Georgetown Water Sampling Project

2013

Final Report

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<u>Georgetown's Coastal Waters</u>

The town of Georgetown lies at the interesting intersection of the Kennebec River, Sheepscot River and the Gulf of Maine. Situated at the tail end of the Kennebec Estuary, Georgetown's shores receive river water that has been impacted by dozens of communities, hundreds of industries, and thousands of landowners. As a coastal community, Georgetown depends upon clean water to support the clamming and fishing industries that provide the livelihoods of many of Georgetown's citizens and form the backbone of Georgetown's history, culture, and economy.

Georgetown Water Sampling Project 2013

Who:

9 committed volunteers set out to find out about Georgetown's water quality.
The project was planned and coordinated by Ruth Indrick from the Kennebec Estuary Land Trust (KELT). Funding was provided by a grant from the Maine Coastal Program that is supported by NOAA. Georgetown project support and guidance was provided by the Georgetown Shellfish Committee, the Georgetown Conservation Commission and John Hentz, Georgetown's Shellfish Warden. Outside project support and guidance was provided by Michele LaVigne from Bowdoin College, Angela Brewer from the Maine DEP, Friends of Casco Bay and Georges River Tidewater Association.

The Volunteer Samplers:

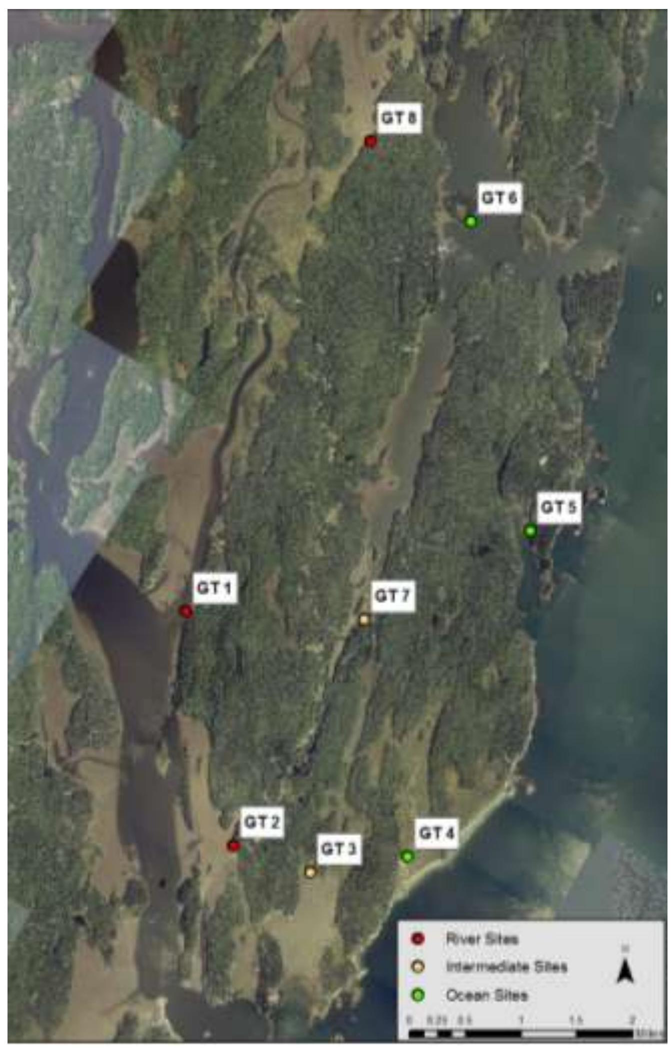
- Georgetown Residents: 6 volunteers
- From Away… Sort of… (Bath and Belfast): 3 volunteers and 1 project coordinator
- Two Student Interns: Bowdoin College and Kenyon College

Where:

8 Sites were set up around Georgetown.
We decided to locate the sites where there are already DMR Water Quality sampling sites.

- 8 were manageable with a limited number of volunteers.
- The sites are dispersed around the island.
- All are at or near shellfish flats of interest to the Georgetown Shellfish Committee.
- By using existing sites, there is a history of information about temperature, salinity, and bacteria levels for each site.

The Sites:	
GT 1	Marrtown Landing
GT 2	Todds Bay
GT 3	Sagadahoc Bay
GT 4	Little River
GT 5	Harmon's Harbor
GT 6	The Knubble
GT 7	Robinhood Cove
GT 8	Hall Bay



When:

10 Sampling dates took place from the summer through the fall in 2013.

- Water samples were collected biweekly from June 26 to October 31, 2013, on Thursdays.
- Samples were collected within 1.5 hours of noon.

How:

80 samples were collected between June and October.
Volunteers went to their site and collected water in a 5 gallon bucket. They then processed and tested the water from the bucket while they were at their site. Some information was collected in the field, and some water was bottled to be further analyzed by the volunteers or the project coordinator at the Town Hall or the KELT office.

Information Tested and Recorded for Each Sample:

- Air Temperature
- Weather Conditions
- Wind Speed and Direction
- Water Temperature
- Salinity
- Dissolved Oxygen (DO)
- pH
- Nitrogen: Nitrate, Nitrite and Ammonia

Characteristics Not Compared:

- Different tide cycles
- Different times of day
- Offshore vs. nearshore
- Surface vs. depth
- Any spring or winter information

The way we sampled either skipped sampling this information or kept these variables constant so it was easier to compare the characteristics that were tested.

Why are all the samples collected at about the same time of day?	Why are samples collected in a Bucket?
<u>Photosynthesis:</u> Some water characteristics change depending upon the time of day because they are impacted by whether or not plants, algae and phytoplankton are doing photosynthesis. By sampling at about the same time, this controls that variable and makes it easier to compare the results between sampling dates and sites. <u>Tides:</u> Tide can also impact water quality characteristics. Several of the sites do not have enough water to collect a sample at low tide. This summer, high tides fell within one or two hours of noon on every sample day.	<u>Safety:</u> Some sites are slippery and difficult to access. The bucket allows a sampler to stand on the shore or in shallow water and still collect water from an area that is deeper. <u>Sample Quality:</u> There can be significant differences between traits of the surface water layer and bottom water layer, even when it's only a few feet deep. The bucket allows the surface and the deeper water to be mixed, so the sampling results describe the water column as a whole.

Equipment Used:

Salinity	Temperature	Dissolved Oxygen (DO)	Nitrogen	pH
Lamotte Hydrometer	Thermometer in °C	Lamotte Winkler Titration Kit	Hach DR850 Colorimeter	Hanna HI98128 pH and Temperature Meter
				

Characteristics Tested and Recorded Each Sample Date **X = recorded**

Date	Air Temp.	Weather	Wind	Salinity	Water Temp.	DO	pH	Nitrate	Nitrite	Ammonia
6/27	X	X	X	X	X	X	0	0	0	0
7/11	X	X	X	X	X	X	0	0	0	0
7/25	X	X	X	X	X	X	0	0	0	X
8/8	X	X	X	X	X	X	X	X	X	X
8/22	X	X	X	X	X	X	X	X	X	X
9/5	X	X	X	X	X	X	X	X	X	X
9/19	X	X	X	X	X	X	X	X	X	X
10/3	X	X	X	X	X	X	X	X	X	X
10/17	X	X	X	X	X	X	X	X	X	X
10/31	X	X	X	X	X	X	X	X	X	X

2013 Results

Salinity

Why

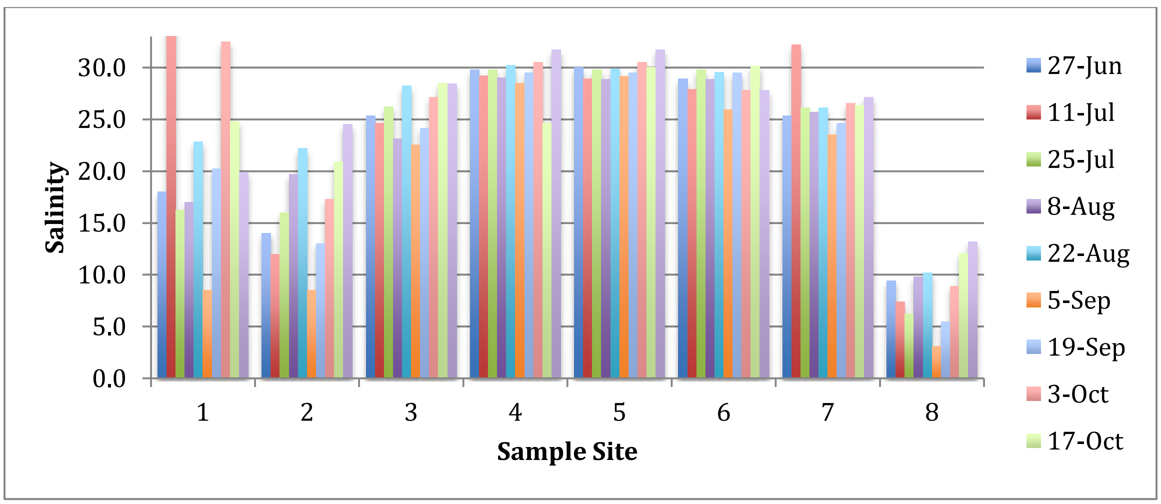
Low water salinity can be stressful for aquatic life that is adapted to higher salinity conditions. Salinity data also gives information about whether the water at a site is from onshore or offshore sources.

