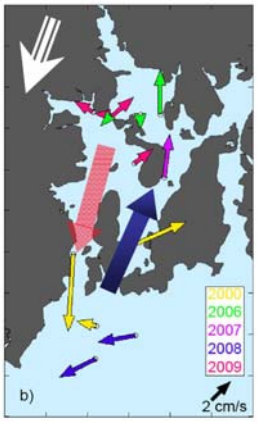
PROJECT HIGHLIGHT

Last revised: 12/1/14

Regional Ocean Modeling System for Upper Narragansett Bay

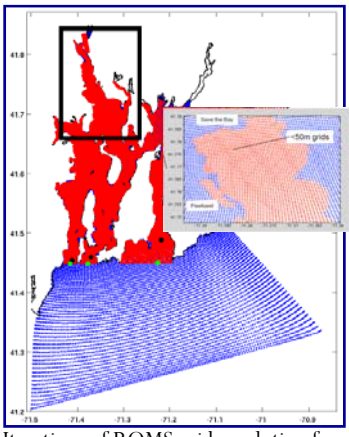
In response to the Greenwich Bay fish kill in 2003, the Rhode Island Department of Environmental Management required 11 Rhode Island wastewater treatment facilities (WWTFs) to lower their nitrogen inputs to upper Narragansett Bay. The Narragansett Bay Commission's (NBC) two facilities, Fields's Point and Bucklin Point, were included in this mandate. To examine the nitrogen reductions from WWTFs and the role of circulation, the NBC invested in refining the Regional Ocean Model Modeling System (ROMS) for upper Narragansett Bay.



What is ROMS?

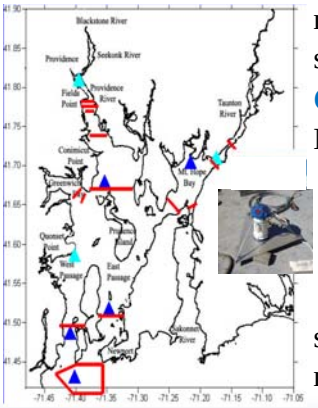
The ROMS is a public domain, three-dimensional hydrodynamic-transport model for coastal systems, which uses a series of physical and numerical algorithms. When specific site/regional data is inputted, ROMS will model the circulation of a given area. Since ROMS is open to the public domain, it is constantly being utilized, tested and improved by scientists around the world. The Kincaid Coastal Hydrodynamics Group at the University of Rhode Island—Graduate School of Oceanography (URI-GSO) applied ROMS to Narragansett Bay. Modeling and various data collection efforts throughout Narragansett Bay shows a counter-clockwise circulation pattern in Narragansett Bay, with inflow through the East Passage and outflow through the West Passage.

Iterations of the Narragansett Bay ROMS



Iterations of ROMS grid resolution for Narragansett Bay

The NBC teamed with the Kincaid Group at URI-GSO to improve and refine the Narragansett Bay ROMS to focus on the Providence River. The initial version of the ROMS model included the Providence River and extended slightly further south (black box pictured right). This model had a coarse grid resolution of 150 m. An external consultant review found that the model did not extend far enough south, so another coarse grid model was prepared and extended to Rhode Island Sound (blue colored grid pictured right); however neither of these models were able to pass skill tests to assess accuracy, commonly run by modeling experts. The outside consultant hired to review to coarse grid resolution ROMS agreed with these findings. To resolve the issues of the previous versions, a new Full Bay ROMS was equipped with a curvilinear grid, meaning it had a 30 m grid resolution to the north in the Providence River expanding to approximately 200 m grid resolution in lower Narragansett Bay (red colored grid pictured right). This Full Bay ROMS was able to achieve the required skill level simulating the collected data. In addition to the skill test, Dr. Kincaid of URI-GSO built a scale model of Edgewood Shoals area in the upper Bay in a specialized Australian research lab. This scale model agreed with the latest ROMS predictions of circulation.



Calibration of ROMS

Many types of data have been collected throughout Narragansett Bay and utilized to calibrate the iterations of ROMS. Acoustic Doppler Current Profilers (ADCPs) and tilt current meter (TCMs) are utilized to measure water column currents and gather information about flow regimes and tidal cycles within the Bay. ADCPs and TCMs have been deployed in the bottom waters throughout Narragansett Bay. ADCPs have also been mounted to boats, transecting sections of the Bay. Salinity, temperature, and dissolved oxygen data collected by the fixed site monitoring network is also used to calibrate the Narragansett Bay ROMS.

