NIWA

Taihoro Nukurangi

Water quality survey of Lake Rotoiti (South Island): 6 July 1999

NIWA Client Report: CHC99/84
Project No.: TDC00501
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prepared for

Tasman District Council

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Executive Summary

- In July 1999 NIWA was asked by Tasman District Council to provide assistance with the sampling of Lake Rotoiti, in particular to collect two temperature and dissolved oxygen profiles and other basic water quality information. This report describes the results of this work and provides some interpretation.

- At the time of sampling temperature, chlorophyll *a* and dissolved oxygen showed Lake Rotoiti water column to be completely mixed.

- The lake is oligotrophic, with a moderate degree of humic staining. The former is indicated by full oxygenation and low chlorophyll *a* and nutrient concentrations. Humic staining was indicated both by water colour, and the rapid attenuation of UV radiation.

- Water clarity was moderately high despite humic staining, with the 1 % light level at 20 m depth, and a secchi disk depth of 7.25 m.

- This survey was conducted in winter but any long term low level monitoring should be based on a minimum of two sampling visits one in winter and one in late summer (March, April).

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1 INTRODUCTION

Lake Rotoiti is within the Tasman District Council's jurisdiction under the Resource Management Act. In July 1999, as part of their baseline monitoring program, TDC approached NIWA to assist with a one-off survey of the lake from which future management and monitoring options could be developed. NIWA were specifically requested to;

- Obtain two profiles for temperature and dissolved oxygen.
- Collect samples for the determination of a number of water quality indicators.
- Collect extra information on light and chlorophyll distribution as time permitted.

Lake Rotoiti is an alpine valley lake of glacial origin. With over 75 % of the catchment in either Native Beech forest or Tussock grassland there is a considerable allochthonous input of humic substances, imparting a brown colour to the lake. Lake Rotoiti has a surface area of 9.2 km^2 and a maximum depth of 82 m (Livingston *et al.* 1986). The main axis of the lake runs North / South and is 8.5 km long allowing for strong wind induced mixing.

2 METHODS

Field sampling was carried out on the 6th July 1999. A boat was used to sample two sites on the lake. The first was over the deepest section (82 m) 41:50.282S, 172:50.434E and the second in the North Eastern Bay (35 m) 41:48.739S, 172:50.702E.

2.1 Water quality sampling

Before water sampling commenced, vertical profiles of dissolved oxygen concentration and temperature were obtained using a YSI self-stirring dissolved oxygen probe and meter, calibrated before commencement of the profile. Water samples were collected at 25 and 75% depth of the water column at each station using a 5-litre Niskin bottle (triggered to close by a weighted messenger). Water samples were returned to the laboratory on ice and in the dark, and processed immediately for further analyses.

For measurement of chlorophyll *a* and suspended solids (SS), known volumes of sample were filtered through Whatman 25 mm GF/F filters (precombusted at 45 °C for SS). The chlorophyll *a* filters were frozen for later analysis, while the SS filter were oven dried for 24 hours at 105°C. Once dried to constant weight, SS filters were combusted at 450°C for three hours to determine the loss on ignition, which was taken to be organic suspensoid (OSS). Chlorophyll *a* was extracted by grinding in cold 90% acetone and the concentration in the extract determined spectrofluorometerically with a Perkin-Elmer LS 50B (Strickland & Parsons 1974; Marker *et al.* 1980).

Ammonia-nitrogen (NH_4-N), nitrate-nitrogen (NO_3-N), and dissolved reactive phosphorus (DRP) concentrations were determined after filtering a known volume through acid washed Whatman GF/F filters, analyses was carried out using a Technicon autoanalyser (Downes 1978). The filters were retained and stored frozen until analysed for particulate nitrogen (PN) and particulate phosphorus (PP) using Kjeldahl digestion (Vincent *et al.* 1991).

