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LakeScience Rotorua

A newsletter about research on the Rotorua Lakes

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Welcome to the Fourth issue of our email newsletter for those involved in or interested in scientific or management work on the Rotorua Lakes. It is up to **you** to make this informal newsletter a success by providing it with copy – our Society is merely providing the vehicle. We email it free of charge to all those who attended the Rotorua Lakes 2001 Symposium and are on email, and also to anyone else who requests it. If you don't wish to receive future copies, please email us. We will snail mail it on request. The newsletters will also be posted on the Royal Society (Rotorua Branch) website at www.rsnz.govt.nz/clan/rotorua. If you are interested in, or working on lakes, but not the Rotorua Lakes, we are still very happy to receive material from you and to send you newsletters.

The more copy we receive, the more frequently we will be able to send this newsletter out. Electronic copy is preferred but not essential. Only minimal editing is carried out. We hope to send another issue out in September 2002 – given sufficient copy.
Technical content of all contributions is essentially the responsibility of the authors

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All material and correspondence relating to *LakeScience Rotorua* to Nick Miller, millern@wave.co.nz, 91 Te Akau Road, R D 4, ROTORUA.

Okawa Bay is very topical at present, with a recent draft report from NIWA casting doubt on the possible effectiveness of proposed remedial action. We understand that further work is being carried out to clarify initial results. Funding for a sewerage scheme has been listed in the Draft Annual Plan of the Rotorua District Council, and the LWQS was among those submitters supporting this project.

We have two descriptions of post-graduate thesis topics, both just starting, in this issue. It is pleasing to see renewed research student interest in the Rotorua Lakes, after a long absence.

Lakes chair, Waikato University
Dr David Hamilton, a graduate of Otago University, has been appointed to this position. He has lately been working at the Department of Environmental Engineering, Centre for Water Research, University of Western Australia. Dr Hamilton specialises in computer modelling and will be applying his skills towards the application of computer models to plan management strategies for the Rotorua lakes. We welcome him back to New Zealand, and wish him, and his students, well in their research.

Lake Restoration Study Tour
On Wednesday 26th June, John McIntosh, from Environment BOP, addressed the Rotorua Branch of the Royal Society of New Zealand. The topic was John's recent study tour of the western United States, where he was looking at lake protection and restoration work. A good turnout of Royal Society and LWQS members plus the general public lead to a good number of questions at the end. Thanks, John, for spreading the work that lake restoration can be carried out. Interesting to see photos of a number of quite small lakes with significant numbers of people living around them, very inconspicuously. We still have much to learn here, in that regard.

GLEANINGS – an interesting paper seen recently (other contributions to this section are welcome.)

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Hens, M., Merckx, R. 2002. The role of colloidal particles in the speciation and analysis of "dissolved" phosphorus. *Water Research* **36** 1483-1492.
Colloidal-sized particles (1-1000nm) and high molecular mass material play an important, yet poorly understood role in the aqueous speciation of P. This study assessed the size distribution of P in 0.45-µm filtered soil-water extracts from three sandy soils (grassland, arable field and forest) using gel filtration chromatography (GFC) and membrane filtration (0.22- and 0.025-µm pore size) and evaluated the impact of P-speciation on colorimetric and ion-chromatographic methods for orthophosphate analysis. Between 40% and 58% of molybdate-reactive P (MRP) and >85% of molybdate unreactive P in the soil solution from the agricultural soils (pH 5.9 – 6.3) were associated with high molecular mass material (apparent size >0.025um, or >600 kDa on Superdex). In solutions from the forest soil (pH 3.2) high molecular mass P (HMMP) compounds were of minor importance. The GFC elution profiles, composition and spectral characteristics of HMMP-containing solutions as well as the small relevance of HMMP at low pH were all indicative for associations between humic substances, Fe and/or Al, and P. Both MRP and ion chromatographic P measurements overestimated the free orthophosphate concentration (up to 2.3 and 1.4 fold, respectively) in 0.45-µm filtered HMMP-containing solutions. In 0.025-µm filtrates, free orthophosphate was the only MRP species present.

