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Studies on the biomass, diversity and nutrient relationships of macroalgae and seagrasses in Lake Illawarra, New South Wales, Australia

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Studies on the biomass, diversity and nutrient relationships of macroalgae and seagrasses in Lake Illawarra, New South Wales, Australia

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Thesis Declaration

I, Karin Rutten, declare that this thesis, submitted in fulfillment of the requirements for the award of Doctor of Philosophy, in the School of Earth and Environmental Sciences, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other institution.

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Abstract

Lake Illawarra is a shallow barrier lagoon, located on the south-eastern coast of Australia. Eutrophication, referring to the enrichment of water by inorganic plant nutrients (primarily nitrogen and phosphorus), is one of the key environmental problems in Lake Illawarra. Management of macroalgae in Lake Illawarra is a major issue; excessive blooms of macroalgae, resulting in odours, access problems and community concern over Lake health, have led to many management strategies, including direct harvesting of algal biomass. Little information is available on the factors responsible for excessive growth of macroalgae in Lake Illawarra, although over supply of nutrients has often been cited as the primary cause. The aim of this study was to investigate the distribution, diversity, biomass and nutrient relationships of seagrasses and macroalgae in Lake Illawarra, and to determine what contribution, if any, macrophytes make to the Lake's nutrient budget.

Firstly, detailed species lists and taxonomic descriptions were prepared for macrophytes occurring in Lake Illawarra, between June 2000 and July 2003. This study focused primarily on shallow (< 1 m depth), inshore areas of Lake Illawarra, where problematic macroalgal blooms frequently occur. Seagrasses found in Lake Illawarra are *Zostera capricorni*, *Ruppia megacarpa*, *Halophila ovalis* and *Halophila decipiens.* In addition, 35 species of macroalgae were recorded and described; these included: 14 species from 7 genera of green macroalgae; 9 species from 9 different genera of brown macroalgae; and, 8 species from 8 genera of red macroalgae.

The biomass of seagrasses and macroalgae in Lake Illawarra were documented seasonally (winter and summer) at four key Lake Illawarra sites; these included two *R. megacarpa* sites and two *Z. capricorni* sites. Average *R. megacarpa* and *Z. capricorni* dry weight (DW) biomasses (above and below-ground material) ranged from 54.8 - 440 g DW m^{-2} and 58.1 - 230 g DW m^{-2}, respectively. Significant die-back, particularly of *Z. capricorni*, occurred in winter; summer biomasses were up to 1.5 - 3.9 times higher than winter biomasses. Below-ground material (roots and rhizomes) comprised 20 - 45 % and 40 - 67 % of total plant biomass for *R. megacarpa* and *Z. capricorni*, respectively. Macroalgal biomass in 2000-03 was notably lower than in previous decades; this may be due to drought, as well as improvements in water quality. Maximum biomasses of macroalgae recorded in the present study were 150 - 370 g DW m^{-2}. Algal blooms were composed primarily of the filamentous chlorophytes, *Chaetomorpha linum* and *Chaetomorpha billardierii*. The highest seagrass (*R. megacarpa*) and macroalgal biomasses usually occurred at the Oasis Caravan Park site, located along the eastern Lake Illawarra peninsula.

Tissue nutrient analyses were conducted on the most abundant seagrasses (*Z. capricorni* and *R. megacarpa*) and macroalgae occurring at four sites in Lake Illawarra, between spring 2000 and

winter 2002. Total C contents of macrophytes varied from 23.3 - 42.0 % C for seagrasses, and 28.0 - 39.7 % C for macroalgae. The $\delta^{13}C$ and $\delta^{15}N$ contents of seagrasses ranged from -7.7 to -15.9 ‰ and 0.7 - 9.0 ‰, respectively. The most significant seasonal variations in seagrass $\delta^{13}C$ contents and, to a lesser extent $\delta^{15}N$ contents, occurred in *Z. capricorni* located at the source of fresh water input, Mullet Creek. Macroalgae showed a greater variation in isotopic signatures than the seagrasses, ranging from -4.9 to -19.8 ‰ ($\delta^{13}C$) and 1.8 - 14.6 ‰ ($\delta^{15}N$). Differences between species at the same site were often more significant than differences between the same species at different sites. Seagrass leaf N and P contents ranged from 1.74 - 4.13 % (mean ± s.e.: 2.62 ± 0.05 % N) and 0.12 - 0.59 % P (mean ± s.e.: 0.31 ± 0.01 % P); leaf N and P contents were typically double those of roots/rhizomes. N contents varied between species and sites, but P contents of *Z. capricorni* were usually significantly higher than *R. megacarpa. Z. capricorni* C and N contents increased in winter, corresponding to lower winter biomasses. Seagrass leaf biomass and tissue P contents peaked in summer 2002, which may be related to higher water column P concentrations in summer. Tissue N and P contents of macroalgae were more variable than those of the seagrasses, and ranged from 0.85 - 3.95 % N and 0.03 - 0.58 % P. The average C/P (808 ± 65) and N/P (47.9 ± 3.47) molar ratios of macroalgae were typically double those of the seagrasses. Low concentrations of tissue P, with respect to N, in *R. megacarpa* and macroalgae implied P limitation on several occasions, particularly when macrophyte biomasses were low. High tissue N contents in Lake Illawarra macrophytes suggested N limitation of biomass formation rarely occurred. Evidence of P, rather than N, limitation in macrophytes is surprising considering most data suggests N limitation of phytoplankton production in Lake Illawarra. The estimated pools of N and P contained in Lake Illawarra macrophyte biomass were similar to those present in the water column, but appeared minute when compared to the N and P stored within Lake Illawarra sediment.

Laboratory culture experiments were conducted to evaluate the response of the most problematic alga, *Chaetomorpha linum*, to nutrient enrichment. Water temperatures of 20 - 25°C were found to promote the highest growth rates (up to 27 % WW d^{-1}) of *C. linum*, but high growth rates (13 % WW d^{-1}) were also recorded at 10°C, the lowest winter water temperature recorded in Lake Illawarra. Enrichment with N, rather than P, had the greatest effect on *C. linum*; growth rates were significantly reduced in treatments without added N, but treatments with N-alone were statistically similar to N+P treatments. It was concluded that in Lake Illawarra, *C. linum* was strongly nitrogen limited. The ability of *C. linum* to grow successfully in culture, under a range of nutrient treatments, and without added phosphorus, in particular, correlates with the excessive growth of this alga in Lake Illawarra.

This study has made a significant contribution to the understanding of seagrass and macroalgal growth, biomass and distribution in Lake Illawarra. This information will assist with the long-term management of macroalgal problems in Lake Illawarra.

Publications arising to date from this study

Rutten, K., Morrison, R.J. and West, R.J. (2004) Macroalgae in Lake Illawarra, New South Wales, Australia. *Wetlands (Australia),* **21**(2), 103-114.

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