Bar Harbor Cruise Ship Monitoring Report 2015

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Executive Summary

Water quality in the port of Bar Harbor was monitored between May and October 2015 by staff and volunteers from the Community Environmental Health Laboratory at MDI Biological Laboratory in Salisbury Cove, ME. Sample sites included the Town Pier, offshore cruise ship anchorages designated Alpha and Bravo, and control site Bell Buoy #7 (Figure 1). Water quality was also monitored weekly at the Town Pier when no ships were present. The Bar Harbor harbormaster transported monitors to the offshore anchorages. Water samples were analyzed for phytoplankton, biological oxygen demand, dissolved oxygen, nutrients, salinity, transparency, turbidity, chlorine, and *Enterococcus* bacteria.

Figure 1. 2015 cruise monitoring stations in Bar Harbor, Maine: Alpha, Bravo, Control Site Bell Buoy #7, and Town Pier.

Introduction

As the world's population expands, there is an increased risk of ocean pollution from a variety of land and marine uses. It is estimated that 80% of ocean pollution comes from land-based activities. However substandard ships or poor shipping practices also contribute to marine pollution (WWF, 2015).

Cruise ships are also a potential source of ocean pollution. A typical cruise ship with 3,000 passengers can generate up to 25,000 gallons of human waste and 143,000 gallons of gray water from showers and sinks each day (Oceana, 2014). There is immense potential for water quality impacts, should an accidental or intentional discharge occur.

Cruise ships are essentially floating cities because they provide all of the services that individuals would need and can receive on land (Oceana, 2014). Although land based sewage treatment systems are strictly regulated by The Clean Water Act (40 CFR 122.3), gray water and black water discharges from cruise ships are only regulated in a couple of states.

Since January 1, 2006, Maine legislation (38 M.R.S.A. §423-D) has required large passenger vessels to have a general permit for the discharge of gray water or a mixture of gray water and black water (DEP Permit #W008222-5Y-A-N). In addition, this legislation requires that large passenger vessels adhere to strict discharge standards that require a certain level of water quality be attained by secondary treatment before discharge within a harbor. Despite this legislation requiring large passenger vessels to obtain a permit before discharging in Maine waters, no ships have applied for a permit in the state of Maine, and there are many boats to which these requirements do not apply. Large commercial passenger vessels are defined in Maine statute as commercial passenger vessels that provide overnight accommodations for 250 or more passengers for hire. The ships that visit the town pier in Bar Harbor, are all considered small commercial passenger vessels.

Although small commercial passenger vessels are exempt from the regulations outlined in 38 M.R.S.A. §423-D, there are best management practices recommended by the cruise industry, US EPA, and the US Coast Guard which are outlined in the Town of Bar Harbor Cruise Tourism Destination Management Plan (2007). These include black water discharges being limited to those that meet effluent guidelines and discharges being limited to when the vessel is proceeding at a speed not less than 6 knots where the ship is more than 4 nm from shore. It is also recommended that ships voluntarily prohibit discharge of gray water while in port and that gray water discharges be limited to when the ship is underway and proceeding at a speed not less than 6 knots where the ship is more than 4 nm from shore.

Despite these guidelines, a small passenger cruise ship, *Independence*, discharged wastewater that was visible to passers-by at the Town Pier in 2010 and again in 2011. Confirmation of these discharges by follow-up water quality monitoring opened lines of communication with the cruise agency and led to apologies and pledges to refrain from these discharges in the future. It also opened up discussion about the need for a pump-out station at the Town Pier.

It is Bar Harbor's policy that visiting ships hold all waste while in the harbor. This is based on best practice recommendations from a variety of federal and state entities. There are no federal or state mandates that support this policy where small cruise passenger vessels are concerned; therefore there is no outside entity that will check for compliance of Bar Harbor's policy if Bar Harbor does not do so.

Checking for compliance with harbor policy regarding discharge of waste water sends a message to visiting ships that water quality is important to citizens of Bar Harbor. Water quality monitoring may serve as a deterrent to discharging of wastewater by all types of vessels visiting Bar Harbor. Not only can wastewater discharges affect the health of the ecosystem, but they can also affect human health. One type of bacteria that is used as an indicator of sewage pollution is *Enterococcus*, which is found in the intestinal tract of warm-blooded animals. *Enterococcus* indicates that other pathogenic organisms may be present. Discharge of untreated wastewater from visiting ships may result in outbreaks of recreational water illnesses or RWIs, since people use the town beach near where small cruise ships and other vessels dock, and local kayaking companies launch from the nearby boat ramp. RWIs may include a wide variety of illnesses, including infections of the skin, eye, ear, and gastrointestinal system.

A monitoring program that includes open communication with the cruise industry has helped to address two questions: Are cruise ships aware of and complying with Bar Harbor's "No Discharge" policy? The second question is: How can we use water quality data to open lines of communication with the cruise industry and others and affect positive change that ensures that Bar Harbor remains a sustainable cruise destination?

Dr. Jane Disney, director of the Community Environmental Health Laboratory (CEHL) at MDI Biological Laboratory, and project manager for the 2015 Cruise Ship Monitoring Program in Bar Harbor, has been engaging citizens in monitoring water quality in Frenchman Bay since 1997 as part of the Maine Shore Stewards program, the Maine Phytoplankton Monitoring Program, and most recently the Maine Healthy Beaches program. In 2004, as director of the non-profit MDI Water Quality Coalition, she was involved in a series of four "Community Conversations on Cruise Ships" in Bar Harbor. Due to citizen concern about the potential for cruise ship impacts on water quality, she designed a water quality monitoring regime to look at water quality at cruise ship anchorages and at the Town Pier in Bar Harbor. Working with citizen volunteers, water quality data were collected in the vicinity of 31 large and small passenger vessels between May and November of 2004. The final report was cited in *From Ship to Shore: Sustainable Stewardship in Cruise Destinations*, published in 2006 by Conservation International. This publication acknowledged that "because of their unique skills and expertise on conservation and community development issues, civil society organizations have an opportunity to work with other stakeholders, including the cruise lines, to develop and implement solutions for addressing their key concerns and increasing the sustainability of cruise tourism."

