Assessing 2035 Climate Change Risks to TMDL in the Rappahannock River using SCHISM

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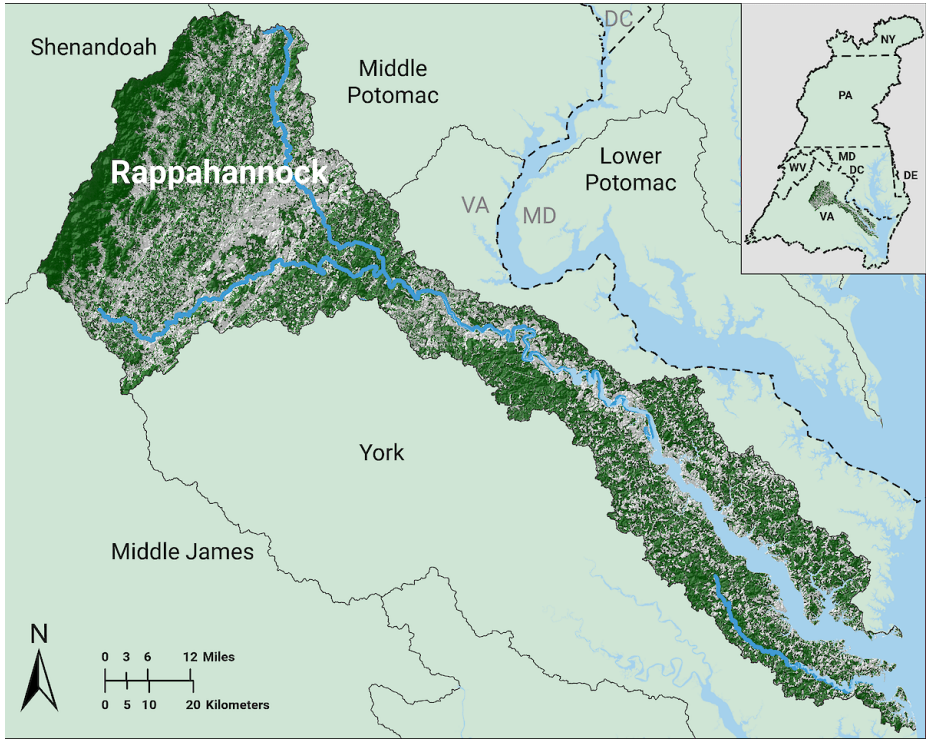
Introduction

