Report to the Environmental Protection Agency

Maine Healthy Beaches Program Annual Beach Grant Report 2018 Season

July 2019

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I. Program Accomplishments

Maine Healthy Beaches (MHB) is managed by the Maine Department of Environmental Protection (ME DEP) and was coordinated by the University of Maine Cooperative Extension (UMaine Extension) until January 1, 2019 when the program transitioned fully to Maine DEP. In 2018, MHB staff worked with 29 local management entities to conduct routine monitoring, assessment, and public notification of water quality conditions for 63 beach management areas spanning Kittery to Mount Desert Island. MHB staff continued to build local capacity for well-informed beach management decisions and to address pollution issues when they arose during the beach season.

The MHB program accomplished the following in 2018:

- Processed 1810 enterococci samples at 146 routine and enhanced monitoring locations.
- Recruited and trained new beach managers and approximately 200 local staff and volunteers to collect water samples, conducted technical trainings for local staff and volunteers, and facilitated planning/problem-solving meetings.
- Recruited a new town to the program (Harpswell) including the addition of 3 new beach management areas.
- Implemented precautionary rainfall advisories at 21 beaches impacted by non-point source pollution.
- Analyzed 351 samples for optical brightener levels to target human-sourced fecal contamination at 51 enhanced monitoring locations.
- Implemented objectives of the updated MHB Quality Assurance Project Plan (QAPP, 2016-2021) approved by ME DEP and EPA.
- Supported enhanced monitoring and pollution remediation efforts for: Cape Neddick River watershed, Ogunquit River watershed, Wells Harbor, Goose Rocks Beach watershed, Kennebunk River watershed, Goosefare Brook watershed, Willard Beach storm drainage network, Crescent Beach State Park, and the Mount Desert Island Biological Laboratory's (MDIBL) efforts in Bar Harbor, Mt. Desert, and Acadia.
- Continued an applied research partnership with the University of New Hampshire (UNH) to test for human and non-human DNA markers utilizing microbial source tracking (MST) techniques.
- Continued updates to the MHB Risk Assessment Matrix (RAM), an evaluation of water quality trends and potential sources of fecal bacteria impacting coastal beaches.
- Continued implementing measures outlined in the EPA approved beach action value (BAV) justification.
- Transformed data to action items and served on several working groups for improving water quality and ecosystem health.
- Provided expertise and advised towns/groups interested in monitoring freshwater recreation areas as well other areas along the coast.
- Presented to local and regional audiences.

II. Program Deliverables/Appendices

Appendix A MHB 2018 Budget Summary
Appendix B MHB 2018 Beach Mgt. Area Classification/Tiered Monitoring Plan
Appendix C MHB 2018 Notification Activity
Appendix D Summary report of Enhanced Monitoring and Pollution Source Tracking Efforts in the Goose Rocks Beach Watershed, Kennebunkport, ME, 2008. Maine Healthy Beaches, University of Maine Cooperative Extension.
Appendix E Summary Report of Enhanced Monitoring and Pollution Source Tracking Efforts in Goosefare Brook, Maine, 2012-2018. Maine Healthy Beaches, University of Maine Cooperative Extension.
Appendix F Summary Report of Enhanced Monitoring and Pollution Source Tracking Efforts in the Willard Beach Watershed, South Portland, Maine, 2012-2018. Maine Healthy Beaches, University of Maine Cooperative Extension.
Appendix G Bar Harbor Cruise Ship Monitoring Report, Bar Harbor, ME. 2018. Community Environmental Health Laboratory at the MDI Biological Laboratory.
Appendix H Exploring the Unseen: From Microplastic pollution to the Microbial World of Cruise Ships, Bar Harbor, ME, 2018. Community Environmental Health Laboratory at the MDI Biological Laboratory.

III. Budget Information

Program Activities

There are more than 29 miles of public access beaches along Maine's coast.
The US EPA sponsored MHB program 2018 budget (Appendix A) supported all routine monitoring, assessment, notification, education/outreach, and enhanced monitoring and source-tracking efforts including:

- Supported one UMaine Extension staff salary and a portion of two DEP staff salaries, and an Americorps Environmental Steward. This team of personnel provided extensive support to 29 local management entities (towns, state parks, a national park, and private beach associations) including program coordination, quality-assured protocols and structure, field/lab trainings, technical assistance, volunteer recruitment, education/outreach, etc.
- The partially supported DEP data specialist provided data management services, transferred MHB data to DEP's Environmental and Geographic Analysis Database (EGAD) system, managed the submission of MHB data into the US EPA databases (STORET and PRAWN), and fulfilled data requests as needed.
- Planning and problem-solving meetings with diverse partners including local beach managers, conservation commissions, consultants, researchers, etc.
- Field monitoring supplies, equipment, volunteer training packets, and quality-assurance including annual field, database, and observational trainings for nearly 200 citizen volunteers and local staff.
- Laboratory equipment, supplies, labor, sample transport (courier), training, and quality assurance support for four laboratories processing enterococci samples for 63 beach management areas spanning a large geographic area (approximately 200 mi.).
- Enhanced monitoring and pollution identification efforts as well as numerous

planning and problem-solving meetings with diverse partners.
- Education and outreach efforts including delivering presentations to local, regional and national audiences, development and distribution of numerous publications, etc.
- A contract with Relyon Media to host the MHB database and public interface, as well as consultant services.
- Direct and indirect expenses including travel, telephone, computer services, postage, office support and supplies, photocopying, etc.

Volunteer Contribution

MHB program participation is voluntary and towns/parks designate local beach managers and field monitors to collect samples. Beach managers are typically town administrators, health nurses, fire chiefs, state park managers, and others who participate as an add-on to full-time jobs and schedules. The time devoted to MHB tasks varies and is difficult to quantify. Towns and state parks utilize citizen volunteers or devote paid staff time to sample collection, transport, and data entry. Each of the local staff/volunteer monitors attend a 2-hour pre-season field training and contribute an average of three hours weekly to sampling during the monitoring season. A conservative estimate of the total volunteer monitor contribution to the MHB program was approximately 8,000 hours ($23/hour) for a total of $184,000 in 2018.

IV. Performance Criteria

In 2018, the MHB program continued to provide a unified structure and quality-assured tools to implement an adaptive monitoring regime, assess the risk of pollution, notify the public of water quality conditions, and promote best practices on the beach and surrounding drainage areas. MHB's QAPP is peer-reviewed and has been used as a model for water quality initiates outside of the program. In 2018, MHB staff also provided ongoing daily training and technical support including responding real-time to water quality data, assessing pollution/risk of illness, and notifying the public of conditions on coastal beaches.