After a purported wastewater discharge incident by a small passenger vessel at the town pier in 2010, staff scientists at CEHL received a request from the harbormaster to take water samples to assess the health of the surrounding water. In 2011, CEHL staff followed up on this incident by implementing a second cruise ship monitoring project, this time focused in the vicinity of small passenger vessels at the town pier. Water quality was monitored on 8 different occasions and a report was prepared for the Town of Bar Harbor. The authors of the report recommended that communications with visiting cruise ships include expectations that ships hold all wastewater until out of port (Megan May and Jane Disney, 2011).

In 2014, the CEHL staff monitored in the vicinity of 19 large and small cruise ships; monitoring revealed elevated bacteria levels three times during the season (Disney, Charabati, Farrell, 2015). Two of the instances were at the Town Pier. On one of these occasions, American Glory had just docked, on the other occasion there was no cruise vessel at the pier. On both occasions, the registered herring carrier from

Columbia, ME, *Reliance* was docked; observers noted discharge coming from *Reliance* on the first of these two occasions and reported the event to the harbormaster. Elevated bacteria levels were also found at anchorage Alpha when the large passenger vessel, Summit, was visiting. The visit corresponded with heavy rainfall and runoff in Bar Harbor, which probably led to the high bacteria levels.

The 2004, 2011 and 2014 cruise ship monitoring projects helped to open lines of communication between ship captains and the harbormaster, provide clarity on wastewater treatment and management practices on-board visiting ships, and allay concerns of Bar Harbor citizens about the potential impact of cruise ships on marine water quality along the Bar Harbor shorefront. As this current report reveals, the 2015 cruise ship monitoring project accomplishes the same goals.

The expertise and experience of CEHL staff with water quality monitoring in Bar Harbor, as participants in state-level initiatives, as well as local cruise ship monitoring projects, were brought to bear on the 2015 cruise ship monitoring project, the results of which are presented in this report.

Methods

What we tested for:

The water quality monitoring protocol is similar to the one described in the MDI Water Quality Coalition Cruise Ship Water Quality Report (2005) and detailed in the Quality Assurance Project Plan (QAPP) that guide all field and lab testing at the Community Environmental Health Laboratory. Variables assessed in water samples taken from the pier or in cruise ship anchorages include water temperature, *Enterococcus* bacteria, dissolved oxygen (DO), biochemical oxygen demand (BOD), nutrients (ortho-phosphate, dissolved inorganic nitrogen (DIN) which is nitrate + nitrite + ammonia), chlorine, transparency, turbidity, salinity, and dominant phytoplankton species.

Why we monitored for these variables:

The presence of *Enterococcus* indicates that pathogenic organisms may be present in the water. Since *Enterococcus* is found in the gut of warm-blooded animals; it can be found in both black water (from sewage) and gray water (from sinks and showers) from boats. Discharges from boats can impact more than human health. The nutrients and organic matter in discharges can affect DO levels, which must be above 4-6 ppm for a healthy marine ecosystem. Measuring BOD helps to determine if there is excessive organic matter in the water column. In metabolizing organic matter, bacteria can quickly multiply and consume dissolved oxygen, leading to high (>2 ppm) BOD results. The nutrients in both black water and gray water can spur phytoplankton blooms, which in turn, can also affect DO levels in the water. Water temperature can also affect DO levels. Concentrations of nutrients can vary in different locations in bays and estuaries. On-going monitoring when ships are in port or when no ships are present helps to establish baseline readings of what is normal or expected in particular marine systems.

How samples were collected and analyses were conducted:

Samples for bacterial analysis were collected using sterile Whirl-Pak sample bags and then tested using the Enterolert® protocol from IDEXX; this method is currently being used in the Maine Healthy Beaches Program. As part of that program, we have data on town beach for comparison with offshore samples. US-EPA recommends *Enterococcus* as the best fecal indicator in marine waters from a public health perspective. It is recommended that *Enterococcus* tests be run as soon as possible, but not later than 6 hours after sampling. CEHL is in close proximity to the sampling sites and we ran the tests well below the 6-hour holding time limit. The Maine Healthy Beaches Program supplied all field equipment and sample bags as well as lab supplies related to running *Enterococcus* tests (dilution jars, multi-well plates for Most Probable Number (MPN) determination, pipets, and media) at no cost to the town, as the data generated may help to inform beach management in Bar Harbor in the future.

DO samples were collected in duplicate and fixed using a LaMotte DO test kit. Water samples for BOD determination were collected in duplicate in bottles covered with aluminum foil and then kept in the dark for 5 days using a method described in Mitchell and Stapp (2000). Both same-day DO and 5-day DO levels were determined using the Winkler Titration Method. BOD was calculated by subtracting the 5-day DO levels from the original DO levels.

Water samples were collected for ortho-phosphate and DIN analysis by filtering through a syringe filter containing a Millipore 0.45 µm filter into sterile vials. These were transported in a seawater ice-bath to CEHL, where they were stored in a -20°C freezer. The samples were shipped on dry ice or transported to the University of Maine-Orono to be analyzed with an Autoanalyzer II by Maura Thomas in Dr. David Townsend's Laboratory.

