Monitoring efforts by Veronica M. Berounsky, Ph.D.

What monitoring do you currently conduct?

My monitoring programs are in the Pettaquamscutt Estuary (Narrow River) which empties into the mouth of Narragansett Bay (See Figure 1). There are 2 separate but related programs. The one in which I am the principal investigator, the Anoxic Basin Comparison Study, is monitoring the environmental conditions of the two anoxic basins in the northern portion of the Pettaquamscutt Estuary. My co-investigators (all at GSO) are David Borkman, Ph.D. with expertise in phytoplankton identification and ecology, Lucie Maranda, Ph.D. with expertise in phytoplankton ecology, and Rebecca Robinson Ph.D. with expertise in nutrients. Future work is being planned with Roxanne Beinart, Ph.D. with expertise in deep sea anoxic areas There have been a number of students who assist in the field, and some also assist with data analysis. The students involved for the longest number of years are Rahat Sharif and Eric Peterson. The second program, called River Watch, I am co-principle investigator with Annette DeSilva (at GSO), and that program monitors the entire estuary and the four largest freshwater point sources for water quality in the near surface waters. The actual sampling is done by myself, Annette DeSilva, and many trained volunteers (187 over the last 26 years).

How long have you been collecting this data?

For the Anoxic Basin Comparison Study, we have been monitoring since October 2007 when the last overturn (or ventilation) of the northern basin occurred. For the RiverWatch Program, we are completing 26 years of monitoring this month. The ten sites in the River itself have been monitored since 1992, the freshwater points sources have been measured since 1992, 1996 2000, or 2004, depending on the site.

What data do you collect, how do you collect it (generally), and what sites do you monitor?

For the Anoxic Basin Comparison Study, we use a boat and YSI Sonde to take profiles of dissolved oxygen, temperature, salinity, chlorophyll, and pH with depth, every other week, at the Upper Pond site and the Lower Pond site (See Figure 2) and once a month we also take water samples at certain depths for nutrients (ammonia, nitrate plus nitrite, inorganic phosphorus, and silica) and phytoplankton at the same locations. We sample May through December, and occasionally in the water if there is sufficient ice to go out on the ponds.

For the RiverWatch Program, there are 10 sites in the river itself, 3 stream sites, and one outfall site (see Figure 2). Every other week samples are taken for dissolved oxygen, chlorophyll, and salinity and temperature measurements are taken. Once a month samples are also taken for bacteria, nutrients (total nitrogen, ammonia, nitrite plus nitrate, total phosphorus, and inorganic phosphorus) and pH. Samples are taken at 0.5m deep and also at 3m in the Upper and Lower Ponds. Samples are taken May through October.

How do you currently reports/share your monitoring data?

We are working on peer reviewed publications, but meanwhile presentations have been made at seminars, and national and local conferences and meetings and some are available on www.narrowriver.org . The Riverwatch data is available in Excell spreadsheets by contacting Annette DeSilva.

How is this monitoring currently funded?

Portions of the Anoxic Basin Comparison study have been funded by URI Completion Grants but most of the work is unfunded. The Riverwatch Study has been funded by the Narrow River Preservation Association, DEM's Aqua Fund, RI Rivers Council, US Fish &Wildlife Service, and grants from the 3 towns in the watershed.

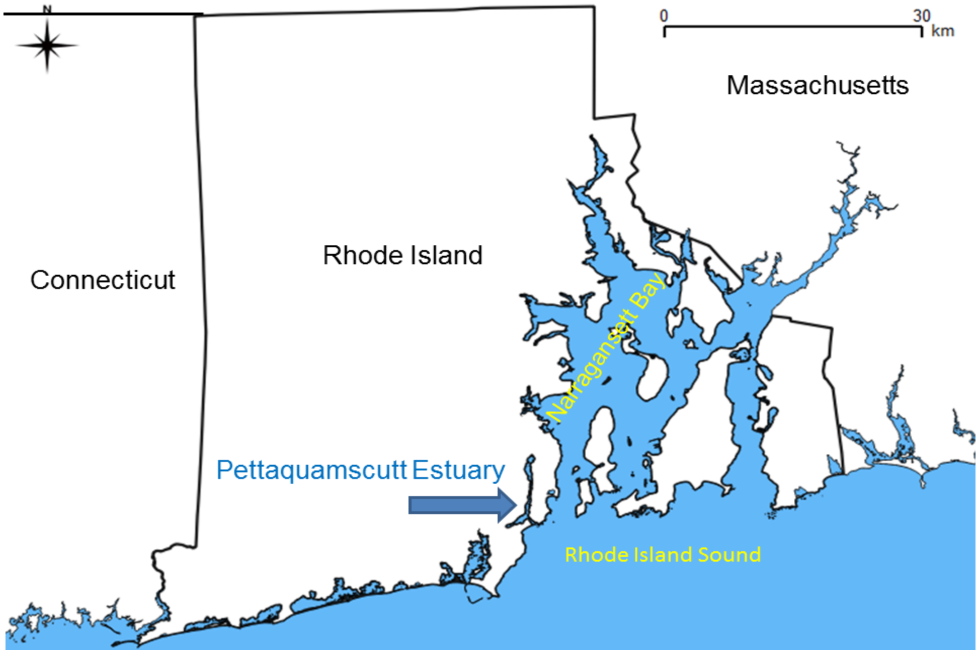
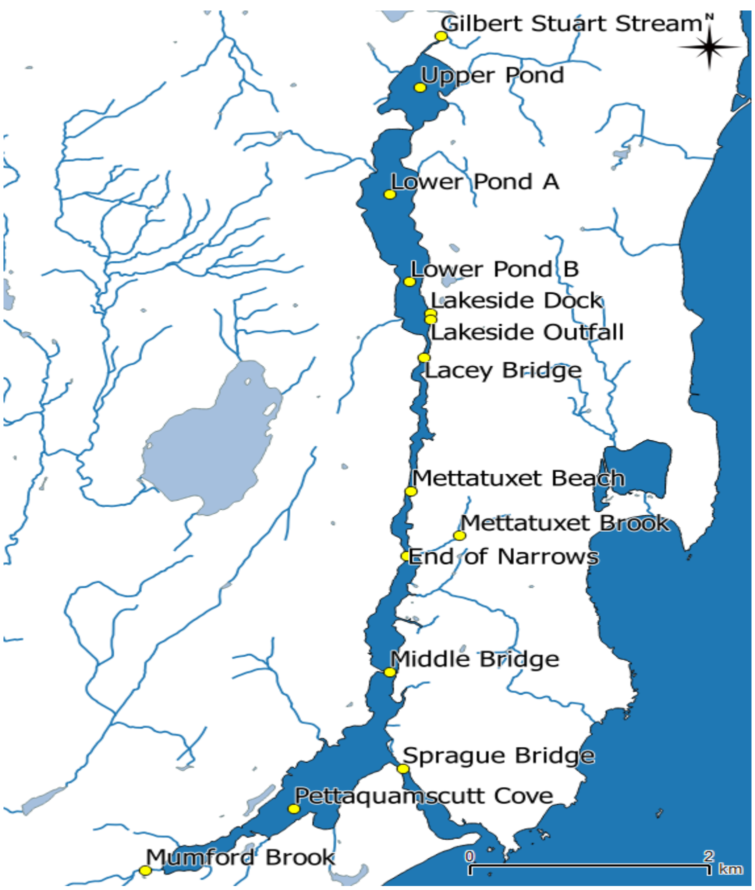


Figure 1 (above) – Pettaquamscutt Estuary location

Figure 2 (below) – Sampling Sites in Pettaquamscutt Estuary



Salt Marsh Monitoring and Assessment Program

Photo by Marlo Garnsworthy

The Narragansett Bay National Estuarine Research Reserve (NBNERR), Save The Bay, the RI Natural History Survey (RINHS) and the Coastal Resources Management Council (CRMC) are currently engaged in a collaborative effort to improve long-term salt marsh monitoring in Rhode Island and have developed a strategy for a comprehensive statewide monitoring and assessment program. The Salt Marsh Monitoring and Assessment Program (SMMAP) is a three-tiered framework for application in assessing changes in salt marsh condition, spatial extent, and community composition over space and time. **Tier 1** involves a statewide, landscape-scale analysis based on automated classification of aerial imagery. **Tier 2** involves the development of a rapid assessment protocol that will be implemented annually at a subset of marshes throughout RI. **Tier 3** builds upon the existing Narragansett Bay National Estuarine Research Reserve's Sentinel Sites Program to carry out more intensive monitoring at a smaller subset of sites throughout RI. Tier 3 metrics will also be developed for use in monitoring specific projects and management actions, such as enhancing marsh drainage networks or beneficially reusing dredged material to build marsh elevation.

Program Goals

The results from this monitoring and assessment program will be used to:

- Evaluate the overall status and condition of RI's salt marshes
- Track changes over time
- Evaluate management outcomes, and
- Prioritize areas where resources should be directed towards management actions.

The SMMAP will facilitate coordinated ecological salt marsh monitoring throughout the state of RI in order to document spatial and temporal patterns in salt marsh conditions and help inform restoration, adaptive management, and prioritization of salt marsh management projects, statewide. The SMMAP will establish standardized protocols for salt marsh monitoring, assessment, data formatting, and data archiving, and will initiate and maintain a long-term salt marsh monitoring and assessment dataset for the state. Data collected according to the SMMAP will also be compatible with established regionally and nationally-implemented programs. When completed, the SMMAP will serve as a component of the broader RI Environmental Monitoring Collaborative Monitoring Strategy.

Three-tiered structure used by the Rhode Island SMMAP

Tier	Description	Frequency	Spatial Extent
1	Landscape-scale marsh habitat mapping	3-5 years	Statewide
2	Salt marsh rapid assess-ments	Annually	Approx. 40 marshes statewide (a subset is assessed each year)
3	Intensive site monitoring	Annually, and as needed for resto-ration / adaptation projects	6-8 marshes statewide and specific individual marshes

Parameters Monitored

Category	Parameter	Tier 1	Tier 2	Tier 3
Geomorphic	Channel widening rate	X		X
	Landward transgression rate	X		X
	Seaward erosion rate	X		X
	Marsh area	X		
	Ponding area	X	X	
Habitat	Habitat composition and zonation		X	X
Physiochemical	Edaphic conditions		X	X
	Elevation			X
	Elevation change (accretion / sub-sidence)			X
	Inundation / hydrology			X
	Nutrients			X
	Total suspended solids (TSS)			X
Biological	Emergent vegetation		X	X
	Marsh crabs			X
	Nekton			X
	Marsh sparrows			X
	Wading birds			X

To view the complete monitoring and assessment strategy document visit:

www.crmc.ri.gov/news/pdf/SMMAP_RI_Strategy.pdf

Questions? Contact Caitlin Chaffee (cchaffee@crmc.ri.gov), Kenny Raposa (Kenny@nbnerr) or Tom Kutcher (tkutcher@rinhs.org)

Workshop on Monitoring Gaps in Narragansett Bay – 2017

D. Codiga GSO/URI 10/9/2017

Long-term monitoring of water circulation and transport in Narragansett Bay

There is a lack of sustained long-term observations of currents anywhere in Narragansett Bay.

