The North River Sewage Spill and the NYHOPS Waterborne Pathogen Forecast Concept

STEVENS INSTITUTE of TECHNOLOGY THE INNOVATION UNIVERSITY

P. Orton[1], G. O'Mullan[2], A. Juhl[3], N. Georgas[1], A. Blumberg[1]; [1]Stevens Institute of Technology; [2]Queens College; [3]Lamont-Doherty Earth Observatory of Columbia University; philip.orton@stevens.edu http://philiporton.com

DAVIDSON LABORATORY CENTER FOR MARITIME SYSTEMS

1. Overview

Thanks to extensive sewage indicator sampling campaigns by Riverkeeper and city and state government agencies, our understanding of sewage pollution risks in the Hudson is rapidly increasing. However, our ability to inform the public of events as they happen, or as forecasts, is limited because observations of sewage indicators require one-day incubation periods. A useful next step is to begin incorporating observations and CSO forecasts into hydrodynamic models, enabling us to provide water quality nowcasts and forecasts for the region's waterways and swimming areas.

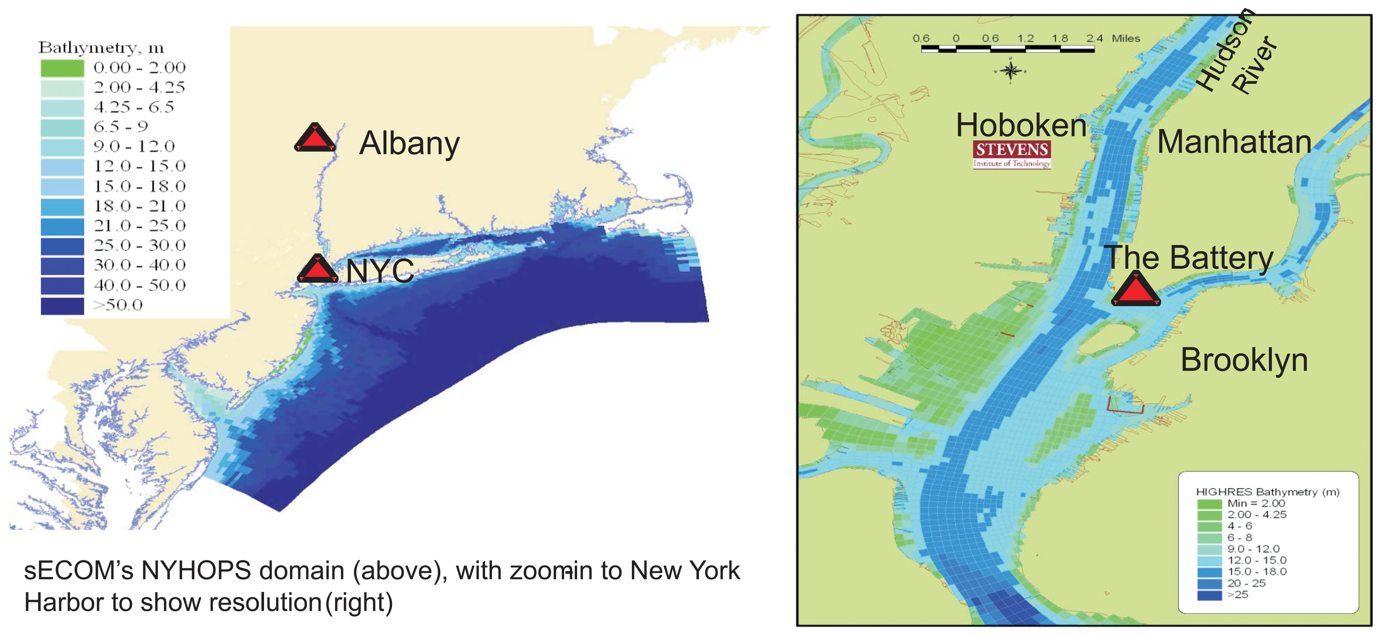
An interesting test case for this concept came last summer when a fire at the North River Wastewater Treatment Plant in New York City disabled the facility and caused a 3-day sewage spill. Here, New York City area observations of the sewage indicator microbe *Enterococcus* are presented, and comparisons are made with real-time (un-tuned) test simulations made using Stevens ECOM, the model utilized for the New York Harbor Observing and Prediction System (NYHOPS).