Monitoring

The MHB program is voluntary and monitoring coastal water quality for swimming and other water contact is the responsibility of local jurisdictions and is not mandated by state law. US EPA funding supports monitoring of moderate to high use beaches with adequate public access. Maine law allows public use of private beaches for "fishing, fowling and navigation" only. Participating beaches must have a management entity capable of meeting objectives and requirements outlined in the MHB program QAPP and MHB Program Town/Park Agreement. New beaches will be recruited over time as resources and funding allow and/or circumstances change eligibility for program participation.

In 2018, MHB staff successfully worked with 29 diverse local management entities to conduct routine monitoring for 63 beach management areas (Appendix B), 48 were classified as "Tier-1," 15 were classified as "Tier-2" (reduced monitoring effort), and "Tier-3" beaches were not monitored (i.e. did not participate in the program). Through the 2016 BAV selection process, Maine's participating beaches were evaluated and reclassified if necessary in order to reallocate resources to support increased monitoring efforts for beaches categorized as "high-risk". For

beaches considered "low-risk", reclassification resulted in a reduced monitoring frequency, typically to a bi-weekly or monthly routine.

The monitoring season lasted approximately three months, extending from Memorial Day to Labor Day. Approximately 1810 samples were collected at 146 routine and enhanced monitoring locations spanning Kittery to MDI. Monitoring sites for each beach were based on where people swim, at freshwater inputs (rivers, streams, storm drains), and near other high-risk features, wildlife areas, etc. Samples were collected in two to three feet of water at six to eight inches below the surface. For areas experiencing chronic bacterial pollution, additional monitoring sites were added in suspect areas to help determine contributing pollution sources and/or the worst-case scenario for water quality.

Parameters included: enterococci bacteria, air and water temperature, salinity, tidal stage, rainfall, and additional weather/field conditions that may affect beach water quality. Monitoring sites were resampled as soon as possible following an exceedance and the monitoring frequency increased until results were within acceptable limits. Samples were transported to the laboratory (4 regional) for analysis within six hours of collection. The majority of samples were processed by Nelson Analytical Laboratory and transported via a courier service. Samples were analyzed using the IDEXX Enterolert ® Most Probable Number enumeration method. All samples and parameters were collected and analyzed according to the US EPA-approved QAPP.

Assessment

In addition to routine beach monitoring, MHB staff evaluated the risk of pollution and potential/actual sources via a Risk Assessment Matrix (RAM), and in some cases, through GIS mapping and analysis, enhanced monitoring, and other pollution source-tracking efforts. MHB staff continued updates to the RAM for each Beach Management Area (BMA) in 2018, and these preliminary assessments of shoreline characteristics, non-point and point sources of pollution (on and offshore) and water quality, inform local beach management decisions. This risk-based ranking system also guides the program's beach classification and monitoring regime, as well as determines the need for more in-depth monitoring and sanitary surveys. The RAMs also fed into the process to select the most appropriate beach action value for Maine and guided efforts to update program pollution source files including the MHB Beach Inventory.

In an effort to assess water quality and pollution sources in 2018, the program supported enhanced monitoring and source-tracking efforts for: Cape Neddick River watershed, Ogunquit River watershed, Wells Harbor, Goose Rocks Beach watershed, Kennebunk River watershed, Goosefare Brook watershed, Willard Beach storm drainage network, Crescent Beach State Park and MDIBL's efforts in Bar Harbor, Mt. Desert, and Acadia (see Section VI Collaborative Efforts).

Notification

In 2018, beach monitoring results were recorded in the MHB program internal database that automatically updated the program website www.MaineHealthyBeaches.org. Maine's US EPA-approved single sample maximum safety threshold or Beach Action Value (BAV) for

enterococci in marine waters was 104 most probable number (MPN[1])/100mL. Once a decision was made to post the beach, the information was also publicly accessible via the website and signage at beach access points. When results exceeded the safety limit, and/or a beach status change occurred, an automatic email alert was sent to local beach managers, MHB staff, and partners. In some cases, towns provided supplemental information by providing educational signage (e.g. risk following rainfall, stagnant tide pools), content on local websites, Facebook pages, and hotlines. All beaches attributes, monitoring, and notification data was transferred to DEP's data management system for final submission into EPA's databases. The MHB program continued to make local beach information (site locations, monitoring and notification data, contact information, etc.) more easily accessible to the public via ArcGIS online.

Beach postings fall under local jurisdiction and are not mandated by state law. The program made recommendations to local beach managers based on the best and most current information available. In some cases, local managers waited for resample results before posting. Typically, this was for "low-risk" beaches, and the decision was based on the results of neighboring sites, the magnitude of bacteria results, similarity of environmental conditions between sample collection day and results, historical water quality, risk of pollution, known pollution events, etc. Additionally, precautionary rainfall advisories (PRAs) (based on local precipitation levels rather than elevated bacteria) were issued in 2018. In an effort to expedite information transfer, an extensive Communication Plan of local beach managers and field monitors was updated for re-sampling efforts and beach status notification in 2018. Following each exceedance, MHB staff contacted local jurisdictions to ensure that program protocols were followed in a timely manner according to the QAPP, and on a daily basis, MHB staff quality-checked the database for accurate entry of field, laboratory, and notification data.

Additionally, MHB staff responded to numerous data and information requests from program participants, state agency partners, non-profits, researchers, students, etc. The MHB program routine and enhanced monitoring data was used by partners to inform ongoing efforts to address impaired water quality including funding proposals to support pollution source identification and elimination projects, biophysical and social science research, as well as watershed management, stormwater management, and comprehensive and water resource protection plans.

Education and Outreach

In 2018, MHB staff brought new beach managers up to speed with the program and notification protocols as needed and routinely shared research findings, program updates, etc. with local staff and volunteers. Additional support was provided as needed regarding local implementation of the program, issues of concern, etc. MHB staff also delivered presentations to diverse audiences and provided extensive support to communities and organizations tackling bacterial pollution issues within and outside of Maine. This included outreach events, training materials, information on best practices, technical reports, and other efforts to raise public awareness and build local capacity to improve and protect water quality (see Section VI).