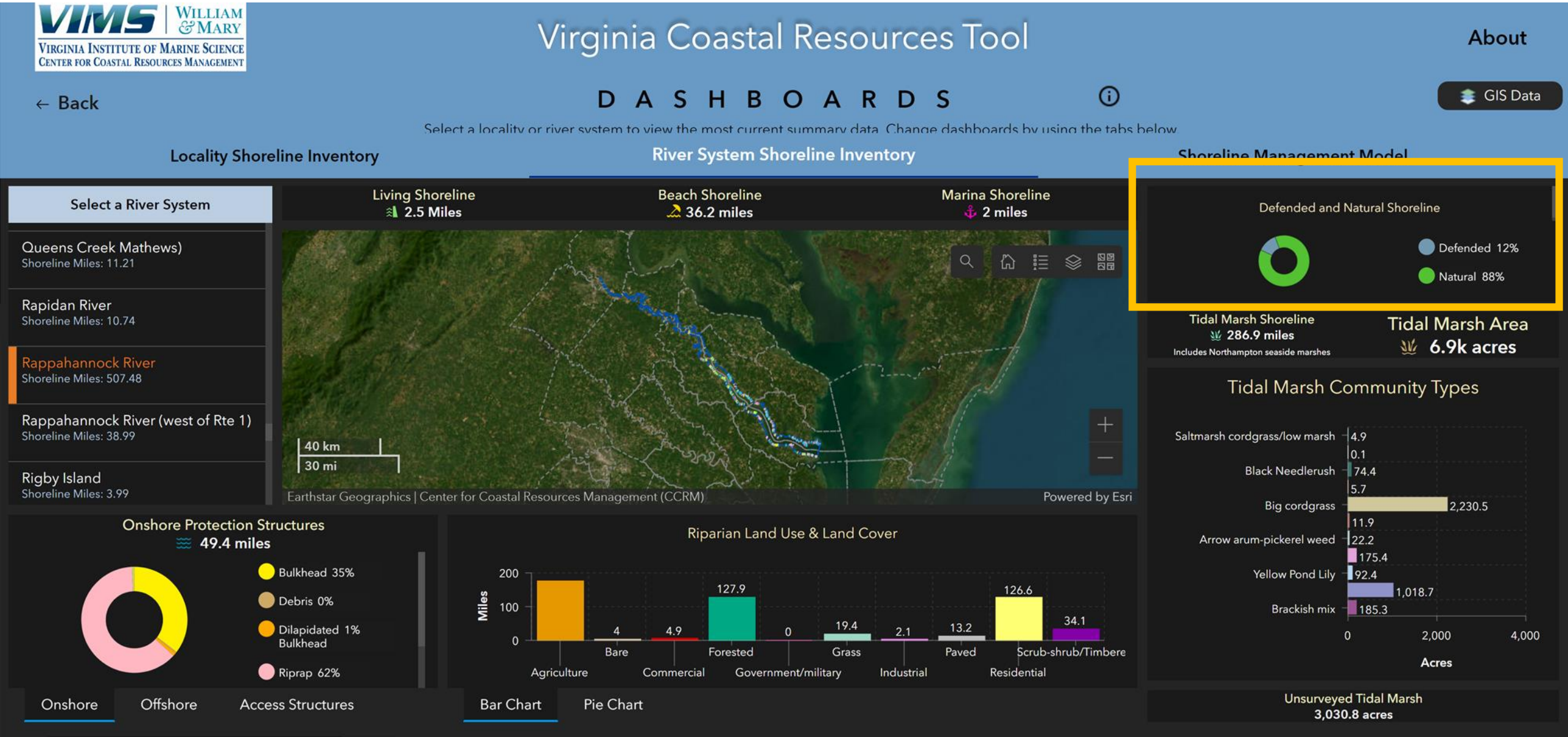
- The Rappahannock River is the longest free-flowing river in Virginia



https://ecoreportcard.org/report-cards/chesapeake-bay/watershed-regions/rappahannock/

