Is the salinity of Lake Clifton (Yalgorup National Park) increasing?

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Abstract

Salinity of Lake Clifton, within Yalgorup National Park, Western Australia, varies annually in step with the annual change in water level. During the 1980s, salinity in the northernmost, permanent basin of the lake was hyposaline, varying between 8-32 g L^{-1}. By the late 1990s, however, recorded salinity values varied between 25-49 g L^{-1}. This brief communication serves to initiate discussion on whether salinity in the lake really is increasing. If the salinity is increasing, then the scientific values of this lake are threatened.

Keywords: Lake Clifton, salinity, Western Australia

Introduction

The limnologically-diverse lakes forming the Yalgorup National Park wetland (Fig 1) in south-western Western Australia constitute a natural laboratory of international scientific significance. The 10 km long reef of thrombolitic microbialites along the eastern shoreline of Lake Clifton (Moore *et al.* 1984) is a significant natural laboratory for investigating biogeochemical processes (Burne & Moore 1987; Moore 1987, 1990; Moore & Turner 1988; Moore & Burne 1994; Konishi *et al.* 2001). The lake is listed (jointly with lakes McLarty and Mealup and the Peel-Harvey Estuary) under the "Ramsar" Convention on wetlands as a Wetland of International Importance Especially as Waterfowl Habitat (Anon 1990).

Lake Clifton comprises essentially three basins; the northernmost is ~4.5 m deep and together with the middle basin is permanent; the southernmost basin dries out in summer. With no surface outflow and only occasional minor surface input (Davies & Lane 1996), the ~1 m annual fluctuation in water level of the lake is controlled by ground water and the balance between rainfall and evaporation.

Lake salinity

In March, 1972, Williams & Buckney (1976) recorded a salinity of 15.3 g L^{-1} in Lake Clifton. Moore (cited in Moore *et al.* 1984) recorded a salinity range of 17-30 g L^{-1} in 1979. In July 1983, after heavy rain, salinity of the lake near the aquifer outflow was 8.4 g L^{-1}. During the 1980s, Lake Clifton was hyposaline and the following salinity ranges were recorded; 17-26 g L^{-1} adjacent to transect A, 15-32 g L^{-1} adjacent to transect C, from two sites measured monthly in 1984 (Moore 1993). Values recorded monthly between May 1985, and July 1986, at the surface and near the bottom of the water column at three sites in

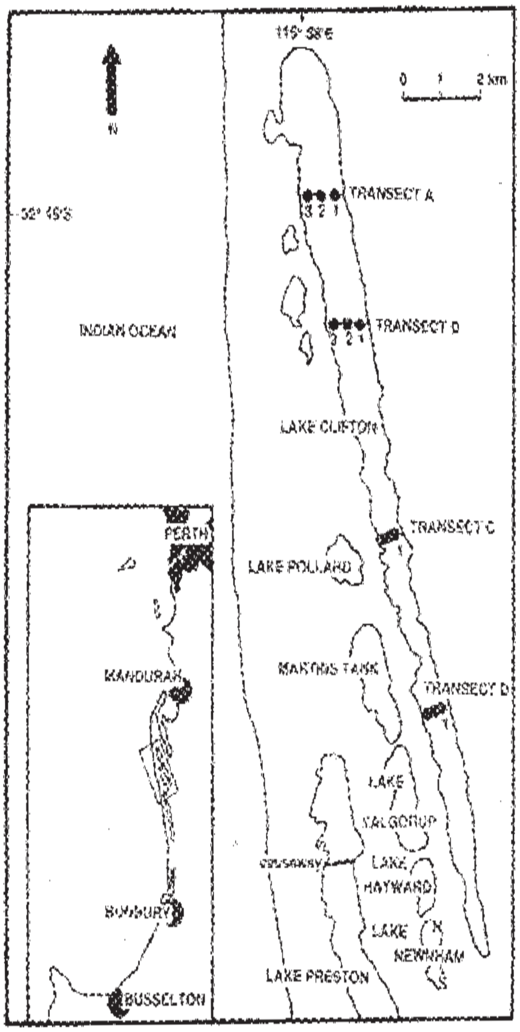


Figure 1. Lake Clifton and other lakes of the Yalgorup National Park. The inset shows the area of the main map, and the position of Lake Clifton relative to Bunbury and Mandurah. Sites C4 and F12 (in Moore 1993) are equivalent to transects A and C, respectively.

Table 1

Salinity values (g L^{-1}), Lake Clifton, 1985-86. Transects and sites are shown in Fig 1. Salinities in bold represent an average of differing top and bottom values.

