



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

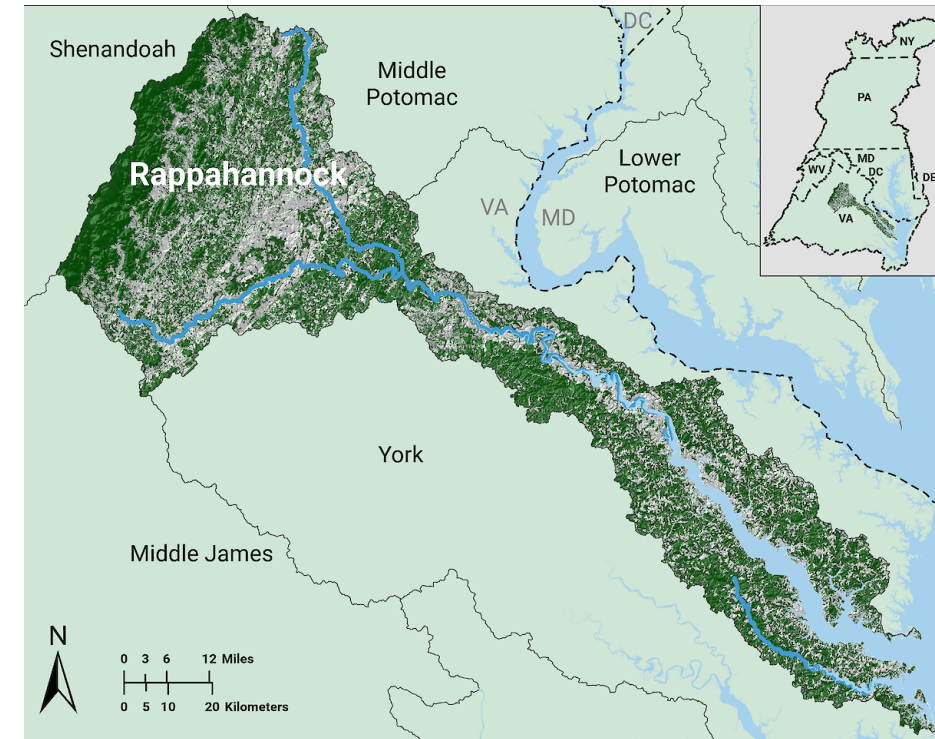


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Advisory team: Joseph Zhang and Marjorie Friedrichs

Introduction

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



Introduction

<https://cmap22.vims.edu/VACoastalResourcesTool>



Virginia Coastal Resources Tool

About

← Back

DASHBOARDS



GIS Data

Select a locality or river system to view the most current summary data. Change dashboards by using the tabs below.

