OHAU CHANNEL DIVERSION WALL

Monitoring of kōura and kākahi populations in the Ōkere Arm and Lake Rotoiti

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Ian Kusabs[1], Willie Emery[2] & Joe Butterworth[3]

[1]Ian Kusabs & Associates Ltd

[2] Te Arawa Lakes Trust

[3]Bay of Plenty Regional Council

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Table of Contents

Cover photo: Kōtuku (white heron, *Egretta alba modesta*) Ohau Channel weir, 24 April 2013. Photo Ian Kusabs.

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

Kōura (*Paranephrops planifrons*) and kākahi (*Echyridella menziesi*) support important customary fisheries in Lake Rotoiti where they are still harvested for human consumption. As part of the efforts to improve water quality in Lake Rotoiti, Bay of Plenty Regional Council has built a wall that diverts nutrient rich water from Lake Rotorua down the Kaituna River, preventing it from entering Lake Rotoiti. The wall has separated Lake Rotoiti into two ecologically separate waterways, an eastern basin (no Lake Rotorua influence) and a small western basin (Lake Rotorua influence). Wall construction was completed in July 2008.

Baseline monitoring of kōura and kākahi populations in the Ōkere Arm and Lake Rotoiti was carried out from December 2005 to September 2007 (Kusabs et al. 2006, 2008). This monitoring showed that kōura and kākahi were present in high numbers in both the Ōkere Arm and Lake Rotoiti. The objective of this study was to monitor kōura and kākahi populations in the Ōkere Arm and Lake Rotoiti since the installation of the Ohau Channel diversion wall.

2 METHODS

2.1 Tau kōura location and lay out

The Lake Rotoiti kōura population was sampled using the tau kōura, a traditional Māori method of harvesting kōura in the Te Arawa and Taupō lakes (Kusabs & Quinn 2009). Three tau kōura were set in Lake Rotoiti, located in the Ōkere Arm (Ōkere), Te Ākau Point (Te Ākau) and near Manupirua hot pools (Hotpools; Fig. 1, see Kusabs et al. 2010 for NZMG grid references). Fieldwork for this survey period (2012 - 2013) was carried out on an approximate 3 monthly basis from November 2012 to September 2013.

The methods used in this study are described in previous reports (see Kusabs *et al.* 2010). Each tau kōura was comprised of 10 dried bracken fern (*Pteridium esculentum*) bundles, with c. 10-14 dried fronds per bundle, which were attached to a bottom line (a 200 m length of sinking anchor rope) and set. The Ōkere Arm, Te Ākau and Hotpools tau kōura were in water depths ranging from 4 to 7 m, 7 m to 17 m and 11 m to 27 m, respectively.

The tau kōura were left for 1 month to allow kōura to colonise the fern and retrieved every 3 months. The tau kōura were replaced back into the water once kōura had been monitored. Owing to decomposition, whakaweku (or fern bundles) were replaced every 6 months.

Figure 1 Kōura and kākahi monitoring sites, Lake Rotoiti, 2005-13. Numbers in red boxes (1 = Ōkere Arm, 2 = Te Ākau, 3 = Hotpools) show the approximate locations of the kōura monitoring sites and numbers in black circles indicate kākahi sites (refer Table 1 for kākahi site names).

2.2 Kākahi

Kākahi transects were located at 5 sampling sites in Lake Rotoiti (table 1 and fig. 1) [1]. At each site 40 m transects, 0.5 m wide, and perpendicular to the shore, were inspected out into the lake from standard points to a depth where the water was regularly wadeable. All kākahi in an area of 0.5 m wide running parallel to and up-current from a weighted survey line were counted using an underwater viewer. Counts were summed for each 1 m interval. Where possible, surveys were carried out when weather conditions and water clarity allowed good visual observations to be made of kākahi in Lake Rotoiti and the Ōkere Arm.

2.3. Data Analysis

Time series analyses were performed for kākahi abundance at the 5 sampling sites and kōura at 2 sites (Ōkere and Te Ākau) over the sampling period (2005 to 2013). Where necessary, data were $\log_{10}$ or Sqrt transformed to approximate the normal distribution.

[1] Note: Kākahi counts at Tumoana Bay were discontinued in 2011 due to the very low numbers present.

Table 1 Sampling site, number, location, grid reference and direction of transect for 6 kākahi monitoring sites located in Ōkere Arm and Lake Rotoiti.

Sampling site	Location	Grid reference (NZ Geodatum)
1. Boat Ramp	Ōkere Arm	E 2802931 N 6346315
2. Rest area	Ōkere Arm	E 2803075 N6346554
3. Ditch	Ōkere Arm	E 2803237 N 6346621
4. Ōkawa Bay	Lake Rotoiti	E 2802903 N 6345642
5. Tūmoana Point	Lake Rotoiti	E 2805639 N 6345842
6. Ruato Bay	Lake Rotoiti	E 2811245 N 6343779

3 RESULTS

3.1 Kōura

Sampling conditions

No count was obtained from Te Ākau in May 2013 as the tāuhu (tau line) had become snagged under a large log and could not be retrieved. The shoreline end of the tāuhu has subsequently been repositioned to avoid this situation re-occurring.

3.1.1 Kōura abundance

A total of 883 kōura were captured at Ōkere, 460 kōura at Te Ākau and 1148 kōura at Manupirua Hotpools, in the 4 surveys (3 surveys at Te Ākau) carried out from 21 December 2012 to 2 September 2013 (fig. 2, table 5 appendix). Mean CPUE (Catch per Unit Effort) at Ōkere ranged from 18.2 to 26.4 kōura per whakaweku, at Te Ākau 8.6 to 27 kōura per whakaweku, and at Manupirua Hotpools 15.1 to 53.4 kōura per whakaweku (fig. 2, table 2).
There have been significant declines in kōura CPUE at Okere ($p < .01$) and Te Ākau ($p < .01$) over the sampling period (2005 to 2013) but no significant change at Manupirua Hotpools ($p > .05$) (fig. 4, appendix).

Table 2 Mean and range of CPUE and biovolume of kōura captured from tau kōura set at Okere, Te Ākau and Manupirua Hotpools from 21 December 2012 to 2 September 2013.