	1985							**1986**					
	23 May	**8 July**	**9-10 Aug**	**20 Sept**	**11-13 Oct**	**9-10 Nov**	**13-15 Dec**	**21-22 Jan**	**18-20 Feb**	**14-16 Mar**	**18-19 Apr**	**16-18 June**	**20-22 July**
A1	32*	20	20	18	17	18	22	26	30	30	**31.5**	31	**27**
A2	32*	20	20	18	17	18	22	**25.5**	30	30	32	31	**27.5**
A3	31*	20	20	18	17	18	20	**25.5**	30	30	32	31	**28.5**
B1	26**		19	16	16	18	22	27	32	30	30	30	28
B2	27**		**20**	**17.5**	17	**17.5**	**21.5**	26.5	30	32	32	30.5	29
B3	27**		20	17	**15.5**	18	21	26	32	32	32	30	28
C1	30.5*	15	15	15	16	16	22	30	38	36	38	33	28
C2	30*	14	16	**14.5**	16	16	22	30	38	36	38	33	27
C3	32*	14	16	14	16	16	22	31				26	29
D1	26*	13	10	12	**13**	15	22	30	43	45	48	36	26
D2	26*	14	10	12	**13.5**	15	22	34	42	43	48	38	26
D3	26*	14	10	12	12	15	22	36	47			42	28

* 23 May 1985; ** 31 May 1985.

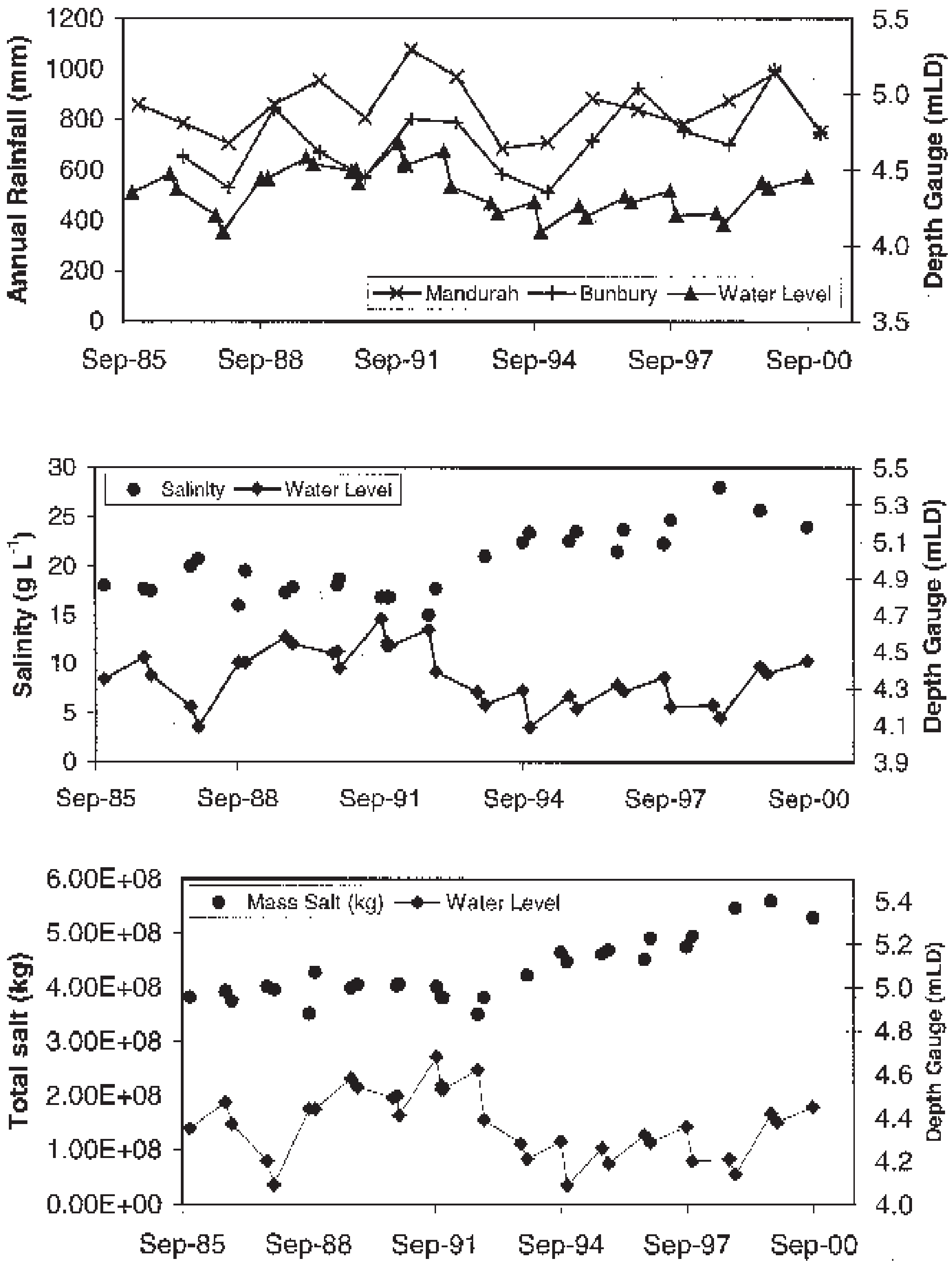
each of four transects (Table 1) showed ranges in the permanent, northern basin, transects A and B, of 17-32 and 15.5-32 g L^{-1} respectively. Salinity gradients reflect interactions between the position of freshwater inflow along the eastern margin, lake bathymetry and wind strength, which are sufficient to mix this lake vertically, but not horizontally. Salinity increased from north to south during the period of low water level (January-March 1986, Table 1), due to the increasing impact of evaporative concentration on successively shallower southern bodies of water. The gradient is reversed with high water level (in spring *e.g.* October 1985, Table 1); the northern basin (transect A) is most saline because of the higher salt load in the larger volume of water contained in the deeper basin. Successively lower salinities occurred along transects B-D during high water level, reflecting the greater impact of the freshwater input in shallower basins. Aquifer input was sufficient to generate an east-west salinity gradient, from 2 g L^{-1} immediately over the aquifer outflow, to 15 g L^{-1} at the edge of the rushes (*Juncus* sp; 23 August 1984, CM Burke & B Knott, unpublished data). Gilgies, *Cherax quinquecarinatus* (Gray), were active in this lens of fresher water at night.

