OHAU CHANNEL DIVERSION WALL

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

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Cover photo: Kōura captured (from a single whakaweku) using the tau kōura method, Lake Rotoiti.

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1 INTRODUCTION

Kōura (*Paranephrops planifrons*) and kākahi (*Hyridella menzeisi*) support important customary fisheries in Lake Rotoiti where large quantities are still harvested. 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 very 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) was carried out on an approximate 3 monthly basis from November 2011 to October 2012.

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 (Fig. 2). 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, 2005-12. Numbers in red boxes (1 = Ōkere Arm, 2 = Te Akau, 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[1] sampling sites in Lake Rotoiti (Table 1 and Fig. 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].

[1] The Tumoana Bay site was not sampled in 2012 because of the very low numbers of kākahi recorded in previous surveys (Kusabs et al. 2011).

[2] Comparisons of kākahi condition were not carried out in 2012 as no significant differences were found pre and post diversion wall. Refer Kusabs et al. 2011 for details.

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. *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 2012). Where necessary, data were $\log_{10}$ transformed to approximate a normal distribution.

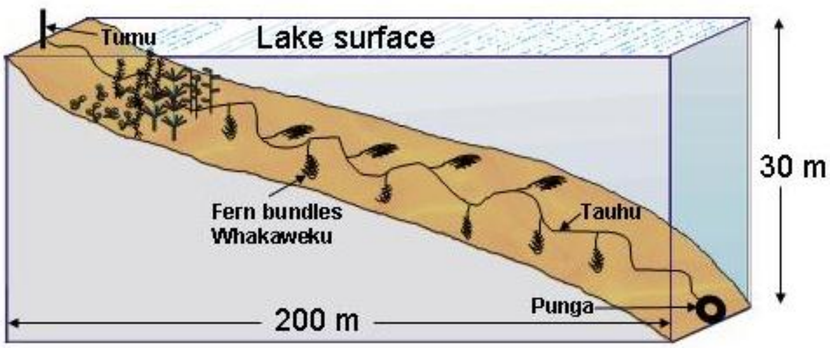

Figure 2 Schematic diagram of the tau kōura. The depth and length of tau are indicative and can be varied depending on lake bathymetry.

3 RESULTS

3.1 Kōura

3.1.1 Abundance

819 kōura were captured at Ōkere, 650 at Te Ākau, and 897 kōura at Manupirua Hotpools, in the 4 surveys carried out from 2 November 2011 to 15 October 2012 (Fig. 3 and Table 5, appendix 1). Mean CPUE (Catch Per Unit Effort) at Ōkere ranged from 13.3 to 97.2 kōura per whakaweku, at Te Ākau 1.9 to 96.7 kōura per whakaweku, and at Manupirua Hotpools 5.9 to 44.9 kōura per whakaweku (Fig. 3, Table 5, appendix 1).

An analysis of Okere kōura shows a significant decline in CPUE ($R^2 = 0.18$, $P = 0.05$) over the sampling period (2005 to 2012) (Fig. 4). At the control site located at Te Ākau, there was a significant decline in kōura CPUE ($R^2 = 0.37$, $P < 0.01$) over the sampling period (2007 to 2012) (Fig. 4). Some of this decline can be attributed to 2 unusually low catches were recorded in July and December 2010 (Figure 2, Table 5 appendix 1) when the whakaweku (fern bundles) were smothered with large accumulations of hornwort (*Ceratophyllum demersum*). There has been no significant change in kōura abundance at Manupirua Hotpools from 2009 to 2012 (Figs. 3 & 4).

