Improving Water Quality in the Short Beach Neighborhood of Branford, Connecticut, 2019—A Citizen Science Project

Sarah Esenther, MPH, Katie Schlick, BA, Christopher Jossart, MPH, Ningjing Wang, MPH, Robert Dubrow, MD, PhD, and Michael Pascucilla, MPH

We initiated a collaboration between local government, academia, and citizen scientists to investigate high frequencies of elevated *Escherichia coli* bacteria levels in the coastal Short Beach neighborhood of Branford, Connecticut. Citizen scientist involvement enabled collection of short-duration postprecipitation outfall flow water samples (mean *E. coli* level = 4930 most probable number per 100 mL) and yielded insights into scientific collaboration with local residents. A records review and sanitary questionnaire identified aging properties with septic systems (3.3%) and holding tanks (0.6%) as potential sources of the *E. coli* contamination. (*Am J Public Health*. Published online ahead of print July 7, 2022:e1–e4. https://doi.org/10.2105/AJPH.2022.306943)

AJPH Published online ahead of print July 7, 2022

Long Island Sound has suffered elevated levels of fecal bacteria for decades.[1] Although fecal contamination from stormwater outfalls is a recognized public health risk,[2] the short duration of stormwater outfall flows following rain events poses obstacles to identification and monitoring of these sources. Partnerships between health departments and local citizen scientists may enhance such outfall sampling.

INTERVENTION AND IMPLEMENTATION

The coastal Short Beach neighborhood of Branford, Connecticut, and its popular beach have experienced high frequencies of elevated *Escherichia coli* bacteria levels compared with nearby waters,[3] possibly from sanitary sewage system breaches into stormwater.[4,5] To better understand the influence of compromised stormwaters on local water quality in Long Island Sound, a team of students and faculty collaborated with the local health department with the aims of mapping local sewage disposal systems to assess possible sources of contamination and using local resident capability and expertise by implementing a citizen science water-sampling program.

Sewage Disposal Records

A 2017 report identified leaking holding and septic tanks as a likely source of water contamination.[5] Similar to other communities, the town of Branford did not maintain sewage disposal records until after most Short Beach homes were constructed, so the sewage system type of 383 coastal properties was unknown. To assess these properties, the student team reviewed records of permits, construction documents, sewage hookup requests, and ownership transferals maintained by Branford's Engineering Department. The team investigated the properties without records through a questionnaire asking residents about their sewage disposal method and year of connection. Questionnaire accuracy was verified by comparing answers with neighboring homes and informally interviewing long-term residents.

Volunteer Water Sampling

All eight stormwater outfalls in Short Beach that flow directly into Long Island Sound were sampled (Figure 1). In partnership with the Civic Association of Short Beach, the health department and students assembled a team of eight citizen science volunteers, primarily retirees, from association meeting

