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Morphodynamic Feedbacks during Vegetation Colonization of Tideflats

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Award Number: N00014-08-1-1008
http:// www.tidalflats.org/

LONG-TERM GOALS

The long-term goal of this effort is to understand interactions and feedbacks between biotic and physical process in tideflat morphodynamics. Investigated biotic processes consist primarily of vegetation colonization of tideflats. Physical process include those related to hydrodynamics, such as flow, sediment transport, salinity regime, inundation period, wave/storm disturbance, flood disturbance.

OBJECTIVES

1. To describe early vegetation colonization process in sandy tideflats. This would include determining rates of change, vegetation species involved, successional patterns (if any), and changes in tideflat biophysical structure, e.g., canopy density and height (in anticipation of these parameters being used in hydrodynamic models).

2. To discern physical controls on the colonization process, e.g., topography, sediment quality, hydrodynamics, salinity regime.

3. To discern physical consequences of vegetation colonization, e.g., direct and indirect topographic responses, including possible channel formation or stabilization and changes in sediment quality.

APPROACH

The project approach includes GIS change analysis, RTK-GPS topographic surveys, a space-for-time substitution sampling design, quantification of vegetation and sediment quality, and development of conceptual and statistical models of colonization processes and consequences.

GIS change analysis was used to identify patterns and rates of channel change and vegetation development. It included analysis of orthophotos from 2004, 2006, 2007, and 2009 with pixel resolution ranging from 15cm to 45cm.

RTK-GPS topographic surveys identified the topographic circumstances that characterize the locations of various species of marsh vegetation, on new islands as well as reference marshes. Additionally, these surveys (at 0.25 to 1.0 m grid resolution depending on island size, and 2 cm horizontal, 3 cm vertical accuracy) identified topographic features and patterns associated with colonizing vegetation, e.g., U-shaped scour channels and island lee deposition tails. GIS will be used to generate TIN representations of island topography along with the adjacent tidal flat.

WORK COMPLETED

The project is focused on small, incipient, marsh islands in tidal flats near the outlet of the principal distributary of the North Fork Skagit River (Fig. 1). Most of these islands are located in a region where the course of the distributary outlet has recently been very dynamic. This year follow-up RTK-GPS surveys were made of 3 incipient marsh islands ranging in size from $0.64m^2$ to $1180m^2$ to evaluate change in vegetation and topography from last year. Three other islands could not be re-surveyed because they had eroded away. Analysis and synthesis of results, including comparisons of topography using GIS tools and development of a vegetation model, is ongoing. Additionally, a paper on predicting the stability and size of delta distributaries was published in the journal *Geomorphology* (see "Publications" below). This paper focused on the distributaries of the North Fork delta of the Skagit River, an area where several other investigators working on the Tidal Flats DRI are also working; consequently the paper is likely relevant to their work.

Figure 1. General location of the study area (yellow rectangle), relative to the principal distributary of the North Fork Skagit River. Photo is from the spring, 2009.

RESULTS

Historical aerial photos from 1956 to 2006 (eight photos: 1956, 1965, 1972, 1980, 1990, 2000, 2004, 2006), without exception, show the study area distributary continuing straight on its course from the tidal marsh across the tidal flats. However, in 2007 the channel suddenly changed course at a nearly right angle to the west (Fig. 2). Observing eight photos without a significant change in channel course

is probable ($P > 0.10$) only if the straight course occurs at least three times more frequently than the westward-bending course. The likely cause of the sudden shift in the course of this distributary appears to be a large windstorm on 15-16 November 2006 which sustained winds from the south-south east (148-153 degrees) of 80 to 100 km/h for 10 hours, with gusts up to 115 km/h. River flow during this storm was 2-3 times mean annual flow. Most of the incipient marsh islands investigated in this study are located in this area of recent channel dynamics. Fieldwork in 2010 indicates significant changes in channel course are continuing and these may also be related to wind forcing (Fig. 3). The cut bank of the distributary bend has an interesting break where the east half of the bank has moved north, encroaching on the older channel course, while the west half of the bank has moved south and west. Either the river is dropping sediment in the east half, sediment is being pushed from the bay flats into the east half by waves, or both are occurring. Additionally, three of the small study island in this are were eroded away by channel migration. Channel migration has also changed the angle at which current flow is impinging on two other study islands and this is affecting island topography and vegetation colonization, but this data has not yet been analyzed.

Figure 2. Comparison of the course of the study area distributary across the tidal flats. North is to the top of each frame. The main course of the distributary flows straight toward the SW in 2006, but bends to the west in 2007. The lower right frame illustrates growth in a point bar (X) from 2007 to 2009, which caused the channel bend curvature to tighten and the channel bend to migrate slightly. Digitized channels are limited to larger tide flat channels. Secondary tide flat channels diminish in some areas (Y) and disappear entirely where the main course of the distributary was located in 2006 and earlier years (Z). Note high elevation of dry sandy areas in the 2009 photo, as indicated light gray color in the point bar and opposite bank, indicating significant accumulation of sediment in these areas.