Locality Shoreline Inventory

River System Shoreline Inventory

Shoreline Management Model

Select a River System

Queens Creek Mathews)
Shoreline Miles: 11.21

Rapidan River
Shoreline Miles: 10.74

Rappahannock River
Shoreline Miles: 507.48

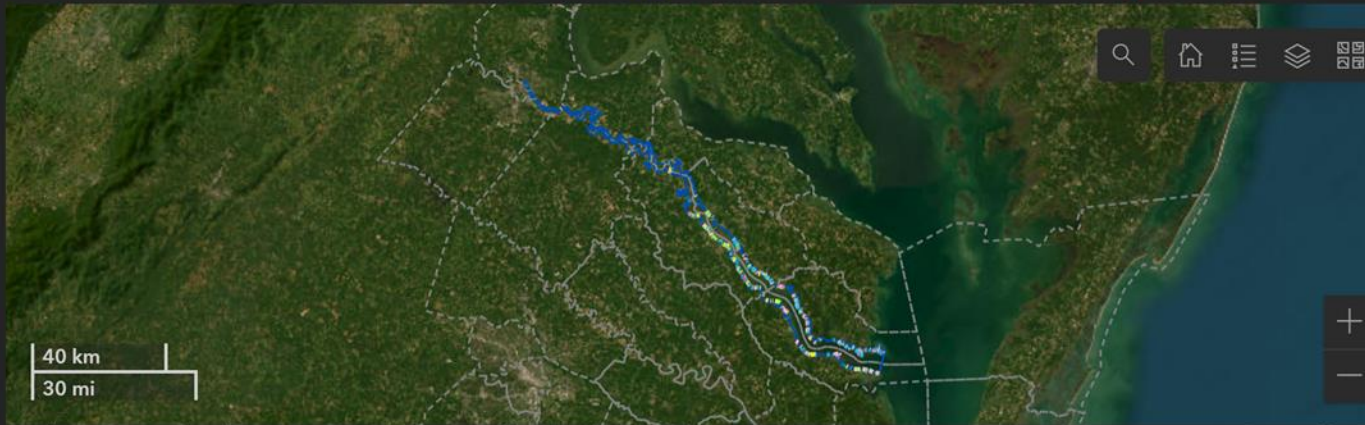
Rappahannock River (west of Rte 1)
Shoreline Miles: 38.99

Rigby Island
Shoreline Miles: 3.99

Living Shoreline
2.5 Miles

Beach Shoreline
36.2 miles

Marina Shoreline
2 miles



Earthstar Geographics | Center for Coastal Resources Management (CCRM)

Powered by Esri

Defended and Natural Shoreline



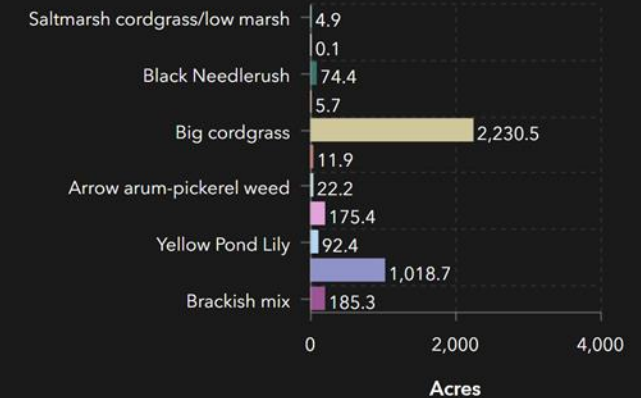
Defended 12%
Natural 88%

Tidal Marsh Shoreline
286.9 miles

Includes Northampton seaside marshes

Tidal Marsh Area
6.9k acres

Tidal Marsh Community Types



Unsurveyed Tidal Marsh
3,030.8 acres

Onshore Protection Structures 49.4 miles



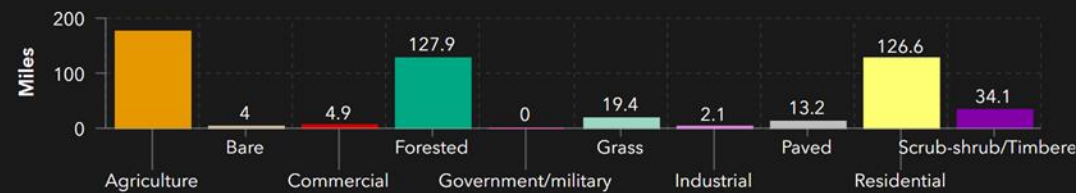
Bulkhead 35%
Debris 0%
Dilapidated Bulkhead 1%
Riprap 62%