2.2 Instrument survey – temperature and chlorophyll fluorescence

At each station a Chelsea Instruments Aquapak was deployed to provide a depth profile of the temperature and chlorophyll fluorescence. Temperature and depth were calibrated using inboard software whereas fluorescence output from the instrument was post corrected using the chlorophyll *a* samples collected in 2.1 above.

2.3 Instrument survey – downwelling irradiance

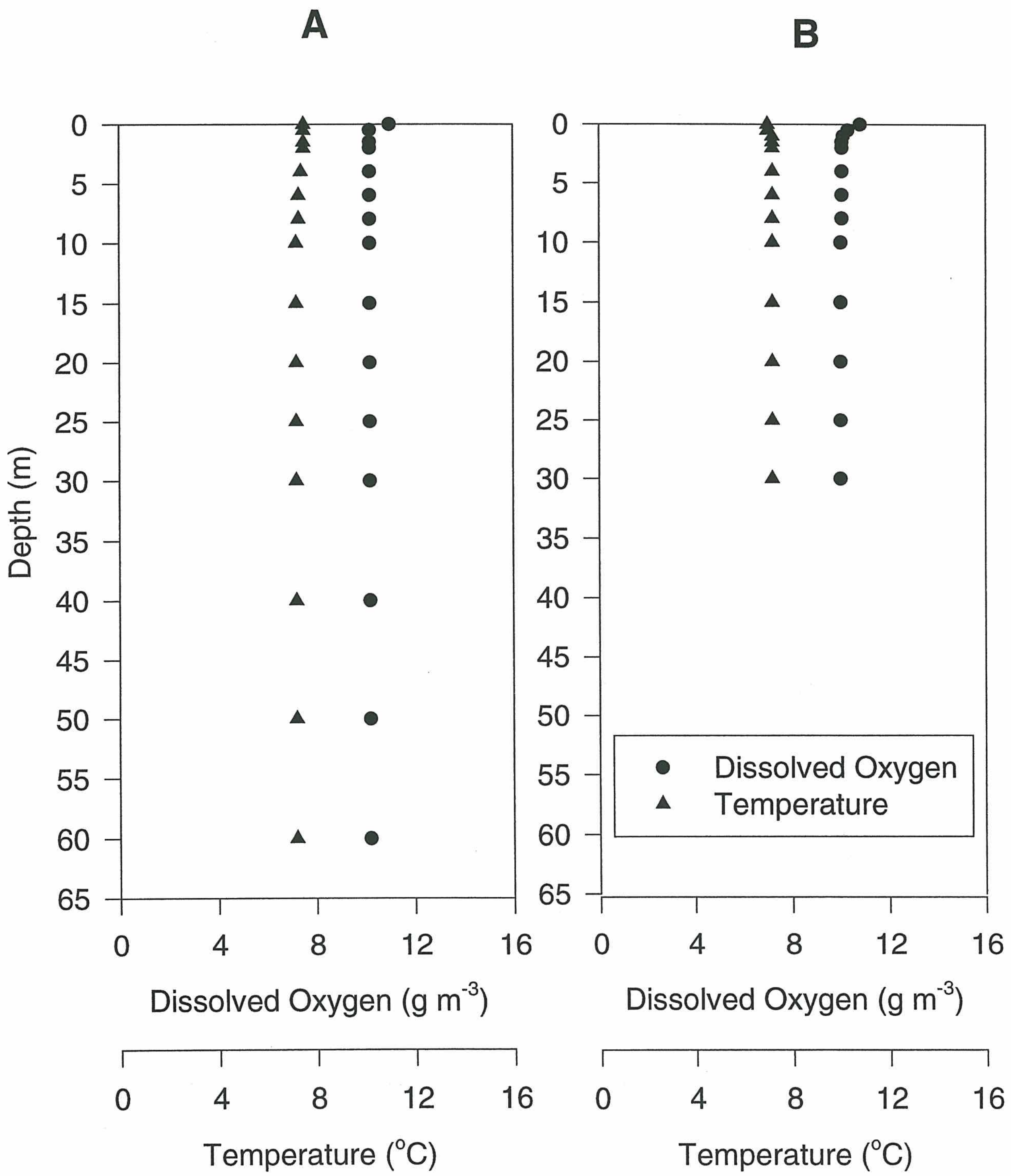
Downwelling irradiance was measured in North East Bay by two methods. The first profile was collected using a Li-Cor cosine corrected underwater probe recording to a Li-1000 datalogger (Li-Cor), corrected for changes in surface irriadance levels by the use of a deck cell. The second profile involved deploying a PUV-500B profiling ultraviolet radiometer (Biospherical Instruments). PUV radiation data were corrected for dark current by subtracting the residual current values after fitting a black neoprene cap over the sensing window (Vincent *et al.* 1998). The downward attenuation coefficient K_d was calculated for both profiles by linear regression of log transformed irradiance *vs* depth (Schwarz *et al.* 1996).

