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Zooplankton composition and a trophic state assessment of fifteen Waikato lakes using Rotifer assemblages: 2011-2012

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Executive summary

Zooplankton species composition was documented from 15 Waikato lakes from net haul samples collected in December 2011, March 2012 and May 2012. The lakes examined were Harihari, Mangahia, Mangakaware, Ngaroto, Ohinewai, Okoroire, Serpentine East, Serpentine North, Serpentine South, Taharoa, Te Kapa, Tunawhakaheke (‘E’), Waahi, Waikare, and Whakatangi (‘A’).

A wide variety of zooplankton species were recorded, including 43 rotifer, five cladoceran and three copepod taxa. All were typical inhabitants of New Zealand lakes.

Rotifer inferred TLI assessments ranked the lakes from best to poorest in the following order: Lake Te Kapa (2.01), Harihari (2.18; both oligotrophic), Serpentine North (3.34), Serpentine East (3.35), Serpentine South (3.58; all mesotrophic), Taharoa (4.08), Waikare (4.78), Ohinewai (4.73), Mangakaware (4.95; all eutrophic), Mangahia (5.09), Ngaroto (5.90; both supertrophic), Okoroire (6.02), Whakatangi (6.39), Waahi (7.12) and Tunawhakaheke (7.75; all hypertrophic). Of those lakes sampled previously, lake rank order remained similar between this study and previous assessments.

1 Introduction

Waikato Regional Council commissioned surveys of 15 lakes in late-2011 and early to mid-2012: Lakes Harihari, Mangahia, Mangakaware, Ngaroto, Ohinewai, Okoroire, Serpentine East, Serpentine North, Serpentine South, Taharoa, Te Kapa, Tunawhakaheke (‘E’), Waahi, Waikare, and Whakatangi (‘A’). Many of these lakes are poorly understood with respect to water quality, largely due to issues with access (i.e., they lie in farmland and/or have no easy boat ramp access). While a number of these have been monitored by Waikato Regional Council (formerly Environment Waikato) over the last few years, Lakes Te Kapa, Mangakaware, Ngaroto, Okoroire, Whakatangi and Tunawhakaheke are being monitored here for the first time. Traditional inference of lake trophic state typically relies on monthly sampling of a variety of indicators (e.g., Secchi transparency, chlorophyll *a* concentrations, nutrients), but for lakes that are isolated or have difficult access such fine-scale monitoring is difficult or unfeasible. Biotic indices are commonly used in such circumstances as they integrate biological, physical and chemical factors over time, allowing for less fine-scale monitoring than traditional methods. Duggan et al. (2001a, b) found that trophic state was the major determinant of rotifer distribution among North Island lakes, and based on these responses developed a quantitative bioindicator index using rotifer community composition for inferring Trophic Lake Index (TLI) values (*sensu* Burns et al. 1999). This approach was used for Waikato lakes in late 2006 (single samples for each lake; Duggan 2007), 2007/2008 (two samples; Duggan 2008), 2008/2009 (Duggan & Fowler 2009), 2009/2010 and 2010/2011 (each using three samples; Duggan 2010; 2011).

In this report, zooplankton community composition was documented from plankton hauls from fifteen lakes sampled in December 2011, March 2012 and May 2012 (i.e., three samples from each lake). From the resulting species datasets, the Rotifer Community Index of Duggan et al. (2001a) was used to infer lake water quality.

2 Methods

Fifteen lakes were sampled by Wendy Paul, Grant Tempero, and other Centre for Biodiversity and Ecology Research (CBER, The University of Waikato) staff for this study. Zooplankton were sampled from a central (or deep) position in each lake in December 2011, and March and May 2012, using vertical hauls through the entire water column with a plankton net (40 µm mesh size; haul speed ~1 $m.s^{-1}$). Samples were immediately preserved using ethanol.