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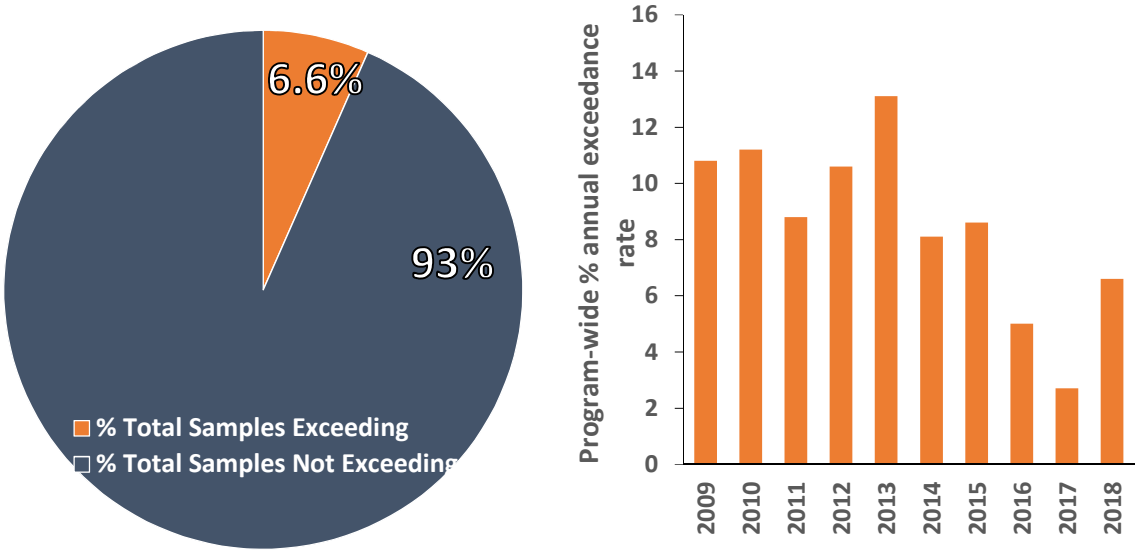
[1] EPA's 2012 Recreational Water Quality Criteria (RWQC) recommends using EPA Method 1600 (resulting in colony forming units (CFUs)) to measure culturable enterococci, or another equivalent culturable method. MHB utilizes the equivalent IDEXX Enterolert ® method (resulting in most probable number (MPN) per 100mL).

V. Data Summaries

- 1810 enterococci samples (including field and laboratory duplicates) were processed at 85 routine beach monitoring sites (comprising 63 BMAs in 29 towns/state parks) and 61 enhanced monitoring sites (Figure 3)[2].
- 100% of Tier 1 beaches were monitored.
- 6.6% routine samples exceeded Maine's 104 MPN/100mL beach notification threshold.
- 171 beach action days were reported including 79 actions at 32 beach management areas. 60 of the reported days were "precautionary rainfall advisories (42 advisories)," based on local precipitation levels rather than recorded bacteria levels (Appendix C). 111 days were for contamination (36 advisories and 1 closure).
- 97.2% of total beach days (beach season length x beach management areas) were free of beach advisories or closures.

Exceedances

Maine's US EPA-approved single sample maximum safety threshold or Beach Action Value (BAV) for enterococci in marine waters is 104 MPN/100mL. The 2018 overall program exceedance rate of Maine's BAV was 6.6%, representing 71 total exceedances at 22 beach management areas (Figure 1, Table 1). Although this represents an increase in exceedance rate compared to the past two beach seasons (2016 and 2017), this rate is the third lowest observed for the past 10 years (Figure 2).



Figures 1-2. The 2018 total annual % exceedance rate of Maine's BAV (104 MPN/100mL) and MHB's program-wide annual exceedance rate for the past ten seasons (2009-2018).

[2] Sites located in close proximity to BMAs or in enhanced monitoring locations to help identify pollution sources.

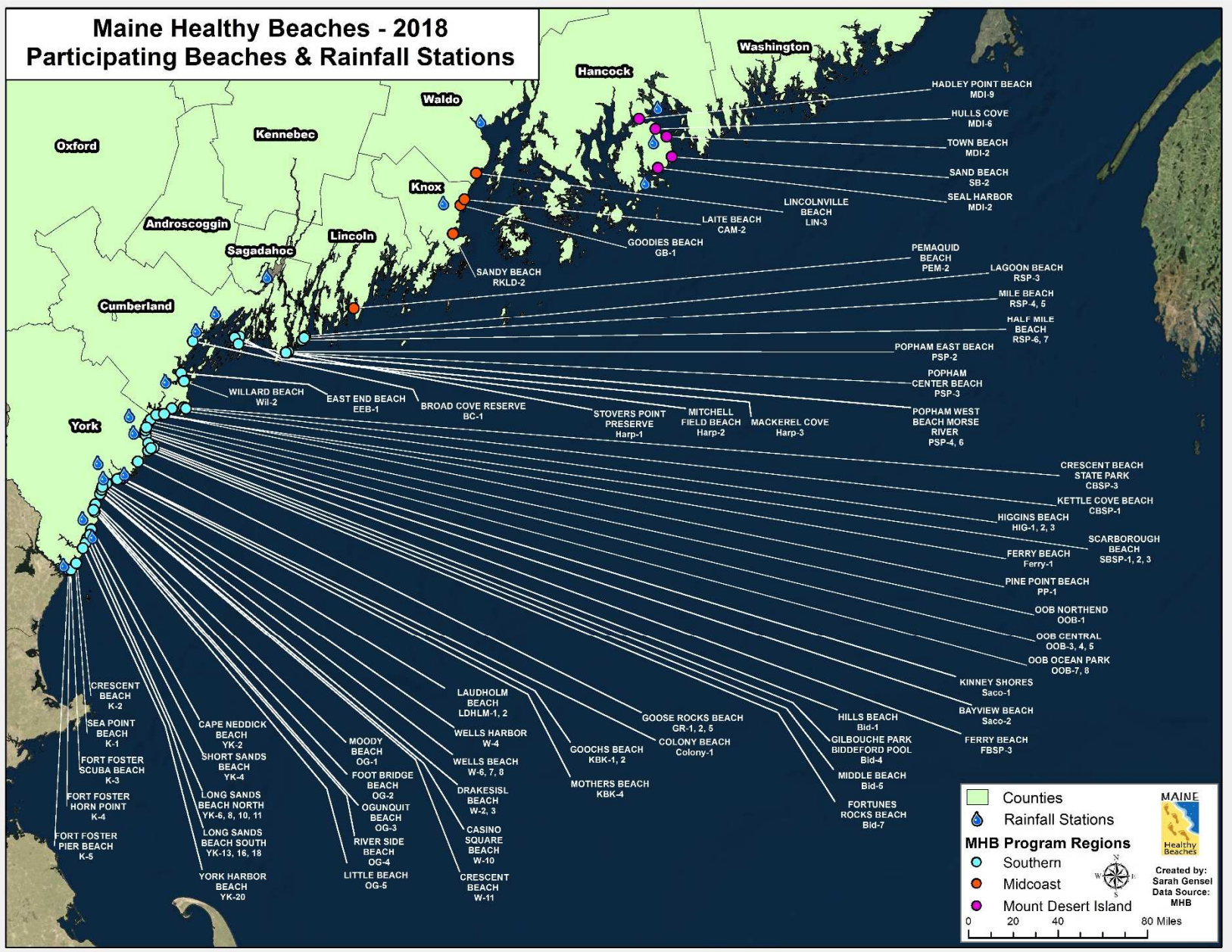


Figure 3. MHB's 2018 participating BMAs (Southern, Midcoast, and Mount Desert Island (MDI) regions) and NCDC rainfall stations.