3 RESULTS

3.1 Water quality sampling

Temperature and dissolved oxygen profiles at both sites showed very little change with depth and indicated a well-mixed water column (Fig. 1). Dissolved oxygen concentrations of 10.3 g m^{-3} approach saturation for the ambient temperature of the

Figure 1. Temperature and dissolved oxygen plots for the two sites:
A mid-lake 82 m, and B North Eastern Bay 35 m.



lake 11.15 g m^{-3}). The values of the water quality variables measured (Table 1) were found to be similar to those recorded previously for this lake by other investigators (unpublished data; Schwarz and Howard-Williams 1992). Values for suspended solids were at the detection limit for the method used.

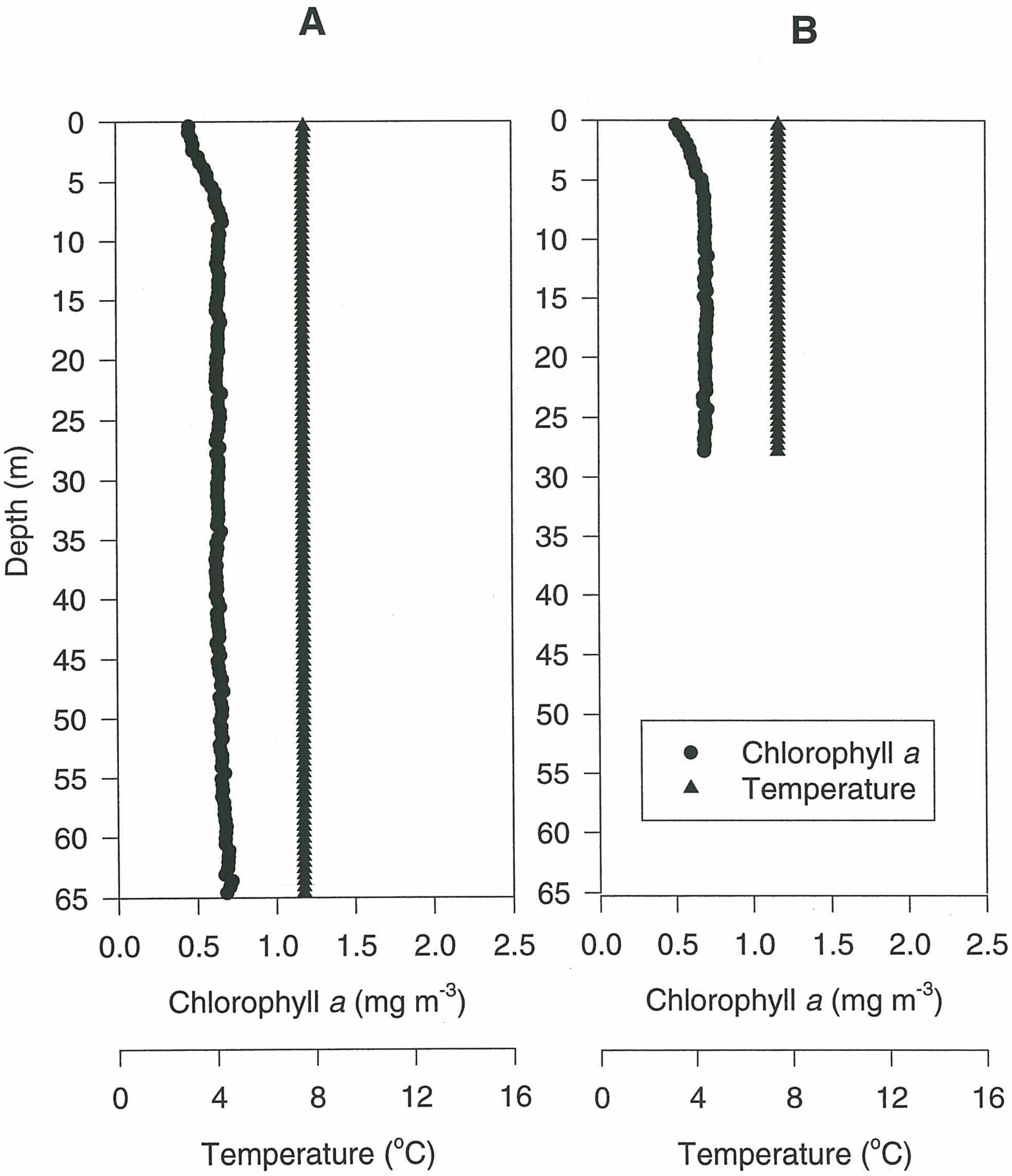
Table 1. *Water quality parameters investigated for the four samples taken during the July 1999 sampling visit to Lake Rotoiti. All parameters are in mg m^{-3} except TSS, ISS and OSS which are in g m^{-3} and conductivity which is $\mu S\ cm^{-1}$.*