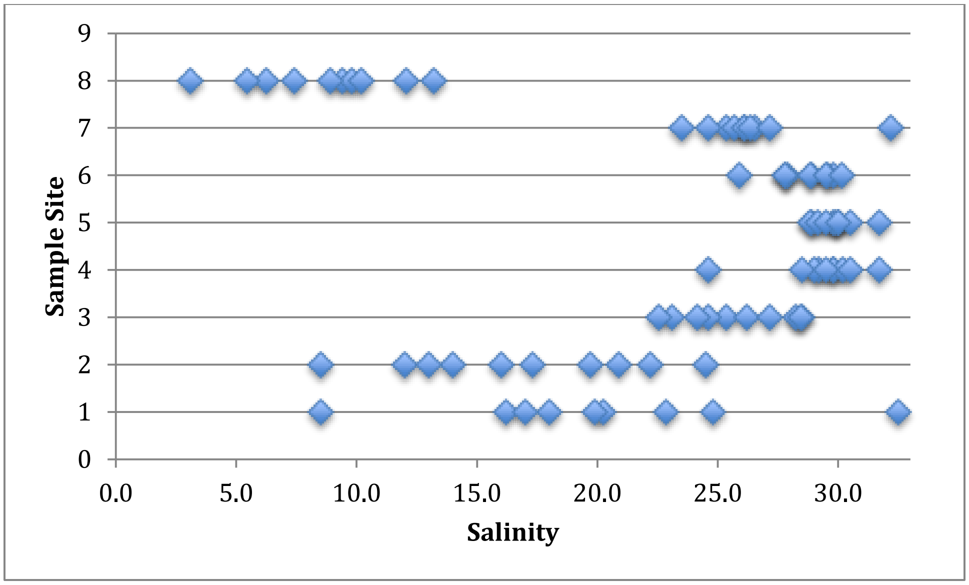
- Typical ocean water salinity: 35 ppt
- Typical river water salinity: <0.5 ppt
- Soft-shell clam habitat requirements: Juveniles grow best at salinities between 16 and 32 ppt. Adult clams cannot grow well below 4 or 5 ppt, but they can survive lower salinities for short periods of time.

What We Found Out

Sites

Salinity was a very site dependent characteristic. Lower salinities were found at sites closer to the Kennebec River. Higher salinities were found at sites closer to the ocean.





River Sites: 1, 2, 8

- Had lower salinities – Sites 2, 8, 3 and 7 all show a very similar pattern of shifting salinities through the season, although the changes are more dramatic at sites 2 and 8 than 3 and 7. Site 1 is less consistent, with high salinities measured on 7/11 and 10/3. Site 1 is upriver from Site 2, so it is unexpected that it would have a higher salinity. It is possible that Site 1 is impacted by flow down Back River.
- **Site 8 always and Site 2 often had salinities below the optimal level for juvenile shellfish.**

Ocean Sites: 4, 5, 6

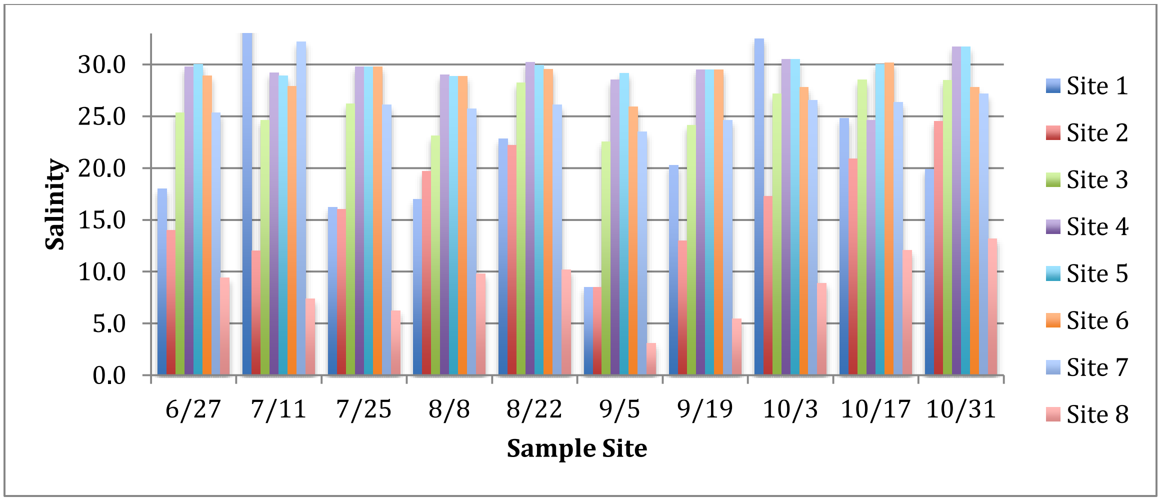
- Had higher salinities – The salinities remained relatively consistent across all sampling dates.

Intermediate Sites: 3, 7

- Had intermediate salinities – on average, lower than the ocean sites, higher than the river sites, and more consistent than the river sites.

<u>**Dates**</u>

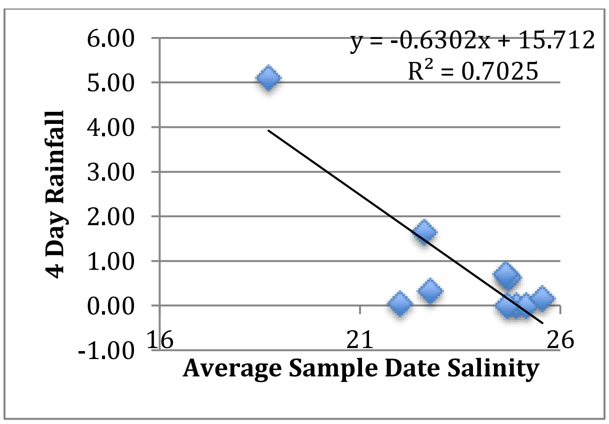
The average salinity was relatively consistent across all sampling dates, and there was no sign of a seasonal change.

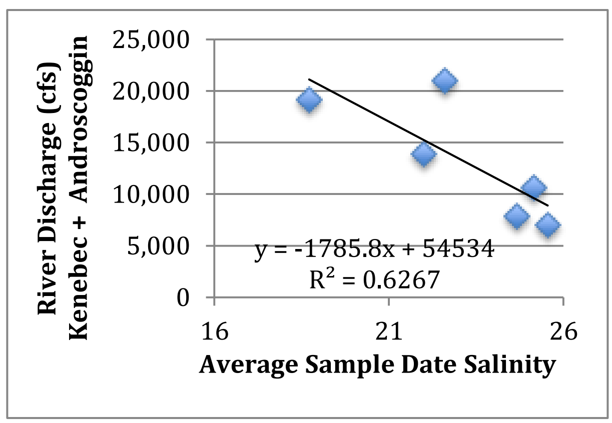


Salinity, River Flow and Rainfall

- How might they relate:
  High river flows, caused by extra input to the rivers from rain, bring more water down the Kennebec and Sheepscot Rivers. This might be expected to lower the overall salinity at several sites.
- How do they actually relate:

Higher river flows = lower average daily salinity
Higher rainfall = lower average daily salinity





The Future

- To evaluate the impact of Back River on salinity and other characteristics in western Georgetown, add a sample site on Back River.
- Look at clam population information and clam shell thickness in Hall Bay to better understand the impact that the low salinities there are having on the clams.
- To find out more about salinity changes at varying river flows, sampling should continue in 2014. The sampling in summer 2013 collected information on moderate river flow dates, but no information was gathered at river discharges at the lowest levels (<6,000cfs) or the higher levels. The highest river discharge on a 2013 sampling date was 20,980cfs, but discharges can reach well above 60,000cfs.

