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Assessment of Trophic State Change in Selected Lakes of the Auckland Region Based on Rotifer Assemblages

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Contents

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Executive Summary

Lake trophic state was assessed from seven Auckland Regional Council lakes between 2001 and late 2004 based on the composition of rotifer assemblages collected during regular State of the Environment monitoring.

Inferred trophic states of the lakes were in general ranked in a similar manner throughout the study period; Lake Ototoa (generally oligotrophic) > Lake Tomarata (oligo- to mesotrophic) > Lake Wainamu (mesotrophic) > Lake Pupuke (eutrophic) > Lake Kuwakatai (eutrophic) > Lake Spectacle (hypertrophic). Lake Kereta was highly variable in its assessment through time (varying between mesotrophic at the end of the study and supertrophic in mid-study).

Inferred trophic states for each lake were generally similar at the beginning and end of the current study, except Lake Spectacle which appears to have become more degraded, and Lake Kereta which apparently improved in water quality. However, a general trend of elevated inferred Trophic Lake Index (TLI) occurred for many lakes in 2003 (most notable in Lakes Ototoa, Tomarata and Kereta). Such consistent changes in assessments through time likely reflect a change in conditions that acted across the region, such as weather patterns that lead to higher production of algal biomass, e.g., warm and/or stable conditions.

1 Introduction

The determination of lake trophic state is usually made by measuring several diverse criteria, none of which are direct measures of trophic state per se, but rather are indicators of it (OECD 1982). Erroneous conclusions may be drawn if only single or few indicators are used, and it is therefore useful to consider an array of different methods (Duggan et al. 2001a). Bioindicator approaches, using the responses of organisms to evaluate trophic state, have often been neglected in favour of chemical and physical techniques. Duggan et al. (2001a, b) found that trophic state was the main 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). Rotifers are thought to make ideal bioindicators as they are discriminating in their responses to the environment, they are typically numerically dominant in the zooplankton, species rich, and communities likely integrate environmental conditions over time. This method provides a useful complement to other methods presently commonly used.

The Auckland Regional Council (ARC) has collected zooplankton samples during regular seasonal monitoring of seven lakes from September 2001 to the present (Figure 1). In this report, the Rotifer Community Index of Duggan (2001b) is used to infer the trophic state of these lakes, and how it has changed in each through time. This information will be used by ARC to complement trophic state assessments based on traditional methods that were undertaken concurrently.