Transparency was documented by using an oceanographic Secchi disk to determine descending and ascending transparencies; these values were then averaged. Secchi disks measurements (in meters) reveal the clarity of the water. Turbidity samples were analyzed in triplicate using the 2020 *e* LaMotte turbidity meter; these values were then averaged. Readouts from the turbidimeter provide a relative measure of turbidity in nephelometer turbidity units (NTU). Samples for phytoplankton analysis were collected by filtering 10 liters of seawater through 20 micron netting. Phytoplankton samples were analyzed with a Sedgewick Rafter slide; dominant phytoplankton types were scored, and slides were scanned for the presence of non-native species. Salinity was measured in ppt using a refractometer.

Additional data regarding environmental characteristics were also recorded, including air and water temperature, tide stage, times of high and low tide, wind speed, weather, and observations of all boats and yachts at the pier and moored in the harbor. Temperatures were taken with a digital thermometer. Times of low and high tides were determined using an online Bar Harbor tide chart. Wind speed and direction were measured with a compass and a Beaufort scale. Weather was determined by conditions in the field at the time of sampling. The amount of precipitation in the 48 hours preceding sampling was determined using data from noaa.gov.

Results and Discussion

Scope of Monitoring:

We obtained samples in the vicinity of 16 different ships on nine separate occasions this year, with a control on each sampling day, for a total of 25 samples. Anchorage Alpha and Anchorage Bravo were each sampled eight times. Control Site Bell Buoy #7 was sampled nine times. Ships at the Town Pier were sampled two times. We also sampled weekly at the Town Pier when no ships were present a total of 18 sample dates.

Bacteria and Oxygen:

For the purposes of this monitoring program, fecal bacteria and oxygen were the most important indicators of healthy water, as bacteria relates to public health and oxygen levels relate to overall ecosystem health.

Enterococcus is recommended by the US EPA as the best fecal indicator in marine waters from a public health perspective. The highest bacteria concentration during the 2015 cruise monitoring season was 41 MPN on August 17, 2015, when Grand Caribe was docked at the Town Pier. 95% of bacteria samples around cruise ships were below 10 MPN. No samples at any site reached the EPA exceedance level of 104 MPN/100 mL.

Many species, including fish, invertebrates, and plants require oxygen to carry out their life cycles. Atmospheric oxygen dissolves readily in water until the water is saturated. Distribution depends on movement of the water. Photosynthetic species, such as marine plants, algae, and phytoplankton also produce oxygen in the water. Different species at different life stages require varying amounts of oxygen, but in general, dissolved oxygen levels below 3 ppm are stressful to most marine organisms and levels below 2 or 1 ppm will not support fish. Levels at or above 5 ppm are required for most life processes (LaMotte, 2001). Average dissolved oxygen over the 2015 monitoring season was 8.8 ppm. The highest average dissolved oxygen content was 10.0 ppm, and the lowest was 7.6 ppm (Figure 2).

Biochemical Oxygen Demand (BOD), as we measured it, reflects the amount of dissolved oxygen that organisms consume to carry out life processes over a specific amount of time. There are natural sources of organic materials (swamps, bogs, vegetation, animal waste), and human sources (wastewater). When BOD levels are high, it means microorganisms are consuming much of the available dissolved oxygen, leaving little oxygen for other organisms (Mitchell and Stapp, 2000). Average actual biochemical oxygen demand (DO-BOD) over the 2015 monitoring season was very low (1.2 ppm). The highest actual biochemical oxygen demand was 2.3 ppm, and the lowest was 0.2 ppm (Figure 2).

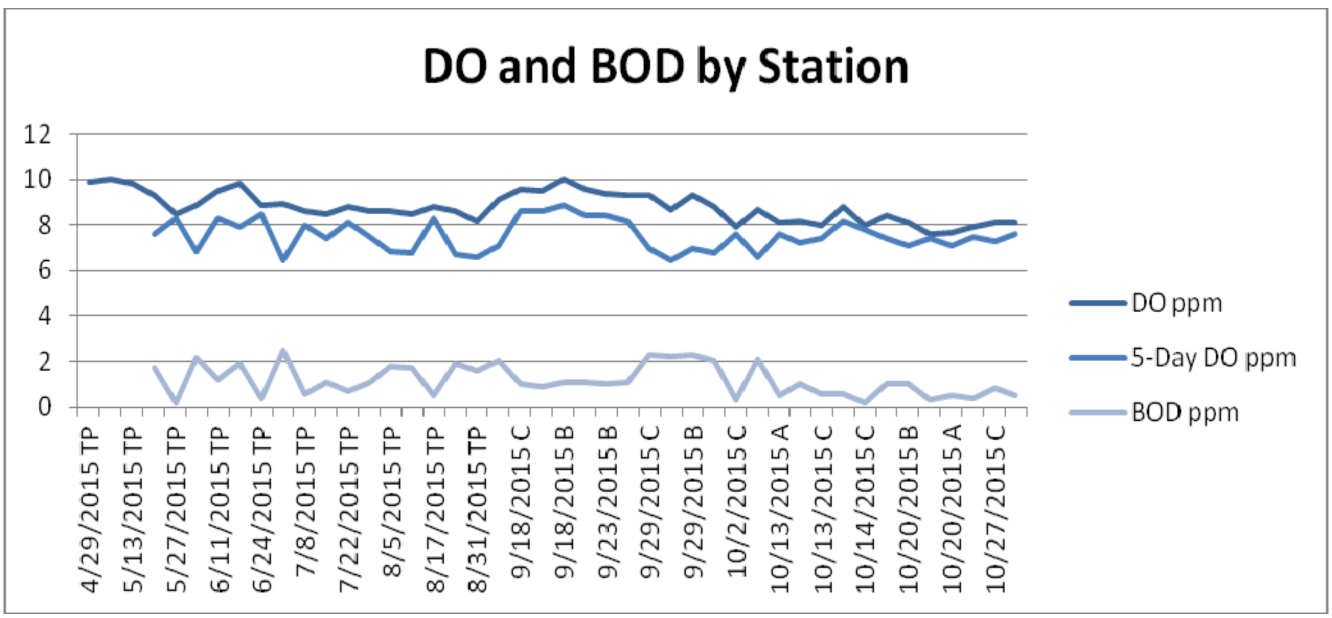

Figure 2. Dissolved oxygen (DO), DO after a five-day hold (5-Day DO), and biochemical oxygen demand (BOD) over the sampling time period.