Temperature

Why

High temperatures can be stressful for aquatic life, particularly eggs and juvenile fish. As waters warm in the spring, temperature is a trigger for when eating and reproduction start in a number of aquatic species. Temperature data also gives information about whether the water at a site is from onshore or offshore sources.

River Water

- Heats up faster in the spring
- Gets hotter in the summer
- Cools faster in the fall

Ocean Water

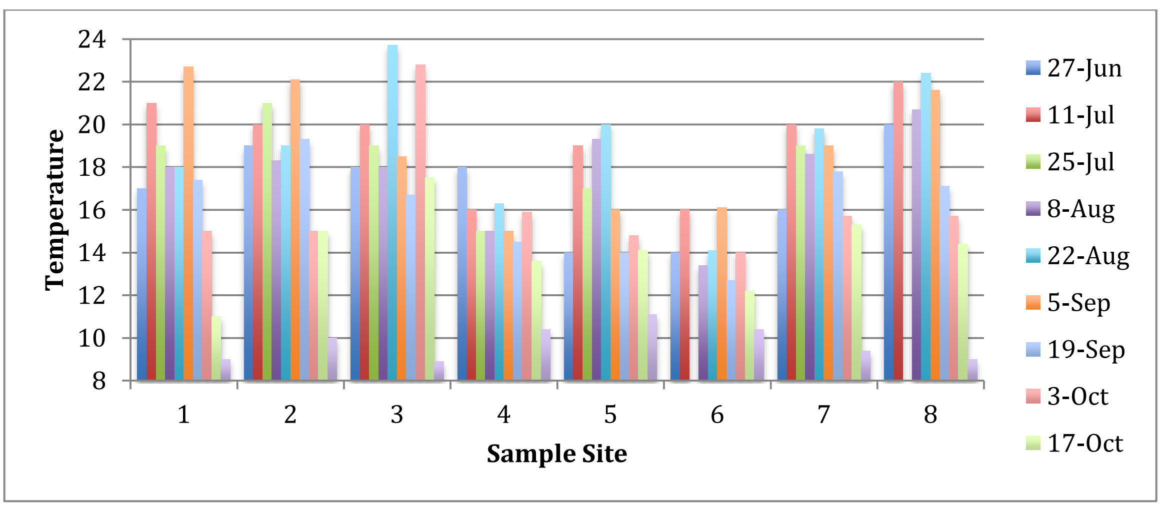
- Stays cooler for longer in the spring
- More moderate temperatures in the summer
- Stays warmer for longer in the fall

Water temperatures warmer than 28°C = Stressful for soft-shell clams

What We Found Out

Sites

The River Sites have similar temperature patterns, and the Ocean Sites have similar temperature patterns.



River Sites: 1, 2, 8

- Had higher temperatures for the first 8 or 9 sampling dates. Had lower temperatures for the last 1 or 2 sampling dates.

Ocean Sites: 4, 5, 6

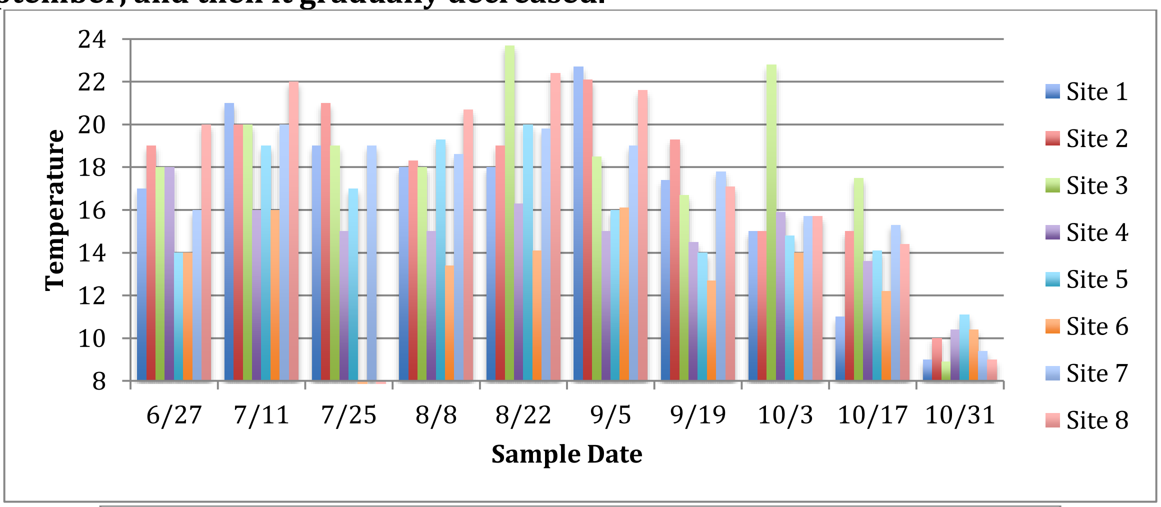
- The temperatures were, on average, lowest at these sites, although they had the highest temperatures on the final sampling date.

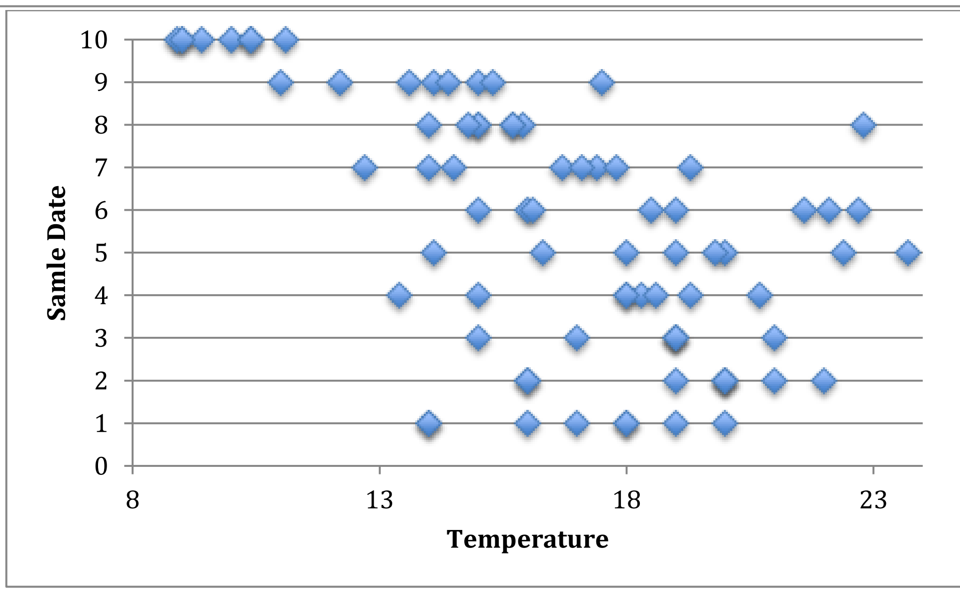
Intermediate Sites: 3, 7

- Site 3 has relatively high temperatures for much of the season and more variable temperatures overall. It sits inside Sagadahoc Bay, more than 250 acres of shallow sandy flats that are almost empty of water at low tide. The high temperatures may be a result of the sun heating the water over the large, shallow expanse of the bay. Site 7 has moderate temperatures throughout the whole sampling season. It typically falls between the 'river sites' and the 'ocean sites,' with temperatures that are usually slightly closer to those at the river sites.

<u>**Dates**</u>

Average temperature was relatively consistent through the first sampling date in September, and then it gradually decreased.





<u>**Temperature, River Flow and Rainfall**</u>

- How might they relate:

Higher rainfall and higher river flow might result in higher water temperatures in the spring and summer and lower water temperatures in the fall.

