Hydrodynamics and Sediment Transport at River Mouths under the Interaction of Tides and Waves

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Rivers and estuaries are habitat to ecologically important species of fish, invertebrates, and macroalgae. Understanding tracer transport and diffusion (dilution) is critical for predicting water quality or for larval recruitment. For many organisms in rivers and estuaries, environmental conditions such as stratification, turbulence, or other water properties present primary controls on their viability.

New River Inlet (NRI) system consists of a backbay (approximately 68km2) and a relatively narrow (200 m wide) and shallow (~3 m depth) inlet adjacent to the Atlantic Ocean This study focuses on how the interaction between waves and strong tidal current near the inlet can change the pattern of wave and current fields and the resulting sediment transport.

Dye experiment performed by Matt Spydell and Falk Feddersen (Scripps) in May 2012; Photo presented here is provided Gordon Farquharson (APL-UW).

1. Hydrodynamics in New River Inlet

The dominant mechanisms controlling stratification and scalar (e.g. pollutant, nutrient and sediment) transport processes are owing to circulations/currents associated with the interaction between tides, waves and bathymetry as well as freshwater riverine outflows [Dalrymple et al., 1992].

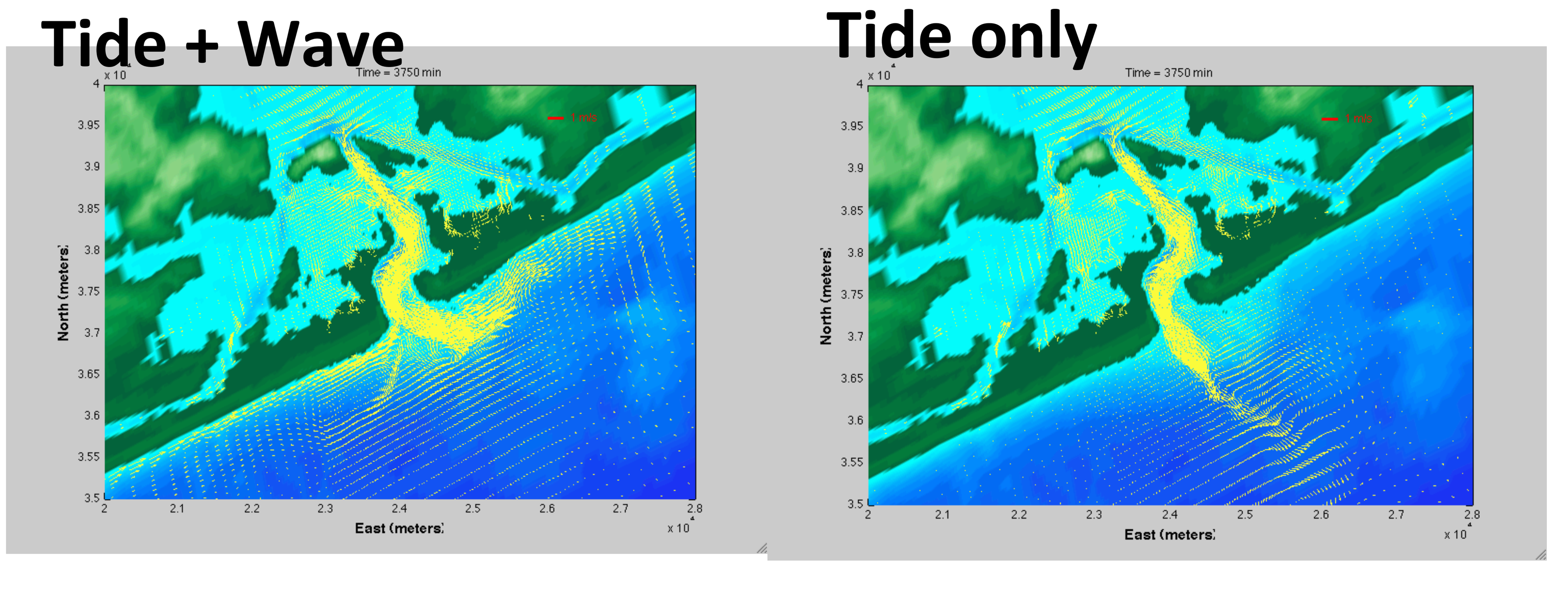

Figure 1: (a) The residual flow intensity under the representative tidal constituent and wave conditions : (a) The flow field driven by tidal and wave forcing. (b) The flow field forced only by Tide.

