

Collaborative Learning Through Citizen Engagement and Bacterial Analysis Findings

Introduction

At many beaches in the U.S., managers and researchers are finding increasing levels of potentially harmful bacteria in ocean waters. According to the National Resource Defense Council's 2014 report of water quality at beaches, New Hampshire ranked 2nd out of 30 states. Standard sampling protocols have found low levels of harmful bacteria at NH's beaches, and we sought to investigate whether a synoptic water sampling approach might provide more precise understanding of NH beach water quality. A synoptic water sampling technique involves many sample sites taken at the same time.

Our team, a group of multi-institutional researchers in collaboration with UNH Cooperative Extension, chose to use a citizen science approach and implemented the Beach Blitz 2015 to use this more intensive sampling method and engage the local community.

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The State of New Hampshire standard for beach water quality is 104 enterococci per 100 ml. This is the concentration that triggers the need to post swimming advisories at beaches, and is used at beaches in all other US coastal states. Enterococci are a group of bacteria that are associated with fecal (sewage) pollution of water, and the 104 per 100 ml concentration has been shown to be associated with an increased risk of infectious disease for swimmers at coastal beaches. Public understanding of beach advisories and the risks associated with poor water quality at beaches is also a concern of agencies and communities in coastal areas.



In New Hampshire, the NH Department of Environmental Services Beach Inspection Program samples the water and inspects public beaches during the summer season. The water samples are tested in a lab for bacteria levels that indicate the level of pollution. If the bacteria levels exceed the amount allowable by state standards then an advisory is issued. The advisory is posted until the pollution levels no longer exceed the state standards. For the Beach Blitz, North Hampton State Beach (NHSB) was chosen based on records indicating this beach has had the most frequent ocean water quality advisories posting for New Hampshire coastal beaches the last three years.

A related social science project over the summer focused on studying surfer's risk perceptions and awareness of water quality. Preliminary data from that research showed that though the majority of surfers have never attributed getting sick to surfing, of those who had, Rye and Jenness beach were cited more than any other NH beach. New Hampshire is notorious for its clean water and these two beaches are some of the most popular surfing areas, so it is not surprising that the majority of surfers in NH have not noticed anything in the water that would make them question its quality.

The NH Beach Inspection Program does an outstanding job of monitoring beach water quality, however, they



rarely have resources to do intensive sampling or to identify sources of the bacterial pollution. Thus, our goals for this activity were to:

- Gather information useful for the state programs that manage these areas.
- Expand the breadth of monitoring to provide a more detailed picture of how much pollution is present and where it is located relative to possible sources.
- Provide more detailed analysis of the water to determine possible pollution sources and collect information about conditions at the beaches that may contribute to elevated levels of bacteria.
- Engage members of the public in the science process and raise awareness about coastal water quality research.

Beach Blitz Approach

Given the numbers of samples needed and our interest in public outreach about water quality at beaches, we chose a citizen science approach to the bacterial sampling effort. The Beach Blitz, which took place on Tuesday, July 28, 2015, involved 26 community volunteers, including families with children, and a team of 13 trained interns, university scientists, and NH Beaches Program staff. During the ½ day “Blitz,” researchers and interns supervised and worked with volunteers to understand research objectives and science protocols, assess beach conditions, and collect water samples at 19 sites at three beaches. Data collected included water and air temperature, beach conditions (amount of seaweed, number of bathers, presence of birds, etc.), a GPS location of the sampling site, and the collection of a water sample in hip-deep water.

Watershed Influences on Beach Water Quality

There was a drain at both beach areas with continuous flow of water from upland watersheds. In the absence of any obvious sources of pollution, these drains and the watersheds they flow from have been shown to be conduits of bacterial pollutants, especially after heavy rainstorms. The water flowing through the drains had

elevated levels of enterococci, with concentrations from up to 122 per 100 ml from the Little River at NHSB and 52 per 100 ml from Eel Pond at Sawyer/Jenness beaches (Figures 1 and 2). Samples collected in the morning prior to the afternoon Beach Blitz showed much higher enterococci concentrations (up to 17,127 per 100 ml) that exceeded the state standard at 7 of 8 sites upstream in the Little River watershed (data not shown).

At NHSB there was little evidence of the drains causing pollution in the beach water. At Jenness/Sawyer beaches, however, there was clear evidence of transport of bacterial pollution from the drain to the ocean and then transport with ocean currents. At NHSB, there was no evidence of bacterial transport from the storm drain to the beach water.