Chlorine:

Chlorine is used to treat wastewater in some ships using Marine Sanitation Devices. Chlorine can be damaging to the environment when discharged, even at low levels. According to the US EPA, the recommended maximum for all fish and aquatic life is 0.01 ppm (2015). Most marine plankton species are killed when levels reach 0.1 ppm. During the 2015 monitoring season, average total residual chlorine levels across all sites were below 0.1 ppm.

Nutrients:

Elevated nutrient levels in the water column may be indicative of pollution events. The breakdown of organic material, which could result from a pollution event, releases nutrients into the water, particularly nitrogen and phosphorus (Mitchell and Stapp, 2000). Excess nutrients can cause algal blooms, leading to a decrease in light and oxygen in the water. We sampled for nitrate and nitrite (NO3+NO2), ammonium (NH4), and phosphorus (PO4). Dissolved Inorganic Nitrogen (DIN) is calculated by adding nitrate, nitrite and ammonium. We detected elevated levels of DIN at the Town Pier in May, and an increase in DIN at offshore anchorages Alpha and Bravo, and the Control Site, in October (see Figure 3). The DIN increase can be attributed to spikes in ammonium on those days (see Appendix 1). Elevated DIN was not accompanied by elevated phosphate levels.

The 2014 cruise monitoring season produced similar results at offshore anchorages Alpha and Bravo in October. Elevated nutrient levels at offshore anchorages may by characteristic of the water column in autumn. A comparison is not available for nutrients at the Town Pier since we did not carry out weekly baseline sampling at that station in 2014. Elevated DIN levels at the Town Pier may be attributed to rinsing of fishing vessel decks at the town dock at the time of sampling.

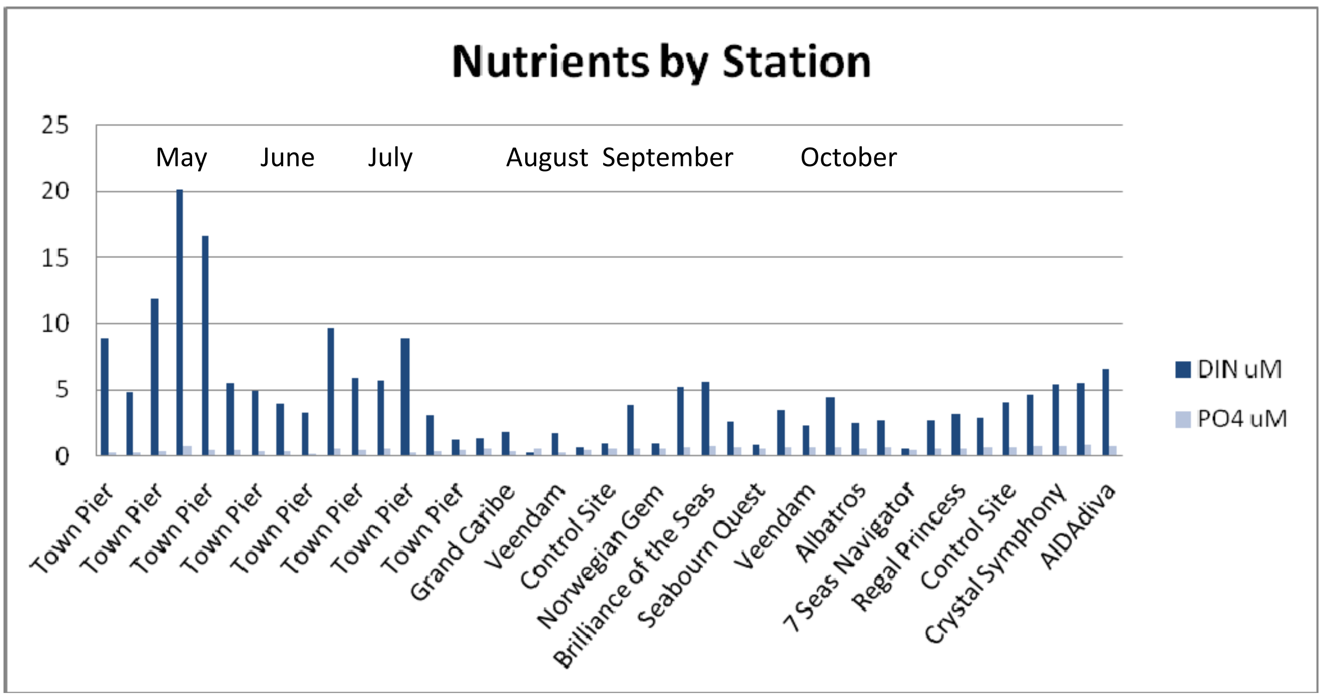

Figure 3. Dissolved Inorganic Nitrogen (DIN) and phosphorus levels over the sampling time period.

