocities near the entrance to each trap, the discharge of water through the channel, and the by-catch of common bullies, koaro and trout were also recorded.

2.2 Adult smelt density

Acoustic surveys of adult smelt density in Lake Rotoiti were first carried out in September 2000 and were repeated annually from 2005 to 2008 using the same transects (Figure 2) and methods as used in previous surveys (Rowe et al. 2006; 2008; 2009).

The 2009 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 is borrowed from the Department of Conservation (Turangi) and 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 on Lake Rotoiti to date. The 2009 survey was carried out on 17th September and it was apparent that the repair of the V-fin cable (which broke in September 2008) had permanently altered the tilt of the V-fin. This introduces a consistent bias into the data with the actual depth of fish echoes now being slightly deeper than before and the strength of the return echo being slightly lower. These changes do not affect the estimation of smelt abundance, but they would reduce the estimation of smelt biomass unless corrected for the drop in mean target strength.

Because the V-fin is now old and no problems with wind and wave action have been experienced to date, we plan to replace the V-fin with a boat mounted pole or stanchion as this would overcome some of the 'noise' problems with the V-fin cable and avert future problems with cable failure. In 2009, contemporaneous data were collected using a new transducer mounted on a pole and stanchion. These new data will allow data from the two transducer systems to be cross-calibrated so that future results obtained via the new mount can be directly compared with the historic data. At present, this analysis has not been carried out and, if the acoustic survey is to be repeated in 2010, some provision for this will need to be provided.

The echosounder was calibrated in situ on the day of the survey and data on ambient ‘noise’ that could potentially confound the results were obtained. 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 occurred (i.e., echoes with target strengths ranging between -55dB and -45dB). This process excludes the smaller, juvenile smelt that are present mainly in surface waters (0-10 m) and which are not amenable to acoustic sampling.

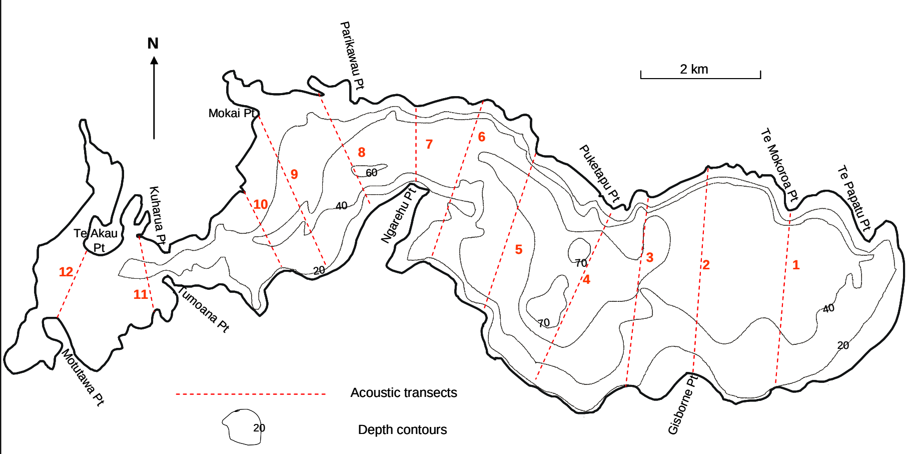

Figure 2: Transects (dashed red lines, labelled 1-12) used for the acoustic survey of Lake Rotoiti in September 2009.

The acoustic data present in the adult smelt regions of each transect were analysed using ESP2 (McNeil et al. 2003) to determine the total amount of acoustic backscatter received from each region (i.e., a measure of the total sound energy reflected by the fish present within a depth delineated region on each transect). This process can be expected to include backscatter from adult rainbow trout and some larval bullies present in these regions. However, trout are generally present in shallower waters above the adult smelt layer (Rowe & Chisnall 1995) and adult smelt occupy deeper waters in lakes (presumably to avoid trout predation). Therefore overlap in distributions is minimised. Although the presence of some trout in the ‘adult smelt’ layer could result in 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 2009 survey and compared with that measured each year from 2005 to 2008 to identify any changes in the spatial patterns of smelt abundance in the lake. 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 2009. As the backscatter produced by a single, average-sized smelt may differ between years (e.g., because of differences in growth rate 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 smelt larvae grow over summer and winter months until they reach a length of around 25 mm at which time they become pigmented, adopt adult coloration, and form large schools in the surface waters (0-5 m) of the lake, where they become the main prey species for rainbow trout. The optimal time for smelt 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 2009 and in April 2010. The Wisconsin drop net has a mouth area of $0.25m^2$ 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 because 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 2009/2010 spawning season (i.e., December 2009 plus April 2010) and expressed in relation to secchi disc depth to reveal any change in density independent of changes in water clarity. The data for 2009/2010 were compared with those for previous years to determine any significant trend.

3. Results

3.1 Ohau Channel smelt

Trap one generally catches more smelt than the other traps. However, exceptions occurred between September and November 2008, in April and May 2009, in September and October 2009, and in April and June 2010 (Fig. 3).

