Bar Harbor Cruise Ship Monitoring Report 2014

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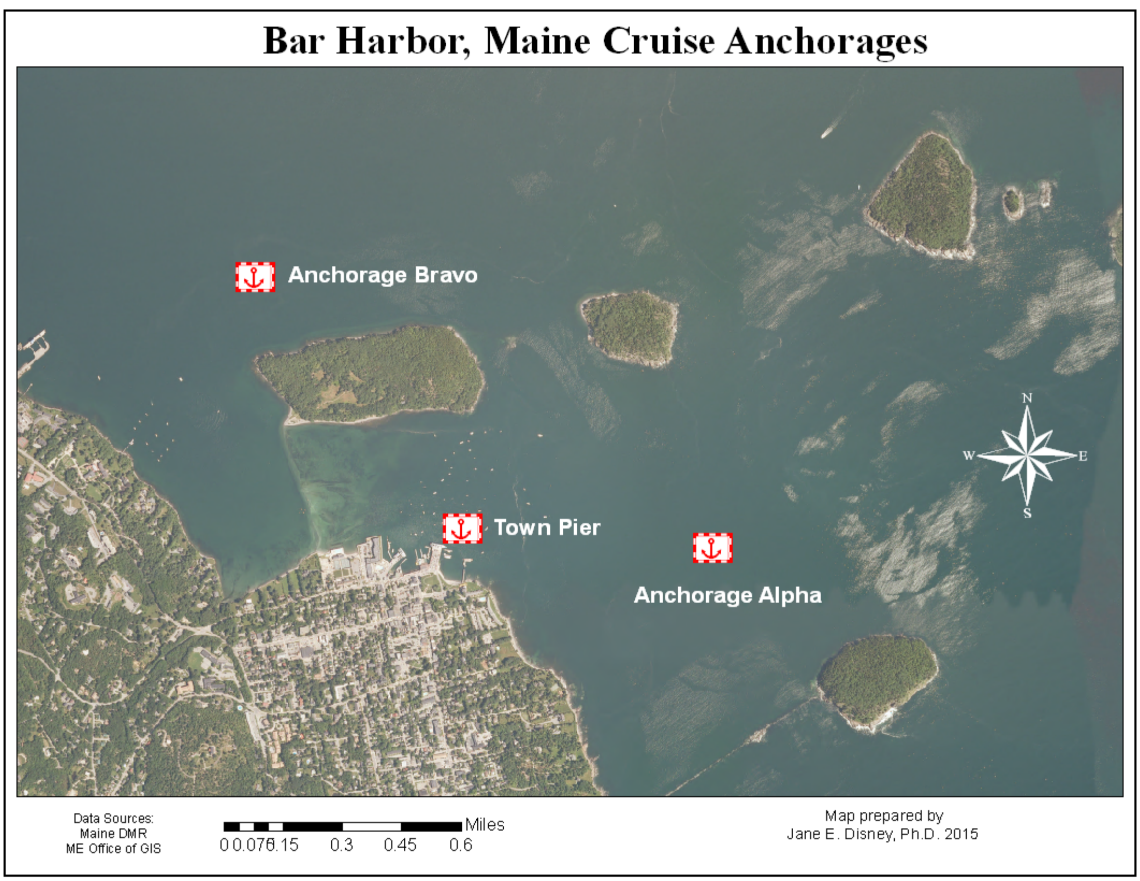
Executive Summary

Water quality in the port of Bar Harbor was monitored between May and October 2014 by staff from the Community Environmental Health Laboratory at MDI Biological Laboratory in Salisbury Cove, ME. Sample sites included the town pier and offshore cruise ship anchorages designated Alpha and Bravo (see map below). The Bar Harbor harbormaster transported monitors to the offshore anchorages. Water samples were analyzed for phytoplankton, biological oxygen demand, dissolved oxygen, metals, nutrients, nitrogen, salinity, transparency and turbidity, chlorine, and *Enterococcus* bacteria. Water was sampled in the vicinity of visiting cruise ships and at times when cruise ships were not in port. Elevated bacteria levels were found on three occasions during the monitoring season: twice 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 herring carrier *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 can be associated with high bacteria counts in the bay.



Introduction

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

Cruise ships are also a potential source of marine pollution. A typical cruise ship with 3,000 passengers can generate up to 25,000 gallons of human waste and143,000 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, USEPA, 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 infections, including 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 affect positive change that ensures that Bar Harbor remains a sustainable cruise destination?

Friends of the Earth (http://www.foe.org/cruise-report-card) have generated a cruise line report card based on a number of variables such as sewage treatment, air pollution reduction measures, and record of water quality compliance. Of the four cruise lines receiving failing grades for sewage treatment, two of them visit Bar Harbor: Crystal Cruise Lines (*Crystal Symphony*) and Silverseas (*Silver Whisper*). By opening lines of communication with these cruise lines (when and where do their ships discharge their gray water and sewage?) and monitoring for water quality when these two cruise lines have ships in port, Bar Harbor can produce its own report card, demonstrating that ships are in compliance with local standards, and allaying public concern that these ships are in some way problematic for Bar Harbor.

Dr. Jane Disney, director of the Community Environmental Health Laboratory at MDI Biological Laboratory, and project manager for the 2014 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." The 2004 cruise ship monitoring project 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 2014 cruise ship monitoring project accomplishes the same goals.

