

Title: Geomorphologic Modeling of a Macro-tidal Embayment with Extensive Tidal Flats: Skagit Bay, WA

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LONG-TERM GOALS

Understand morphology changes of mud tidal flats and provide quantification of the sensitivity of these changes to tidal action, river discharge and shoreline development.

OBJECTIVES

Demonstrate the use of a community numerical model for estimating the tidal flat morphology. The ONR/Delft Community model is being evaluated as a physically-based numerical simulation tool for several kinds of investigations. The objective of the project is to further demonstrate its use for tidal flat/channel systems.

Investigate the relative roles of tidal action, river discharge and shoreline development on morphology. From a model tuning perspective, this objective includes advancing the understanding of the sensitivity of the model to parameter value adjustments and inclusion or exclusion of specific sediment transport processes and characterization in tidal flat and channel systems.

Integrate model analyses with observations and field planning efforts. The model fidelity will be improved by incorporation of observational data in terms of model configuration, the assignment of boundary and initial conditions and for calibration and validation efforts. There is also a benefit to using the model to help with the design of the field programs and the interpretation of observational datasets. This has been demonstrated in other studies (e.g. Hibler, et al, 2008).

APPROACH

A three-phase approach will be used. All phases are model configuration and evaluation intensive. In the first phase the model was configured with best available information. Sensitivity tests were conducted on variations on discharge to circulation in the Skagit Bay. In the second phase,

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adjustments to the model will be made to intensify focus in portions of the bay where field activities have occurred and where they are planned to occur in the future (see Figure 1). Incorporation of the observational dataset will enable further model improvement. In the third phase, final model evaluation and the incremental phased improvement assessment will be completed and reported upon.

This work will build upon what has been reported for numerical modeling of geomorphology (Lesser, 2004; Tonnon, 2007; van Duin et al. 2004; Van Rijn et al 2007; and Marciano et al. 2005). The sensitivity analysis of will focus on bottom type classification (sediment type, vegetation coverage, etc.) and its impact on sediment transport through bottom roughness parameter variation. Process studies on idealized channels will be conducted as needed.

Both Mr. Lyle Hibler and Dr. Adam Maxwell will conduct model simulations. Lyle Hibler will focus on project management, model experimental design, circulation modeling, reporting and interaction with other program participants. Adam Maxwell will focus on carrying out numerical experiments, sediment transport and morphology, and data visualization and management.

WORK COMPLETED

Work completed since work was the project was initiated (May 1, 2008) includes development of the initial mesh (see Figure 1) and incremental refinements guided by preliminary results and consideration of the sampling plans provided by other program investigators (Dr. Jamie MacMahan at the Naval Postgraduate School, Dr. Britt Raubenheimer at Woods Hole Oceanographic Institute, and Dr. Jim Thomson at UW/APL). Preliminary simulations focused on likely conditions during August and September 2008 for coincident field programs.

RESULTS

We have begun to quantify the sensitivity to Skagit River discharge rates of estimated drifter trajectories in one study region (in Skagit Bay near the mouth of the North Fork of the Skagit River). We have learned that in order to provide the most relevant estimates to the program, we need to refine our model mesh with finer resolution near the field studies sites (i.e. to begin to resolved select tidal channels). We anticipate that the nominal resolution in these area will be $O(10m)$. In order to achieve this, we will need to use the model options including mesh decomposition or nesting as well as incorporation of higher resolution bathymetry. The current computational mesh, simulated particle clouds for low and high river flow rates are shown in Figure1. This figure also includes simulated drifter tracks at possible NPS drifter release points (planned for September, 2008), UW/APL's in situ instrument arrays (planned for June,2009) and WHOI's CTD and ADV (August, 2008) field sites. Figure 2 shows the simulated drifter tracks and particle clouds using predicted September 23, 2008 tides and a range of Skagit River flow rates (200 and 800 m^3/s).