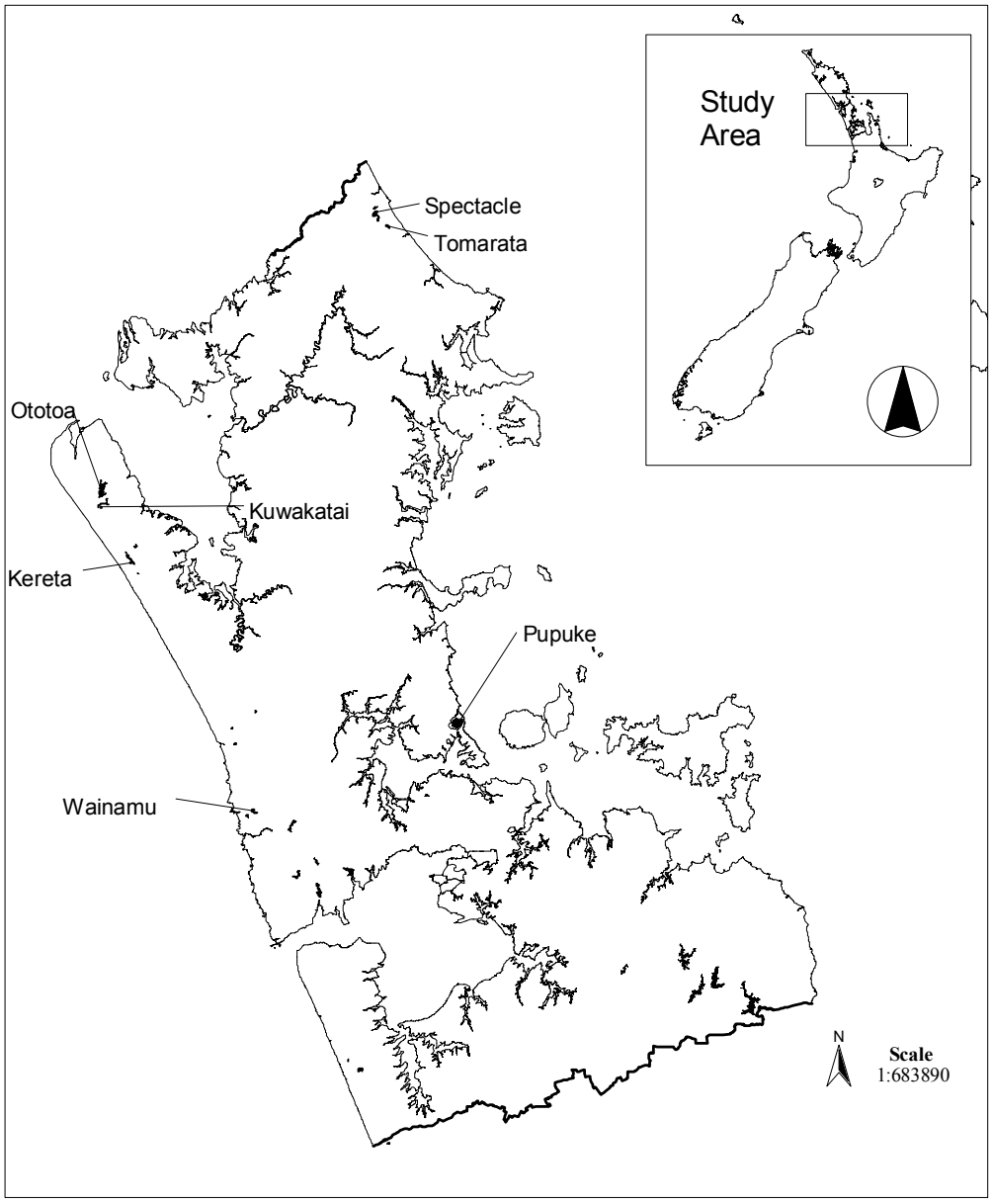

Figure 1: Location of the seven monitored lakes within the Auckland Region.

2 Method

Seven lakes were monitored approximately quarterly by the ARC between September 2001 and November 2004; Lakes Ototoa, Kereta, Tomarata, Wainamu, Pupuke, Spectacle and Kuwakatai (aerial photographs in appendices). During this monitoring zooplankton were sampled using vertical hauls through the top 5 m of the water column with a 0.2 m diameter plankton net with a 72 µm mesh size (haul speed ~1 $m.s^{-1}$). After July 2004 collection methods were modified, such that zooplankton were subsampled from a 5 m integrated tube sample. Samples were preserved in ~10% formalin.

Rotifers were enumerated and identified, as these are the zooplankton group most useful for trophic state monitoring. Crustacea have not been fully enumerated or identified at this time because they are of little or no value for assessing lake water quality due being either generally ubiquitous (e.g., Cladocera, cyclopoid copepods) or have distributions limited by geological history and not water quality (calanoid copepods).

Samples were enumerated until at least 300 individuals of rotifer indicator taxa were counted, or until the whole sample was complete if less than this number was found. Based on the resulting lists, the bioindicator scheme of Duggan et al. (2001b) was used to infer trophic state. It was recommended by Duggan et al. (2001b) that four quarterly samples over the year be averaged to obtain trophic state, and this was done where possible. However, it was common during the ARC monitoring for fewer samples to be taken each year, or for samples to contain few individuals. In the latter case, failure in preservation techniques (rarely), or collection problems (apparently more common) were responsible. For example, May and August 2004 samples from almost all lakes appeared to be largely devoid of zooplankton or associated phytoplankton or detritus. In such instances, TLI was inferred using the preceding two or three (rather than the recommended four) samples collected during the previous year only. Samples were ultimately used in analyses if they had > 25 individuals of rotifer indicator species. Change in trophic state is presented as a moving average, whereby TLI is calculated for each date as the average of samples within the previous year. For example, the February 2002 inferred TLI is the average of the trophic state inferred by individual samples from February 2002 and the three samplings undertaken beforehand.

