A survey of the range and spatial variation of pH in the Bagaduce River estuary

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1. Statement of Problem

A field survey of the Bagaduce River estuary will be conducted in the summer of 2017 to assess the range and spatial variability of mudflat porewater pH. Arc GIS, a mapping software, will be utilized to create a multi-layer map of the Bagaduce system. This map will be used to visualize the pH data and identify any spatial patterns that may be present. A map allowing for pH visualization in the Bagaduce is valuable because there are no quantitative pH data available for this estuary; it would allow for comparison between other Maine estuarine systems where there is clear acidification influence. A secondary GIS analysis will be conducted to rank the important soft shell clam (*Mya arenaria*) habitat for its potential susceptibility to acidification. The analysis will include a GIS data layer on shellfish closure areas (available from the Maine Office of GIS) which will be overlain with the pH data, allowing for open mudflats with lower pH values to be identified. Identification of these sensitive areas will provide insight for resource managers on which mudflats need close monitoring for potential signs of acidification on soft shell clams and locations where mitigation efforts may be beneficial.

2. Rationale

The anthropogenic production of carbon dioxide (CO_2) due to the burning of fossil fuels is changing the chemical composition of Earth's atmosphere and oceans (Orr et al. 2005; Saraswat et al. 2015). Oceans act as a carbon sink by absorbing atmospheric CO_2 which helps mitigate climate change (Bourgeois et al. 2016; Sutton et al. 2016). However, this absorption of CO_2 from the atmosphere is leading to an ocean-wide drop in pH (Orr et al. 2005; Saraswat et al. 2015). In the 257 years since the start of the Industrial Revolution, the pH of ocean water has dropped 0.1 units and is expected to continue to decline (Orr et al. 2005; Clements et al. 2016). In 1751, the average surface water pH was around 8.25 (Jacobson 2005). By the year 2100, ocean pH is expected to drop another 0.3-0.4 units to be around 7.85 (Jacobson 2005; Orr et al. 2005; Clements et al. 2016). Coastal waters are particularly susceptible to this rising acidity because they are naturally more acidic (Gledhill et al. 2015). Rivers transport nutrients and freshwater from inland watersheds to coastal waters. Freshwater is more acidic than salt water by nature and has a lower capacity to act as a buffer to fluctuations in pH (Wang et al. 2013; Gledhill et al. 2015; Maine Coastal and Ocean Acidification Commission 2015). Nutrient loading can induce blooms in plankton and microalgae, causing elevated levels of respiration from the organisms that feed upon the blooms and thus, increased local CO_2 concentrations (Gledhill et al. 2015).

The Gulf of Maine is at notably higher risk for coastal acidification than coastal locations at lower latitudes (Gledhill et al. 2015). This risk is because Maine's colder waters more readily dissolve CO_2, creating faster rates of acidification (Gledhill et al. 2015). Ocean waters should be supersaturated ($\Omega_{arag}>1$) with respect to the mineral aragonite[1] (Gledhill et al. 2015). High levels of acidity in ocean water result in a reduced saturation state of aragonite ($\Omega_{arag}=1$ or $\Omega_{arag}<1$): similarly, aragonite saturation provides an understanding of the ambient pH (Orr et al. 2005; Clements and Hunt 2014; Clements et al. 2016; Sutton et al. 2016). The aragonite saturation state was found to be undersaturated ($\Omega_{arag}<1$) in the mouths of two Maine rivers: the Penobscot River and the Kennebec (Gledhill et al. 2015). The pH and aragonite saturation state in a control plot in West Bath, Maine were found to be 7.04 and 0.25 respectively and the porewater of two stations in the Casco Bay (Maine) were found to be undersaturated with

Commented [MU1]: Footnote 1. *Aragonite* is a crystalline form of calcium carbonate that is important for shell building in calcifying organisms.

respect to aragonite (Ω_{arag}<1) (Green et al. 2009). Green et al. (2013) found a value range of 0.16-2.10 in the aragonite saturation state in sediments in South Portland Harbor (Maine), with 0.75 as the median value and roughly 40% of all measurements at a value lower than 0.6. These data are testimony that many areas in Maine have begun to see signs of coastal ocean acidification.