Onshore

Offshore

Access Structures

Riparian Land Use & Land Cover

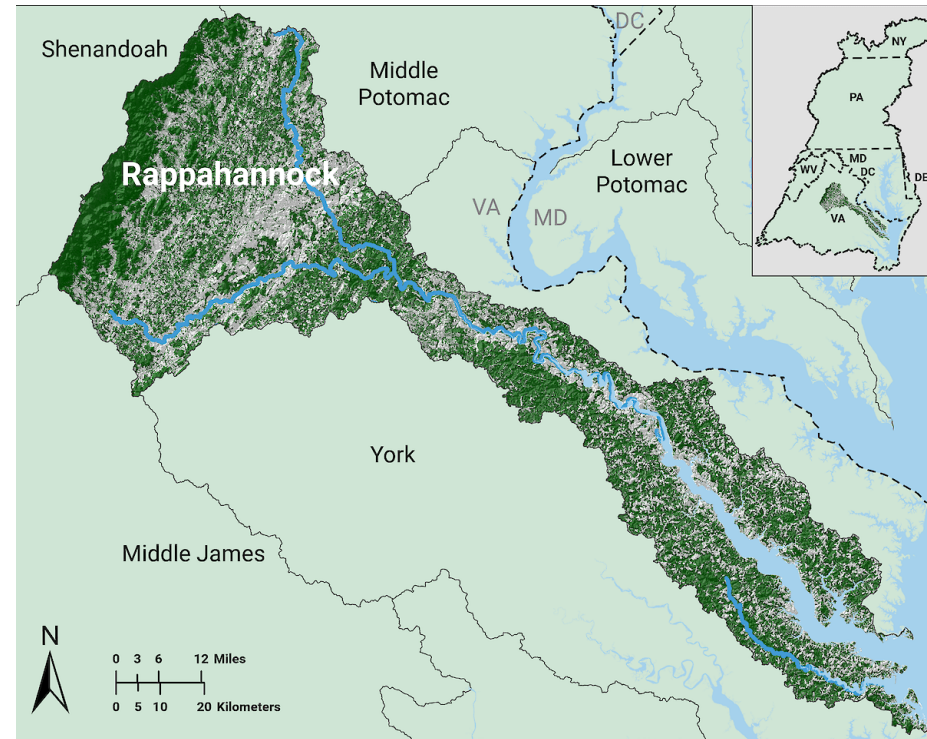


Bar Chart

Pie Chart

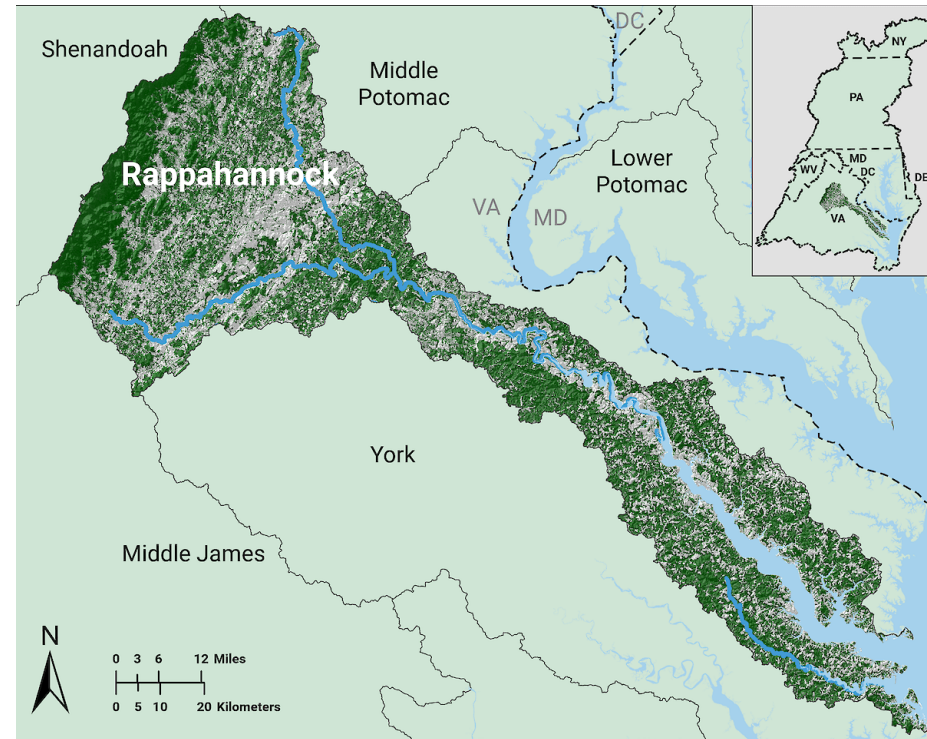
Introduction

- 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 affected 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



