# Technical Report of Oceanographic Research in Georges River Estuary (2022)

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**Work Co-conducted by Georges River Shellfish Committee, Maine Shellfish Learning Network, and University of Maine**

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## Introduction

The Georges River estuary near Thomaston, ME is home to (insert number of harvesters) engaged in wild shellfish harvesting across multiple growing areas. Over the last decade, these harvesters' livelihoods have been threatened by complex issues such as predation, shellfish population declines, ocean warming and acidification, as well as water quality closures. In particular, two issues have been identified as priorities by local managers: (1) understanding how wastewater treatment plants can impact the estuary, and (2) the reclassification of "the Bay", an area at the head of the Georges River which has been conditionally restricted for some time.

Recognizing these issues, the Georges River Shellfish Committee (a collaborative shellfish committee with representatives from five towns, Warren, St. George, South Thomaston, and Cushing) has responded by conducting multiple studies related to water quality, including the additional testing of streams in the area, testing water samples for DNA to understand pollution sources, among others.

This report describes a recent effort to create a three-dimensional computational oceanographic model. This model supports future decision-making in a number of ways, including providing information related to the residence time of polluted waters, calculating transport time of water from nearby wastewater treatment plants to the estuary, and facilitating new insight on shellfish settlement patterns.

## Methodology

This effort occurred in three stages. To support building an accurate oceanographic model, we gathered multiple forms of environmental data, including gathering surface current data using bucket drifters, gathering data of cross channel velocities using an Acoustic Doppler Current Profiler (ADCP) We include brief methodological overviews of each step.

*Bucket Drifters*

Following Hillyer et al., 2022, we deployed bucket drifters to measure how water moved at the surface. Bucket drifters are created by combining a counterweight, a 5 gallon bucket, a recycled lobster buoy, a satellite GPS unit, and a Garmin ETrex Hiking GPS. Each bucket drifter is equipped to take a GPS data point every 30 seconds as they float around the estuary. This allows us to measure how fast the bucket drifter is moving, and therefore how fast the water is moving. Throughout spring and summer, we deployed 2-3 bucket drifters at a time, for 24-48 hours, to cover the upper Georges River Estuary as well as the Bay. Each track was mapped out and shared with the shellfish committee. Speed, direction, and current speed were also calculated.

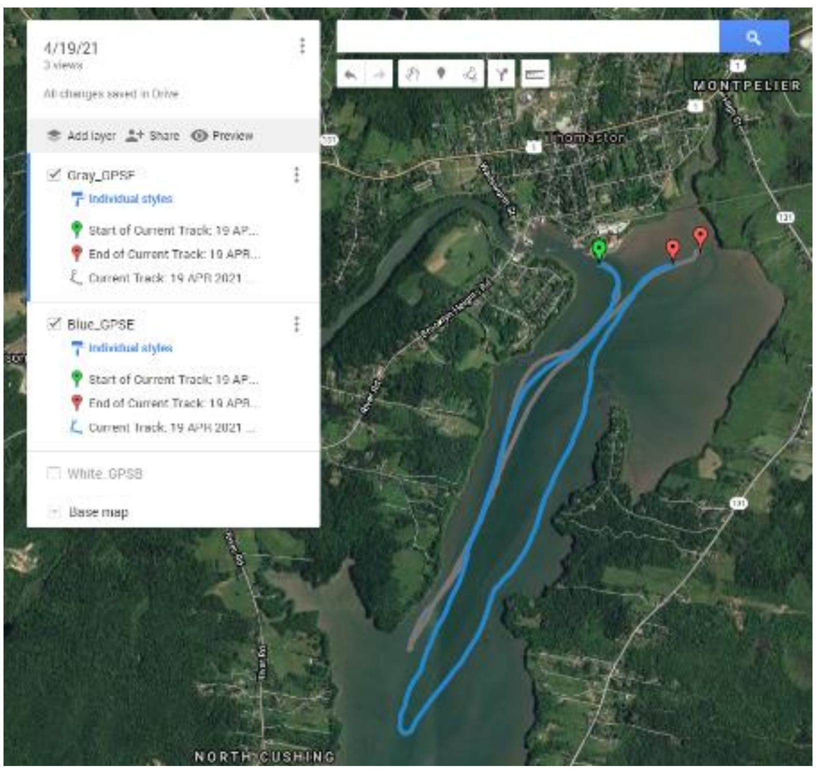


Figure 1. A drifter track from early April. This shows the tide coming in and out of the Bay over a 12 hour period.