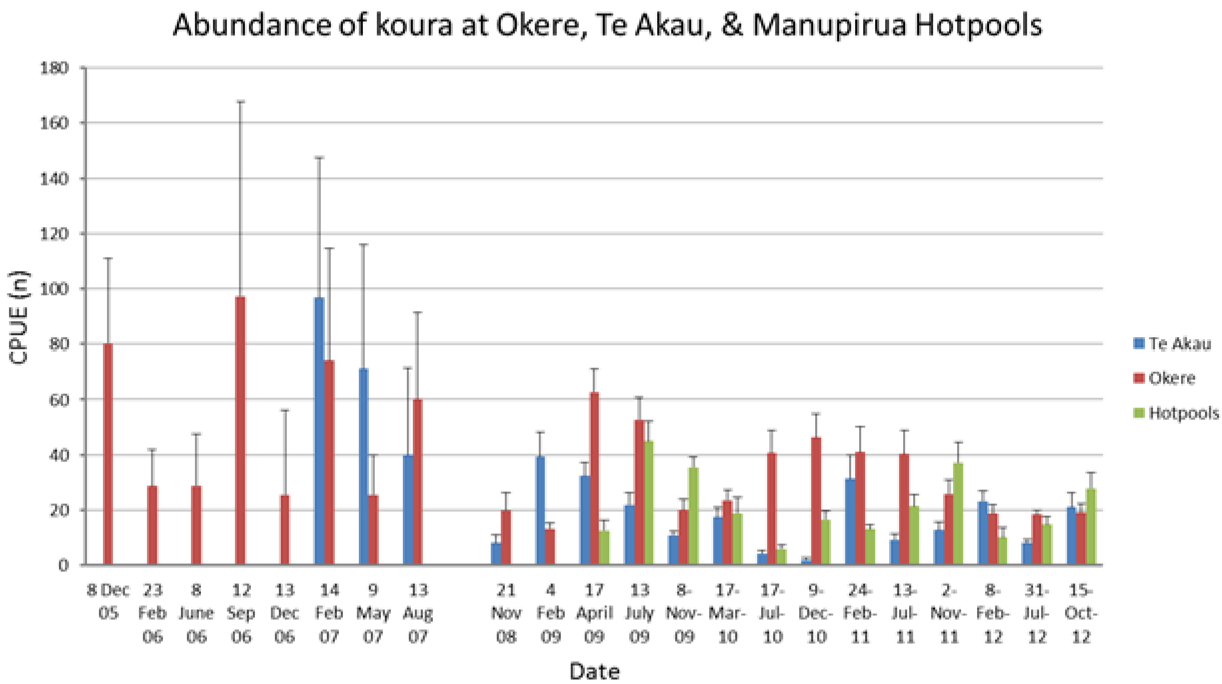

Figure 3 Mean catch per unit effort (CPUE) of kōura (± SE; n = 10) captured in tau kōura set in Ōkere Arm, Te Ākau and Manupirua hot pools, Lake Rotoiti, 8 December 2005 to 15 October 2012.