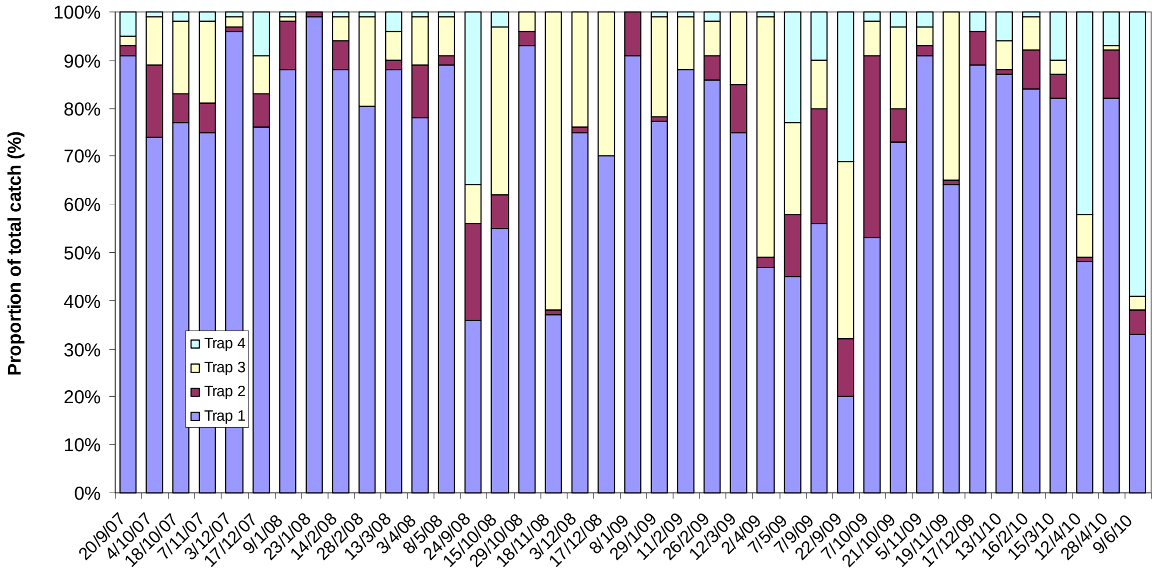

Figure 3: Proportions of all smelt caught by the four traps between September 2007 and June 2010 (Traps 1 and 2 are located near the top of the Ohau Channel and Traps 3 and 4 are located further downstream, just above the old outlet to Lake Rotoiti).

The daily catch for Trap 1 was negatively correlated (Pearson's product moment) with the daily catch for all other traps (Table 1). This indicates that when Trap 1 caught high numbers of smelt, all other traps caught lower numbers. Site-specific differences in capture rates are most likely to 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. Boat-based electro-fishing surveys have shown that smelt abundance is highest near the top of the Channel, just below the weir, and decreases with distance downstream (Bris et al. 2008).

Table 1: Correlations between smelt catches per trap.

	Trap 1	Trap 2	Trap 3	Trap 4
Trap 1	1			
Trap 2	-0.368161	1		
Trap 3	-0.587281	-0.169192	1	
Trap 4	-0.660954	0.152127	-0.085102	1

Flow rates in the Ohau Channel varied greatly over time (Fig. 4), hence water velocities also varied over time and between the trap sites (Fig. 5). Water velocities were generally highest at the Trap 1 site (Fig. 5) and this could account for the generally higher catch rates here between 2008 and 2009, but not at other times.

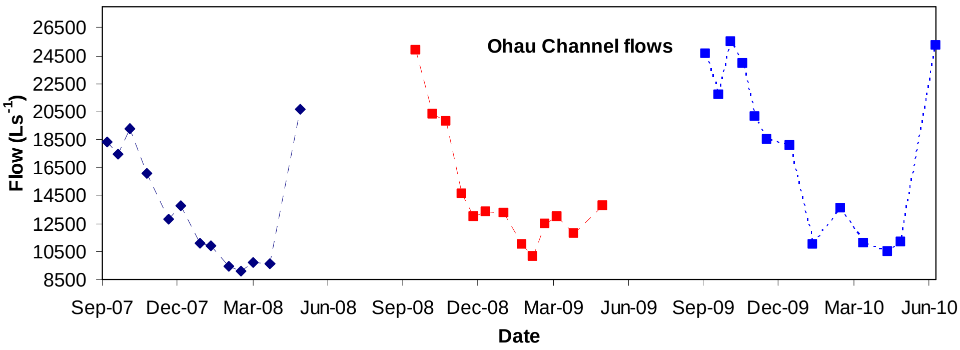

Figure 4: Flows through the Ohau Channel September 2007 to June 2010.

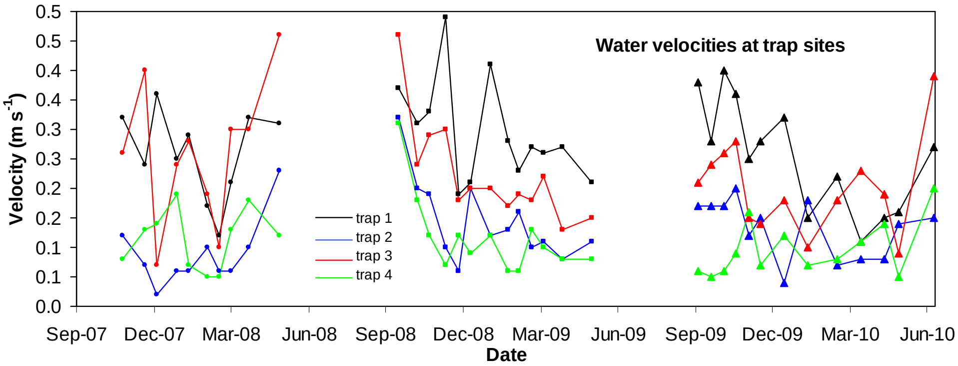

Figure 5: Variations in water velocity at the four trap sites over time.

The daily mean catch rate of smelt remained below 2 fish min^{-1} throughout the 2007/2008 and 2008/2009 monitoring seasons (Fig. 6) but increased to 3.5 fish min^{-1} in October 2009 (Fig. 6). Runs of smelt in the channel are usually accompanied by an increase in predators (i.e., shags, gulls, trout) and by an increase in anglers. Shag numbers were also high at this time (Fig. 7) indicating that a run of smelt was occurring. Observations of predators and angling activity made at this time by a local angler of many years experience (Mr Proud) confirm that a smelt run was occurring (Table 2).