Site	Mean CPUE (n)	Mean CPUE (n) range	Mean biovolume (l)	Range mean biovolume (l)
Okere	22.1	18.2 – 26.4	39	2.3 – 5.1
Te Ākau	15.3	8.6 – 27	88.8	5.7 – 22.5
Hotpools	29.4	15.1 – 53.4	168.3	7.5 – 10.5

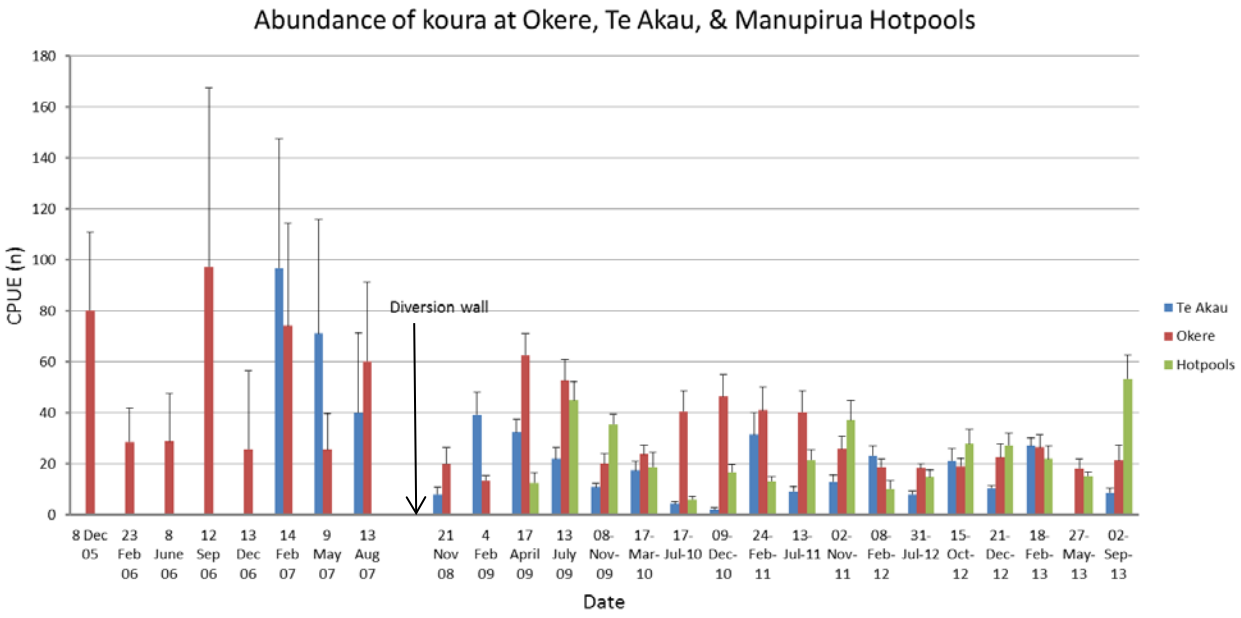

Figure 2 Mean catch per unit effort (CPUE) of kōura (± SE; n = 10) captured in tau kōura set in Ōkere Arm, Te Ākau and Manupirua hot pools, Lake Rotoiti, 8 December 2005 to 15 October 2012. Diversion operational in July 2008.

3.1.2 Biovolume

Biovolume ranged from 2.3 l to 5.1 l at Ōkere, 5.7 l to 22.5 l at Te Ākau and 7.5 l to 10.5 l at Manupirua Hotpools (table 2). There was a significant decline in biovolume of kōura captured at Ōkere over the sampling period ($p < .05$), a weak statistical decline in kōura biovolume at Te Ākau ($p = .07$), and no significant change in biovolume of kōura at Manupirua Hotpools ($p > .5$) (fig. 5, appendix).

3.1.3 Size

As in previous years, the highest mean size of kōura (OCL = 28.2 mm) was recorded at Te Ākau, followed by the Hotpools (OCL = 24 mm), with the smallest kōura at Ōkere (OCL = 16.3 mm) (table 3). Kōura ranged in size from 6 to 40 mm at Ōkere, 6 to 51 mm at Te Ākau and 6 – 47 mm at the Hotpools (table 6, appendix). There has been a significant decline in mean size of Hotpools kōura over the sampling period ($p < .05$) whereas there has been no significant change in mean size of kōura at Te Ākau ($p > .05$) or Ōkere ($p > .05$) (Fig. 6, appendix).

Table 3 Kōura mean OCL size (mm), range OCL size (mm), % female and % soft shells for Okere, Te Ākau and Manupirua Hotpools for 4 surveys (3 surveys at Te Ākau) carried out from 21 December 2012 to 2 September 2013.

Site	Mean OCL (mm)	OCL range (mm)	% Female (mean)	% Soft shell (mean)
Okere	16.3	6 - 40	53.2	3.8
Te Ākau	28.2	6 - 51	41	6.9
Hotpools	24	6 - 47	50	5.5

3.1.4 Percentage females, breeding size with eggs and soft shells

The mean percentage of females in subsamples from Ōkere Arm, Te Ākau and Hotpools were 53.2 %, 41 % and 50 %, respectively (table 3). The percentage of females ranged from 48.6 to 59.1 % at Ōkere, 36 to 44.2 % at Te Ākau and 45.5 to 51.8 % at Manupirua Hotpools (table 7, appendix).

Females with eggs or young were present throughout the year, with the highest percentage of breeding sized females with eggs or hatchlings highest at all sites in winter (table 3). The mean percentage of kōura with soft shells in subsamples from Ōkere Arm, Te Ākau and Hotpools were 3.8 %, 6.9 % and 5.5 %, respectively (table 3). The proportion of kōura with soft shells ranged from 2.5 % to 6.8 % at Ōkere, 3.5 % to 10.6 % at Te Ākau and 2.4 % to 6.7 % at Hotpools over the sampling period (table 7, appendix).

3.2 Kākahi

Sampling conditions

Excessive periphyton growth adversely affected the accuracy of kākahi surveys carried out at Okawa Bay on 12 December 2012 and 8 February 2103. In contrast, a combination of low water levels and good water clarity resulted in excellent conditions for counting kākahi at the Ditch and Rest Area sites in the July 2013 survey.

3.2 Kākahi abundance

The highest densities of kākahi in this year's survey were recorded at Okawa Bay (control) sites and at the Ditch (treatment) (table 4, Fig. 3). Kākahi abundance varied markedly at all sites including those that were not subjected to adverse sampling conditions (i.e. Ruato Bay, Boat Ramp) (table 4).