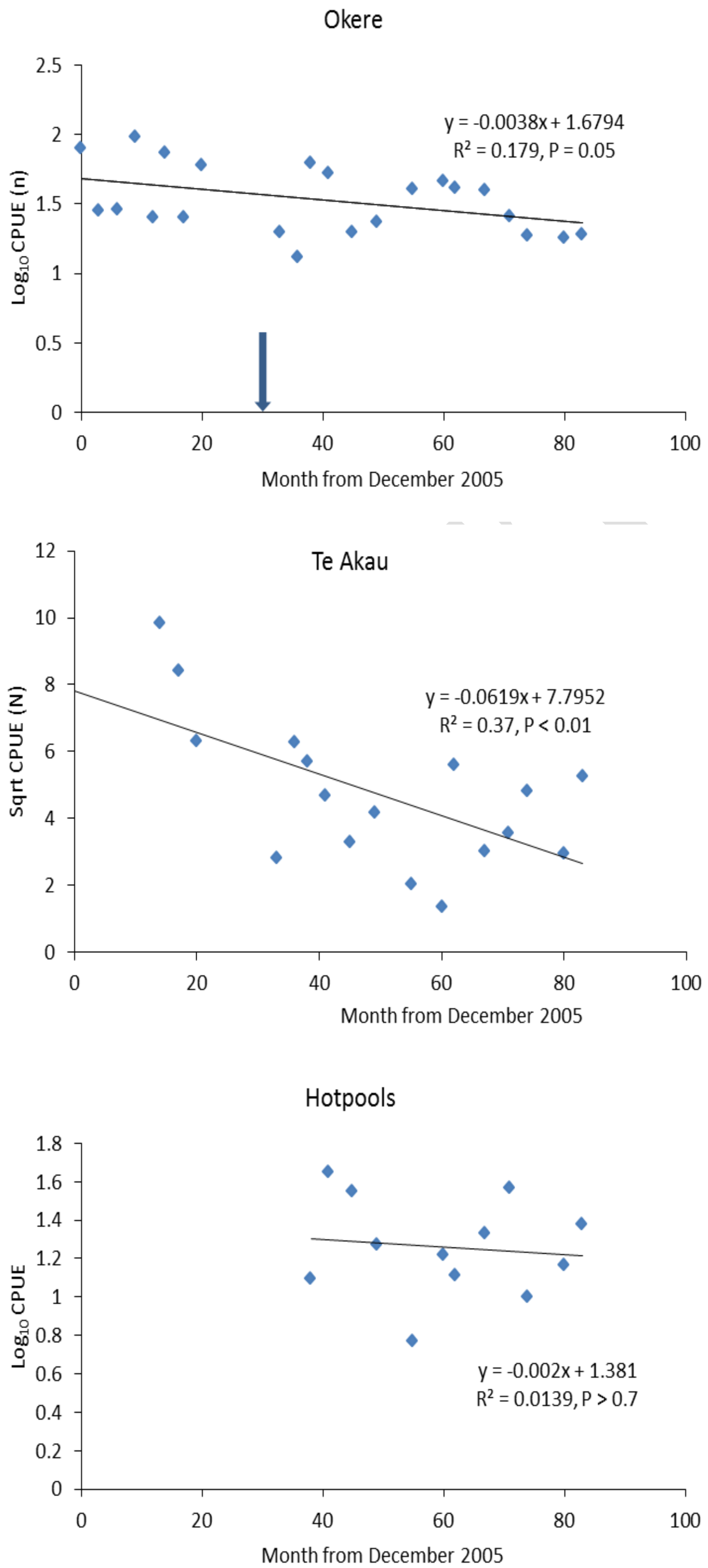

Figure 4 Relationship between Ōkere, Te Akau and Hotpools kōura abundance (mean CPUE) and time. The arrow indicates when the diversion wall was completed at month 30 (July 2008).

3.1.2 Biovolume of the catch (yield)

Biovolume ranged from 1.6 l to 17.4 l at Ōkere, 2.7 l to 44 l at Te Ākau and 4.5 l to 22.2 l at Hotpools (Table 5, appendix 1). There was a significant decline in biovolume of kōura captured at Ōkere over the sampling period (R^2 = 0.335, P < 0.01), however, there was no significant difference in kōura biovolume at Te Ākau (R^2 = 0.21, P = 0.067) or Manupirua Hotpools (R^2 = 0.06, P = 0.46) (Fig. 5).