2. Sediment transport in New River Inlet

During a spring-tide large-wave condition with waves incident from the southeast, sediment flux in the southwestern (deeper) channel is enhanced seaward of the ebb shoal (extending beyond the 6 m bathymetric contour), relative to the flux simulated without waves. However, when waves are incident from the southwest, the enhanced transport in the adjacent ebb tidal delta is less significant.

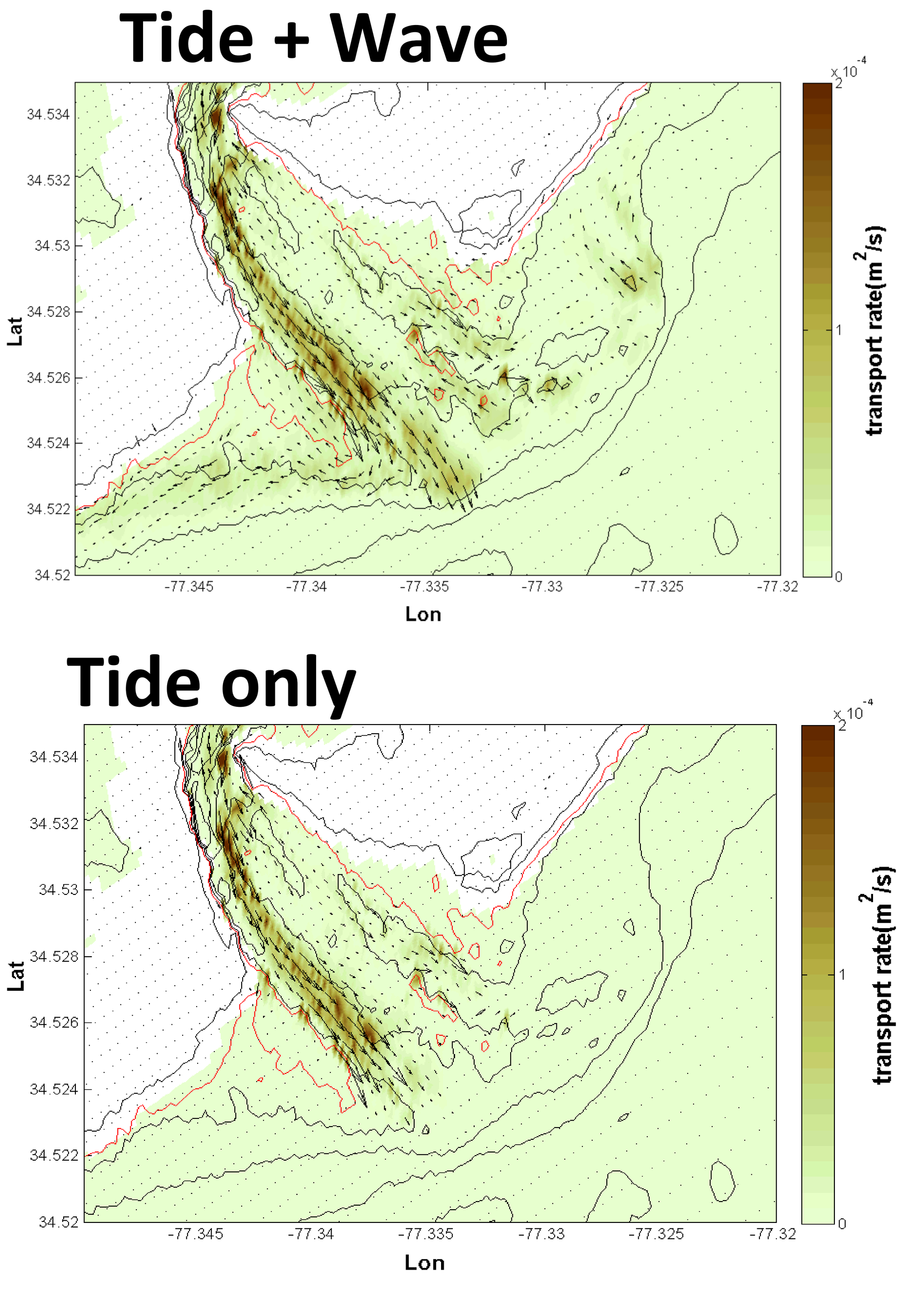

Figure 2 (a) The tidally-average residual sediment transport fluxes under the representative tidal constituent and wave conditions. (b) Results driven by tidal forcing only. The solid lines indicate the contour line of 0, 2, 4, 6, and 8m depth. The red contour line (1m depth) indicates the shallower region which can also be observed from the photo. Photo presented here is provided Gordon Farquharson (APL-UW).