Kākahi abundance has generally increased in Lake Rotoiti, over the sampling period (2005 to 2013, fig. 3), except at the ditch site (a treatment site) where there has been a significant decline ($p < .005$) (fig. 7, appendix).

Table 4 Mean and range of kākahi counted (per 20 m^2) at five sampling sites, Lake Rotoiti from 12 December 2012 to 31 July 2013 (4 surveys).

Site	Total No. kākahi $20m^{-2}$	Range No. kākahi $20m^{-2}$	Mean No. kākahi $20m^{-2}$
Boat Ramp	156	32 – 52	39
Rest Area	355	61 – 139	88.8
Ditch	673	121 – 265	168.3
Okawa Bay	1304	159 – 484	326
Ruato Bay	160	28 - 60	40

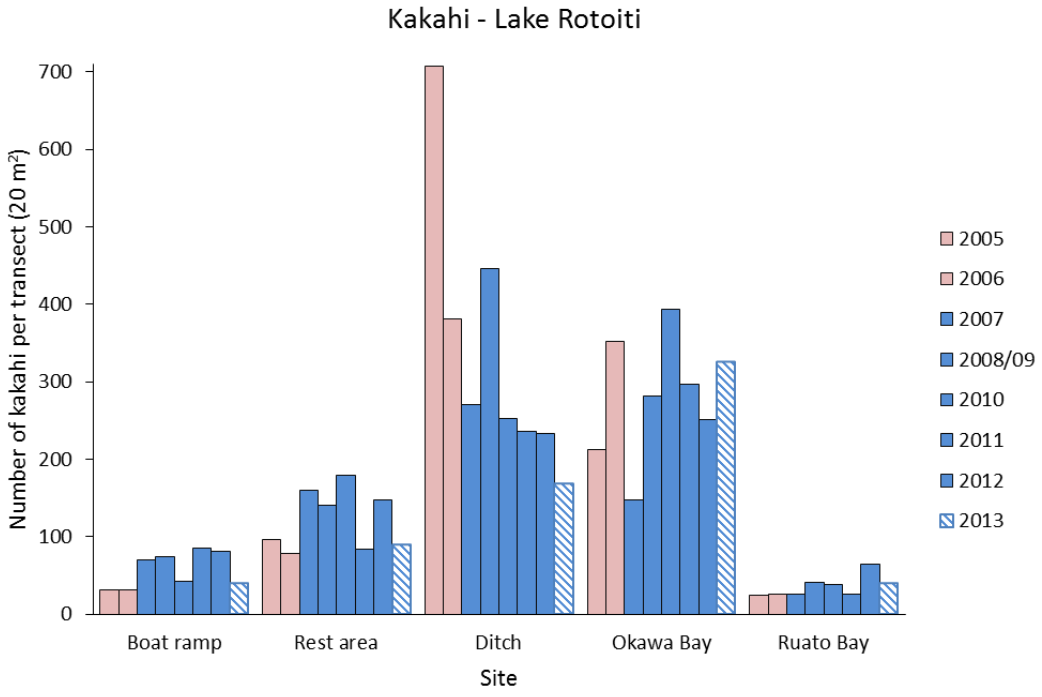

Figure 3 Mean annual kākahi counts (per 20 m^2) at five sampling sites, Lake Rotoiti from 2005 to 2013 (24 surveys). The mauve bars represent those counts recorded prior to completion of the Ohau channel diversion wall, the blue bars, those counts after completion, and the patterned bars represent this year's count (November 2012 to July 2013).

4 DISCUSSION

4.1 Kōura

The Ōkere Arm and Lake Rotoiti continue to support abundant kōura populations 5 years after the completion of the diversion wall. However, there has been a significant decline in kōura abundance and biovolume at Ōkere (treatment) and in kōura abundance at Te Ākau (control). In contrast, there has been no significant change in kōura abundance or biovolume at Manupirua Hotpools, but there has been a significant decline in mean size.

The reasons for these declines are unknown although the improvement in water quality in lakes Rotorua and Rotoiti since 2005, has led to an increase in hornwort (growth and deposition) at Te Ākau and in the Okere Arm. Hornwort is a brittle, poorly attached plant (anchorage is by buried, modified leaves) and is prone to dislodgement by water currents, wave action and other disturbances. Because it is easily dislodged, hornwort can smother the whakaweku, not only restricting kōura access to the whakaweku but also leading to the rapid decay of the fern itself. Furthermore, weed proliferation and accumulation of decaying organic matter can markedly degrade the habitat quality of the surrounding lake bed. The inundation of tau kōura at Te Ākau and Manupirua Hotpools with hornwort first occurred in early to mid-2010.

Owing to excellent water clarity in the Okere Arm this winter, it was possible, for the first time since kōura sampling commenced in 2005, to see the lake bed, which revealed extensive beds of aquatic macrophytes. In 2005 this site was chosen as echo sounding revealed that it was relatively free of aquatic macrophytes, enabling whakaweku to be deployed directly on the lake bed. The recent invasion of aquatic macrophytes may have resulted in an overall decrease in kōura abundance in the Okere Arm, or, reduced the efficacy of the whakaweku which are now positioned on top, or amongst, the weed beds.

Hornwort may have had less impact at Manupirua Hotpools where whakaweku were set at depths ranging from 12 to 25 m. This greater depth may provide more weed-free areas (and whakaweku) for kōura to inhabit than at the shallower, Te Ākau and Okere sites (compared to 11.5 to 16 m at Te Ākau and < 7 m at Okere).

Size

There was no significant change in the mean size of Ōkere or Te Ākau kōura over the sampling period. However, there has been a significant decline in the mean size of Hotpools

kōura. The reasons for this are unknown and as this site was a late addition to the sampling programme (April 2009), it will be interesting to see whether this trend continues.

4.2 Kākahi

Kākahi abundance examined over the sampling period has generally increased at all study sites in Lake Rotoiti except at the ditch site (a treatment site) where there was a significant decline. Sediment type is an important determinant of mussel density in lakes (James 1985). Since the diversion wall has been in place there has been a noticeable accumulation of silt in the Ōkere Arm monitoring sites particularly at the Ditch site where the mean silt depth has increased 10-fold (Kusabs et al. 2011). Interestingly, over the past 2 ½ years or so this silt has been colonised by extensive growths of low growing turf species e.g. *Glossostigma elatinoides*. This has resulted in the consolidation of the lake bed, creating habitat more suitable to kākahi. It is possible that the establishment and proliferation of these turf plants is due to the shelter provided by the diversion wall which has markedly reduced easterly wave action. The Ōkere Arm is a dynamic environment and future changes in kākahi abundance are inevitable until equilibrium is reached.

