OHAU CHANNEL DIVERSION WALL

Monitoring of kōura and kakahi populations in the Okere Arm and Lake Rotoiti

REPORT NUMBER 3 PREPARED FOR ENVIRONMENT BAY OF PLENTY

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

[1]Ian Kusabs & Associates

[2] Te Runanga O Ngati Pikiao

[3]Environment Bay of Plenty

September 2009

TABLE OF CONTENTS

Cover photo: Kōura captured on a tau kōura prior to measuring. The largest kōura has an Orbital Carapace Length (OCL) of 50mm.

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

Kōura (*Paranephrops planifrons*) and kakahi (*Hyridella menzeisi*) support important customary fisheries in Lake Rotoiti where significant quantities are still harvested (W. Emery, kaumatua, pers. comm.). As part of the efforts to improve water quality in Lake Rotoiti, Environment Bay of Plenty has built a wall that diverts nutrient rich water from Lake Rotorua down the Kaituna River. 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.

Ngati Pikiao are the kaitiaki of Lake Rotoiti and are actively involved in kaitiakitanga, the sustainable protection of natural resources. Kaitiakitanga ensures conservation, protection and maintenance of resources through responsible actions, behaviour, conduct and practices. Two of the main concerns to Ngati Pikiao are the potential impacts of the Ohau channel diversion wall on kōura and kakahi in Lake Rotoiti and the Okere Arm.

Kōura, are the largest bottom-living crustacean in Lake Rotoiti with a maximum orbit-carapace length (OCL) of about 50mm (Kusabs & Quinn 2009) and support a highly valuable customary fishery. In contrast, kakahi are still consumed today but are not as popular or as important as they were in the past. This is mainly due to the insipid taste of kakahi rather than a decline in harvestable quantities. Moreover, there is a perception that kakahi may be unhealthy to eat as they accumulate pollutant, heavy metals and toxins.

Baseline monitoring of kōura and kakahi populations in the Okere Arm and Lake Rotoiti was carried out, from December 2005 to September 2007, prior to the completion of the diversion wall in July 2008 (Kusabs et al. 2006 & 2008). This monitoring showed that kōura and kakahi were present in high numbers in both the Okere Arm and Lake Rotoiti. The objective of this study was to carry out the first year's assessment of kōura and kakahi populations since the completion of the wall.

2 METHODS

2.1 Tau location and lay out

The Lake Rotoiti kōura population was sampled using the tau kōura, a traditional Maori method of harvesting kōura in the Te Arawa and Taupō lakes (Kusabs & Quinn 2009). Two tau kōura were set in Lake Rotoiti, one was located in the Okere Arm (Okere) at about NZMS

260 U15 038 482 and the other was set off Te Akau Point (Te Akau) at about NZMS 260 U15 037 465 (Fig. 1). Fieldwork was carried out on an approximate 3 monthly basis from November 2008 to September 2009.

Figure 1 Kōura and kakahi monitoring sites, Lake Rotoiti, 2005 to 2009. Numbers in red boxes show the approximate location of the koura monitoring sites and numbers in black circles kakahi sites.

The tau kōura method was developed by Te Arawa and Ngati Tuwharetoa to harvest large quantities of kōura in the Rotorua and Taupō lakes, respectively. It was therefore important to abide by culturally correct protocols and procedures when using this customary fisheries practice, particularly in those waterways where iwi have exclusive rights to mahinga kai (traditional food) resources. Before deploying tau kōura in Lake Rotoiti for this study, approval was obtained from the Te Arawa lakes Trust (the legal owner of the lakebed), the Ngati Pikiao resource committee, and Ngati Pikiao kaumatua (elders).

The tau kōura were comprised of 10 whakaweku, dried rarauhe or bracken fern (*Pteridium esculentum*) bundles, each with c. 14 dried fronds per bundle, were attached to a bottom line (a 200m length of sinking anchor rope) and set. One end of the bottom line was attached discreetly to the base of a tree on the shoreline while the lake end was anchored to the lake bottom using a heavy weight (a car tyre filled with concrete). The Okere Arm tau was set in an area relatively free of large aquatic macrophytes in a water depth of approximately 4 to 7m. The Te Akau tau (fern bundles) was set in water depths ranging from 7m to 17m.

