Using Simulated Dye Releases to Examine Wastewater Effluent Transport in Casco Bay

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Introduction:

As population and aquaculture rapidly grow along Maine's coastlines, monitoring the environmental influence of coastal development and associated wastewater remains a challenge for local governments. As of 2021, Maine still does not have the capacity to properly manage populations of most wild shellfish species throughout its coastline (Webber et al. 2021).

The Casco Bay Estuary:

Below are the hydrodynamic regimes in western Casco Bay which drive residual circulation (Sinnet 2012) and therefore may play a significant role in determining residence times of water parcels around the outfall site:

- Portland Channel (PC) [well-mixed barotropic seaward flow from western bay; seasonally consistent flow regime]
- Hussey Sound (HS) [stratified bidirectional flow within central bay; seasonally-varied exchange between bay and shelf]
- Presumpscot River Mouth (PRM) [fresh barotropic flow into western bay; seasonally stronger in winter/spring – can strengthen PC outflow]

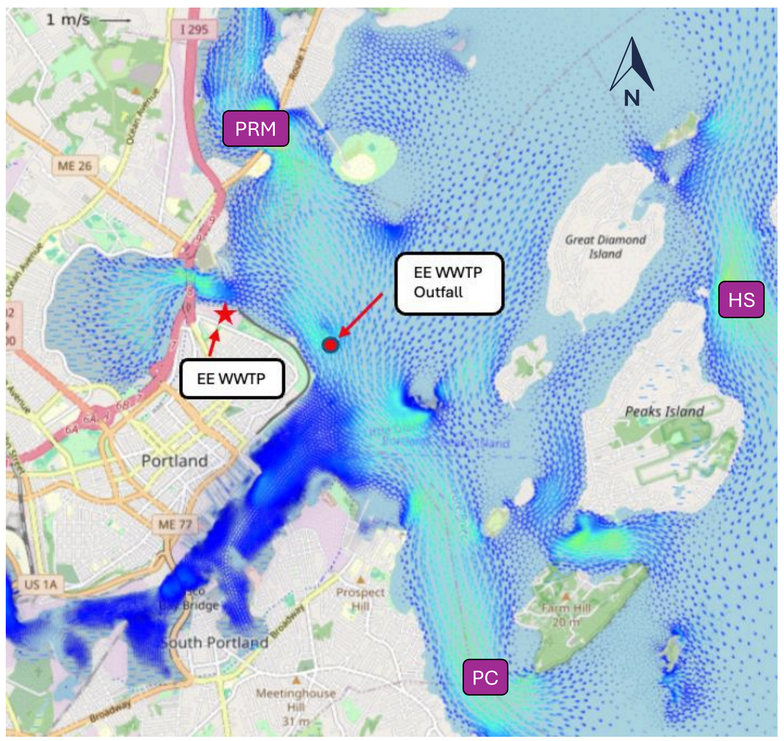


Figure 1. Chart of area around the East End Wastewater Treatment Plant (EE WWTP) outfall within Casco FVCOM model domain. Vectors indicate predicted speed and direction of surface currents at 04:00 on 08/18/2026. The EE WWTP and its outfall are indicated by a red star and circle respectively. Significant inlets/outlets for wastewater transport are labeled in purple.

Study Goal:

Inform shellfish industry constituents about the circulation of wastewater within Casco Bay and provide a framework for data-informed conditional openings and permanent closures of the surrounding mudflats.

Specific Objectives

1. *Simulate the spatial extent of effluent from the East End Wastewater Plant outfall, the largest wastewater discharger in Maine, using a high-resolution model of Casco Bay*

2. *Identify the regions of western Casco Bay most likely to be exposed to wastewater effluent under seasonally-mean and extreme storm conditions*