Increases in ocean acidification are hypothesized to have negative consequences on populations of marine species. The reduction of calcite and aragonite saturation in ocean waters can affect calcifying organisms, such as shellfish, which rely upon these minerals for shell formation. Calcifiers play an important environmental role by sequestering atmospheric CO_2 in the process of shell building (Saraswat et al. 2015). The formation and dissolution of shells and exoskeletons are part of the natural carbon and calcium cycles (Clements and Hunt 2017). With rising oceanic acidity, organismal hard-parts made from biogenic calcite and aragonite are more easily dissolved, which causes a faster release of the sequestered CO_2 and speeds up the carbon cycle (Saraswat et al. 2015). This dissolution, and other effects of reduced pH, can lead to stunted growth and reduced survival in a variety of calcifying organisms (Green et al. 2009; Appelhans et al. 2012; Bressan et al. 2014).

Studies have identified bivalves as a group of calcifiers that appear to be at a particular risk to the negative implications of coastal ocean acidification (Clements and Hunt 2013; Green et al. 2013; Bressan et al. 2014; Gledhill et al. 2015; Clements and Hunt 2016). Clements et al. (2016) found that decreased pH may interfere with important bivalve biological processes. Studies found that the metabolic rate, respiration, ingestion, gene expression, and behavior of a variety of bivalves were either disrupted or altered with lowered pH (Gazeau et al. 2013;

Watson et al. 2014; Clements and Hunt 2015; Clements et al. 2016). When exposed to acidic conditions, blue mussels (*Mytilus edulis*) and Pacific oysters (*Crassostrea gigas*) experienced increased shell breakage and decreased heath and calcification (Gazeau et al. 2007; Applehans et al. 2012; Clements et al. 2016). Bressan et al. (2014) found that both Mediterranean mussel juveniles (*Mytilus galloprovincialis*) and Venus striped clam juveniles (*Chamelea gallina*) endured shell damage when exposed to a pH of 7.4 for a period of six months. In particular, the Venus striped clams exposed to the 7.4 pH experienced reduced shell length, stunted growth, shell dissolution (as evident by the smoothing of concentric ribs), and a 40% increase in mortality (compared to clams that had not been exposed to low pH conditions) (Bressan et al. 2014). Settlement of bivalve larvae in the intertidal is vital to the recruitment, or increase in population, of the species. In studies done by Green et al. (2013), Clements and Hunt (2014), and Clements et al. (2016) the burrowing of both juvenile hard shell clams (*Mercenaria mercenaria*) and juvenile soft shell clams (*Mya arenaria*) was significantly reduced in sediments with low pH and undersaturated with respect to aragonite. In the study by Clements and Hunt (2014), the pH and aragonite saturation of the overlying water were kept high (7.80 ± 0.03 pH and 1.81 ± 0.11 $\Omega_{Aragonite}$) while the sediment porewater was reduced, at its lowest, to 6.8 and 0 respectively. It was found that, despite the high pH level and aragonite saturation of the overlying water, the juvenile soft shell clams still rejected the acidic sediment. Based off this study, it is likely that porewater pH is more important than the overlying water pH in the burrowing, settlement, and eventual recruitment of infaunal bivalve juveniles (Clements and Hunt 2014).

In the Gulf of Maine and along the East Coast, the soft shell clam, *Mya arenaria*, is an economically and environmentally important species of infaunal marine bivalve. Soft shell clams play a significant role in cycling of elements in the marine benthic environment (Saraswat et al. 2015) and have the ability to change the flow and settlement of particles and larvae (Gutiérrez et al. 2003; Clements and Hunt 2017). Through filter feeding, soft shell clams help to redirect the flow of energy to benthic food webs (Gutiérrez et al. 2003; Gazeau et al. 2013) as well as remove harmful algae and waste nutrients from the water column, creating cleaner water and allowing for deeper light penetration (Gazeau et al. 2013; Gledhill et al. 2015; Clements and Hunt 2017). The soft shell clam has an annual average harvest of 10.6 million pounds of clams worth roughly $14.6 million USD per year, making it the third most valuable fishery in the state of Maine and the most valuable bivalve fishery (Beals 2015; Phillips 2016). This fishery provides many jobs, both in the management sector and in harvesting.