The tau kōura were left for 1 month to allow kōura to colonise the fern and was retrieved every 3 months. Owing to rapid decomposition in warm water, our whakaweku (bracken fern bundles) were replaced on 30 October 2008 and 4 March 2009.

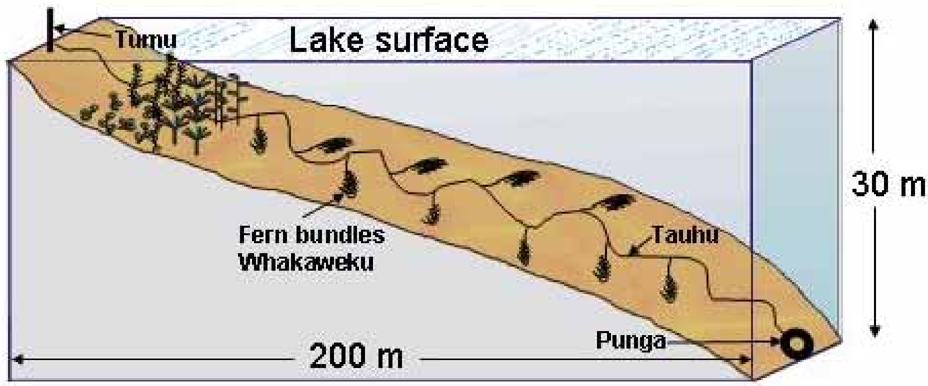

Figure 2 Schematic diagram of the tau kōura. The depth and length of tau are indicative and can be varied depending on lake bathymetry.

2.2 *Kōura harvesting*

Harvesting was achieved by lifting one end of the rope and successively raising each whakaweku while moving along the bottom line in a boat. A korapa (a large net designed especially for this purpose) was placed beneath the whakaweku before it was lifted out of the water. The whakaweku were then shaken to dislodge all kōura from the fern into the korapa. The whakaweku was then returned to the water. The kōura were then collected and sorted into labelled plastic boxes with lids above them to keep them shaded and calm before being measured and weighed. All kōura were counted and the volume of the total kōura catch measured.

2.3 *Kōura measurement*

Subsamples of the population were measured, typically this comprised all kōura captured on whakaweku 3, 5 and 7, or at least 100 individuals, to assess size class distribution. All kōura in the subsamples were measured for OCL (orbit-carapace length) to the nearest 1mm using callipers, and shell softness, sex and reproductive state (presence of eggs or young) recorded. After processing, all kōura were returned live to the water in close proximity to the tau.

2.4 Data Analysis

A detailed statistical comparison of the survey results pre and post wall completion was not attempted as it was decided that it would be more useful to conduct such an analysis after the collection of another year's data (i.e. 2 year's following the completion of the wall).

2.5 Kakahi monitoring

Kakahi transects were located at each of 3 sites along the area between Ohau channel and the Rotoiti delta and at 3 reference sites in Lake Rotoiti that were outside the diversion wall area. Grid references for the 6 sampling sites and locations are shown in Table 1 and Fig. 1, respectively. At each site 40m 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 kakahi within 0.5m up current from a weighted survey line, observed with an underwater viewer, were counted with the counts summed for each 1 m interval.

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

Sampling site	Location	Grid reference (NZ Geodatum)	Compass bearing
1. Boat Ramp	Okere Arm	E2802931 N 6346315	70°
2. Rest area	Okere Arm	E 2803075 N6346554	110°
3. Ditch	Okere Arm	E 2803237 N 6346621	90°
4. Okawa Bay	Lake Rotoiti	E 2802903 N 6345642	75°
5. Tumoana Point	Lake Rotoiti	E 2805639 N 6345842	350°
6. Ruato Bay	Lake Rotoiti	E 2811245 N 6343779	290°

An 'L' shaped measuring device constructed of 25mm PVC pipe (1.2m high x 0.5m wide) was used to measure water depth (to the nearest 1cm) and to maintain the 0.5m distance from the survey line. Sediment type is an important determinant of mussel density (James 1985) and was visually assessed along the transect lines as mud, mud-sand, clean sand, gravely sand, sandy gravel etc. These surveys were carried out on 30 November 2008, 19 February 2009 and 5 June 2009. A survey was attempted in April but was abandoned due to poor water visibility (a blue green algae bloom was present in Lake Rotorua and the Okere Arm from February through to May 2009).