- How do they actually relate?
    - Rainfall does not have a significant relationship with temperature.
    - There appears to be a direct relationship between river flow and temperature, but this may be due to a lack of river discharge information from sample dates in July and August. River discharge information on the 6 sample dates that it was available shows a gradual decrease from the first sampling date to the final sampling date. Although this matches the temperature change, it also matches the change in season from summer to fall. River discharge was variable throughout summer and fall 2013, but, by chance, that variability is not evident from the days that we sampled. Because river discharge is primarily controlled by rainfall in the summer and fall months, it appears likely that river discharge, like rainfall, is not the key driver of water temperatures at the sample sites.

Salinity and Temperature

- How might they relate:
  Because salinity indicates whether the water at a site is primarily from river or from marine sources, sites with a similar salinity might be expected to have a similar temperature. For the spring and early summer, river water is typically warmer than ocean water. By the fall, river water is typically colder than ocean water.
- How do they actually relate?
    - No direct or indirect relationship - when comparing all sites for all dates.
    - The two dates that salinity was highest at Site 1, the temperatures were also significantly higher than average.
    - The 3 ocean sites that on average had higher salinities also had, on average, lower temperatures. The 3 river sites that on average had lower salinities typically had higher temperatures.

The Future:

- To find out more about temperature changes at varying river flows, sampling should continue in 2014. The continued sampling will better capture the variability in Kennebec and Androscoggin River discharge that occurs throughout the spring, summer and fall.
- To find out more about temperature fluctuations as the water heats up in the spring, it would be beneficial to collect samples in May and June.

Dissolved Oxygen (DO)

Why

Dissolved oxygen is essential for breathing by aquatic life. Low levels can lead to stressful or deadly conditions.

Oxygen can become depleted in the water when:

- Temperatures get too warm: warmer waters cannot hold as much dissolved gas as colder waters.
- There is a die-off of plants or animals in the water. As bacteria decompose the dead organisms, they use up oxygen in the water.

Organisms become stressed when DO drops below 5 mg/L. Larval fish and shellfish can die if exposed to these conditions for an extended period of time.

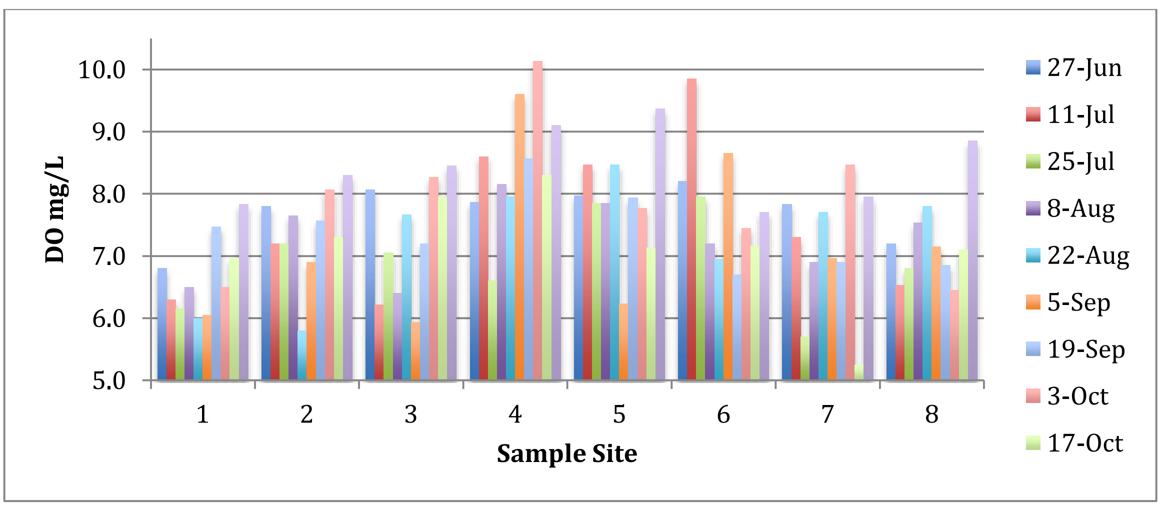
What We Found Out

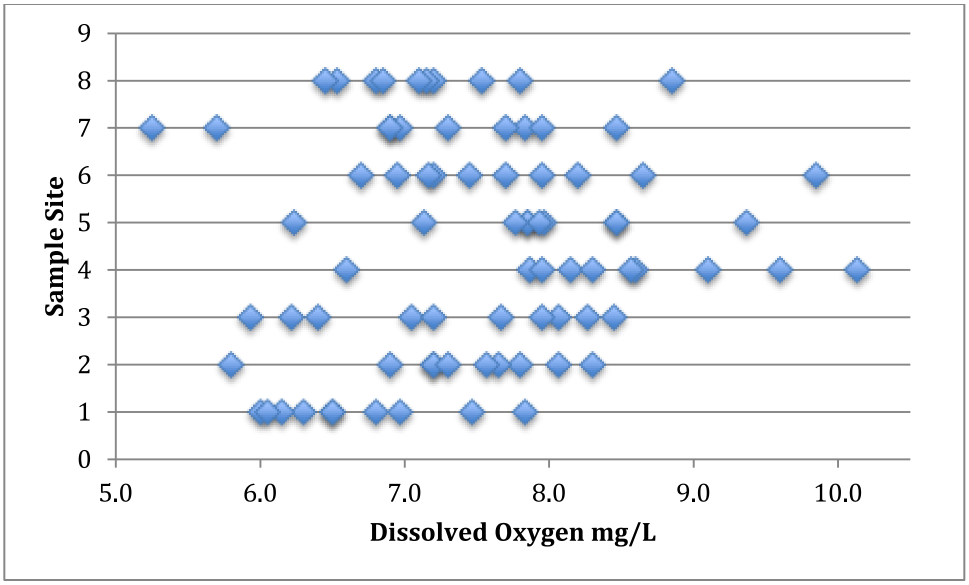
Sites

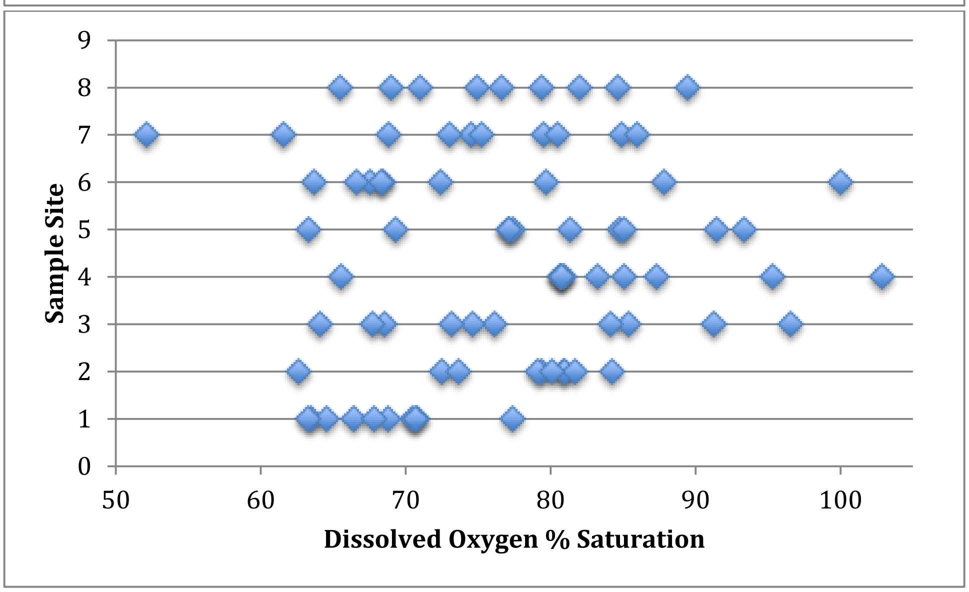
None of the dissolved oxygen concentrations fell below the 5.0mg/L threshold.

Site 1 had the lowest average DO. Site 4 had the highest average DO. Site 7 had the 2 lowest measured DO concentrations.

The three ocean sites (4,5,6) have both the highest average dissolved oxygen and the highest average salinity.