A series of *ad hoc* salinity readings late in the 1990s suggest that salinity has increased since the 1980s. Values recorded at times of low water level have been; 44 g L^{-1} (adjacent to transect A; 17 May 1997, Konishi 1997); 49-34 g L^{-1} at site 2 (adjacent to transect C), and 45-25 g L^{-1} at site 3 (adjacent to transect D; Gartrell 1998); 48 g L^{-1} (adjacent to transect A, 24 April 1999). During the 1990s salinity values at times of high water level, too, have been higher than those noted in the 1980s; 25 g L^{-1} (both adjacent to transect A, 22 September 1999, and again on 5 September 2000).

Despite the limited evidence available, the data indicate that there has been an increase in salinity since the 1980s. The total annual rainfall at the two nearest meteorological stations, Bunbury and Mandurah, are plotted against water levels measured at Lake Clifton in September 1986 to 1999 (at the end of the rainy season) in Fig 2A. It is clear that there is a direct correlation between rainfall and water level in the lake. Measurements of salinity during the same period are shown in Fig 2B (J Lane, CALM, unpublished data). As expected, there is an inverse correlation between water level and salinity. However, if rainfall was the only driving factor in determining the lake's salinity, then increased rainfall in the late 1990s and the subsequent water level rise should have returned the salinity to the lower levels observed in the 1980s (during years of similar rainfall and water level). This trend has not been observed. An approximate estimation of the total salt content of the lake was calculated as the salinity multiplied by the total lake volume. Measurements of salinity were made in September when the lake was fully mixed, and lake volume was calculated as a function of water level based on bathymetry data supplied by the Water and Rivers Commission. These calculations indicate that although the mass of salt in Lake Clifton remained relatively constant from 1985 to 1992, it has since increased by 40% from 1993 to 2000 (Fig 2C). Since this calculation is independent of rainfall, this indicates a possible increase in proportion of brackish ground water to fresh ground water inflow into the lake. Clearly, further investigations are necessary to substantiate whether the observed increases in salinity of Lake Clifton are permanent, and if so what are the cause(s).

Consequences

If the salinity of Lake Clifton is increasing and continues to do so, then changes in the pattern of microbialite growth, reduction in faunal diversity within the lake, and change in usage by waterbirds, are inevitable consequences unless the cause(s) are identified and corrected. Even if the salinity is increasing, any ecological perturbations already in train may not yet be irreversible given immediate remedial action. The limnology of Lake Hayward altered substantially during the dry summer of 1987/1988, but subsequently returned to its pre-drought pattern, probably through internal homeostatic mechanisms (Burke & Knott 1997). With a permanent change to hypersalinity, the international scientific significance of the lake may well be lost. It must



A

B

C

Figure 2. A comparison of changes in annual rainfall, water level and salinity of Lake Clifton 1985 to 1999. A: Rainfall and water level data. B: Salinity and water level data. C: Total salt and water level data. mLD = mean lake data, equivalent to Australian height datum + 4.035 m. Rainfall data from the Commonwealth of Australia Bureau of Meteorology; water level and salinity measurements from the Western Australian Department of Conservation and Land Management.

also be acknowledged that concerted action by the government departments responsible for managing the environment may be required to prevent them presiding over the irreversible loss of a major scientific laboratory of international standing.

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