3 Results & discussion

3.1 Overall trends among lakes

A wide variety of rotifer indicator taxa was collected from each of the study lakes (Appendix 1). Overall lake trophic state was assessed as being best in Lake Ototoa (generally oligotrophic), followed by Lake Tomarata (oligo- to mesotrophic) and Lake Wainamu (mesotrophic throughout; Figure 2).

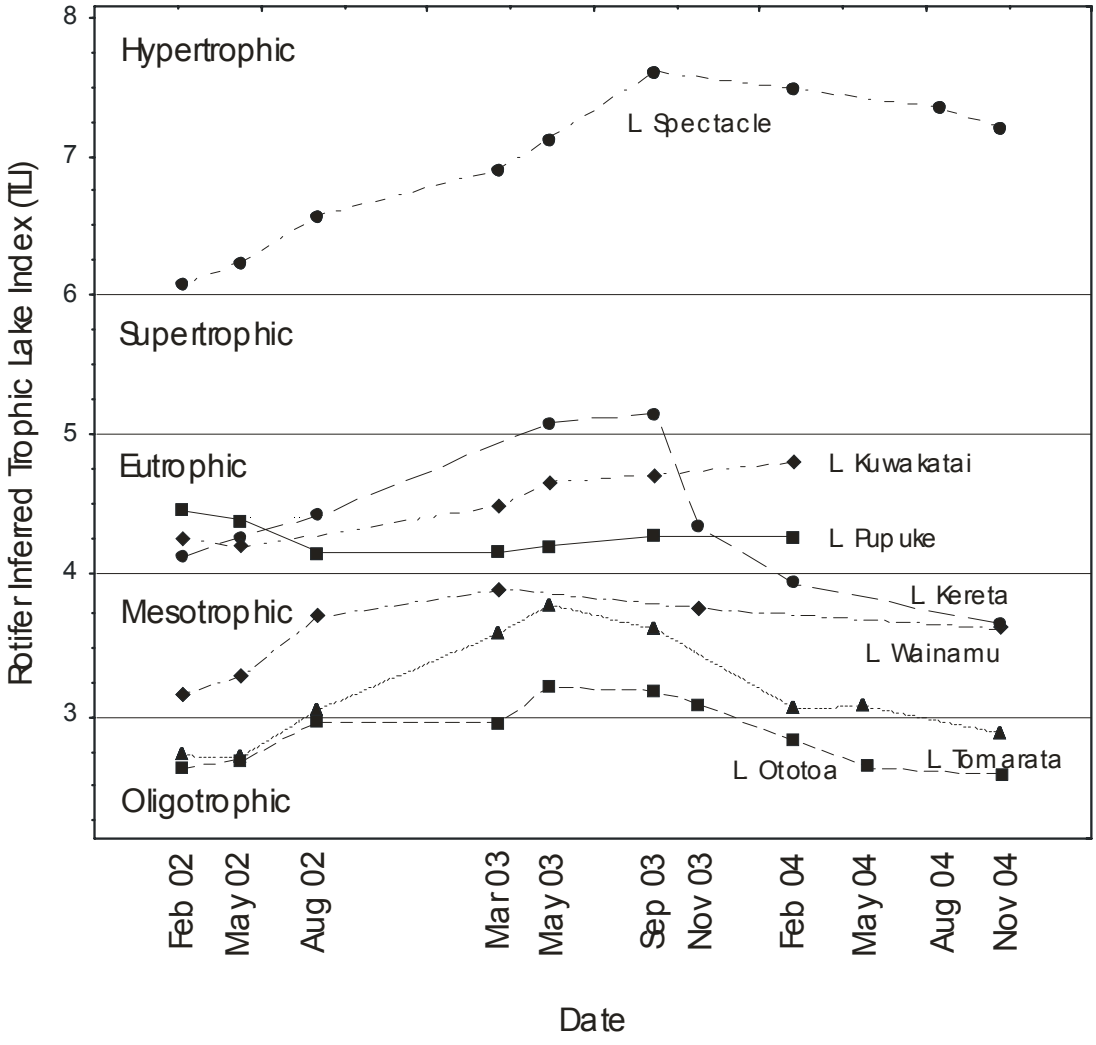

Figure 2: Assessed trophic state (TLI) of seven lakes in the Auckland region between February 2002 and November 2004. Data points for each lake indicate a moving average TLI assessment, using the average of samples collected from that month and from samples collected within the year prior to that sample. All assessments are made using between two and four samples.

Lakes Pupuke and Kuwakatai were assessed as eutrophic throughout, while Lake Kereta was highly unstable throughout the study period, being initially assessed as eutrophic, then supertrophic (mid 2003), before subsequently dropping to mesotrophic (through 2004). Lake Spectacle was consistently assessed as hypertrophic. Other than Lake Kereta, there was generally a consistency in the rankings from lowest to highest trophic state through time. Most lakes showed some temporal variability through the study period, having generally higher inferred TLI during 2003 than 2002 or 2004. Changes in rotifer communities, and associated inferred trophic states, are considered separately in the following section.

3.2 Indicator taxa relative abundances and temporal changes

