MODELLING FRESHWATER MUSSEL DYNAMICS

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Freshwater mussels, also known as unionids, are a very important natural resource in North America; unfortunately, the combined effect of habitat alteration and invasive species dispersion has placed them among the most imperiled faunal groups (Lydeard et al., 2004 and references there in). Applying Ecohydraulics principles a numerical model has been developed to enhance the understanding of freshwater mussel dynamics and support the design of appropriate conservation strategies. This paper presents a general description of the model and its application to a case study in the Upper Mississippi River (UMR).

The Mussel Dynamics Model (MDM, Morales et al., 2003; Morales-Chaves, 2004) is a mathematical model for simulating interactions between freshwater mussels and their environment. It integrates traditional habitat suitability criteria with a population dynamics model describing the functional processes responsible for mussels' distribution and assemblage. Various modules provide input information defining the environmental conditions in the domain (Fig.1), which becomes the forcing function driving mussels' response. An individual-based configuration model approach is used; this gives flexibility to account for individuals' heterogeneity in the population. At each time step, individual mussels evolve according to the outcome of various routines describing mortality, aging, growth, food competition, reproduction, larvae dispersion, and adult movement in search of suitable habitats.

MDM was used to investigate the effect of substrate and hydrodynamic conditions on freshwater mussels' distribution in a 10 km reach of Pool 16 UMR. The model successfully captured mechanisms of mussel bed formation (Fig.2). Suitable areas for mussel survival were identified based on substrate and hydrodynamic variables, particularly by the application of a substrate stability parameter. Simulating the hydrodynamic transport of mussel larvae it was possible to distinguish those suitable patches that can be accessed by the mussels and have the potential to evolve into mussel beds. It became clear that active mussel beds not only have to present suitable habitats, but should also be connected to the larvae dispersal routes.

The model was also used as a numerical experiment to explore the effect of food competition and it was observed that in food shortage conditions this can be a significant factor affecting population assemblage.

Invasive species effect was estimated in terms of food competition. Simulated survival rates of native mussels after zebra mussels infestation resemble empirically derived values by Hart et al. (2001). According to the simulation results, unionids may survive the zebra mussel infestation, despite important losses in biomass. However, this estimate only considers food competition and other factors are likely to worsen the situation for the native mussels.

MDM simulation integrates many sources of information, each with its own uncertainty derived from the quality and resolution of the input data. In addition, there is only limited mussel density survey data to verify the simulation results. For these reasons, the results are qualitative more than quantitative, but provide a framework for future research and applications.

The results presented in this paper demonstrate how MDM can be used to assess the potential impact of different stressors on long-term mussel population dynamics and consequently improve the current understanding of cause and effect relationships in such a complex system. The focus on development of the model was on application of basic principles to ensure generality (no case dependency) and facilitate transferability of the model concepts across disciplines. It was shown that even a simple model formulation can provide insightful information. In the future, MDM can be a useful tool for evaluating the effects of alternative management practices for freshwater mussel communities.

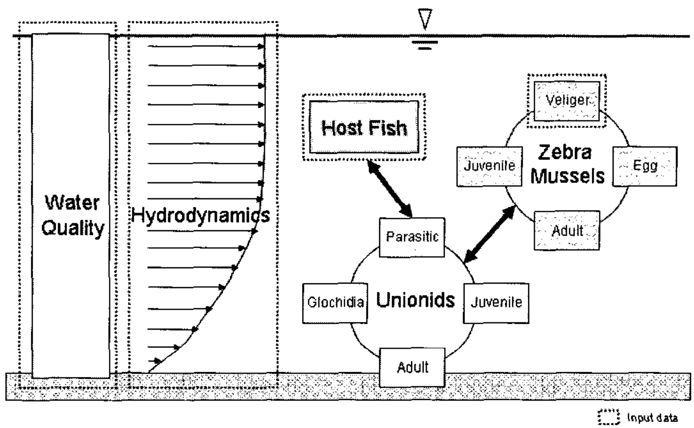

Fig. 1 Components of the Mussel Dynamics Model (MDM).

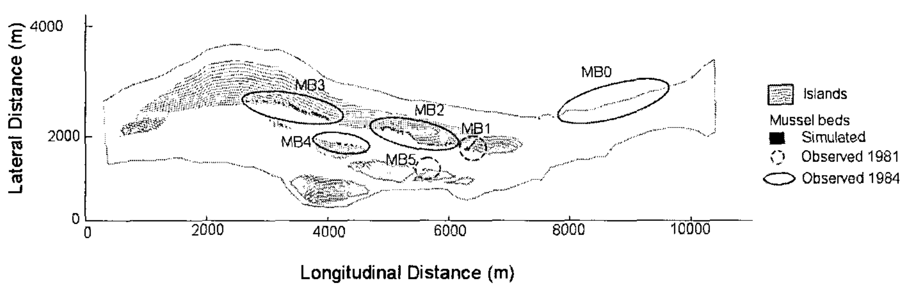

Fig. 2 Mussel accumulations after 1 year simulation.

REFERENCES

Hart, R.A. et al., 2001. Empirically derived survival rates of a native mussel, *Amblema plicata*, in the Mississippi and Otter Tail Rivers, Minessota. Am. Midl. Nat., 146(2), pp. 254-263.

Lydeard, C. et al., 2004. The global decline of nonmarine molluscs. BioScience, 54(4), pp. 321-330.

Morales, Y., Weber, L.J., and Mynett, A.E., 2003. An Individual Based Model for freshwater mussels of the Mississippi River. Proc. 30th IAHR Congress, Thessaloniki, Greece, Vol. 2, Inland waters: research, engineering and management, pp. 497-503.

Morales-Chaves, Y., 2004. Analysis of mussel population dynamics in the Mississippi River. Ph.D. Thesis, Civil and Environmental Engineering, University of Iowa, Iowa City.