Other Water Quality Variables:

In addition to collecting information on bacteria and nutrients, we looked at a host of associated water quality variables (Appendix 2). In addition to rainfall, water temperature, dissolved oxygen, and biochemical oxygen demand, the transparency and turbidity of the water were assessed at each site on each sampling day. Transparency and turbidity are different measures of water clarity. Both measure the passage of light through particles suspended in the water, but use different techniques (see Methods section). Turbidity increases, and transparency decreases, as a result of suspended solids in the water. These solids may be natural, i.e. clay, silt, and plankton, or human induced, i.e. industrial wastes and sewage. When water clarity decreases, temperatures may rise, causing oxygen levels to fall. In addition, photosynthesis decreases because less light penetrates the water. A combination of these things makes it very difficult for some species to survive (Mitchell and Stapp, 2000). Our transparency and turbidity measurements show that Bar Harbor has exceedingly clear water, often with a transparency above three meters, at times as high as six or eight meters. Turbidity measurements also indicated clear water: numbers were usually below 1.0 NTU. When transparency is high, turbidity tends to be low (Figure 4).

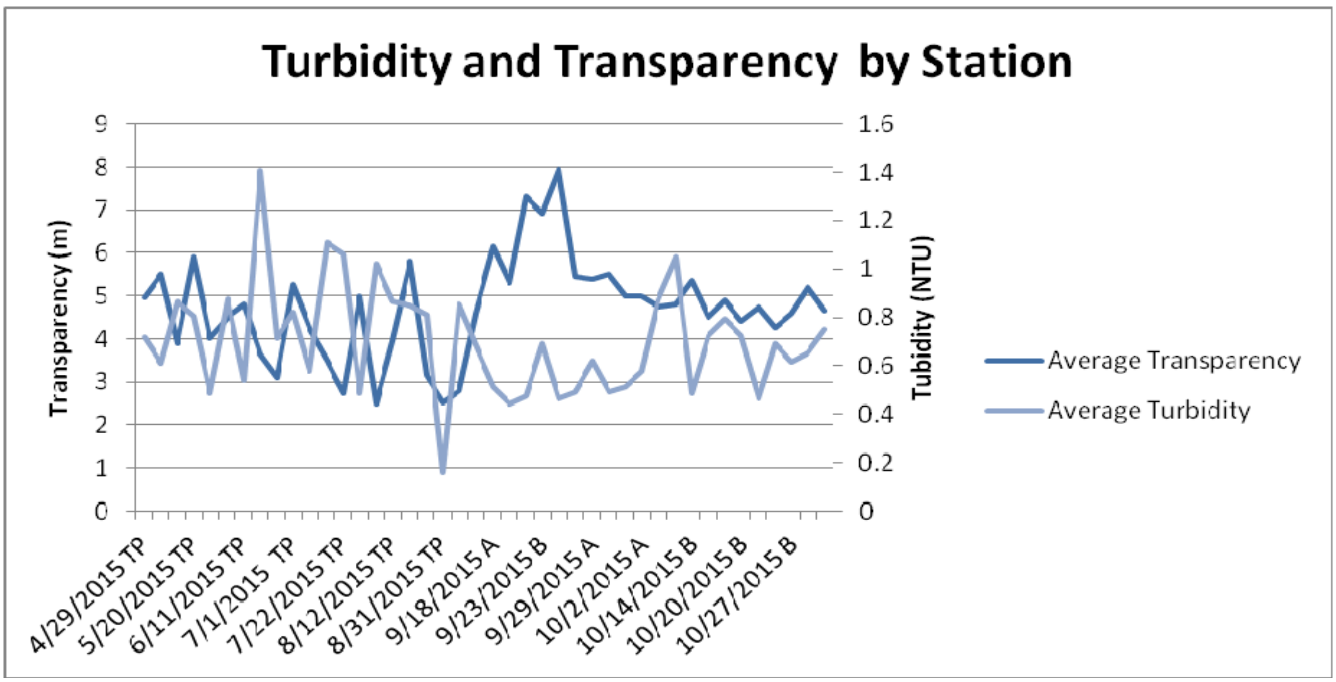

Figure 4. Transparency and turbidity are inversely related at all stations through the 2015 cruise season.

Phytoplankton:

Phytoplankton populations were also tracked during the cruise season (Appendix 3). The array of phytoplankton species observed in samples taken in the vicinity of visiting cruise ships mirrored those seen at Department of Marine Resources (DMR) phytoplankton monitoring locations in Frenchman Bay. *Chaetoceros* was most frequently the dominant species in water samples, followed by *Rhizosolenia* and a mix of other species (Figure 5). *Chaetoceros, Rhizosolenia, Phaeocystis, and Scripsiella* are non-toxic phytoplankton common in the Gulf of Maine. We did not see any phytoplankton species that were atypical for Gulf of Maine; in other words, there were no apparent non-native (foreign) phytoplankton species that would be indicative of a ballast water exchange.

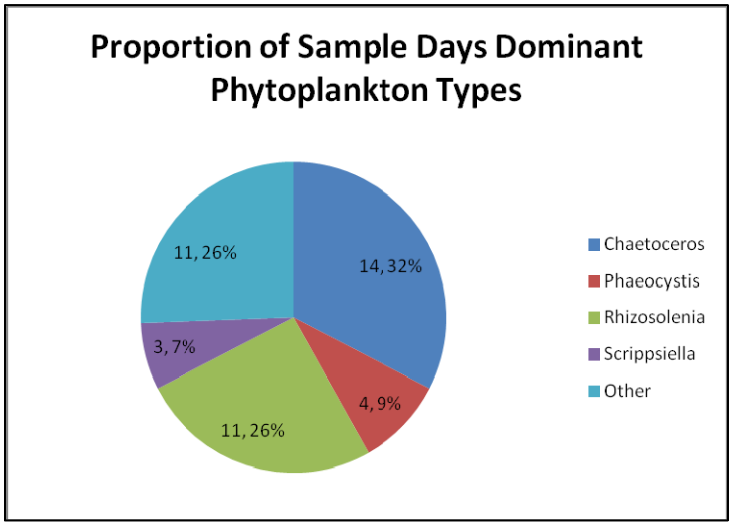

Figure 5. Phytoplankton types in vicinity of visiting cruise ships in Bar Harbor, 2015.