5 SUMMARY

The Ōkere Arm and Lake Rotoiti continue to support abundant kōura and kākahi populations 5 years after the completion of the diversion wall. Nevertheless, there have been some significant changes in the kōura and kākahi populations in the Ōkere Arm and Lake Rotoiti over the sampling period (2005 to 2012).

Kōura

There has been a significant decline in kōura abundance and biovolume at Ōkere (treatment) and in kōura abundance at Te Ākau (control). The reasons for these declines are unknown, but could be due to the invasion and inundation of the lake bed (and whakaweku) with hornwort. Because it is easily dislodged, hornwort can smother the whakaweku not only restricting kōura access to the whakaweku but also leading to the rapid decay of the fern itself. Furthermore, weed proliferation and accumulation of decaying organic matter can markedly degrade habitat quality.

Kākahi

Kākahi remain abundant in the Ōkere Arm and Lake Rotoiti. While kākahi abundance has generally increased in Lake Rotoiti over the sampling period there has been a significant decline in kākahi abundance at one of the 3 treatment sites (Ditch).

Since the diversion wall has been in place there has been a noticeable accumulation of silt in the Ōkere Arm monitoring sites particularly at the Ditch site where the mean silt depth has increased 10-fold (Kusabs et al. 2011). Interestingly, over the past 2 ½ years the shallow margins of the Okere Arm have been colonised by extensive growths of low growing turf plants e.g. *Glossostigma elatinoides*. This has resulted in the consolidation of the lake bed, creating habitat more suitable to kākahi. It is possible that the establishment and proliferation of these turf plants is due to the shelter provided by the diversion wall which has markedly reduced easterly wave action. The Ōkere Arm is a dynamic environment and future changes in kākahi abundance are inevitable until equilibrium is reached.

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8 APPENDIX

Table 5 Mean CPUE (Catch Per Unit Effort), biovolume (l), wet weight (kg) of kōura captured in a tau kōura (comprised of 10 whakaweku) set in the Ōkere Arm (Ōkere), Te Ākau (T Ākau) and Manupirua hot pools (Hot) sampling sites 8 December 2005 to 2 September 2013. ND = no data collected.

Sampling date	Mean CPUE			Biovolume (l)			Wet weight (kg)		
	Ōkere	T Ākau	Hot	Ōkere	T Ākau	Hot	Ōkere	T Ākau	Hot
8 December 2005	80.3	ND	ND	14.9	ND	ND	ND	ND	ND
23 February 2006	28.6	ND	ND	5.7	ND	ND	ND	ND	ND
8 June 2006	28.8	ND	ND	7.98	ND	ND	ND	ND	ND
12 September 2006	97.2	ND	ND	12.3	ND	ND	ND	ND	ND
13 December 2006	25.6	ND	ND	9.7	ND	ND	1.0	ND	ND
14 February 2007	74.2	96.7	ND	17.4	38.5	ND	6.6	12.8	ND
9 May 2007	25.5	71.2	ND	2.7	44	ND	1.8	13.8	ND
13 August 2007	60.2	39.9	ND	6.6	16.1	ND	2.0	4.7	ND
21 November 2008	19.9	8	ND	3.5	3.4	ND	0.8	1.0	ND
4 February 2009	13.3	39.3	ND	3.3	26.4	ND	0.6	8.0	ND
17 April 2009	62.7	32.4	12.5	11.7	19.9	5.9	3.0	7.0	2
13 July 2009	52.7	21.9	44.9	9.1	15.0	22.2	2.5	5.0	8.2
8 November 2009	20.1	10.9	35.5	3.2	8.9	16.5	1.4	3.0	5.2
17 March 2010	23.6	17.4	18.8	2	14.4	11.5	0.2	4.8	3.6
17 July 2010	40.6	4.2	5.9	5.3	5.3	4.2	1.4	1.0	1.0
9 December 2010	46.3	1.9	16.6	8	2.7	6.8	2	0.55	2
24 February 2011	41.1	31.44	13	4.6	31.9	6.2	1	8.9	2.5
13 July 2011	40.3	9.2	21.44	8.7	7.2	8.8	1.5	1.6	2.6
2 November 2011	25.8	12.7	37.1	3.5	7.8	16.8	1.1	2.25	5
8 February 2012	18.7	23.2	10.1	2.6	16	7.6	0.9	3	1.8
31 July 2012	18.3	8.7	14.7	1.6	5.2	5.3	0.4	1	1.2
17 October 2012	19.1	21.1	27.8	2.9	13.1	10	0.6	4	2.4
21 December 2012	22.4	10.4	27.1	5.1	5.7	7.7	1.5	1.5	2
18 February 2013	26.4	27	21.9	5.1	22.5	7.5	1.2	6	2
27 May 2013	18.2	ND	15.1	2.7	ND	10.2	0.2	ND	2.1
2 September 2013	21.3	8.6	53.4	2.3	6.8	10.5	0.1	1.9	6

Table 6 Mean size orbital carapace length (OCL + standard deviation) and OCL range of kōura captured in a tau kōura (comprised of 10 whakaweku or fern bundles) set in the Ōkere Arm, Te Ākau and Manupirua hot pools sampling sites 8 December 2005 to 15 October 2102.