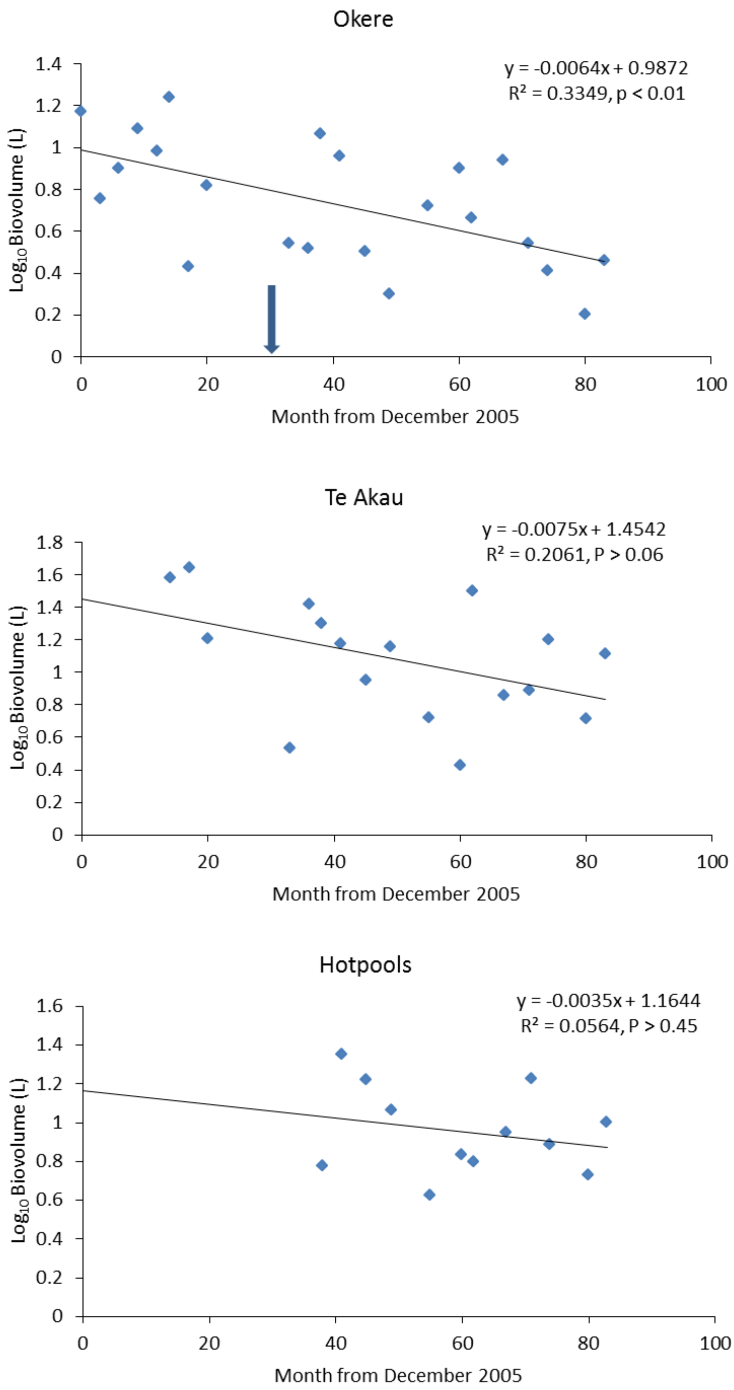

Figure 5 Relationship between kōura biovolume (l) and time (sampling period beginning December 2005). The arrow indicates when the diversion wall was completed at month 30 (July 2008).

3.1.3 Size

As in previous years, the largest kōura were captured at Te Ākau, followed by the Hotpools, with the smallest kōura at Ōkere (Fig. 6). 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 1).There was a significant decline in mean size of Hotpools kōura over the sampling period ($R^2 = 0.55$, $P < 0.006$) whereas there was no significant change in mean size of the catch at Te Ākau or Ōkere (Fig. 6).