Maine's beaches span a wide geographic area and as a result, average precipitation levels observed at 13 coastal rainfall stations located in close proximity to participating BMAs varied distinctly (7.05-12.41 inches) (Figure 3). The pattern of yearly exceedance rates shown in Figure 2 corresponds with the amount of average precipitation during the seasons. The 2018 season had higher average precipitation (10.16 inches) than 2016 (9.14 inches) and 2017 (7.29 inches), which had lower exceedance rates than the 2018 season. The 2018 season had lower average precipitation than the 2012-2015 seasons, which had higher exceedance rates.[3]

Inter-annual variability of the total program percent exceedance rate is due to multiple factors including but not limited to: precipitation levels, beach and watershed characteristics (e.g. impervious surfaces, pollution sources), sample collection day/time, the number of monitoring sites and beach management areas, etc.

Table 1. All BMAs with exceedances of Maine's single sample maximum BAV for enterococci in marine waters (104 MPN/100mL). Summaries include total number of samples, number of samples ≥104 MPN/100mL, and % samples ≥104 MPN/100mL.

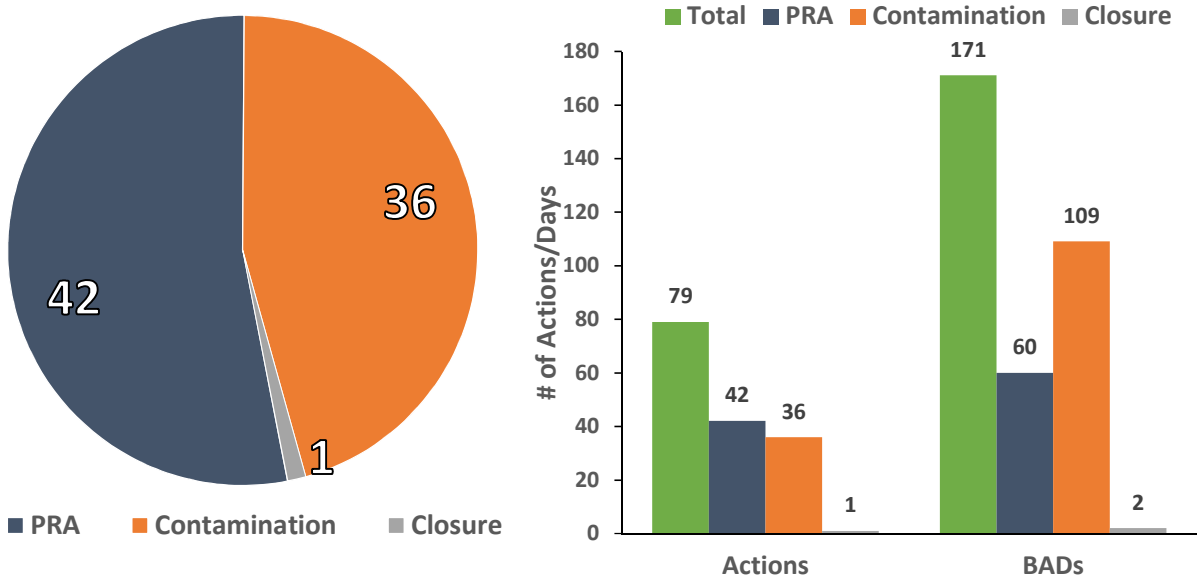
Beach Management Area	Site Name(s)	# Samples	# Samples ≥104	% Samples ≥104
LINCOLNVILLE BEACH	LIN-3	16	5	31.3%
MACKEREL COVE BEACH	HARP-3	13	4	30.8%
RIVERSIDE (OGUNQUIT)	OG-4	14	4	28.6%
WILLARD BEACH	WIL-2	26	5	19.2%
GOOSE ROCKS BEACH	GR-1, GR-2, GR-5	104	19	18.3%
BROAD COVE RESERVE	BC-1	12	2	16.7%
FERRY BEACH	FERRY-1	12	2	16.7%
COLONY BEACH	COLONY-1	25	4	16.0%
LITTLE BEACH	OG-5	13	2	15.4%
CAPE NEDDICK BEACH	YK-2	15	2	13.3%
MOTHERS BEACH	KBK-4	15	2	13.3%
GOOCHS BEACH	KBK-1, KBK-4	33	4	12.1%
EAST END BEACH	EEB-01	26	3	11.5%
OCEAN PARK BEACH	OOB-7, OOB-8	28	2	7.1%
SANDY BEACH	RKLD-2	14	1	7.1%
TOWN BEACH	MDI-5	14	1	7.1%
WELLS HARBOR BEACH	W-4	14	1	7.1%
YORK HARBOR BEACH	YK-20	14	1	7.1%
LAUDHOLM BEACH	LDHLM-1, LDHLM-2	29	2	6.9%
LONG SANDS - NORTH	YK-6, YK-8, YK-10, YK-11	46	3	6.5%
LONG SANDS - SOUTH	YK-13, YK-16, YK-18	37	1	2.7%
CENTRAL BEACH	OOB-3, OOB-4, OOB-5	40	1	2.5%

[3] Precipitation data source: NOAA NCDC (www.ncdc.noaa.gov).

Beach Actions

In Maine, beach actions include advisories (Contamination or Precautionary Rainfall) and closures. Contamination advisories represent those issued in response to elevated bacteria results, while Precautionary Rainfall Advisories (PRAs) are issued pre-emptively based on local precipitation levels (typically following 1 inch of rainfall or more in a 24-hour period). A Beach Action Day (BAD) represents the amount of time a beach is under an advisory or closure. This distinction is used as the duration of actions varies depending on the conditions under which they were posted. BADs are calculated for each beach as the number of days where the beach was under an action for any part of a day. This may over-estimate the length of BADs in some cases.

There were 171 recorded BADs in 2018, including 109 contamination BADs (36 actions), 60 rainfall BADs (42 actions), and 2 closure days (1 closures)[4]. Rainfall advisories accounted for 35% of the total 171 recorded action days as well as 54% of the total number of actions (Figures 5-5). Overall, 97.2% of total beach days (beach season length x beach management areas) were free of beach actions.



Figures 4-5. The 2018 total number of beach actions (PRAs, contamination, closures) and BADs for all participating beaches.