Conclusions

Bar Harbor has excellent water quality. Based on sample results, visiting cruise ships and other vessels are adhering to harbor policy and holding all waste. There are also pollution sources on land which threaten the quality of water in Bar Harbor, particularly after heavy rain. Sources of bacteria on land include malfunctioning septic systems, broken sewer lines, pet waste, and waste from farm animals, as well as wildlife. Runoff from the land can confound the results of harbor monitoring. Nonetheless, water quality monitoring in the harbor provides a baseline for future reference, reveals trends, provides incentive for visiting ships to comply with harbor policy, and allays the concerns of citizens with regard to water quality in the harbor.

Recommendations

1. We recommend that Bar Harbor continue to invest in a healthy future for the harbor by supporting water quality monitoring. In our opinion, the focus of a monitoring program does not need to be on cruise ships in particular. A broader-based monitoring program will help to address behaviors by operators of all types of vessels, may help pinpoint land-based pollution sources, and provide on-going baseline data so that we understand changes that may occur over time. We also recommend that the monitoring program be focused on the most informative water quality variables, including bacteria, DIN, and associated environmental variables such as water temperature, DO, BOD, transparency, turbidity, salinity, and rainfall. We propose that establishing sampling sites along the shoreline in Bar Harbor, with a focus near the bar, the town pier, and one offshore site, on a routine basis, may suffice to follow emerging trends in our coastal waters.

2. We recommend that the Harbor Committee review harbor policies, and discuss ways to ensure that all boat owners who visit Bar Harbor understand and acknowledge their understanding of harbor policies. The current standard operating procedure for Bar Harbor expands on existing federal and state requirements regarding discharges of black water and specifically states that "All cruise ships calling in Bar Harbor, whether in anchorage A or B or laying alongside the Town Pier floats are expected to hold all waste water including gray water while in port." We recommend that the SOP be modified to include all boats that visit Bar Harbor. We suggest that there should be repercussions for boat owners who do not comply with harbor policy. In the case of intentional discharge of bacteria-laden water into the harbor, those repercussions should be designed to ensure public health.

3. There are numerous resources available to help Bar Harbor with boater education. Adapting one of these resources to meet the needs of Bar Harbor, for example, the "Pump it Don't Dump It" flyer developed by the Maine Healthy Beaches program for West Penobscot Bay (http://mainehealthybeaches.org/documents/UseYourHead.pdf), may be one avenue to addressing boater behavior and helping to ensure good water quality in the future.

Acknowledgements

This project was made possible with cruise passenger fees and the support of the Maine Healthy Beaches Program, which provided field monitoring equipment and supplies (valued at $1280) for bacteria analysis, at no cost to the town of Bar Harbor. We appreciate the input of the Maine Healthy Beaches coordinator, Keri Kaczor, on project design and report editing. Maine Conservation Corps helped us with selection and training of AmeriCorps environmental steward, Anna Farrell, who was integral to the success of this monitoring project. Bar Harbor Harbormaster, Charlie Phippen, provided transportation to offshore vessels and was helpful with creation of a reasonable monitoring schedule. We appreciate the assistance of a myriad of citizen volunteers, who helped us with sampling, lab tests, and data management.

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Appendix 1

Date	Berth	Cruise Ship Name	Enterococcus /100ml	Assoc. Chlorine	NO3+NO2 (uM)	NH4 (uM)	DIN (uM)	PO4 (uM)
4/29/2015	BH Town Pier	Baseline	5	0.03	0.31	8.51	8.82	0.29
5/4/2015	BH Town Pier	Baseline	5	0.03	0.83	3.95	4.78	0.29
5/13/2015	BH Town Pier	Baseline	5	0.03	0.46	11.46	11.92	0.39
5/20/2015	BH Town Pier	Baseline	5	0.03	0.84	20	20.84	0.72
5/27/2015	BH Town Pier	Baseline	5	0.01	1.28	15.36	16.64	0.47
6/4/2015	BH Town Pier	Baseline	5	0.03	1.37	4.18	5.55	0.47
6/11/2015	BH Town Pier	Baseline	10	0.04	1.33	3.6	4.93	0.35
6/17/2015	BH Town Pier	Baseline	10	0.02	0.5	3.4	3.9	0.3
6/24/2015	BH Town Pier	Baseline	10	0.03	0.29	3.03	3.32	0.08
7/1/2015	BH Town Pier	Baseline	5	0	0.71	8.95	9.66	0.58
7/8/2015	BH Town Pier	Baseline	5	-0.02	1.12	4.8	5.92	0.43
7/15/2015	BH Town Pier	Baseline	10	-0.02	0.78	4.98	5.76	0.55
7/22/2015	BH Town Pier	Baseline	5	-0.02	0.28	8.58	8.86	0.29
7/27/2015	BH Town Pier	American Glory	10	-0.02	1.45	1.64	3.09	0.3
8/5/2015	BH Town Pier	Baseline	5	-0.02	0.3	0.95	1.25	0.4
8/12/2015	BH Town Pier	Baseline	31	-0.01	0.46	0.94	1.4	0.53
8/17/2015	BH Town Pier	Grand Caribe	41	-0.05	0.3	1.42	1.72	0.39
8/24/2015	BH Town Pier	Baseline	5	0	N/A	N/A	N/A	N/A
8/31/2015	BH Town Pier	Baseline	5	-0.03	N/A	N/A	N/A	N/A
9/14/2015	BH Town Pier	Baseline	5	0.01	N/A	N/A	N/A	N/A
9/18/2015	Bell Buoy #7	Control Site	5	0.02	0.11	0.12	0.23	0.52
9/18/2015	Alpha	Veendam	5	-0.02	0.09	1.55	1.64	0.29
9/18/2015	Bravo	Serenade of the Seas	5	-0.02	0.09	0.57	0.66	0.46
9/23/2015	Bell Buoy #7	Control Site	5	-1.33	0.31	0.67	0.98	0.56
9/23/2015	Bravo	Regatta	5	-1.76	0.3	3.54	3.84	0.54
9/23/2015	Alpha	Norwegian Gem	5	-1.38	0.55	0.39	0.94	0.53
9/29/2015	Bell Buoy #7	Control Site	5	0	2.9	2.33	5.23	0.66
9/29/2015	Alpha	Brilliance of the Seas	5	0	3.73	1.93	5.66	0.74
9/29/2015	Bravo	Queen Mary II	5	-0.01	1.47	1.07	2.54	0.61