In the laboratory, preserved samples were examined for zooplankton community composition. As rotifers are the zooplankton group most useful for water quality monitoring, samples were enumerated where possible until a total of at least 100 individuals of “indicator species” were recorded; i.e., species that have an assigned TLI optima and tolerance score given by Duggan et al. (2001a). Based on the resulting lists, the bioindicator scheme of Duggan et al. (2001a) was used to infer lake trophic state. All identifications were made to species level wherever possible.

3 Results and Discussion

3.1 Community Composition

Forty-three rotifer, 5 cladoceran and 3 copepod taxa were distinguished in the current study (Table 1). The zooplankton taxa recorded in this survey were typical North Island lake inhabitants. Taxon richness for all of the major groups of zooplankton were lower in this study than for the previous survey, which was likely due largely to the reduced number of lakes surveyed (15 rather than 17).

Table 1: Zooplankton species present in net hauls from fifteen Waikato lakes. Lakes are ordered alphabetically.

	Harihari	Harihari	Harihari	Mangahia	Mangahia	Mangahia	Mangakaware	Mangakaware	Mangakaware	Ngaroto	Ngaroto	Ngaroto	Ohinewai	Ohinewai	Ohinewai	Okoroire	Okoroire	Okoroire	Serp. East	Serp. East	Serp. East	Serp. Nth	Serp. Nth	Serp. Nth
	14/12/2011	21/03/2012	24/05/2012	14/12/2011	21/03/2012	23/05/2012	12/12/2011	20/03/2012	23/05/2012	13/12/2011	21/03/2012	23/05/2012	08/12/2011	23/03/2012	30/05/2012	13/12/2011	20/03/2012	23/05/2012	12/12/2011	20/03/2012	13/05/2012	12/12/2011	20/03/2012	23/05/2012
ROTIFERA																								
Anuraeopsis fissa																				x				
Anuraeopsis navicula																							x	
Ascomorpha ecaudis																			x	x				
Ascomorpha ovalis	x	x	x																		x	x	x	x
Ascomorpha saltans																								
Asplanchna brightwelli								x		x						x	x							
Asplanchna priodonta							x	x	x		x	x			x				x	x	x	x	x	x
Brachionus angularis																x	x						x	
Brachionus budapestinensis																x								
Brachionus caliciflorus					x		x	x	x	x						x	x							
Brachionus caudatus																								
Brachionus quadridentatus																								
Collotheca sp.					x	x					x	x			x									
Conochilus coenobasis					x	x													x	x	x		x	
Conochilus unicornis																			x	x		x		
Epiphanes macrourus																				x				
Filinia novaezealandiae				x	x	x	x		x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
Filinia pejleri						x																		
Filinia longiseta							x					x												
Hexarthra intermedia								x	x	x									x	x				
Hexarthra mira	x		x	x	x	x							x		x							x	x	
Keratella cochlearis	x	x	x	x	x	x		x		x	x	x		x	x	x			x		x	x	x	x
Keratella procurva							x																	
Keratella slacki							x	x	x							x	x	x						x
Keratella tecta										x	x			x	x	x								
Keratella tropica				x	x	x			x	x	x	x	x		x		x	x						
Lecane bulla		x																						
Lecane hamata																								
Lecane hornemanni			x																					
Lecane luna																								
Lecane lunaris																								
Platyais quadricornis						x																		
Polyarthra dolichoptera	x	x	x				x		x		x		x	x	x	x	x	x	x	x	x	x	x	x
Polyarthra vulgaris				x	x	x																		
Pompholyx complanata				x	x	x	x		x	x	x	x	x	x	x		x						x	
Synchaeta longipes	x	x	x																					
Synchaeta oblonga					x	x							x						x			x	x	x
Synchaeta pectinata		x		x	x	x							x	x	x				x					x
Trichocerca pusilla	x	x	x		x	x				x		x	x		x									
Trichocerca similis		x	x				x		x	x	x	x	x	x	x									
T. simils grandis																								
Trichocerca stylata										x	x	x												
Bdelloids			x									x			x			x						
ARTHROPODA																								
Cladoceans																								
Bosmina meridionalis				x	x	x	x	x	x	x	x	x	x	x	x		x		x	x	x	x	x	
Chydorus sp.																			x					
Daphnia galeata					x		x	x	x	x	x	x	x	x	x							x		
Ceriodaphnia dubia				x	x	x		x	x										x	x	x			
Ilyocryptus																								
Copepods																								
Boeckella delicata				x	x	x	x		x											x	x			
Calamoecia lucasi	x	x	x				x	x		x		x	x	x	x				x	x	x	x	x	x
Mesocyclops leuckarti		x			x	x	x	x	x	x	x	x	x	x	x		x	x		x	x	x	x	x
nauplii	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Tenagomysis chiltoni																								