To determine which rotifer indicator taxa are primarily responsible for the trophic state assessed for each lake, and to examine changes in taxa that lead to variations in the assessed TLI through time, the relative abundances of indicator taxa for each lake are presented as an average of each year.

Lake Ototoa

Overall, Lake Ototoa was generally dominated by rotifers indicative of low trophic state (TLI <4), including *Conochilus dossuarius*, the indicator species having the lowest TLI optima value (TLI optima = the peak of a species bell curve in response to the trophic state gradient; Duggan et al. 2002b). The assessed increase in trophic state based on rotifers through 2003 is largely due to a decrease in *C. dossuarius* through this time, with an associated increase in *Ascomorpha ovalis* (Figure 3).

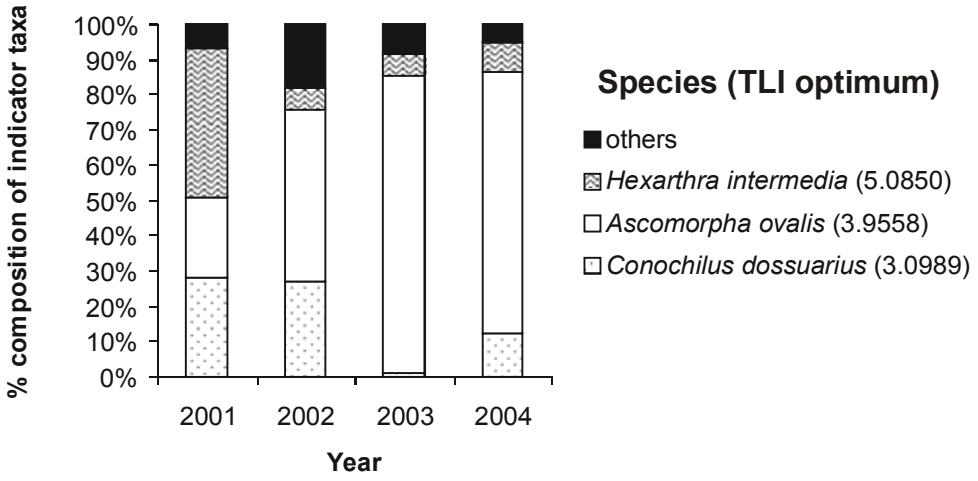

Figure 3: Comparison of percent composition of dominant (comprising > 10% of assemblage in any year) rotifer indicator species from Lake Ototoa. Taxa are ordered on the graph from highest TLI optima (top) to lowest TLI optima (bottom).

Lake Tomarata

In 2001, Lake Tomarata was dominated by *Conochilus coenobasis*, another indicator of low trophic state in New Zealand lakes. Like Lake Ototoa, the increase and subsequent decrease in inferred TLI was likely because of a relative decrease of this species through time, followed by its subsequent increase, and due to the reverse pattern shown by *Asplanchna priodonta*, a species indicative of higher trophic states (Figure 4).