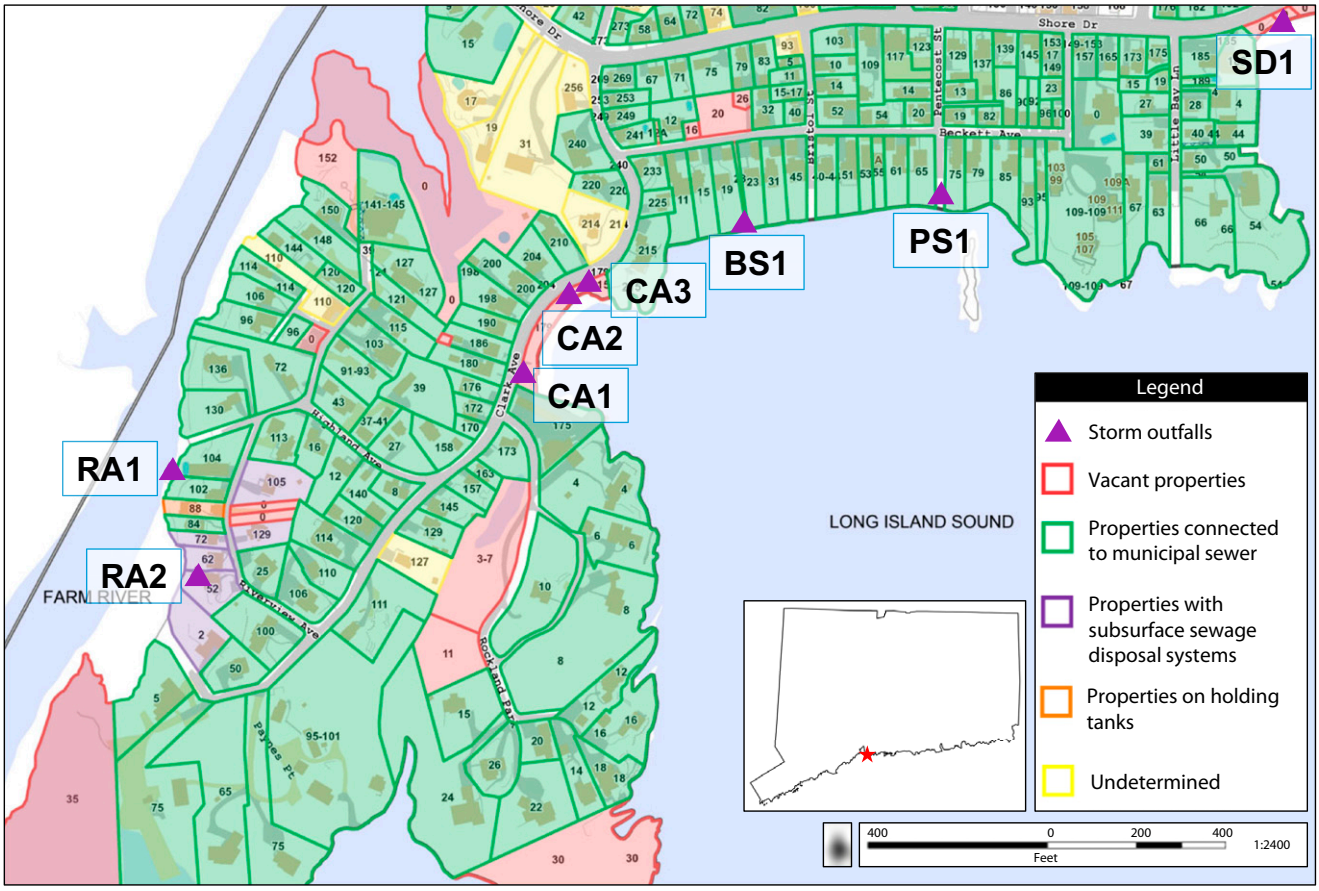

FIGURE 1— Map of Short Beach Neighborhood: Branford, CT, 2019

Note. Volunteers checked eight outfalls (RA1, RA2, CA1, CA2, CA3, BS1, PS1, SD1) that discharge into the Long Island Sound for flow following rain events. The majority of properties in Short Beach are connected to the municipal sewer, with a cluster of subsurface sewage disposal systems near outfalls RA1 and RA2.

AJPH Published online ahead of print July 7, 2022

attendees and their contacts. The volunteers were trained and supplied a written protocol for sample collection, labeling, and delivery of water samples to the state public health laboratory, then tasked with collecting samples from any outfalls that flowed intermittently after every rain event. Volunteers coordinated assignment of collection dates and sampling locations among themselves. The health department supplied sampling bottles and paperwork to the citizen scientists.

The Connecticut State Public Health Laboratory processed samples to determine *E. coli* levels. Samples were tested using the SM 9223B Enzyme Substrate Test (IDEXX Laboratories, Westbrook, ME) to determine the most probable number (MPN) per 100 milliliters.[6]

PLACE, TIME, AND PERSONS

The Short Beach neighborhood is located at the southern end of the Farm River Watershed in New Haven County. This study was conducted in spring, summer, and fall 2019 in collaboration with local residents and four university students.

PURPOSE

To inform efforts to improve long-impaired neighborhood recreational and shell-fishing water quality,[7] this study aimed to (1) identify possible sewage disposal system sources of beach water *E. coli* contamination; (2) quantify and identify outfall sources of this contamination; and (3) foster engaged relationships between academia, local government, and neighborhood residents.

EVALUATION AND ADVERSE EFFECTS

The records review revealed potential contamination from septic or holding tanks, and the water sampling, conducted by citizen scientists and students, documented *E. coli* contamination of outfall flows.

Sewage Disposal Records

Of the 383 properties with unknown sewage system type, the type of 314 (82.0%) was determined from records and 24 (6.3%) by questionnaire; the type of 45 (11.7%) remained unknown from lack of records or survey response. Of the 338 properties with known type, 325 were connected to public sewage (96.2%), 11 had septic tanks (3.3%), and 2 had holding tanks (0.6%). Thus, the study identified several aging coastal properties that lack public sewage access, posing a possibly elevated risk of water contamination from failing septic systems or holding tanks. Most houses along public sewer lines are attached to the public sewer system with gasketed PVC (polyvinyl chloride) and are considered unlikely to be dilapidated enough for substantial sewage leakage.[8]

Volunteer Water Sampling

Students and health department members attended Civic Association meetings to give project updates, answer questions, and garner input. Meeting attendees recommended policies for improving local water quality based on their experiences in the neighborhood (e.g., observing dog walkers discard dog feces into stormwater outfall grates, which the health department subsequently investigated).