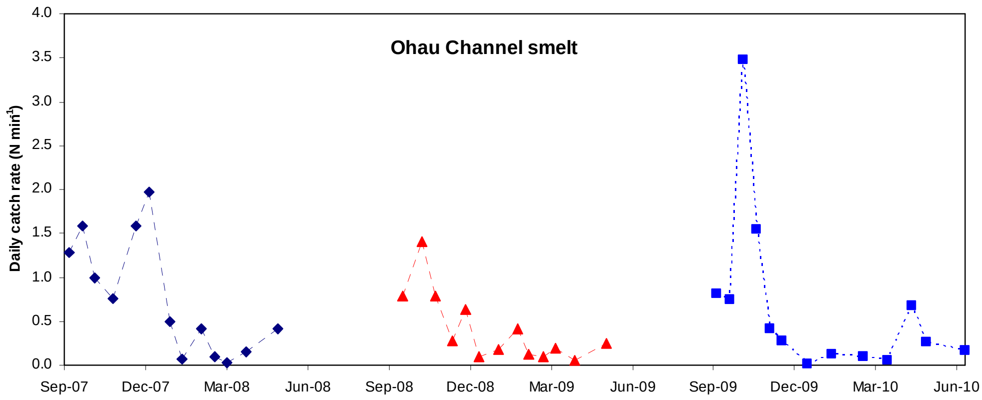

Figure 6: Daily catch rate for smelt in the Ohau Channel from September 2007 to May 2009.

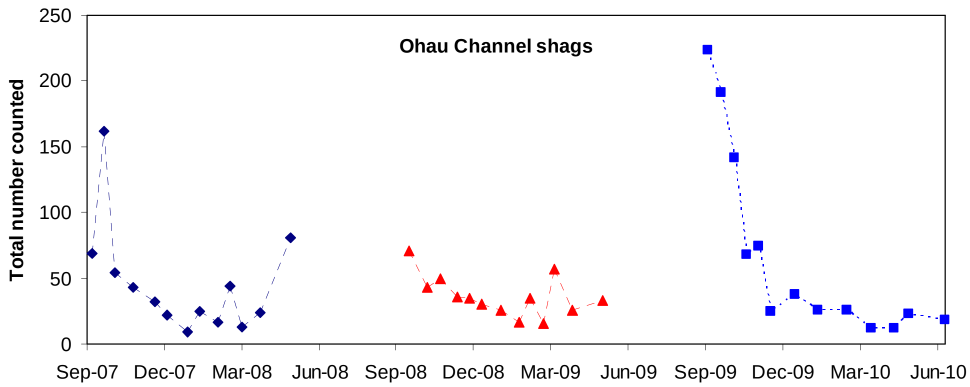

Figure 7: Counts of shags along the side of the Ohau Channel from September 2007 to June 2010.

Table 2: Observations made by Mr Proud of birdlife, fish activity and angling in the vicinity of the Ohau Channel weir on a near daily basis between September 2009 and June 2010 (observations indicative of smelt runs are in red, 'std' is standard daily time, 'nos' is numbers).

Date	Daily observations and notes (2009-2010)
31/08/2009	13:00. No birds observed around weir or to main road bridge. **Run reported in morning**
2/09/2009	14:00. No birds observed around weir or to main road bridge
3/09/2009	14:00. No birds observed around weir or to main road bridge
7/09/2009	Smelt survey by Niwa.
8/09/2009	9:30 am. Small no of birds observed working
12/09/2009	11:30 am. Large no of shags above main road bridge
14/09/2009	9:15 am. Large no of shags above main road bridge
14/09/2009	12:00 (noon). Shags and trout going to town below weir
14/09/2009	15:30. No birds below weir
15/09/2009	14: 30. Bird nos. low
17/09/2009	12.30 pm. No birds
18/09/2009	9:30 am. Some birds above main road bridge
20/09/2009	A lot of birds around trap one pers comm
21/09/2009	No birds weir to trap 2
22/09/2009	Smelt survey by Niwa. A lot of birds in morning
23/09/2009	Lots of whitebaiters below weir in morning, none at 12.00 (photos)
24/09/2009	9:00 am. No birds around weir, a few trap one and two and none else where (photos)
25/09/2009	A few birds below weir, about 12 shags sunning themselves above trap one and a few birds above main road bridge. (photos)
1/10/2009	8.00 am. A lot of shags, gulls and herons. **Smelt run evident,** 50-60 fisherman and 124 fish measured by 9.00 am
2/10/209	7.30 am. A lot of shags and gulls, a few herons, **A smelt run noticed** and 30-40 fisherman
4/10/2009	6.30 am. Low number of shags and herons and no gulls. A lot of smelt but not called a run. 12 fisherman.
7/10/2009	Smelt survey by Niwa. Whitebaiter above trap one. Same guy who was in fish and game photos and F&G magazine.
11/10/2009	3.00am. Few shags, gulls and herons.A lot of smelt and about 14 fisherman.
11/10/2009	8.30 pm. Hardly any shags, no gulls and low nos of herons.A lot of smelt and 3 fisherman.
17/10/2009	7.30 pm. Hardly any shags, no gulls and a few herons. A lot of smelt and 6 fisherman.
18/10/2009	7.00 am. Low nos of herons(10-20) but a lot of shags and gulls. **Smelt run evident** and trout caught. 13 fisherman
19/10/2009	6.30 am. A lot of shags and gulls. Low no. of herons (10-20). A lot of smelt, fish caught and about 20 fisherman.
21/10/2009	Smelt survey by Niwa.
25/10/2009	7.00 am. A lot of gulls. Low no of herons(10-20) and low no of shags(10-20).a lot of smelt, fish caught and about 8 fisherman
26/10/2009	7.30. A lot of gulls and shags. Many herons. A lot of smelt, fish caught and about 15 fisherman.
28/10/2009	8.00am. Many shags and gulls. Low no of herons(10-20). A lot of smelt, fish caught and about 8 fisherman.
29/10/2009	7.00 am. Low no of shags(10-20), low no of gulls(10-20) and many gulls. A lot of smelt, fish caught and about 5 fisherman,
2/11/2009	7.00am. Many shags, many gulls and quite a few herons and lots of smelt evident and about 8 fisherman.
2/11/2009	6.30pm. Few shags, Many gulls and few herons and lots of smelt evident and about 3 fisherman.
5/11/2009	Smelt survey by Niwa. Lots of anglers in morning and also birds but activity subsided during the day. No anglers at night.
7/11/2009	6.30 am. Many shags and gulls. Few herons and lots of smelt and about 15 fisherman.
19/11/2009	Smelt survey by Niwa.
17/12/2009	Smelt survey by Niwa.
13/01/2010	Smelt survey by Niwa.
16/02/2010	Smelt survey by Niwa.
15/03/2010	Smelt survey by Niwa.
12/04/2010	Smelt survey by Niwa staff. Anglers catching fish at weir.
28/04/2010	Smelt survey by Niwa staff. Anglers catching fish at weir.
7/05/2010	7.30 am. Few shags, gulls and quite a few herons. 3 fisherman. A lot of smelt. Fish being caught.
9/05/2010	8.30 am. No shags and gulls and a couple of herons. 3 fisherman. No smelt evident. No fish caught.
9/05/2010	5.45 pm. No shags and a couple of gulls and herons.4 fisherman and no smelt evident. Fish being caught.
20/05/2010	7.30 am. Many shags (>20). A few gulls and herons. 3 fisherman and few smelt evident. Fish being caught.
20/05/2010	7.00 pm. A few shags, no gulls and between 5 - 10 herons. 1 fisherman and a few smelt evident. No fish caught.
23/05/2010	8.00 am. A few shags, no gulls and a few herons. 4 fisherman and a few smelt evident. Fish being caught.
23/05/2010	5.45 pm. No shags , gulls or herons. 5 fisherman and no smelt evident. No fish being caught.
26/05/2010	6.30 pm. No shags and few gulls and herons. No fisherman and no smelt evident. No fish being caught.
27/05/2010	7.00 am. Between 10-20 shags. A few gulls and herons. 2 fisherman and no smelt evident. Fish being caught.
29/05/2010	5.00 pm. A few shags, gulls and herons. 4 fisherman and no smelt evident. No fish caught.
31/05/2010	9.30 am. A few shags. No gulls and herons. 4 fisherman and no smelt evident. Fish being caught.
31/05/2010	6.00 pm. No shags or gulls and a few herons. 1 fisherman and no smelt evident. Fish being caught.
1/06/2010	7.30 am. A lot of shags (>20) and between 10-20 gulls and herons. 2 fisherman and no smelt evident. Fish being caught.
9/06/2010	Smelt survey by Niwa.