	Site 1		Site 2	
	20 m	60 m	7 m	20 m
Chl *a*	0.64	0.65	0.72	0.69
Conductivity	35.3	33.8	33.8	35.3
TSS	1.056	0.451	0.454	0.451
ISS	0.522	0.092	0.083	0.090
OSS	0.534	0.359	0.371	0.361
PN	15.8	16.4	18.1	17.3
NO_3-N	14	14	14	14
NH_4-N	1.5	1.0	1.5	0.5
DON	28.5	27.5	24.0	23.0
TDN	44.0	42.5	39.5	37.5
TN	59.8	58.9	58.1	55.8
PP	1.50	1.15	1.18	1.33
DRP	0.6	0.4	0.35	0.55
DOP	0.4	0.6	0.65	0.45
TDP	1.0	1.0	1.0	1.0
TP	2.5	2.15	2.18	2.33

3.2 Instrument survey – temperature and chlorophyll fluorescence

The Aquapak profiles at the two sites were similar, and confirmed that the lake was completely mixed from top to bottom. The temperature and chlorophyll profiles for the two sites demonstrate this clearly (Fig. 2). Fluorescence is only an indicator of chlorophyll *a* concentration and the slightly lower chlorophyll *a* values for the near surface water is probably due to altered physiological states of the cells in this high light region.

Figure 2. Temperature and chlorophyll *a* plots for the two sites:
A mid-lake 82 m, and B North Eastern Bay 35 m.



3.3 Instrument survey – downwelling irradiance

The light profiles used to establish the K_d (Table 2) were gathered only in the North Eastern Bay. Profiling was not carried out at the mid lake site due to highly variable surface light conditions, though a secchi disk reading of 7.25 m was obtained. Surface light conditions were more settled in the bay. Radiation in the UVA and UVB wavelengths was rapidly attenuated in the surface waters, with the photosynthetically available radiation (PAR) penetrating further into the water column (Table 2).