3 RESULTS

3.1 *Kōura*

3.1.1 *Abundance and yield*

A total of 1486 kōura were captured in the Okere Arm tau in the 4 surveys from 21 November 2008 to 13 July 2009 while 1016 kōura were captured at Te Akau over the same period (Table 1). The mean CPUE at Okere ranged from 13.3 to 62.7 kōura per whakaweku, whereas the mean CPUE at Te Akau ranged from 8.0 to 39.3 kōura per fern bundle (Fig. 3). The highest catch (n = 627) and yield (11.7 l) of Okere kōura were recorded in April 2009, whereas, the highest catch (n = 393) and yield (26.4 l) of Te Akau kōura was recorded in February 2009 (Table 2).

The difference in yield can be attributed to the fact that most kōura captured in the Okere Arm were < 25 mm OCL whereas at Te Akau almost half of the kōura population were > 25 mm OCL.

Table 2 Mean CPUE (Catch Per Unit Effort), biovolume, wet weight, mean (± SD) OCL and OCL range of kōura captured in a tau kōura (comprised of 10 whakaweku or fern bundles) set in the Okere Arm between 8 December 2005 and 13 July 2009, and at Te Akau between 14 February 2007 and 13 July 2009. ND, no data collected.

Sampling date	CPUE of kōura		Biovolume (l)		Wgt of catch (kg)		Mean OCL (mm ± SD)		OCL range (mm)	
	Okere	T A	Okere	T A	Okere	T A	Okere	T A	Okere	T A
8 December 2005	80.3	ND	14.9	ND	NR	ND	20.5 (5.9)	ND	12-40	ND
23 February 2006	28.6	ND	5.7	ND	NR	ND	21.6 (4.6)	ND	9-36	ND
8 June 2006	28.8	ND	7.98	ND	NR	ND	19.2 (6.4)	ND	9-44	ND
12 September 2006	97.2	ND	12.3	ND	NR	ND	15.0 (3.5)	ND	9-29	ND
13 December 2006	25.6	ND	9.7	ND	1.0	ND	17 (4.0)	ND	11-31	ND
14 February 2007	74.2	96.7	17.4	19.2	6.6	12.8	19.8 (4.1)	24.9 (5.5)	8-34	13 - 41
9 May 2007	25.5	71.2	2.7	22.0	1.8	13.8	14.8 (4.3)	26.8 (6.2)	9-29	6 - 47
13 August 2007	60.2	39.9	6.6	8.0	2.0	4.7	15.8 (4.1)	22.2 (8.2)	10-32	10 - 50
10 September 2007	ND	26.7	ND	6.3	ND	4.6	ND	22.1 (7.3)	ND	10 - 38
21 November 2008	19.9	8.0	3.5	3.4	0.8	1.0	17.5 (3.7)	26.7 (4.8)	10 - 32	15 - 42
4 February 2009	13.3	39.3	3.3	26.4	0.6	8.0	13.9 (7.0)	29.8 (5.2)	7 - 32	18 - 43
17 April 2009	62.7	32.4	11.7	19.9	3.0	7.0	17.6	29.9 (4.8)	8 - 38	16 - 45
13 July 2009	52.7	21.9	9.1	15.0	2.5	5.0	16.9	31.5 (4.7)	9 -34	21 - 50