Appendix 1

10/2/2015	Bravo	Seabourn Quest	5	0	0.79	0.03	0.82	0.56
10/2/2015	Bell Buoy #7	Control Site	5	-0.02	2.1	1.39	3.49	0.63
10/2/2015	Alpha	Veendam	5	0.01	1.84	0.44	2.28	0.64
10/13/2015	Alpha	Regatta	5	-0.01	2.53	1.84	4.37	0.63
10/13/2015	Bravo	Albatros	5	0.01	1.54	0.92	2.46	0.58
10/13/2015	Bell Buoy #7	Control Site	5	-0.01	1.84	0.82	2.66	0.63
10/14/2015	Bravo	7 Seas Navigator	5	-0.01	0.06	0.47	0.53	0.43
10/14/2015	Bell Buoy #7	Control Site	5	0	2.07	0.6	2.67	0.57
10/14/2015	Alpha	Regal Princess	5	0	3.02	0.17	3.19	0.55
10/20/2015	Bravo	Pearl Mist	5	-0.01	2.78	0.08	2.86	0.63
10/20/2015	Bell Buoy #7	Control Site	5	-0.02	3.78	0.25	4.03	0.69
10/20/2015	Alpha	Brilliance of the Seas	5	0.01	3.7	0.86	4.56	0.72
10/27/2015	Bravo	Crystal Symphony	5	0	4.66	0.74	5.4	0.79
10/27/2015	Bell Buoy #7	Control Site	5	-0.03	4.73	0.81	5.54	0.89
10/27/2015	Alpha	AIDAdiva	5	-0.02	5.07	1.43	6.5	0.75

Appendix 2

Date	Berth	Cruise Ship Name	H2O Temp (°C)	Transparency Avg. (m)	Avg. DO (ppm)	Salinity (ppt)	Avg. BOD (ppm)	NTU Avg.
4/29/2015	BH Town Pier	Baseline	5.2	4.95	9.9	31	N/A	0.72
5/4/2015	BH Town Pier	Baseline	8.5	5.5	10	32	N/A	0.61
5/13/2015	BH Town Pier	Baseline	8	3.9	9.8	32	N/A	0.87
5/20/2015	BH Town Pier	Baseline	7	5.9	9.3	33	1.7	0.80
5/27/2015	BH Town Pier	Baseline	9	4	8.5	31	0.2	0.48
6/4/2015	BH Town Pier	Baseline	9.5	4.5	8.9	31	2.15	0.88
6/11/2015	BH Town Pier	Baseline	10	4.8	9.5	31	1.2	0.54
6/17/2015	BH Town Pier	Baseline	12.5	3.65	9.8	32	1.9	1.41
6/24/2015	BH Town Pier	Baseline	11	3.1	8.9	31	0.4	0.71
7/1/2015	BH Town Pier	Baseline	13	5.25	8.95	32	2.5	0.82
7/8/2015	BH Town Pier	Baseline	12	4.25	8.6	32	0.6	0.58
7/15/2015	BH Town Pier	Baseline	12	3.5	8.5	32	1.1	1.11
7/22/2015	BH Town Pier	Baseline	13	2.72	8.8	31	0.7	1.06
7/27/2015	BH Town Pier	American Glory	13	5	8.6	32	1.1	0.48
8/5/2015	BH Town Pier	Baseline	14	2.5	8.6	32	1.75	1.02
8/12/2015	BH Town Pier	Baseline	13	3.95	8.5	32	1.7	0.87
8/17/2015	BH Town Pier	Grand Caribe	15	5.8	8.8	31	0.5	0.85
8/24/2015	BH Town Pier	Baseline	17	3.17	8.6	32	1.9	0.81
8/31/2015	BH Town Pier	Baseline	15	2.51	8.2	30	1.6	0.16
9/14/2015	BH Town Pier	Baseline	15	2.8	9.1	32	2	0.86
9/18/2015	Bell Buoy #7	Control Site	15.6	4.6	9.6	32	1	0.69
9/18/2015	Alpha	Veendam	15.4	6.15	9.5	32	0.9	0.51
9/18/2015	Bravo	Serenade of the Seas	15.9	5.3	10	32	1.1	0.44
9/23/2015	Bell Buoy #7	Control Site	14.1	7.3	9.55	32	1.1	0.48
9/23/2015	Bravo	Regatta	14.5	6.9	9.4	32	1	0.69
9/23/2015	Alpha	Norwegian Gem	14.3	7.95	9.3	32	1.1	0.46
9/29/2015	Bell Buoy #7	Control Site	12.8	5.45	9.3	32	2.3	0.49