In the Bagaduce Estuary, soft shell clam populations have been declining. Figure 1 shows the softshell clam harvest data for the town of Penobscot from the year 2007, when it first became mandatory for landings[2] to be reported, until 2012, when the reported landings became so low they were deemed confidential (B. Bowden, e-mail message, April 11, 2017). Harvest data can be used as a proxy for species population and by these landings, it is clear that the population numbers are low. Predation, particularly by moon snails (*Lunatia heros*) and green crabs (*Carcinus maeuas*), is a major decimator of soft shell clam populations and appears to be the reason for local soft shell clam decline, not ocean acidification (B. Bowden, e-mail message, April 11, 2017). Though predation is currently the biggest burden on local clam population, it is not the only variable. In Portland Harbor, Portland, Maine, sediment acidity and

Commented [MU2]: Insert first sentence about the importance of clams in the Bagaduce estuary, how populations are declining (use landings as proxy? Or cite as personal commun), decline appears to be due to predation, not OA

Commented [MU3]: Footnote 2. *Landings* refers to the numbers of individuals that are caught or, in the case of shellfish, *harvested* and sold commercially.

undersaturation of aragonite were hypothesized to prompt juvenile soft shell clams to determine sediment unfavorable and reject it, thus decreasing juvenile recruitment, an important factor in a species' population (Green et al. 2013). Anecdotal evidence suggest that effects of ocean acidification on juvenile clam recruitment and adult shell dissolution do not yet appear to have a significant impact on the local soft shell clam populations in the Bagaduce River (B. Bowden, personal communication, April 11, 2017). To date, there has been no survey that quantifies the range or spatial variation of pH in the Bagaduce River. It is important to delineate a baseline for pH in the Bagaduce. Using ArcGIS, shellfish closure areas will be filtered out and open clam beds with higher pH will be identified as sensitive and marked as a priority. By initiating the monitoring of pH change, policymakers and shellfishermen alike will better be able to detect early influence of acidification and enact the appropriate mitigation efforts to protect the soft shell clams from the negative effect of rising ocean acidification.

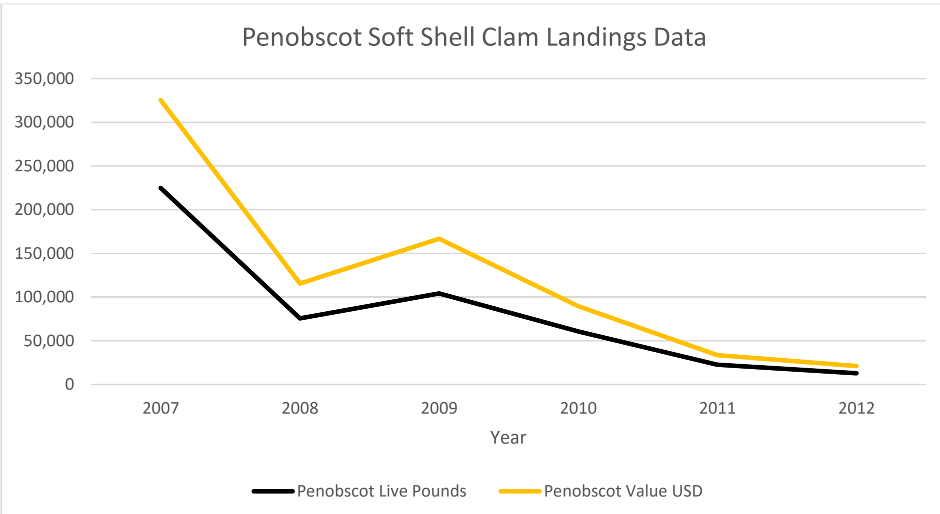

Fig 1. Penobscot soft shell clam landings from 2007-2012. The vertical axis units are in live pounds (black plot line) or U.S. dollars (yellow plot line). Landings data can be used as a proxy for population. In the year 2011, the soft shell clam population was decimated by a moon snail invasion. In 2012, green crabs cause a complete collapse in the population. By 2013, soft shell clam populations were, and continue to be, so low they are considered confidential. (B. Bowden, personal communications, April 11, 2017).

3 Methods

3.1 Overview

There will be two pH surveys conducted in the Bagaduce River Estuary. The Bagaduce River Estuary Survey will take place over two months and will cover a variety of mudflat locations, from Toms Cove (Fig. 2, point A), located near the mouth of the Bagaduce, to Northern Bay (Fig. 2, point B), at the northernmost part of the river. The Hatch Cove Survey will focus on data collection once a week for two months at Hatch Cove, Castine, Maine.