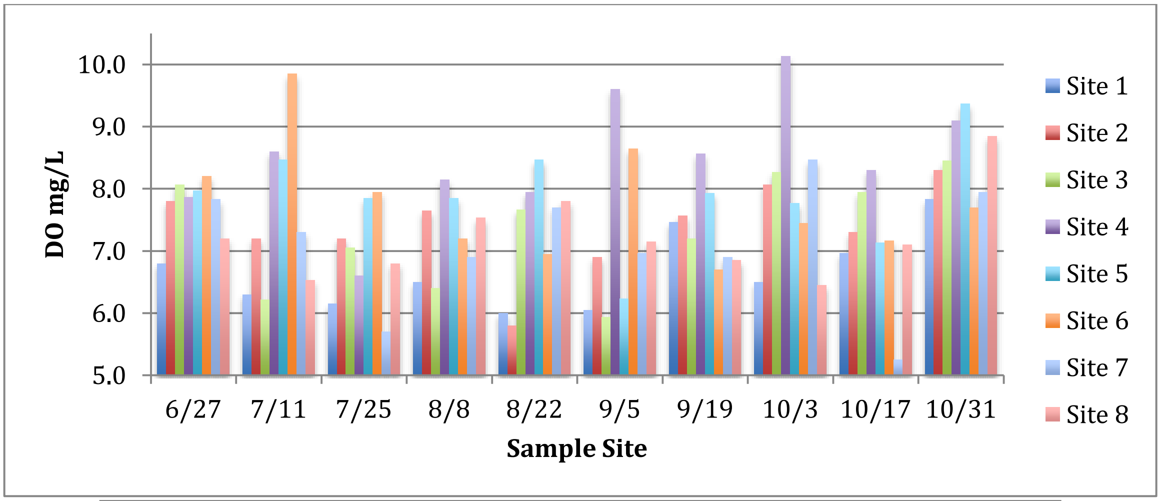


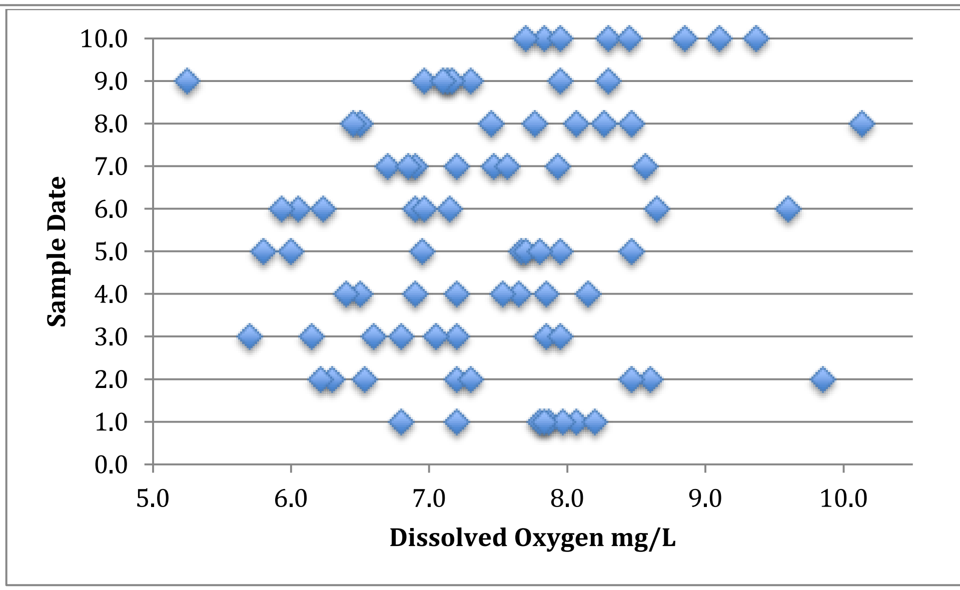
- Ocean Sites: 4, 5, and 6
    - On average, dissolved oxygen was higher at the three ocean sites than either the river or intermediate sites.
- Site 4 (Ocean):
    - Had the highest average DO and often had the highest DO concentration. The highest wind speeds were also most often recorded at Site 4. The wind in this exposed area may have caused waves that increased the amount of DO in the water.
- Site 7 (Intermediate):
    - Although Site 7 often had higher DO concentrations, between 6.5 and 8, it was also the only site that had two dates where the DO value fell below 6.0mg/L. On those two dates (7/25 and 10/19), it also had the lowest DO % saturation that was measured during the 2013 sampling season.
- Site 1 (River):

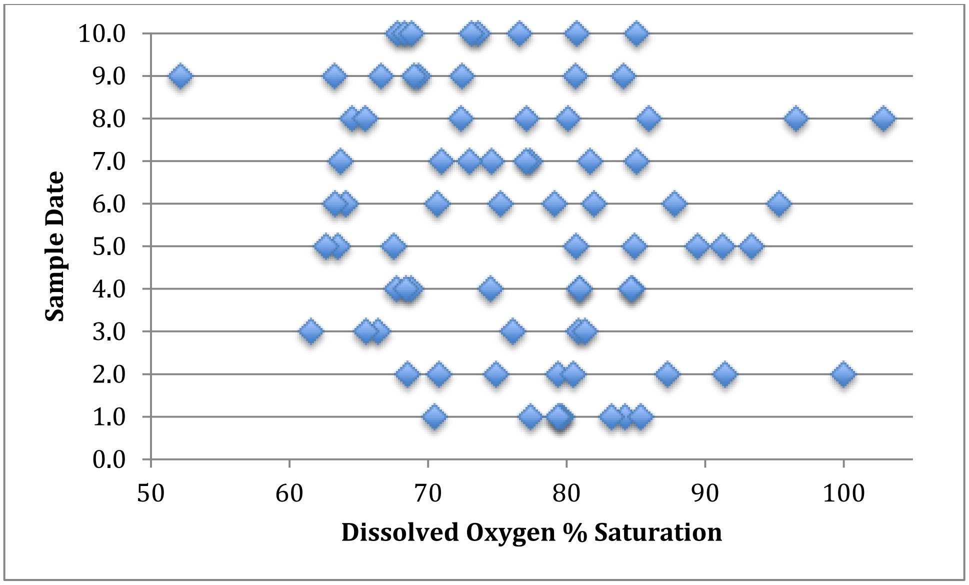
- Has the lowest average DO concentration. This may be influenced by either its location on the Kennebec River or its location at the mouth of the Back River. There are a large amount of wetlands along Back River, and as areas where a lot of decomposition is taking place, the wetlands may play a role in decreasing the DO.

__Dates__

The average DO concentration was highest on the final sampling date that also had the coldest temperatures. For the rest of the season, the average DO was relatively consistent.







<u>Dissolved Oxygen, River Flow and Rainfall</u>

- <u>How might they relate</u>:
  Often when there is a storm, rainfall, and faster moving water, more oxygen is incorporated into the water. As a result, DO might be higher. An increase in fresh water from the rain and the river might also increase the amount of DO because fresh water can hold more dissolved gas than saline water.
- <u>How do they actually relate</u>:
  No relationship was identified.
  - No direct or indirect relationship - when comparing average daily values for all dates.

<u>Dissolved Oxygen and Salinity</u>

- <u>How might they relate</u>:
  Saltier water can hold less gas than fresher water, so it might be expected that sites with a higher salinity would have a lower amount of dissolved oxygen.
- <u>How do they actually relate</u>:
  - No direct or indirect relationship - when comparing all sites for all dates.
  - The three ocean sites that had the highest salinities have, on average, the highest DO concentrations. This is the opposite of the relationship suggested above.

<u>Dissolved Oxygen and Temperature</u>

- <u>How might they relate</u>:
  Warmer water can hold less gas than colder water, so it might be expected that sites with higher temperatures would have less dissolved oxygen.
- <u>How do they actually relate</u>:
  - No direct or indirect relationship - when comparing all sites for all dates.
  - The three ocean sites that had the lowest temperatures have, on average, the highest DO concentrations. This fits with the relationship suggested above.

Temperature appears to have a stronger impact on the amount of dissolved oxygen at the sites than salinity.

The Future:

- To determine the relative impact of Back River on DO concentrations, a sampling site could be added upstream on the Back River.
- Site 7 should definitely continue to be sampled for DO. The two low values measured at this site are near the threshold DO concentrations that are stressful for larval fish and shellfish.

pH

Why

pH is an indicator of how acidic something is. The acidity is important because of the impact it has on marine life, particularly marine life with shells.