Table 1 (cont): Zooplankton species present in net hauls from fifteen Waikato lakes. Lakes are ordered alphabetically.

	Serp. Sth 12/12/2011	Serp. Sth 20/03/2012	Serp. Sth 23/05/2012	Taharoa 14/12/2011	Taharoa 21/03/2012	Taharoa 24/05/2012	Te Kapa 08/12/2011	Te Kapa 22/03/2012	Te Kapa 25/05/2012	Tunawhakaheke 08/12/2011	Tunawhakaheke 22/03/2012	Tunawhakaheke 23/05/2012	Waahi 13/12/2011	Waahi 23/12/2012	Waahi 24/05/2012	Waikare 13/12/2011	Waikare 23/03/2012	Waikare 25/05/2012	Whakatangi 08/12/2011	Whakatangi 22/03/2012	Whakatangi 25/05/2012
ROTIFERA																					
Anuraeopsis fissa					x	x															
Anuraeopsis navicula																x		x			
Ascomorpha ecaudis																					
Ascomorpha ovalis				x	x																
Ascomorpha saltans																		x			
Asplanchna brightwelli			x							x		x		x							
Asplanchna priodonta	x	x	x	x		x								x	x				x	x	x
Brachionus angularis				x						x	x	x		x	x				x		
Brachionus budapestinensis										x				x	x				x		
Brachionus caliciflorus										x	x	x							x		
Brachionus caudatus											x										
Brachionus quadridentatus												x			x						
Collotheca sp.			x	x	x	x											x				
Conochilus coenobasis			x					x	x												
Conochilus unicornis																					
Epiphanes macrourus																					
Filinia novaezealandiae	x	x	x	x	x	x	x			x	x		x	x	x	x	x	x	x	x	x
Filinia pejleri																					
Filinia longiseta														x					x		
Hexarthra intermedia	x	x	x	x		x				x		x	x	x					x	x	
Hexarthra mira																					
Keratella cochlearis	x	x	x	x	x	x					x		x	x	x		x				
Keratella procurva								x			x	x					x		x	x	x
Keratella slacki										x											
Keratella tecta					x	x					x	x	x	x	x		x	x			
Keratella tropica			x					x		x	x	x	x	x	x		x		x	x	
Lecane bulla						x															
Lecane hamata																				x	
Lecane hornemanni																					
Lecane luna				x	x	x															
Lecane lunaris						x															
Platyais quadricornis																					
Polyarthra dolichoptera	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
Polyarthra vulgaris																					
Pompholyx complanata				x		x					x				x	x		x	x	x	x
Synchaeta longipes																					
Synchaeta oblonga	x	x	x	x	x	x						x							x		
Synchaeta pectinata	x	x	x	x			x	x	x	x		x									
Trichocerca pusilla				x	x	x							x	x	x		x	x		x	
Trichocerca similis				x	x	x		x	x	x										x	
T. simils grandis				x										x							
Trichocerca stylata				x	x	x															
Bdelloids				x		x					x						x	x			
ARTHROPODA																					
Cladoceans																					
Bosmina meridionalis	x	x	x	x	x	x	x	x	x		x	x			x	x	x				
Chydorus sp.																					
Daphnia galeata				x								x		x	x		x	x	x	x	x
Ceriodaphnia dubia			x				x		x												
Ilyocryptus																	x				
Copepods																					
Boeckella delicata			x				x		x												
Calamoecia lucasi	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x
Mesocyclops leuckarti			x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x
nauplii	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Tenagomysis chiltoni																	x	x			