2. Hydrodynamic and Pathogen Modeling

The hydrodynamic model used in this study is Stevens ECOM (sECOM), the model used by thousands of researchers worldwide, and for the New York Harbor Observing and Prediction System (NYHOPS; http://stevens.edu/ maritimeforecast). It has been demonstrated to provide highly accurate salinity, temperature, velocity, salt intrusion, and water level predictions throughout the Hudson River, New York Bight, and Long Island Sound, as well as other regional waterways (e.g. Blumberg et al. 1999; Georgas et al., 2010).

Table: Parameter values and choices used for pathogen modeling

Parameter	Units	Value	Comment
k_{base}	day^{-1}	0.8	default
rate constant k_i	day^{-1}	0	default
rate constant k_s	day^{-1}	0	default
θ	none	1.07	default



sECOM's NYHOPS domain (above), with zoom-in to New York Harbor to show resolution (right)

Abundances of enteric organisms in natural systems are determined by rates of inputs (loads) to the bay from outfalls and shoreline sources, transport due to currents, and dispersion and loss processes that include phototoxicity, temperature, salinity, predation or die-off and settling. **Our model simulates the time-dependent, three-dimensional transport of sewage indicator bacteria and utilizes first-order decay terms approximating these loss processes**, with settings summarized in the adjacent table.

$$k = k_d + k_i + k_s \quad \text{where:}$$

k_d is the rate coefficient for death in the dark; includes effects of temperature, salinity and predation

k_i is the rate coefficient for death as mediated by irradiance

k_s is the rate coefficient for sedimentation loss

$$k_d = (k_{base} + 0.006 * (\%seawater)) * \theta^{(T-20)} \quad \text{where}$$

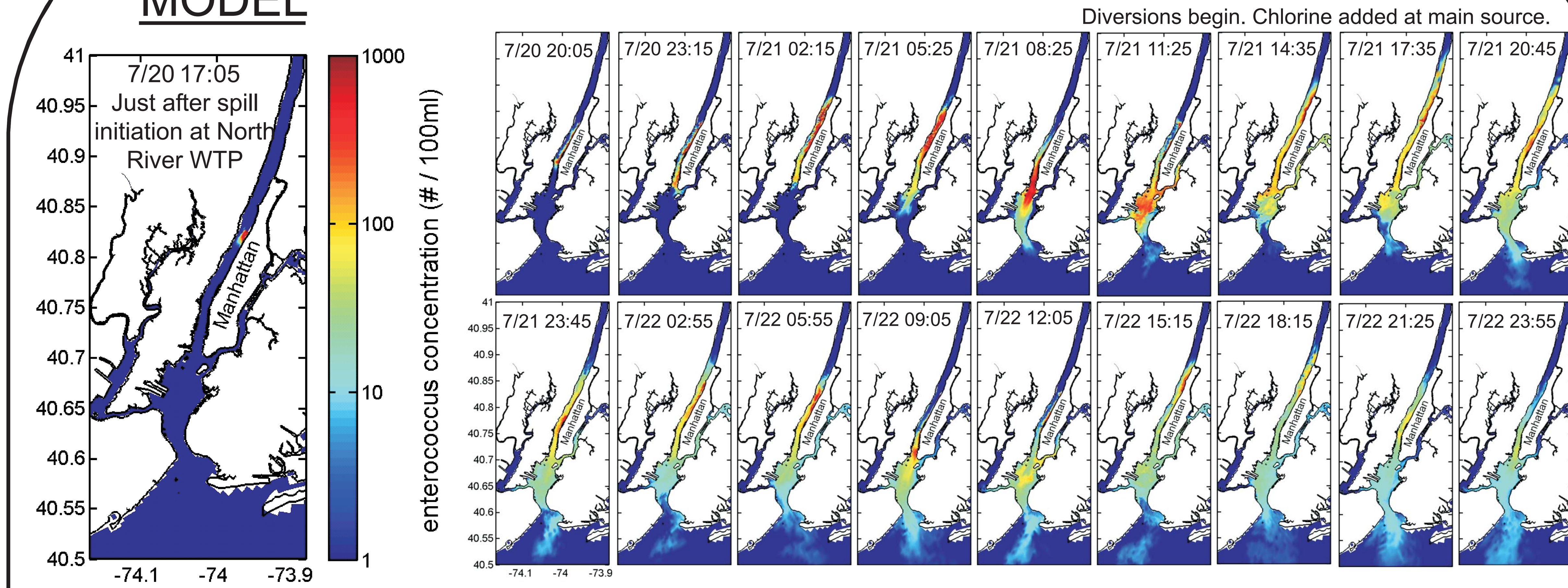
θ is a dimensionless constant that describes the relationship between the rate coefficient and temperature (T)