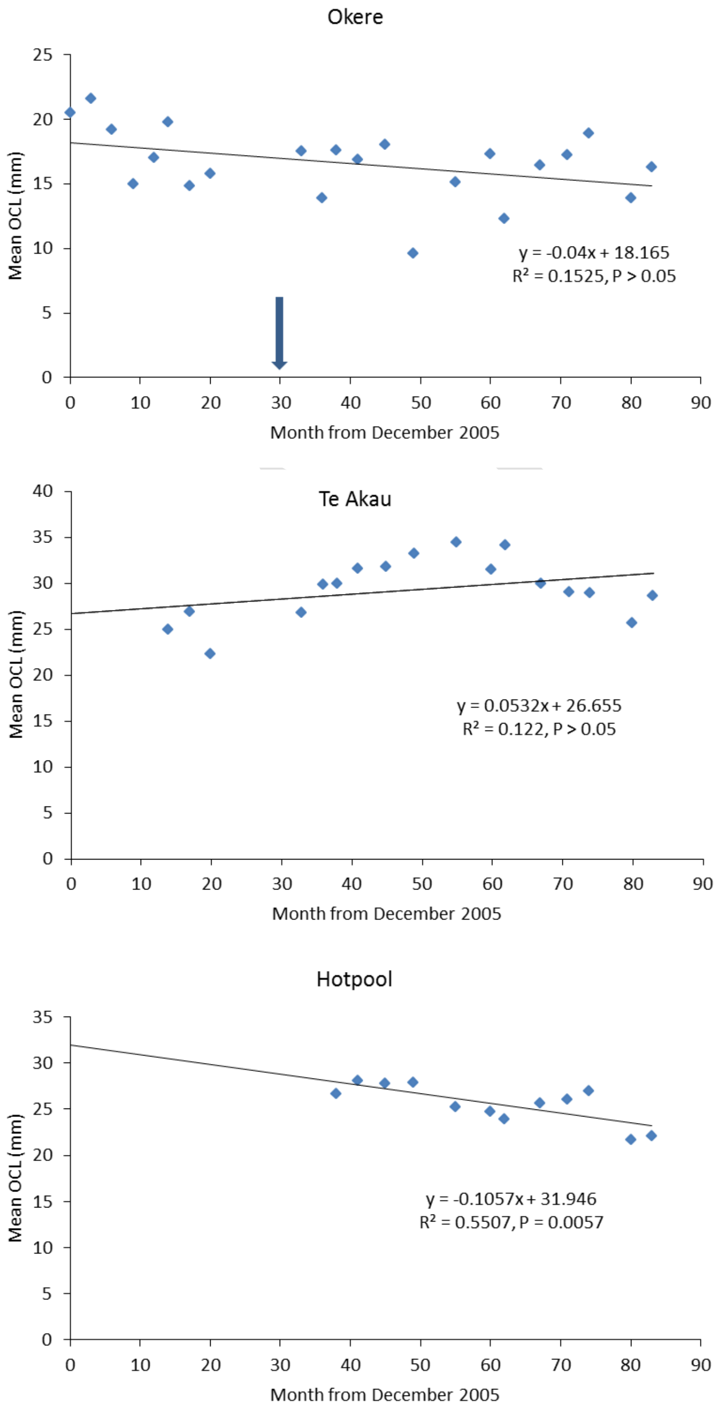

Figure 6 Relationship between mean size (OCL) of kōura catch and time (sampling period beginning December 2005). Arrow indicates when the diversion wall was completed (July 2008).

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 52.6 %, 51 % and 47.6 %, respectively (Table 2). The percentage of females ranged from 42.1 to 59.8 % at Ōkere, 35.5 to 69.7 % at Te Ākau and 41.6 to 63.7 % at Manupirua Hotpools (Table 7, appendix 1).

Females with eggs or young were present throughout the year, except in February and March. The percentage of breeding sized females with eggs or hatchlings was highest at all sites in winter (Table 7, appendix 1).

The mean percentage of kōura with soft shells in subsamples from Ōkere Arm, Te Ākau and Hotpools were 6.4 %, 8.1 % and 13.1 %, respectively (Table 2). The proportion of kōura with soft shells ranged from 0.7 % to 34.3 % at Ōkere, 0.7 % to 23.5 % at Te Ākau and 4.1 % to 20.5 % at Hotpools over the sampling period (Table 7, appendix 1). The highest proportion of kōura with soft shells (34.3%) was recorded in the Ōkere Arm in November 2009 and the lowest proportion (0.7%) in both Te Ākau in February 2007 and Ōkere in November 2008 (Table 7, appendix 1).

Table 2 Sampling site, number of kōura sampled, mean percentage of females, mean percentage of breeding size females with eggs or young (defined as >23 mm OCL) and mean percentage of kōura with soft shells, in subsamples taken from tau kōura (comprised of 10 fern bundles) set in the Ōkere Arm (n = 19) Te Ākau (n = 14, and Hotpools (n = 9) sampling sites, Lake Rotoiti, 8 December 2005 to 15 October 2012.

Site	Number of kōura sampled	% Female ± SD	% Female Range	% Breeding size females with eggs ± SE	% Soft shells ± SE
Ōkere	3730	52.6 ± 4.9	42.1 – 59.8	21.8 ± 6.1	6.4 ± 1.8
Te Ākau	2459	51 ± 10.1	35.5 – 69	45.2 ± 9.6	8.1 ± 1.6
Hotpools	2185	47.6 ± 6.3	41.6 – 63.7	40.9 ± 8.8	13.1 ± 1.7

3.2 Kākahi abundance

A total of 19,717 kākahi have been recorded in Lake Rotoiti in 24 surveys carried out from June 2005 to October 2012 (Table 3). Kākahi counts in the Ōkere Arm are, at times, compromised by algae blooms in Lake Rotorua which can result in poor water clarity in the Okere Arm. However, since September 2010, water clarity has improved with accurate counts possible. In general, the highest densities of kākahi were recorded at the Ditch (treatment) and Okawa Bay (control) sites (Table 3, Fig. 7).

Kākahi numbers varied markedly amongst sampling events, for example at the Okawa Bay site, kākahi numbers ranged from 94 to 608 per kākahi transect (20 m^2; Table 3). The highest count recorded was 1156 per kākahi transect (20 m^2) from the Ditch site in November 2008 (3-4 months after the completion of the diversion wall). Unusually high counts were recorded at all sites in November 2008 (Table 3).

