Using a multi-component indicator to identify major variables controlling the health of water resources

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Phytoplankton blooms have continued to pose a significant challenge for water resource management. Two Australian water resources, Lake Burragorang, a large reservoir in Sydney, and the Swan River estuary, an iconic estuary in Perth, are sites where managers face this challenge. The first severe bloom occurred in 2007 in Lake Burragorang. In the Swan River estuary, however, algal blooms occur frequently and management of the resource focuses on reducing their occurrence. Management strategies to prevent large-scale algal blooms in Lake Burragorang or decrease bloom occurrences in the Swan River estuary uniquely depend on the characteristics of the bloom and the water resources.

In this study, we applied the Index of Sustainable Functionality (ISF) to the two sites of interest (domains) firstly to assess their health and functionality, and thus sustainability, and to identify the major controlling variables in each domain towards better management strategies. The ISF is a robust index, with the ability to reflect the level of complexity of different domains, and flexibility to consider more than social, environmental and economic issues, depending on data availability. It overcomes subjectivity in defining "need" in conventional approaches by focusing on the present level of functioning of the system(s) under consideration to indicate longevity, instead of sustainability, as a state or a future point of reality.

In Lake Burragorang, changes in climate, expressed in a much lower water level and more frequent extreme events created the challenge for water managers of increasing the risk of (severe) algal bloom occurrences, giving further significance (and complexity) to lake water level management. A model simulation was performed based on the same conditions as during the period of the 2007 algal bloom, except at a higher (20 m) lake water level. Figure 1 shows that, at a higher water level, the phytoplankton bloom would not have occurred. Vilhena *et al*. (2010) further elaborates on this.

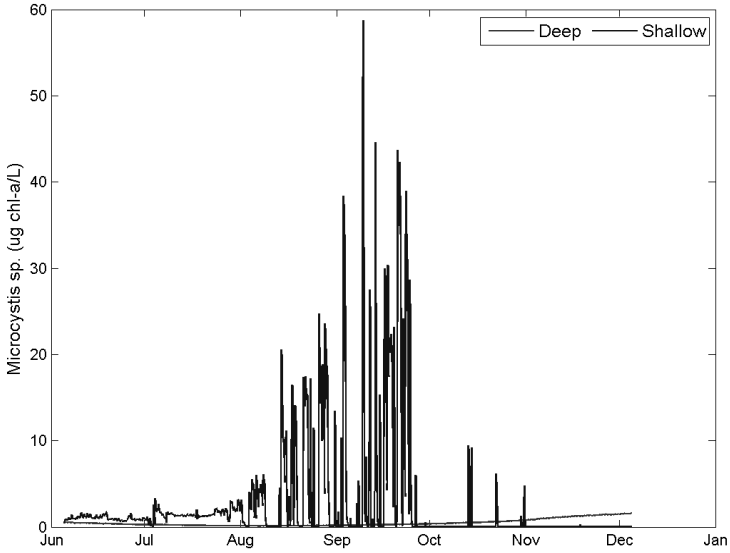

Fig. 1 Surface chlorophyll-*a* concentration for shallow (actual conditions) and deep (20-m deeper) simulations during the period of the algal bloom event (June–December 2007).

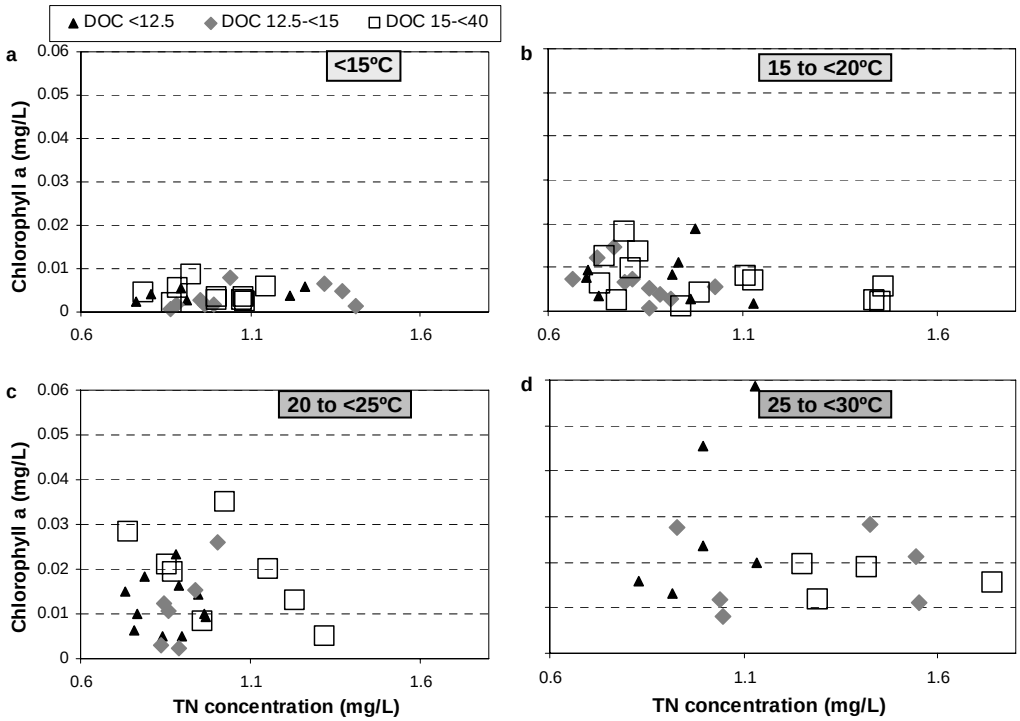

Fig. 2 Chlorophyll-*a vs* TN concentrations in the *upper* estuary at different DOC concentrations and water temperature ranges, showing the dominance of water temperature.

The investigation on Lake Burragorang identified the importance of external forcings such as the changing climate. We included the concept of forcings or "drivers" in the ISF application to the second domain, the Swan River estuary, where reducing algal bloom occurrences is the main management concern. The drivers of the systems in the domain were identified through data analyses and correlations. The significance of water temperature and organic matter in the water (Fig. 2) points to climate and catchment land use as drivers, with climate-driven inflows regulating catchment inputs; thus management strategies should focus on these. The study also emphasized that the changing climate has a direct impact on system processes.

The two studies showed that the ISF, as a framework to assess the functionality and health of a domain for sustainability, is a valuable tool, not only in evaluating the effects of different management actions on the systems and the domain itself, but also allowing for the examination of possible (external) factors and their impacts, and more importantly, it can direct and focus management activities on dominant factors within the domain for more effective management towards sustainable water resources.

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