3.2 Location

The Bagaduce River Estuary will be sampled in a minimum of ten location. Each location will be sampled once during the summer of 2017, from June to August. These sample stations were chosen intentionally to achieve a broad spatial distribution throughout the Bagaduce estuary (Table 1). The listed stations were chosen based off the Department of Maine Resources (DMR) GIS map of Aquaculture using a Low Tide orthoimagry layer (http://www.maine.gov/dmr/aquaculture/leases/decisions/index.html) and Google Earth was used to collect the approximate latitudes and longitudes. The coordinates were saved in Excel as a CSV (Comma delimited) file and uploaded as a layer to the GIS base map, overlaid onto the NOAA_RNC layer (Figure 2). All stations were given a 'Station Code' to will assist in the recording and organization of data.

Station number	Common Name	Sation Code	Lat	Long
1	Hatch Cove	HC	44.40004	-68.796725
2	Northern Bay	NB	44.458474	-68.717309
3	Green Cove	GC	44.409153	-68.72306
4	Tom Cod Cove	CC	44.358528	-68.803649
5	Wasson Cove	WC	44.377225	-68.768476
6	Great Island Cove	GIC	44.377945	-68.790105
7	Tills Cove	TC	44.43325	-68.743728
8	Lower Negro Island	LNI	44.405665	-68.774316
9	Grindels Eddy	GE	44.428646	-68.763482
10	Gravel Island	GVI	44.440057	-68.726309

Table 1: Approximate geographic locations of sample stations. Distribution of sample stations can be seen in Fig. 2.

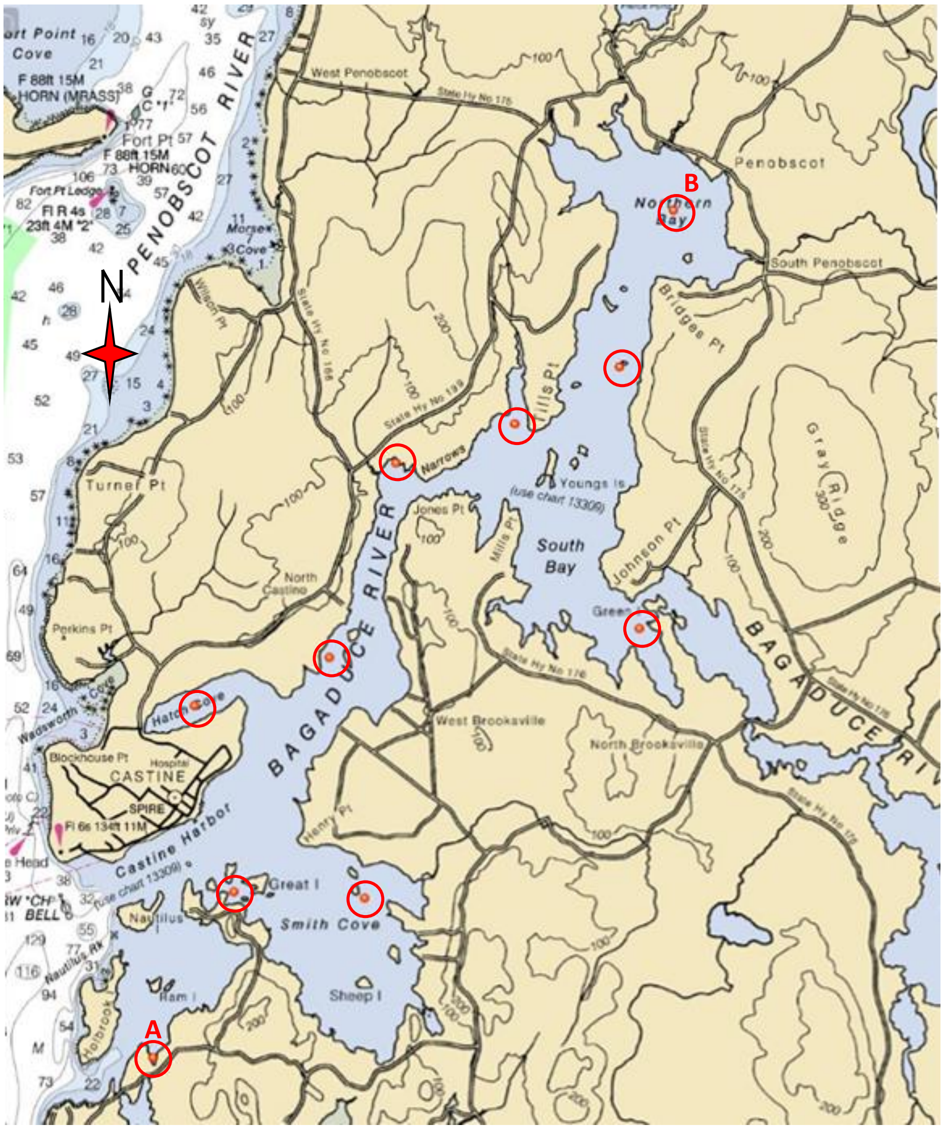

Fig. 2: Bagaduce River GIS map displaying NOAA_RNC layer and CSV Sample Locations layer. The ten sample stations are indicated by red dots, highlighted by red circles. Station A is Toms Cove. Station B is Northern Bay.

