Simulating the Dispersal of Invasive Clams in a Freshwater Lake Using a Three-Dimensional Hydrodynamic Model; a prototype for Simulating Invasions in Marine Ecosystems

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Simulating the Dispersal of Invasive Clams in a Freshwater Lake Using a Three-Dimensional Hydrodynamic Model
A Prototype for Simulating Invasions in Marine Ecosystems

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Raincoast Scientific - Salish Sea Ecosystem Conference 2016

Abstract
The discovery of several populations of an invasive Asian clam (Corbicula fluminea) in Lake Whatcom, the drinking water source for approximately 100,000 people in Northern Washington State, created a need among elected officials, local government staff, and the public for a better understanding of lake hydrodynamics during the reproductive season for the Asian clam, and for times when Oyster and Zebra mussel invasions are likely. Seasonal vertical thermal stratification of the lake and a desire to predict likely locations of additional clam populations or of new populations of mussels led to the choice of a model that could be configured for three-dimensional hydrodynamic analysis to predict likely trajectories of larvae after spawning. The General Estuarine Transport Model (GETM) was chosen. GETM is a standard model widely used for near-shore oceanographic modeling where stratification and steep bottom topography are similar to the physical conditions in Lake Whatcom.

Setting
Lake Whatcom, which discharges to Bellingham Bay in the Salish Sea, is a deep freshwater lake in the Cascade foothills of Northwestern Washington State. In 1998, Lake Whatcom was listed as an impaired water body by the Washington Department of Ecology and a Total Maximum Daily Load (TMDL) was inserted into the water at model cells corresponding to seven locations where clams had been found and one location where the possibility exists of future clam infestation. Preliminary surveys were conducted and areas of clam infestation were identified.

Methods
Three computational grids were constructed in GETM, each for a specific modeling task. For modeling the purpose of tracking, analysis, and visualization of clam larvae dispersion, soundings data were transferred to a 183-by-599 cell horizontal grid of 25 meter-square cells. For this task, depths were divided into 21 regularly-spaced terrain-following (=coordinate) vertical layers.

Elevation grid was used in a novel approach to derive wind area-wide stress boundary conditions for the lake surface from wind speed and direction data measured at a single point on the lake.

Results
For clam larvae dispersion simulations corresponding to the assumption that most of larvae are released in a short period of time, a passive tracer was inserted into the water at model cells corresponding to seven locations where clams had been found and one location where the possibility exists of future clam infestation. Initial tracer concentration was calculated so that a total of 1,000,000 units of tracer were released at each location using horizontal cell area and depth. By measuring subsequent tracer concentrations, it was possible to characterize the transport and fate of 1,000,000 hypothetical clam larvae both graphically and mathematically.

Future Research
Because application of this work to an estuarine environment would be straightforward—requiring the specification of open boundaries, the input of tidal elevations at open boundaries, and salinity profiles—it serves as a platform for similar studies of invasive species in the Salish Sea. The Stanford unstructured-grid nonhydrostatic parallel coastal ocean model (SUNTANS) is being considered for this future work.

References

Acknowledgements
This work was funded by a grant from the Puget Sound Partnership through the City of Bellingham. Funding for wind stations placed on private docks on Lake Whatcom was provided by Washington SeaGrant. The authors acknowledge the generosity of private citizens who provided dock space for the stations.