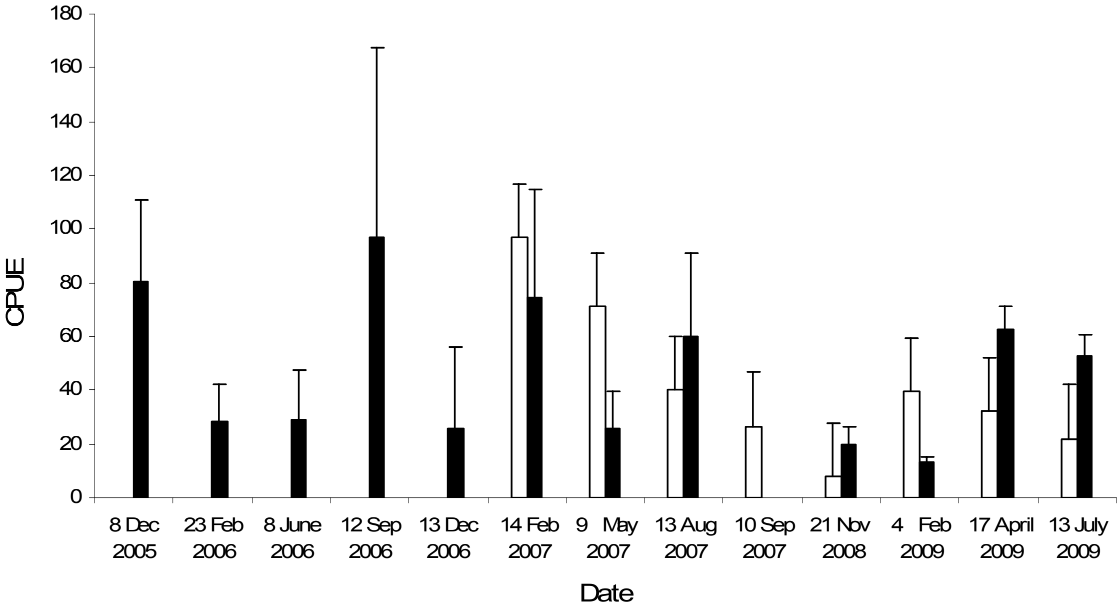

Figure 3 Mean catch per unit effort (CPUE) of kōura (±SD; n=10) for kōura captured in the Okere Arm (shaded bars) and Te Akau tau kōura (unshaded bars), Lake Rotoiti, for all sampling occasions, December 2005 to July 2009. Note: the diversion wall became fully operational in July 2008.

3.1.2 Size

Kōura ranged in size from 7 to 38 mm and 15 to 50 mm OCL at Okere and Te Akau respectively, over the 4 sampling periods (Table 2). In addition, kōura were larger at Te Akau where the highest mean OCL was 31.5mm (July 2009) compared to a mean OCL of 17.5mm (November 2008) for Okere kōura (Table 2).

Length frequency distributions of the 4 samples of Okere and Te Akau kōura are shown in Fig. 4. These distributions show that the kōura population was comprised mainly of small (OCL < 18mm) and medium (OCL 19-29mm) sized kōura in the Okere Arm, whereas the Te Akau kōura population was comprised mainly of medium and large, harvestable (OCL > 30mm) kōura.