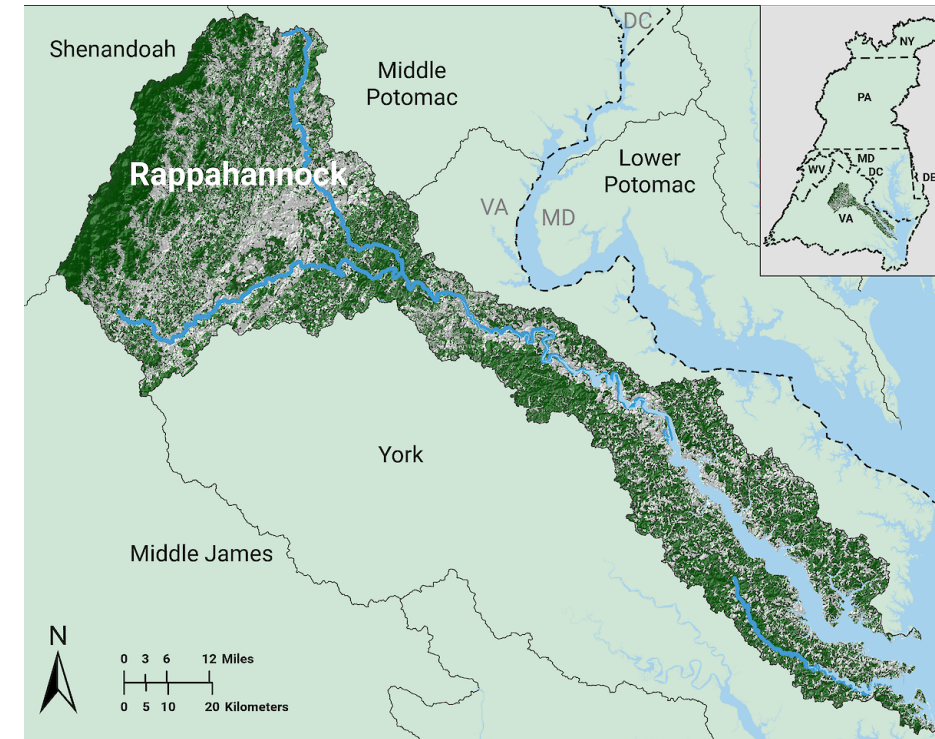
Introduction

- 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



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

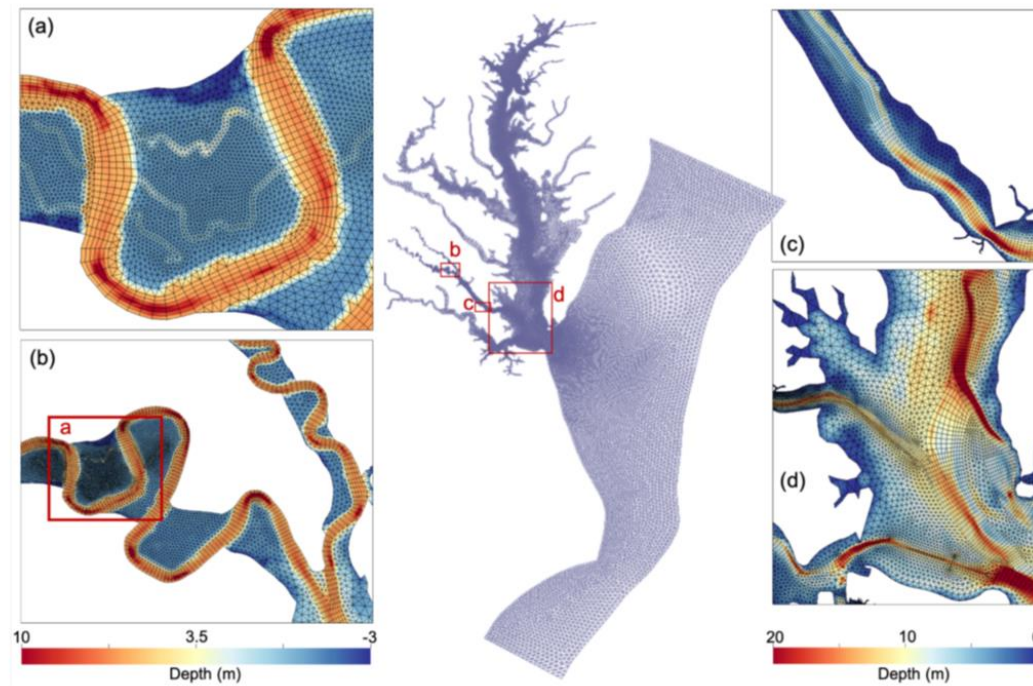