Table 3 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 September 2011. 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	Tūmoana Control	Ruato Bay Control
Jun-05	20	125	633	236	NI	NI-
Sep-05	33	57	686	269	0	19
Dec-05	40	106	803	131	9	29
Mar-06	28	28	471	240	4	42
Jun-06	28	119	329	413	3	7
Dec 06	37	89	343	402	0	29
May 07	81	119	269	140	0	33
Sep 07	59	201	272	155	2	19
Nov 08	118	374	1156	401	4	74
Feb 09	85	85	205	94	2	16
June 09	59	92	266	240	1	17
Sep 09	54	91	157	396	7	53
Dec 09	51	60*	57*	274	0	44
Mar10	21	NC	NC	265	1	10
June 10	53	NC	NC	608	0	33
Sep 10	69	196	338	472	0	86
Dec 10	27	162	168	229	0	26
Feb 11	83	97	269	434	0	13
July 11	91	144	372	273	0	18
Sep 11	102	39	163	187	2	31
Dec 11	66	54	138	295	NI	42
March 12	100	82	150	232	NI	74
July 12	47	188	251	191	NI	41
Oct 12	97	171	298	331	NI	77
Mean ± SE	60.4 ± 5.9	121.8 ± 16.1	368 ± 55.8	287 ± 25.2	2 ± 0.6	36.2 ± 4.8

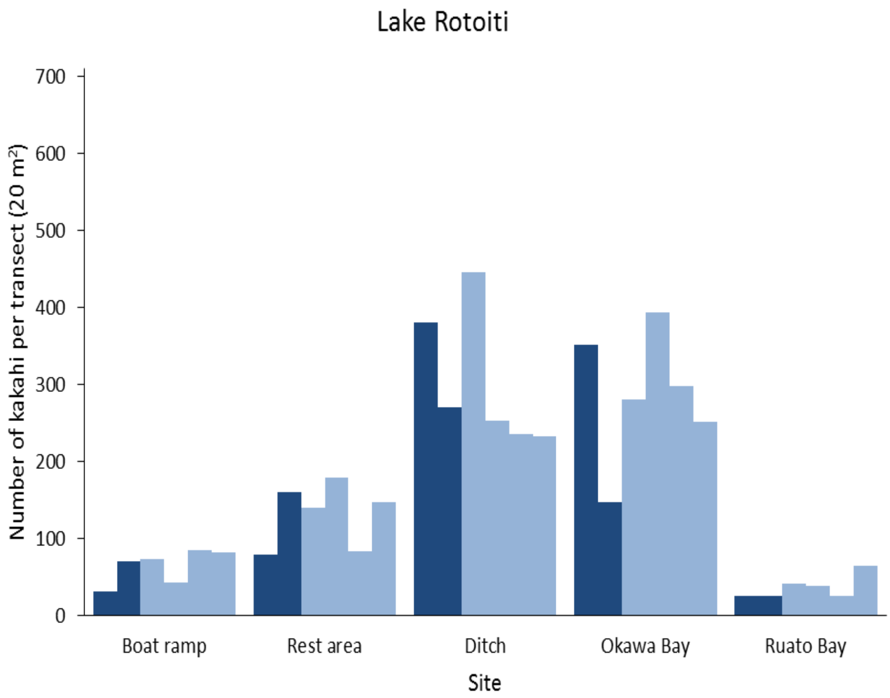

Figure 7 Annual kākahi counts (per 20 m^2) at six sampling sites, Lake Rotoiti from 2005 to 2012 (n = 20). Dark bars represent those counts recorded prior to the completion of the Ohau channel diversion wall and the light bars those counts after completion.

Kākahi abundance examined over the sampling period (2005 to 2012) showed two significant relationships. At the Boat Ramp site (a treatment site) there was a significant positive relationship between kākahi abundance over the sampling period (R^2 = 0.29, P < 0.01; Fig. 7), and at the Ditch site (also a treatment site) there was a significant decline in kākahi abundance over the sampling period (R^2 = 0.39, P < 0.05; Fig. 7). There was no significant change in kākahi abundance at the Rest Area (a treatment site) or at the control sites - Ruato Bay or Okawa Bay (Fig. 7).