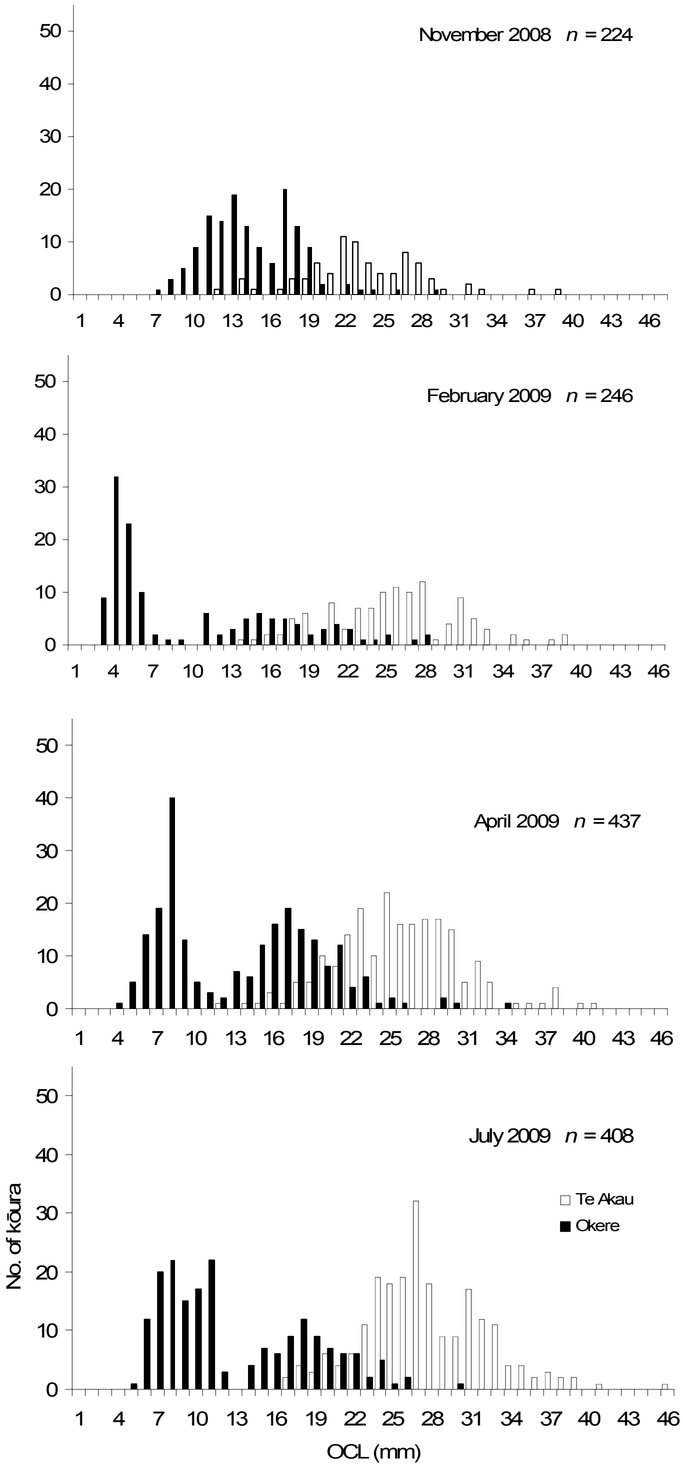

Figure 4 Length (OCL) frequency distributions of kōura captured from tau kōura at Te Akau Point (unshaded bars) and Okere Arm (shaded bars), 21 November 2008, 4 February 2009, 17 April 2009, 13 July 2009.

3.1.3 Breeding

The percentage of females in subsamples from Okere Arm and Te Akau ranged from 42.1% to 58.7% and 44.2% to 66%, respectively for the 2008/09 sampling period (highlighted in Table 3). Females with eggs or young were present at Okere and Te Akau in November 2008, April 2009, and July 2009 but none were recorded in February 2009 at Okere or at Te Akau (Table 3). The proportion of "breeding size" females with eggs or young was highest at Te Akau in July 2009 (87.2%) and at Okere in November (66.7%) and July (63.2%) (Table 3).

The proportion of kōura with soft shells was least in November 2008 (Okere 0.7% and Te Akau 1.3%) and greatest in April 2009 (Okere 6.2% and Te Akau 13.4%) (Table 3).

Table 3 Percentage of females, percentage of breeding size females with eggs or young (defined as >23 mm OCL) and percentage of kōura with soft shells, in subsamples taken from a tau kōura (comprised of 10 fern bundles) set in the Okere Arm, 8 December 2005 to 13 July 2009 and at Te Akau, 14 February 2007 to 13 July 2009. n = actual number of females with eggs or young. ND, no data collected. A breeding size female was defined as >23mm OCL. Shaded area indicates this report's sampling period.

Sampling date	Number of kōura sexed		% of females in sample		% of breeding size females with eggs (n)		% of sample with soft shells	
	Okere	Te Akau	Okere	Te Akau	Okere	Te Akau	Okere	Te Akau
8 December 2005	74	ND	44.6	ND	0 (0)	ND	NR	ND
23 February 2006	139	ND	54.7	ND	0 (0)	ND	NR	ND
8 June 2006	121	ND	50.4	ND	33 (7)	ND	14.8	ND
12 Sept 2006	322	ND	43.8	ND	50 (8)	ND	7.8	ND
13 December 2006	256	ND	54.7	ND	0 (0)	ND	3.5	ND
14 February 2007	233	299	55.4	52.8	0 (0)	0	0.8	0.7
9 May 2007	240	341	51.6	45.7	0 (0)	36.8 (45)	1.6	6.2
13 August 2007	123	200	50.4	44.0	100 (2)	54.3 (19)	2.3	3.5
10 September 2007	ND	75	ND	41.3	ND	55.6 (5)	ND	1.3
21 November 2008	143	80	58.7	46.3	66.7 (3)	18.2 (6)	0.7	1.3
4 February 2009	57	113	42.1	44.2	0	0	1.5	4.4
17 April 2009	193	209	53.9	66	16 (4)	16 (21)	6.2	13.4
13 July 2009	175	219	54.3	58.4	63.2 (12)	87.2 (109)	1.7	7.3