Sampling date	Mean OCL (mm + SD)			OCL range (mm)		
	Ōkere Arm	Te Ākau	Hotpools	Ōkere Arm	Te Ākau	Hotpools
8 December 2005	20.5 (5.9)	ND	ND	12-40	ND	ND
23 February 2006	21.6 (4.6)	ND	ND	9-36	ND	ND
8 June 2006	19.2 (6.4)	ND	ND	9-44	ND	ND
12 September 2006	15.0 (3.5)	ND	ND	9-29	ND	ND
13 December 2006	17 (4.0)	ND	ND	11-31	ND	ND
14 February 2007	19.8 (4.1)	24.9 (5.5)	ND	8-34	13 - 41	ND
9 May 2007	14.8 (4.3)	26.8 (6.2)	ND	9-29	6 - 47	ND
13 August 2007	15.8 (4.1)	22.2 (8.2)	ND	10-32	10 - 50	ND
21 November 2008	17.5 (3.7)	26.7 (4.8)	ND	10 - 32	15 - 42	ND
4 February 2009	13.9 (7.0)	29.8 (5.2)	ND	7 - 32	18 - 43	ND
17 April 2009	17.6 (6.0)	29.9 (4.8)	26.7 (6.2)	8 - 38	16 - 45	8 - 38
13 July 2009	16.9 (5.7)	31.5 (4.7)	28.1 (5.7)	9 - 34	21 - 50	12 – 44
8 November 2009	18.0 (5.0)	31.7 (4.2)	27.8 (5.9)	9 – 35	21 – 43	11 – 43
17 March 2010	9.6 (3.3)	33.1 (5.4)	27.9 (7.2)	6 – 32	16 - 48	6 - 45
17 July 2010	15.1 (4.8)	34.4 (4.4)	25.2 (7.5)	8 - 34	24 - 43	11 - 38
9 December 2010	17.3 (3.8)	31.4 (8.6)	24.7 (6.5)	11 - 35	14 – 45	11 – 40
24 February 2011	12.3 (6.3)	34 (6.4)	23.9 (6.1)	6 - 38	19 – 51	14 – 47
13 July 2011	16.4 (4.9)	29.9 (8.1)	25.6 (5.7)	7 - 35	10 – 48	8 – 44
2 November 2011	17.2 (4.5)	28.9(7.6)	26.0 (5.5)	11 - 32	12 - 48	12 - 41
8 February 2012	18.9 (5.1)	27 (6.4)	28.8 (6.9)	7.5 – 35	15 – 50	11.5 – 44
31 July 2012	13.9 (3.3)	21.7 (8.4)	25.6(7.7)	9 – 30	13 – 42	11 - 41
17 October 2012	16.3 (4.7)	22.1 (7.5)	28.5(8.5)	11 – 32.5	11 - 49	7.5 - 41
21 December 2012	19.5 (5.3)	25 (8.2)	21.9 (6.8)	12 - 41	14 - 47	8 - 39
18 February 2013	16.8 (7.6)	29.9 (7.3)	21.5 (6)	8 - 35	16 - 52	9 – 38.5
27 May 2013	14.1 (5.1)		28.9 (6.9)	9 - 30		15 - 43
2 September 2013	14.5 (3.3)	29.6 (9.3)	23.5 (6)	9 - 27	13 - 48	11 - 40

Table 7 Number of kōura analysed, percentage females, percentage breeding size females with eggs or young (defined as >23 mm OCL) and percentage of kōura with soft shells, in subsamples taken from tau kōura (comprised of 10 fern bundles) set in the Ōkere Arm (Ok), Te Ākau (TA), and Hotpools (Hot) sampling sites, Lake Rotoiti, 8 December 2005 to 15 October 2012. n = actual number of females with eggs or young. ND, no data collected.

Date	Number of kōura			% female			% Breeding size females with eggs (n)			% soft shells		
	Ok	TA	Hot	Ok	TA	Hot	Ok	TA	Hot	Ok	TA	Hot
8 December 2005	74	ND	ND	44.6	ND	ND	0 (0)	ND	ND	ND	ND	ND
23 February 2006	139	ND	ND	54.7	ND	ND	0 (0)	ND	ND	ND	ND	ND
8 June 2006	121	ND	ND	50.4	ND	ND	33(7)	ND	ND	14.8	ND	ND
12 Sept 2006	322	ND	ND	43.8	ND	ND	50(8)	ND	ND	7.8	ND	ND
13 December 2006	256	ND	ND	54.7	ND	ND	0(0)	ND	ND	3.5	ND	ND
14 February 2007	233	299	ND	55.4	52.8	ND	0(0)	0	ND	0.8	0.7	ND
9 May 2007	240	341	ND	51.6	45.7	ND	0(0)	36.8(45)	ND	1.6	6.2	ND
13 August 2007	123	200	ND	50.4	44.0	ND	100(2)	54.3(19)	ND	2.3	3.5	ND
21 November 2008	143	80	ND	58.7	46.3	ND	66.7(3)	18.2(6)	ND	0.7	1.3	ND
4 February 2009	57	113	ND	42.1	44.2	ND	0	0	ND	1.5	4.4	ND
17 April 2009	193	209	124	53.9	66	63.7	16(4)	16(21)	24(14)	6.2	13.4	5.6
13 July 2009	175	219	449	54.3	58.4	45.9	63.2(12)	87.2(109)	66(130)	1.7	7.3	9.4
8 November 2009	200	109	355	56	62.4	55.8	22(5)	82(55)	62(105)	34.3	14.7	14.6
17 March 2010	78	174	187	56.4	46.6	48.1	0(0)	3.8(3)	2.7(2)	4.2	14.9	19.1
17 July 2010	244	42	59	59.8	69	42.4	42(5)	90(26)	77(13)	7.7	16.7	15.3
9 December 2010	148	18	166	55.4	35.5	43.4	0	100(5)	10(4)	4.1	23.5	20.5
24 February 2011	238	142	130	46.3	45.8	43.8	0	3.2(2)	3(1)	1.3	9.9	20
13 July 2011	157	92	173	53.1	62	44.5	42.9(3)	90.6(48)	62(34)	10.3	4.3	14.5
2 November 2011	143	98	128	55.9	50	48.4	14.3(1)	79.1(34)	48(22)	4.2	5.1	15.6
8 February 2012	133	128	101	56.7	39.1	41.6	0	0	0	15.8	7	13.9
31 July 2012	183	80	147	47.4	40	47.6	0	22(18)	64.9(24)	2.2	2.5	4.1
17 October 2012	130	115	166	54.8	58.4	46.4	30 (3)	86(43)	71.1(27)	2.3	1.7	4.2
21 December 2012	159	104	150	59.1	43.3	51.8	0	35.5 (11)	10.8 (4)	2.5	6.7	6.7
18 February 2013	138	104	142	48.6	44.2	50.7	0	2.3 (1)	3.4 (1)	2.9	10.6	7
27 May 2013	132		101	50.8		45.5	42.8 (3)		46.3 (19)	3		5.9
2 September 2013	132	86	169	54.3	36	51.5	40 (2)	54.5 (12)	35.5 (22)	6.8	3.5	2.4

Table 8 Number of kākahi counted, mean and standard errors for 0.5 m wide x 40 m long transects at the six sampling sites situated in Lake Rotoiti, June 2005 to July 2013. Shaded area indicates this year's sampling period. NI = not included in monitoring programme until September 2005. NC = no count possible due to poor water clarity. * = count compromised by poor water visibility.