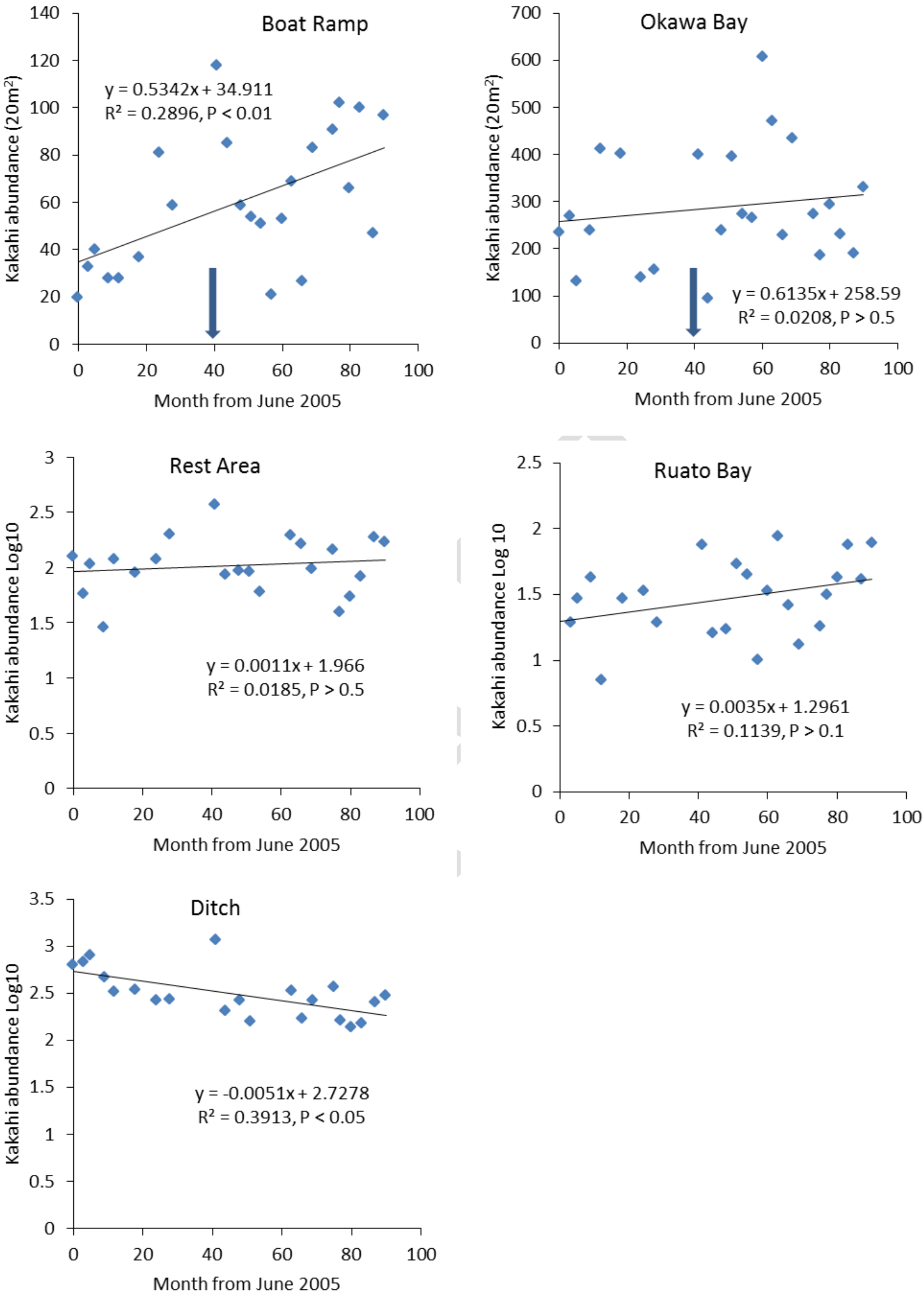

Figure 8 Kākahi abundance at 6 sites (0.5 m x 40 m transects) situated in Lake Rotoiti, over the sampling period June 2005 to October 2012. The arrow indicates when the diversion wall was completed on July 2008.

4 DISCUSSION

4.1 Kōura

The Ōkere Arm and Lake Rotoiti continue to support abundant kōura populations 4 years after the completion of the diversion wall. However, there has been a significant decline in kōura abundance and yield at Ōkere (treatment) and in kōura abundance at Te Ākau (control).

The reasons for the decline in the abundance and yield in the Ōkere Arm are unknown. However, it is evident that the greatest kōura catches at Okere and Te Akau occurred in the first year of tau deployment i.e. from December 2005 to September 2006 and from February 2007 and May 2007, respectively (Fig. 3). It appears that the tau kōura method is most effective in the first 12 months of deployment after which time catches stabilise and reach equilibrium. The tau kōura is a new method and its use as a monitoring tool is still being researched. These effects and other aspects of the methodology (such as optimum saturation time) are being investigated as part of a PhD study by the primary author.