Introduction

https://cmap22.vims.edu/VACoastalResourcesTool



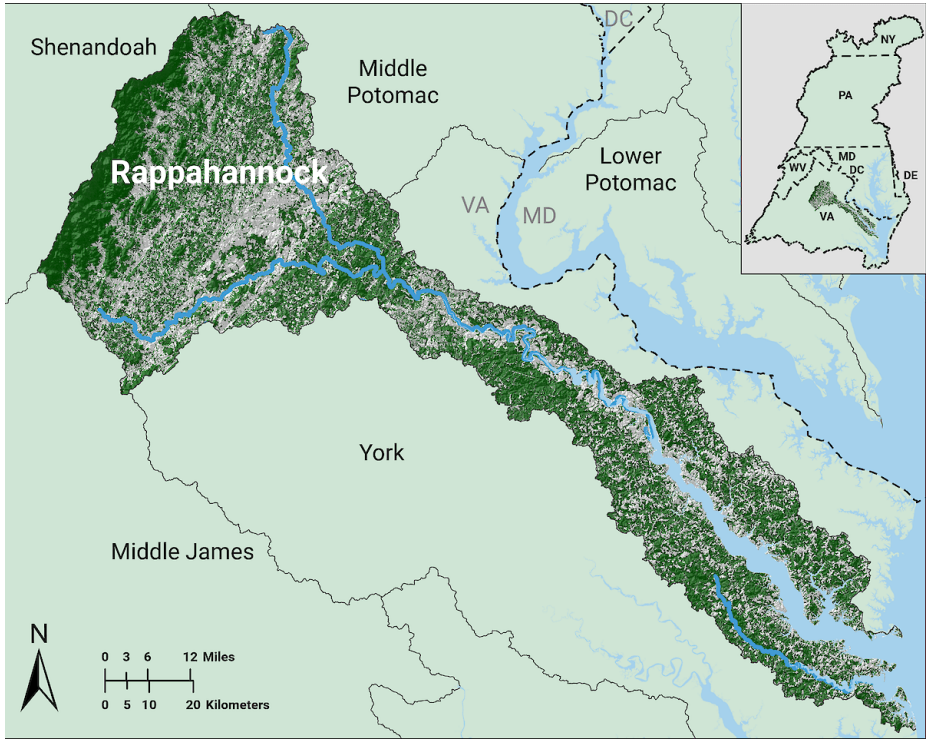
Introduction

- The Rappahannock River is the longest free-flowing river in Virginia
- Limited studies on the water quality
  - Kuo and Neilson (1987):

    hypoxia in the lower portion, which is affect by the exchange between the river and the bay
  - Llansó (1992): hypoxia impacts the benthic community
  - Moore et al. (2001): SAV has been degrading
  - Devereux et al. (2021) – EPA CBP study:

    summer bottom oxygen have degraded in the lower river over 1985-2018;

    long-term trends of other water quality state variables



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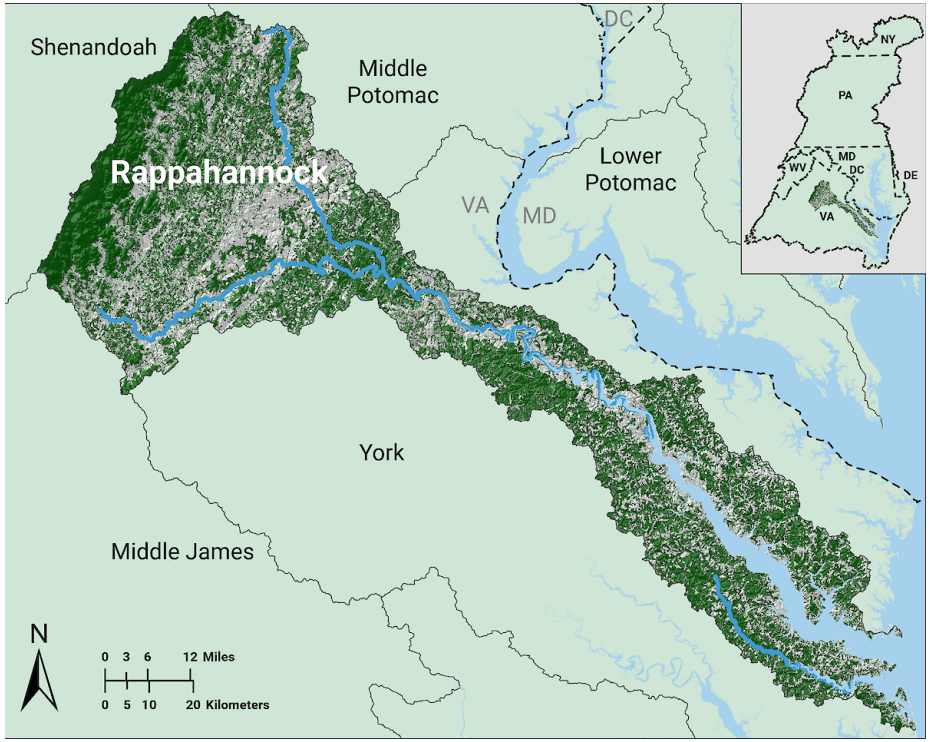
Introduction

- The Rappahannock River is the longest free-flowing river in Virginia
- Limited studies on the water quality
- Limited studies using numerical models
  - Park et al. (1996) developed a hydrodynamic model to explain the occurrence of hypoxia in the river
  - Shen and Kuo (1996, 1998) developed an inverse water quality model for the Rappahannock River
  - Gong et al. (2009) developed a structured grid hydrodynamic model using EFDC to discuss the impact of wind on the water age in the Rappahannock River
  - Sturdivant et al. (2013) developed a simplified model for the lower Rappahannock River and showed that hypoxia negatively affects macrobenthic biomass