3.2 Trophic State Assessment

Based on rotifer inferred TLI values in the current study, Lake Te Kapa (2.01) and Lake Harihari (1.30) were inferred as oligotrophic, Serpentine North (3.34), Serpentine East (3.35), Serpentine South (3.58) were mesotrophic, Taharoa (4.08), Waikare (4.78), Ohinewai (4.73) and Mangakaware (4.95) were inferred as eutrophic, Mangahia (5.09), Ngaroto (5.90) were supertrophic, and Okoroire (6.02), Whakatangi (6.39), Waahi (7.12) and Tunawhakaheke (7.75) were all assessed as hypertrophic.

For those lakes which had been sampled previously, the rank order of lake trophic state assessments has remained similar. For example, Lakes Harihari and Serpentine East have been amongst those lakes having the lowest TLI values in previous reports (Table 2), while Lakes Mangahia and Waahi have had the highest assessed TLI values.

Of trends across the data, Lakes Serpentine North and Serpentine South have been assessed using rotifers to be gradually improving in water quality. However, these lakes have been inferred in recent years to be supertrophic using traditional methods. As mentioned in the previous two reports (Duggan 2010; 2011), this may potentially be due, in part, to both the standard and rotifer inferred assessments being inadequate for the assessment of dystrophic lakes. For example, lakes with a high humic content are likely to have lower algal concentrations than might be expected based on extant nitrogen and phosphorus concentrations, while Secchi depth readings will also be reduced due to factors other than primary production. As such, TLI assessments using the methods of Burns et al. (1999), which rely on Secchi depth, nutrient concentrations and chlorophyll *a*, will assess dystrophic lakes as having poorer water quality than they may actually have. Zooplankton species composition may also be affected by dystrophic conditions, perhaps favouring zooplankton species that feed on small particle sizes (i.e., such as those more typical in lower trophic states). However, it is interesting to note that Lakes Serpentine East and South both score highly using the Lake SPI index due to having a moderate coverage of native macrophytes, indicating that these lakes may indeed be of better quality than traditional methods infer (Edwards et al. 2005). The assessments for the remaining lakes have been relatively stable throughout the last five years of surveys, although Lake Waikare had its best assessment in the current survey.

The lakes sampled for the first time here varied greatly in their trophic state assessments, with Lake Te Kapa being inferred to have extremely good water quality (oligotrophic), while at the other extreme Lake Tunawhakaheke was assessed as having the poorest water quality (hypertrophic).