After a purported wastewater discharge incident by a small passenger vessel at the town pier in 2010, the Community Environmental Health Laboratory (CEHL) at MDI Biological Laboratory 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. We sampled on 8 different occasions and prepared a report for the Town of Bar Harbor with recommendations which included continued communications with visiting cruise ships about harbor policies which include expectations that ships hold all wastewater (Megan May and Jane Disney, 2011).

Our expertise and experience 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 2014 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), biological oxygen demand (BOD), nutrients (ortho-phosphate, dissolved inorganic nitrogen (DIN) which is nitrate + nitrite + ammonia, total organic nitrogen (TON) which is total Kjeldahl nitrogen (TKN) minus ammonia), metals (copper, nickel, and zinc) 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 the 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 and metals 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 or 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 triplicate and fixed using a LaMotte DO test kit. Water samples for BOD determination were collected in triplicate in bottles covered with aluminum foil and then kept in the dark for 5 days. Both 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 um filter into sterile vials. These were transported in a seawater ice-bath to the Community Environmental Health Laboratory, where they were stored in a -20°C freezer. The samples were shipped on dry ice to the University of Maine-Orono to be analyzed with an Autoanalyzer II by Maura Thomas in Dr. David Townsend's Laboratory. Silicic acid results were reported back to us with the other nutrient values.

Water samples for determining levels of TKN, ammonia, and metals were analyzed by Katahdin Analytical in Scarborough Maine. Samples for TKN and ammonia analysis were collected in plastic bottles provided by Katahdin Analytical. These samples were preserved in the field, kept in a cooler under 10˚C, and then stored at 4˚C at the lab. Likewise, water samples for metals analysis were collected in plastic bottles from Katahdin Analytical and stored similarly until shipping. Samples were shipped on ice within 14 days; upon arrival; TKN and ammonia were analyzed using analytical methods EPA 351.2 and EPA 350.1 and metals were analyzed using analytical method EPA 200.8.

Transparency was documented by using an oceanographic Secchi disk to determine descending and ascending transparencies; these values were then averaged. Turbidity samples were analyzed in triplicate using the 2020 *e* LaMotte turbidity meter; these values were then averaged. Samples for phytoplankton analysis were collected by filtering 10 liters of seawater through 20 micron netting. 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 on-line 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.

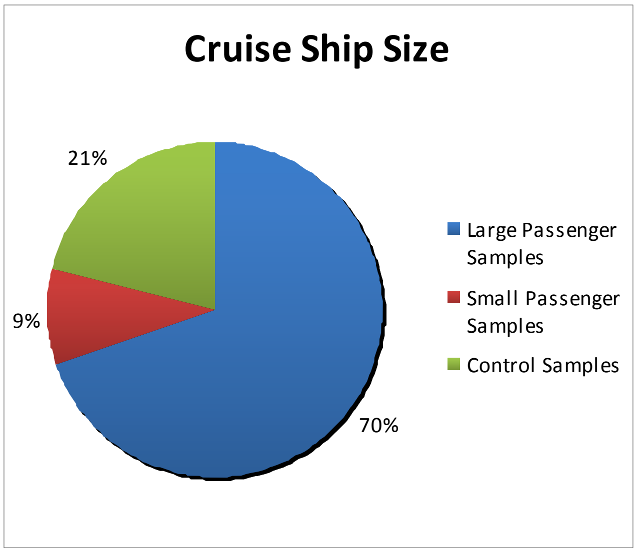


Figure 1: Size classification of the cruise ships as the percentage of total samples.

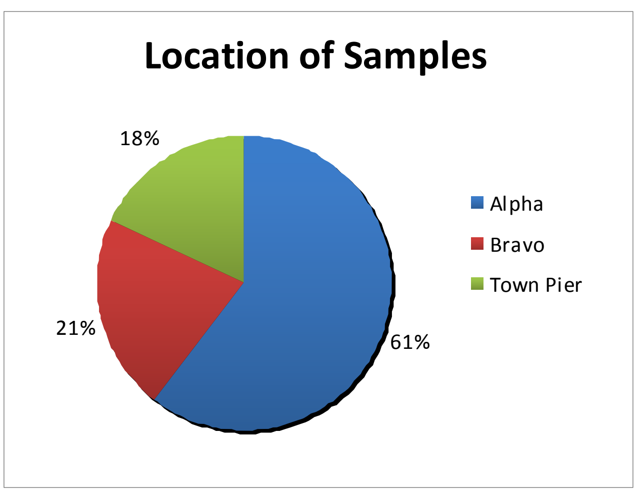


Figure 2: Location where samples were taken within the port of Bar Harbor.

Results and Discussion

Scope of Monitoring:

We obtained samples in the vicinity of 19 different ships on 26 separate occasions this year as well as 7 control samples (no ships present) for a total of 33 samples. The majority of the samples (70%) were collected in the vicinity of large passenger vessels. The remaining samples were collected in the vicinity of small passenger vessels (21%) or control samples (9%), Figure 1.

Most of the samples were obtained in Anchorage Alpha (61%). The remaining samples came from Anchorage Bravo (21%) and the Town Pier (18%), Figure 2.

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.

Samples had significant levels of *Enterococcus* on three separate occasions during the cruise season (Table 1). On two of these occasions, bacteria levels exceeded the EPA standard for recreational water contact, which is 104 MPN/100 ml.