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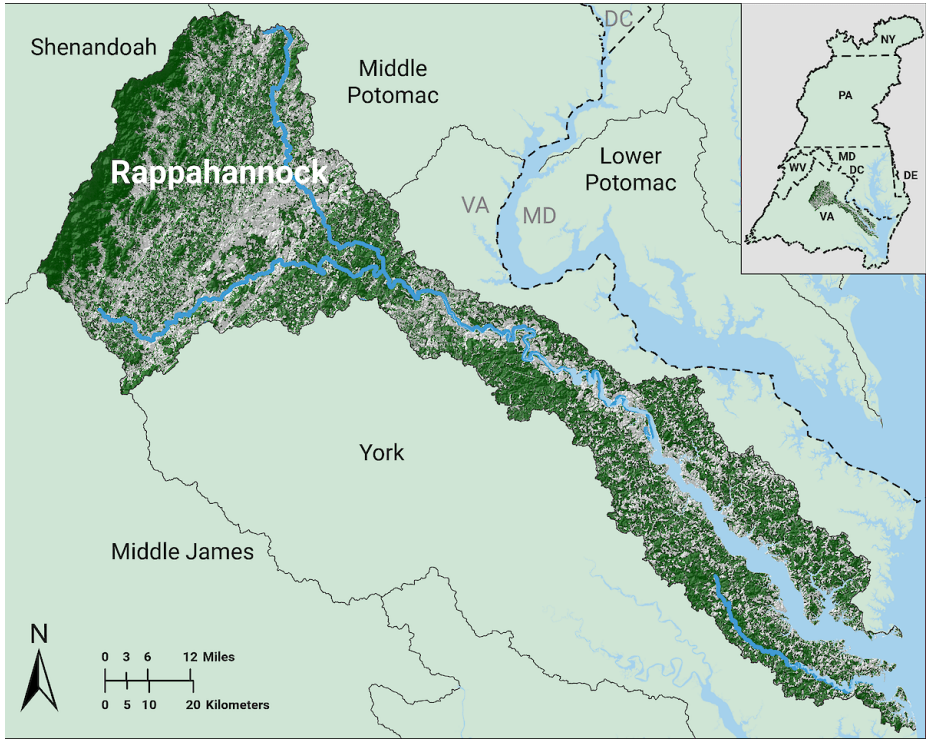
Introduction

- The Rappahannock River is the longest free-flowing river in Virginia
- Limited studies on the water quality
- Limited studies using numerical models
- Previous modeling studies by our team in the river
  - St-Laurent (Da et al. submitted) developed a ROMS model for the Rappahannock River to study water quality and acidity
  - Qin et al. (2022) developed the SCHISM model of the Rappahannock to assist Virginia DEQ and VMRC to assess the impact of freshwater withdrawal on larval transport