The total number of contamination BADs in 2018 (109) was greater than the past two beach seasons (2017 = 35, 2016 = 70). Four beach management areas (Goose Rocks, Lincolnville, Riverside, and Mackerel Cove) collectively accounted for 59% of the reported contamination BADs in 2018 (Table 2). The increase in beach actions and total BADs for 2018 compared to the past two seasons is likely due, in-part, to greater levels of precipitation as historical MHB program data indicates a larger number of bacteria exceedances and total BADs for seasons with higher rainfall accumulations.

[4] Total BADs include all action types (Contamination, Closure, and Precautionary Rainfall).

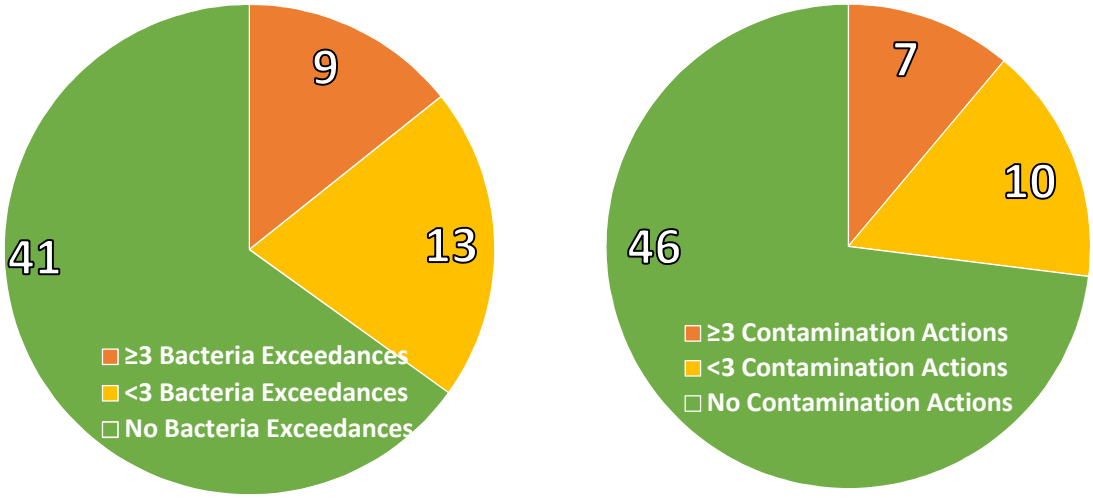
Depending on the timing of results and the availability of monitors/laboratories, resampling did not always occur the same day results were available. Also, beach managers sometimes kept an advisory in place until the next routine monitoring day indicated acceptable enterococci levels. There were also some "running" advisories where PRAs blended with contamination advisories and vice versa. PRAs often preceded contamination advisories and once bacteria results were available, PRAs were lifted, and contamination advisories were put in place until routine results indicated safe levels. These factors, as well as the practice of counting any part of one day as an action day, inflated the duration and number of beach action days in 2018.

Table 2. All BMAs with contamination actions (closures and advisories) in 2018. Summaries include the total number of contamination actions, number of contamination BADs, and the % of total contamination BADs the number of contamination BADs represents for each beach.

Beach Management Area	Site Name	# Contamination Actions	# Contamination BADs	% Total Contamination BADs
GOOSE ROCKS BEACH	GR-1, GR-2, GR-5	6	24	22.0%
LINCOLNVILLE BEACH	LIN-3	3	19	17.4%
RIVERSIDE BEACH	OG-4	3	11	10.1%
MACKEREL COVE	HARP-3	3	10	9.2%
GOOCHS BEACH	KBK-1, KBK-4	3	8	7.3%
COLONY BEACH	COLONY-1	3	6	5.5%
LITTLE BEACH	OG-5	2	6	5.5%
WILLARD BEACH	WIL-2	3	5	4.6%
BROAD COVE RESERVE	BC-1	2	5	4.6%
OCEAN PARK BEACH	OOB-7, OOB-8	1	3	2.8%
WELLS HARBOR BEACH	W-4	1	3	2.8%
EAST END BEACH	EEB-01	1	2	1.8%
CAPE NEDDICK BEACH	YK-2	1	2	1.8%
CENTRAL BEACH	OOB-3, OOB-4, OOB-5	1	2	1.8%
LAUDHOLM BEACH	LDHLM-1, LDHLM-2	1	1	0.9%
GOODIES BEACH	GB-1	1	1	0.9%
MOTHERS BEACH	KBK-4	1	1	0.9%

High Risk Beaches

In 2018, 65% of BMAs (41 BMAs) were free of bacteria exceedances (Table 1, Figure 5). For the remaining 22 BMAs, 13 were observed to have <3 exceedances while the majority of exceedances (BMAs with ≥3 exceedances) were observed at just 9 BMAs (Tables 1, 3; Figure 5). These 9 BMAs accounted for 72% or 51 out of the total 71 observed exceedances. Similarly, 73% of BMAs were free of contamination beach actions in 2018 and the majority of contamination actions (BMAs with ≥3 actions) were observed at just 7 BMAs (Table 2, Figure 6.). The MHB program provides beach management recommendations to local beach managers, but the decision to post an action at a beach falls under local jurisdiction. For that reason, the number of bacteria exceedances does not always reflect the number beach actions as action posting protocols vary locally.



Figures 5-6. The number of BMAs with ≥3, ≤3, or no bacteria exceedances and the number of BMAs with ≥3, ≤3, or no contamination actions for the 2018 beaches season.

Overall, most of MHBs participating BMAs experience either very few or no exceedances in any given season. Typically, only a handful of beaches contribute to the majority of exceedances in a season and, as a consequence, the majority of beach actions each year. MHB considers these BMAs with persistent bacterial contamination issues to be "higher-risk" due to various non-point and point sources of pollution impacting those beaches. In 2018, there were 13 BMAs for which ≥10% of samples collected exceeded Maine's BAV, many of which were also among the top beaches with exceedances for the past several years. At 12 of these 13 BMAs, sample exceedances were associated with antecedent precipitation 50% or more of the time, and for 9 BMAs sample exceedances were associated with antecedent precipitation 75% or more of the time (Table 3, Figure 7).

Antecedent precipitation calculations include any precipitation concentrations observed 48 hours prior to the monitoring date as well as any precipitation observed the day of sample collections because rainfall often occurred overnight and in the early pre-monitoring morning hours. Including the precipitation levels from the day of sample collection may over-estimate the % exceedances with antecedent precipitation as it includes a portion of the day after samples have been collected; however, a reliable dataset with the precision for hourly measurements is not available at this time.

Table 3. BMAs for which ≥10% of enterococci samples exceeded Maine's BAV. Summaries include total number of samples, number of samples ≥104 MPN, % samples ≥104 MPN, and % exceedances associated with antecedent precipitation.