Beach Conditions and Possible Sources of Bacterial Pollution

The volunteers recorded information at each site on the amount of seaweed, and the numbers of bathers, bathers in diapers and birds (Table 1). There were no clear relationships between any of these three variables and the levels of enterococci. For example, there were 100-200 birds at one site on Jenness Beach but the enterococci concentration was 10 per 100 ml, the limit of detection. This is despite our findings that the herring gull feces at the site contained 14,000 enterococci per gram, a lot of bacteria in a small drop of feces. These findings help to put in perspective all potential sources of pollution and the effects of currents and waves on dispersing and diluting bacteria entering the beach under dry weather conditions, and the importance of the storm drains as sources during wet weather.

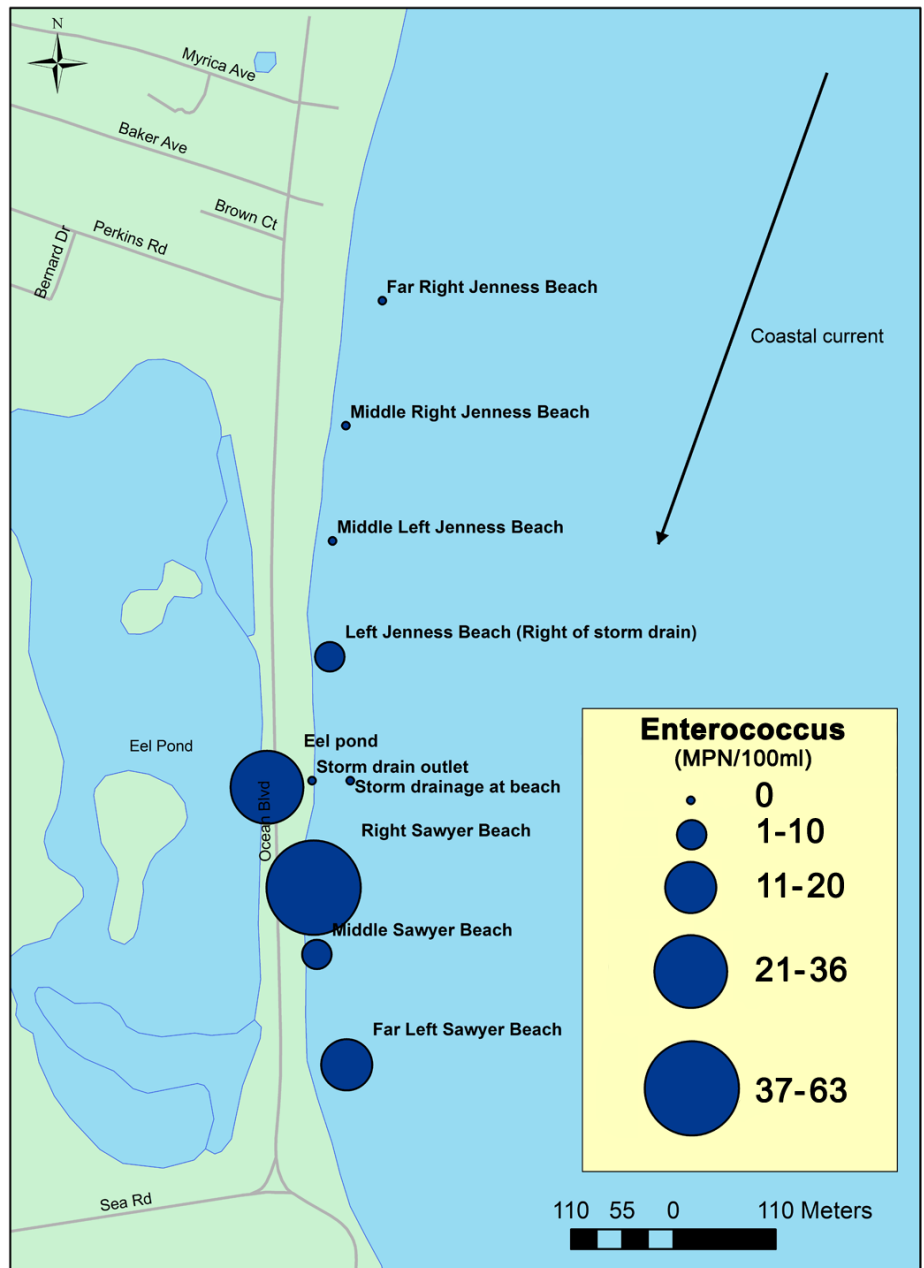


FIGURE 1. Relative concentrations of enterococci at Jenness and Sawyer beaches: July 28, 2015 Beach Blitz. The size of the circles is proportional to the enterococci levels.