The decline in kōura abundance at Te Ākau may also have been caused by hornwort invasion and deposition. In July and December 2010 the very low numbers of kōura captured at Te Ākau and at the Hotpools was due to the inundation of the whakaweku with large amounts of dislodged hornwort. 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. Prevailing wind conditions are therefore an important consideration when selecting suitable locations for tau kōura, especially in lakes which have large beds of hornwort.

The inundation of tau kōura at Te Ākau and Manupirua Hotpools with hornwort first occurred in early to mid-2010. It is possible that there has been an increase in hornwort biomass in Lake Rotoiti in recent years – an unintended consequence of the improvement in water quality (clarity).

Size

In general, kōura were larger at Te Ākau and Hotpools than at Ōkere, where the smaller size range was similar to that of stream populations (Parkyn *et al*. 2002b). This confirms the findings of Devcich (1979) who found that juvenile kōura are released by their mothers into the productive littoral zone in Lake Rotoiti where there is more food and warmer temperatures, whereas adult kōura assemble into high-density bands above the 30 m depth contour during the day.

There was no significant change in the mean size of Ōkere or Te Akau kōura over the sampling period. However, there has been a significant decline in the mean size of Hotpools kōura. This site was a late addition to the sampling programme (April 2009) and it will be interesting to see whether this trend continues. Future surveys will help to determine whether this is change is real or perceived.

Egg Bearing

Kōura breeding appears to be continuous in Lake Rotoiti, although the least likely time to find females with eggs is in February. In general the percentage of "breeding" size females with eggs or hatchlings peaked in the autumn and winter months with another rise in spring. This confirms the findings of Devcich (1979) who reported that breeding females were most common from May to July in a 1975/76 study in Lake Rotoiti.

Moulting

Moulting activity (proportion of soft shells) of adult kōura was continuous with no discernible patterns evident. This was not surprising as female and male crayfish often moult at different times and crayfish in deeper (cooler) waters are known to moult later than those in shallow water (Capelli and Magnuson 1975). At ecdysis, crayfish are most vulnerable to predation and seek the seclusion of burrows and shelters within which to moult. It is therefore possible that moulting kōura are over-represented in our whakaweku catches.

4.2 Kākahi

Kākahi numbers varied markedly between the monitoring sites and over the sampling period (2005 – 2011). In general, kākahi were most numerous at the Ditch (treatment site) and Okawa Bay (control site).

There have been two significant changes in kākahi abundance in the Ōkere Arm (treatment sites) over the sampling period - an increase at the Boat Ramp site and a decline at the Ditch site. There was no signifcant change in kākahi abundance at the Rest Area (tretment site) or at the control sites – Okawa Bay and Ruato Bay. 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 18 months 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.

It is pleasing to report that he large scale algae blooms (*Microcystis wesenbergii*) in Lake Rotorua that compromised kākahi surveys in late 2009 to July 2010 have not been repeated in subsequent surveys.

5 SUMMARY

The Ōkere Arm and Lake Rotoiti continue to support abundant kōura and kākahi populations 4 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 yield at Ōkere (treatment) and in kōura abundance at Te Ākau (control). The reasons for the decline in the abundance and yield in the Ōkere Arm are unknown.

The extremely high numbers of kōura captured from December 2005 to September 2006 (Fig. 3) have not been repeated in subsequent surveys. A similar pattern is also evident at Te Akau where initial surveys in February 2007 and May 2007 resulted in the highest catches recorded (Fig. 3). It appears that the tau kōura method is most effective in the first 12 months of deployment after which time catches stabilise and reach equilibrium. The tau kōura is a new method and its use as a monitoring tool is still being researched.

The decline in kōura abundance at Te Ākau (control site) could be due to inundation of the whakaweku with large amounts of dislodged, decaying 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 remained stable in Lake Rotoiti over the sampling period there have been a range of changes at the Ōkere Arm (treatment). In the Ōkere Arm there has been a significant increase in kākahi abundance at the Boat Ramp, no significant change at the Rest Area, and a significant decline at the 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 18 months 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.

6 ACKNOWLEDGEMENTS

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8 APPENDIX 1

Table 4 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 17 April 2009 to 15 October 2012. 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

Table 5 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

Table 6 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