Beach Management Area	Site Name	Number of samples	# Samples ≥104	% Samples ≥104	% Exceedances with Antecedent Precipitation
LINCOLNVILLE BEACH	LIN-3	16	5	31.3%	80.0%
MACKEREL COVE	HARP-3	13	4	30.8%	50.0%
RIVERSIDE BEACH	OG-4	14	4	28.6%	75.0%
WILLARD BEACH	WIL-2	26	5	19.2%	80.0%
GOOSE ROCKS BEACH	GR-1, GR-2, GR-5	104	19	18.3%	63.2%
BROAD COVE RESERVE	BC-1	12	2	16.7%	50.0%
FERRY BEACH	FERRY-1	12	2	16.7%	100.0%
COLONY BEACH	COLONY-1	25	4	16.0%	75.0%
LITTLE BEACH	OG-5	13	2	15.4%	100.0%
CAPE NEDDICK BEACH	YK-2	15	2	13.3%	100.0%
MOTHERS BEACH	KBK-4	15	2	13.3%	0.0%
GOOCHS BEACH	KBK-1, KBK-4	33	4	12.1%	50.0%
EAST END BEACH	EEB-01	26	3	11.5%	100.0%

Non-point source pollution likely contributed to fecal indicator bacteria (FIB) loading at BMAs with the greatest exceedance rates in 2018, as the majority of them are impacted by freshwater inputs (rivers, streams, storm drains). As a result, pollutants are transported from upland areas during all weather conditions, but especially when it rains. MHB's historical data demonstrates a relationship between antecedent precipitation and observed bacteria exceedances. In response, many of Maine's participating towns/state parks have begun implementing preemptive PRAs during and following moderate/heavy rainfall. Given the limited 1-2x per week sampling frequency for Tier 1 beaches, this preemptive advisory protocol allows beach managers to be more protective of public health at these BMAs when bacteria results are not available.

When feasible, MHB partners with towns/state parks managing high-risk BMAs to support ongoing efforts to find, fix, and prevent bacterial pollution sources. In 2018, MHB supported efforts in the Cape Neddick River watershed, Ogunquit River watershed, Wells Harbor, Goose Rocks Beach watershed, Kennebunk River watershed, Goosefare Brook watershed, Willard Beach storm drainage network, Crescent Beach State Park, and MDIBL's efforts in Bar Harbor, Mt. Desert, and Acadia in an effort to improve water quality at participating BMAs (see VI. Collaborative Efforts).

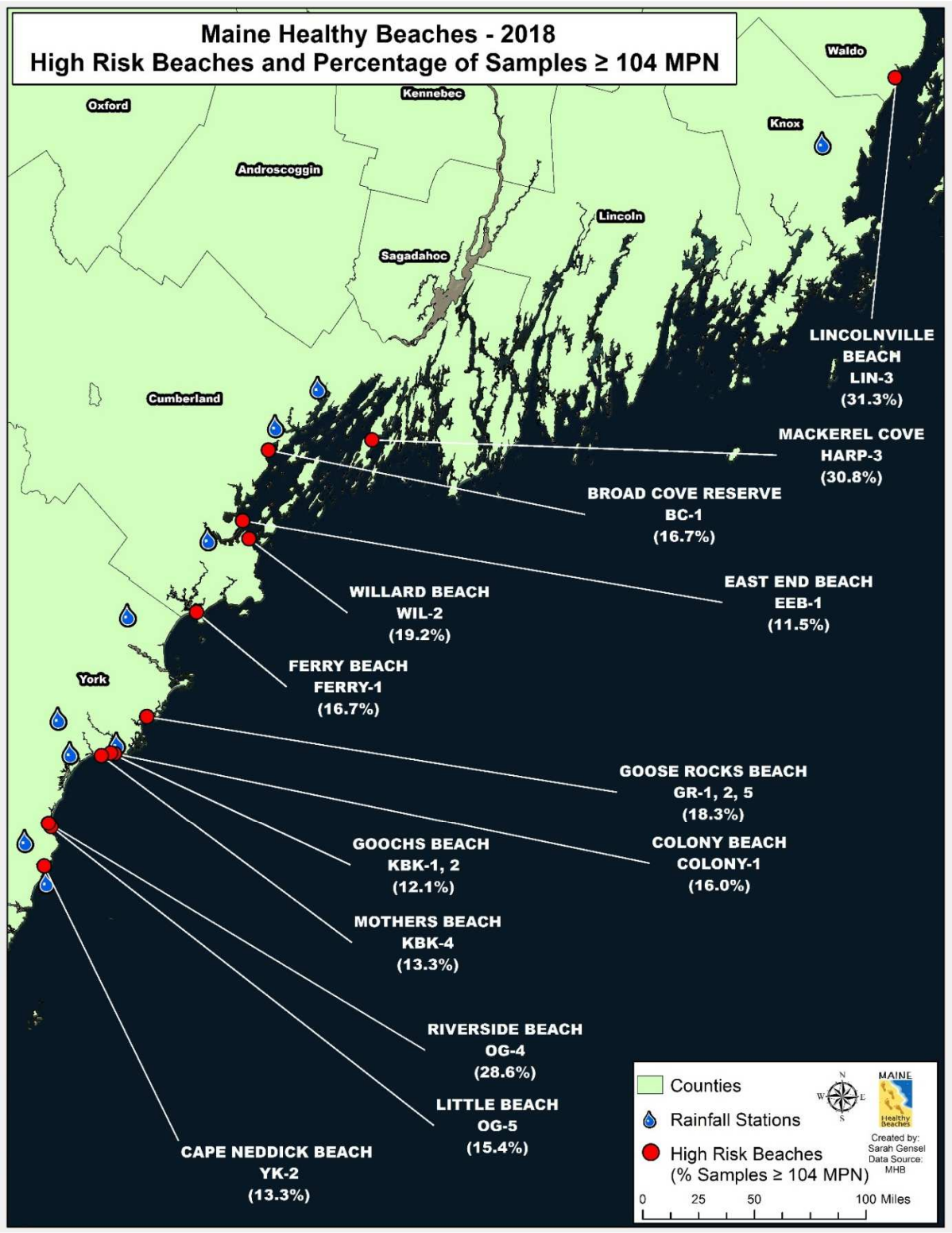


Figure 7. BMAs for which ≥10% of samples exceeded Maine's single sample maximum BAV for enterococci in marine waters (104 MPN/100mL).

VI. Collaborative Efforts

Maine's coastal tourism and recreation industry contributes billions of dollars annually to Maine's economy. Clean coastal waters are a major priority. Results from a 2015 survey of Maine residents and visitors revealed reducing coastal pollution as the first of 13 possible priority actions, and clean waters and sandy beaches were the two most important factors when planning visits to coastal areas. However, the majority of Maine's beaches are impacted by freshwater inputs that transport pollutants from upland areas. Sources are typically difficult to find, often requiring intensive investigations beyond the immediate shoreline. Once sources are verified, solutions are often complex and expensive.