The observations of birdlife and angling activity at the Ohau Channel mouth indicate that smelt runs were probably more extensive in both frequency and duration than recorded by trap monitoring. This is to be expected when trapping is staged at 2-3 week long intervals and the timing and duration of smelt runs is highly variable.

The seasonal timing of adults and juvenile fish remained much the same as in previous years, with juveniles increasing over the warmer, summer months and adults being more abundant at other times of the year (Fig. 8). Adults were responsible for the run of smelt in October 2009 and adult smelt occurred in large numbers in the Channel up until December 2009. No 'summer/autumn' runs of juvenile smelt have been recorded since 2006.

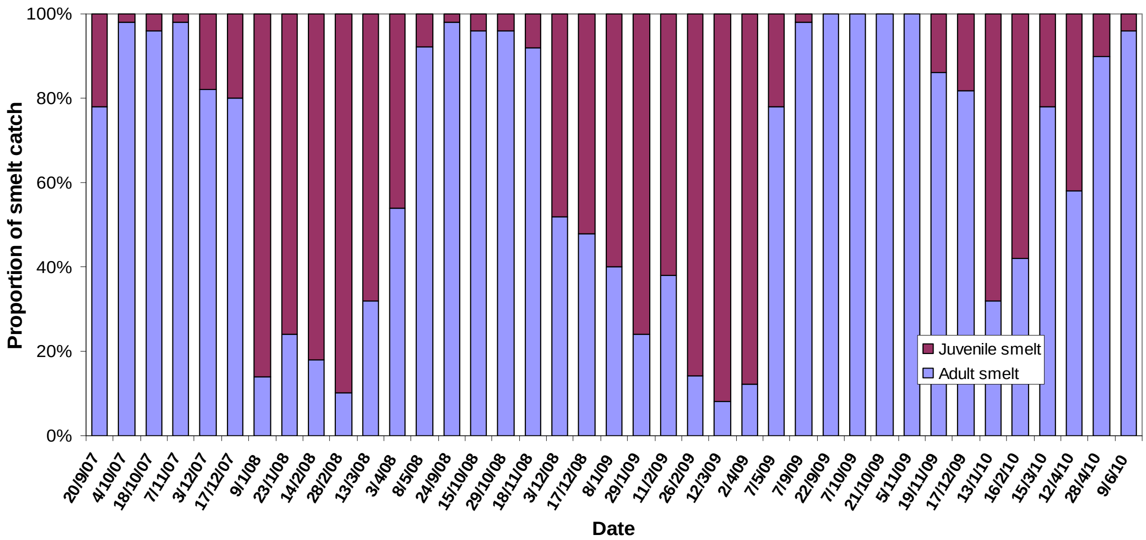

Figure 8: Proportion of juvenile versus adult smelt in the Ohau Channel trap catch from September 2007 to June 2010.

The catch of smelt was positively correlated with flow (Table 3) suggesting that smelt may swim closer to the bank (and hence become more vulnerable to capture) when high water velocities, related to higher flows, occur in mid-channel.

Table 3: Correlations between the variables measured between 2007 and 2010.