Objectives and tasks

- **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



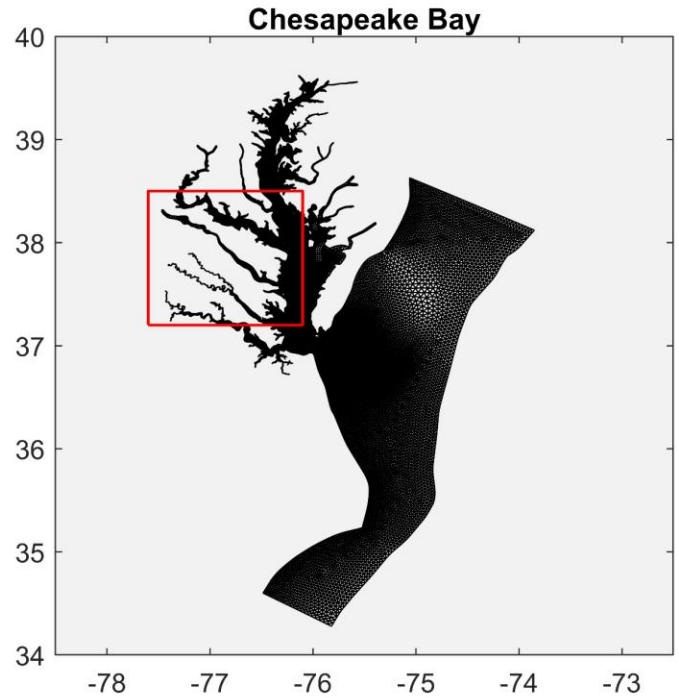
Cai et al. 2022

Rapp. River Model

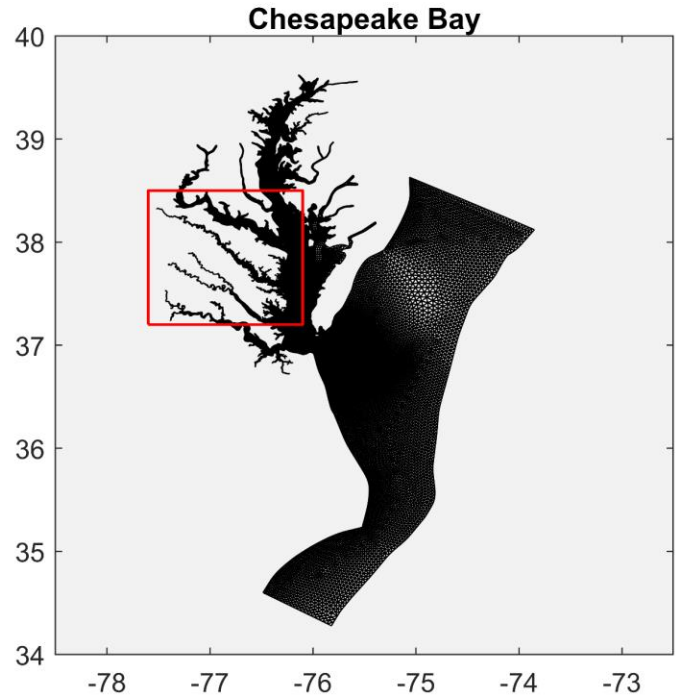