Date	Berth	Cruise Ship	*Enterococcus* MPN/100 ml	Presence of *Reliance*
5/13/2014	Anchorage Alpha	none	10	--
7/21/2014	Town Pier	*American Glory*	3255	+
8/26/2014	Town Pier	none	471	+
10/17/2014	Anchorage Alpha	*Summit*	86	--

Table 1: Bacteria levels in cruise anchorages; in all other samples, bacteria were less than 10 MPN/100 ml. sample water (see Appendix 1).

It is likely that the elevated bacteria counts on 7/21 and 8/26 were due to a discharge from a Maine registered herring carrier from Columbia Maine, *Reliance*, which was in port on both occasions. A fisherman reported a visible discharge emanating from the *Reliance* on 7/21. The positive result (86 MPN/100 ml) from the sample taken near *Summit* could have been due to runoff during a concurrent rainstorm event. As part of a separate monitoring project in Bar Harbor, we have been collecting water samples from streams after heavy rainstorms; on the day *Summit* was in port, we tested nearby Cromwell Brook, and detected 1,265 colonies per 100 ml. of water after 2.5 inches of rainfall. There was very little rainfall in the weeks preceding this event (see Appendix 2), perhaps leading to accumulation of bacteria on land that later was washed into the sea.

Low DO levels and/or high BOD values can be indicative of organic matter in the water column, potentially from a discharge of pollution into the water column, however all DO and BOD values were within normal and expected ranges (see Figure 3 and Appendix 2). The average DO levels were 8.8 ppm on average throughout the season, with a range of 7.8-9.45. After a five-day holding period the DO levels were 7.4 ppm on average. BOD is determined by subtracting these two numbers; BOD was 1.4 ppm on average.

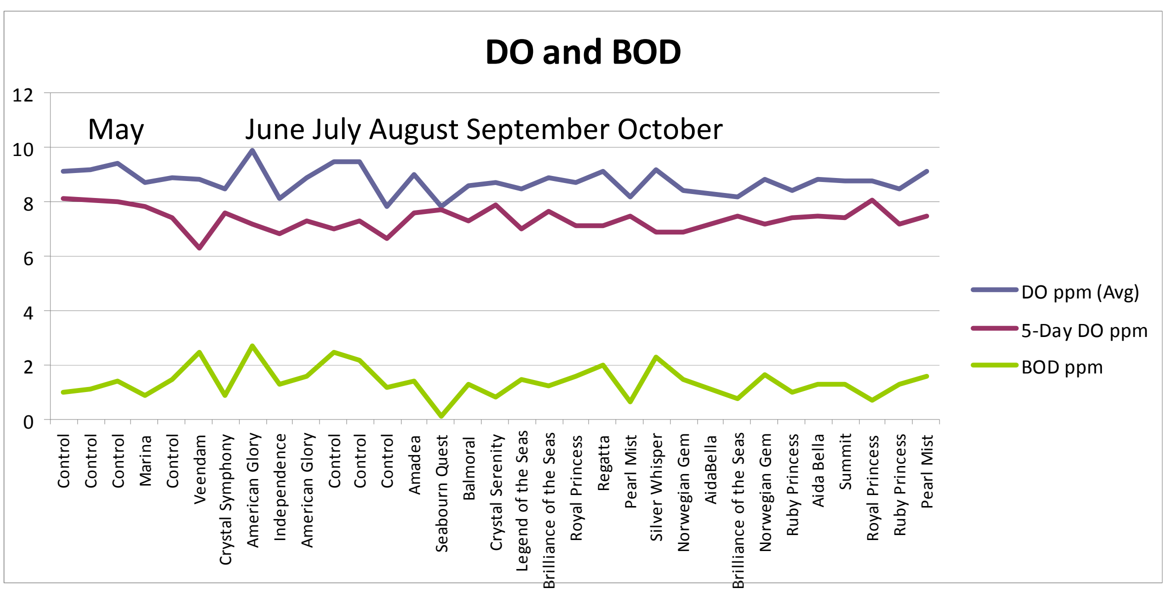


Figure 3: Dissolved oxygen (DO), DO after a five-day hold (5-Day DO), and biological oxygen demand (BOD) over the sampling time period.

Nutrients:

Elevated nutrient levels in the water column can also be indicative of pollution events. We did not detect elevated levels of nutrients until dissolved inorganic nitrogen (DIN) increased in October (Figure 4). The DIN increase was attributable to spikes in ammonia on those days (see Appendix 1). Elevated DIN was not accompanied by elevated phosphate levels, or increases in Total Organic Nitrogen (TON). Increased DIN levels did not correlate with a particular cruise line; however all of the elevated nutrient levels were at Anchorage Alpha. There were no days in October without a cruise ship at Anchorage Alpha, so we do not have controls for comparison in that month. However, these elevated nutrient levels could be characteristic of the water column at Anchorage Alpha in autumn.