(*Hmmm….as time goes by our knowledge of phosphorus and its behaviour in water seems to become less and less clear-cut than it once seemed. Ed.*)

And some books/papers observed by Megan Gee, of NIWA, Christchurch. Thanks, Megan, for your input.

1) The lake foodweb : modelling predation and abiotic/biotic interactions / Lars Hakanson & Victor V. Boulion. - Leiden : Backhuys, 2002. -- 352 p.
This book presents the Lake Webmodel, a general model to quantify all important lake foodweb interactions, including biotic/abiotic feedbacks. The model has been critically tested against very comprehensive empirical data sets mainly from Eastern and Western Europe, including many new

empirical models. Lake Web includes the key functional groups of organisms: phytoplankton, bacterioplankton, benthic algae, macrophytes, zoobenthos, herbivorous and predatory zooplankton, prey fish and predatory fish. The model is based on many new approaches of structuring lake foodweb interactions. It uses ordinary differential equations and gives weekly variations in production and biomass for its nine groups of organisms. The model also includes a new mass-balance model for phosphorus and new approaches to quantify suspended particulate matter and the depth of the photic zone. Funamental concepts include consumption rates, metabolic efficiency ratios, distribution coefficients, migration of fish and predation pressure. An important feature of LakeWeb is that it can be run by just a few driving variables readily accessible from standard maps and monitoring programs. Several scenarios describe how the model can be applied to address important management issues, like consequences of biomanipulations (fish kill catastrophes), changes in land-use (eutrophication and humification), acidification and global temperature changes. LakeWeb takes a holistic approach and is a powerful tool to simulate such measures and to get realistic expectations of positive and negative consequences of remedial measures.

2) Lake Rerewhakaaitu project /report prepared by J.J. McIntosh ... [et al.]. - Whakatane, N.Z. : Environment B.O.P, 2001
ix, 84 p. : ill. (some col.), col. maps ; 30 cm.
(Environmental report / Environment BOP ; 2001/15)

3) Mean zooplankter weight as a characteristic feature of an aquatic ecosystem / Haberman, J; Kunnap, H AF IN: Proceedings of the Estonian Academy of Sciences, Biology Ecology vol. 51, no. 1, pp. 26-44, 2002. The mean zooplankter weight is largely shaped by the trophic state of the water body. At the same time, it reflects even relatively slight differences in the trophy of lakes. In moderately eutrophic L. Peipsi (Estonia) the mean zooplankter weight is 4.4 mu g and in strongly eutrophic L. Vyrtsjaerv is 2.7 mu g. The mean cladoceran weight is 28 and 10 mu g, the mean copepod weight 10 and 6.7 mu g, the mean rotifer weight 0.9 and 0.6 mu g, respectively. For individuals of the gen Daphnia the mean weight is 52 and 30 mu g, and for individuals of the gen. Bosmina, 21 and 7 mu g, respectively. The average zooplankter of moderately eutrophic L. Peipsi is considerably larger compared with the average zooplankter of strongly eutrophic L. Vytrsjaerv. Therefore, the zooplankton in L. Peipsi is in a far better condition than in L. Vyrtsjaerv and it can play its role in the transfer of energy from the algae to the fish more efficiently. Correlation analysis shows that the mean zooplankter weight is mainly built by the cladocerans and rotifers. The relationship between the mean weight of the individual and water temperature is less pronounced where the amount of coexisting planktonic animals with different temperature requirements is larger. Mean zooplankter weight characterizes both the zooplankton community and the whole ecosystem of the water body. Indirectly, it characterizes the animal groups dominating in zooplankton, feeding relationships between phyto- and zooplankton and between zooplankton and fish, as well as the pressure of fish on zooplankton and the trophy of the water body. Mean zooplankter weight can be used as a marker characteristic in the qualification of the ecosystem of the water body.
Author Affiliation Vortsjarv Limnological Station, Institute of Zoology and Botany, Estonian Agricultural University 61101 Rannu, Tartumaa Estonia; E-mail: juta@zbi.ee