The volunteers and students collected 24 *E. coli* water samples from outfalls on six different dates. The *E. coli* levels ranged from 270 to 24 196 MPN per 100 milliliters (mean = 4930 MPN/100 mL; SD = 5147 MPN/100 mL; Table 1).

Strong engagement from community members and the scientific integrity of the volunteer samplers increased research capacity. As some outfalls flowed for only 15 minutes following a rain event, many samples would have been unattainable without citizen scientists. Residents expressed concerns at Civic Association meetings, including whether they may be forced into costly public sewer connections if failing septic systems were found at fault and lack of public access to past reports and data. Full transparency with citizen science collaborators requires acknowledgment of power differences and potential conflicts of interest. Openly recognizing the legitimacy of resident concerns and the value that cooperation brings to the health department is key to maintaining balance between collaborators. The health department is committed to ongoing discussion, data sharing through its Web site,[9] and sensitivity regarding its regulatory power to force public sewer connections, preferring to work alongside the community to achieve a mutually beneficial and mutually understood outcome.[10]

SUSTAINABILITY

Strong engagement of citizen scientists and students permitted minimal sampling involvement by health department staff, and the data obtained provided unique insight into the state of water contamination in the neighborhood. Although the initiative ended owing to the COVID-19 pandemic, with increased citizen science involvement, the health department–citizen scientist collaboration has the potential to be sustainable beyond student participation, with discussion of reinstatement ongoing.

Lessons learned by the local health department on working with citizen scientists during this project will facilitate future intervention design. Communication is essential with all volunteers: to maintain open communication and trust, volunteers need to feel that the value of their contributions is recognized.[10,11] To that end, the citizen scientists were honored at a local awards event. Engagement of dedicated

TABLE 1— *Escherichia coli* Results From the 8 Outfalls Sampled on 6 Dates: Branford, CT, 2019

	Escherichia coli (MPN/100 mL), Outfall Identification							
Date	BS1	CA1	CA2	CA3	PS1	RA1	RA2	SD1
July 12, 2019	NA	NA	NA	NA	NA	2 300	NA	650
July 17, 2019	NA	270	NA	NA	NA	NA	NA	NA
July 18, 2019	7 900	3 400	24 000	7 600	7 600	2 000	NA	290
July 23, 2019	8 200	2 400	3 300	24 196	9 800	2 300	4 900	8 700
July 24, 2019	NA	1 300	810	NA	NA	NA	NA	NA
August 8, 2019	1 200	3 100	8 700	NA	6 500	1 200	NA	2 300
Outfall average	5 767	2 094	9 203	15 898	7 967	1 950	4 900	2 985

Note. MPN = most probable number; NA = nonflow.

AJPH Published online ahead of print July 7, 2022

community members from the outset of research design, establishment of all parties' expectations and a conflict-of-interest policy, and health department willingness to adapt in light of community knowledge and concerns are crucial to the vitality and sustainability of a relationship with the community.[11] Discussion of citizen science program duration and funding commitment at the outset may also increase initiative longevity.

PUBLIC HEALTH SIGNIFICANCE

Although neither the US Environmental Protection Agency nor the Connecticut Department of Public Health provide threshold guidelines for *E. coli* levels from stormwater outfalls, all samples exceeded the Connecticut Department of Public Health's 235 MPN per 100 milliliters *E. coli* threshold for recreational waters.[12] This suggests that the outfalls could be a critical pathway for transfer of fecal matter and associated pathogens to recreational bathing waters.

This project provided the students with an opportunity to experience real-world public health practice, and their involvement enabled the records review and established the framework for the sampling campaign. Without citizen scientists, the breadth and frequency of sampling would not have been possible. Furthermore, citizen scientists identified an outfall, RA2, not in the original sampling plan. Citizen science can increase data capture in water sampling as well as in other public health programs relying on highly time-sensitive collections. AJPH

ABOUT THE AUTHORS

Sarah Esenther, Christopher Jossart, Ningjing Wang, and Robert Dubrow are with the School of Public Health, Yale University, New Haven, CT. Katie Schlick is with the Yale College Environmental Studies Program, Yale University. Michael Pascucilla is with the East Shore District Health Department, Branford, CT.

CORRESPONDENCE

Correspondence should be sent to Michael Pascucilla, 688 East Main St, Branford, CT 06405 (e-mail: mpascucilla@esdhd.org). Reprints can be ordered at http://www.ajph.org by clicking the "Reprints" link.

PUBLICATION INFORMATION

Full Citation: Esenther S, Schlick K, Jossart C, Wang N, Dubrow R, Pascucilla M. Improving water quality in the short beach neighborhood of Branford, Connecticut, 2019—a citizen science project. *Am J Public Health*. Published online ahead of print July 7, 2022:e1–e4.