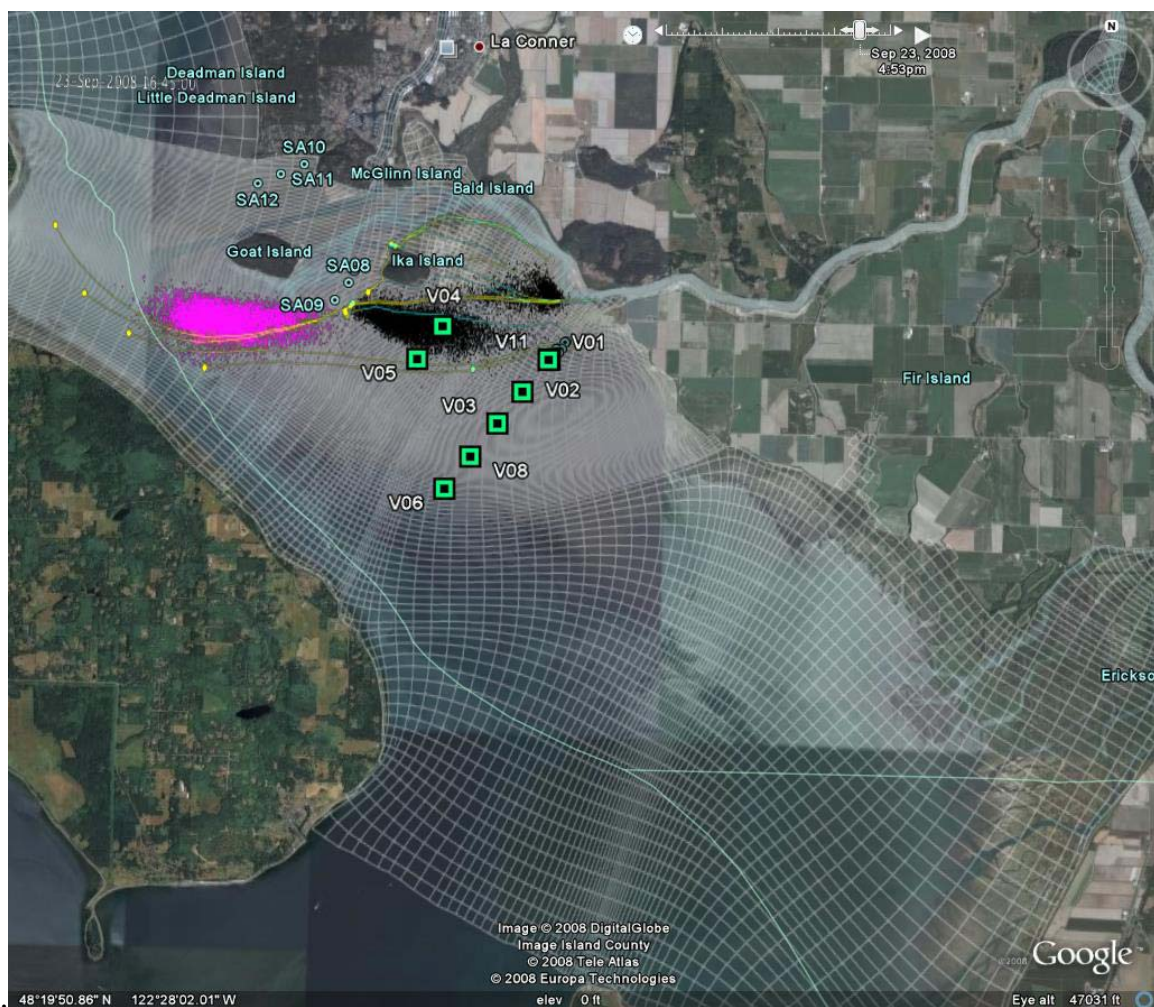


Figure 1. Computational mesh developed in Phase 1 with large river discharge (pink) and low river discharge (black) particle clouds. Locations labeled V are the WHOI 8/2008 field sites, the location labeled SA are the planned UW/APL 6/2009 field sites. The green and yellow lines are simulated surface drifter tracks place in region close (Craft Island) to planned drifter release by NPS.