4) Simplified food webs lead to energetic bottlenecks in polluted lakes / Sherwood, GD; Kovecses, J; Hontela, A; Rasmussen, JB IN: Canadian Journal of Fisheries and Aquatic Sciences vol. 59, no. 1, pp. 1-5, 2002. Very little is known about the consequence of human activities on the flow of energy through natural ecosystems. Here, a trophic-based approach is presented in describing energy relationships in pollutant-disturbed lakes, emphasizing the importance of prey diversity in maintaining energy transfer to growing fish. Both diet and community analysis indicated that the

food web leading to yellow perch (Perca flavescens) in metal-polluted lakes was extremely simplified compared with reference lakes. Through the application of an in situ marker for fish activity costs (muscle lactate dehydrogenase activity) and through bioenergetic modelling, it is shown how this has severe consequences on the efficiency of energy transfer to perch from their prey; premature energetic bottlenecks (zero conversion efficiency) occur when successively larger prey types are not available to growing perch. These observations provide a much needed ecological and physiological framework for assessing how energy transfer can be affected in polluted systems. This approach need not be limited therein but should be applicable to any aquatic system where food web structure is variable and (or) disrupted.
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Wade Tozer describes his PhD project, being carried out at Waikato University

Using Stable Isotope Techniques to Identify Losses of Nitrogen from Rotorua Catchments with Different Land-Use Management Practices.

Background

There is an increasing burden of responsibility on land users in New Zealand to show that their management practices are sustainable. Nitrogen (N) losses from catchments resulting from different land-use practices have become a public and political issue as a considerable body of evidence has identified N as the most important contributor to rising eutrophication of water bodies. A variety of land-use practices have been implicated in the increasing eutorphication of water bodies, including farming, forestry, sewage disposal (both septic tanks and municipal), and increasing urbanisation generally. However, as yet no quantification has been made of the proportional N contribution each of these practices makes to eutrophication of associated water bodies. This research will therefore attempt to compare a range of land-use practices within the Rotorua region for their relative abilities to lose N from their systems.

Proposed work

The proposed work will be primarily undertaken by Wade Tozer, a PhD student working under the direction of Professor Warwick Silvester at the University of Waikato and would involve the following elements:

- Determine the isotopic fractionation of N within a natural system experiencing the addition of effluent (eg Rotorua Land Treatment System within the Whakarewarea Forest or a septic tank plume). Using one of these as a model, we will attempt to trace N into a water body and determine total N burden form this source.
- Examine the isotopic fractionation of N within catchments of the Rotorua region experiencing different land-use practices (for example dairy farming, native forest cover, and exotic forestry plantations). We will attempt to use any differences to model inputs into receiving water bodies.
- Compare different land-use management practices within Rotorua catchments and attempt to determine a relative comparison of their contribution to eutrophication.

Methology
To meet the objectives outlined above, the major technique employed will be the use of stable isotope methodology. Stable N isotopes have been used widely in a range of scientific fields to determine N dynamics in physical and biological process, on both small and large scales.

Nitrogen exists as two isotopes; 15N and 14N. 15N is the heavier and is called a heavy stable isotope (ie it is not radioactive). These two exist in nature with the heavy one normally at 0.3663% of the total N in any system. Small changes in the relative abundance of these isotopes accompany many biological reactions. For example we have found that N in the nitrate coming from the Rotorua waste water system is significantly enriched in 15N. We are able to use this as a tracer and have so far traced this signal into pine trees and soil in the land treatment system. Using stable isotope mass spectroscopy we are able to identify minute changes in the natural abundance of 15N that give evidence of its origins and have identified isotopic signals ranging from 15 parts per thousand enriched to 23 parts per thousand depleted in 15N. Given that our mass spectrometer can resolve better than 0.5 parts per thousand these numbers represent excellent environmental signals that can be traced. There is good reason to believe that the processes that lead to nitrate formation in each land-use practice is so different that they will each give a unique isotopic signal that we will be able to use as a tracer. We have already found an enrichment of 15N in sewage and have also identified isotopic enrichment in native plant species growing under N stress, both of which are providing useful tracers of N in natural systems. We believe strongly that we will be able to trace N losses from catchments within the Rotorua region experiencing different land-use practices and compare these practices for their relative contributions of N to associated water bodies.