	Smelt catch (No. min^{-1})	Bully catch (No. min^{-1})	Shags (No.)	Black disc (m)	Flow (Ls^{-1})
Smelt catch	1.00				
Bully catch	0.16	1.00			
Shags	**0.46**	0.02	1.00		
Black disc	0.05	0.43	-0.22	1.00	
Flow	**0.50**	0.02	**0.63**	-0.25	1.00

The daily mean catch of smelt was positively correlated with shag counts (r = 0.46) (Table 3), indicating that shag numbers increase in response to increased prey (i.e., smelt). The relatively high correlation between shag number and flow rate suggests that more shags accumulate in the channel at times of high flow. This could be because smelt are easier to feed on when flows are high (i.e., they form dense schools which move closer to the bank), but this is hypothetical.

The by-catch of bullies and koaro is shown in Figures 9 and 10 respectively. The summer peaks in bully abundance are related primarily to the presence of juveniles. Because their ability to swim against a high water velocity is very limited, they are likely to be moving downstream from Lake Rotorua close to the bed of the channel. This means that they will be caught in the traps as they seek shelter from high water velocities by congregating behind the downstream end of the traps. Major peaks in juvenile koaro counts occurred mainly during mid-summer months (December and January) when juveniles are known to undertake a migration from lakes into tributary streams. They are relatively good swimmers compared with bullies and are likely to be moving upstream in the Ohau Channel at this time.

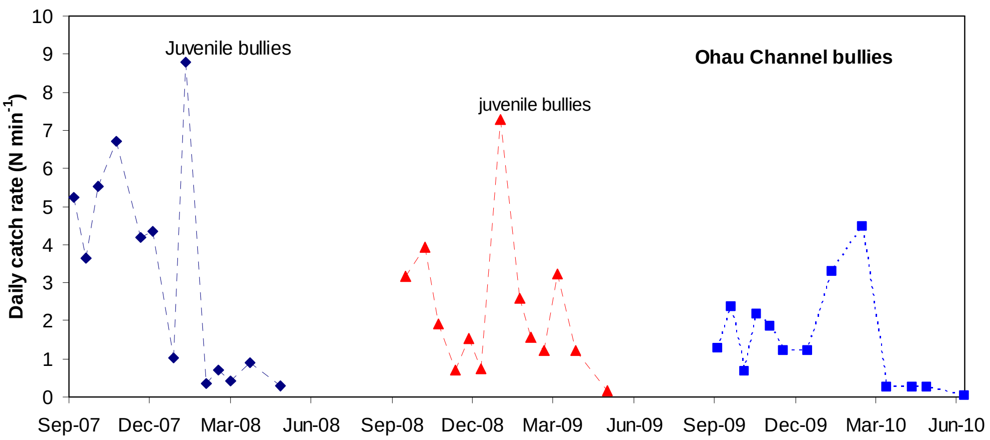

Figure 9: Total daily catch rate for bullies in the Ohau Channel.

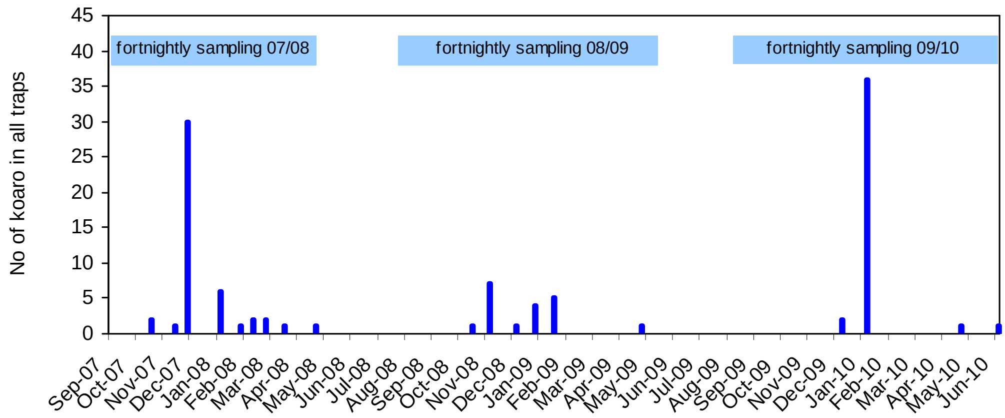

Figure 10: Catches of koaro in the Ohau Channel traps over each sampling period (blue bars).

Between September 2009 and June 2010, water temperatures in the Ohau Channel ranged from 9ºC to 26ºC (Fig. 11) - a similar range to that recorded in previous years.

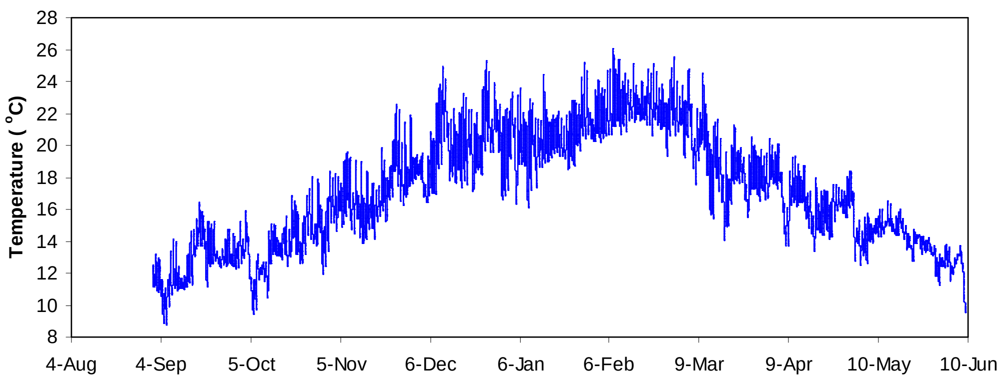

Figure 11: Water temperature in the Ohau Channel over the 2009/2010 sampling period.