3.3 Data Collection

Mudflat sediments and overlying ocean water will be tested for pH using a HI99121 Hanna Soil pH meter. This model measures both temperature and pH and has automatic temperature compensation which will remove errors that stem from changes in the electrode's sensitivity that are due to fluctuations in temperature. A manual, hand-held HRS16 refractometer will be used to test the salinity of the overlying ocean water. All data will be collected in the field.

Prior to sampling, the soil pH meter and refractometer will be calibrated in the lab. Both instruments will first be rinsed in Deionized (DI) water to remove any films or impurities that may interfere with measurements. The soil pH meter will be calibrated using a 7.01 buffering solution and a 10.01 buffering solution. These buffering solutions are recommended for measuring substances where the pH will fall within the alkaline scale, such as ocean water. The refractometer will be calibrated using DI water and cross-checked using a Sper Scientific 300034 Digital Refractometer.

In field work there are many variables that must be accounted for because they cannot be controlled. Ambient temperature, freshwater inputs, time of day, and weather are all variables that may affect the porewater and surface water pH. To account for these variables and to help interpret collected pH data, the daily temperature range, temperature at time of sampling, and weather conditions for sample day/day before will be collected from BuoyF10 in Penobscot Bay and from the weather reporting tower on top of Dismukes Hall in Castine, Maine.

3.4 Bagaduce River Estuary Survey

The Bagaduce River Estuary Survey will begin in June 2017 and will conclude in August 2017. It will focus on sampling pH range and spatial variability throughout the Bagaduce River, Handcock County, Maine. A minimum of ten stations (Table 1, Fig. 2), chosen intentionally to provide broad, spatial distribution, will be sampled once over the course of this survey.

Sampling will begin three hours before low tide on an ebbing tide and continue until slack low tide. Temperature, weather conditions, and start time will be recorded at each sample station. A handheld Garmin eTrex® 20x will be used to take the actual latitude and longitude of the individual sample sites within a sample station. At each sample station, there will be a minimum of five sample sites where porewater data are collected. These sites will be spaced roughly five meters apart, about 6.5 paces, along a transect line. This distance was chosen to achieve a comprehensive mudflat profile within a limited, three hour, time slot. The exact number of sample sites will vary based on local field conditions, such as mudflat size and accessibility. Sample sites will run parallel to the falling tide line at about 1 meter (1.5 paces) above the current water height (see Fig.3). This is done to maintain homogeny in the porewater saturation and time that the sediments spend exposed. In order to understand the variability in seawater pH between mid and low ebb tide, the overlying water data (pH, temperature, and salinity) will be collected at the first sample site and at the last sample site. In 15 cm (ankle height) seawater, the pH meter probe will be partially submerged in ocean water and two separate pH/temperature reading will be taken (providing the error is not greater than 0.2). The refractometer will be used for two salinity readings.

At each sample site, three replicate samples will be taken within a 0.5 m^2 quadrat. If there is greater than a 0.2 error between any of the three replicates, a fourth replicate will be taken. Each replicate will consist of one pH meter probe reading at a sediment depth of 2 cm and one reading at a sediment depth of 5 cm. For each replicate, a hole must first be made using a plastic dribble (a stick the diameter of the probe), to reduce the risk of breaking the probe. The dribble will be marked at 2 cm and at 5 cm so that it can be inserted to the proper depth.

3.4.1 Completing One Replicate:

A 2 cm deep hole will be made using the dribble. The pH probe will then be inserted and temperature and pH will be recorded when the NOT STABLE indicator on pH meter display is turned off. The dribble will be reinserted into the same hole, to the new depth of 5cm, and the pH probe will follow. After each replicate, and between sample sites, the dribble and probe will be rinsed with DI water to prevent any cross-contamination.