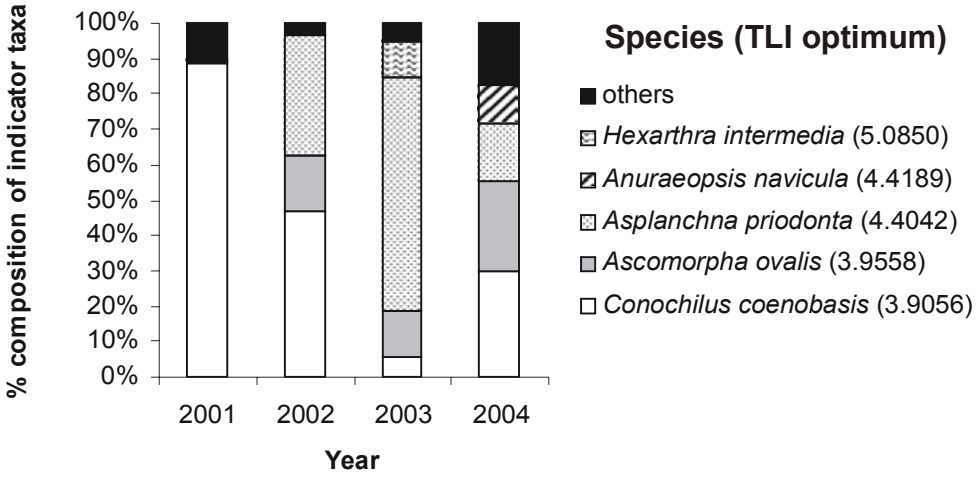

Figure 4: Comparison of percent composition of dominant (comprising > 10% of assemblage in any year) rotifer indicator species from Lake Tomarata. Taxa are ordered on the graph from highest TLI optima (top) to lowest TLI optima (bottom).

Lake Wainamu

Lake Wainamu was constantly assessed as being mesotrophic throughout the study period, although had highly variable rotifer assemblages. An initial increase in assessed trophic state (low to more highly mesotrophic) was due to species with TLI optima < 4 initially dominating the assemblage, with a shift to species dominance with TLI optima > 4 in 2002 and 2004. This lake contained species with a wide range of indicator values, but proportions of different species were typically fairly "even" in any year, balancing out the assessment to be mesotrophic (Figure 5).

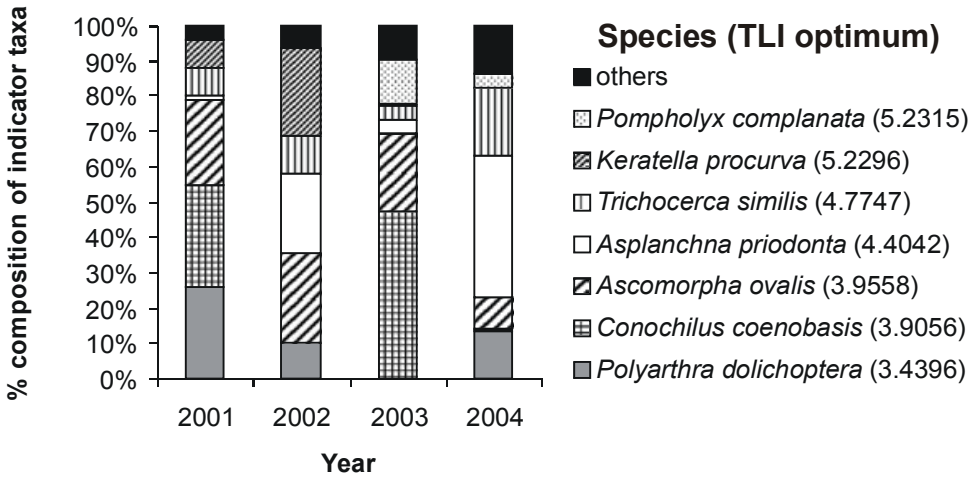

Figure 5: Comparison of percent composition of dominant (comprising > 10% of assemblage in any year) rotifer indicator species from Lake Wainamu. Taxa are ordered on the graph from highest TLI optima (top) to lowest TLI optima (bottom).