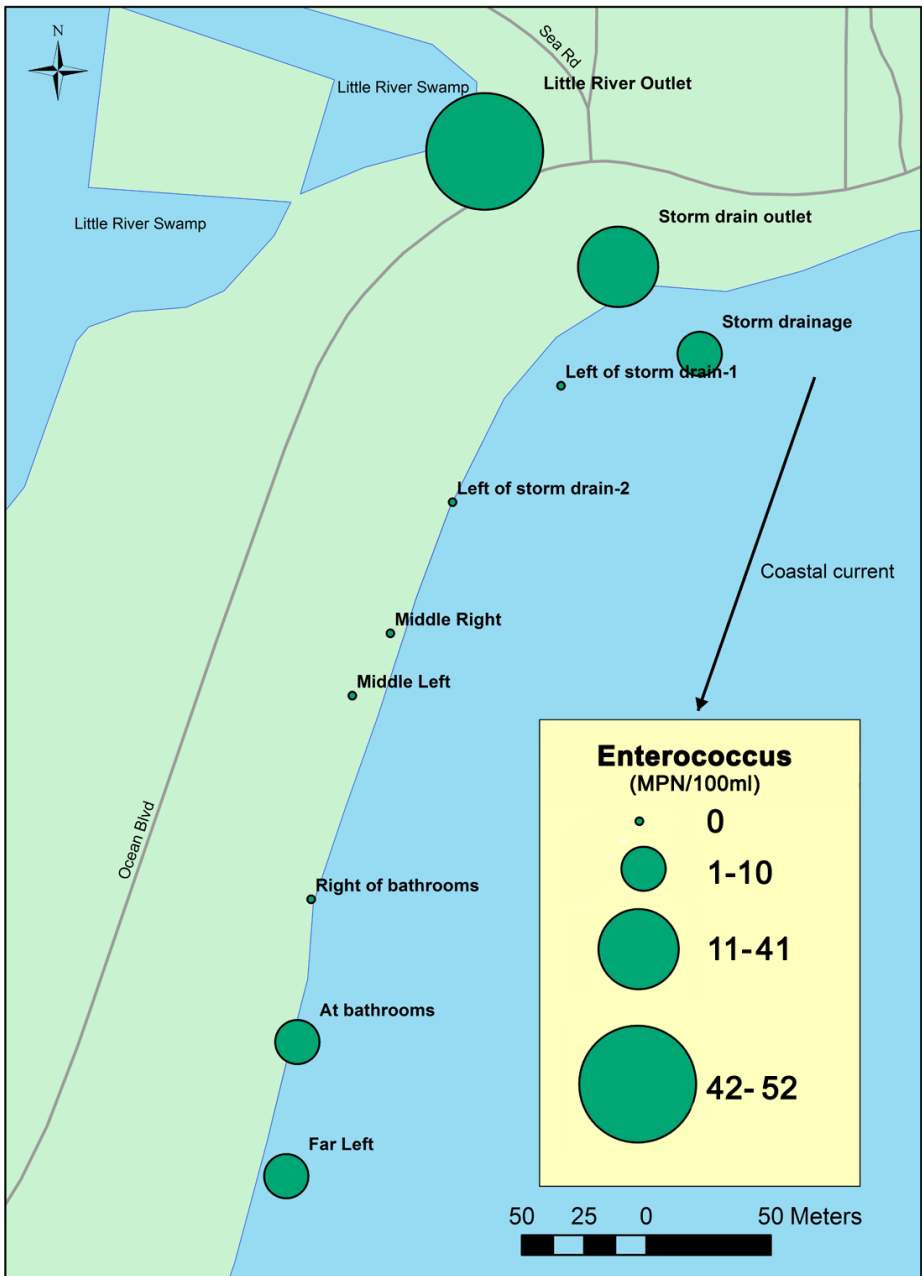


FIGURE 2. Relative concentrations of enterococci at North Hampton State Beach: July 28, 2015 Beach Blitz. The size of the circles is proportional to the enterococci levels.

The UNH Microbial Source Tracking Laboratory also extracted DNA from some of the water samples to identify possible human contamination. Bacterial DNA from human pollution was detected in both storm drains at the two beach areas, and the only human-specific DNA detected in beach water occurred at the site just down-current from the drains at both beach areas. All three samples from the Little River watershed that were analyzed also showed evidence of human fecal pollution.