(The only exception I know of is the NOAA PORTS program. It includes current measurements at three shallow port sites, in the Providence River, Quonset Point, and Fall River. Currents from these isolated inshore sites, while useful for practical vessel navigation purposes as is their intended application, are not valuable for scientific exploration of processes influencing biological conditions in the bay.)

This constitutes a serious gap, which any effort intending to move bay monitoring activities toward being more comprehensive needs to address. Water quality conditions, and the biological processes forming the primary influences on them, are recognized to be extremely variable in space and time. Much of the variability is associated with advection by currents, so a primary limitation to monitoring and understanding water quality conditions is how little we know about the circulation.

This is not to say that past and present research activities (for example, by Kincaid, Ullman, and others) ignore current measurements. On the contrary, many circulation-related studies have taken place and there will be more. But none so far address the need for sustained long-term sampling to help close the gap in monitoring. These other targeted projects are valuable in their own ways and have provided useful perspectives. But they consist of measurements from different locations in different years, and are rarely sustained for more than one year, let alone on a longer-term basis as needed.

Some good ways to help address the gap include: (1) adding bottom-mounted acoustic Doppler current profiler (ADCP) deployments at some of the Narragansett Bay Fixed Site Monitoring Network sites, routinely, each time the CTD/DO moorings are deployed there; and (2) instrumenting one or more ferries (e,g, Prudence Island ferry, Newport-Jamestown ferry) with a hull-mounted ADCP. These are both standard, proven technologies, suitable for long-term monitoring, with known costs.

In the case of ferry-based sampling, the ADCP can be one component of a more comprehensive multi-disciplinary program – see other one-page description "Ferry-based sampling for long-term monitoring of biological conditions in Narragansett Bay" for explanations of the advantages. Use of ADCPs on ferries is well established and there are many success stories around the world. As noted in that other one-page description, ferry-based sampling in Narragansett Bay includes two main possibilities: the Bristol to Prudence Island ferry and the Jamestown to Newport ferry. These locations can each capture the oceanic-origin Rhode Island Sound water moving north through the East Passage (toward the upper bay where, for example, hypoxia is a problem). A similar sampling program from a ferry in Long Island Sound gave a fundamentally new view of its estuarine exchange flow and rates of transport (citation below), which are of course very relevant to understanding biological conditions (as well as designing successful sampling and monitoring of biological indicators).

Codiga, DL, and DA Aurin, 2007. Residual circulation in eastern Long Island Sound: Observed transverse-vertical structure and exchange transport. Continental shelf research, 27 (1), 103-116. (Available at ftp://www.po.gso.uri.edu/pub/downloads/codiga/pubs/2007CodigaAurin-ResidualCircEasternLIS-CSR.pdf)

Workshop on Monitoring in Narragansett Bay – 2017

D. Codiga, GSO/URI 10/9/2017

Ferry-based sampling for long-term monitoring of biological conditions in Narragansett Bay

- A pumped flow-through system with standard in-situ sensor can measure the suite of surface water quality parameters (temperature, salinity, chlorophyll fluorescence, oxygen, turbidity, pH)
  - Straightforward to add specialty sensors (e.g., wet chemistry nutrients, optics, etc)
  - An automated water sampler can collect water, for later delivery to an onshore lab and more complete analysis (e.g., phytoplankton & zooplankton identification/counts)
- Long-term (typically year-round) and high-frequency (multiple times daily) crossings
  - Captures tidal variations (after a few months all phases of tide are sampled, as opposed to any one tidal period); weather-band events; seasonal cycles; and long-term trends
- Spatial coverage extends along a transect from shore to shore
  - Captures patchy variability better than small number of sites (or single mid-channel site)
  - Ferry routes span East Passage where oceanic Rhode Island Sound water enters bay
- Additional sampling potential of ferries as platforms for sensors
  - Hull-mounted acoustic Doppler current profiler (ADCP) to measure currents throughout the water column; estuarine exchange flow, net volume transports through the transect
  - Meteorological conditions
- The technologies are low-risk and proven (citation below summarizes worldwide examples)
  - Designed for unattended routine operation—ferry staff need not be involved—including real-time remote communication (cellular modems) to retrieve data & monitor sensors
- Methods for analyzing the resulting datasets (including tidal variations) are established
- Overall costs are well-understood and modest compared to other long-term monitoring efforts
- The return on investment is enormous relative to cost of equivalent research vessel time
- Ferry passenger areas are natural showcases for education and outreach displays if desired

There are two main platforms available for ferry-based sampling in Narragansett Bay (in addition to the Block Island ferry, which will not be mentioned here but also represents a great opportunity):

- The Bristol to Prudence Island ferry (runs year-round)
- Jamestown to Newport ferry (runs from May through ~mid-October)

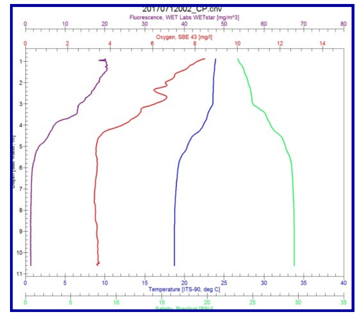
In recent years the Bristol to Prudence Island ferry operator was initially supportive of hosting a sampling system, funding from NOAA to GSO was obtained as part of the Coastal Hypoxia Research Program, and the installation process had begun. However, for completely unrelated reasons, shortly thereafter the company stopped operating, so the project was not completed. A new ferry operator took over then, is now well-established, and the process of contacting them regarding potential for hosting a sampling system on their vessel is underway. Contact has also been made with the Jamestown to Newport ferry operator, who is receptive to the idea of hosting sensors.

Codiga, D. L., W. M. Balch, S. M. Gallager, P. M. Holthus, H. W. Paerl, J. H. Sharp and R. E. Wilson, 2012: Ferry-based Sampling for Cost-Effective, Long-Term, Repeat Transect Multidisciplinary Observation Products in Coastal and Estuarine Ecosystems. Community White Paper, IOOS Summit, Herndon, VA, November, 2012. (Available at ftp://www.po.gso.uri.edu/pub/downloads/codiga/pubs/2012CodigaEtAl-FerryBasedSamplingWhitePaper-IOOSsummit.pdf)

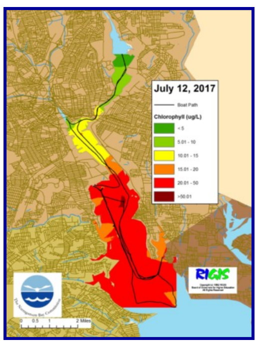
The Narragansett Bay Commission Water Quality Monitoring Initiatives

The Narragansett Bay Commission's (NBC) water quality program includes the monitoring initiatives listed below. More information and data for each of these programs are available at: http://snapshot.narrabay.com.

Fixed Site Water Quality Monitoring: The NBC maintains two water quality stations in conjunction with the Narragansett Bay Fixed Site Monitoring Network (NBFSMN). Sensors at Phillipsdale Landing and Bullock Reach record temperature, salinity, dissolved oxygen, pH, chlorophyll *a*, and turbidity at 15-minute intervals during the summer season. Data from the stations are updated on the Snapshot website every hour, providing near real-time conditions of water quality in the Providence and Seekonk Rivers.



Water Column Profiles: The NBC collects water quality profiles at six locations throughout the upper bay every week or every two weeks. These profiles provide a cross-sectional view of the structure of the water column and aid in assessing when the water is stratified and/or at risk for hypoxic conditions. The parameters collected include depth, density, temperature, salinity, dissolved oxygen, photosynthetically active radiation (PAR), and fluorescence.

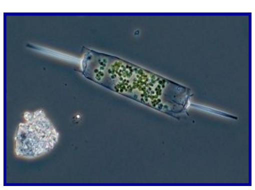


Surface Mapping: The NBC uses a sonde to collect surface water quality data while their vessel, R/V *Monitor*, is underway. The benefit of this monitoring is the ability to document surface water quality over a large area while traveling between the NBC monitoring stations. Parameters measured include temperature, salinity, dissolved oxygen, pH, and chlorophyll *a*. From this data, the NBC can create spatial maps to show and extrapolate data over a large area of the upper bay.

Water Clarity: The NBC collects water clarity samples on a weekly basis at six locations throughout the upper Bay, utilizing both the Secchi disk as well as a PAR meter. Clear water is important so that ample sunlight is available for the aquatic plants, algae, and phytoplankton living in Narragansett Bay.

Pathogen Monitoring: The NBC collects bacteria samples every two weeks at 20 stations throughout the upper Bay, and weekly samples at 23 stations in the urban rivers. This sampling can demonstrate if water quality is suitable for swimming and shellfishing. All samples are analyzed for fecal coliform and 25% of the samples are also analyzed for enterococci.

Nutrient Monitoring: The NBC samples for various nutrient parameters twice a month at six upper Bay stations and 14 river stations. Several river stations are located at the state border to determine what is coming into the bay from outside the state. Parameters monitored include nitrite, nitrate, ammonia, total dissolved nitrogen, total nitrogen, orthophosphate, silicate, and chlorophyll.