Table 2. *Downward attenuation coefficient* K_d, *and depth at which the 1% level for each wavelength would be found.*

Sensor	Wavelength	K_d	Depth of 1% level (m)
Li-Cor	PAR (400-700 nm)	0.22	20.91
PUV-500B	PAR (400-700 nm)	0.23	20.00
	305 nm	2.33	1.97
	320 nm	2.44	1.89
	340 nm	1.69	2.72
	380 nm	0.94	4.89

4 DISCUSSION

Lake Rotoiti is a long narrow lake running North - South and as such can be expected to be well mixed in winter. This was the case in July when sampled, with the lake mixed from the top to the bottom as demonstrated by both temperature and dissolved oxygen concentrations (Fig. 1), and chlorophyll *a* (Fig. 2).

At 10.3 g m^{-3} dissolved oxygen was close to saturation (11.15 g m^{-3}) for the temperatures recorded in the lake, and indicates a well-mixed water column, taking into account the low chlorophyll *a* levels there appears to be little internal consumption or production.

Chlorophyll *a* levels were found to be low (0.64 – 0.72 mg m^{-3}) and in the lower range of those previously recorded for Lake Rotoiti (NIWA unpublished data). Chlorophyll *a* would be expected to be low in winter, as deep mixing will circulate the planktonic algal community out of the illuminated upper layers for much of the time. As the lake starts to thermally stratify towards spring, the increased light available to the community as well as sufficient nutrients should see the chlorophyll *a* levels increase to levels determined by nutrient availability.

Suspended solids were low and dominated by the organic fraction (Table 1), as can be expected in a lake without significant inorganic catchment inputs. The input of dissolved organic material of a humic nature has a strong influence on the attenuation of light. This is the largest contributor to K_d in this lake thus determining the depth to which light penetrates. The humic discolouration also contributes to the strong attenuation of the ultra violet wavelengths (Table 2). Humic staining will affect the bottom limits for the submerged macrophytes. Using the equation:

$$Zc = 4.5 / Kd - 2.2 \qquad \text{(Schwarz } et\ al. \text{ 1996),}$$

we find the theoretical bottom limit for macrophytes is 17.4 m, which compares favorably with Schwarz *et al.* (1996) who established the actual bottom limit for Lake Rotoiti at 18 m.

Total nitrogen and phosphorus, as well as inorganic forms of nitrogen and phosphorus, were found to be well within the range recorded in previous NIWA studies (Unpublished data) for Lake Rotoiti. It is of interest to note that, of the total dissolved nitrogen present, on average 63 % (26 mg m^{-3}) is in an organic form in contrast to the inorganic nitrate and ammonium. This is most likely due to allochthonous (mainly humic substances), rather than autochthonous sources. Aromatic humic and fulvic acids are very recalcitrant compounds, so provide little nitrogen to the phytoplankton community present, except through slow bacterially mediated decomposition processes or photolysis.

The data gathered for this report indicates that Lake Rotoiti is oligotrophic, as demonstrated by full oxygenation with low chlorophyll *a* and dissolved nutrient concentrations. However, as it will change seasonally, it is only with long term monitoring that the underlying trends in water quality can be established. As a minimum it is recommended that the lake be monitored at least twice a year. This would typically consist of a winter (August), and a late summer (March, April) sampling.

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APPENDIX 1. *Temperature (°C) and dissolved oxygen (g m^{-3}) concentrations as recorded in Lake Rotoiti on the 6 July 1999 at the two stations; A, mid lake, and B the North Eastern Bay.*

	Station A		Station B	
Depth (m)	Dissolved oxygen	Temperature	Dissolved oxygen	Temperature
0.1	11	7.5	10.8	7
0.5	10.2	7.5	10.3	7
1	10.2	7.5	10.1	7.2
1.5	10.2	7.5	10.05	7.2
2	10.2	7.5	10.05	7.2
4	10.2	7.4	10.05	7.2
6	10.2	7.3	10.05	7.2
8	10.2	7.3	10.05	7.2
10	10.2	7.2	10.0	7.2
15	10.2	7.2	10.0	7.2
20	10.2	7.2	10.0	7.2
25	10.2	7.2	10.0	7.2
30	10.2	7.2	10.0	7.2
40	10.2	7.2		
50	10.2	7.2		
60	10.19	7.2		
70	10.19	7.2		
75	10.19	7.2		