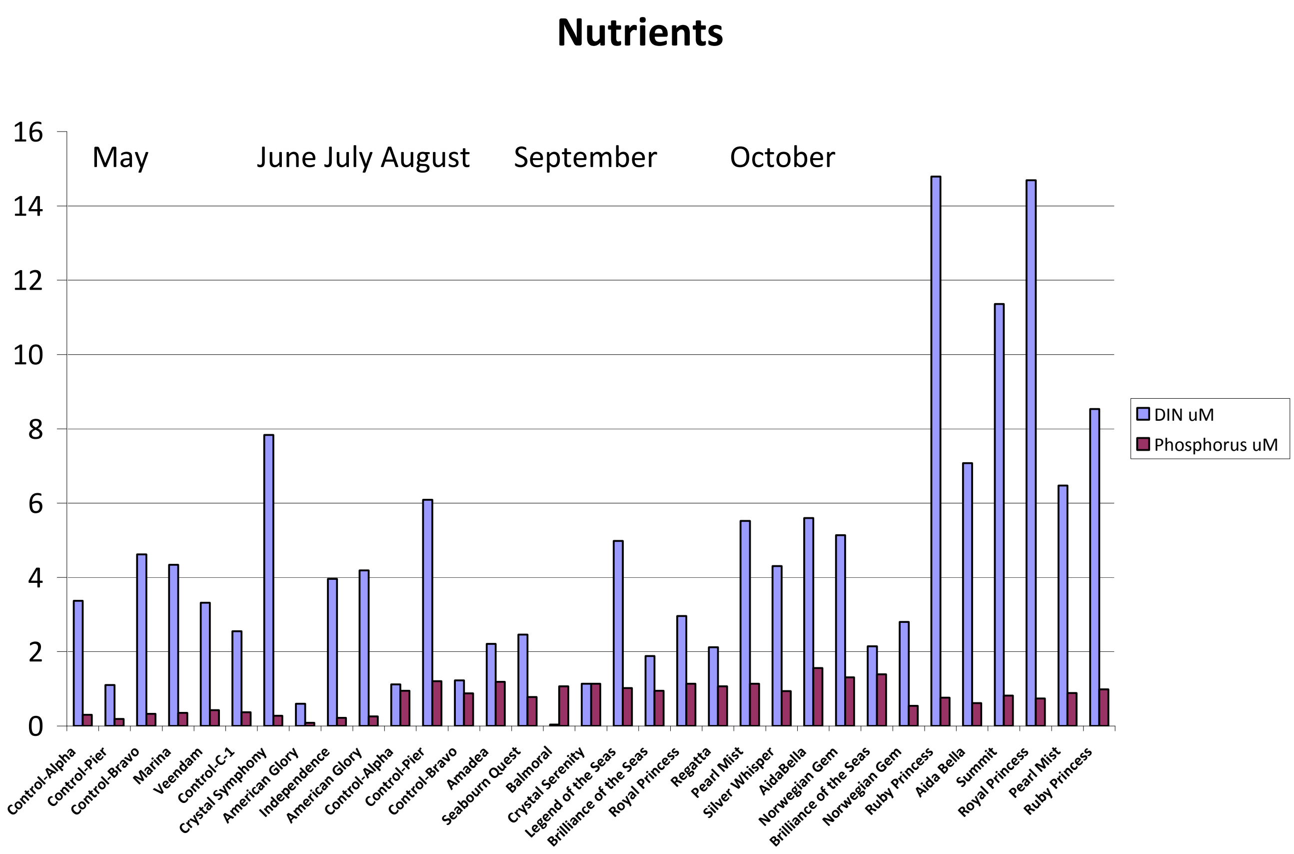


Figure 4. Dissolved Inorganic Nitrogen (DIN) and orthophosphate levels over the sampling time period.

In addition to DIN and ortho-phosphate, we collected samples to determine Total Organic Nitrogen or TON. TON is calculated from Total Kjiedahl Nitrogen or TKN, which is organic nitrogen plus ammonia. When ammonia is subtracted, the result is the level of TON in the sample. In most samples, TON was below detection limits. Where it was detectable it was just above detection limits. We also looked for traces of nickel, copper, and zinc, which might indicate a discharge of effluent from a visiting cruise passenger vessel. Again, in most cases, these metals were undetectable. Where they were detectable, levels were just at or slightly above the level of detection. Chlorine was assessed as well; total chlorine was undetectable or slightly above the level of detection (see Appendix 3).

Other Water Quality Variables:

In addition to collecting information on bacteria and nutrients, we looked at a host of associated water quality variables (see Appendix 2). Sometimes, these variables help to explain what is going on, or exclude certain possibilities. In addition to rainfall, water temperature, dissolved oxygen and biological oxygen demand, the transparency and turbidity of the water were assessed on each sampling day. Bar Harbor has exceedingly clear water, often with a transparency above 3 meters, at times as high as 6 or 8 meters. Turbidity follows suit. When transparency is high, turbidity tends to be low, see Figure 5. The turbidity of water samples in October is significantly higher than water samples from earlier in the year at Anchorage Alpha (t-test, p= .000021), perhaps providing some explanation for the higher DIN levels later in the fall. Daily visitation and anchoring may dislodge bottom sediments which disperse inorganic nitrogen into the water column.