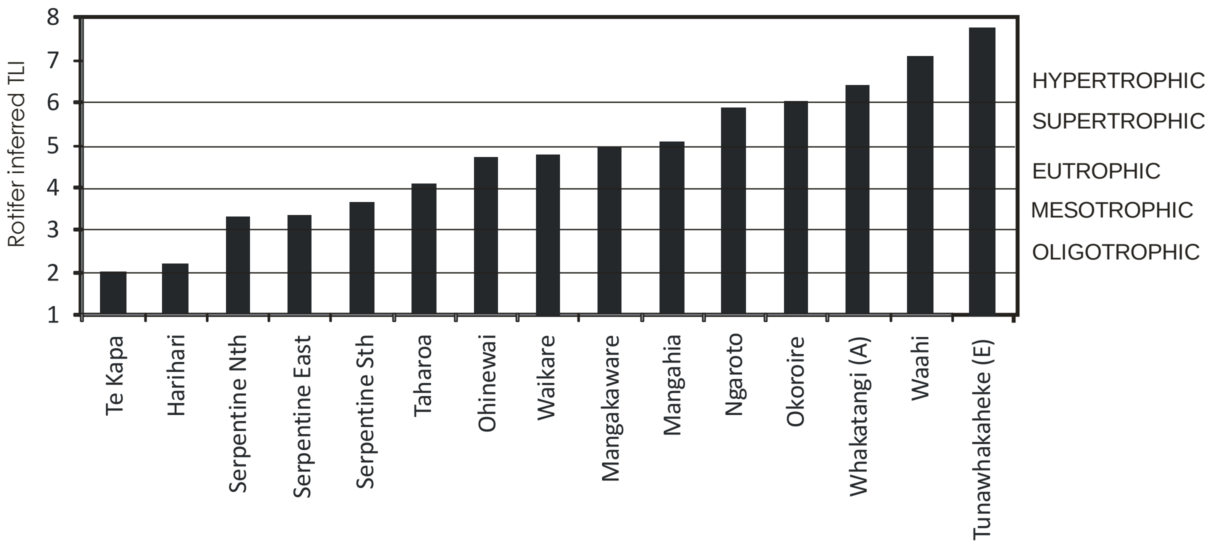

Figure 1: **Averaged rotifer inferred TLI values from samples collected in late 2011 and early 2012 from fifteen Waikato Lakes. Lakes are ordered from lowest to highest inferred TLI values.**

Table 2: **Rotifer inferred TLI values for 15 Waikato lakes from samples collected in December 2011, March 2012 and May 2012, and an average of these values. Lakes are ordered from lowest to highest inferred TLI values. Comparisons of TLI values are made for lakes that were assessed by Duggan (2008, 2010, 2011) and Duggan & Fowler (2009).**

Lake	Date of sampling 2009/2010	Rotifer Inferred TLI (average) 2011/2012	Rotifer Inferred TLI (average) 2010/2011	Rotifer Inferred TLI (average) 2009/2010	Rotifer Inferred TLI (average) 2008/2009	Rotifer Inferred TLI (average) 2007/2008*
Te Kapa	December	1.75				
	March	2.36				
	May	1.91				
	Average	**2.01**				
Harihari	December	2.70	1.39	3.40	4.51	4.54
	March	2.37	1.16	2.33	3.72	4.93
	May	1.46	1.34	1.21	4.40	
	Average	**2.18**	**1.3**	**2.31**	**4.21**	**4.74**
Serpentine North	December	3.98	2.79	4.15	4.16	4.25
	March	3.83	3.8	4.16	3.29	5.95
	May	2.20	4.08	3.89	4.07	
	Average	**3.34**	**3.56**	**4.07**	**3.84**	**5.10**
Serpentine East	December	2.73	2.68	2.58	2.12	2.68
	March	2.91	1.96	2.95	3.50	4.07
	May	4.41	4.26	4.27	3.87	
	Average	**3.35**	**2.97**	**3.27**	**3.16**	**3.38**