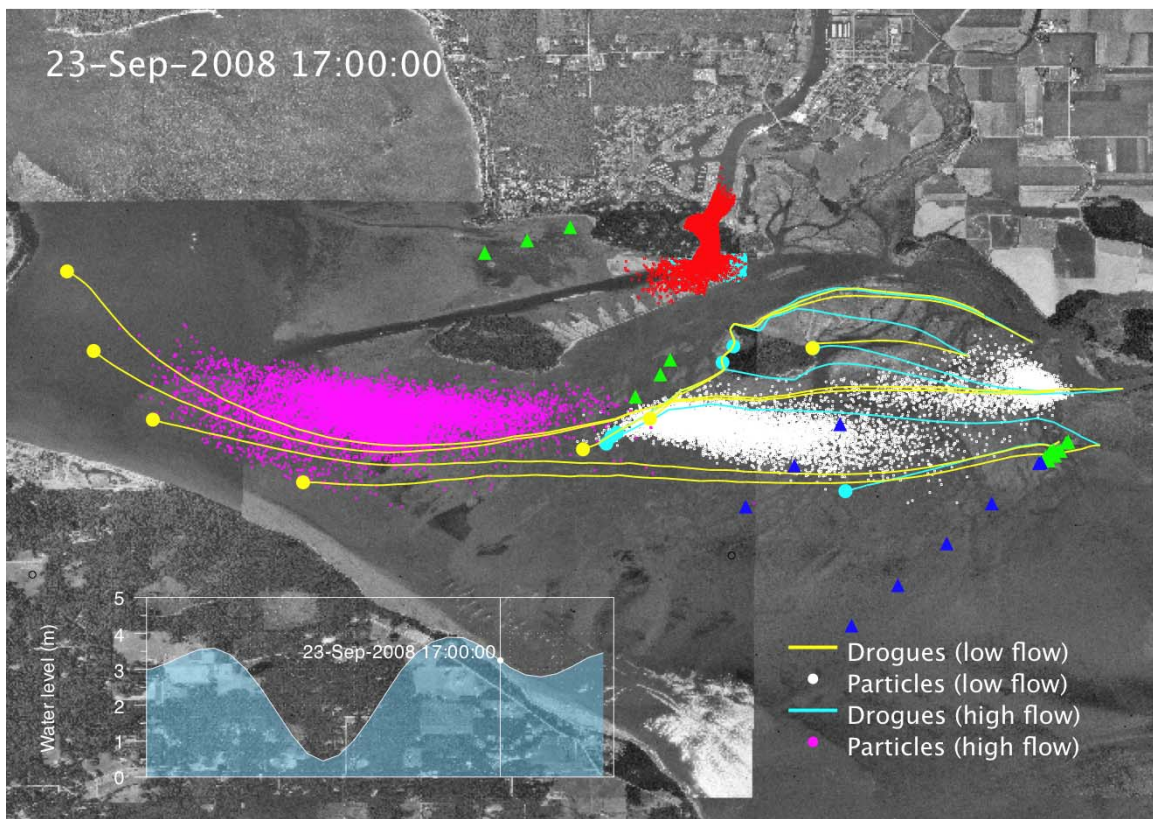


Figure 2. Simulated drifter tracks and particle clouds for high (magenta) and low (white) Skagit River flow conditions. WHOI instrument locations are shows as blue triangles and UW/APL instrument locations shown as green triangles.

IMPACT/APPLICATIONS

The potential future impact from this work will be that the ONR/Delft community model will be further evaluated for geomorphological simulation in an enviroment that is of interest to the Office of Naval Reseach and in DoD-Navy where the software is already being used for other applications.

RELATED PROJECTS

Modeling work is concurrently being done to support a program entitled *Observations and Modeling for Source Characterization* (N000140810508) with Dr. Mark Moline at(<http://www.marine.calpoly.edu/auv/>) and in collaboration with Dr. Eric Terrill at Scripps Institution of Oceanography, and Dr. Ap Van Dongeren at WL|Deltares. Lyle Hibler and Adam Maxwell will be using the same numerical modeling software to investigate the circulations Southern California coast with focus on San Diego Bay and the Tijuana River under subcontract to California Polytechnic State University. Integration of modeling efforts with observational datasets will be the focus of this effort.

REFERENCES

Hibler, L.F., A.R. Maxwell, L.M. Miller, N.P. Kohn, D.L. Woodruff, M.J. Montes, J.H. Bowles, and M.A. Moline, (2008). Improved fine scale transport model performance using AUV and HSI feedback in a tidally dominated system, *J. Geophys.Res.* Vol. 113, C08036,doi: 10.1029/2008JC004739.

Lesser, G. R., J. A. Roelvink, J. A. T. M. van Kester, and G. S. Stelling. 2004. Development and validation of a three-dimensional morphological model. *Coastal Engineering* 51, 883-915.

Tonnon, P. K., L. C. Van Rijn, D. J. R. Walstra. 2006. The morphodynamic modeling of tidal sand waves on the shoreface. *Coastal Engineering* 54, 279-296.

van Duin, M. J. P., N. R. Wiersma, D. J. R. Walstra, L. C. van Rijn, and M. J. F. Stive. 2004. Nourishing the shoreface: observations and hindcasting of the Egmond case, the Netherlands. *Coastal Engineering* 51, 813-837.

van Rijn, L. C. 2007. Unified view of sediment transport by currents and waves. II: Sediment transport. *Journal of Hydraulic Engineering*. 133(7), 668-689.

van Rijn, L. C. 2007. Unified view of sediment transport by currents and waves. III: Graded beds. *Journal of Hydraulic Engineering*. 133(7), 761-775.

van Rijn, L. C., D. J. R. Walstra, and M. van Ormondt. 2007. Unified view of sediment transport by currents and waves. IV: Application of morphodynamic model. *Journal of Hydraulic Engineering*. 133(7), 776-793.

PUBLICATIONS

Hibler, LF and AR Maxwell. 2008. Simulating particle dispersion in a tidal flat and channel system: Skagit Bay, (USA). America Geophysical Union Fall Meeting. San Francisco,CA. December 12-16.[submitted]