The MHB program plays a critical role in keeping coastal waters healthy. Since 2003, the program has provided extensive support to communities experiencing bacterial pollution issues with a focus on sharing resources and solving problems. Some examples include: circulation studies, sanitary surveys, GIS mapping/analysis, stakeholder workshops, outreach campaigns, applying pollution source tracking tools like optical brighteners and DNA markers, etc. This work has built the foundation for historical and current local actions to identify, remove, and prevent pollution sources. For example, this work includes surveys of the shoreline and watershed, investigations of and improvements to wastewater/stormwater infrastructure, septic/cesspool removal, boat pump out installation, beach and watershed management plans, protective ordinances, local monitoring efforts and outreach campaigns, etc.

Working groups and applied research partnerships

In 2018, MHB staff actively participated in numerous working groups, as well as applied research partnerships that have been instrumental in improving decision-making, addressing pollution issues, reaching diverse audiences, and supporting student advancement in Maine and beyond. For example, MHB staff continued to seek feedback from local participants for the 2018 implementation of the EPA approved BAV plan (approved in 2016). MHB staff will continue to collaborate with EPA, consulting their expertise on the latest research and development of new guidance, and to seek the expertise of its advisory committee the research community, and other partners when necessary in establishing important program policies as well as addressing challenges.

Coastal beaches are complex systems and the regrowth and persistence of enterococci in sand, seaweed and sediments confounds our understanding of recorded bacteria levels, especially because these "naturalized" contributions have not been linked to human illness. However, studies in Maine and elsewhere have indicated extremely elevated bacteria levels in seaweed that has been cast and warmed on the beach, as well as in neighboring beach water that has rinsed previously stranded algal mats. In response to concerns, MHB staff continued to consult experts in 2018 to guide information shared with beach managers, the public, press, etc. MHB staff also worked with local and state agency partners to inform strategies that would allow communities to better and more quickly respond to episodic events that pose safety and other concerns. More research is needed to understand any health risks posed by fecal indicator bacteria (FIB) levels generated from seaweed that's been "seeded" with fecal material from birds, pets, stormwater, etc. The MHB program will continue to consider FIB levels sourced from seaweed as a potential health risk until further research and guidance develops.

Additionally, UMaine staff continued active membership on the Marine Extension Team (MET), a collaboration of Maine Sea Grant and UMaine Extension, and also served on the Goosefare Brook Restoration and Outreach Committees, Casco Bay Working Group, Ogunquit River Watershed Restoration Committee, Kennebunk River 319 planning committee, and Coastal Watersheds Working Group. As part of MHB's ongoing efforts to improve the program and its effectiveness, MHB staff will continue to seek opportunities for collaboration in 2019.

Enhanced monitoring

The MHB program has supported enhanced monitoring of multiple parameters (toolbox approach) targeting human sourced fecal contamination for areas demonstrating persistent bacterial pollution issues. Typically, as the number of parameters that exceed a threshold (or detectable) limit increases, so does the confidence that human sources are impacting water quality. The focus areas have changed over time with the primary targets being freshwater inputs to the shoreline. However, program data and support (historical and current) has raised awareness regarding water quality issues and has helped make addressing them a priority. Although limited resources and staff has reduced the number of toolbox parameters monitored for the past several years, MHB staff continued an applied research partnership with researchers at UNH in 2018 to incorporate microbial source tracking (MST) tools into ongoing pollution source identification and remediation efforts.

Beyond routine beach monitoring, 449 samples were analyzed for enterococci bacteria at 61 enhanced monitoring locations in 2018. Samples were collected upland in freshwater inputs to the beach on designated dates throughout the season or were collected on a routine basis in "high-risk" areas such as the mouths of rivers and streams, storm drains, stagnant tide pools, etc. MHB also supported assessment of intermittent, suspected sources such as seepages and runoff typically associated with heavy rainfall. Additionally, MHB staff analyzed 351 samples for optical brightener (OB) levels at 51 enhanced monitoring locations in 2018. Optical brighteners are commonly used in commercial/retail products and are typically flushed down the drain. Therefore, when optical brightener concentrations are coupled with elevated fecal bacteria levels, it can be indicative of human-sourced fecal contamination.

Cape Neddick River Watershed (York)

The MHB program has supported multi-year enhanced monitoring studies, microbial source tracking, GIS watershed risk analysis, stakeholder workshops and more to supplement York's actions to address impaired water quality. York is a designated "MS4" community, has hired and retained a Stormwater Manager/Shoreland Resource Officer, partnered with local groups, and held numerous outreach events to augment efforts to address the health of its water resources.

In 2018, York completed implementing objectives of their 319-funded Phase I Implementation grant (issued by Maine DEP and funded by US EPA) for the Cape Neddick River Watershed including intensified bacteria monitoring efforts, the installation of three vegetated goose barriers along the river, and targeted education and outreach initiatives. Additionally, the town continued to use a site-specific, weather-based model developed for York's beaches to inform precautionary rainfall advisories. York continued contracting with consultants as part of the York

County MS4 Stormwater Working Group to ensure MS4 priorities were met and made improvements to sewer and stormwater infrastructure as well as routine maintenance consisting of catch basin and sewer line cleaning and street sweeping. York conducted stormwater outreach initiatives including a collaboration with York Land Trust and Southern Maine Stormwater Working Group to hold a "Wild-scaping Workshop", a Lawns to Lobsters Program providing yardscaping information to residents, and additional municipal outreach.

Ogunquit River Watershed (Ogunquit, Wells)

In an effort to improve water quality in the Ogunquit River and understand the fate and transport of pollutants, the MHB program has supported a circulation study and multi-year enhanced monitoring and pollution source identification efforts. Ogunquit's commitment to water quality expands beyond the coastal zone to include protective ordinances in upland areas. In 2018, Ogunquit completed the objectives of Phase II of its 319 Ogunquit River Watershed implementation grant (issued by Maine DEP and funded by US EPA) including pet waste education activities, outreach focused on septic maintenance, stormwater BMP (Best Management Practices) installations, and bacteria monitoring. Ogunquit was awarded additional 319 (Phase III Implementation) grant funding to support ongoing efforts to restore water quality in the Ogunquit River. MHB continued to serve on the Ogunquit River Watershed Restoration committee in 2018.