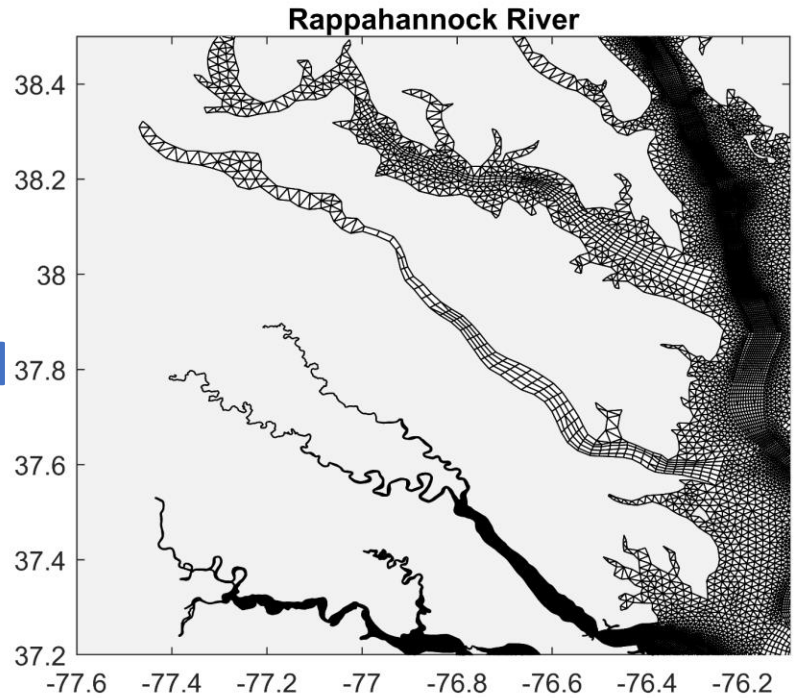


<https://ecoreportcard.org/report-cards/chesapeake-bay/watershed-regions/rappahannock/>

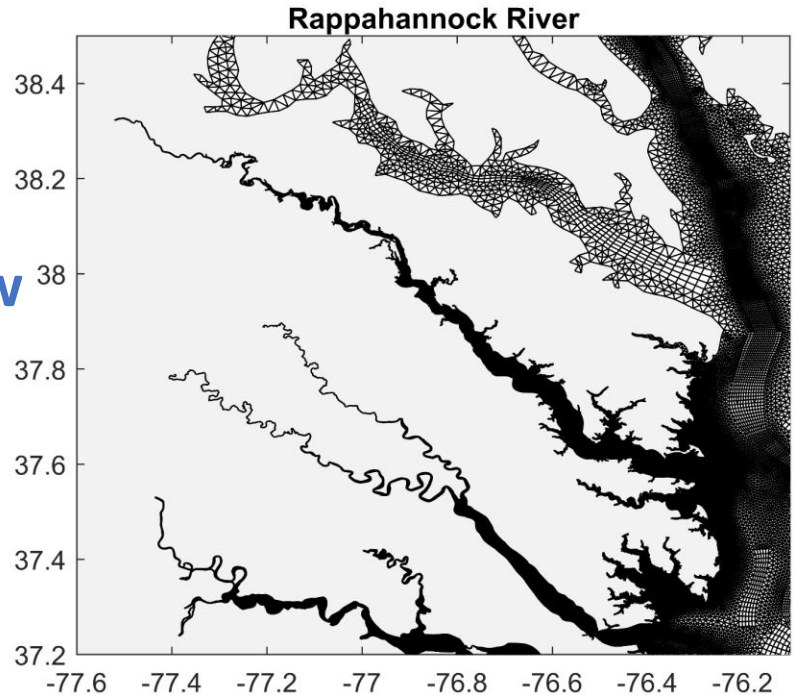
First, refine the Rappahannock River in the Bay model