3. The bottom friction parameterization with wave-current interaction

The simulated flow field is very dynamic under the effect of tides and waves. To characterize the transitional region from the near-field to far-field of a flow jet entering coastal waters, three surveys were conducted using an autonomous underwater vehicle (AUV) .

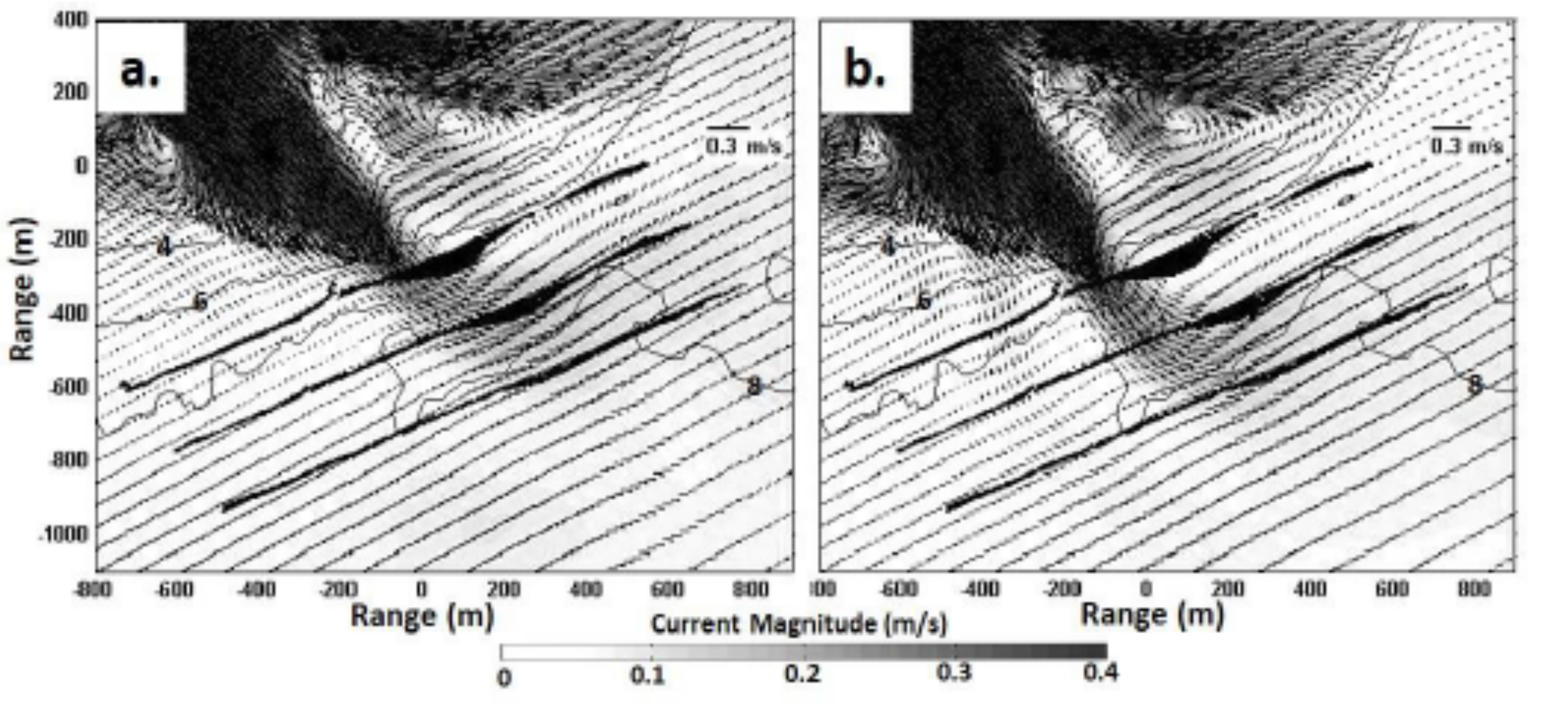

Figure 3. Depth-averaged velocity model output (black arrows, high-resolution grid) overlaid with depth-averaged AUV velocity outputs for transects 1–3 (dark black arrow) for the (a)17 May 2012 and (b) 19 May 2012 surveys. Bottom friction for current flow only is assumed for model runs. Numbers denote contours in meters.