This research is supported by an enterprise scholarship from FRST, Fletcher Challenge Forests, Environment Bay of Plenty and Forest Research.

Here is a contribution from Will Esler, of Rotorua, also describing post-graduate research.
Will has been awarded the Waikato Carbon Dating Scholarship for 2002, and welcomes correspondence on his topic from interested Society members and other readers of this item. (will.e@clear.net.nz)

Will Esler: MPhil Topic

Title:

Evolution of the Rotorua Basin, North Island, New Zealand, since 220 cal. ka.

This MPhil. proposal is to investigate and document environmental changes in the Rotorua Basin from caldera formation c. 220 cal. ka up to the present. This period encompasses marine oxygen isotope stages 7-1. Fieldwork is necessarily a major component of this study. A variety of laboratory techniques on carefully selected samples will be required to confirm stratigraphic correlation and to characterise the deposits, and will include petrographic and mineralogical studies, electron probe microanalysis of glass shards and minerals, XRF chemical analysis of whole pumice clasts, XRD of clays, and 14C dating.

Tephrostratigraphy is the most important single tool in unraveling the environmental history of the Rotorua Basin. In this instance, positive identification and correlation of tephras is of the highest priority.
Established multi-component identification methods include field characteristics, mineralogy, and geochemistry. Techniques relevant to this study include XRD, heavy mineral separates and petrography, and electron probe microanalysis. Some tephras and some catchments have unusual or

unique mineral or lithologic characteristics; these will be useful in tracing temporal and spatial dispersion in derived sediments.

Reconnaissance fieldwork has located outcrops representing a wide variety of sedimentary environments. These include alluvial fans, alternating deltaic silts and sands, lake floor diatomites, cross-bedded lake margin sands, and underwater debris flows. Grain size analysis using laser sizing and magnetic susceptibility may reveal loessial influences on sedimentation. Some aeolian landforms have been noted in the field and on aerial photos.

Chaotic strata in many localities are strong evidence for repeated earthquakes. Some events may be placed accurately within the stratigraphy of the lake basin sequence. Structural analysis of deformed strata will be used to distinguish local from regional stress regimes.

XRD determination of clay and zeolite mineralogy may illuminate the geothermal history of several localities. Glycolation and firing will be used to determine whether swelling mineral species are present. The several probable palaeosols identified within lake sediments, alluvium and loess will require characterization by XRD and other methods. Several undocumented peat deposits are suitable for radiocarbon dating.

Preliminary evidence suggests phytoliths occur within the Rotoiti Tephra Formation. Combined with charcoal and plant macrofossils in the upper part of the sequence, this indicates a possible need to elaborate the established stratigraphy of the Formation to accommodate a significant time interval.

Rudimentary phytolith identification is possible by established techniques. These include light microscopy to distinguish between grass and tree types, and comparison of SEM images with published phytolith floras.

An important objective of this study is to identify both evidence of, and the mechanism for, past gross variation in lake level in the Rotorua Basin.

High stands are recognizable by the presence of lake sediments at high altitude. Low stands allow fluvial sedimentation at low altitude.

Comparison of major lake level changes with the marine oxygen isotope record is a high priority, and is achievable using tephra marker horizons together with 14C chronological tie points.

Part of the caldera rim which maintained high lake levels has been destroyed by downfaulting and erosion within the Tikitere Graben. Earlier gross lake level variation was determined by the interplay of climatically controlled rainfall and the rate of discharge from the lake. Discharge variation is likely to have had a geological component, such as the competence of aquifers following seismic disturbance and volcanic activity. Evidence for some association between such events and lake level is expected.