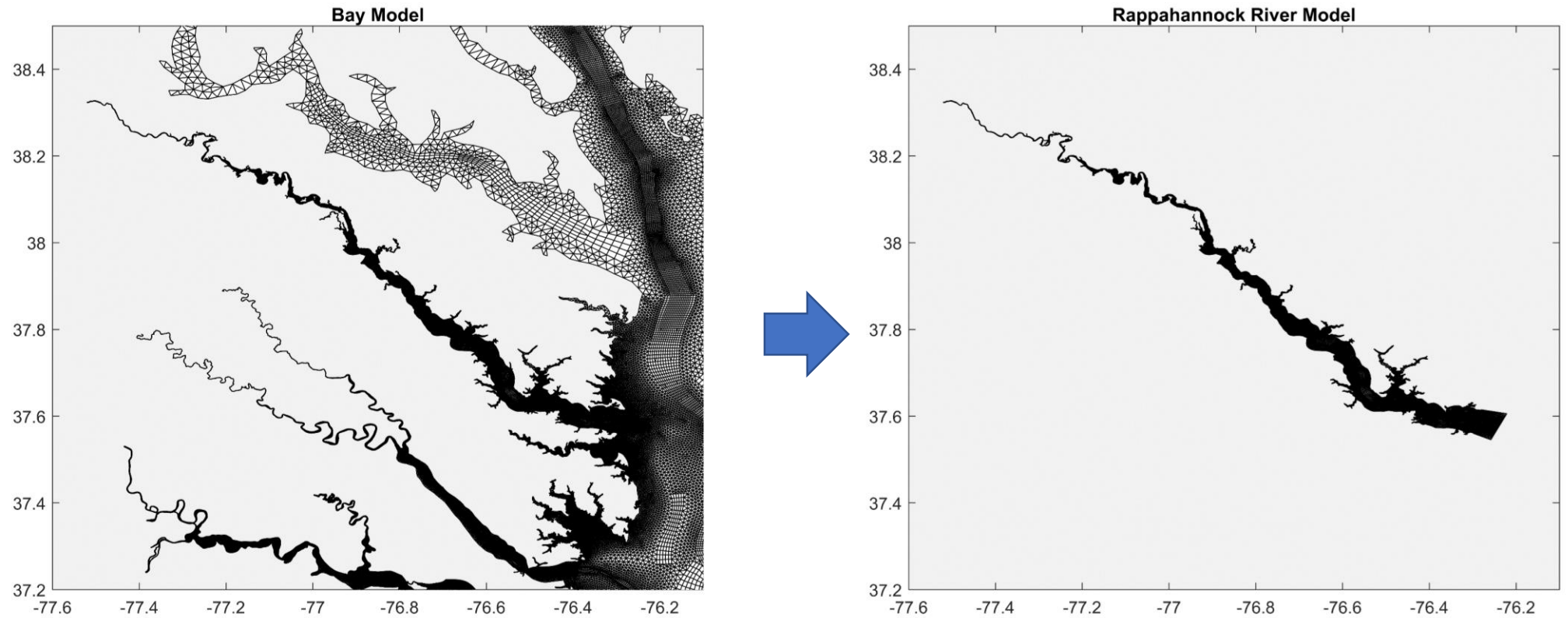
Old



New



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