*ADCP Deployment*

We also used an ADCP to measure water velocities at the surface and at depth. The ADCP was deployed for a week-long period in early April over the channel. This allowed us to get a clear picture of how water was moving at depth and at the surface, as well as provide extensive data for model validation (Figure 2).

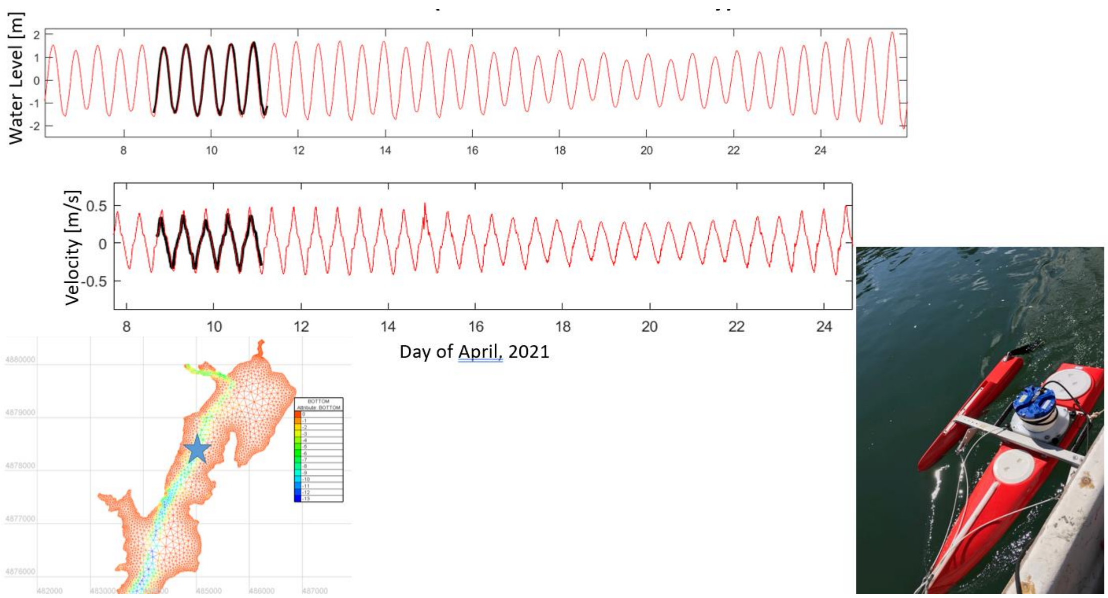


Figure 2. Validation with ADCP data. The graph on the top shows velocities and water levels produced by the model in red, with data from the ADCP and drifters in black. The map in the lower left with the blue star shows where the ADCP was deployed. The ADCP is shown on the bottom right.

## Results

There are four major findings from this work. In this section we describe each of the results as follows:

- Circulation patterns under tidal cycle progressions
- Residence Time of the Bay under different tidal conditions
- Transport Calculation from Warren Treatment Plant
- Salinity measurements

### *Circulation Patterns Under Tidal Cycle Progressions*

The model was first used to determine how water masses moved in the estuary. This included how currents changed under different tidal conditions. As shown in Figure 4, The Bay has strong currents that come in through the channel, a feature of the Georges River. The incoming tide moves faster, or harder, into the bay and often piles up in the corner near Hospital point. On the outgoing tide, the water remains clustered in that corner.