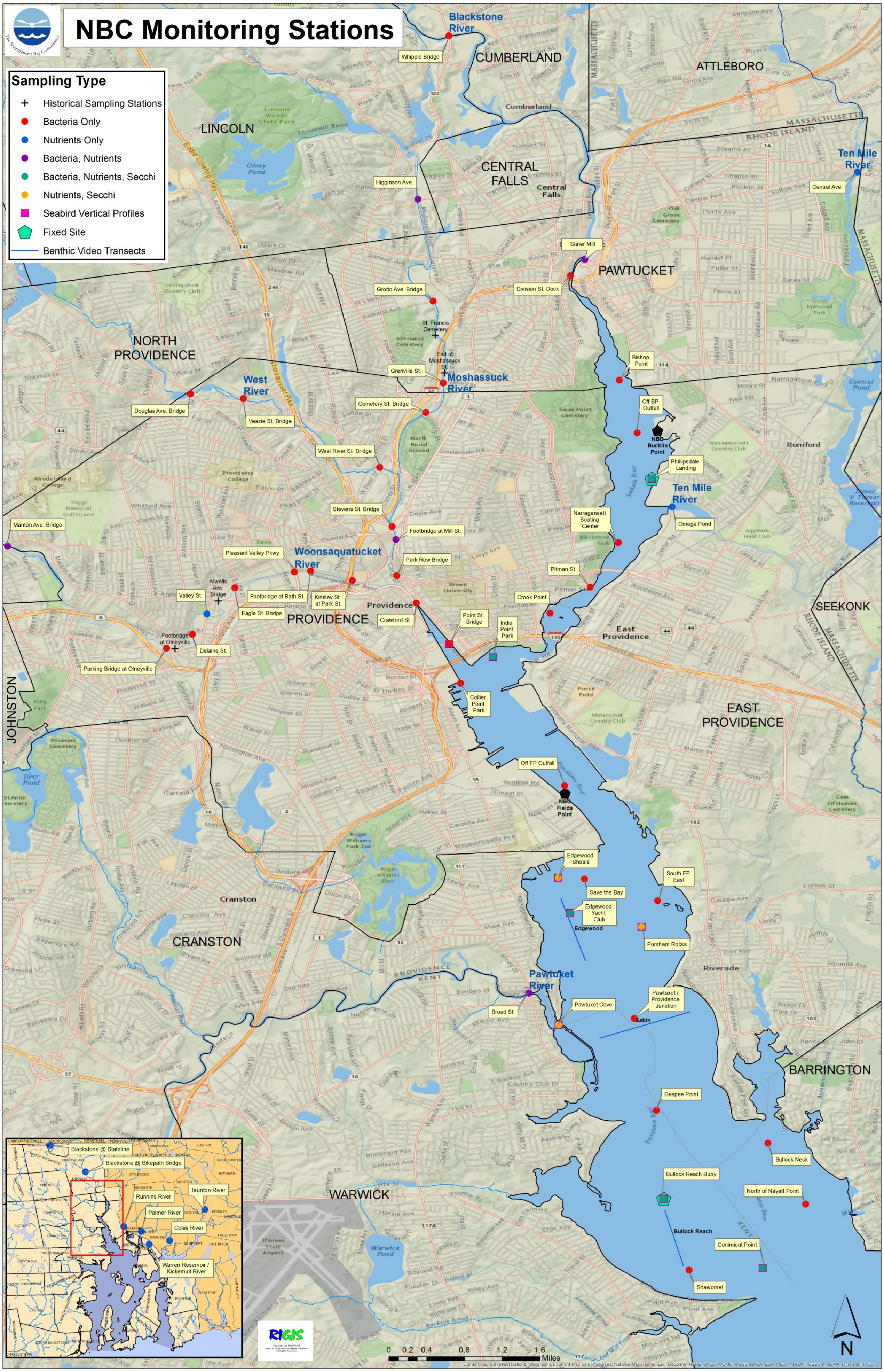


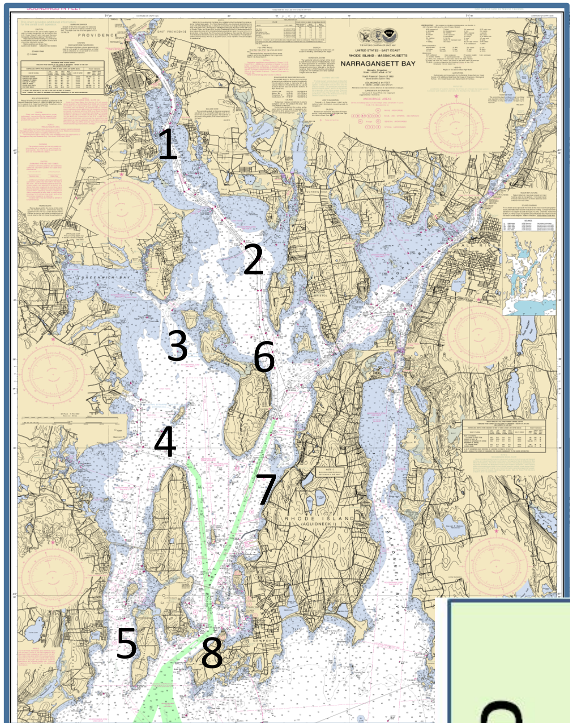
Plankton Monitoring: The NBC collects phytoplankton samples once per week or every other week at the Bullock Reach station. Samples are analyzed to document the presence and number of various groups of phytoplankton present in the sample. Both quantitative counts of common taxa and qualitative presence/absence analysis of rare taxa are performed.

Benthic Video Monitoring: Over the summer months, the NBC collects video footage of the bottom waters of the upper Bay to track potential changes in the benthic habitat as nitrogen loading to the Bay is reduced by WWTFs. An underwater camera is attached to a specialized sled to collect video as the NBC's boat transects areas of the Bay. The NBC targets the Edgewood Shoal area, as well as the Bullock Reach and Sabin Point areas of the upper Bay for these surveys.

For further information, please contact the NBC at:
(401) 461-8848 ext. 261 or emda@narrabay.com or snapshot@narrabay.com
Visit the NBC's websites – www.narrabay.com & http://snapshot.narrabay.com/app/
for information on all Narragansett Bay Commission news, as well as to download NBC water quality data

Map of NBC monitoring stations for all monitoring initiatives





EPA Atlantic Ecology Division's monthly monitoring.

We also:

-periodically measure stable isotopes in seaweeds and hard clams.

-conduct more detailed surveys of carbonate chemistry (latter effort led by Jason Grear, grear.Jason@epa.gov)

POC for this work is Autumn Oczkowski, oczkowski.autumn@epa.gov

FIELD

At Station (*8 stations*)

CTD Cast
Temp., salinity, pH, dissolved oxygen, depth

Niskin Bottles
3 x 1L bottles at each:
Surface, Middle, Bottom

LAB

Chlorophyll
3 replicates

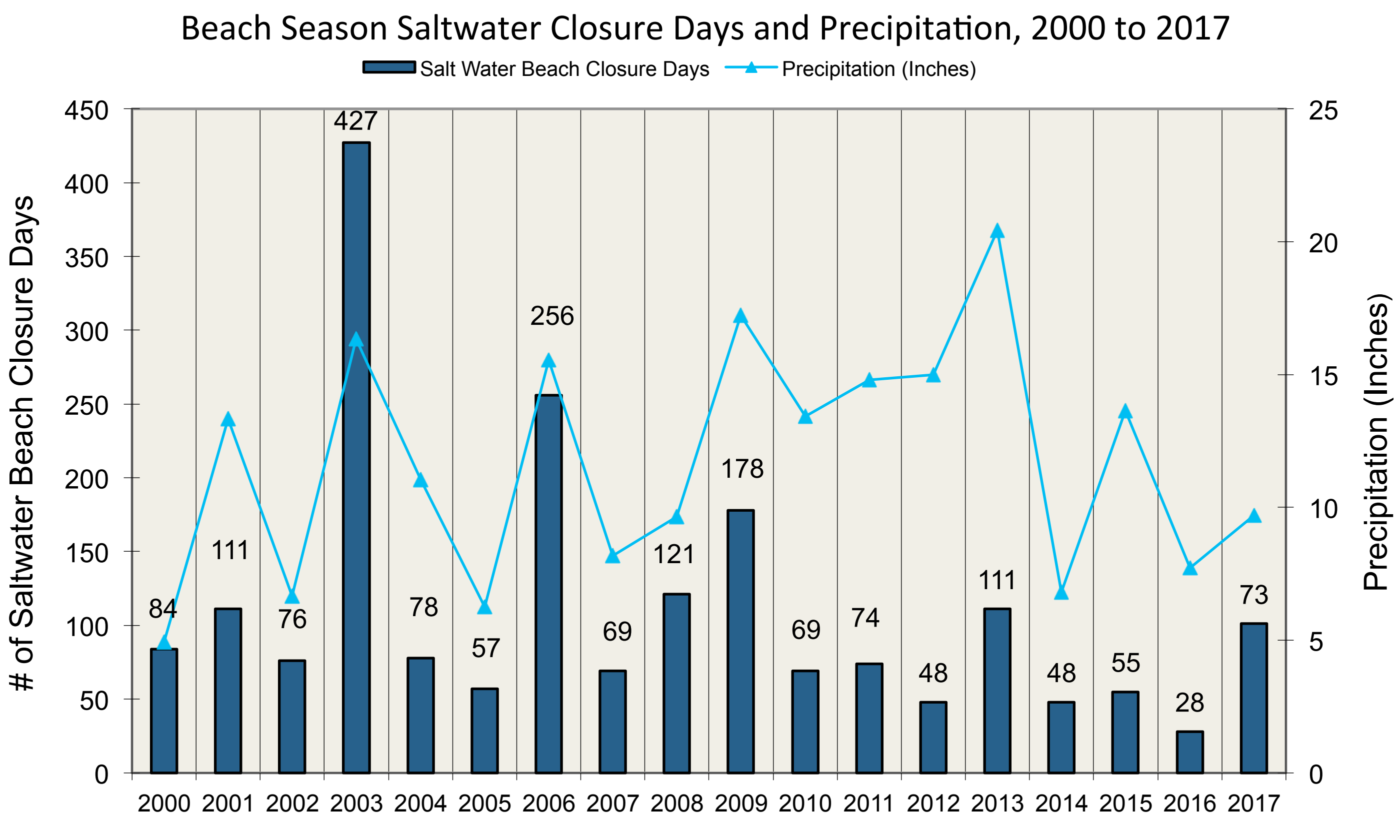
Nutrients
•Analyze for nitrate, nitrite, ammonium, phosphate, silica, TDN, TDP

DIC & DOC
2 reps DIC and 2 reps DOC

Particulate Stable Isotopes
2 replicates

TSS & %Organic Matter
2 replicates

Alkalinity



In 2017, 73 closure days occurred across 15 of the 70 monitored saltwater beaches while 55 beaches did not close. This is an increase in closure rate relative to recent years, but much of the increase is due to multiple days of closure per closure event (see table, below).

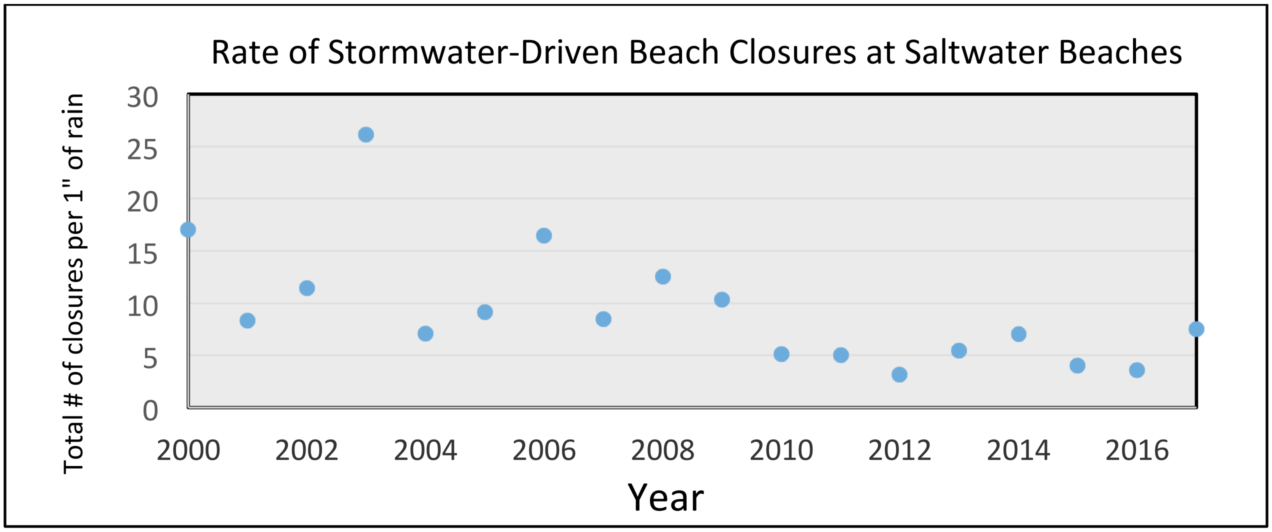
RI Saltwater Beach Closures in 2017: Per Beach, Number of Days/Number of Events.