A lower pH indicates a higher acidity. The scale for pH is set up so that each unit of change (example: from 8 to 7) indicates that the water has changed to be 10 times more acidic.

The thing that decreases the pH of ocean waters is the amount of carbon dioxide in the water. When CO_2 mixes with water, it makes a weak acid, so it lowers the overall pH. Three primary factors impact the CO_2 level:

1) The amount of CO_2 in the atmosphere.
2) The amount of CO_2 that the water can hold based on its temperature and salinity. Cold liquids can hold more gasses than warm liquids. Fresher liquids can hold more gasses than saltier liquids.
3) The amount of CO_2 that is released by respiration; in the water, this often comes from bacteria that are respiring when they are breaking down dead or decaying plants, animals, algae, or plankton. More dead things decomposing in the water or on the mud result in more CO_2.

Once that CO_2 is in the water, other factors decide how much it changes the pH. Salts and other dissolved minerals that are in the water can serve to decrease the impact of added acidy and stabilize or increase the pH.

Georgetown has one other big factor that impacts the pH: rivers. Waters flowing in from both the Sheepscot and the Kennebec will have lower pH values than the waters of the Gulf of Maine.

The average pH of rivers ranges from: 6.5 - 8.5
The average pH of the ocean ranges from: 8.1 - 8.5
The average pH of rainwater is: 5.6

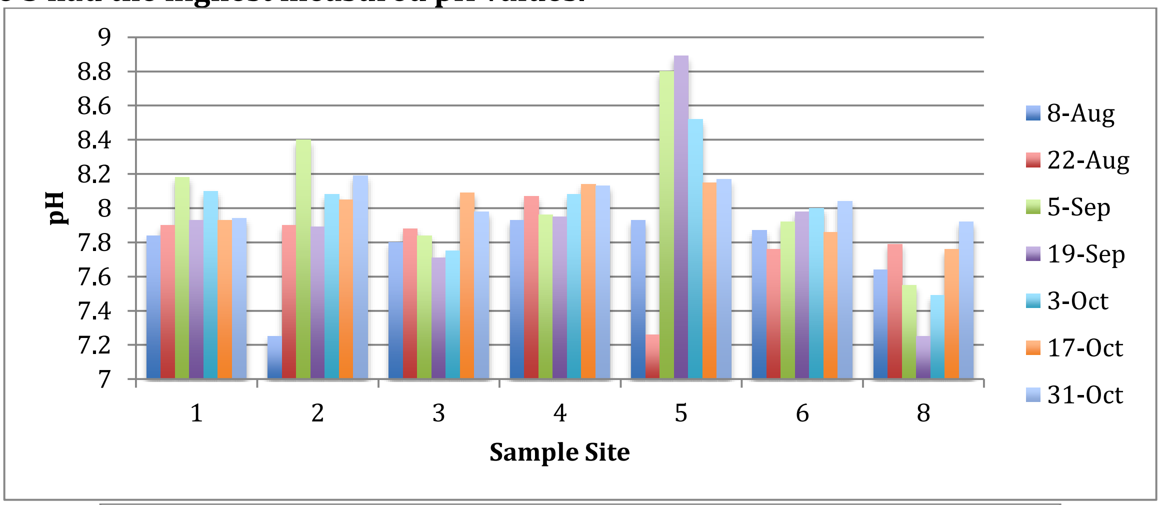
Studies by Mark Green have found that juvenile clams are at risk when pH values drop below 7.5.

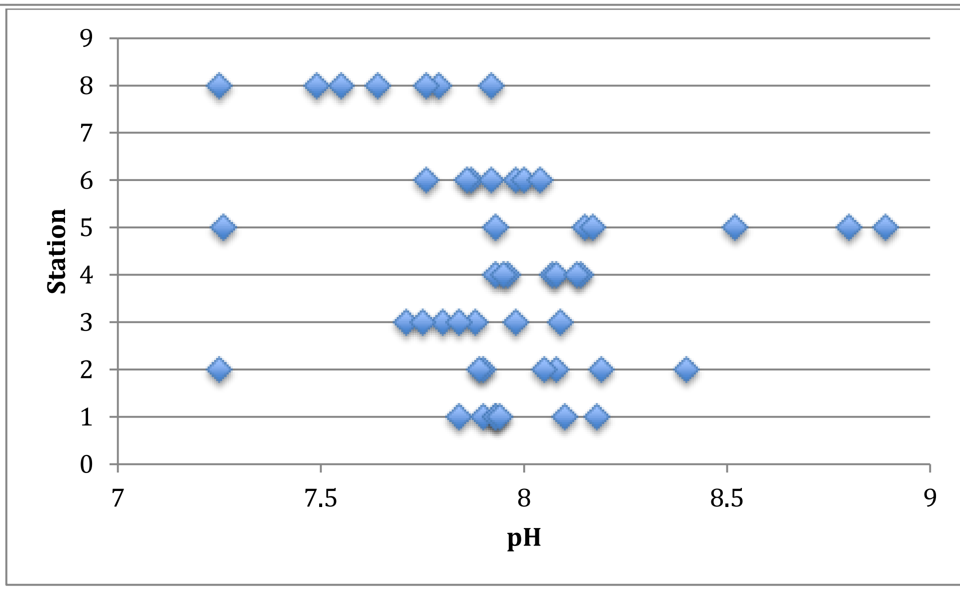
Why are juvenile clams more at risk than adult clams to pH changes?
Adult clam shells = primarily made of the mineral calcite Juvenile clam shells = primarily made of the mineral aragonite. • These two minerals are made of the exact same components: $CaCO_3$ • Their difference is in structure. The structure of aragonite is weaker, so it can be more easily dissolved by water with a higher pH (a lower acidity) than can calcite.

What We Found Out

Sites

None of the sites had pH values below 7, but 3 sites had one date with a pH value below the 7.5 threshold. These sites were 2, 5, and 8.
Site 5 had the highest measured pH values.