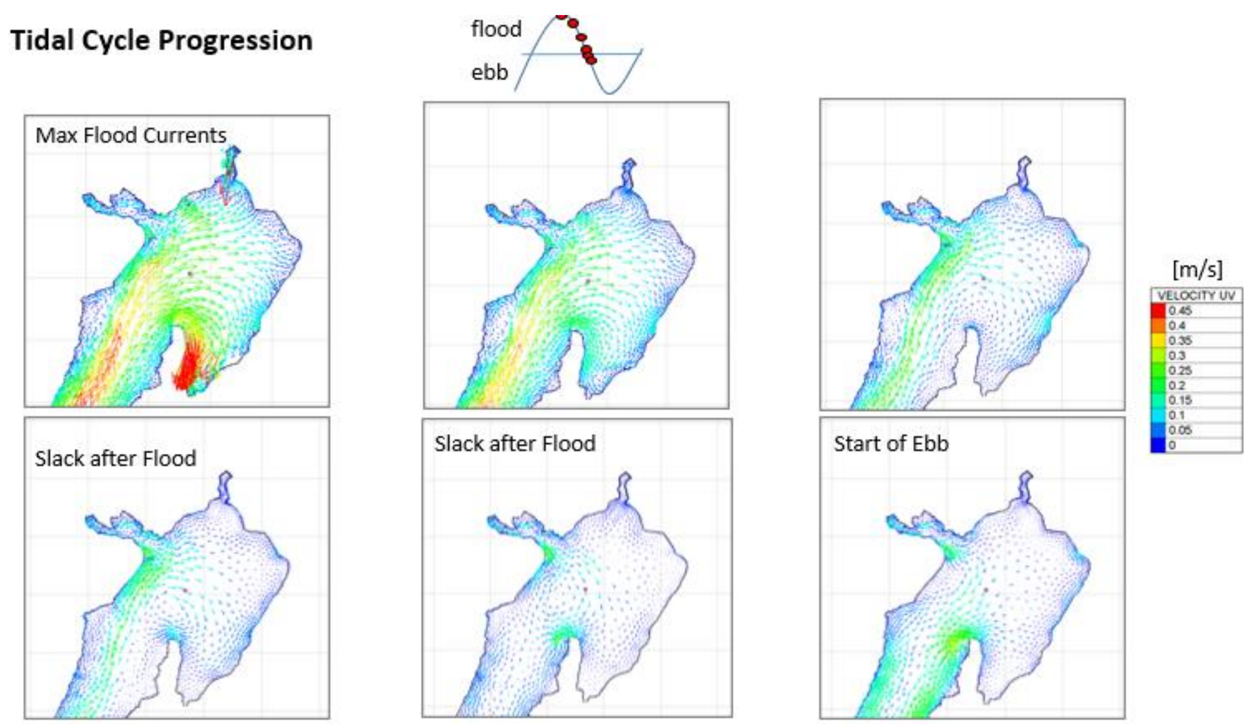


Figure 4. Tidal cycle progression in The Bay. The arrows show directionality of water movement under different tidal conditions. Colors show speed, where warmer colors show higher speeds.

*Residence Time Calculations*

Residence time, or how long water masses remain within an area, was also calculated under different tidal schemes. As expected, the residence time is relatively short, around 1-2 days. However, there was a lot of variability across the entire estuary. Areas near The Bay or within smaller coves exceeded 5-7 days, and in certain instances exceeded 2 weeks. This has direct implications on shellfish settlement, as shellfish settle within 2 weeks. So, areas with a residence time longer than two weeks may have more local recruitment from shellfish than others.

However, this experiment is also limited. Due to computational limitations, particles were placed in a deep channel, as particles could not be placed in areas that became dry. This means that these calculations are more than likely a low estimation of residence time as the channel remains where currents are strongest during different tidal conditions. Therefore, it is inferred by the researchers that it is more than likely residence time of shallow areas near mudflats may be considerably longer, and therefore more likely to be sourced by local settlement.