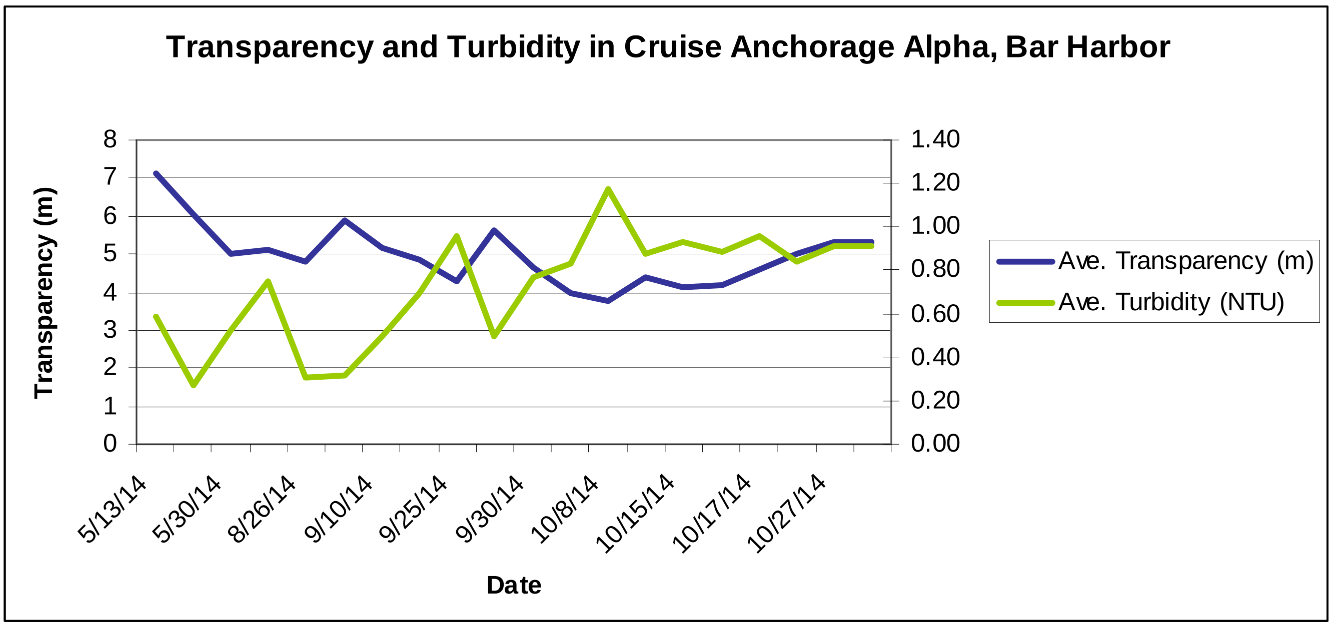


Figure 5. Transparency and turbidity are inversely related at Anchorage Alpha in Bar Harbor throughout the 2014 cruise season.

Phytoplankton:

Phytoplankton populations were also tracked during the cruise season (see Appendix 4). 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. *Pseudonitzchia* was most frequently the dominant species in water samples (Figure 6). *Pseudonitzchia* is a pennate diatom, some species of which produce a toxin that can cause Amnesiac Shellfish Poisoning or ASP. Despite the rise in these diatoms throughout the bay, there were no shellfish bed closures due to elevated toxin levels. We did not see any phytoplankton 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.

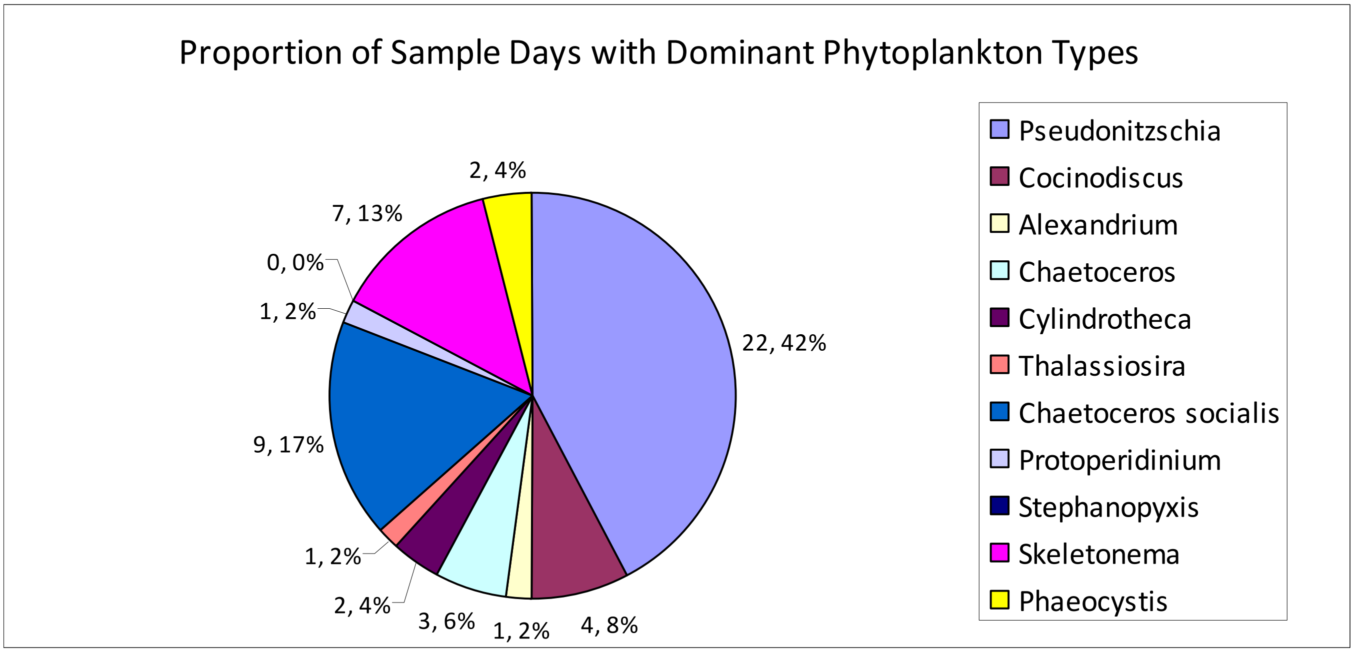


Figure 6. Phytoplankton types in vicinity of visiting cruise ships in Bar Harbor, 2014

Conclusions

Bar Harbor has excellent water quality. For the most part, visiting cruise ships and other vessels are adhering to harbor policy and holding all waste. Monitoring has revealed that there are instances when discharges occur from boats. There are also pollution sources on land which threaten the quality of water in Bar Harbor, in particular 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 to 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.

