Influence of Storm Surge Barrier on Residence Time

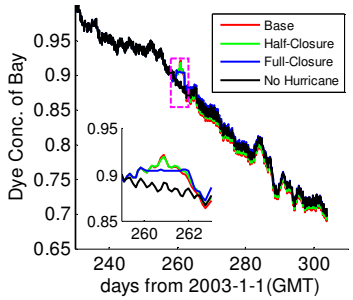
VIMS | William & Mary
Virginia Institute of Marine Science

Residence time is one of the key parameters to quantify overall dynamic condition of an estuary. Nixon et al. (1996) suggest that the retention of and export of nutrients are controlled by the residence time. The retention time is a key parameter that controls nutrient budgets in estuaries. We investigated the influence of a storm surge barrier on change of residence time. We also examined the change of freshwater transport time, which is represented by the water age (Shen and Wang, 2007), due to the use of a temporary and permanent storm surge barrier.

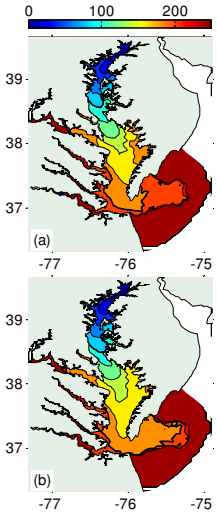
- A short-term closure of the Bay mouth during the storm surge period has a minor impact on residence time.
- A large permanent storm surge barrier will result in a decrease of freshwater transport time. The change of the transport time near the mouth is about 5-10 days. The 200-day contour is moved far outside of the estuary.

We used a conservative tracer to simulate residence time. The tracer was released inside the bay at Day 230, 30 days before hurricane Isabel. Closure of the Bay mouth occurred during Days 260-262.

- The residence time is estimated as the time corresponding to the total mass decrease to the fraction of e^{-1} (e-fold).
- Total mass increased during the storm as outside water began moving into the Bay.
- A short-term closure of the Bay mouth during the storm has minimal impact on residence time.



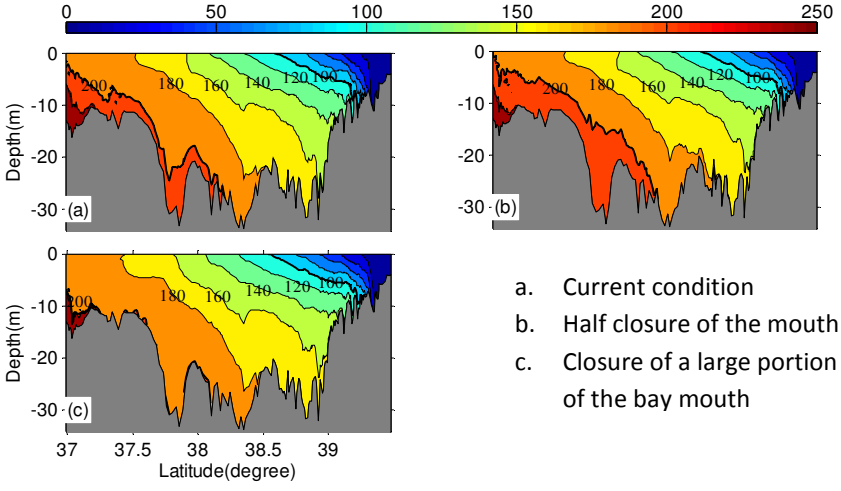
For a large permanent storm surge barrier with two open deep-water channels, water in the surface layer moves rapidly out of the Bay because of a decrease of tidal mixing. The 180-day contour can reach to the mouth and the 200-day contour is located far outside of the mouth.



Current condition

With large permanent storm surge barrier

In the case of a hypothetical permanent storm surge barrier, the transport time of the freshwater, which is indicative of residence time, will be altered. The magnitude of change depends on the barrier size. With half closure of the Bay mouth, the transport time of the bottom water increases near the mouth. However, the transport time decreases with closure of a large portion of the Bay mouth. The 200-day contour moves further downstream. The different responses of the estuary to the size of the storm surge barrier need more study.



a. Current condition
b. Half closure of the mouth
c. Closure of a large portion of the bay mouth

References: Nixon et al 1996. Biogeochemistry 35,141e-180; Boynton et al. 1995. Estuaries 18, 285-314; Shen and Wang, 2007. ECSS. 74,750-763