Name (monitoring frequency)	Year			Name (monitoring frequency)	Year		
Tier I (2x/week)	2015*	2016*	2017*	Tier II Beaches (2x/month)	2015*	2016*	2017*
Oakland Beach	9/6	9/1	26/5	King Park Swim Area	1/1	0	4/3
Conimicut Beach	4/4	6/3	12/2	Saunderstown Yacht Club	0	0	4/1
Goddard State Park	8/7	2/2	1/1	Sandy Point Beach	2/1	0	2/1
Peabody's Beach	7/2	0	3/2	Spouting Rock Beach	0	2/1	2/1
Warren Town Beach	4/3	0	6/3	Mackerel Cove	0	3/2	0
Easton Beach	6/4	1/1	0	Hazard's Beach Newport	0	0	2/1
Barrington Town Beach	0	1/1	5/2	North Kingstown Town Beach	2/2	0	0
City Park Beach	3/2	0	2/1	Fort Adams State Park	1/1	0	0
Third Beach	2/2	0	2/2	Plum Beach	0	0	1/1
Bristol Town Beach	1/1	2/1	1/1				
Scarborough State Beaches	1/1	0	0				

It is notable that, of the Tier 1 beaches (highest risk, most frequently monitored), only Oakland Beach and Warren Town Beach had more closure events in 2017 than in 2016 and none had more events than in 2015.

Six Tier II beaches had closures in 2017, compared with only two in 2016 and four in 2015. There were no Tier III closures in 2017.

The chart below, with beach closure days normalized to total seasonal rainfall, suggests that in recent years stormwater contributes less to the closure rate. This may be a useful metric to track improvements associated with aggressive efforts within the state to manage stormwater!



There were four freshwater beaches that closed during 2017, for a total of 28 days during seven events. Due to the variable sampling frequency at freshwater beaches, between-year comparisons are not valid.

Project Progress in 2017

Rapid Detection Project

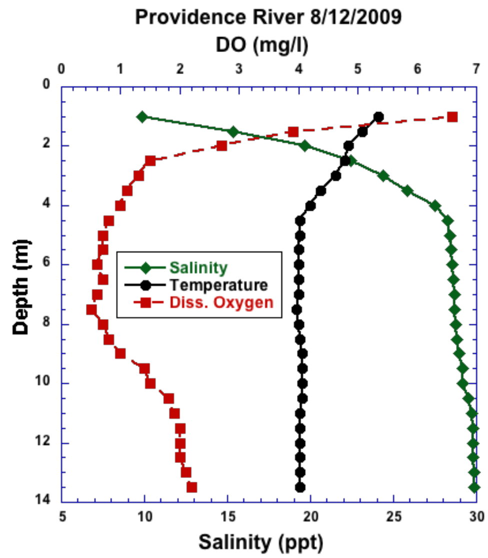
The Enterolert® test is the standard method, nation-wide, for monitoring beach water quality. It is a 24-hour assay, so results represent the previous days' water quality. This delay poses health risks because swimming in impaired waters may occur for up to 24 hours before the risk is discovered. To address this problem, RIDOH received a grant from EPA's Southeast New England Program to develop capacity for Quantitative Polymerase Chain Reaction (qPCR) testing. qPCR provides results in six hours, potentially allowing same-day management actions. While the project achieved a primary objective (to develop RIDOH laboratory proficiency in qPCR for Enterococci enumeration), the strength of the correlation between qPCR and the Enterolert method was poor, leading to concern that the method is not reliable. In the final stage of the study, we will re-test split samples to compare results from Enterolert® and the standard membrane filtration culture method 1600 (EPA, 2002), while also testing with the qPCR method. Results from the two culture-based methods have apparently been found to select for different Enterococcus species (Ferguson et al., 2013), and also may produce false positive results in up to a quarter of tested samples (Raith et al., 2013).

2018 Focus

One objective for the upcoming year will be to continue to engage beach managers to update profiles of health risks, source identification and controls. Most profiles date back to 2003. Additionally, if resources allow, we hope to initiate modelling to predict water quality at the most impaired beaches using EPA's "Virtual Beach" software. The absence of funding to monitor freshwater beaches continues to be a problem.

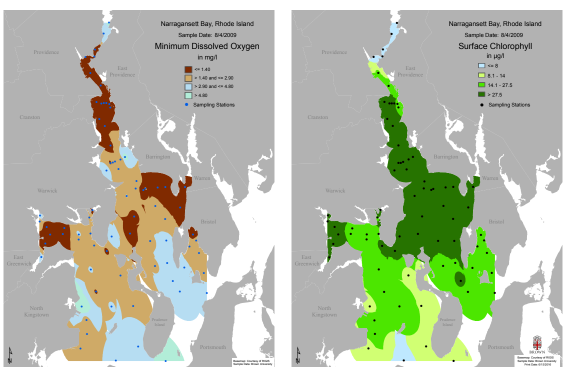
Spatial Surveys of Summer Hypoxia and Water Quality

Warren Prell and David Murray,
Depart. Earth, Environment, and Planetary Science, Brown University

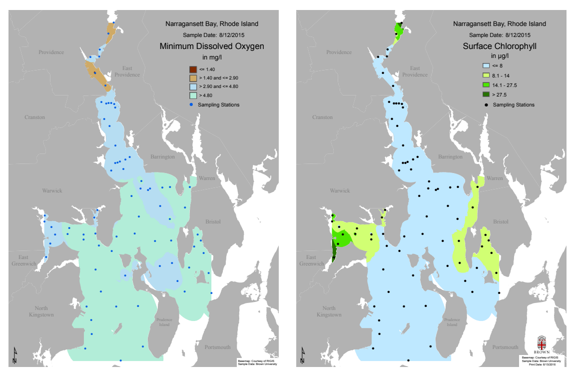


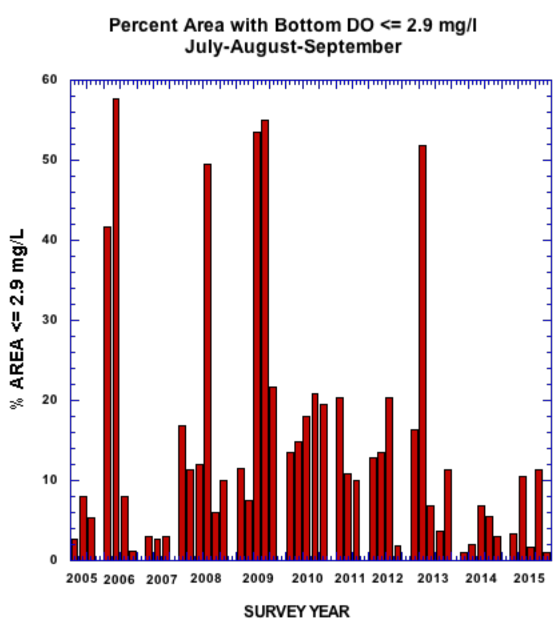
3 boat groups: Brown, STB/Brown, URI/DEM
77 stations in upper and mid bay, 4 to 7 surveys per year
Measure temperature, salinity, density, dissolved oxygen (DO), and chlorophyll (Chl)
2005-2017, continuous water column profiles using SeaBird CTD
71 surveys, ~5100 individual profiles (through 2017)
Map bottom DO and surface Chl to identify the area of hypoxic and bloom conditions
Most data is available through NBEP and Brown University
Data processing and most data collection is unfunded

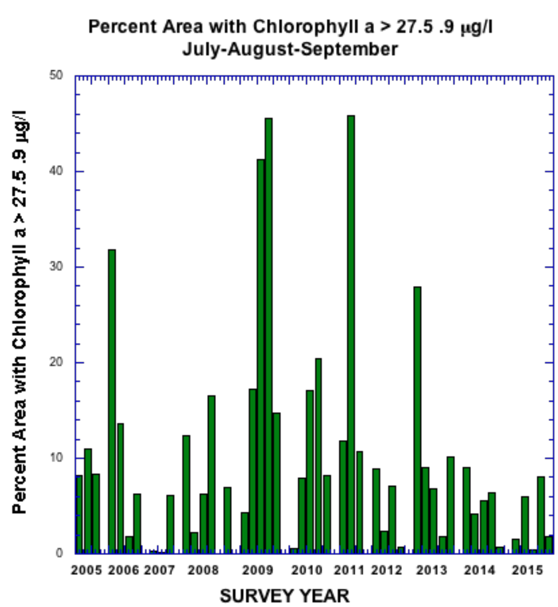
Max hypoxia and Chl   8/04/2009



Min hypoxia and Chl 8/12/2015







Observing and Modeling Post-Storm Intrusion Events

Kevin Rosa, Chris Kincaid, Dave Ullman

In September 1999, an Acoustic Doppler Current Profiler (ADCP) moored in Narragansett Bay's East Passage captured a first-of-its-kind view of how the Bay responds to a tropical cyclone. Hurricane Floyd was a weak tropical storm by the time it made landfall in New England (max windspeed 20 m/s, max surge 0.8 m above predicted tide) but the velocity and the temperature measurements show a substantial intrusion of shelf-water. These data provide a robust test of our numerical models and have lead us to the following conclusion: <u>a 3D stratified model is essential when calculating residual transports, even in a storm event characterized by intense vertical mixing</u>.

The 300 kHz ADCP sat under the Newport Bridge (41.5057°N, 71.3518°W) and sampled velocities at 2 meter vertical bins. Following Floyd's landfall in Narragansett Bay, the bottom temperature at the ADCP dropped nearly 4°C in 3 days. This is the largest magnitude temperature change observed during the deployment.

This temperature drop is caused by an intrusion of cool Rhode Island Sound shelf-water. This poorly-understood exchange process could be a significant source of nutrients after a storm event.

In order to better understand what is forcing the shelf intrusion and to quantify the associated fluxes, we employ the Regional Ocean Modeling System (ROMS) numerical model. Two model configurations are presented here: a baroclinic (i.e. stratified) 3D model with realistic temperature and salinity gradients and a barotropic (i.e. unstratified) 3D model with constant density. Current operational storm surge models are 2D barotropic and there have been several studies assessing the advantages of a *3D* barotropic model. Baroclinic effects have not been shown to have enough of an effect on storm surge to warrant the extra computational power.

The model domain covers all of Narragansett Bay and Rhode Island Sound. Spatial resolution in the East Passage is about 150 m in the cross-channel and 225 m in the along-channel direction. There are 14 terrain-following layers in the vertical.

Atmospheric forcing comes from the ECWMF ERA-Interim reanalysis product. Free-surface height and depth-averaged velocities at the open boundaries come from a basin-scale 2D ADCIRC storm surge model.

Comparing model output for Floyd, there is essentially no difference in sea surface height between the baroclinic and barotropic models, as expected (Fig 1a). Additionally, both models show good agreement with sea surface height observed at NOAA's Newport tide gauge.