Water clarity (as measured by black disc transparency) ranged from 0.5 to 2.0 m over the 2009/2010 sampling period (Fig. 12). In general, water transparency in the Channel has tended to decrease each season. The reductions in water transparency recorded in February 2008 and December 2009 are likely to be related mainly to algal blooms in Lake Rotorua.

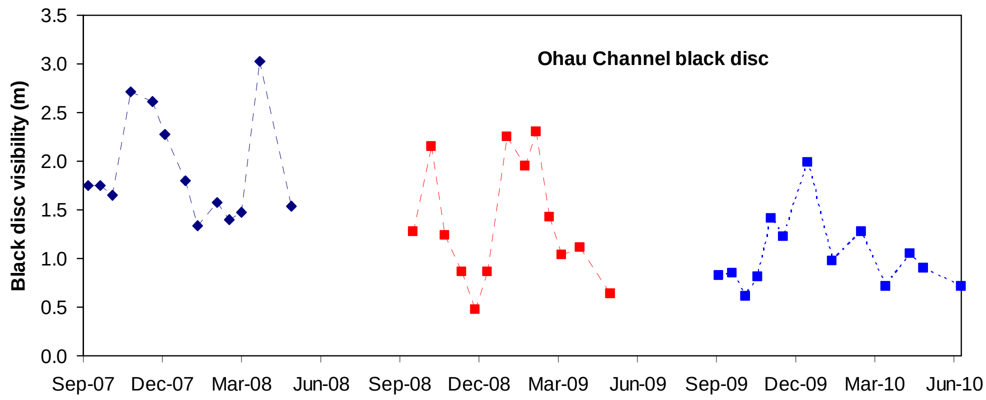

Figure 12: Water transparency in the Ohau Channel from September 2007 to June 2010.

3.2 Adult smelt density

As in previous years, adult smelt abundance in 2009 decreased from transect 1 (deeper eastern basin end) to transect 12 (shallow western basin, close to the Ohau Channel) (Fig. 13).

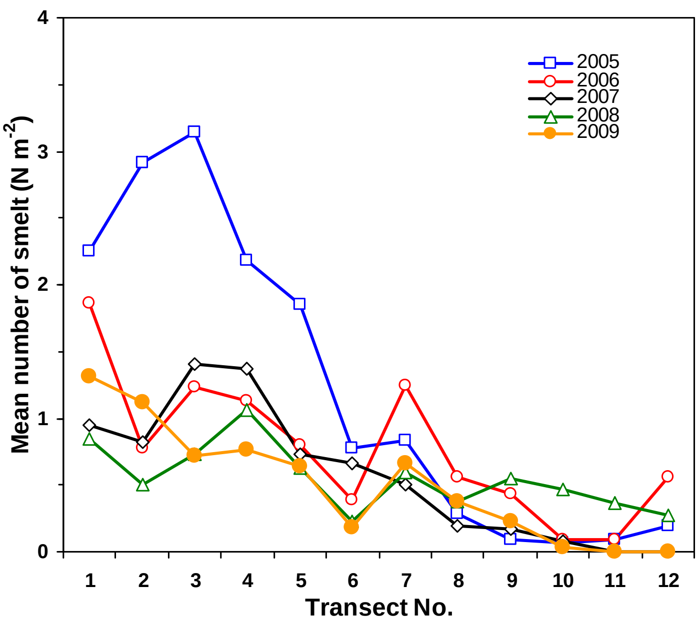

Figure 13: Mean number of adult smelt (N m^{-2}) per transect for each of the acoustic transects in Lake Rotoiti between September 2005 and September 2009.

The 2009 target strength (TS) frequency distribution for 'individual' echoes from smelt revealed several distinct modes, as in previous years (Figure 14). In 2009, the modal value for all smelt was close to -56dB, which is similar to that recorded in 2008 and slightly lower than in previous years, apart from 2005. Lower values were expected in 2008 and 2009 as a consequence of the slight transducer tilt, but this effect is likely to be minor in relation to the effect of other factors and does not affect estimates of abundance.

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, and 2005 to 2009 respectively. The estimate for 2008 was adjusted (upward) to account for a processing error related to the estimate of mean target strength for an individual smelt. As a consequence, the abundance of adult smelt in Lake Rotoiti in September 2009 is much the same as it was in 2007 and 2008. The decline in abundance that occurred between 2000 and 2007 has therefore been halted, but there is as yet no sign of an increase in smelt abundance back to the levels recorded in 2000.

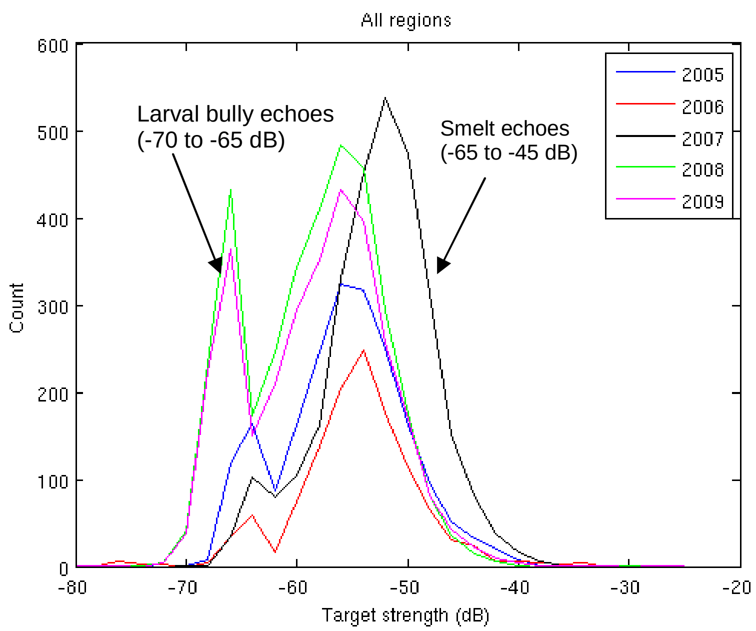

Figure 14: Frequency distributions for 'individual' echoes in Lake Rotoiti 2005 to 2009 showing inter-annual variation in the modal echo strength for individual smelt (both adults and juveniles).