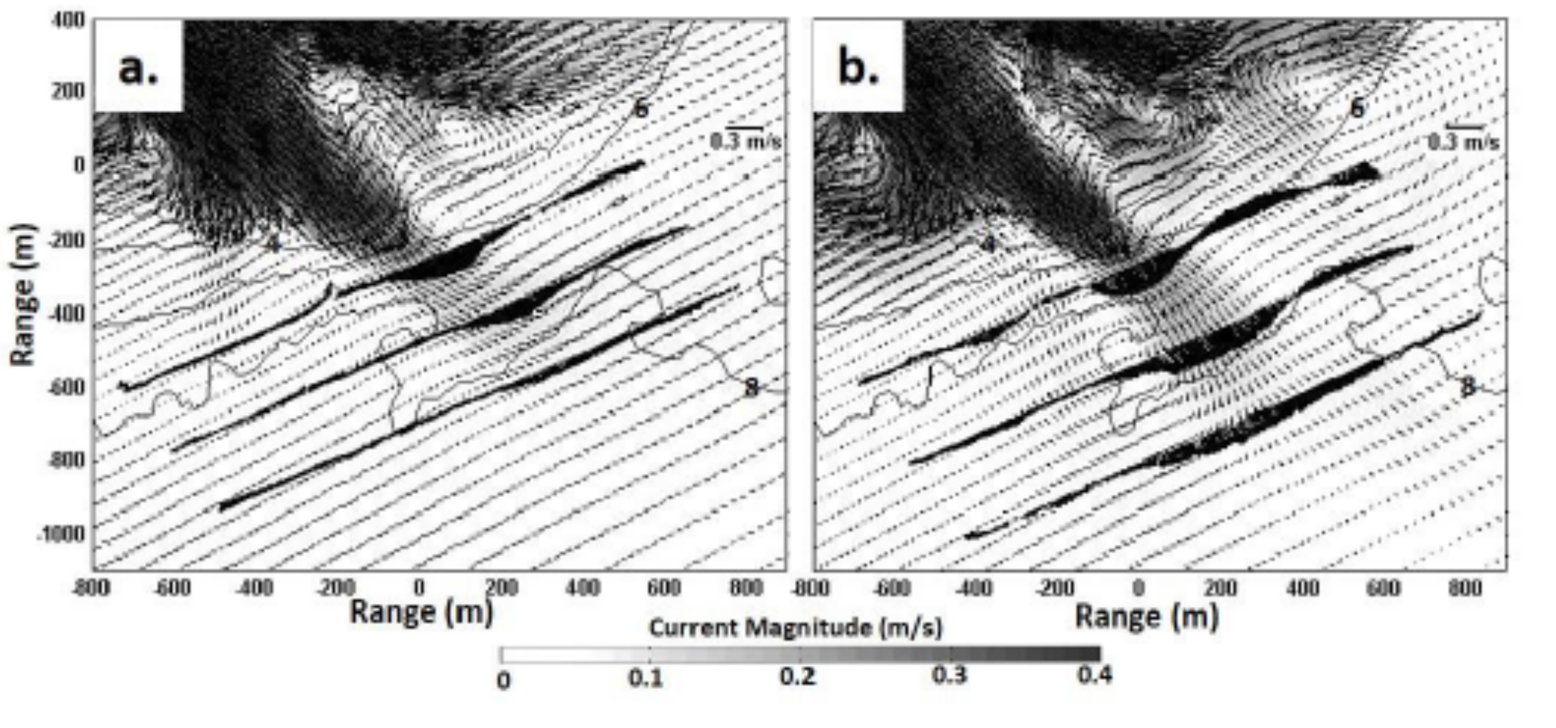

Figure 4. Depth-averaged velocity model output (black arrows, high-resolution grid) overlaid with depth-averaged AUV velocity outputs for transects 1–3 (dark black arrow) for the (a) 17 May 2012 and (b) 19 May 2012 surveys. Bottom friction in random waves plus current flow is assumed for model runs. Numbers denote contours in meters.

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Research Interests:
Hydrodynamics in Rivers and Estuaries;
The Impacts of Human Activities on Water Resources;
Turbulent Mixing; Water Quality; Sediment Transport

Chen's research focuses on combining advanced numerical models with observations to facilitate the prediction and risk management of natural hazards, under the current and future challenges of climate change.