Although the instantaneous velocities for the two configurations also appear similar to each other (Fig 1b), it becomes clear when integrating through time that the barotropic model is actually not suitable for calculations of residual transport (Fig 1c).

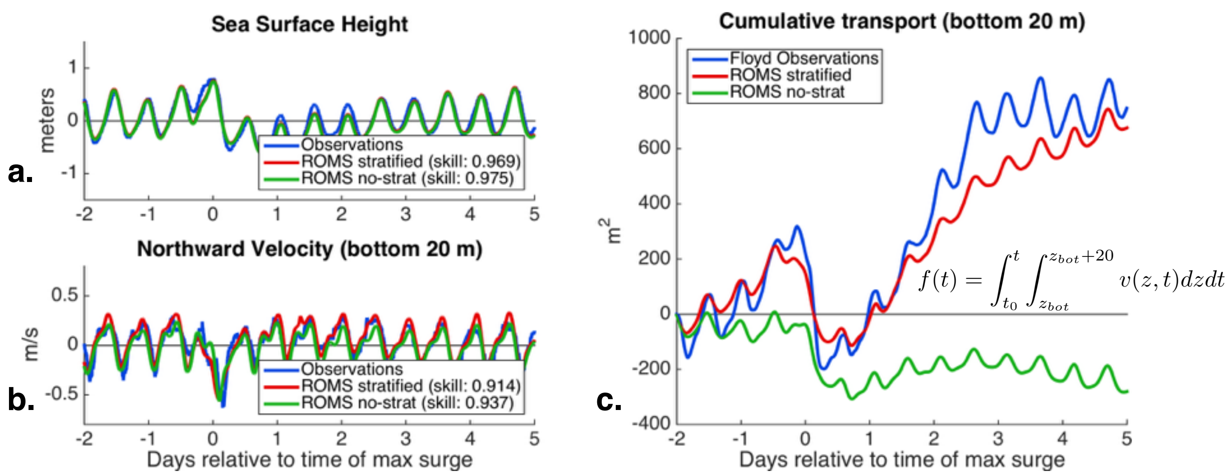


Figure 1: Model-data comparisons. In *a-b*, model-data agreement is calculated using the Willmott Skill. Skill of 1 represents perfect agreement. In *c*, northward velocity is averaged for the bottom 20 meters of the water column and then integrated in time. The stratified model is in good agreement with the residual transport but the unstratified model completely misses it.

In the open ocean, the extreme wind-driven vertical mixing may make the baroclinic pressure gradients negligible but Narragansett Bay is characterized by large *lateral* density gradients in addition to vertical gradients. Strong mixing results in vertical isopycnals which generate non-tidal circulation during the return to normal stratification.

Next steps will be to quantify the nutrient load of such an event. The 4 days following Floyd's landfall saw ~5x10^7 m^3 of river input compared to ~5x10^8 m^3 through the East Passage (according to the ROMS baroclinic model).

Ecological monitoring and assessment framework for Southeast New England coastal waters

Emily J. Shumchenia

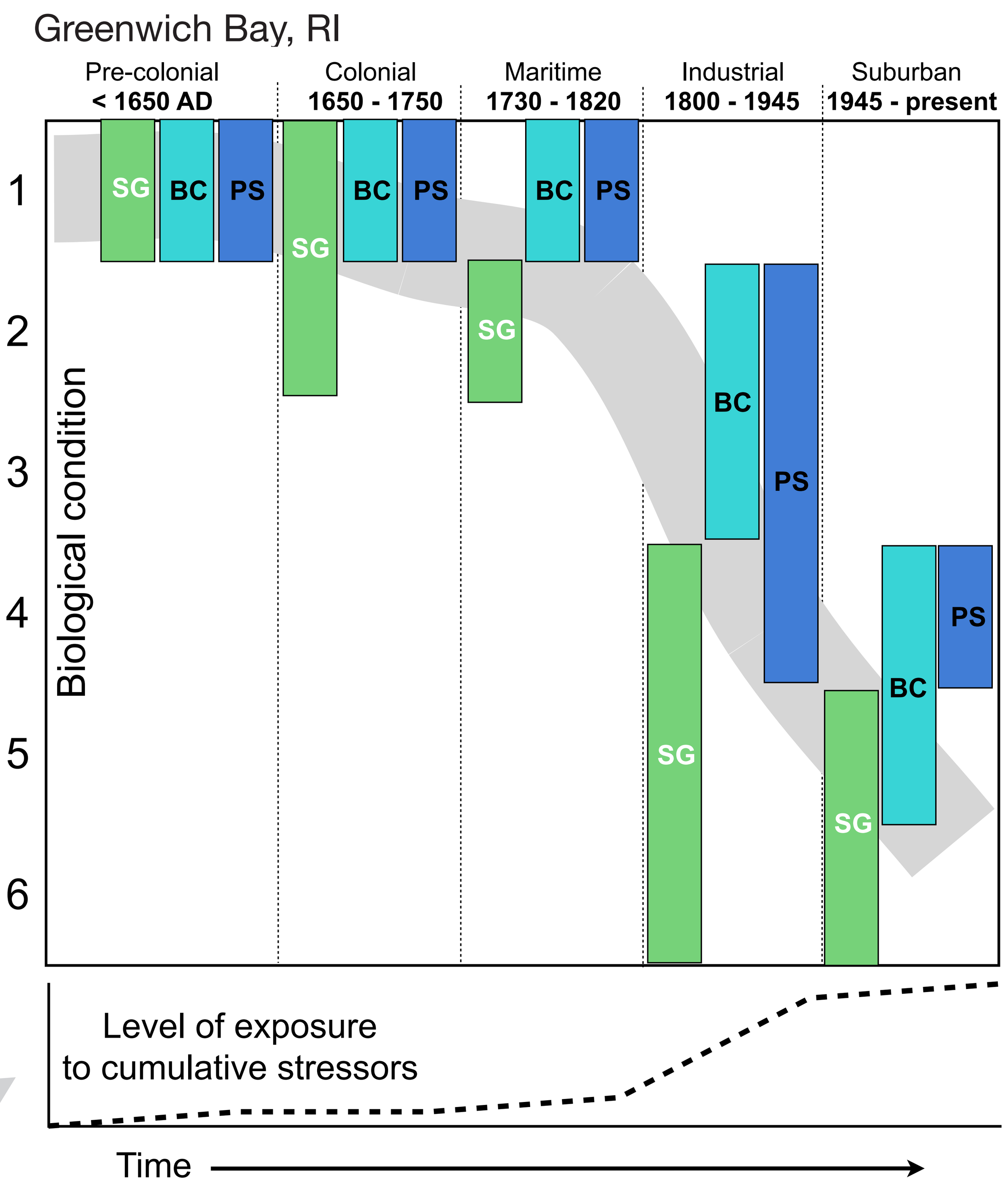
Biological Condition Gradient (BCG)

WHAT IS IT? A comprehensive, descriptive, and ecosystem-based framework that integrates biological, physical, and chemical conditions independent of assessment methods in order to effectively identify, communicate, and prioritize management action.

Describes a gradient in resource condition ranging from undisturbed or minimally disturbed reference condition (Level 1) to severely altered condition (Level 6)

SG = Seagrass
BC = Benthic Community
PS = Primary productivity and Shellfish

Measureable ecological attributes and ecosystem services aid in judging the degree to which a system may have departed from a natural condition



Evaluates cumulative stressors and tracks improvement over time and spatial extent

A BCG synthesizes existing data, observations, and accepted interpretations to document the trajectories (responses) of these measures across a generalized stressor gradient

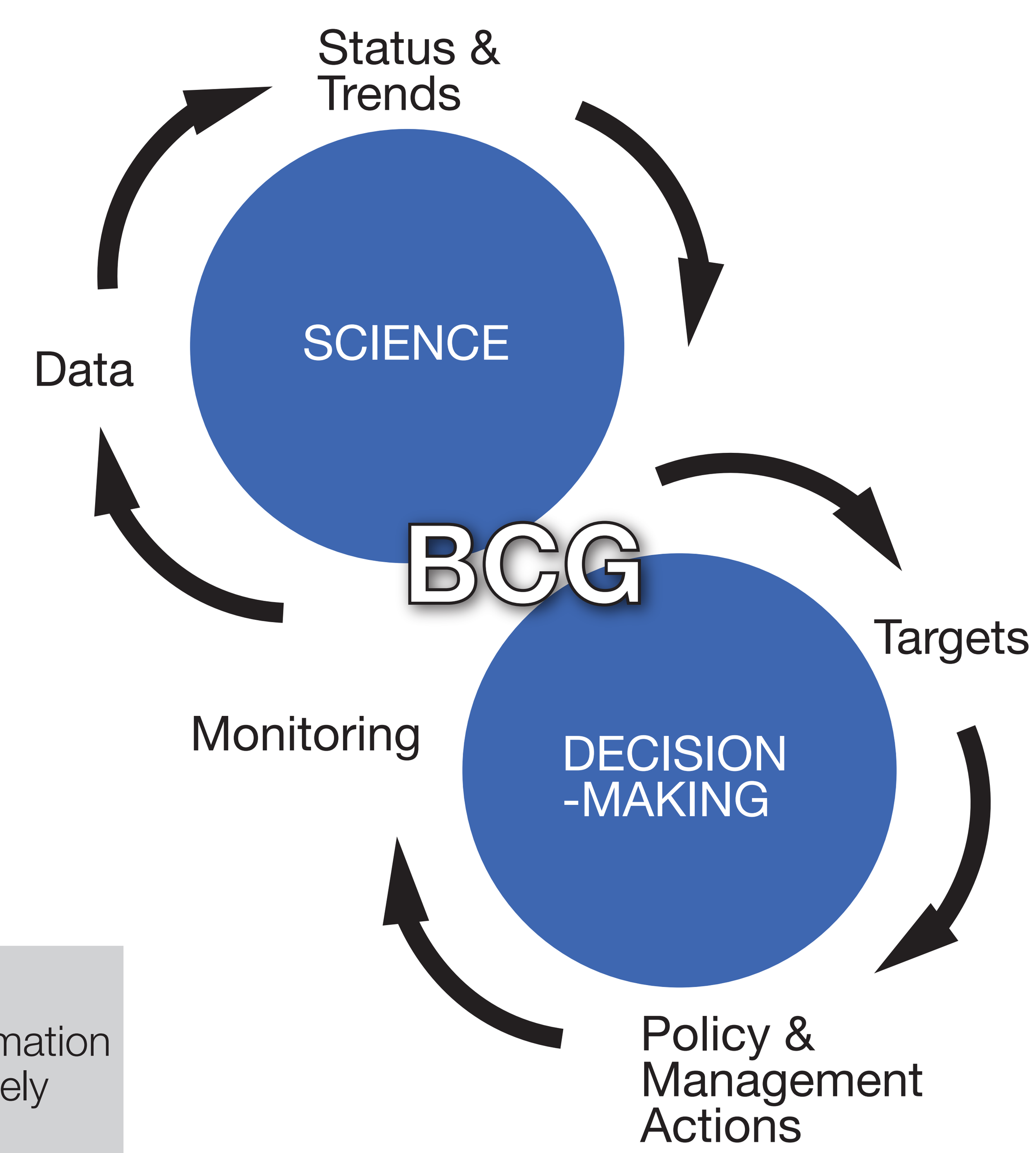
Provides a framework for organizing scientific information so it can be more effectively used and understood by managers and the public