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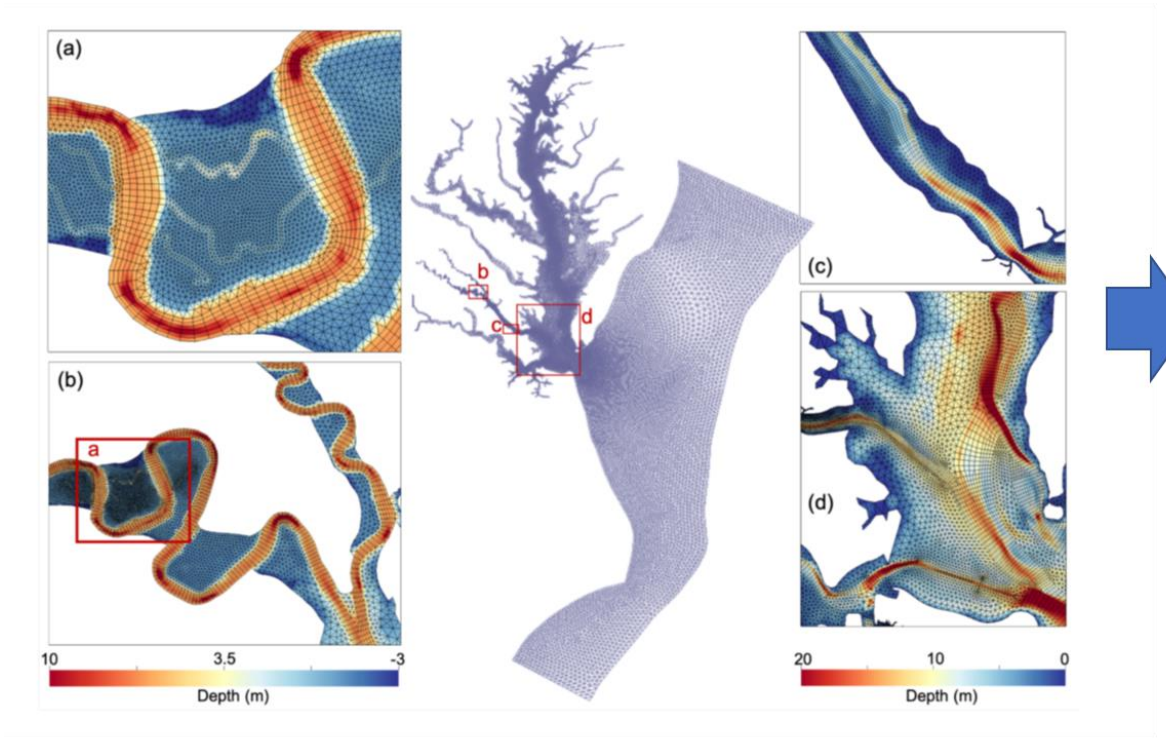
Objectives and tasks

- **Goal**: to develop and calibrate a high-resolution hydrodynamic-water quality model for the Rappahannock River, which will enable us to investigate and assess the water quality of the river.
- Specifically, we aim to use the model to forecast the potential risks to TMDL due to climate change by the year 2035.

- Task 1: revise the current MBM grid of the Rappahannock River and increase the resolution in accordance with Modeling Workgroup's recommendations and important dynamic properties of the river to ensure sufficient spatial coverage and resolution to represent the true geometry and bathymetry of the river.

Chesapeake Bay Model



Cai et al. 2022

Rapp. River Model

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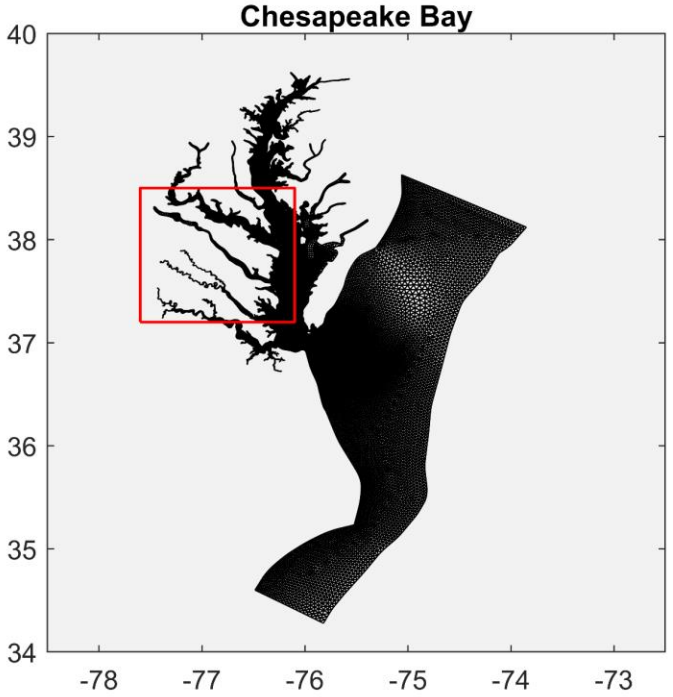
First, refine the Rappahannock River in the Bay model