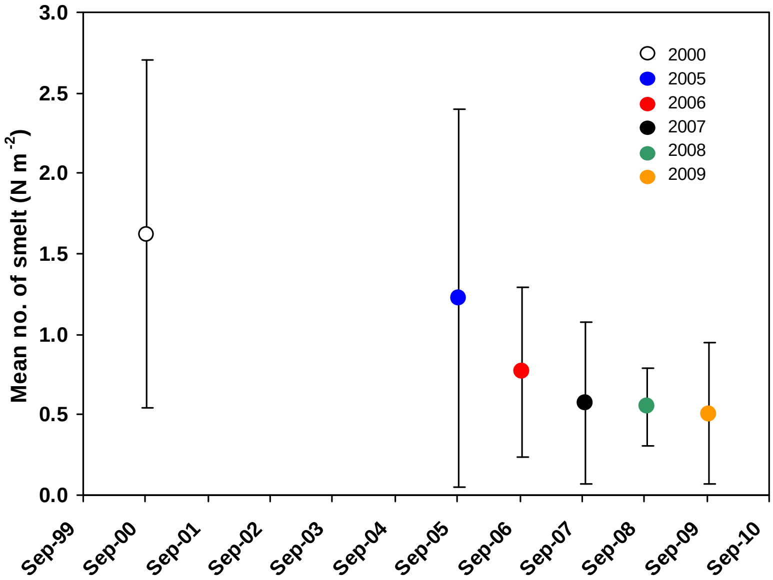

Figure 15: Mean density (±SD) of adult smelt estimated from acoustic surveys in September for 2000 and 2005 to 2009 in Lake Rotoiti.

3.3 Larval smelt density

Mean catch rates for larval smelt, reflecting areal densities throughout the water column, are shown in Table 4. Catch rates in both December 2009 and April 2010 were more than double those recorded in previous years.

Table 4: 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
2009/2010 (n =30)	2.52 ± 1.39	1.68 ± 1.49

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 measurements in lakes therefore need to be standardised for changes in lake water transparency. The mean smelt CPUE for the 2009/2010 summer period is shown relative to other years and to other Rotorua lakes in Figure 16. The density of larval smelt over the 2009/2010 summer period was higher than recorded for the previous three summers indicating higher than usual recruitment. However, recruitment was not as high as recorded during the 1995/1996 summer. The increase in larval smelt recruitment in Lake Rotoiti in 2009/2010 could be a consequence of natural variation related to weather conditions (i.e., an increase occurred in all local lakes), or it could be lake-specific and related to the increased water clarity and/or absence of blue green algal blooms in Lake Rotoiti during 2009/2010.

The total length of larval smelt sampled ranged from 5-23 mm in December 2009 and from 5-18 mm in April 2010. The presence of small larvae (TL 4-8 mm) on each sampling occasion 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. The frequency distribution for 2009/2010 (Fig. 17) indicates that there has been a general increase in both the size and number of larval smelt present.

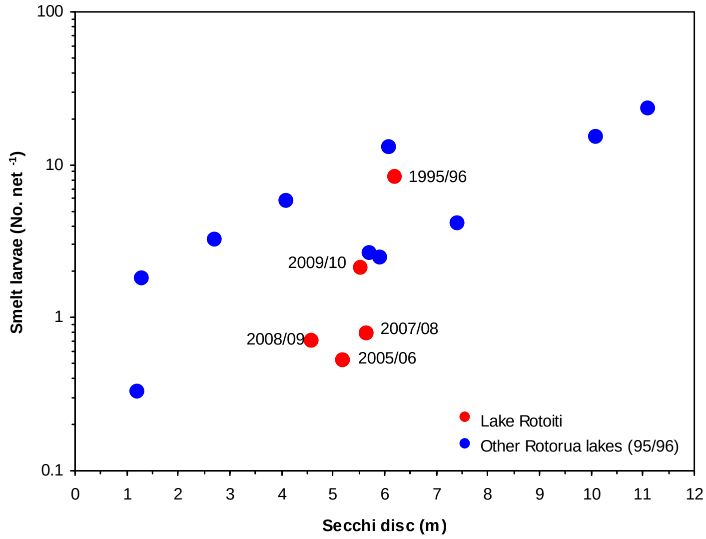

Figure 16: Mean abundance of larval smelt (No. net-haul^{-1}) in Lake Rotoiti for December and April in the 1995/1996 summer period, and for summer periods between 2005/2006 and 2009/2010, all in relation to mean water transparency as measured by secchi disc depth (red circles). Data for Rotoiti are shown in relation to data for 10 other Rotorua lakes (blue circles) over the 1995/1996 summer, showing the positive relationship between larval smelt abundance and water transparency among lakes (Rowe & Taumoepeau 2004).