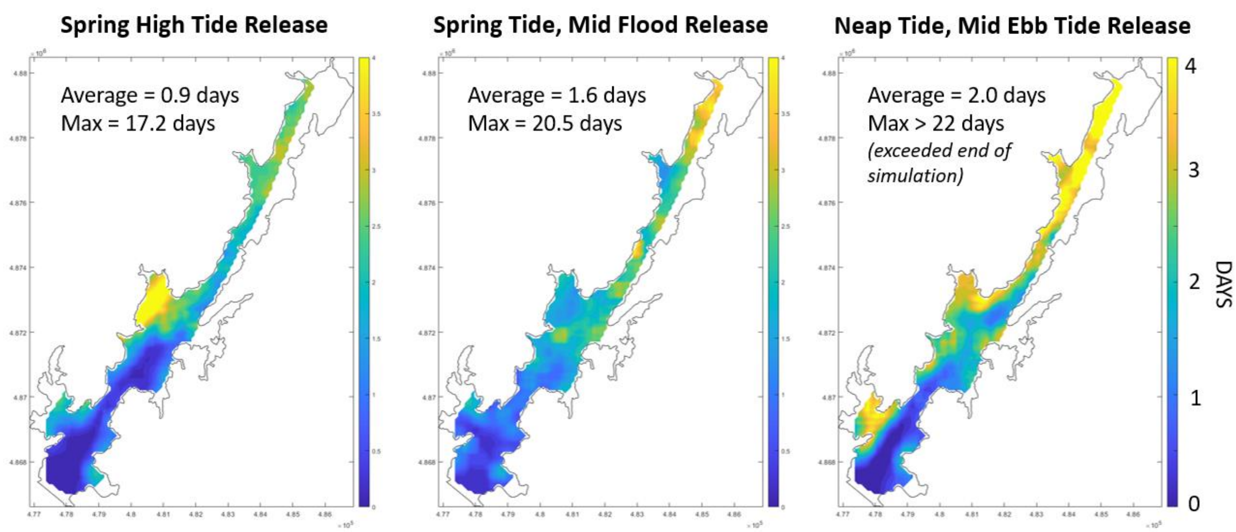


Figure 5. Residence Time Calculations. Residence time varied across various tidal regimes. This figure shows how shallower areas, and areas near or around The Bay can exceed average residence time calculations.

*Transport Time Calculations - Warren Treatment Plant*

A point of concern for reclassifying The Bay is making sure there is enough time between any malfunctions at the Warren Treatment Plant and closing down shellfish harvesting in the Bay to protect consumers. To do this, we first ran a particle estimation at the highest point upriver in our model domain, to the entryway of the Bay (Figure 6). Based on this experiment, it would take about 1.14 hours for water masses to reach the bay at a constant flow at max ebb conditions. The flow average was calculated using StreamStats for April of that year, which is usually considered the fastest flowing time period due to winter melt.