3.4.2 ArcGIS Layer Analysis

The pH replicates will be averaged by sample site. The mean and standard deviation will be loaded into an excel spreadsheet and converted into a GIS data layer. The pH data layer will be overlaid on the Public Health NPPS Classification layer, which shows clam bed closure status, and a Bagaduce River base map for final analysis and mudflat prioritization in ArcGIS 10.01 (see Section 4).

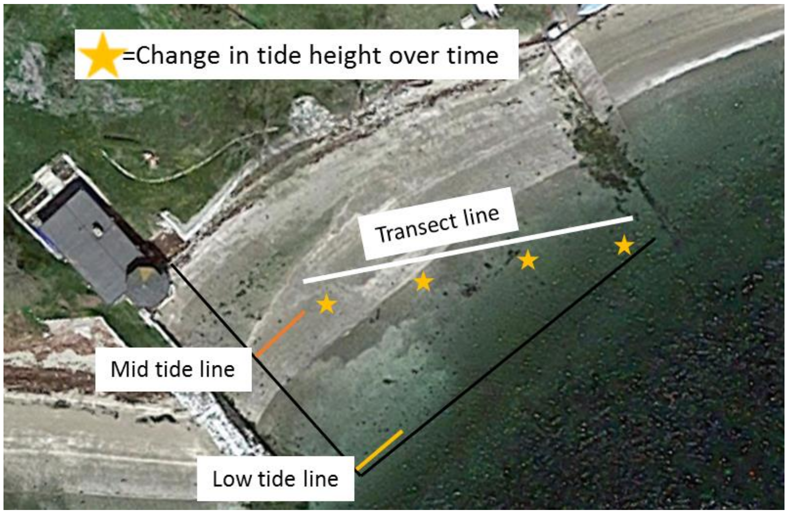

Fig 3: The orientation of a potential transect line across a "sample station". The orange line marks the mid tide line, where the first sample site will be located. The yellow line marks the low tide line, where the last sample site will be located. The yellow stars indicate the change tidal height over time (time passed increases from left to right), while the white transect line follows parallel to the tide height, roughly one meter above it.

3.5 Hatch Cove Survey:

The Hatch Cove Survey will take place in the Hatch Cove mudflat in Castine, Maine (see Fig. 4). The purpose of this survey is to gain an understanding of the variability of pH experience by an area over time and to provide a baseline that can be used to assist in interpreting the data from the Bagaduce River Estuary Survey (see Section 3.4).

Samples will be collected once every week for a minimum of 10 weeks between June 2017 and August 2017. The sampling method is a modified version of the Hancock County Soil and Water Conservation District, Marine Sediment Monitoring Project protocol (Unpublished Report 2016). Sampling will begin one hour before low tide. A vertical transect, from the wrack/high tide line to the water, will be made with three sediment sample sites (high tide line, mid tide, and low tide) and one water site (seawater at low tide) (see Fig. 4). At each sediment sample site, three replicate samples will be taken (unless error exceeds .02) following the methods for completing one replicate (see Section 3.4.1). The overlying seawater pH/temperature sample will be made in 15 cm of water, with the probe partially submerged. The refractometer will be used to sample salinity. Two separate readings of pH, temperature, and salinity will be taken (providing the error is not greater than 0.2).

3.5.1 Hatch Cove Survey Data Analysis

All replicate samples by sample site will be averaged and the mean and standard deviation of temperature and pH will be plotted on by week for each sample site. The pH data will be displayed as a color gradient in ArcGIS along the survey transect for each week. Patterns, if any, throughout the three month survey will be identified and the data will be used as a baseline and comparison for the data collected in the Bagaduce River Estuary Survey (see Section 3.4).

Fig. 4: Location of Hatch Cove. Inset picture depicts the sample sites (yellow stars) along the transect line at high, mid, and low tide.

3.6 GIS

3.6.1 GIS Analysis of Bagaduce River Estuary Survey

ArcGIS 10.01 will be utilized to analyze and identify any potential patterns within the range and/or spatial variability of mudflat porewater pH. A base map of the Bagaduce River and the Public Health NSSP Classification Layer (showing mudflat closure areas) will be downloaded from the Maine Office of GIS website and overlain by the mudflat porewater pH data layer. The pH data will be separated out into a minimum of three bins (i.e. categories) which will be determined based on research of the pH tolerance 'thresholds' of *Mya arenaria* and the surveyed range of pH in the Bagaduce River. These bins (titled Neutral, Low-threat, and

Elevated-threat) will be used in conjuncture with the categorization of closure areas to prioritize mudflats for monitoring and rate their potential susceptibility to increased coastal acidification.

