Introduction

The Gippsland Lakes, the largest estuarine coastal lagoon system in Australia, have suffered recurrent summer toxic blooms of cyanobacterium Nodularia spumigena since 1985. Diatoms and dinoflagellates are also common bloom forms seen in the lakes. Nodularia is usually found in brackish waters. It has the ability to fix free nitrogen and its growth is known to be controlled by a combination of biological, chemical and physical drivers, which are impossible to simultaneously assess experimentally. The key drivers of the blooms include intermediate salinity, stratification, bottom water hypoxia and sediment phosphorus release that are broadly well understood; however, we lack a quantitative tool to predict blooms and explore management options to mitigate blooms. The aims of this study include:

• Refine and validate our conceptual understanding of algal bloom dynamics within a robust quantitative framework;
• Obtain better model representation of phytoplankton composition and phytoplankton-zooplankton interactions based on the autecology and population dynamics of different phytoplankton species;
• Obtain better understanding of the process of nutrient recycling in the water column and the mechanisms controlling long-term storage of phosphorus and nitrogen in the sediment;
• Investigate possible options to control and mitigate Nodularia blooms in the Gippsland Lakes;

Methods

We used a 3-D fully coupled hydrodynamic biological/ecological model to explore the interaction between the physical and biogeochemical controls over Nodularia blooms. For the hydrodynamics, it uses the k-epsilon model to simulate the turbulent mixing of the water column. The model contains 41 state variables and 242 processes, which are parameterised by 176 constants, to describe the biological/ecological and chemical reactions occurring in the water column and sediment compartments. Some of key processes include:

• Photosynthesis
• Phosphorus sorption and desorption
• Nitrogen fixation
• Sediment transport
• Vertical migration
• Respiration
• Grazing
• Mineralisation
• Nitrification
• Denitrification
• Multi-species: Nodularia, dinoflagellates and diatoms

Results

Conclusions

Over the 2-year simulation period, the model has reproduced the hydrodynamics very well. Although the model has not been fully calibrated, it has replicated the spatial and temporal distributions of Nodularia blooms closely to what have been recorded. The model has provided us with valuable insights into the key controls over Nodularia blooms:

• Salinity and temperature are the primary factors controlling the growth of Nodularia;
• High carbon delivery to sediment in winter and spring due to floods and diatoms/dinoflagellates blooms caused depleted bottom-water oxygen in summer, which lead to a large release of inorganic phosphorus from the sediments.
• Upwelling of phosphorus-rich water from the salt wedge driven by the easterly winds plays a very important role in initializing a Nodularia bloom as well as controlling its duration, size and severity.

The model will be fine tuned in the next stage of the study and will eventually be used to test a number of mitigation and prevention scenarios.

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Yafei Zhu*, Matthew Hipsey, John Beardall, Andrew McCowan, Perran Cook

*Yafei.zhu@monash.edu 1Water Studies Centre, School of Chemistry, Monash University 2School of Earth and Environment, The University of Western Australia 3School of Biological Sciences, Monash University 4Water Technology Pty Ltd

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