3.2 Kakahi

3.2.1 Abundance

Field work was carried out on 30 November 2008, 19 February 2009 and 5 June 2009. A survey was attempted in April but was abandoned due to poor water visibility (a blue green algae bloom was present in Lake Rotorua and the Okere Arm from February through to May 2009). Surveys were carried out when weather conditions and water clarity allowed good visual observations to be made of kakahi in Lake Rotoiti. A total of 3289 kakahi were counted in the 3 (2008/09) surveys (these are highlighted in Table 4). Kakahi were more numerous in the Okere Arm than at the control sites (Table 4). The highest densities of kakahi were recorded at the 'Ditch' site (situated in the Okere Arm) and in the Okawa Bay site (a control site) (Fig. 5).

Kakahi numbers varied markedly amongst sampling events, for example at the 'Ditch' site kakahi numbers ranged from 205 to 1156 per transect (or per $20m^2$). The lowest numbers of kakahi were present at the 'Tumoana' site which had a mean count of 2.3 kakahi transect $^{-1}$ (Table 4).

No assessment of kakahi health was carried out this year. However, kakahi samples were collected in September 2009 for analysis by NIWA (National Institute of Water and Atmospheric Research) in order to determine kakahi condition relationships for comparison with samples collected in September 2007.

Table 4 Number of kakahi counted, totals, mean and standard errors for 0.5m wide x 40m long transects at the six sampling sites situated in Lake Rotoiti, June 2005 to June 2009. Shaded area indicates this report's sampling period. NI = not included in monitoring programme until September 2005.

Date	Boat ramp Okere Arm	Rest area Okere Arm	Ditch Okere Arm	Okawa Bay Control	Tumoana Bay Control	Ruato Bay Control	Total
Jun-05	20	125	633	236	NI	NI-	1014
Sep-05	33	57	686	269	0	19	1064
Dec-05	40	106	803	131	9	29	1118
Mar-06	28	28	471	240	4	42	813
Jun-06	28	119	329	413	3	7	899
Dec 06	37	89	343	402	0	29	900
May 07	81	119	269	140	0	33	642
Sep 07	59	201	272	155	2	19	708
Nov 08	118	374	1156	401	4	74	2127
Feb 09	85	85	205	94	2	16	487
June 09	59	92	266	240	1	17	675
Total All	326	844	3806	1986	18	178	7158
Mean ± SE	53.5±9.2	126.8±28	494±89.2	247.4±34.7	2.5±0.9	28.5±6	895