Findings: Bacterial Concentrations

The highest enterococci concentration in beach water was 63 per 100 ml at Sawyer Beach (Figure 1), which is still well below the state standard of 104 per 100 ml. The enterococci concentrations at all other beach sites at Sawyer, Jenness and NHS beaches were low—less than 20 per 100 ml (Figure 2). These findings are consistent with the Beach Inspection Program results for this summer, where they have not had to post an advisory at any of these beaches due to high enterococci levels.



Beach Blitz: Lessons Learned in Citizen Science

The Beach Blitz approach enabled the research team to collect more detailed information about beach conditions and water quality than is possible in the regular water sampling conducted by the NH Beach Inspection Program. With this intensive sampling approach, we could better gauge how much of a potential problem the pollution from the drains may have on associated beaches.

NORTH HAMPTON STATE BEACH

Site number	Location (north to south)	Enterococcus (count/100mL)	Seaweed abundance	Bathers number	Birds number	Babies in Diapers number	Source Human
1	Little River outlet	52	abundant	0	0	0	no
2	Storm drain outlet	41	covered	0	1	0	YES
3	Storm drainage at beach	10	some	0	0	0	no
4	Left of storm drain-1	0	some	0	1	0	YES
5	Left of storm drain-2	0	some	3	10	2	N/A
6	Middle Right	0	abundant	1	1	0	N/A
7	Middle Left	0	none	15	4	1	N/A
8	Right of bathrooms	0	abundant	16	9	0	N/A
9	At bathrooms	10	abundant	0	9	0	N/A
10	Far Left	10	some	0	5	0	N/A

JENNESS-SAWYER BEACHES

Site #	Site Location	Enterococcus (count/100mL)	Seaweed abundance	Bathers number	Birds number	Babies in Diapers number	Source Human
1	Far Left Sawyer Beach	20	none	5	40	0	N/A
2	Middle Sawyer Beach	10		35	6	2	N/A
3	Right Sawyer Beach	63	none	3	55	0	YES
4	Eel Pond	36	none	0	8 seagulls 1 swan	0	no
5	Storm drain outlet	0	none	0	75+	0	no
6	Storm drainage at beach	0	some	11	4	0	YES
7	Left Jenness Beach (Right of storm drain)	10	some	6	200	0	no
8	Middle Left Jenness Beach	0	some	31	5	0	N/A
9	Middle Right Jenness Beach	0	some	7	30	0	N/A
10	Far Right Jenness Beach	0		33	18	0	N/A

Bacterial concentrations in herring GULL FECES found on beach to the right of storm drain (halfway to ocean)	Enterococcus (count/100mL)	Fecal coliforms (count/100mL)	E. coli (count/100mL)
	14,000	50,000	32,000

TABLE 1. Beach Blitz sampling locations, enterococci concentrations, beach conditions and potential pollution source identifications.

Findings from the Beach Blitz were consistent with the Beach Inspection Program data from this summer. We were also able to link Beach Blitz data with upstream water sampling that showed elevated pollution levels in the watersheds, which further refined our understanding of how pollution and waterways interact in complex coastal environments. We also learned that other beach conditions such as seaweed, birds and bathers did not appear to affect pollution levels on that day at beaches. Finally, community volunteers contributed to an authentic science experience, and learned about the NH Beach Inspection Program, water quality protection efforts, and the meaning and process for posting of beach advisories in New Hampshire. Their efforts have provided scientists with much more scientific information than is normally possible.

Throughout the day there were many questions that arose. While setting up for the Beach Blitz we received questions from people at the beach asking what we were doing and why. During the Beach Blitz the volunteers asked questions about the scientific process such as “Do we count as bathers?” and “Do I sample from the side or the front?” Some questions were more serious such as “What is the DO Concentration?” and “Why does the water look dirty in the water but clean in the bag?” Many bystanders asked what the water temperature was. As questions arose, participants attempted to provide answers and to explain the Beach Blitz project and its goals. The volunteers were very focused on whether they were conducting the scientific protocols correctly.

For future Beach Blitz efforts, the team offers several recommendations. First, make sure to involve public agencies early on in the planning of the project, as these important players can offer significant contributions to the sampling event. Second, beaches are crowded places with a lot of agency oversight. Permits for events such as a Beach Blitz held on public lands are usually required and need to be secured well in advance of the event.

Third, consider providing bus transportation for volunteers. Not only will it alleviate issues of parking for large numbers of volunteers at crowded summer beaches, but it will allow participants to meet each other, relax, ask questions and create a sense of unity of scientific purpose. And finally, have a plan for all aspects of the project, including how to communicate the results of the event.



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