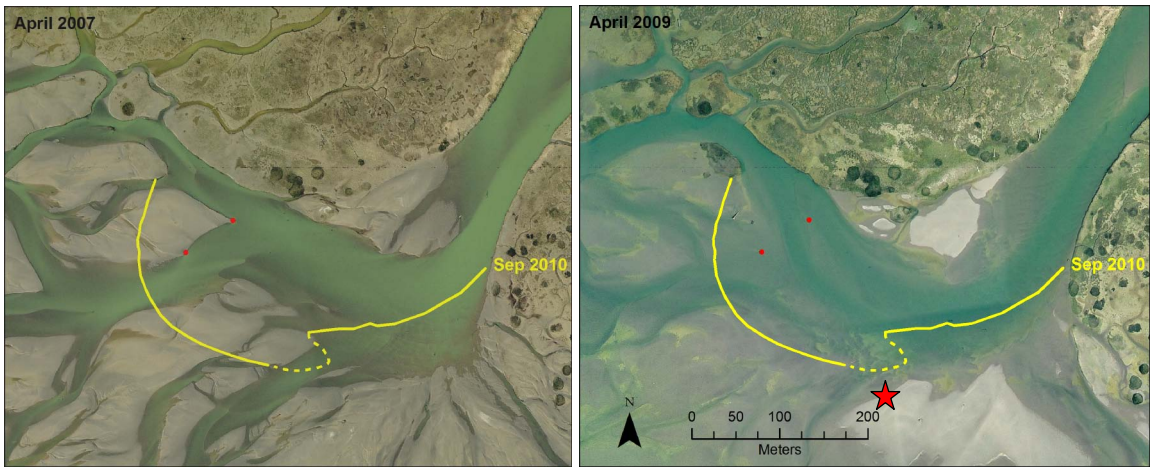

Figure 3. Yellow lines indicate location of distributary bank at low tide as measured with RTK-GPS. Background photographs indicate channel change relative to 2007 and 2009. Red dots indicate location of a couple of study islands that no longer exist. The red star indicates the location of a persistent island that is about 30 cm higher in elevation than other study islands of comparable size, suggesting sediment deposition.

Vegetation change has been observed for the largest two islands studied (Fig. 4) and the patterns of change are consistent with a developing conceptual model where an initial, relatively stable vegetated island that is exposed to flow produces and leeward tail of sedimentary deposits that facilitate further vegetation colonization, not necessarily through vegetative growth of existing vegetation, but through additional colonization. Islands that have been abandoned by a distributary through channel migration do not have a depositional tail (the tail has been dissipated through tidal ebbs and floods) and so they either grow very slowly or not at all.

Changes in island topography, including the depth and orientation of associated scour channels have also been observed, likely a result of ongoing changes in the course of the local distributary, but these data have not yet been analyszed. Distributary dynamics appear to be important to the development of island topography and vegetation colonization and this interaction will be further developed as work progresses.

Figure 4. Vegetation change in the largest of the studied islands from 2009 to 2010. Green points are Carex lyngbyei, blue are Schoenoplectus americanus, white are very low density S. americanus, red are unvegetated sand. Note also that dramatic shoaling is occuring in the tidal channel in the NW corner of the image.

IMPACT/APPLICATIONS

This project will generate measurements of parameters that can be used to model hydrodynamics and sediment transport in the presence of intertidal vegetation. It will also generate conceptual models and hypotheses that can be used to focus future investigations and model development. In addition to immediate application to development of hydrodynamic models, this work will provide useful insights and guidance for system management, e.g., [1] to anticipate and plan for the effects of sea-level rise and other climate-change effects on system hydrodynamics, sediment dynamics, and landscape-scale ecology; [2] to plan for potential habitat restoration, particularly the restoration of historical river distributaries in the delta; or [3] to anticipate system impacts from engineering efforts, such as a system-scale flood management project proposed by the US Army Corps of Engineers.

RELATED PROJECTS

This project is related to other DRI projects (http://www.tidalflats.org/) located in the Skagit Delta, particularly those involving Jim Thomson and Chris Chickadel (Applied Physics Laboratory, University of Washington), Eric Grossman (USGS, Santa Cruz), Steve Henderson (Washington State University), and Brit Raubenhiemer and Steve Elgar (WHOI) all of whom are working in the North Fork area.

This project has also spawned interest in pursuing the influence of wind forcing on distributary dynamics and submission of an NSF proposal on this topic under the lead of James Lerczak (Oregon State University) with collaboration by Britt Raubenheimer (WHOI), Steve Elgar (WHOI), and myself.

REFERENCES

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PUBLICATIONS

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