Date	Boat ramp Ōkere Arm	Rest area Ōkere Arm	Ditch Ōkere Arm	Ōkawa Bay Control	Ruato Bay Control
Jun-05	20	125	633	236	NI-
Sep-05	33	57	686	269	19
Dec-05	40	106	803	131	29
Mar-06	28	28	471	240	42
Jun-06	28	119	329	413	7
Dec 06	37	89	343	402	29
May 07	81	119	269	140	33
Sep 07	59	201	272	155	19
Nov 08	118	374	1156	401	74
Feb 09	85	85	205	94	16
June 09	59	92	266	240	17
Sep 09	54	91	157	396	53
Dec 09	51	60*	57*	274	44
Mar10	21	NC	NC	265	10
June 10	53	NC	NC	608	33
Sep 10	69	196	338	472	86
Dec 10	27	162	168	229	26
Feb 11	83	97	269	434	13
July 11	91	144	372	273	18
Sep 11	102	39	163	187	31
Dec 11	66	54	138	295	42
March 12	100	82	150	232	74
July 12	47	188	251	191	41
Oct 12	97	171	298	331	77
Dec 12	52	61	165	159	60
Feb 13	34	93	122	199	36
May 13	32	62	121	462	28
July 13	38	139	265	484	36
Mean $\pm$ SE	57.3 $\pm$ 5.3	116 $\pm$ 14	336 $\pm$ 49.2	293 $\pm$ 24.2	36.8 $\pm$ 4.2

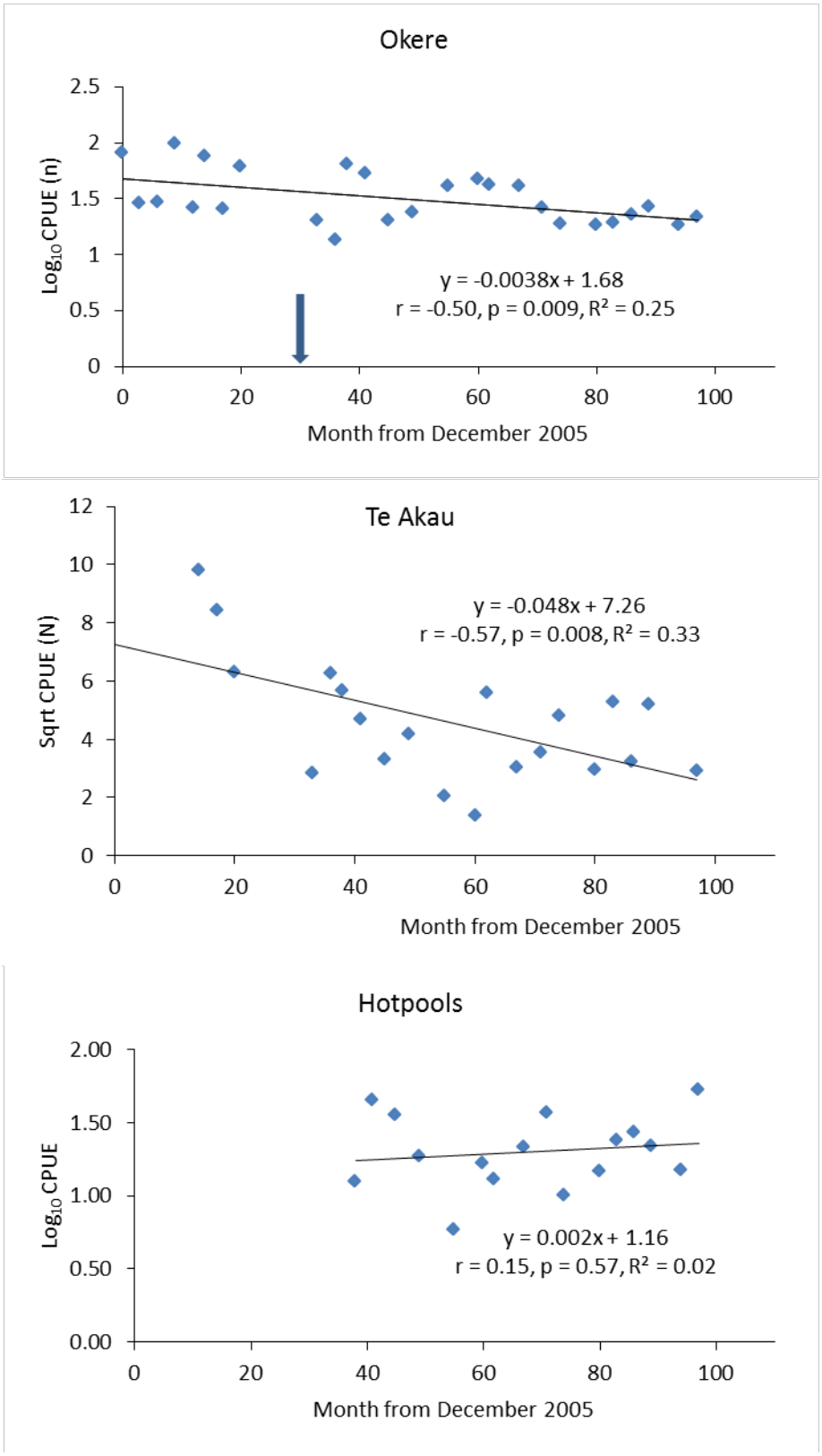


Figure 4 Relationship between Ōkere, Te Ākau and Hotpools kōura abundance (mean CPUE) and time. The arrow indicates when the diversion wall was completed at month 30 (July 2008).