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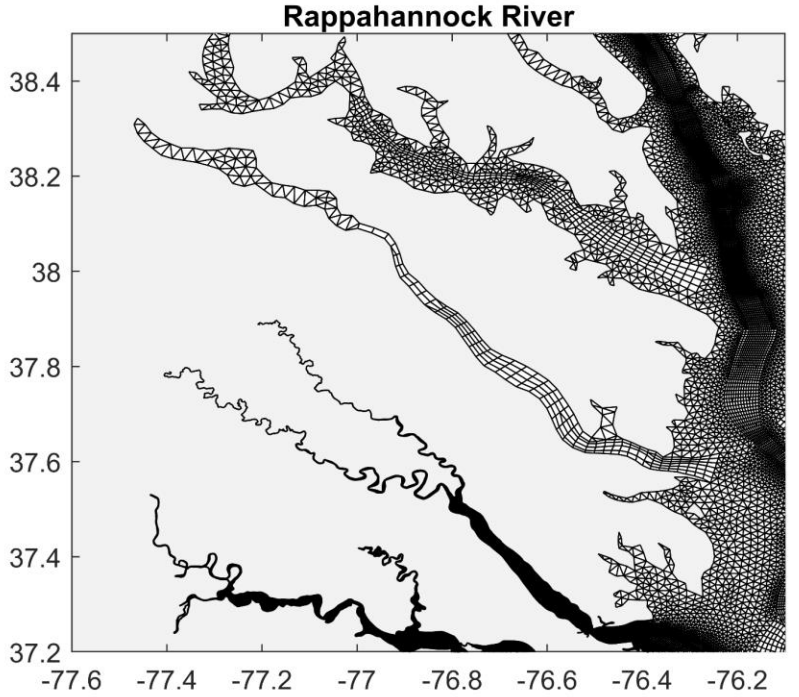