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 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 volunteers who were 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.

References

1. Conservation International. From Ship to Shore: Sustainable Stewardship in Cruise Destinations, 2006. <http://www.conservation.org/Documents/CI_ecotourism_from_ship_to_shore_eng.pdf>

2. May, Megan and Jane Disney, 2011 Impact of Cruise Ship Discharge on Ambient Water Quality Bar Harbor, ME: 1-12.

3. MDI Water Quality Coalition Cruise Ship Water Quality Report, 2005: 1-19.

4. Oceana. ©2014 Cruise Ship Pollution: Overview
<http://oceana.org/en/our-work/stop-ocean-pollution/cruise-ship-pollution/overview>

5. Oceana. ©2014 Protect Our Oceans: Stop Cruise Ship Pollution
<http://oceana.org/sites/default/files/o/uploads/cruisepollution_summarysheet.pdf>

6. Stancioff, Esperanza, Keri Lindberg, and Sarah Mosley, 2007 Maine's Healthy (coastal) Beaches Program: Community Resource Guide. University of Maine Cooperative Extension and Sea Grant. 2007.

7. Town of Bar Harbor Cruise Tourism Destination Management Plan, 2007

8. WWF. ©2015 Marine Problems:
<http://wwf.panda.org/about_our_earth/blue_planet/problems/>

Appendix 1: Bacteria and Inorganic Nutrient Data

Date	Berth	Cruise Ship Name	Enterococcus bacteria /100ml	Nitrogen ppm	Ammonia uM	DIN uM	Silicic Acid uM	Phosphorus uM
10/16/2014	Alpha	Aida Bella	5	1.39	5.69	7.08	1.14	0.62
10/8/2014	Alpha	AidaBella	5	3.2	2.4	5.6	2.43	1.56
9/6/2014	Alpha	Amadea	5	1.08	1.13	2.21	2.91	1.19
7/21/2014	Town Pier	American Glory	3255	0.11	0.49	0.6	2.83	0.09
8/18/2014	Town Pier	American Glory	5	0.31	3.88	4.19	1.64	0.26
9/18/2014	B-2	Balmoral	5	0.01	0.03	0.04	0.39	1.07
9/26/2014	Alpha	Brilliance of the Seas	5	1.11	0.77	1.88	3.68	0.95
10/10/2014	Alpha	Brilliance of the Seas	5	1.11	1.04	2.15	4.02	1.39
9/18/2014	Alpha	Crystal Serenity	5	1.02	0.12	1.14	2.95	1.14
6/5/2014	Alpha	Crystal Symphony	5	0.79	7.04	7.83	6.92	0.28
7/30/2014	Town Pier	Independence	5	0.23	3.73	3.96	2.26	0.22
9/25/2014	Alpha	Legend of the Seas	5	2.92	2.06	4.98	3.65	1.02
5/24/2014	Alpha	Marina	5	2.77	1.57	4.34	8.86	0.35
10/8/2014	B-1	Norwegian Gem	5	3.01	2.13	5.14	4.55	1.31
10/15/2014	B-2	Norwegian Gem	5	1.02	1.78	2.8	1.42	0.54
10/27/2014	Alpha	Pearl Mist	5	3.05	3.42	6.47	4.96	0.89
10/7/2014	B-2	Pearl Mist	5	2.9	2.62	5.52	2.86	1.14
10/6/2014	Alpha	Regatta	5	0.8	1.32	2.12	2.27	1.07
9/30/2014	Alpha	Royal Princess	5	2	0.96	2.96	3.42	1.14
10/21/2014	Alpha	Royal Princess	5	1.4	13.29	14.69	1.51	0.74
10/15/2014	Alpha	Ruby Princess	5	2.46	12.33	14.79	1.56	0.76
10/27/2014	Alpha	Ruby Princess	5	3.95	4.58	8.53	5.39	0.99
9/10/2014	Alpha	Seabourn Quest	5	0.54	1.92	2.46	3.09	0.78
10/7/2014	B-1	Silver Whisper	5	2.9	1.41	4.31	2.39	0.94
10/17/2014	Alpha	Summit	86	3.01	8.35	11.36	2.67	0.82
5/30/2014	Alpha	Veendam	5	2.95	0.37	3.32	9.17	0.43
5/13/2014	Alpha	Control	10	2.21	1.16	3.37	9.61	0.3
8/26/2014	Alpha	Control	5	0.23	0.89	1.12	2.34	0.95
8/26/2014	Town Pier	Control	471	0.72	5.37	6.09	3.14	1.21
5/13/2014	Town Pier	Control	5	0.41	0.69	1.1	8.2	0.19
5/13/2014	Bravo	Control	5	2.25	2.37	4.62	7.81	0.33
8/26/2014	Bravo	Control	5	0.2	1.03	1.23	1.92	0.88
5/30/2014	C-1	Control	5	2.1	0.45	2.55	9.13	0.37

Highlighted rows have elevated bacteria and/or dissolved inorganic nitrogen (DIN) levels. C-1 is a control site between Anchorage Alpha and Bravo.