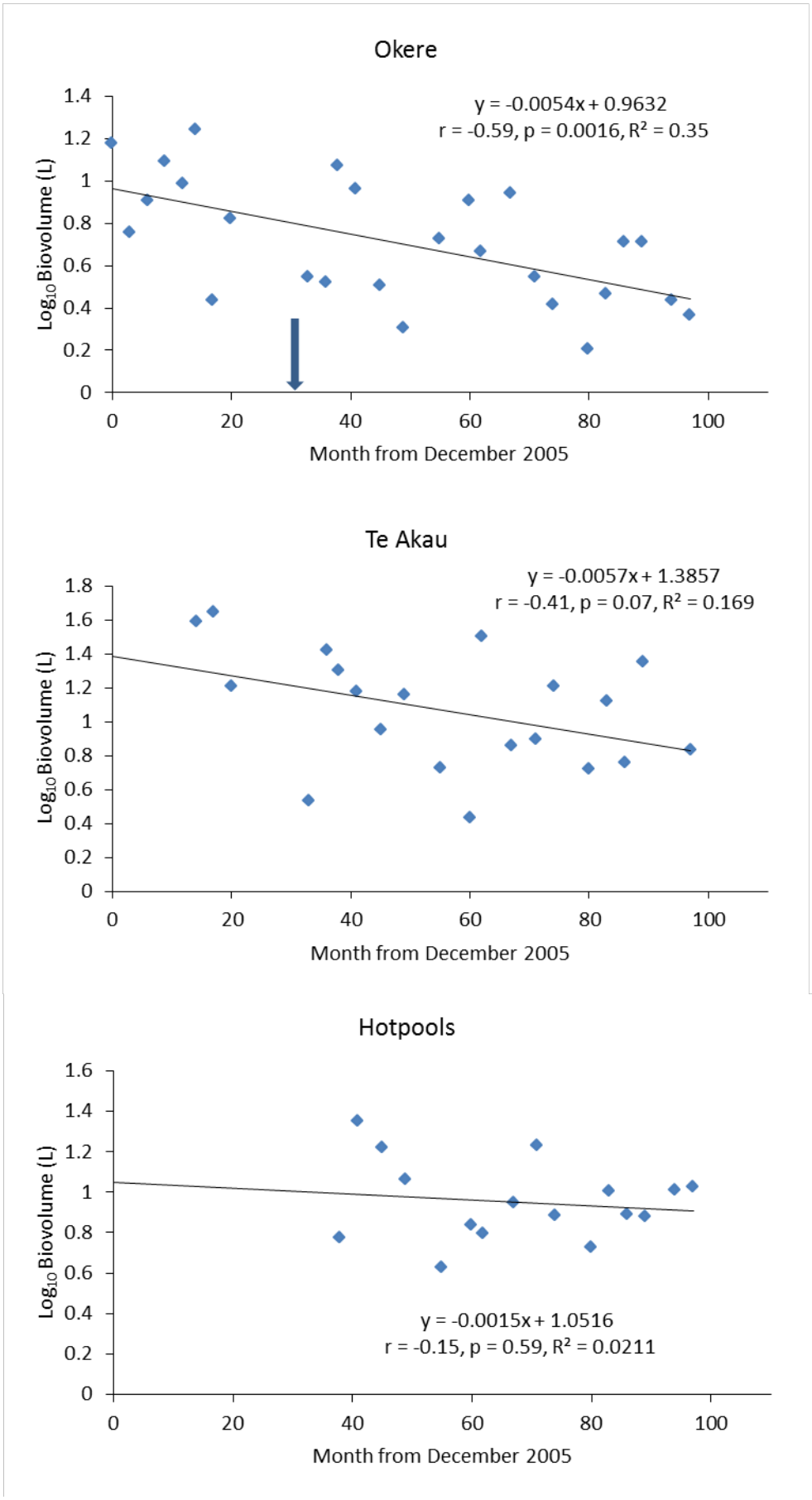
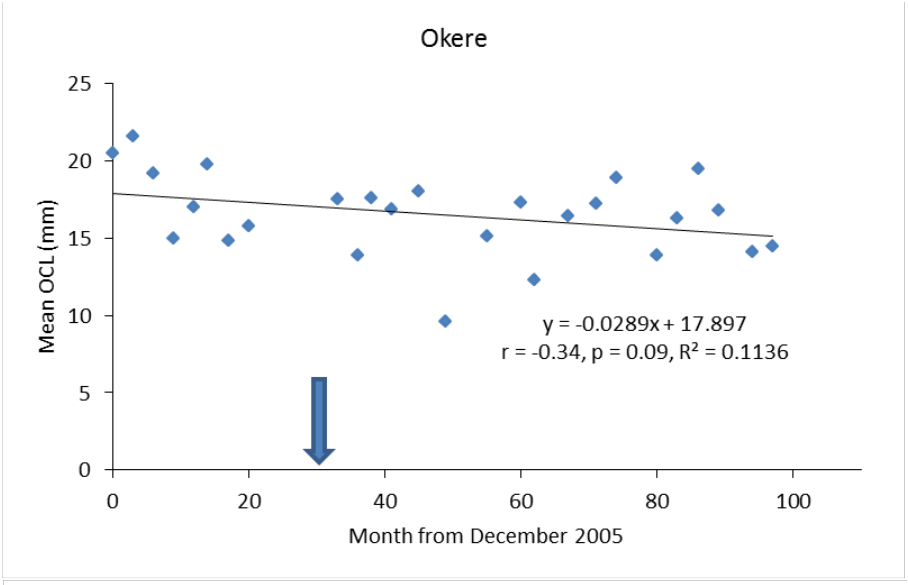
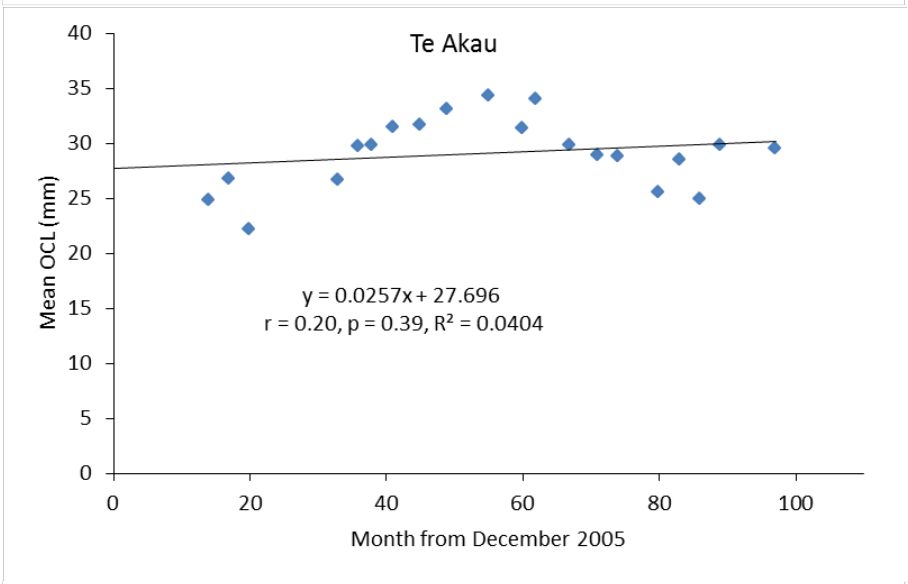


Figure 5 Relationship between kōura biovolume (l) and time (sampling period beginning December 2005). The arrow indicates when the diversion wall was completed at month 30 (July 2008).