3.6.2 Rating Process

Ratings will be color coded based on two variables: assigned bin and level of closure. Level or classification of closure areas may fall into one of the following categories: Prohibited, Restricted, Conditionally Restricted, Conditionally Approved, and Not Otherwise Specified. Each bin and closure level was given a point value from 1 to 3. These point values will added through the use of a vend-diagram model (see Fig. 5 and Fig. 6). Based off the total number of points earned by each sample location, the prioritization rating from a resource management's perspective will be assigned. Areas of high priority will be indicated on the GIS map in red, areas of intermediate priority in yellow, and areas of low priority in green. Prohibited and Restricted areas will automatically rate a mudflat as low priority because these areas not never, or very rarely open for clamming. This form of low priority will be indicated in purple on the GIS map.

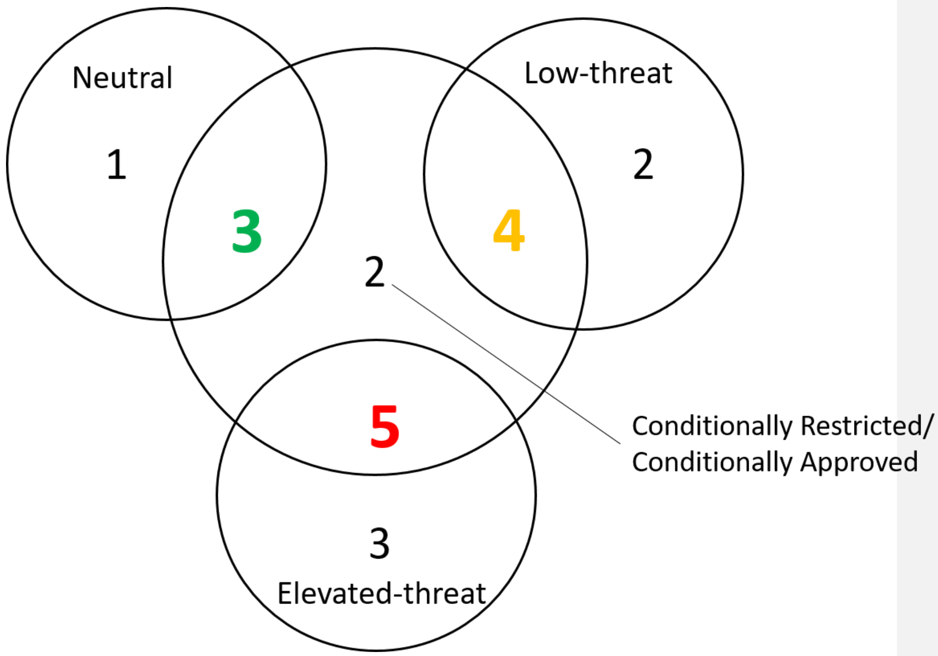

Fig. 5: See Fig. 6 caption.