Appendix 2: Environmental Data

Date	Berth	Cruise Ship Name	Water Temp °C	Ave. Transparency	Ave.DO ppm	Salinity ppt	Ave. BOD ppm	Ave. Turbidity NTU
10/16/2014	Alpha	Aida Bella	12.7	4.2	8.8	33	1.3	0.88
10/8/2014	Alpha	Aida Bella	12.6	3.75	8.3	33	1.1	1.17
9/6/2014	Alpha	Amadea	15.1	5.9	9	31	1.4	0.32
7/21/2014	Town Pier	American Glory	13.7	3.57	9.9	32	2.7	0.95
8/18/2014	Town Pier	American Glory	14.3	3.7	8.9	31	1.6	0.56
9/18/2014	B-2	Balmoral	13	5.2	8.6	31	1.3	0.57
9/26/2014	Alpha	Brilliance of the Seas	12	5.65	8.9	31	1.25	0.50
10/10/2014	Alpha	Brilliance of the Seas	12.5	4.4	8.2	32	0.75	0.87
9/18/2014	Alpha	Crystal Serenity	13	4.85	8.7	31	0.8	0.70
6/5/2014	Alpha	Crystal Symphony	9.4	5.1	8.5	31	0.9	0.75
7/30/2014	Town Pier	Independence	15	2.5	8.1	31	1.3	1.21
9/25/2014	Alpha	Legend of the Seas	12.8	4.3	8.5	33	1.5	0.96
5/24/2014	Alpha	Marina	10	6.05	8.7	34	0.9	0.27
10/8/2014	B-1	Norwegian Gem	12.3	4.3	8.4	32	1.5	1.27
10/15/2014	B-2	Norwegian Gem	12.6	4.1	8.8	32	1.65	1.19
10/27/2014	Alpha	Pearl Mist	12	5.3	9.1	33	1.6	0.91
10/7/2014	B-2	Pearl Mist	12.6	4.3	8.15	32	0.65	0.88
10/6/2014	Alpha	Regatta	13.1	4	9.1	32	2	0.83
9/30/2014	Alpha	Royal Princess	12.5	4.65	8.7	32	1.6	0.77
10/21/2014	Alpha	Royal Princess	12.2	5	8.75	32	0.7	0.84
10/15/2014	Alpha	Ruby Princess	12.7	4.15	8.4	32	1	0.93
10/27/2014	Alpha	Ruby Princess	11.8	5.3	8.5	32	1.3	0.91
9/10/2014	Alpha	Seabourn Quest	13.4	5.15	7.8	31	0.1	0.49
10/7/2014	B-1	Silver Whisper	12.5	4.3	9.2	32	2.3	1.34
10/17/2014	Alpha	Summit	12.7	4.6	8.75	33	1.3	0.96
5/30/2014	Alpha	Veendam	8.4	5	8.8	35	2.5	0.52
5/13/2014	Alpha	Control	7.1	7.1	9.1	32	1	0.59
8/26/2014	Alpha	Control	16.2	4.8	9.45	31	2.15	0.30
8/26/2014	Town Pier	Control	16.7	3.53	7.8	32	1.15	0.47
5/13/2014	Town Pier	Control	7.6	6.5	9.4	33	1.4	0.82
5/13/2014	Bravo	Control	6.9	8.1	9.15	32	1.1	0.65
8/26/2014	Bravo	Control	16.9	5	9.45	32	2.45	0.18
5/30/2014	C-1	Control	8.8	4.8	8.9	35	1.5	0.47