Lake Pupuke

Lake Pupuke was fairly stably eutrophic throughout the study period. All of the dominant indicator taxa had TLI optima greater than 4 and less than 5 throughout the study period, and the assessed TLI was therefore correspondingly stable. *Asplanchna priodonta* dominated the assemblage through most years (Figure 6).

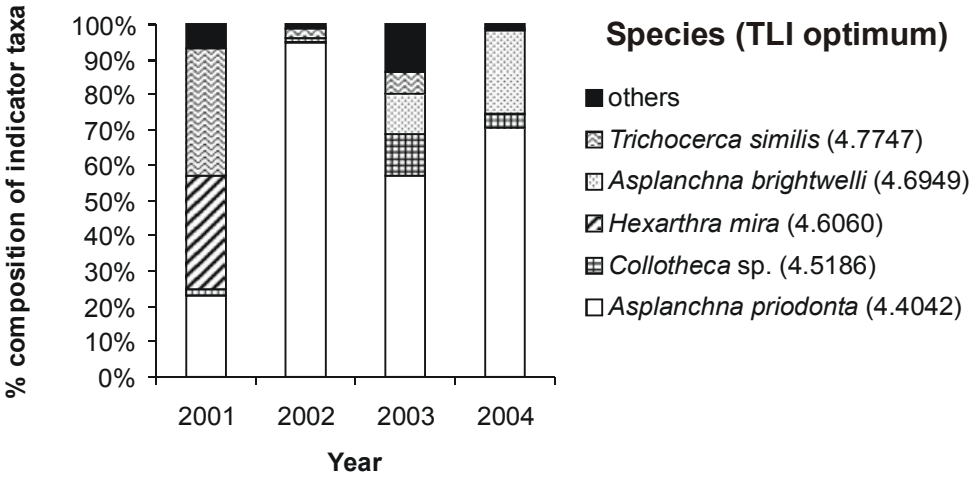

Figure 6: Comparison of percent composition of dominant (comprising > 10% of assemblage in any year) rotifer indicator species from Lake Pupuke. Taxa are ordered on the graph from highest TLI optima (top) to lowest TLI optima (bottom).

Lake Kuwakatai

Like Lake Pupuke, Lake Kuwakatai was typically dominated by *Asplanchna priodonta*, which showed similar patterns in relative abundance through time. Lake Kuwakatai was also assessed as eutrophic through the study period, but gradually increased through time. Indicator values of the dominant taxa were within a reasonably narrow range (4.2 to 5.2), and changes in species composition therefore did not alter the assessed trophic state greatly. A gradual increase in inferred TLI was due to the increased importance of taxa with TLI optima greater than 4.5 (especially *Keratella cochlearis* and *Pompholyx complanata*) in 2003 and 2004 (Figure 7).