COMMUNICATION: provides the vocabulary and common language to describe ecosystem conditions and answer questions in a meaningful way

GOAL SETTING: helps capture ecologically-based priorities and vision for the system, shifts focus from pollution control to biological impacts (ecosystem health)

CONSISTENCY: enables consistent evaluation of condition that still addresses local priorities and ecological condition

GUIDANCE: assists in prioritizing resource investments



2017+ Examine other habitat types and SNEP areas, like Buzzards Bay

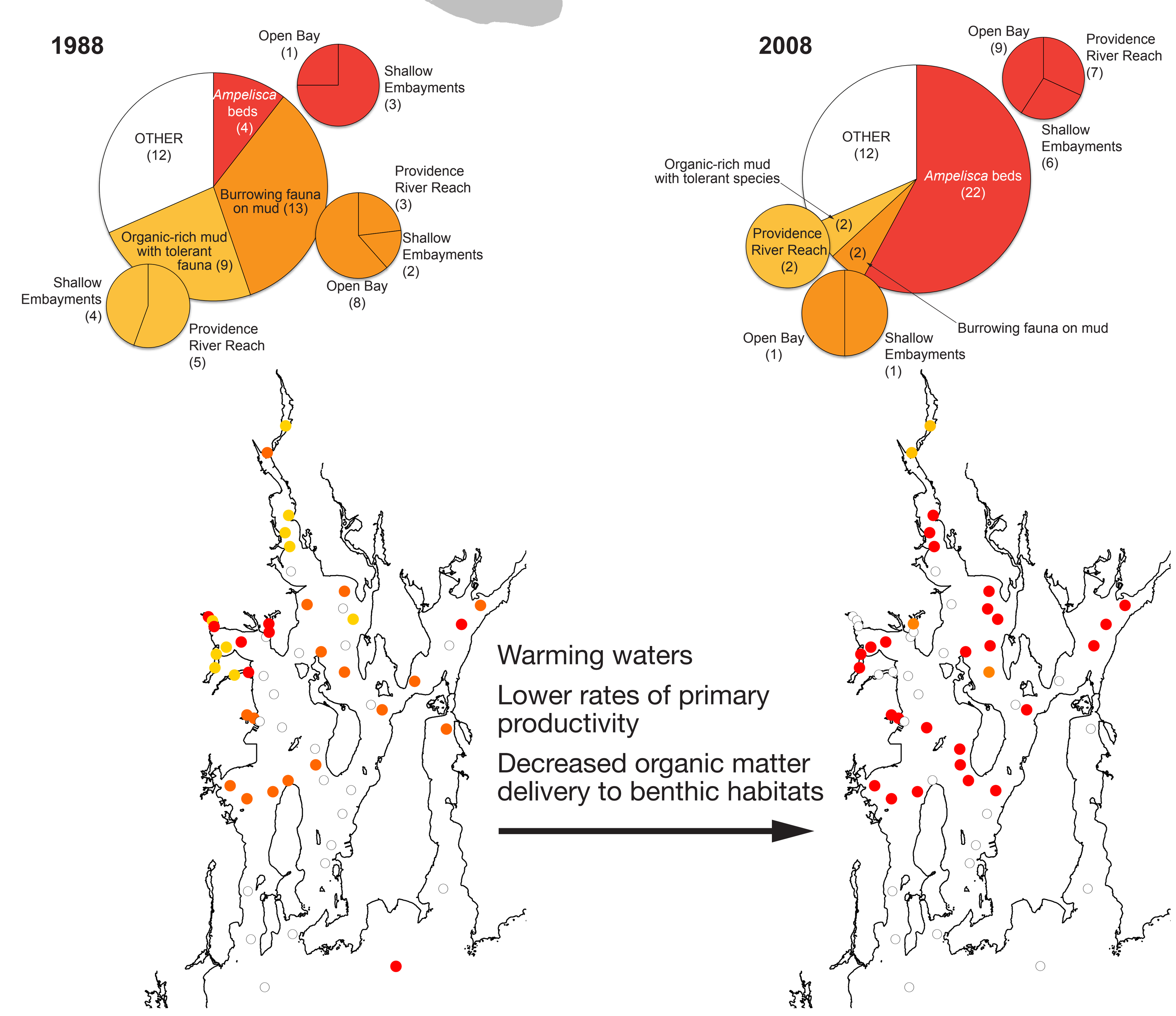
Seagrass, saltmarsh, shellfish beds, and macroalgae in Narragansett Bay >175 years of data

Explore ways to apply BCG + biotope mosaic approaches in other SNEP estuaries

Biotope Mosaic

WHAT IS IT? Evaluates the condition of a water body through the mix of biotopes it contains. One way that the cumulative impacts of stressors manifest is through destruction and conversion of biotopes. Returning the proportions or balance of biotopes to a previous and less-disturbed state would benefit the estuary as a whole, by moving the estuary closer to the mosaic of biotopes under which native species evolved.

For Narragansett Bay, the biotope mosaic approach has already been used to assess changes to benthic communitites (see maps at right). Other important bay habitats with historical quantitative data, such as seagrasses and salt marshes, are good candidates for a future whole-estuary biotope mosaic approach. Because historical changes in the bay's overall biotope mosaic can be related to alterations in the natural functions of and production in the bay ecosystem, this approach could inform and motivate the public, stakeholder, scientific, and management communitites to continue and expand efforts to study, protect, and restore the Narragansett Bay ecosystem.



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Questions?

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Characterizing Hypoxic Events for an Assessment Tool for Managers within Narragansett Bay, RI

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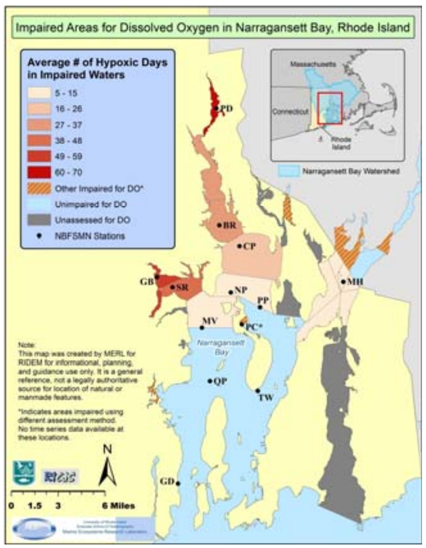
ABSTRACT

About 32.5% of Narragansett Bay is impaired for hypoxia. The Bay experiences seasonal intermittent hypoxia events with the potential to threaten ecological health from May-October. Based on previous work, these hypoxic events (daily average oxygen < 2.9 mg O²/L) are correlated with river flow. Years with higher numbers of hypoxic events have anomalously large summer seasonal river runoff and/or high spring/summer temperatures. Years with the lowest temperatures and low flow from river runoff are correlated with the fewest hypoxic events. The time-series records for 12 years (2001-2016) were examined to identify any potential to use hypoxia events to evaluate nutrient loading reductions that are occurring in the watershed. The Narragansett Bay Fixed-Site Monitoring Network (NBFSMN) is necessary to provide managers with assessment tools to evaluate hypoxia in Narragansett Bay.

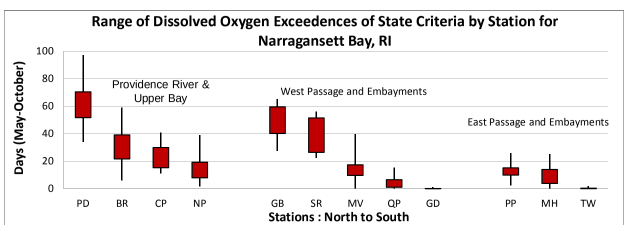
INTRODUCTION



The Narragansett Bay Fixed-Site Monitoring Network (NBFSMN) was created to analyze the spatial and temporal distribution of hypoxia in Narragansett Bay. This goal is achieved through an interagency collaboration.

NBFSMN Partners:

DEM-OWR (Lead Agency), URI/GSO, Narragansett Bay Commission (NBC), and Narragansett Bay National Estuarine Research Reserve (NBNERR).

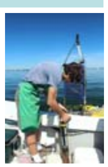


For more information visit: www.dem.ri.gov/bart/stations.htm

METHODS

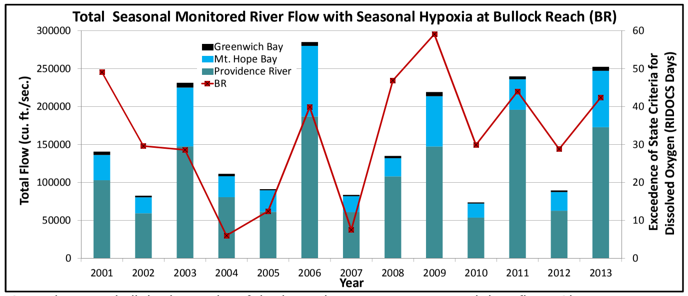
Measurements are made on a15-minute interval at about 1 meter above bottom and below surface.

Parameters measured are temperature (accuracy +/-0.15ºC), salinity (0.1ppt), and dissolved oxygen (0.2 mg/L) at near-surface and near-bottom depths, and near-surface chlorophyll fluorescence.

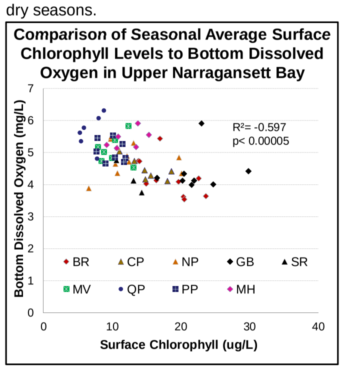


SEASONAL FORCING FACTORS ANALYSIS

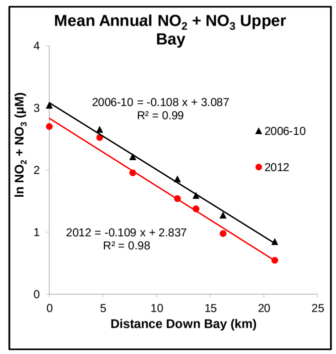
Hypoxia refers low dissolved oxygen (DO) concentrations that adversely affect organisms. Hypoxic events were identified using Rhode Island's water quality criteria for DO which relates a series of thresholds to varying time durations, e.g., DO not be less than 2.9 mg/L/24 hours for waters below a pycnocline. For this analysis, the seasonal spatial extent & seasonal cumulative duration of hypoxia were examined with forcing factors. All years were analyzed from at least June-September based on data availability.