Appendix 2

9/29/2015	Alpha	Brilliance of the Seas	12.5	5.4	8.7	32	2.25	0.62
9/29/2015	Bravo	Queen Mary II	13.3	5.5	9.3	33	2.3	0.49
10/2/2015	Bravo	Seabourn Quest	13.3	5	8.8	31	2	0.51
10/2/2015	Bell Buoy #7	Control Site	13.1	N/A	7.9	32	0.3	0.56
10/2/2015	Alpha	Veendam	13	5	8.7	33	2.1	0.58
10/13/2015	Alpha	Regatta	12.3	4.75	8.1	32	0.5	0.87
10/13/2015	Bravo	Albatros	12.2	4.8	8.2	33	1	1.05
10/13/2015	Bell Buoy #7	Control Site	12.4	N/A	8	32	0.6	1.05
10/14/2015	Bravo	7 Seas Navigator	12.4	5.35	8.8	33	0.6	0.49
10/14/2015	Bell Buoy #7	Control Site	12.2	4.5	8	33	0.2	0.72
10/14/2015	Alpha	Regal Princess	12.4	4.9	8.4	33	1	0.79
10/20/2015	Bravo	Pearl Mist	11.4	4.4	8.1	34	1	0.72
10/20/2015	Bell Buoy #7	Control Site	11.5	4.75	7.6	34	0.5	0.47
10/20/2015	Alpha	Brilliance of the Seas	11.5	4.25	7.7	34	0.3	0.69
10/27/2015	Bravo	Crystal Symphony	10.8	4.6	7.9	34	0.4	0.61
10/27/2015	Bell Buoy #7	Control Site	10.9	5.2	8.1	33	0.8	0.65
10/27/2015	Alpha	AIDAdiva	11	4.65	8.1	33	0.5	0.75

Appendix 3

Date	Berth	Cruise Ship Name	Phytoplankton Dominant 1	Phytoplankton Dominant 2
4/29/2015	BH Town Pier	Baseline	Phaeocystis	Chaetoceros
5/4/2015	BH Town Pier	Baseline	Chaetoceros socialis	Chaetoceros
5/13/2015	BH Town Pier	Baseline	Phaeocystis	scripsiella
5/20/2015	BH Town Pier	Baseline	Scripsiella	Cylindrotheca
5/27/2015	BH Town Pier	Baseline	Leicomophora	Cylindrotheca
6/4/2015	BH Town Pier	Baseline	Scrippsiella	Pseudo-nitzschia
6/11/2015	BH Town Pier	Baseline	Scripsiella	Thalassiosira
6/17/2015	BH Town Pier	Baseline	Cylindrotheca	Thalassiosira
6/24/2015	BH Town Pier	Baseline	Thalassiosira	Pleurosigma
7/1/2015	BH Town Pier	Baseline	Thalassiosira	Skeletonema
7/8/2015	BH Town Pier	Baseline	Rhizosolenia	Dinophysis norvegica
7/15/2015	BH Town Pier	Baseline	Rhizosolenia	Chaetoceros
7/22/2015	BH Town Pier	Baseline	Rhizosolenia	Chaetoceros
7/27/2015	BH Town Pier	American Glory	Cylindrotheca	Scripsiella
8/5/2015	BH Town Pier	Baseline	Pseudonitzschia	Stephanopysis
8/12/2015	BH Town Pier	Baseline	Gonyaulax	Pseudonitzschia
8/17/2015	BH Town Pier	Grand Caribe	Stephanopysis	Scripsiella
8/24/2015	BH Town Pier	Baseline	Ditylum	Dinophysis norvegica
8/31/2015	BH Town Pier	Baseline	Rhizosolenia	Ditylum
9/14/2015	BH Town Pier	Baseline	Chaetoceros	Rhizosolenia
9/18/2015	Bell Buoy #7	Control Site	Chaetoceros	Rhizosolenia
9/18/2015	Alpha	Veendam	Chaetoceros	Rhizosolenia
9/18/2015	Bravo	Serenade of the Seas	Chaetoceros	Rhizosolenia
9/23/2015	Bell Buoy #7	Control Site	Rhizosolenia	Ceratium lineatum
9/23/2015	Bravo	Regatta	Rhizosolenia	Ceratium lineatum
9/23/2015	Alpha	Norwegian Gem	Rhizosolenia	Thalassiosira
9/29/2015	Bell Buoy #7	Control Site	Rhizosolenia	Chaetoceros
9/29/2015	Alpha	Brilliance of the Seas	Rhizosolenia	Guinardia
9/29/2015	Bravo	Queen Mary II	Rhizosolenia	Chaetoceros
10/2/2015	Bravo	Seabourn Quest	Chaetoceros socialis	Rhizosolenia
10/2/2015	Bell Buoy #7	Control Site	N/A	N/A
10/2/2015	Alpha	Veendam	Rhizosolenia	Chaetoceros socialis
10/13/2015	Alpha	Regatta	Chaetoceros	Detonula
10/13/2015	Bravo	Albatros	Chaetoceros	Detonula
10/13/2015	Bell Buoy #7	Control Site	Chaetoceros	Gyrosigma
10/14/2015	Bravo	7 Seas Navigator	Chaetoceros	Phaeocystis
10/14/2015	Bell Buoy #7	Control Site	Chaetoceros	Phaeocystis
10/14/2015	Alpha	Regal Princess	Chaetoceros	Phaeocystis
10/20/2015	Bravo	Pearl Mist	Chaetoceros	Chaetoceros socialis
10/20/2015	Bell Buoy #7	Control Site	Chaetoceros	Chaetoceros socialis
10/20/2015	Alpha	Brilliance of the Seas	Chaetoceros	Chaetoceros socialis
10/27/2015	Bravo	Crystal Symphony	Phaeocystis	Chaetoceros
10/27/2015	Bell Buoy #7	Control Site	Chaetoceros	Phaeocystis
10/27/2015	Alpha	AIDAdiva	Phaeocystis	Chaetoceros