Acceptance Date: May 6, 2022.

DOI: https://doi.org/10.2105/AJPH.2022.306943

CONTRIBUTORS

S. Esenther recruited and liaised with the citizen scientist volunteers and wrote the first draft of the article. S. Esenther, K. Schlick, C. Jossart, and N. Wang performed water quality analyses and assisted in records review and report writing. S. Esenther, K. Schlick, and N. Wang sampled outfalls. S. Esenther, R. Dubrow, and M. Pascucilla reviewed multiple drafts of the article C. Jossart delivered samples to the laboratory. R. Dubrow partnered with the East Shore District Health Department and supervised the students. R. Dubrow and M. Pascucilla conceptualized the study. M. Pascucilla arranged sample testing at the state laboratory and records review access and provided the resources of the East Shore District Health Department for sampling.

ACKNOWLEDGMENTS

The research study was conducted by the East Shore District Health Department and Yale University with in-kind funding and support from the High Tide Foundation.

M. Pascucilla presented a preliminary version of this project at the American Public Health Association's October 24–28, 2020 Virtual Annual Meeting and Expo.

The authors would like to thank the staff of the Connecticut Department of Public Health Laboratory for their timely and conscientious analytical support, with special thanks to environmental microbiology supervisor Kim Holmes-Talbot et al., the Town of Branford Engineering Department, and the Short Beach, Connecticut, community. The Civic Association of Short Beach, particularly Ann Davis, were invaluable partners. We also thank the High Tide Foundation for its generous support.

CONFLICTS OF INTEREST

The authors have no potential or actual conflicts of interest to declare.

HUMAN PARTICIPANT PROTECTION

No protocol approval was necessary because no human participants were involved in this study.

REFERENCES

1. Long Island Sound Study Pathogen Contamination. Long Island Sound Study. 2022. Available at: https://longislandsoundstudy.net/about/our-mission/management-plan/pathogen-contamination. Accessed June 2, 2022.
2. Ahmed W, Hamilton K, Toze S, Cook S, Page D. A review on microbial contaminants in stormwater runoff and outfalls: potential health risks and mitigation strategies. *Sci Total Environ.* 2019; 692:1304–1321. https://doi.org/10.1016/j.scitotenv.2019.07.055
3. National Water Quality Monitoring Council. Water quality data. May 2021. Available at: https://www.waterqualitydata.us/portal. Accessed June 2, 2022.
4. Brooks L, Romrick L, Pascucilla M. *Pollution Source Survey and Assessment of the Farm River Watershed in East Haven and Branford, Connecticut.* Branford, CT: Yale University and East Shore Health Department; 2012.
5. Lehane A, Marks B, Ramsden D, Chen R. *Bacterial Contamination in Long Island Sound: Improving Beach Closure Policy and Assessing the Impact of Climate Change.* New Haven, CT: Yale School of Public Health and East Shore District Health Department; 2017.
6. US Environmental Protection Agency. 2012 Recreational water quality criteria. 2012. Available at: https://www.epa.gov/sites/production/files/2015-10/documents/rec-factsheet-2012.pdf. Accessed June 2, 2022.
7. Connecticut Department of Energy and Environmental Protection. Estuary 8: Branford/East Haven, watershed summary. September 2013. Available at: http://www.ct.gov/deep/lib/deep/water/tmdl/statewidebacteria/estuary8_branford_easthaven.pdf. Accessed June 2, 2022.
8. Folkman S. PVC pipe longevity report: affordability and the 100+ year benchmark standard. May 2014. Available at: https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1170&context=mae_facpub. Accessed June 2, 2022.
9. East Shore District Health Department. 2022. Available at: https://www.esdhd.org. Accessed June 2, 2022.
10. Strasser BJ, Baudry J, Mahr D, Sanchez G, Tancoigne E. "Citizen science"? Rethinking science and public participation. *Sci Technol Stud.* 2019;32(2): 52–76. https://doi.org/10.2398July sts.60425
11. Hecker S, Bonney R, Haklay M, et al. Innovation in citizen science—perspectives on science-policy advances. *Citiz Sci.* 2018;3(1):4. https://doi.org/10.5334/cstp.114
12. State of Connecticut Department of Public Health. State of Connecticut guidelines for monitoring swimming water and closure protocol. 2016. Available at: https://portal.ct.gov/-/media/Departments-and-Agencies/DPH/dph/environmental_health/recreation/pdf/030316GuidelinesforMonitoringSwimmingWaterpdf.pdf?la=en. Accessed June 2, 2022.

AJPH Published online ahead of print July 7, 2022