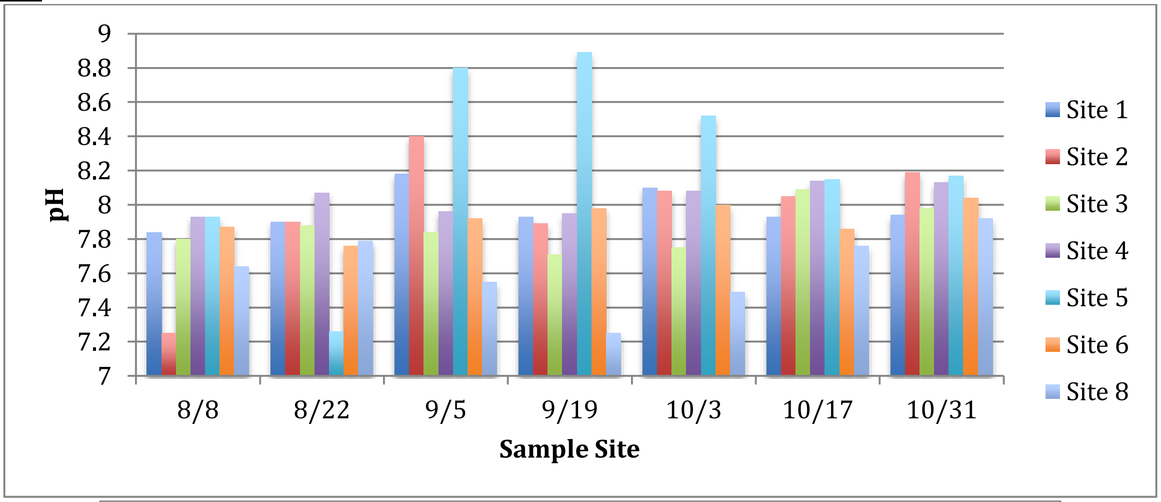


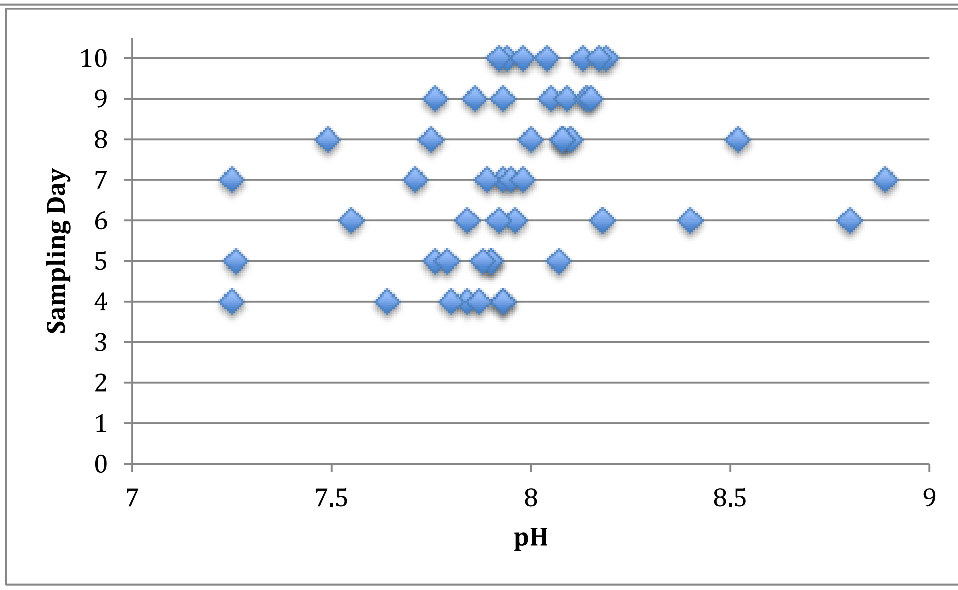
- 5 of the 8 measurements at Site 5 (Harmon's Harbor) had a pH of above 8, and the 3 highest pH measurements collected during the season were all from Site 5. This may be because Site 5 is collected off of a dock that sits over an area with abundant rockweed and some kelp. When these plants do photosynthesis, they remove CO_2 from the water. The pH variation at Site 5 does not appear to be linked to sunlight. Both the lowest and highest values at the site were collected on sunny days.
- The results from Site 7 (Robinhood Cove) are not included because there are some quality assurance concerns about the data from that site.
- On average, Site 8 (Hall Bay), the site that shows the greatest influence from river flow, has the lowest pH.

- Three sites had pH readings below 7.5. These were all on different dates.

Site 2	Site 5	Site 8
8/8	8/22	9/19, 10/3

Dates





- Although there were some high individual pH values throughout the season, the day with the highest average pH was the final sampling date, Oct. 31.
- Average pH varied between the 10 sampling dates, but there was no consistent change to higher or lower values throughout the season.

pH, River Flow and Rainfall

- How might they relate:
  River flow and rainfall can both add water that is a lower pH and increase the amount of freshwater at a site. Rain water typically has a pH of around 5.6, and river water often has a pH of slightly above 7. Both of these are significantly lower than the 8.1-8.3 that is found in the ocean. The freshwater leads to a lower concentration of the salts and minerals in the water that can insulate the water from

pH changes, making them less effective. The combination of these factors may result in lower pH values when there is high river flow and rainfall.

- How do they actually relate?
    - No direct or indirect relationship - when comparing average daily values at all sites.

pH and Salinity

- How might they relate:
  Saltier water has more ions (charged particles) in it that can react with added acidity to reduce it and increase the pH. Fresher water doesn't have as much of a buffer, so the pH may be higher.
- How do they actually relate:
    - No direct or indirect relationship - when comparing all sites for all dates.
    - Site 8 had the lowest pH on the majority of sample dates, and it also had the lowest salinity on corresponding dates. The impact of fresh water at this site may be a source of the lower pH.
    - The other sites that are more influenced by the river (Site 1 and Site 2) did not show any relationship between salinity and pH.
    - Sites 4 and 5 are the two sites that most often have the highest daily pH values and they also most often have the highest daily salinity values.

  Site 8 had the lowest pH on the majority of sampling dates. It also had the lowest salinity on corresponding dates.

pH and Temperature

- How might they relate:
  Warmer water can hold less gas than colder water, so there may be less CO_2 in the water on warmer days. This might result in a higher pH. Alternatively, the opposite may happen because the chemical reaction that makes solutions become acidic happens faster at warmer temperatures. This would cause a decrease in the pH as the temperature increases.
- How do they actually relate:
    - No direct or indirect relationship - when comparing all sites for all dates.
    - The highest average pH was on the final sampling date. This date also had the lowest temperatures.

pH and Dissolved Oxygen

- How might they relate:
  Dissolved oxygen may be an indicator of photosynthesis. Photosynthesis removes CO_2 from the water, so high levels of DO may be tied to higher pH values.
- How do they actually relate:
    - No direct or indirect relationship - when comparing all sites for all dates.
    - Site 5: Although Site 5 does have slightly higher than average DO, the dates with the highest DO do not correlate to the dates with the highest pH.
    - Sites 4 and 5 are the two sites that most often have the highest daily pH values and most often have the highest daily DO values.

The Future:

- Potentially move Site 5 so that it collected from an area that is not directly over seaweed. This will demonstrate whether the increased photosynthesis by the seaweed in another part of the bay has any impact on the overall pH of Harmon's Harbor.
- pH sampling should target Site 7 and the three sites with measured pH values below 7.5: Sites 2, 5, and 8.
- Potentially work with Bowdoin College to compare clam shells from Hall Bay to the other areas.
- Site pH information could be increased by testing pH of sediments as well as the water.

Inorganic Nitrogen

Why

High levels of nitrogen can cause algae blooms that decrease dissolved oxygen and pH and can be harmful to marine life.

Nitrogen is found in fertilizers, pet and farm animal waste, decaying plant material, failing septic tanks, atmospheric deposition, and waste water treatment plant outfalls. There are 3 primary forms of inorganic nitrogen: Nitrate (NO_3^-), Nitrite (NO_2^-), and Ammonia (NH_3).

High amounts of nitrogen in the water can cause algae blooms. In the short term, this algae adds oxygen to the surface of the water, but it also blocks sunlight from reaching lower down in the water. Any plants deeper in the water may suffer. When the algae dies off, falls to the bottom, and starts to decay, the chemical conditions of the water and sediment where all the dead algae is rotting change as the bacteria that are decomposing the algae use up oxygen and release carbon dioxide. This decreases the amount of dissolved oxygen in the water and increases the pH.

Very high levels of nitrogen can be toxic to marine organisms.

What We Found Out

Nitrate: All the nitrate concentrations were less than 0.10 mg/L.

Nitrite: All of the nitrite concentrations were less than 0.01 mg/L.

Ammonia: All of the ammonia concentrations were less than 0.10 mg/L. Most were below 0.05 mg/L.

Nitrate, nitrite and ammonia are the three primary forms of nitrogen that make up the inorganic nitrogen component of the water. By adding together the results received for the three different tests, the total concentration of inorganic nitrogen in Georgetown's waters can be determined.

Method Problems: There was some trial and error with the methods used to test for Nitrate, Nitrite, and Ammonia this year. The methods were changed slightly during the season. Although these changes resulted in higher quality measurements by the end of the season, they also make it difficult to compare and evaluate the results.

<u>What about the conclusions above about nitrate, nitrite, and ammonia?</u>

- These statements all take into account the variability and potential errors that were caused by the inconsistent methods.

<u>A quick assessment of methods:</u>

- Ammonia: By the end of the season, the precision for ammonia was +-0.05 from a standard. Earlier in the season, the results were less precise, +-0.09.

- Nitrite: Nitrite values were all very small. The quality of the method was tested by running a blank sample to determine how much background noise was a part of the test. This showed that the test was not reliable for values less than 0.008mg/L. We were unable to use a nitrite standard to test the accuracy of the method.
- Nitrate: These values were the most variable. When checked with a standard, the method used earlier in the season gave results that were lower than the actual value. The method was altered throughout the season. Later in the season, some of the measured values may have been higher than the actual values.

Nitrate Water Quality Standards:
The State of Maine is still in the process of developing standard criteria for nitrogen levels in Maine's estuarine and marine waters. According to conversations with DEP staff and information published by the Georges River Tidewater Association in their *2012 State of the St. George Estuary* report, the DEP will be assessing nutrients based on the amount of total nitrogen in the water. This includes both the organic and inorganic nitrogen. They have identified 0.4 mg/L total nitrogen as a possible lower limit of nutrient over-enrichment.