Serpentine South	December	3.93	4.73	4.18	4.16	3.94
	March	3.77	3	4.27	3.18	3.57
	May	3.04	3.8	4.08	3.83	
	Average	**3.58**	**3.84**	**4.18**	**3.73**	**3.76**
Taharoa	December	2.95	1.98	4.56	2.88	5.25
	March	5.42	5.01	4.32	4.01	6.11
	May	3.87	2.09	2.56	5.41	
	Average	**4.08**	**3.03**	**3.81**	**4.10**	**5.68**
Ohinewai	December	5.20	4.78	5.03	3.61	7.27
	March	4.06	6.63	4.21	2.99	6.07
	May	4.94	4.34	4.40	4.36	
	Average	**4.73**	**5.25**	**4.54**	**3.65**	**6.67**
Waikare	December	6.21	7.22	5.17	5.17	7.81
	March	4.10	5.7	6.36	7.65	5.77
	May	3.96	4.73	4.79	4.83	
	Average	**4.78**	**5.88**	**5.44**	**5.89**	**6.79**
Mangakaware	December	4.85				
	March	4.83				
	May	5.17				
	Average	**4.95**				
Mangahia	December	4.71	8.3	6.80	6.38	4.69
	March	5.61	6.19	7.18	8.06	5.38
	May	4.94	4.31	4.41	4.74	
	Average	**5.09**	**6.27**	**6.13**	**6.39**	**5.03**
Ngaroto	December	5.56				
	March	5.14				
	May	6.99				
	Average	**5.90**				
Okoroire	December	5.17				
	March	5.25				
	May	7.65				
	Average	**6.02**				
Whakatangi	December	7.49				
	March	5.72				
	May	5.94				
	Average	**6.39**				
Waahi	December	7.71	5.39	6.14	6.96	7.37
	March	6.31	6.86	7.77	6.73	8.38
	May	7.34	7.15	6.43	5.53	
	Average	**7.12**	6.47	**6.78**	**6.41**	**7.88**
Tunawhakaheke	December	7.21				
	March	8.25				
	May	7.79				
	Average	**7.75**				