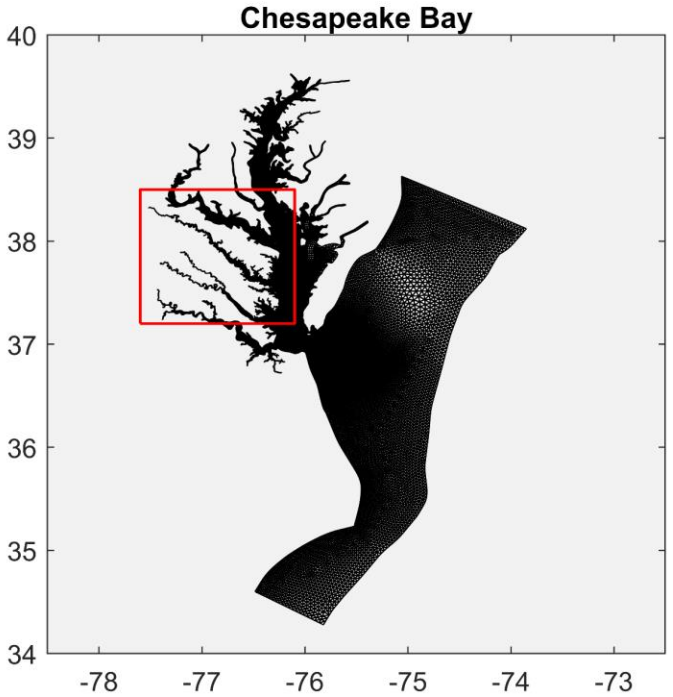

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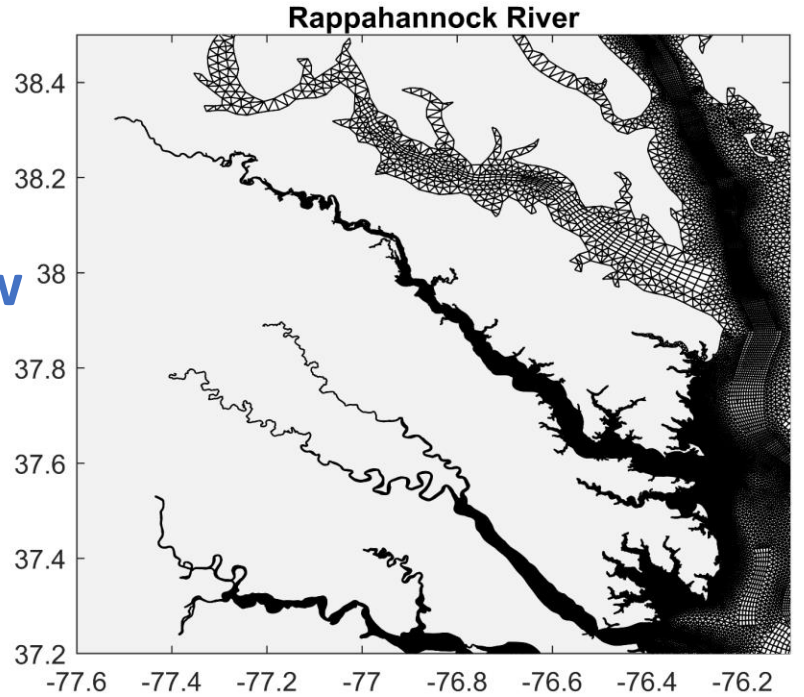
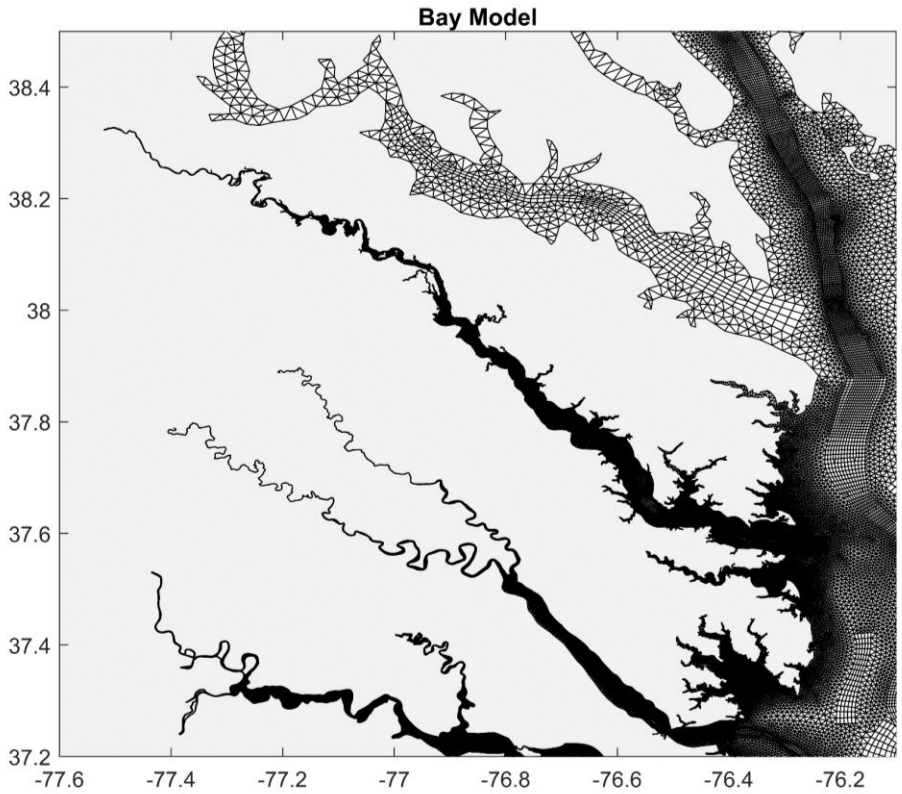
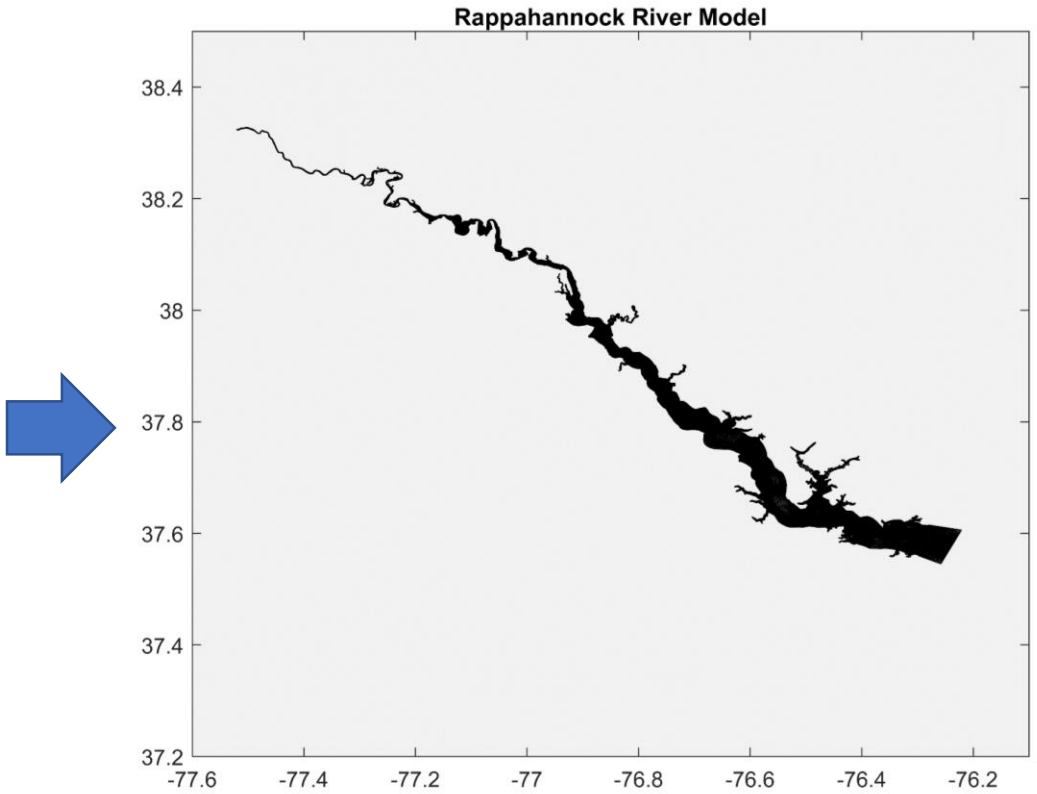