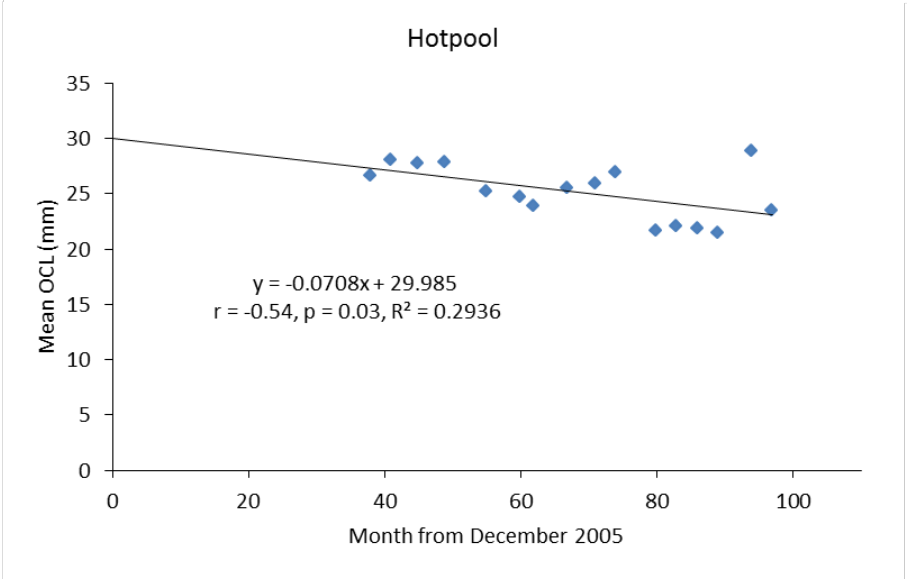


Figure 6 Relationship between mean size (OCL) of kōura catch and time (sampling period beginning December 2005). Arrow indicates when the diversion wall was completed (July 2008).

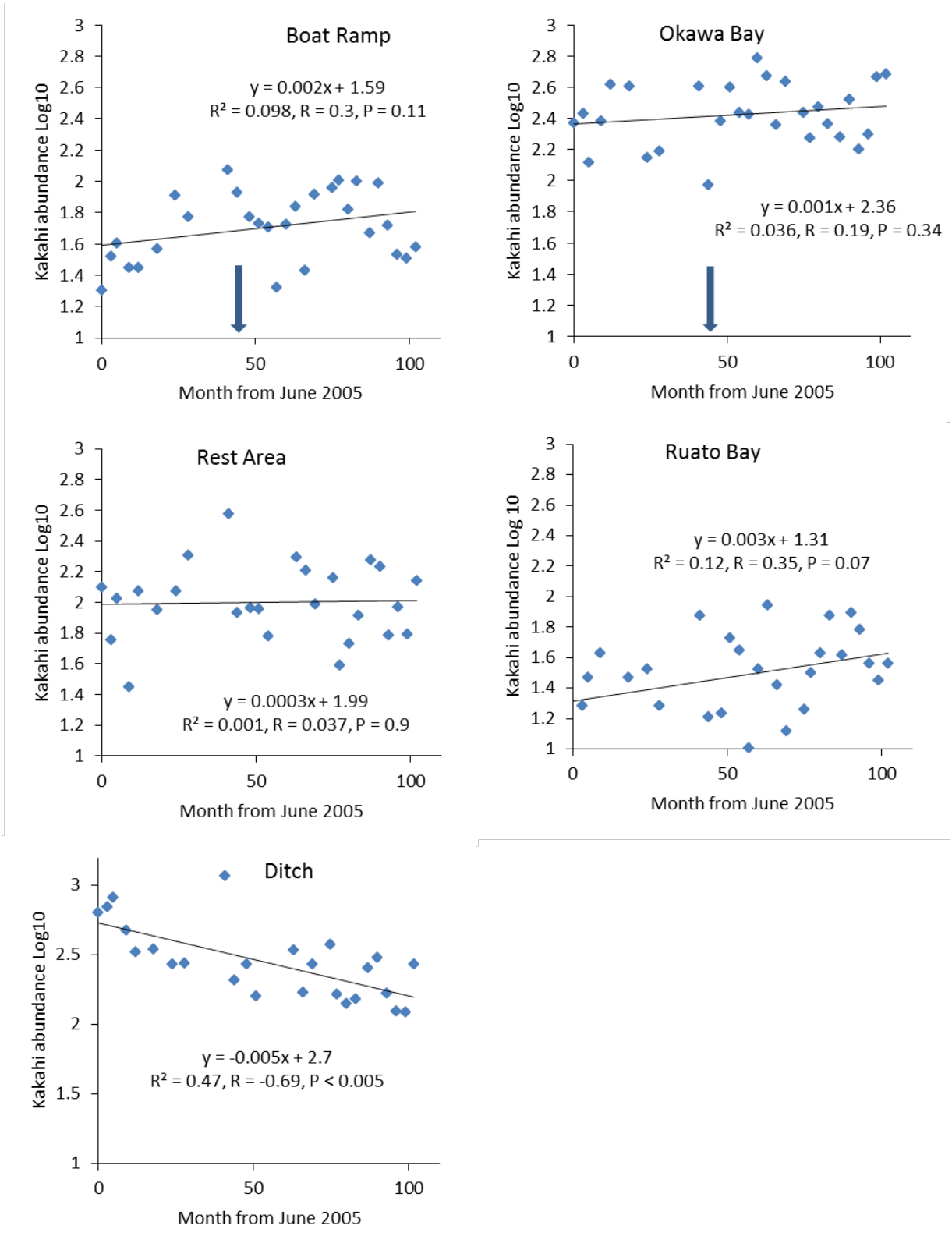


Figure 7 Kākahi abundance at 6 sites (0.5 m x 40 m transects) situated in Lake Rotoiti, over the sampling period June 2005 to July 2013. The arrow indicates when the diversion wall was completed on July 2008.