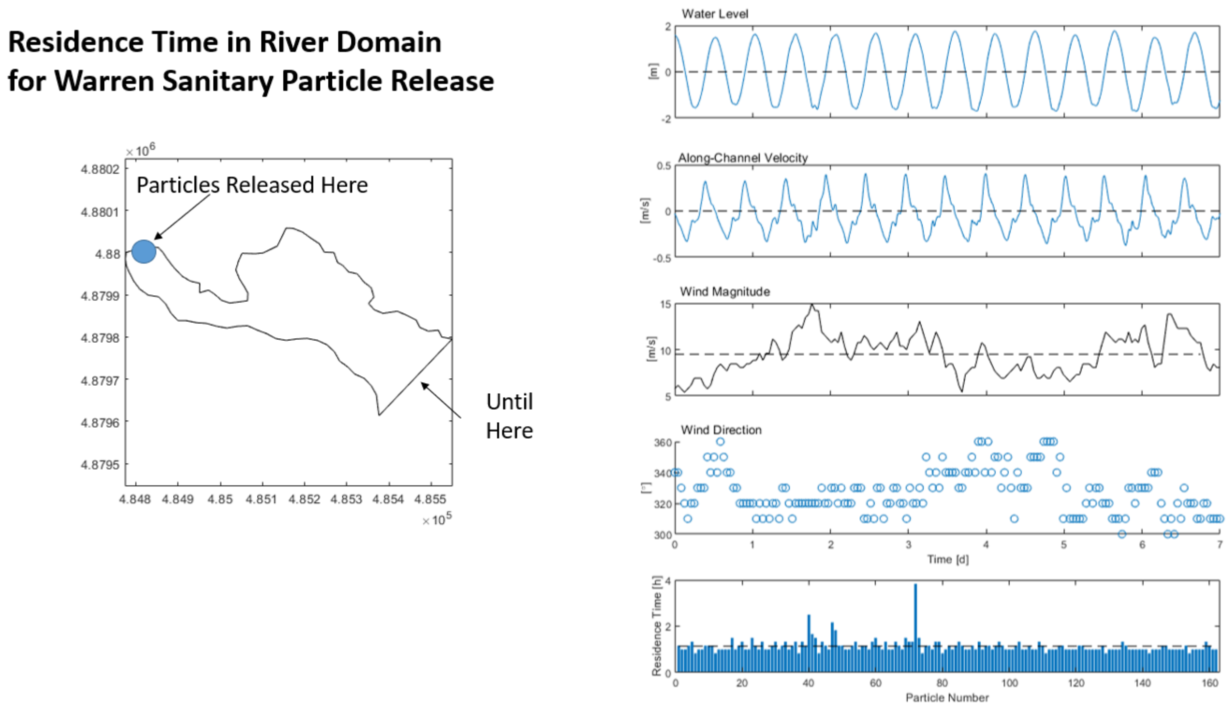


Figure 6. This series of graphs shows raw data from a particle experiment conducted in the model to determine how fast particles could get to the entry of the Bay. The graphs on the right show velocities that were used over tidal cycles, as well as how wind direction changed.

Because of the limitations of the model domain, we then multiplied that time period by two to account for a difference in distance. Specifically, the particle experiment covers 0.5 miles of river, whereas the Warren Treatment plant is 2 miles upriver. In that way, an average time period of 2 hours was given to DMR to supplement information about their reclassification.

*Salinity Experiment*

As part of the preliminary research for this work, we reviewed environmental factors that impact bacterial persistence within coastal waters. One of the most specific factors we could test on was salinity. As described by (Solic & Krstulovic, 1992) salinity scores higher than 29 generally create unlivable conditions for bacteria if they are within those waters for more than 24-48 hours. To better understand dynamics within the Georges River estuary, we ran an experiment that showed salinity scores above 29, and below 29. Throughout multiple tidal stages, upper areas of the Georges River remained below 29 (Figure #). This means that the upper areas of the Georges River will always be more susceptible to bacterial pollution.

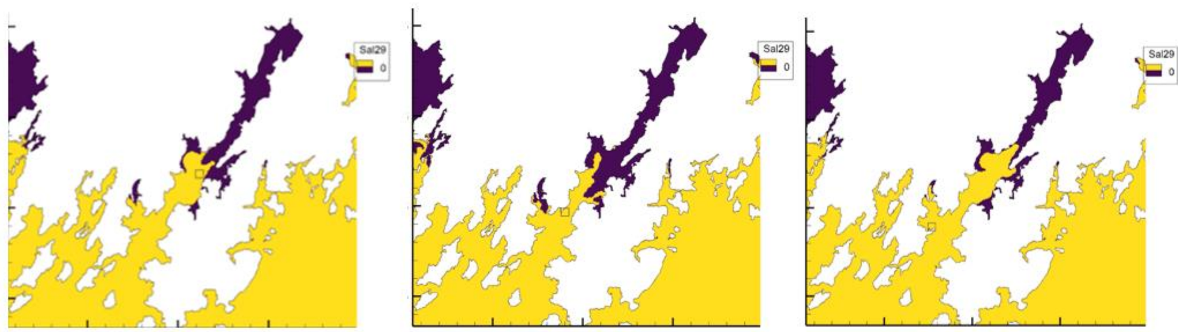


Figure 7. Screenshots of salinity video - showing distribution of salinity of 28 psu over tidal cycles. This screenshot shows how salinity at the Bay and upper regions of the Georges River estuary stays under 29psu, making it more susceptible to bacterial persistence.

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