Introduction

A potentially very detailed environmental record for the Rotorua Basin is contained in the many and widely spread outcrops of lake sediments and associated deposits up to c. 400 m asl. This record includes evidence of highly variable lake level, complex Rotoiti Tephra Formation deposits, Mangaone Subgroup tephras; and more subtle signs of climatic and vegetation change, loess deposition, geothermal activity, and remote andesitic volcanism.

Rotorua caldera was formed c. 220 cal. ka ago during and immediately after the single eruption of the Mamaku Ignimbrite (Milner 2001). It has a relatively straightforward later volcanic history, with the voluminous effusion of largely de-gassed rhyolite lava at an unknown but probably brief interval after caldera formation. Minor pyroclastic flows, collectively termed the Paradise Valley Ignimbrites, accompanied some early rhyolite lava eruptions (Dravitzki 1999). No pyroclastics have yet been linked with the few small eruptions of a later rhyolitic magma body. The Rotorua Basin produced no regionally significant pyroclastic deposits after caldera formation. With minor exceptions, local tephrostratigraphy consists of the study of ejecta from other volcanic centres: Okataina, Kapenga, Taupo, Tongariro, and Taranaki in decreasing order of volume.

Post-caldera geothermal activity became established in several locations, principally in Rotorua city and Whakarewarewa in the southeast. The long-term pattern of geothermal activity has not yet been documented at any local site. Certain clays and zeolites are mineralogical indicators of geothermal activity, potentially detectable in dateable sediments, especially in the Utuhina Valley and around Lake Rotokawa.

Milner (2001), and Milner et al. (2002) described the structure of the caldera, with brief discussion of later faulting. Following Bayrante (1984) and others, he noted a north-northwest trending fault system overprinting the caldera. Dravitzki (1999) made passing reference to disturbed lake sediments in Paradise Valley. Preliminary examination of sediment outcrop reveals many episodes of disturbance, probably mainly seismic events. Some disturbed strata appear to be traceable across the basin. These may record major Okataina or Kapenga volcanism independently of tephrostratigraphy.

Lake sediments in the Rotorua Basin were mapped at 1:250,000 by Healy et al. (1964) and according to altitude by Thompson (1974). Dravitzki (1999) discussed geomechanical properties of lake sediments in Paradise Valley in detail, and established a rational local stratigraphy for the valley.

In contrast with the relatively simple volcanic history of the Rotorua Basin, variation in lake level has been sudden, frequent, and extreme, especially in the period c. 70 - c. 20 cal. ka. Reconnaissance studies suggest that lake level has risen and fallen c. 100 m about three times in the past 100 cal. ka. There is evidence for many lesser fluctuations. Their causes are unknown. Regional tectonic activity, activity in the adjacent Okataina Volcanic Centre, and rainfall and other climatic variables are possible causes. The Mamaku Plateau loess and paleosol sequence has been successfully matched with marine oxygen isotope stratigraphy (Kennedy 1994, Newnham et al., 1999). This well-established record of global climate change may also correlate with Rotorua lake level changes. For the last c. 20 cal. ka lake level has been within c. 10 m of the present and has been well documented by Kennedy et al. (1978).

TVZ tephrostratigraphy has advanced greatly in recent decades, with the advent of new concepts and techniques. These advances have not yet been applied to older lake sediments in the Rotorua Basin, although a few studies have examined recent tephras in shallow lake-bed cores. Kennedy et al. (1978), Wood (1992), and Dravitzki (1999) explicitly recognized the value of tephrostratigraphy in the study of lake sedimentation. Dravitzki referred to sediments derived from the Rotoiti Tephra Formation and in greater detail to putative Mangaone Subgroup tephras in a well-dated peat section within the lake sequence. Kennedy et al. (1978) published a landmark paper in understanding the more recent (especially post c. 25 cal. ka) variations in lake level and climate. The authors also synthesized a long lake level history from two outcrops of sediments: one south of the Hemo Gorge, outside the Rotorua basin; the other of diatomite clasts in dominantly Rotoiti Tephra-derived sediment east of Rotorua Airport.

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