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Environmental impacts and the ecology of sponges and ascidians in south-eastern Australian coastal lakes and lagoons

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ENVIRONMENTAL IMPACTS AND THE ECOLOGY OF SPONGES AND ASCIDIANS IN SOUTH-EASTERN AUSTRALIAN COASTAL LAKES AND LAGOONS

A thesis submitted in fulfilment of the requirements for the award of the degree

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by

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Frontispiece: *Suberites* sp. in Wallis Lake

Declaration

I, Peter Brendan Barnes declare that this thesis submitted in fulfilment of the requirements for the award of Doctor of Philosophy in the Department of Biological Sciences, University of Wollongong is wholly my own work unless otherwise referenced or acknowledged. This document has not been submitted for qualifications at any other academic institution.

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Peter Brendan Barnes

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Abstract

Estuaries worldwide are under threat from urbanisation and development and will need effective management for their successful conservation. Coastal lakes and lagoons have been identified as one of the estuary types most susceptible to human impacts largely because of their isolated nature and slow flushing times. Management of estuaries will be most effective when based on a sound scientific understanding of the patterns of distribution, biology and ecology over the full range of biodiversity of these systems, however, such an understanding is lacking for many systems and many taxa. Studies of sponges and ascidians in coastal lakes and lagoons are rare compared to other taxa, particularly in the southern hemisphere. This study represents the first detailed scientific investigation of the ecology of sponges and ascidian in coastal lakes and lagoons of southeastern Australia. Consequently, a large part of this thesis was devoted to quantifying basic patterns of distribution. I started with a pilot study to develop an effective sampling design, followed by large-scale comparisons among different types of lake, comparisons among habitats within lakes and an environmental impact study. I concluded with a manipulative experiment to examine processes responsible for small-scale patterns of distribution of sponges in seagrass meadows.

In the pilot study, distributions of sponges and ascidians were quantified at a hierarchy of three spatial scales in each of two coastal lakes. Nested analyses of variance were then used to identify spatial scales at which variation was significant. Most sponges and ascidians were very patchily distributed at a range of spatial scales from 10s of metres up to 100s of kilometres. Unlike other published examples of cost–benefit analyses, very few taxa were widespread over the larger spatial scales. Cost–benefit analyses done to determine the optimal sampling design revealed inclusion of

patchily distributed taxa in analyses improved the overall precision of sampling for comparisons of assemblages among lakes.

Large-scale comparisons of assemblages of sponges and ascidians were made among lakes of different size (big versus small), opening regime (mostly open to the ocean versus mostly closed) and level of environmental modification (extensively modified versus more pristine). Similar to other taxa studied in coastal lakes, in general there were more species in lakes mostly open to the ocean compared to the mostly closed lakes, and importantly, no sponges and only one species of ascidian was found in the small closed lakes. There also appeared to be an effect of the level of modification of a lake with relatively smaller abundances of ascidians in extensively modified lakes, and a complete absence of sponges from one of the extensively modified lakes.

Habitat-associated patterns were examined at smaller spatial scales by comparing the distributions of sponges and ascidians with the species composition and percentage cover of seagrass and macroalgae within two lakes; St Georges Basin and Wallis Lake. Several patterns of association were observed, but these varied among species of sponge and ascidian. In St Georges Basin, the most common sponge, *Aplysinella* cf. *rhax* and the native ascidian *Pyura stolonifera* were positively correlated with the seagrass, *Posidonia australis*. In contrast, the introduced ascidian, *Styela plicata* was more abundant in areas dominated by the seagrass, *Zostera capricorni.* In Wallis Lake, sponges were most diverse and some species most abundant in large beds of the macroalga, *Lamprothamnion* sp., while other sponges were found only on the holdfasts of brown macroalgae. In both lakes, sponges were generally less common in areas dominated by dense meadows of the seagrass, *Zostera capricorni*.

Among the many anthropogenic impacts threatening the ecology of coastal lakes, the discharge of cooling water from coal-fired power stations represents an

almost ideal case study from which to develop appropriate sampling regimes for detecting impacts on sponges and ascidians. Using reference locations both within and outside Lake Macquarie which has two cooling water outlets, I found assemblages of sponges and ascidians were often more diverse, more abundant and less temporally variable near to the outlets compared to reference locations.

Based on the observation that the sponge, *Suberites* sp. which contains photosynthetic symbionts was absent from meadows of dense *Zostera capricorni*, I used *in situ* manipulative experiments in Smiths Lake to investigate processes which maybe affecting their distribution. Individual *Suberites* sp. were shaded, had water flow reduced and were transplanted into areas of dense *Z. capricorni*. There were no measurable short-term effects of shading or reduced water flow, but transplanted sponges were quickly eaten and I concluded predation by fish was likely to be a key process determining small-scale patterns of distribution of *Suberites* sp. in seagrass meadows. This result was in stark contrast to the majority of previous studies of the effects of seagrass habitat complexity on predation which have found predation to decrease with increasing density or complexity.

In conclusion, I have sought to provide sound scientific information to aid in the management of these systems. A simple, but nevertheless key finding was that sponges and ascidians are indeed present and widespread in coastal lakes and lagoons of southeastern Australia and should not be continually overlooked in the management and conservation of these systems. Conservation will be complex and requires an understanding of environmental impacts and the consequences of management on the full range of biodiversity. The distributions of sponges and ascidians at large 'lake-wide' scales appear to behave similarly to other taxa. Management strategies which change the characteristics of a lake at these large spatial scales such as artificial

openings of entrances could therefore be predicted to have similar effects across a range of taxa including sponges and ascidians. In contrast, at smaller spatial scales such as the complexity of seagrass meadows, some species of sponges and ascidians may behave very differently from other taxa. At present, our understanding of these naturally variable and complex systems is incomplete and will require ongoing scientific investigation to identify natural patterns of distribution, environmental impacts, important natural processes and the ecological consequences of management strategies.

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