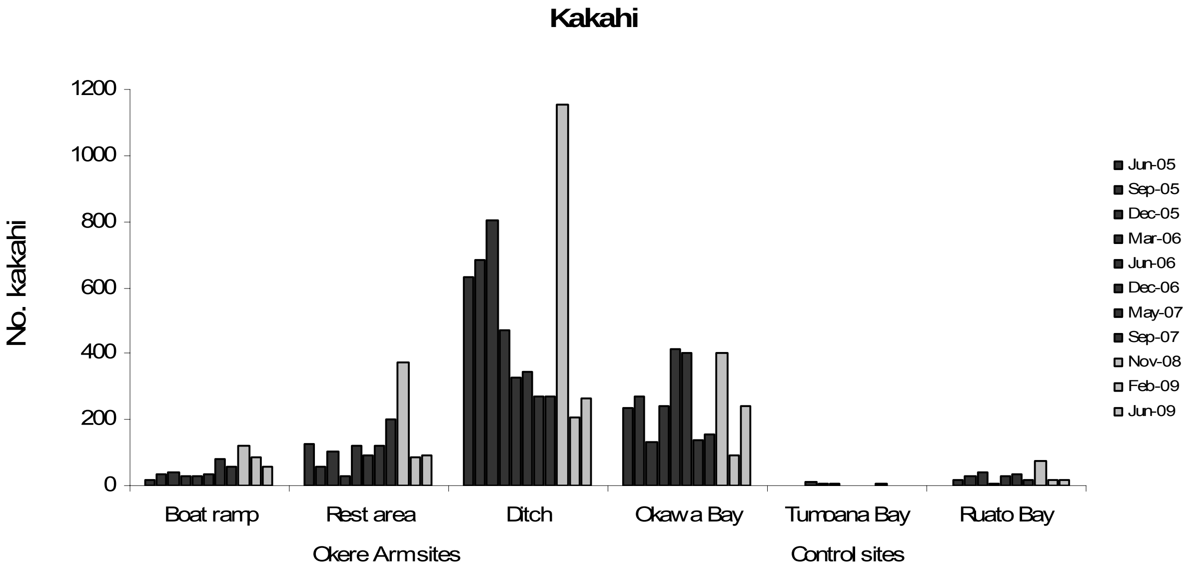

Figure 5 The mean number of kakahi recorded at 6 sites (0.5m x 40m transects) situated in Lake Rotoiti, June 2005 to June 2009. Dark shaded bars represent those surveys carried out prior to the operation of the Ohau Channel diversion wall.

4 DISCUSSION

4.1 Kōura

The Okere Arm continues to support an abundant kōura population following the completion of the Ohau Channel diversion wall in July 2008. Nevertheless, kōura abundance at Okere and Te Akau during this study period (2008/2009) was noticeably lower than that recorded in previous surveys (2005 – 2007)[1]. The lowest mean CPUE's recorded at both Okere (13.3 in February 2009, 19.9 in November 2009) and Te Akau (8.0 in November 2009, 21.9 in July 2009) were recorded during the 2008/2009 study period. The reasons for this are unclear but the low mean CPUE'S recorded in November 2009 could be related to the short period (3 week compared to 4 weeks) between replacement of whakaweku (fern bundles) and their retrieval. The tau kōura is a new monitoring method and it appears that the optimum saturation time for the whakaweku (fern bundles) are dependent on a number of factors including the time of year (season) and kōura densities. These aspects of the methodology are being investigated as part of a PhD study by the primary author. Kōura abundance does seem

[1] A detailed statistical analysis of koura population dynamics is planned for September 2010 when 2 year's monitoring data (since wall completion) will be available.

to have rebounded somewhat in subsequent surveys particularly at Te Akau. Nevertheless, the only way to determine whether these perceived declines in koura abundance at Te Akau and Okere are real is to continue with future monitoring surveys.

Comparison with other Rotorua lakes

Koura abundance Lake Rotoiti is high in comparison to other Rotorua lakes. In a recent survey (using the tau koura method) in seven Rotorua Lakes CPUE of koura at Okere and Te Akau was comparable to those recorded at; Manupirua Hot pools (Lake Rotoiti), lakes Rotoma and Rotorua and higher than those from lakes Okaro, Okareka, Tarawera and Rotokakahi (Table 5) (Kusabs unpublished PhD data). The CPUE of 62.7 recorded at Okere was the highest recorded during a survey of kōura populations in 7 Rotorua lakes (Table 5). A further monitoring of the seven lakes is planned for November 2009 and upon completion will be followed by an in-depth analysis of koura abundance, population structure, egg-bearing times, and moulting times. Koura monitoring at Te Akau and Okere Arm will be included in this analysis.

Table 5 Mean CPUE of kōura captured in tau kōura (comprised of 10 whakaweku or fern bundles) set in 7 Rotorua lakes on 3 to 6 March 2009 and retrieved on 14 - 17 April 2009 and 9 - 14 July 2009. Note: the mean CPUE for lakes Tarawera, Rotoma, Okareka, Rotokakahi and Rotorua was obtained from 2 tau kōura (Kusabs unpublished data). Hot pools = Manupirua Hot pools located in the eastern basin of Lake Rotoiti.

Mean CPUE	**Okere**	**Te Akau**	**Hot pools**	Tarawera	Rotoma	Okareka	Rotokakah	Rotorua	Okaro
April	62.7	32.4	11.1	3.4	41.8	7.1	3.5	37.9	0
July	52.7	21.9	44.9	9.4	30.0	3.6	12	56.5	0

Size

As in previous samplings kōura were larger at Te Akau than at Okere, 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. The aggregation of kōura is a response to light levels and, during periods of stratification (i.e. spring to autumn), to deoxygenation of the hypolimnion (Devcich 1979).