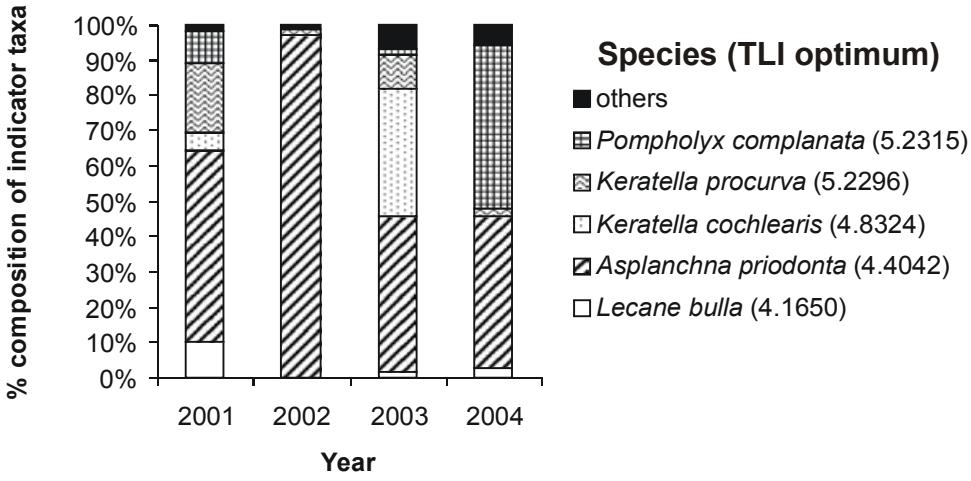

Figure 7: Comparison of percent composition of dominant (comprising > 10% of assemblage in any year) rotifer indicator species from Lake Kuwakatai. Taxa are ordered on the graph from highest TLI optima (top) to lowest TLI optima (bottom).

Lake Kereta

While the proportion of *Trichocerca similis* was stable throughout the study years, the occurrences of other taxa were highly variable. This was reflected in the inferred trophic states being highly variable through time. From an initial eutrophic assessment, inferred TLI increased greatly with the occurrence of the more eutrophic indicator *Keratella procurva*, and dropped through late 2003 and 2004 with the appearance and increased importance of indicators of progressively greater oligotrophic conditions, i.e., *Ascomorpha ovalis* and *Polyarthra dolichoptera* (Figure 8).

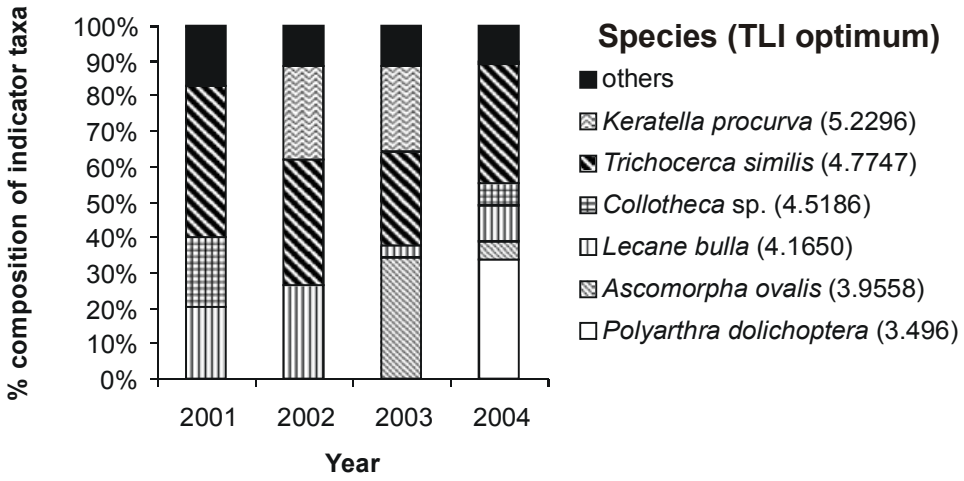

Figure 8: Comparison of percent composition of dominant (comprising > 10% of assemblage over any year) rotifer indicator species from Lake Kereta. Taxa are ordered on the graph from highest TLI optima (bottom) to lowest TLI optima (top).

While the proportion of *Trichocerca similis* was stable throughout the study years, the occurrences of other taxa were highly variable. This was reflected in the inferred trophic states being highly variable through time. From an initial eutrophic assessment, inferred TLI increased greatly with the occurrence of the more eutrophic indicator *Keratella procurva*, and dropped through late 2003 and 2004 with the appearance and increased importance of indicators of progressively greater oligotrophic conditions, i.e., *Ascomorpha ovalis* and *Polyarthra dolichoptera*.

Lake Spectacle

Lake Spectacle was dominated by species with TLI optima greater than 4.5, and unlike all other lakes commonly had high proportions of taxa with TLI optima greater than 6 (*Keratella tecta* and *Filinia longiseta*; two of only four rotifer species with TLI optima > 6). The inferred trophic state of Lake Spectacle increased through 2002 and 2003 because of an increased importance of *K. tecta* and *F. longiseta* through this time, and a corresponding reduction in the importance of *Trichocerca similis* (TLI optima 4.8) (Figure 9).