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Appendix 1: List of indicator rotifer species

List of “indicator” rotifer species recorded during this survey as a percentage of all indicator taxa. Indicator taxa are ordered based on TLI optima from lowest to highest.

	TLI Optima	14/12/2011 Harihari	21/03/2012 Harihari	24/05/2012 Harihari	14/12/2011 Mangahia	21/03/2012 Mangahia	23/05/2012 Mangahia	12/12/2011 Mangakaware	20/03/2012 Mangakaware	23/05/2012 Mangakaware	13/12/2011 Ngaroto	21/03/2012 Ngaroto	23/05/2012 Ngaroto	08/12/2011 Ohinewai	23/03/2012 Ohinewai	30/05/2012 Ohinewai	13/12/2011 Okoroire	20/03/2012 Okoroire	23/05/2012 Okoroire	12/12/2011 Serp. East	20/03/2012 Serp. East	13/05/2012 Serp. East	12/12/2011 Serp. Nth	20/03/2012 Serp. Nth	23/05/2012 Serp. Nth
Synchaeta longipes	3.3232	0.70	9.17	9.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Polyarthra dolichoptera	3.4396	62.24	7.50	81.36	0.00	0.00	0.00	1.22	0.00	0.96	0.00	3.48	0.00	6.15	33.64	5.61	73.47	35.51	9.09	2.58	2.47	1.39	2.73	11.39	81.39
Trichocerca stylata	3.7553	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.38	12.17	1.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Conochilus unicornis	3.8036	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.97	32.60	0.00	2.73	0.00	0.00
Conochilus coenobasis	3.9056	0.00	0.00	0.00	0.00	3.57	4.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	56.46	23.84	5.09	0.00	6.05	0.00
Ascomorpha ovalis	3.9558	12.59	62.50	5.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93	27.73	0.71	2.16
Lecane bulla	4.1650	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Synchaeta oblonga	4.3875	0.00	0.00	0.00	0.00	0.45	1.32	0.00	0.00	0.00	0.00	0.00	0.00	3.08	0.00	0.00	0.00	0.00	0.00	2.58	0.00	0.00	0.45	3.56	6.93
Asplanchna priodonta	4.4042	0.00	0.00	0.00	0.00	0.00	0.00	84.15	86.27	72.12	0.00	2.61	0.86	0.00	0.00	36.45	0.00	0.00	0.00	11.07	27.67	12.96	1.36	36.65	0.87
Anuraeopsis navicula	4.4189	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.35	0.00
Synchaeta pectinata	4.5011	0.00	1.67	0.00	38.84	3.13	11.84	0.00	0.00	0.00	0.00	0.00	0.00	2.31	27.10	0.93	0.00	0.00	0.00	0.74	0.00	0.00	0.00	0.00	2.16
Collotheca sp.	4.5186	0.00	0.00	0.00	0.00	1.34	1.32	0.00	0.00	0.00	0.00	4.35	0.86	0.00	0.00	5.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Filinia pejleri	4.5193	0.00	0.00	0.00	0.00	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hexarthra mira	4.6060	6.29	0.00	0.85	18.60	0.45	3.51	0.00	0.00	0.00	0.00	0.00	0.00	2.31	0.00	2.80	0.00	0.00	0.00	0.00	0.00	0.00	0.91	0.36	0.00
Asplanchna brightwelli	4.6949	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.90	0.00	0.66	0.00	0.00	0.00	0.00	0.00	4.76	14.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trichocerca similis	4.7747	0.00	4.17	0.85	0.00	0.00	0.00	3.05	0.00	0.96	5.96	46.09	5.17	43.85	19.63	4.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Anuraeopsis fissa	4.8205	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.74	0.00	0.00	0.00	0.00
Keratella cochlearis	4.8324	17.48	12.50	0.85	0.41	6.25	6.58	0.00	1.96	0.00	1.32	0.87	0.86	0.00	5.61	2.80	6.12	0.00	0.00	1.11	0.00	6.48	60.45	12.46	1.73
Filinia novaezealandiae	4.8392	0.00	0.00	0.00	22.31	59.38	46.93	3.05	0.00	2.88	8.61	20.00	26.72	9.23	4.67	27.10	2.04	0.00	5.68	8.12	4.93	73.15	3.64	6.76	2.16
Trichocerca pusilla	4.8556	0.70	1.67	1.69	0.00	8.48	0.44	0.00	0.00	0.00	31.13	0.00	0.86	13.08	0.00	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hexarthra intermedia	5.0850	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	9.62	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	5.75	0.00	0.00	0.00	0.00
Keratella procurva	5.2296	0.00	0.00	0.00	0.00	0.00	0.00	3.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pompholyx complanata	5.2315	0.00	0.00	0.00	19.42	0.89	12.72	2.44	0.00	2.88	2.65	2.61	6.03	7.69	8.41	1.87	0.00	36.23	0.00	0.00	0.00	0.00	0.00	0.71	0.00
Keratella tropica	5.8483	0.00	0.00	0.00	0.41	14.73	9.21	0.00	0.00	7.69	2.65	6.96	56.03	12.31	0.00	8.41	0.00	7.97	11.36	0.00	0.00	0.00	0.00	0.00	0.00
Brachionus quadridentatus	5.9200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Keratella slacki	5.9414	0.00	0.00	0.00	0.00	0.00	0.00	0.61	4.90	1.92	0.00	0.00	0.00	0.00	0.00	0.00	2.04	4.35	73.86	0.00	0.00	0.00	0.00	0.00	2.60
Keratella tecta	6.0166	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.31	0.87	0.00	0.00	0.93	2.80	4.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Brachionus caliciflorus	6.1631	0.00	0.00	0.00	0.00	1.34	0.00	1.22	0.98	0.96	0.66	0.00	0.00	0.00	0.00	0.00	6.12	1.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Filinia longiseta	6.3957	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Brachionus budapestinensis	6.5324	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