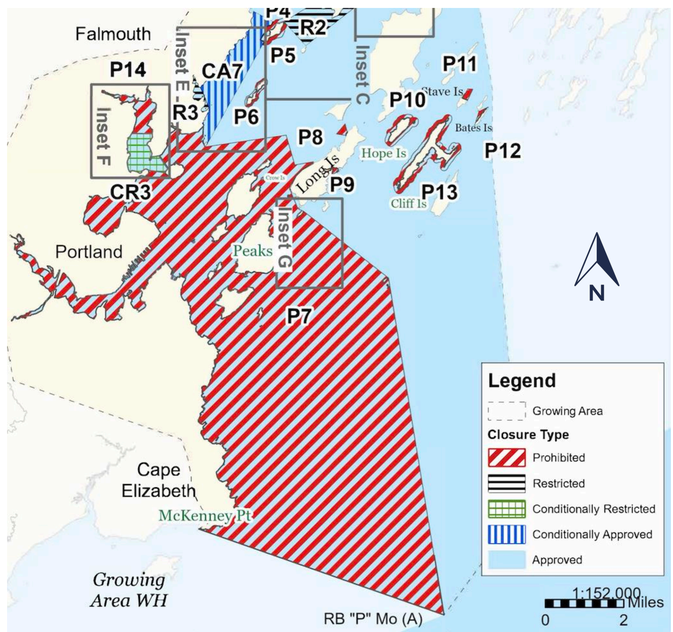
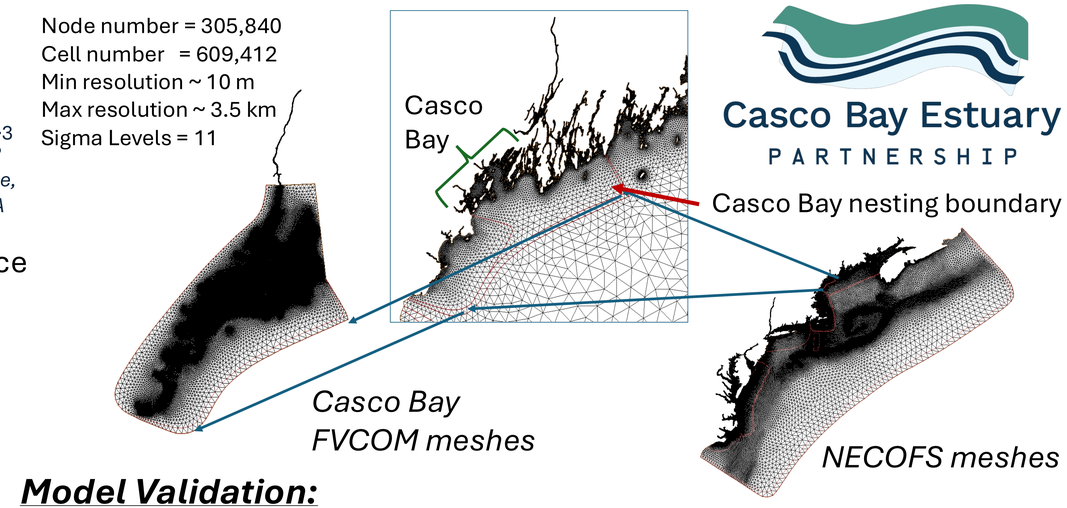


Figure 2. Closure regimes of Shellfish Growing Area WI. Adapted from Maine DMR 'Bacterial Notice Map' for WI region: https://www.maine.gov/dmr/sites/maine.gov.dmr/files/closures/WIMaps.pdf?v=070226



Model Validation:

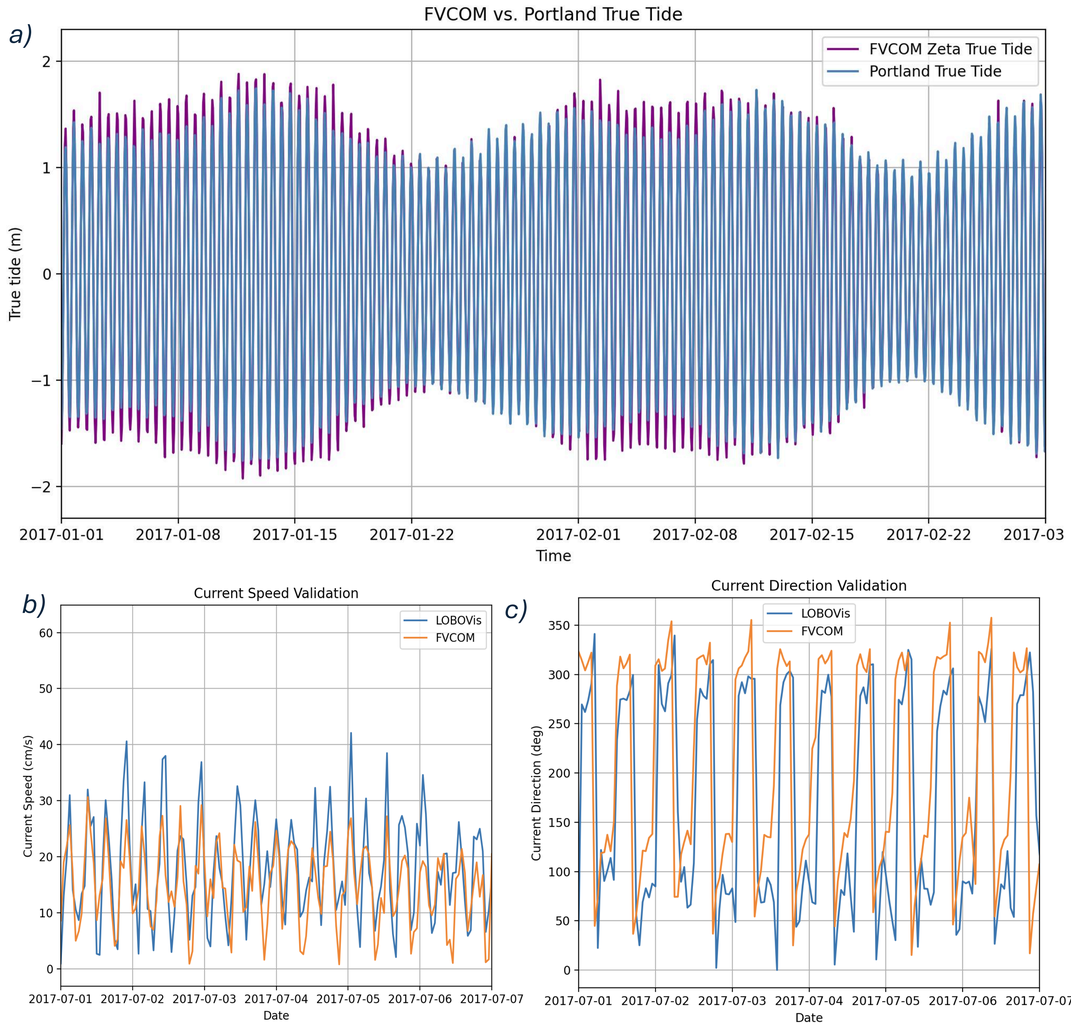


Figure 3. Model validation demonstrating that FVCOM can accurately simulate sea surface height at the Portland tidal gauge (R^2 = 0.9858) but has some difficulty simulating current speed and direction in more inland regions of the Casco Bay estuary. **a)** Tidal validation between measured tides and predicted sea surface height in FVCOM at the Portland tidal gauge. Mean tide difference between FVCOM Zeta True Tide and Portland True Tide: 0.0012 m. **b)** FVCOM current speed and **c)** direction tested using LOBO data collected in the New Meadows River near Bombazine Island. RMSE between measured and simulated current speed: 7.923 cm/s. RMSE between measured and simulated current direction: 107.0 deg.

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References:

- Evans, K. S., Athearn, K., Chen, X., Bell, K. P., & Johnson, T. (2016). Measuring the impact of pollution closures on commercial shellfish harvest: The case of soft-shell clams in Machias Bay, Maine. *Ocean & Coastal Management*, *130*, 196–204. https://doi.org/10.1016/j.ocecoaman.2016.06.005
- Sinnett, Gregory H., "Circulation and Transport in Casco Bay, Maine" (2012). Electronic Theses and Dissertations. 1786. http://digitalcommons.library.umaine.edu/etd/1786
- Webber, M. M., Stocco, M., Schmitt, C., & Tenga-González, K. (2021). The Maine Shellfish Handbook.