The Future:

- Based on what was learned this year, the methods used next year to test for nitrate, nitrite, and ammonia will be altered to increase precision and accuracy.
- The best way to check the quality of the methods would be to collect a sample and send part of it to a lab to be tested for nitrate, nitrite, and ammonia and then test the other part using the colorimeter methods. This is a possibility for this upcoming season.
- The Darling Marine Center has offered to assist with instrument calibration for sampling in 2014.
- The Town of Georgetown has a large number of licensed overboard discharges that have the potential to be a source of added nitrogen pollution along the coast. Adding a sample site in an area with multiple OBDs may reflect whether or not they are impacting nitrogen concentrations in Georgetown's coastal waters.
- Work with the Maine DEP to identify nitrogen testing needs.

Other Things Noticed and Tested in 2013

- **Green Crabs:** The prevalence of green crabs on Georgetown's coastline has reached very high levels in 2013. Members of the Georgetown Shellfish Committee completed reseeding projects and found that most of the new seed was gone within a few months of being added to the flats. This was attributed to green crabs. Trapping of green crabs was completed in Heal Eddy by members of the shellfish committee. They caught consistent numbers of crabs on a daily basis during trapping from July - October. A survey of crab populations by 7th graders from Bath Middle School found large populations at Reid State Park and at Robinhood Cove. An eel trap set out overnight at Robinhood Cove caught more than 100 crabs, and an eel trap set out overnight in Reid State Park caught more than 70 crabs.
- **Thin Clam Shells:** A Bowdoin College Marine Biogeochemistry class looked at water quality, sediment characteristics, and clam shells at one site with thick shells (Harmon's Harbor) and one site with thin shells (Little River). They compared the information from the two sites to see if they could explain why the shells were thinner at one site than the other. Their brief study found:
    - <u>Harmon's Harbor</u>:
        - *Clams*: thicker hinge, thicker edge, less dry tissue mass
        - *Water*: lower salinity, lower particulate organic carbon, lower DO, lower pH, higher temperature, higher alkalinity, higher pH, higher phosphate, higher nitrate, higher saturation state for aragonite
        - *Sediments*: clay, higher particulate organic material, higher particulate organic carbon
    - <u>Little River</u>:
        - *Clams:* thinner hinge, thinner edge, more dry tissue mass
        - *Water:* higher salinity, higher particulate organic carbon, higher DO, higher pH, lower temperature, lower alkalinity, lower pH, lower phosphate, lower nitrate, lower saturation state for aragonite
        - *Sediments:* sand, lower particulate organic material, lower particulate organic carbon
    - There were so many differences identified between the two sites that it was difficult to identify which characteristic were responsible for the changes in shell thickness. The students made 3 main conclusions:
        - The lower nitrogen, particulate organic material, and particulate organic carbon at Little River means that the clams have less available food. This may be why they are growing more soft tissue than shell.
        - The lower saturation state at Little River means that there is less of the material the clams use the make their shells available in the water.
        - Little River is naturally acidic due to its freshwater inputs. With rising CO_2 in the atmosphere, the acidity of Maine's coastal waters are expected to decrease. Little River may serve as a demonstration of what may be found on future Maine shellfish flats.

Project Summary

Salinity

- **Salinity was a very site dependent characteristic. Lower salinities were found at sites closer to the Kennebec River. Higher salinities were found at sites closer to the ocean.**
- **Site 8 always and Site 2 often had salinities below the optimal level for juvenile shellfish.**
- **The average salinity was relatively consistent across all sampling dates, and there was no sign of a seasonal change.**
- **Higher river flows = lower average daily salinity**
- **Higher rainfall = lower average daily salinity**

Temperature

- **The River Sites have similar temperature patterns, and the Ocean Sites have similar temperature patterns.**
- **Average temperature was relatively consistent through the first sampling date in September (9/5), then it gradually decreased.**

Dissolved Oxygen

- **None of the dissolved oxygen concentrations fell below the 5.0mg/L threshold.**
- **Site 1 had the lowest average DO.**
- **Site 4 had the highest average DO.**
- **Site 7 had the 2 lowest measured DO concentrations.**
- **The three ocean sites (4,5,6) have the highest average dissolved oxygen, the highest average salinity, and the lowest average temperature. Temperature appears to have a stronger impact on the dissolved oxygen of the sites than salinity.**
- **The average DO concentration was highest on the final sampling date that also had the coldest temperatures.**

pH

- **None of the sites had pH values below 7, but 3 sites had one date with a pH value below the 7.5 threshold. These sites were 2, 5, and 8.**
- **Site 5 had the highest measured pH values.**
- **Site 8 had the lowest pH on the majority of sampling dates. It also had the lowest salinity on corresponding dates.**

Nutrients

- **Nitrate: All the nitrate concentrations were less than 0.10 mg/L.**
- **Nitrite: All of the nitrite concentrations were less than 0.01 mg/L.**
- **Ammonia: All of the ammonia concentrations were less than 0.10 mg/L. Most were below 0.05 mg/L.**

Remaining Questions

1. Is flow from Back River impacting the salinity at Site 1?
2. Do the low salinities at Site 8 and Site 2 impact shellfish growth at these sites?
3. How much does the salinity vary between the sites when the river is flowing at very high (>25,000) or very low (<6,000) levels?
4. Does the level of river discharge have an impact on water temperature?
5. What rate does the temperature change in the spring, and how does it vary between the different sites?
6. Will Site 7 continue to have periodic low DO levels, and if so, can they be linked to any other factors?
7. Does the location of a site directly over seaweed change the pH?
8. What is the pH at Site 7?
9. Do clams grow differently in areas where the water has a lower average pH?
10. Is the total nitrogen concentration anywhere near the nutrient limit proposed by the DEP?
11. Does the size of the tide make a difference for any of the observed water quality characteristics?
12. Are the results observed in 2013 similar to those that would be seen any other year?

Answering the Questions in 2014 and Beyond

1. Add a sample site on Back River.

2+9. Get information from the Georgetown Shellfish Committee about any clam flat surveys they have completed in Hall Bay and potentially work with a Bowdoin Biogeochemistry Professor to look at the clam characteristics.

3. Continue sampling so samples are collected when river discharges are at high levels (>25,000) or low levels (<6,000cfs).

4. Continue sampling so more sampling days have information about both water temperatures and river discharge.

5. Collect samples in May and June.

6+8. Continue sampling to gather more information about DO and pH at Site 7 and the other sites.

7. Add another site in Harmon's Harbor that is not located over seaweed so it can be compared to Site 5.

10. Improve the nitrogen testing methods and communicate with the DEP and Darling Marine Center to validate the methods.

11. Look at the impact of tide size on DO and pH.

12. Continue volunteer water sampling program in future years.

<u>Conclusions</u>

- **Georgetown's unique setting, framed by the Kennebec River to the west, the mixing waters from the Kennebec and Sheepscot to the north, and the Gulf of Maine to the south leads to interesting and complicated water quality conditions and variations around the island. There is significant variation between the sites based on the amount of influence exerted on the area by the rivers or the oceans.**
- **Water sampling in 2013 returned information that has increased knowledge and understanding about the conditions of Georgetown's coastal waters.**
- **Because marine fisheries depend upon clean water and are so vital to the economy, recreation and culture of Georgetown, the work completed this year has the potential to benefit the economy, recreation and culture of Georgetown.**
- **Sampling in 2013 gave a quick snapshot of Georgetown's water conditions in only one year, only 2 seasons and only nearshore sites. Continued and expanded sampling around the coast of Georgetown and in Georgetown's neighboring towns will increase the available information and increase the understanding of Georgetown's coastal resources.**

<u>Plans for Next Year</u>

- **Plans are to continue volunteer sampling in 2014.**
- **There is the potential to add more sites:**
    - **End of Bay Point Road**
    - **Along Back River**
    - **Farther inland at Harmon's Harbor**
- **Sampling is planned to start earlier in 2014, gathering new information from May and early June.**
- **Improvements in methods and method consistency will be implemented.**

Have Any Questions or Want to Volunteer Next Year?

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