List of “indicator” rotifer species recorded during this survey as a percentage of all indicator taxa. Indicator taxa are ordered based on TLI optima from lowest to highest (cont).

	TLI Optima	Serp. Sth 12/12/2011	Serp. Sth 20/03/2012	Serp. Sth 23/05/2012	Taharoa 14/12/2011	Taharoa 21/03/2012	Taharoa 24/05/2012	Te Kapa 08/12/2011	Te Kapa 22/03/2012	Te Kapa 25/05/2012	Tunawhakaheke 08/12/2011	Tunawhakaheke 22/03/2012	Tunawhakaheke 23/05/2012	Waahi 13/12/2011	Waahi 23/12/2012	Waahi 24/05/2012	Waikare 13/12/2011	Waikare 23/03/2012	Waikare 25/05/2012	Whakatangi 08/12/2011	Whakatangi 22/03/2012	Whakatangi 25/05/2012
Synchaeta longipes	3.3232	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Polyarthra dolichoptera	3.4396	33.59	30.77	45.08	55.00	13.99	46.18	88.65	82.68	89.60	21.89	1.65	4.85	2.11	5.65	0.98	28.57	0.94	1.27	14.00	0.00	0.00
Trichocerca stylata	3.7553	0.00	0.00	0.00	2.27	2.75	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Conochilus unicornis	3.8036	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Conochilus coenobasis	3.9056	0.00	0.00	6.44	0.00	0.00	0.00	0.00	3.94	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ascomorpha ovalis	3.9558	0.00	0.00	0.00	2.27	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lecane bulla	4.1650	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Synchaeta oblonga	4.3875	1.91	17.79	0.76	14.09	7.57	5.62	0.00	0.00	0.00	0.00	0.00	3.88	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
Asplanchna priodonta	4.4042	1.15	10.58	17.80	3.18	0.00	2.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.91	10.29	0.00	0.00	0.00	5.00	24.66	16.00
Anuraeopsis navicula	4.4189	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.29	0.00	65.82	0.00	0.00	0.00
Synchaeta pectinata	4.5011	11.07	1.44	11.74	0.91	0.00	0.00	0.71	0.79	8.00	0.59	0.00	5.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Collotheca sp.	4.5186	0.00	0.00	0.38	0.45	0.69	2.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.89	0.00	0.00	0.00	0.00
Filinia pejleri	4.5193	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hexarthra mira	4.6060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Asplanchna brightwelli	4.6949	0.00	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	2.07	0.00	0.97	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trichocerca similis	4.7747	0.00	0.00	0.00	4.55	2.75	3.21	0.00	3.15	1.60	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.74	0.00
Anuraeopsis fissa	4.8205	0.00	0.00	0.00	0.00	25.23	2.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Keratella cochlearis	4.8324	49.24	34.13	4.92	9.55	17.20	12.85	0.00	0.00	0.00	0.00	0.41	0.00	0.84	4.78	11.27	0.00	5.66	0.00	0.00	0.00	0.00
Filinia novaezealandiae	4.8392	1.91	2.88	4.92	5.45	6.88	9.64	10.64	0.00	0.00	0.89	0.41	0.00	0.84	0.87	0.98	50.00	7.55	13.92	2.00	2.74	1.60
Trichocerca pusilla	4.8556	0.00	0.00	0.00	0.91	1.15	3.21	0.00	0.00	0.00	0.00	0.00	0.00	6.75	24.35	1.47	0.00	38.68	10.13	0.00	1.37	0.00
Hexarthra intermedia	5.0850	1.15	2.40	6.44	0.91	0.00	2.81	0.00	0.00	0.00	6.21	0.00	0.97	5.06	16.52	0.00	0.00	0.00	0.00	3.00	1.37	0.00
Keratella procurva	5.2296	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.66	0.00	0.00	2.07	12.62	0.00	0.00	0.00	0.00	0.94	0.00	4.00	53.42	81.60
Pompholyx complanata	5.2315	0.00	0.00	0.00	0.45	0.00	0.40	0.00	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.98	7.14	0.00	6.33	1.00	12.33	0.80
Keratella tropica	5.8483	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.79	0.00	62.13	7.85	9.71	1.27	16.96	66.18	0.00	1.89	0.00	62.00	1.37	0.00
Brachionus quadridentatus	5.9200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.00	0.00	0.98	0.00	0.00	0.00	0.00	0.00	0.00
Keratella slacki	5.9414	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Keratella tecta	6.0166	0.00	0.00	0.00	0.00	21.56	8.03	0.00	0.00	0.00	0.00	83.47	51.46	83.12	25.65	5.88	0.00	42.45	2.53	0.00	0.00	0.00
Brachionus caliciflorus	6.1631	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.14	3.72	8.74	0.00	0.00	0.00	0.00	0.00	0.00	4.00	0.00	0.00
Filinia longiseta	6.3957	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	3.00	0.00	0.00
Brachionus budapestinensis	6.5324	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.18	0.00	0.00	0.00	0.43	0.98	0.00	0.00	0.00	1.00	0.00	0.00