Wells Harbor

Beyond routine beach monitoring, the MHB program has supported the analysis of samples collected intermittently to assess bacteria levels in sand, seaweed and stormwater impacting Wells beaches. In 2018, the program continued to support enhanced monitoring in the Webhanett River impacting water quality on Wells Harbor Beach. As part of this effort, 26 samples were collected at two locations. Enterococci values ranged from <10 MPN to 292 MPN/100mL with seasonal geometric mean values of 17 MPN (site W-12) and 23 MPN (W-13).

Kennebunk River/Goose Rocks Beach Watershed (Kennebunk/Kennebunkport)

The MHB program has supported multi-year enhanced monitoring and pollution source identification efforts including monitoring of multiple water quality parameters, in-depth data analysis, a circulation study, sanitary surveys, GIS watershed risk analysis, stakeholder workshops and more to support improving water quality in the adjacent rivers that impact neighboring beaches in Kennebunk and Kennebunkport.

In 2018, local volunteers continued enhanced monitoring efforts in the Kennebunk River and MHB staff collaborated with diverse stakeholders to share data and recommendations as part of the Kennebunk River 319 planning committee. Staff also supported watershed monitoring efforts with members of Maine DEP's Environmental Assessment Division to assist with efforts to assess and improve water quality in the river.

In 2018, Kennebunkport increased the routine beach testing frequency at Goose Rocks Beach to 3x per week and Colony Beach to 2x per week. Kennebunkport's health nurse conducted education/outreach initiatives regarding the MHB program, including promoting best practices at the beach and larger watershed areas. The town also provided timely notification of water

quality conditions on the community website and via the public health office's outgoing message. The town also installed a sewer extension providing hookup opportunities to homes previously serviced by septic systems and dye tested 13 properties with suspect systems.

Over the past several years, routine monitoring at Goose Rocks beach has revealed consistently elevated fecal bacteria concentrations, which contributed to increased beach advisories and threatened public health. In response, MHB staff worked with Kennebunkport to design and implement an intensified pollution source monitoring plan to identify bacterial contamination hot spots and support the town's efforts to address those pollution sources (Appendix D). As part of these efforts, the town hired a summer intern to assist with septic surveys, perform education/outreach initiatives, and conduct enhanced monitoring.

Goosefare Brook Watershed (Saco and Old Orchard Beach (OOB))

For the past 7 years, the MHB program has supported enhanced monitoring and pollution source tracking efforts, held stakeholder workshops, and more to address impaired water quality in the Goosefare Brook (GFB) watershed. These efforts were initiated in response to persistently elevated bacteria concentrations within the GFB and at downstream beaches. In 2018, MHB staff continued to serve on the Goosefare Brook Restoration and Outreach committees, provided GIS support, assisted with education/outreach events, delivered presentations, and conducted enhanced source tracking monitoring in priority areas (Appendix E). MHB staff also continued an applied research partnership with researchers at the University of New Hampshire to incorporate MST techniques into ongoing pollution identification and remediation efforts.

In response, Saco and OOB continued their collaborative efforts to restore water quality in the GFB by implementing objectives of their Watershed Based Management Plan (WBMP) utilizing 319 Phase I Implementation grant funds issued by ME DEP (funded through US EPA) in 2018. The focus of this work included stormwater retrofits, erosion/buffer control projects, and education/outreach initiatives with local schools. Both communities worked collaboratively to obtain additional 319 grant funding (Phase II Implementation) to continue implementing WBMP priority projects.

Both communities continue to investigate the integrity of and make improvements to sewer/stormwater infrastructure, remediating any potential sources of illicit discharge. When feasible, the MHB program will continue its collaboration with Saco, OOB, and UNH researchers to identify sources of fecal contamination in GFB priority areas utilizing MST methods in conjunction with bacteria and optical brightener monitoring in 2019. MHB staff will continue to serve on the Restoration and Outreach committees established to help inform future 319 grant funded efforts.

Willard Beach (South Portland)

In an effort to address Willard Beach water quality, the MHB program supported multi-year enhanced monitoring efforts, education/outreach initiatives, a shoreline/watershed survey, and stakeholder meetings. Of particular concern are the six stormwater drainage pipes discharging directly to the beach, draining stormwater from ~ 1 km^2 of residential and commercially developed areas. In 2018, the City continued posting preemptive rainfall advisories including the

utilization of a flag system in support of public health due to the elevated risk for fecal pollution following moderate to heavy precipitation at this location. The MHB program continued to support enhanced monitoring (Appendix F) in 2018 utilizing the pollution source tracking toolbox approach in an effort to pinpoint human sources of fecal pollution. Parameters used to date include enterococci bacteria, OBs, pharmaceutical and personal care products, canine detection utilizing sewage sniffing dogs, ammonia, surfactants, total residual chlorine, and MST.

In 2017, the City continued implementing outreach initiatives focused on stormwater education including specific efforts to educate pet owners regarding the impacts of pet waste on beach water quality. The City also performed maintenance and improvements to sewer and stormwater infrastructure and successfully identified and repaired an inadvertent cross connection of gray water into the separated storm drain system. When possible, MHB program will continue supporting enhanced monitoring efforts within the storm drain system and will continue to support South Portland's efforts to promote responsible pet ownership in 2019.

Crescent Beach State Park

In 2018, 11 enterococci samples were analyzed at two sites in a neighboring marsh with results ranging from 98 to ≥24,200 MPN/100mL (marsh-east geometric mean 3,429 MPN/100mL and marsh-west geomean 1,920 MPN/100mL). Both marsh and beach sites were infrequently elevated in 2017, indicating the marsh discharge may only impact beach water quality after heavy rainfall as elevated counts have been observed historically associated with moderate to heavy precipitation (including 2018). More information is needed to better understand any impacts these "naturalized" Enterococci have on recorded bacteria levels as well as human health.

Bar Harbor, Mt. Desert, and Acadia

The MHB program has supported local water quality initiatives on Mount Desert Island including enhanced monitoring, surveys, special projects, stakeholder workshops, and more. In 2018, the Community Environmental Health Laboratory at the MDIBL examined multiple water quality parameters in the port of Bar Harbor to assess potential contributions of fecal contamination by vessels illicitly discharging in the port in addition to efforts to engage citizens in water quality and further establish clear communication lines with the cruise industry (Appendix G). MHB supported the analysis of 84 enterococci samples at 4 monitoring sites. In conjunction with this cruise ship study, MDIBL also assessed the incidence of microplastics and examined the water column microbiome in the vicinity of cruise ships in the harbor (Appendix H). The MHB program supported Acadia National Park in its efforts to assess water quality on Sand Beach by supporting the analysis of 12 samples collected at a site capturing marsh/stream runoff behind the public beach area. Results ranged from <10 to 86 MPN/100mL of sample water with a geometric mean of 15 MPN/100mL.

The MHB program would like to thank EPA for their continued support.