3. Pathogen Sampling Methods

Sampling for pathogens was based on the fecal-indicating bacterium, *Enterococcus*. Surface water samples were collected by hand from the Riverkeeper survey vessel, R. Ian Fletcher, and processed on board. *Enterococcus* concentration was determined using Enterolert media and Quanti- tray/2000 (IDEXX Laboratories). The trays were incubated at 41 °Cfor 24 hours and counted using Enterolert's Most Probable Number (MPN) method based on total numbers of large and small positive wells per tray. Some samples were diluted to increase the upper detection limit of the assay. The *Enterococcus* data shown here are part of a larger, on-going water-quality testing program on the HRE (study description and additional data available at http://www.riverkeeper.org). We gratefully acknowledge Riverkeeper, Captain John Lipscomb, and Rob Friedman for their cooperation in sample collection and processing.

4. Results: July 20-22

MODEL



OBSERVATIONS

7/21/2011 *Enterococcus* conc. (most probable number per100 ml)

Station (Approx river mile – name)	Cross-channel location: West (NJ)	Mid	East(Manhattan)
North			
27.5 - Tappan Zee mid		<10	
18.5 - Yonkers mid		<10	
18.5E - Sawmill River Mouth			<10
17.5E - Yonkers STP			<10
14W - Englewood boat basin	<10		
14E - Dykeman			>24196
12 - GWB mid		313	
8W - Edgewater, NJ	31		
8 - 125th St mid		74	
7.9E - 125th Pier			>24196
7.9E - 125th Pier			104,620
7 - 79th St mid		161	
7 - 79th mid		132	
7E - 79th St boat basin			1722
6W - Weehawken, NJ	<10		
6E - Pier 98			12033
4.7W - Castle Pt, NJ	<10		
0 - NYC Battery		10	
South			

7/22/2011 *Enterococcus* conc. (most probable number per100 ml)

Station (Approx river mile – name)	Cross-channel location: West (NJ)	Mid	East(Manhattan)
North			
27.5 - Tappan Zee mid		<10	
18.5 - Yonkers mid		<10	
18.5E - Sawmill River Mouth			10
17.5E - Yonkers STP			<10
14W - Englewood boat basin	<10		
14E - Dykeman			12033
14E - Dykeman			7030
12 - GWB mid		20	
8W - Edgewater, NJ	52		
8 - 125th St mid		41	
8E - North River STP			75
7.9E - 125th Pier			98
7 - 79th St mid		41	
7 - 79th St mid		31	
7E- 79th St boat basin			160
6W - Weehawken, NJ	63		
6E- Pier 98			1500
4.7W - Castle Pt, NJ	<10		
South			

Green: Enterococcus count (under 35/100ml) is acceptable by EPA standards

Yellow: Enterococcus count (between 25 and 104/100ml), if sustained over time, would be unacceptable by EPA standards

Red: Enterococcus count (over 104/100ml) is unacceptable by EPA standards

5. Conclusions and our Future Goal

- The event was captured with Riverkeeper, NYC-DEP and NJ-DEP boat survey data on every day from July 21 through 28 – useful for future model adjustments and validation
- Tides dominated the transport, and the model showed that the **tidal phase of sampling** was important to the resulting observed spatial distribution and cross-channel transport
- Model results suggest that daytime-only observations missed strong cross-channel transport events that occurred at the end of flood tides each evening

Our future goal is to fund a broader project to refine the pathogen modeling and set up a real-time forecast system and webpage within NYHOPS that displays our nowcasts and forecasts. The project could also seek to expand experimental work associated with pathogen persistence in the environment, a crucial aspect of the modeling effort. As with the Stevens Storm Surge Warning System (http://stevens.edu/SSWS), it could have the capability to notify the public of water quality problems at selected sites by text message and email.