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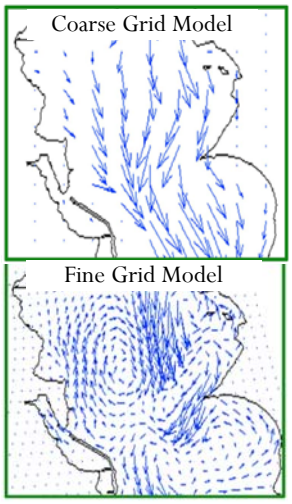
ROMS Results

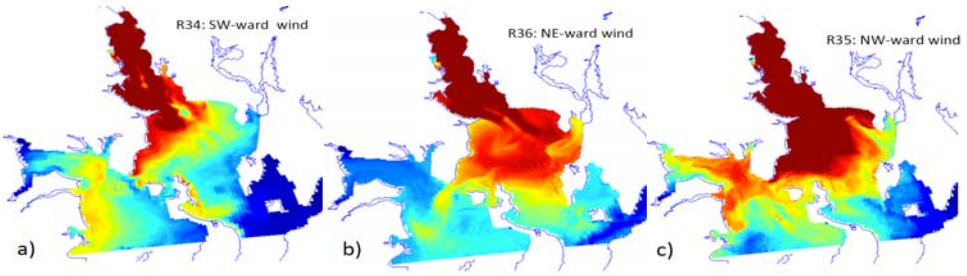
The Full Bay ROMS shows that in Edgewood Shoals a gyre exists which traps water on the shoal. TCM data was collected in this area to confirm this feature, as well as the scale model built in Australia. Particle tracking within the ROMS shows this gyre causes increased water retention time on the order of 7 to 10 days, which is one driver of decreasing water quality. ROMS also shows that the breakwall at the Pawtuxet River directs bottom water north onto the shoal, which further intensifies water quality issues on Edgewood Shoals. Data to confirm this northward flow of the Pawtuxet River was collected in the summer of 2014 and is in process. Results of 2010 model runs show that specific runoff and wind conditions control the retention time in the Providence River, as well as how water is directed to the East and West Passages. Southwestward winds cause the Providence River to drain effectively and force the flow through the West Passage, while a northward blowing wind hold water in the Providence River, increasing retention times on the Edgewood Shoal and directing water into the East Passage.



Modeling of Edgewood Shoals through the versions of ROMS

Nutrient Tracking in the Bay

To further improve the ROMS for management use, the NBC worked with URI-GSO to incorporate the capability of introducing particles from different sources which are tracked as they travel throughout the Bay. In the NBC's model runs, these particles represent nitrogen loading coming from various sources, specifically 16 different sources, including WWTFs and rivers. The ROMS runs show that the Blackstone and Pawtuxet River tend to dominate nitrogen levels in the Providence River, except in low flow conditions. From winter to mid-summer, ROMS predicts that the Taunton River is an important source of nitrogen in the East Passage, Providence River, West Passage and even into Greenwich Bay. This demonstrates that sources to the south, such as the Taunton and Pawtuxet Rivers, can still impact areas to the north, such as Edgewood Shoals. Model runs in ROMS also showed that decreasing nitrogen concentrations from NBC'S WWTFs did not seem to effect concentrations further down the Bay.



Comparison of near-surface nutrient transport patterns for water from the Blackstone River for cases with a runoff pulse and variable wind conditions (highest concentration in red).

Ongoing Efforts

The NBC is continuing to develop the ROMS with URI-GSO. In future phases of the ROMS, full hydrodynamic modeling of the Seekonk River will be included. In addition, the NBC is supporting the inclusion of a biological-oxygen model to the Narragansett Bay ROMS. Model runs will be able to predict phytoplankton and dissolved oxygen concentrations as a result of changing nutrient inputs. In the future, the NBC has discussed the options of modeling scenarios of engineering solutions to improve water quality condition in upper Narragansett Bay. Examples of possible options include dredging a channel on Edgewood Shoal to increase flushing, removing the breakwall at the Pawtuxet River to see if bottom water is directed south out of Edgewood Shoals or even moving the NBC outfall at Field's Point to Edgewood Shoals to see if it can break up the gyre. The NBC sees the Narragansett Bay ROMS as a valuable investment that can assist in management decisions to ensure that future expenditures improve water quality.