Egg Bearing

Breeding appears to be continuous in Lake Rotoiti, although the least likely time to find females with eggs is in February. The percentage of "breeding" size females with eggs in the current study was highest in July at Te Akau and in July and October at Okere Arm. This is similar to previous surveys where the proportion of "breeding" size females peaked in the winter and spring months.

Kakahi

Kakahi numbers varied markedly between the monitoring sites and over the sampling period (2008 – 2009). In general, kakahi were far more numerous in the Okere Arm sites than in the control sites. This is not surprising given that there is a constant flow of highly productive water through the Okere Arm.

Kakahi counts were compromised by algae blooms that resulted in poor water clarity and the abandonment of the autumn survey. Nevertheless Kakahi abundance was similar to that recorded in previous surveys with the highest count recorded in the Okere Arm ditch site, of 1115 kakahi per $20m^2$, since surveys began in 2005. There was a noticeable accumulation of silt in the Okere Arm monitoring sites (within the diversion wall) which is probably due to a reduction in easterly wave action and/or an eddying affect. Sediment type is an important determinant of mussel density (James 1985) and future surveys will help to determine what affect silt accumulation has on kakahi health and abundance in the Okere Arm.

5 SUMMARY

Lake Rotoiti and the Okere Arm continue to support abundant kōura populations with CPUE's comparable to those recorded at, Rotoma and Rotorua and higher than those in lakes Okaro, Okareka, Tarawera and Rotokakahi (Kusabs unpublished PhD data). Nevertheless, kōura numbers appear to be lower at Okere and Te Akau (especially November 2008) than those recorded in pre-wall surveys. The reasons for this are unknown but it could possibly be due to the shorter period between replacement of whakaweku (fern bundles) and their retrieval. The only way to determine whether this perceived decline is real is to continue with future surveys.

Kakahi remain abundant in the Okere Arm with the highest monthly count being recorded in November 2008 since surveys began in 2005 (Table 5). There was a noticeable accumulation of fine silt at the Okere Arm monitoring sites which may affect kakahi health and abundance in the Okere Arm. Kakahi samples were collected in September 2009 for comparison (analysis will be carried out by NIWA) with pre-wall samples to compare health and condition relationships. A detailed statistical comparison of the kōura and kakahi monitoring results pre and post wall will be carried out following the completion of next seasons (2009 to 2010) sampling.

6 ACKNOWLEDGEMENTS

Thanks to John Quinn and Chris Hickey from NIWA for their on-going assistance with the monitoring programme (supported by the FRST funded Aquatic Restoration Programme 0010305). Roger Bawden from Wildland Consultants provided the map of Lake Rotoiti.

7 REFERENCES

Devcich, A. A. 1979. An ecological study of *Paranephrops planifrons* (White) (Decapoda: Parastacidae) in Lake Rotoiti, North Island, New Zealand. Unpublished PhD thesis, The University of Waikato, Hamilton, New Zealand.

Hiroa T.R. 1921. Maori food supplies of Lake Rotorua, with methods of obtaining them, and usages and customs appertaining thereto. *Transactions of the New Zealand Institute 26.* 429-451.

James, M.R. 1985. Distribution, biomass and production of the freshwater mussel, *Hyridella menzeisi* (Gray), in Lake Taupo, New Zealand. *Freshwater Biology 15*: 307-314.

Kusabs, I. & Quinn, J. 2009. Use of a traditional Māori harvesting method, the tau kōura, for monitoring kōura (freshwater crayfish *Paranephrops planifrons*) populations in Lake Rotoiti, New Zealand. *NZ Journal of Marine and freshwater research 43*: 713 – 722.

Kusabs, I. & Emery, W. 2006. *Ohau channel diversion wall – an assessment of the kōura and kakahi populations in the Okere Arm and Lake Rotoiti*. Report number 1 prepared for Environment Bay of Plenty. 15pp.

Kusabs, I. & Emery, W. 2008. *Ohau channel diversion wall – an assessment of the kōura and kakahi populations in the Okere Arm and Lake Rotoiti*. Report number 2 prepared for Environment Bay of Plenty. 23pp.

Walker, K., Byrne, M., Hickey, C., Roper, D. 2001. Freshwater mussels (Hyriidae) of Australasia. Ecological studies, vol. 145, in Bauer and Wachtler (*eds.*) Ecology and evolution of the freshwater mussels unionoida.