Second, cut out the Rappahannock River and use the large bay model to provide the boundary conditions





- Task 1: revise the current MBM grid of the Rappahannock River and increase the resolution in accordance with Modeling Workgroup's recommendations and important dynamic properties of the river to ensure sufficient spatial coverage and resolution to represent the true geometry and bathymetry of the river.
- Task 2: work with the MBM team to transfer of the latest version of the SCHISM-ICM model code and the open boundary conditions generated by the MBM. We will setup the model and test the tributary model. We will also provide feedback to MBM for any issues and required changes in tools used for model setup.
- Task 3: work closely with watershed, airshed, hydrological modeling groups to ensure proper execution of coupling, scaling, and interface mechanisms, as well as incorporating information on climate change and model biochemical parameters for the water quality model.
- Task 4: conduct full calibration and verification of hydrodynamic and water quality model.
- Task 5: understand the physical-biogeochemical processes in the Rappahannock River and conduct management and climate change scenarios.
- Task 6: document the findings and recommendations in the final report.
- Task 7: transfer of the software package to CBPO for operational testing. During this phase, we will collaborate with CBPO personnel to conduct tests on the model package in operational environments and address any issues that may arise.
- Task 8: disseminate our research findings and experiences via 1-2 journal papers each year.

Timeline

- Two phases
  1. 2023-2026 (three years):
     - development, calibration, and application of the Rappahannock River model

  2. 2026-2028 (two years):
     - a review of the CBP model in 2026
     - subsequent application of the model, scenario development, and analysis as directed by CBP decision-makers in 2027
     - documentation of the model