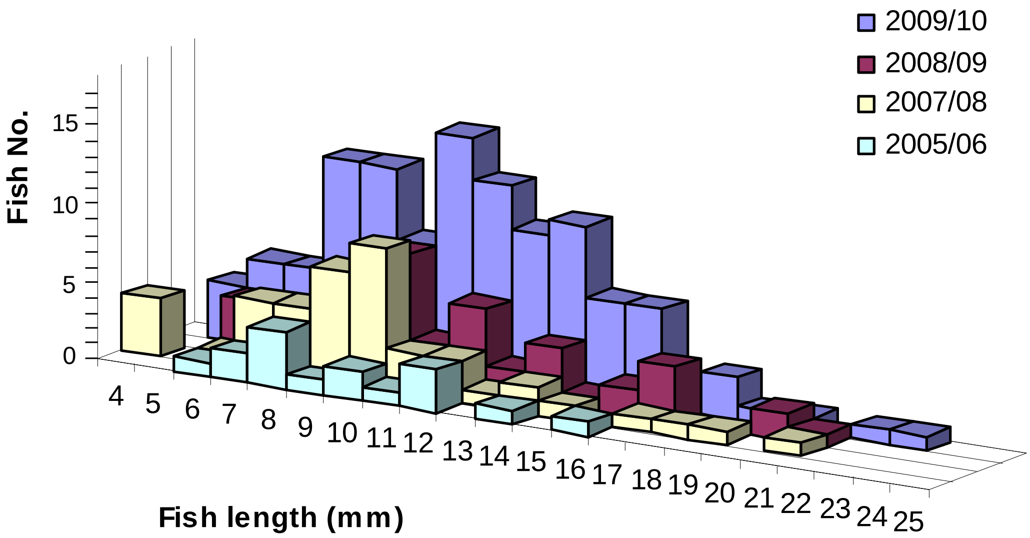

Figure 17: Size frequency distributions for larval smelt in Lake Rotoiti during the past four summers.

4. Discussion

Comparison of the Ohau Channel trap data between June 2005 and June 2010 indicates that large runs of smelt occurred in the 2005/2006 summer season (pre-wall), but not in the 2007/2008 (pre-wall) and 2008/2009 (post-wall) seasons (Fig. 18). However, a run of adult smelt was recorded in the 2009/2010 season. This indicates that the Ohau Channel diversion wall does not prevent runs of adult smelt from occurring in the Channel during spring months. However, runs of juvenile smelt, which can be expected in summer/autumn months have not been detected by fortnightly trapping to date. This may be because they have not occurred or because they occur after trapping ceases (e.g., June). Whereas a smelt run was reported to us in June 2008, trapping through to mid-June in 2009 did not reveal any increase in smelt at this time.

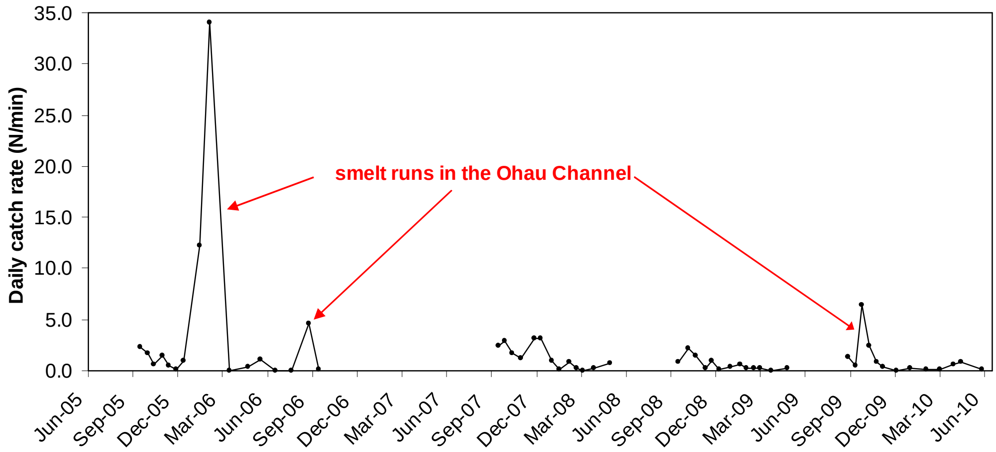

Figure 18: Long-term changes in the mean CPUE of smelt in the Ohau Channel from Traps 1 and 2 (traps 3 & 4 were not installed until 07/08).

The abundance of adult smelt in Lake Rotoiti was much the same in 2009 as it was in 2008, indicating that the marked and steady decline of smelt that occurred between 2000 and 2007 (Fig. 15) has now been halted. This may reflect the positive effect of the diversion wall on the water quality of Lake Rotoiti (i.e., improved water clarity and absence of blue green algal blooms). However, monitoring over a longer time frame would be required to confirm this.

The recruitment of larval smelt into Lake Rotoiti was significantly higher during the 2009/2010 summer season than in the previous two seasons indicating that recruitment of smelt to Lake Rotoiti is not dependant on any influx of larvae from Lake Rotorua or on spawning over the sandy banks of the former delta region of the Ohau Channel. In both December 2009 and April 2010, the distribution of larval smelt was spread throughout the lake and was not confined primarily to the deeper eastern basin as occurred in previous years. This augers well for next season, as by September 2010, many of these fish will be adults and this could then increase the acoustically estimated adult smelt population. However, this assumes that the predation rate by trout does not increase significantly (i.e., stocking densities remain the same) and that the survival of smelt is not density dependent or limited by food.

In conclusion, runs of adult smelt occurred in the Ohau Channel during the 2009/2010 summer indicating that the diversion wall has not affected these fish. Spring runs of juveniles have not been detected since 2006, but they did not occur in 2007 (i.e., before the diversion wall was installed) so may only occur in some years. Anecdotal reports of a run of smelt in the channel in June 2008 (just after sampling ended) suggested that runs of juveniles may still be occurring but during early-winter rather than late summer/autumn months.

5. Recommendations

Monitoring should be carried out for at least one more year to confirm that smelt runs in the Ohau Channel continue and to provide another opportunity to detect runs of juvenile smelt. Monitoring for a further year is also recommended in Lake Rotoiti to determine whether the increase in larval smelt and the halt to the annual decline in adult smelt numbers in Lake Rotoiti continues.

6. Acknowledgments

Joe Tahana organised access to private property along the Ohau Channel. Chris Fern, Julie Proud and Joe Butterworth helped with the smelt sampling and Shane Grayling assisted with drop-netting in Lake Rotoiti. In particular, George Proud provided valuable notes on bird, fish and angling activity near the Ohau Channel weir. We thank all these people for their assistance and valuable input into this study.

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