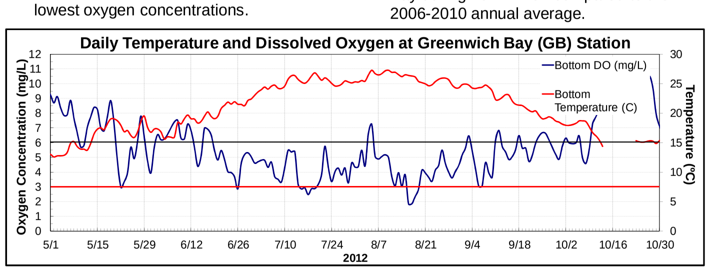
A previous study linked severity of the hypoxic season to seasonal river flow. Above average seasonal flow corresponded with above average number of days of hypoxia and extended spatial extent of hypoxia coverage. 2003, 2006, and 2008 have data missing during hypoxic events (amounts may be under-estimated). 2002, 2005, 2007, 2010, and 2012 are considered dry seasons.



The headwater stations tend to have the highest summer seasonal average chlorophyll levels corresponding with the lowest oxygen concentrations.



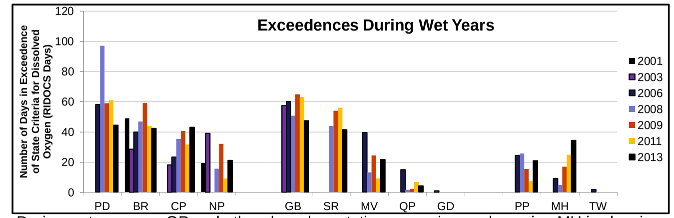
Preliminary analyses show a reduction in nitrogen concentrations in Narragansett Bay during 2012 when compared to the 2006-2010 annual average.



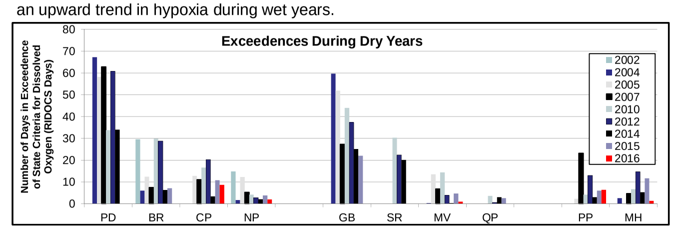
Hypoxic conditions do not usually occur with temperatures under 15º C. Normally, temperatures are below 15º C before the first week in June. In 2012, hypoxia was documented in May for the first time in Greenwich Bay.

ASSESSMENT TOOLS

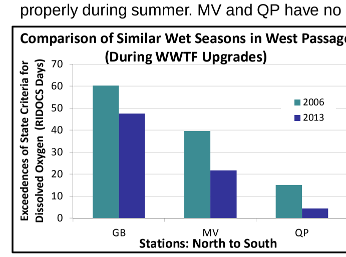
Since 2006, several wastewater treatment facilities (WWTFs) have upgraded their facilities to reduce nutrient loadings to Narragansett Bay. By 2017, nitrogen removal is expected from 11 RI WWTFs and is projected to reduce their summer season nitrogen loading by 65%, but dropping to 48% as WWTFs flows reach approved design flows (data from RIDEM-OWR). Managers are expecting to see hypoxia reductions at outer reaches of the spatial extent for hypoxia first (i.e. Quonset Point). Results from the state assessment tool (RIDOCS) were examined for any potential trends.



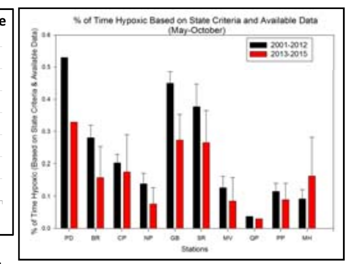
During wet seasons, QP and other down bay stations experiences hypoxia. MH is showing an upward trend in hypoxia during wet years.



NP shows a downward trend. 2010 may be anomalous because of WWTFs not operating properly during summer. MV and QP have no data for 2002.



Although 2006 and 2013 had somewhat similar seasonal flow patterns, stratification was higher in 2006. The downward trend may be influenced by stratification more than nutrient reductions. Sites with data gaps are not included in this graph.



There is a downward trend at most stations from pre and post WWTF upgrades. Although these trends are not statistically significant, yet.

CONCLUSIONS

1. Inter-annual variability in hypoxia is linked to inter-annual variability in flow and temperature. High flow and/or warm years produce longer durations during hypoxic events. The lowest flow years are linked with the lower hypoxia (spatial extent and seasonal duration). Increasing seasonal temperatures (May-Oct) can prolong hypoxic season.
2. Examining similar hypoxic events/seasons allow for intermediate assessments.
3. The data generated by the NBFSMN is vital to monitoring and assessing the impact of reduced pollutant loadings resulting from WWTF upgrades within the Narragansett Bay Watershed.

ACKNOWLEDGEMENTS

The monitoring network is funded in part by RIDEM-OWR, EPA Clean Water Act, NBC, NBNERR, and previously NOAA Bay Window Program. Thank you to all that contribute to NBFSMN. This program could not have been possible without the contributions of the late Dr. Dana Kester.

Spatial and temporal variability in macroalgal blooms in a eutrophied coastal estuary*

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Abstract:

All three macroalgal clades (Chlorophyta, Rhodophyta, and Phaeophyceae) contain bloom-forming species. Macroalgal blooms occur worldwide and have negative consequences for coastal habitats and economies. Narragansett Bay (NB), Rhode Island, USA, is a medium sized estuary that is heavily influenced by anthropogenic activities and has been plagued by macroalgal blooms for over a century. Over the past decade, significant investment has upgraded wastewater treatment from secondary treatment to water-quality based limits (i.e. tertiary treatment) in an effort to control coastal eutrophication in this system. The goal of this study was to improve the understanding of multi-year macroalgal bloom dynamics through intensive aerial and ground surveys conducted monthly to bi-monthly during low tides in May–October 2006–2013 in NB. Aerial surveys provided a rapid characterization of macroalgal densities across a large area, while ground surveys provided high resolution measurements of macroalgal identity, percent cover, and biomass.

Macroalgal blooms in NB are dominated by *Ulva* and *Gracilaria* spp. regardless of year or month, although all three clades of macroalgae were documented. Chlorophyta cover and nutrient concentrations were highest in the middle and upper bay. Rhodophyta cover was highest in the middle and lower bay, while drifting Phaeophyceae cover was patchy. Macroalgal blooms of >1000 g fresh mass (gfm)/m^2 (max = 3,510 gfm/m^2) in the intertidal zone and >3000 gfm/m^3 (max = 8,555 gfm/m^3) in the subtidal zone were observed within a heavily impacted embayment (Greenwich Bay). Macroalgal percent cover (intertidal), biomass (subtidal), and diversity varied significantly between year, month-group, site, and even within sites, with the highest species diversity at sites outside of Greenwich Bay. Total intertidal macroalgal percent cover, as well as subtidal *Ulva* biomass, were positively correlated with temperature. Dissolved inorganic nitrogen concentrations were correlated with the total biomass of macroalgae and the subtidal biomass of *Gracilaria* spp. but not the biomass of *Ulva* spp. Despite seasonal reductions in the nutrient output of wastewater treatment facilities emptying into upper Narragansett Bay in recent years, macroalgal blooms still persist. Continued long-term monitoring of water quality, macroalgal blooms, and ecological indicators is essential to understand the changes in macroalgal bloom dynamics that occur after nutrient reductions from management efforts.

Fig 1. Subtidal (left) and intertidal (right) macroalgal blooms in Narragansett Bay are dominated by *Ulva* blades (sea lettuce) and coarsely branched red seaweeds (*Gracilaria*/*Agardhiella*).

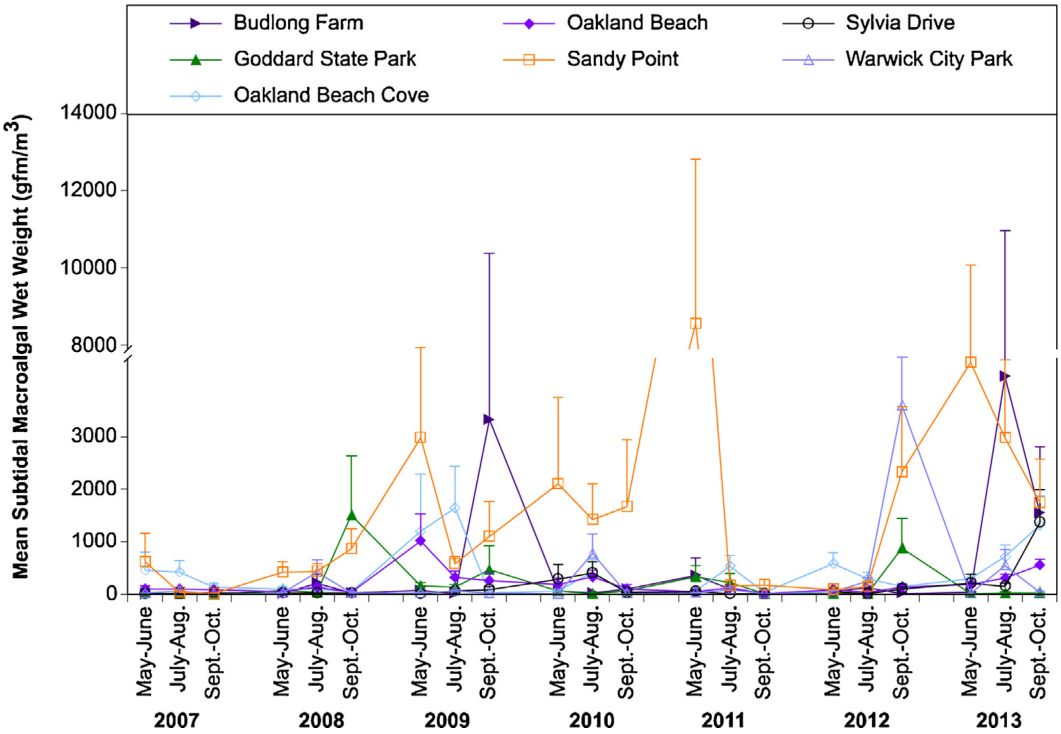


Fig. 2. Mean total algal biomass (grams fresh weight, gfm) observed during subtidal surveys at 7 sites in Greenwich Bay.

