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Coupling of Hydrodynamics and Water Quality for Numerical Simulations of the Swan River

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It is readily apparent that hydrodynamics plays a significant role in the transport, mixing, resuspension and sedimentation of nutrients and micro-organisms in tidal estuaries such as the Swan River. It is less obvious that the biology of the river can modify the hydrodynamics of the basin in a manner that may impact biological productivity. A simple example is visible in the Swan River where colonies of macroalgae can blockade shallow regions, effectively damping the propagation of surface waves inshore of the algae and providing a quiescent environment more suitable to macroalgae growth. It is reasonable to presume that the river-bed-to-surface algae colonies also provide both significant bottom drag and viscous dissipation of flow energy throughout the water column, reducing advection rates and decreasing mixing. Thus, computational ecosystem simulation cannot accurately model the transport of macroalgae unless it can also model how the macroalgae changes the transporting velocity field. In this presentation, we discuss issues related to feedback from biology to hydrodynamics and the development of numerical models that allow full coupling of biology and hydrodynamics. Of particular interest are modeling (1) the hydrodynamics drag of macroalgae and macrophytes, (2) breakup of macroalgae colonies by storm surges, (3) changes in heat transfer due to increased turbidity, and (4) possible sediment trapping by seagrasses. Each of these effects has the possibility of changing the local hydrodynamics and/or thermodynamics in a manner that feeds back into the biogeochemical cycle in the water column. Development of accurate numerical models of these "bio-hydrodynamic" effects is hampered by a lack of field data that is suitable for parameterization and validation. With a view toward stimulating further research into the hydrodynamic effects of biological organisms, we discuss the basis for introducing such models into the Navier-Stokes equations and the resulting parameterizations that are necessary.

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