Appendix 3: Potential Effluent Compounds

Date	Berth	Cruise Ship Name	Total Organic Nitrogen (TON)	Metals: Nickel	Metals Copper	Metals Zinc	Total Chlorine
10/16/2014	Alpha	Aida Bella	< 1.2	0.011	< 0.015	< 0.050	0.03
10/8/2014	Alpha	Aida Bella	< 1.2	< 0.010	< 0.015	< 0.050	0.02
9/6/2014	Alpha	Amadea	< 0.25	< 0.010	< 0.015	< 0.050	0.03
7/21/2014	Town Pier	American Glory	0.29	0.007	0.003	0.012	0.03
8/18/2014	Town Pier	American Glory	< 1.2	< 0.010	< 0.015	< 0.050	0.02
9/18/2014	B-2	Balmoral	< 1.2	0.020	< 0.015	< 0.050	0.01
9/26/2014	Alpha	Brilliance of the Seas	< 1.2	0.019	< 0.015	< 0.050	0.05
10/10/2014	Alpha	Brilliance of the Seas	< 1.2	< 0.010	< 0.015	< 0.050	0.04
9/18/2014	Alpha	Crystal Serenity	< 1.2	0.020	< 0.015	< 0.050	0.04
6/5/2014	Alpha	Crystal Symphony	< 0.25	0.005	< 0.003	< 0.010	0
7/30/2014	Town Pier	Independence	< 0.25	0.006	0.007	0.033	0
9/25/2014	Alpha	Legend of the Seas	< 1.2	0.018	< 0.015	< 0.050	0.01
5/24/2014	Alpha	Marina	< 1.2	0.005	< 0.003	0.012	0
10/8/2014	B-1	Norwegian Gem	< 1.2	< 0.010	< 0.015	< 0.050	0.03
10/15/2014	B-2	Norwegian Gem	< 1.2	< 0.010	< 0.015	< 0.050	0.05
10/27/2014	Alpha	Pearl Mist	< 1.2	0.012	< 0.015	< 0.050	0.01
10/7/2014	B-2	Pearl Mist	< 1.2	< 0.010	< 0.015	< 0.050	0.01
10/6/2014	Alpha	Regatta	< 1.2	< 0.010	< 0.015	< 0.050	0
9/30/2014	Alpha	Royal Princess	< 1.2	0.020	< 0.015	< 0.050	0.02
10/21/2014	Alpha	Royal Princess	< 1.2	0.010	< 0.015	< 0.050	0.03
10/15/2014	Alpha	Ruby Princess	< 1.2	< 0.010	< 0.015	< 0.050	0.04
10/27/2014	Alpha	Ruby Princess	< 1.2	0.011	< 0.015	< 0.050	0.04
9/10/2014	Alpha	Seabourn Quest	0.31	< 0.010	< 0.015	< 0.050	0.03
10/7/2014	B-1	Silver Whisper	< 1.2	< 0.010	< 0.015	< 0.050	0.04
10/17/2014	Alpha	Summit	< 1.2	0.011	< 0.015	< 0.050	0.03
5/30/2014	Alpha	Veendam	< 1.2	0.005	0.003	0.012	0
5/13/2014	Alpha	Control	< 1.4	0.004	< 0.003	0.010	0.02
8/26/2014	Alpha	Control	1.8	< 0.010	< 0.015	< 0.050	0.02
5/13/2014	Bravo	Control	< 0.56	0.004	< 0.003	0.010	0.04
8/26/2014	Bravo	Control	< 1.2	< 0.010	< 0.150	< 0.050	0.02
8/26/2014	Town Pier	Control	< 1.2	< 0.010	< 0.015	< 0.050	0.07
5/13/2014	Town Pier	Control	< 0.57	0.004	< 0.003	0.010	0.03
5/30/2014	C-1	Control	< 1.2	0.005	< 0.003	0.012	0.11

Total Organic Nitrogen (TON), Metals (Nickel, Copper and Zinc) are, for the most part, undetectable in marine water samples collected in the vicinity of visiting cruise ships. Total chlorine levels are very low across all sites and dates. C-1 is a control site between the Alpha and Bravo Anchorages.

Appendix 4: Dominant Phytoplankton Types

Date	Berth	Cruise Ship Name	Phytoplankton Dominant 2	Phytoplankton Dominant 1
5/13/2014	Alpha	Control	Alexandrium	Phaeocystis
5/13/2014	Bravo	Control	Alexandrium	Phaeocystis
5/13/2014	Town Pier	Control	Alexandrium	Pseudonitzschia
5/24/2014	Alpha	Marina	Cylindrotheca	Pseudonitzschia
5/30/2014	C-1	Control	Cylindrotheca	Pseudonitzschia
5/30/2014	Alpha	Veendam	Cylindrotheca	Pseudonitzschia
6/5/2014	Alpha	Crystal Symphony	Thalassiosira	Pseudonitzschia
7/21/2014	Town Pier	American Glory	Skeletonema	Stepanophysis
7/30/2014	Town Pier	Independence	Stephanopyxis	Skeletonema
8/18/2014	Town Pier	American Glory	Pseudonitzschia	Skeletonema
8/26/2014	Alpha	Control	Pseudonitzschia	Skeletonema
8/26/2014	Bravo	Control	Pseudonitzschia	Skeletonema
8/26/2014	Town Pier	Control	Pseudonitzschia	Skeletonema
9/6/2014	Alpha	Amadea	Pseudonitzschia	Skeletonema
9/10/2014	Alpha	Seabourn Quest	Pseudonitzschia	Skeletonema
9/18/2014	B-2	Balmoral	Chaetoceros	Pseudonitzschia
9/18/2014	Alpha	Crystal Serenity	Pseudonitzschia	Chaetoceros
9/25/2014	Alpha	Legend of the Seas	Pseudonitzschia	Chaetoceros
9/26/2014	Alpha	Brilliance of the Seas	Chaetoceros	Pseudonitzschia
9/30/2014	Alpha	Royal Princess	Pseudonitzschia	Chaetoceros socialis
10/6/2014	Alpha	Regatta	Pseudonitzschia	Chaetoceros socialis
10/7/2014	B-2	Pearl Mist	Pseudonitzschia	Chaetoceros socialis
10/7/2014	B-1	Silver Whisper	Pseudonitzschia	Chaetoceros socialis
10/8/2014	Alpha	Aida Bella	Pseudonitzschia	Chaetoceros socialis
10/8/2014	B-1	Norwegian Gem	Chaetoceros socialis	Pseudonitzschia
10/10/2014	Alpha	Brilliance of the Seas	Pseudonitzschia	Chaetoceros socialis
10/15/2014	B-2	Norwegian Gem	Pseudonitzschia	Chaetoceros socialis
10/15/2014	Alpha	Ruby Princess	Cocinodiscus	Pseudonitzschia
10/16/2014	Alpha	Aida Bella	Pseudonitzschia	Chaetoceros socialis
10/17/2014	Alpha	Summit	Cocinodiscus	Chaetoceros
10/21/2014	Alpha	Royal Princess	Protoperidinium	Pseudonitzschia
10/27/2014	Alpha	Pearl Mist	Cocinodiscus	Pseudonitzschia
10/27/2014	Alpha	Ruby Princess	Pseudonitzschia	Cocinodiscus