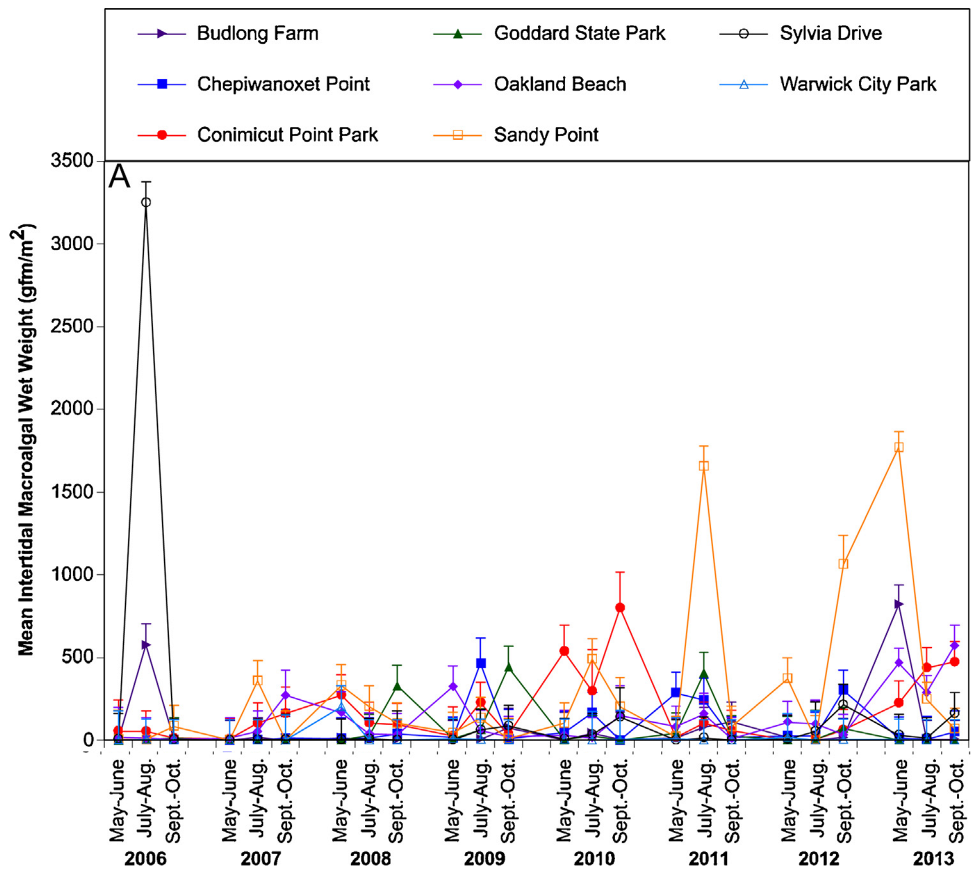


Fig. 3. Mean total algal biomass observed during intertidal surveys at 8 sites in Greenwich Bay.

MyCoast RI – Monitoring for Nuisance Flooding, Storm Damages and Habitat Impacts from Sea Level Rise

Introduction

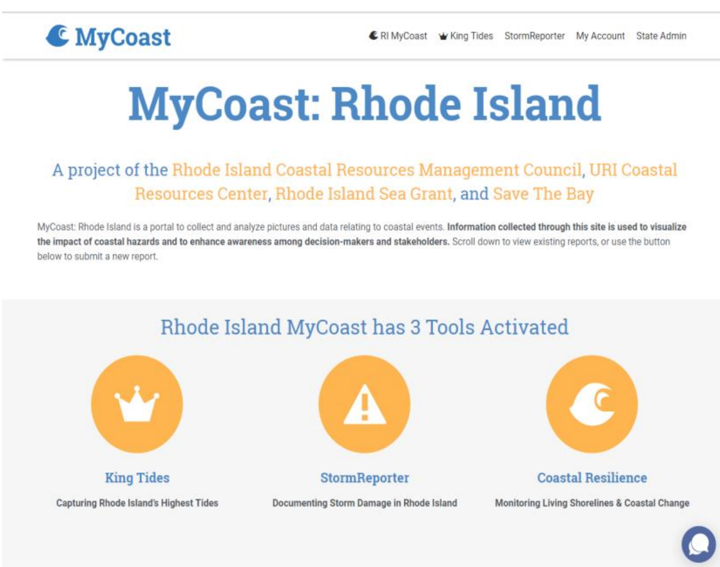
The Narragansett Bay Estuary Program identifies sea level rise as one of the climate stressors in the ***State of Narragansett Bay and Its Watershed - Technical Report***. Rising sea levels impact several bay ecosystems, particularly salt marshes and stresses many elements of the humanly altered landscape. Many low lying roads are currently inundated by nuisance flooding. In the future these transportation systems and other critical infrastructure in coastal areas will be inundated more and more frequently.

Low lying coastal roads are frequently flooded in Rhode Island when tides are higher than normal. This road flooded when tides were 2 feet above MHHW. Nuisance flooding events like this are compared to modeled inundation data to validate the models.

Stormtools 2 foot SLR map matches the observed flood levels.

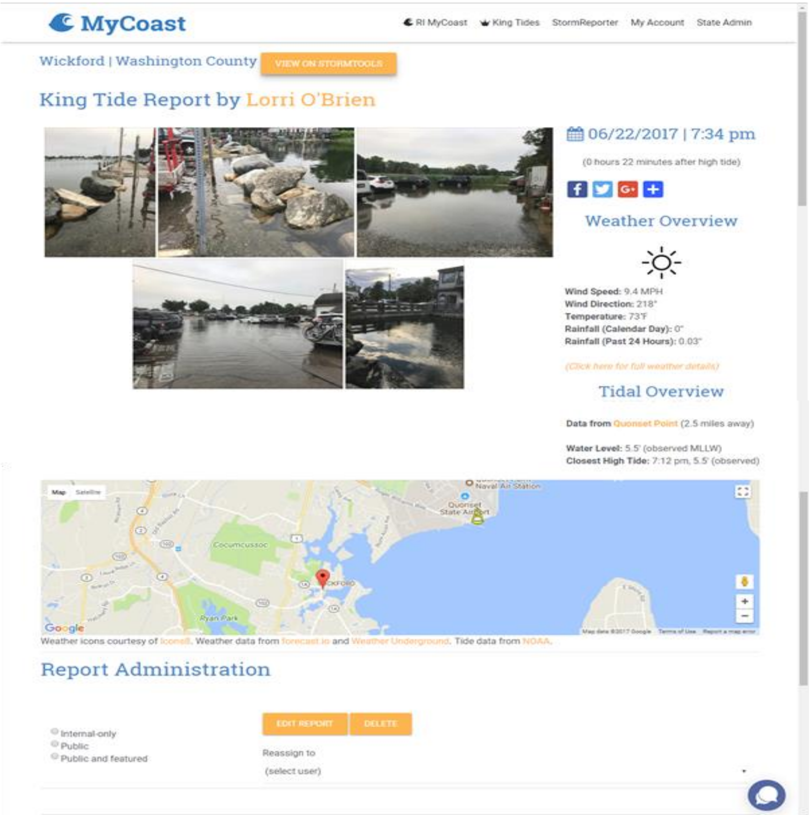
The MyCoast App

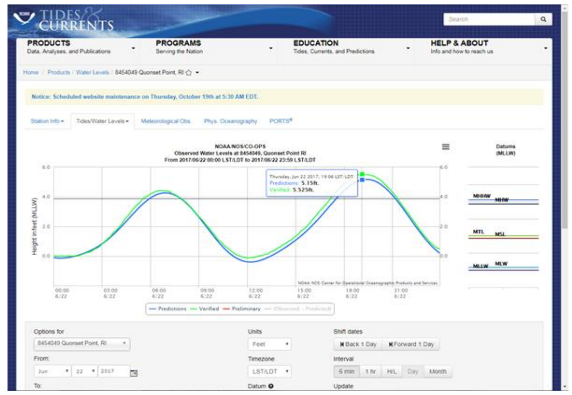
The MyCoast free app for iPhone or android allows citizen scientists to quickly submit photos of coastal events, such as storm damage or nuisance flooding, especially when caused by extreme high tides. The app allows users to quickly and easily upload images taken on a smartphone to a central database. Photographs are automagically geolocated and assigned metadata, including meteorological and tidal conditions. A small selection of that information is then displayed on the public site, where visitors can view the reports on a map, photo gallery, or list.

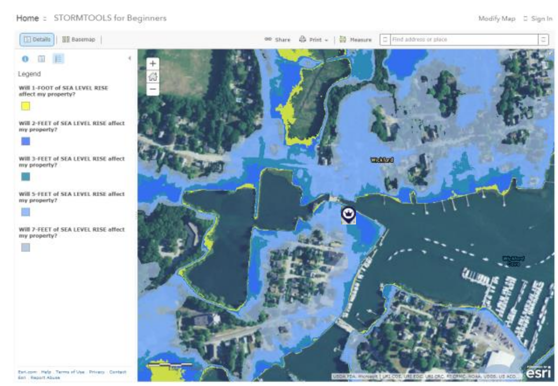


The MyCoast app has three options for coastal flood reporting; extreme high tides, sometimes referred to as king tides; storm reports to document storm damages to coastal properties and habitat; and a new coastal resilience tool to document impacts and changes to coastal ecosystems. The tools have been used to determine thresholds for coastal flooding advisories put out by the National Weather Service, and to identify areas at risk to coastal flooding and to help visualize future daily conditions as sea levels rise. .

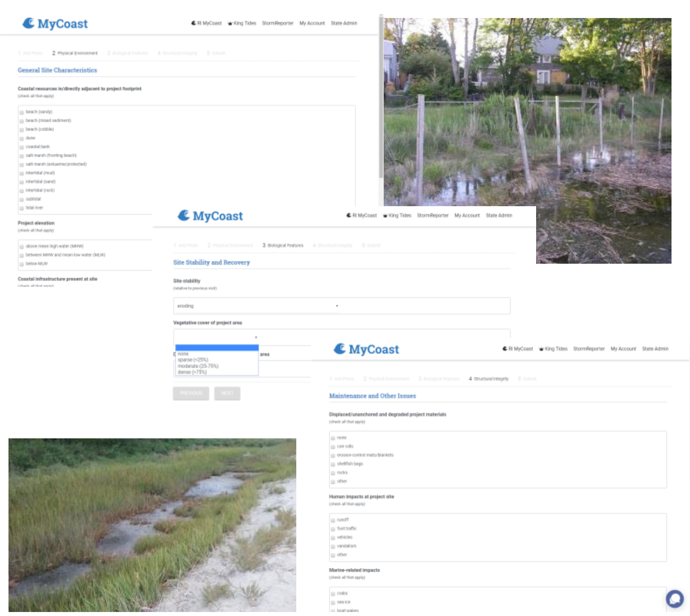
Photos highlight current conditions within Narragansett Bay and are indicators of increasing trends of the future. Information collected helps to ground truth Stormtools inundation maps and models, to visualize the impact of coastal hazards and to enhance awareness of community decision-makers and citizens. These data can be used to develop thresholds for nuisance flooding for coastal lands within the bay that are far from the Providence Tide Gage (8454000). A Coastal Resilience component has been recently added to document changes to coastal ecosystems.







MyCoast reports include geolocated photographs, tide and weather data , and a link to Stormtools inundation maps. Photographs and the linked database are downloadable from the website mycoast.org.



The Coastal Resilience tool was recently developed under a coastal resiliency grant from the Northeast Regional Ocean Council and has not been utilized yet. This tool has great potential for documenting the impacts of sea level rise on marshes and marsh migration.

Data inputs include the general site characteristics, site stability and recovery (stable, eroding, accreting; vegetation cover and type), and maintenance issues such as boat wake damage, crab predation, etc. The reporter fills in applicable fields on a pre-populated form for collection of consistent site characteristics. Additional comment may also be entered into the report.

Rhode Island Coastal Resources Management Council, URI Coastal Resources Center, Save the Bay, Northeast Regional Ocean Council, National Weather Service, Northeastern Regional Association of Coastal and Ocean Observing Systems. A Blue Urchin, LLC production