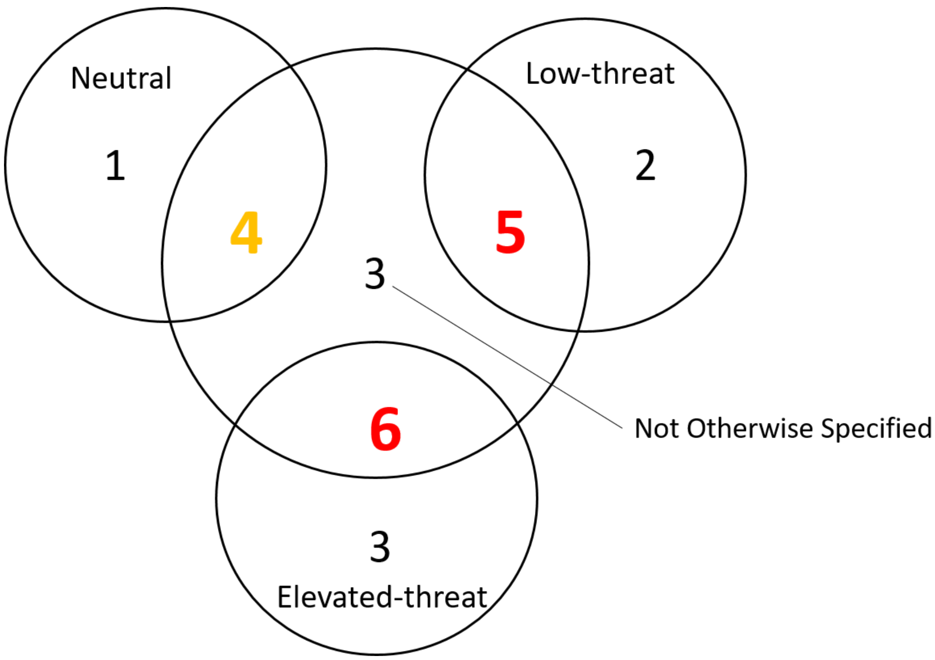

Fig. 5 and Fig. 6: The closure classifications of Conditionally Restricted/Conditionally Approved mudflats will be assigned a point value of 2 (Fig. 5). The closure classification of Not Otherwise Specified is assumed to be open to all clamming and will be assigned a point value of 3 (Fig. 6). Bin pH point values are: Neutral=1, Low-threat=2, and Elevated-threat=3. When point values of both the bins and the closure classification are added the resulting value will determine the location's color on the GIS map: 3= green, 4=yellow, and 5-6=red.

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5 Time Schedule

2017 June

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
28	29	30	31	01	02	03
04	05	06 SEANET Sample 3	07 SEANET Sample 3	08	09 Hatch Cove Survey PM	10
11 Gravel Island Full Survey PM	12	13	14 Hatch Cove Survey AM	15	16	17 Hatch Cove Full Survey AM
18 Begin working on Methods Section	19	20 SEANET Sample 4	21 SEANET Sample 4	22	23 Hatch Cove Survey PM	24 Begin GIS work
25 Hatch Cove Survey PM	26	27	28 Full Survey LNI AM	29	30 Full Survey Tills Cove AM	01
02	03	Notes: AM/PM refer to the time of low tide that I will survey at that day (http://me.usharbors.com/monthly-tides/Maine-Midcoast/Bucks%20Harbor/2017-06) for tide charts				

2017 July

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
25	26	27	28	29	30	01 Rough draft of methods section
02	03	04	05 SEANET Sample 5	06 SEANET Sample 5	07 Hatch Cove Survey PM	08
09 Have McKenna review methods	10 Northern Bay Full Survey PM	11	12 Hatch Cove Survey AM	13	14 Great Island Cove Full Survey AM	15
16	17 Hatch Cove Survey AM	18	19 SEANET Sample 6	20 SEANET Sample 6	21	22
23	24 Green Cove Full Survey PM	25 Tom Cod Cove Full Survey PM	26	27	28 Hatch Cove Survey AM	29
30	31 Hatch Cove Survey PM	Notes: So there are a lot of things that need to be taken into account: When can I use boats? How do I get certified on them? Do I need someone with me at all times? When are people available? Time restrictions? Cost of boat time?				

2017 August

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
30	31 Hatch Cove Survey PM	01	02 SEANET Sample 7	03 SEANET Sample 7	04	05
06	07 Wasson Cove Full Survey PM	08 Grindels Eddy Full Survey PM	09 Hatch Cove Survey PM	10	11 End SEANET?	12
13	14 Hatch Cove Survey AM	15	16 SEANET Sample 8	17 SEANET Sample 8	18 RPT Start?	19 Begin Rationale
20	21 Hatch Cove Survey PM (Douglas B-Day)	22	23	24	25	26 Begin Results
27	28 School Starts: Week 1 (Robert B-Day)	29	30	31	01	02 By today have all loose ends with data tied up and logged into excel
03	04	Notes:				

2017 September

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
27 Week 1	28 School Starts	29	30	31	01	02 All loose ends with data tied up and logged into excel
03 Week 2	04 Contact Rob Watts DMR about poster presentation	05 SEANET Sample 9	06 SEANET Sample 9	07	08	09 All excel sheets will be working data layers
10 Week 3	11	12	13	14	15	16 Methods section done, GIS base map done
17 Week 4	18	19 SEANET Sample 10	20 SEANET Sample 10	21	22	23 Rough draft of rationale done
24 Week 5	25 Have McKenna review rationale	26	27	28	29	30 GIS maps complete
01	02	Notes:				

2017 October

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
01 Week 6	02	03	04	05	06	07 Rough draft of results
08 Week 7	09 Have McKenna review results	10	11	12	13	14 Rough draft of discussion done
15 Week 8	16 Have McKenna review disscussion	17	18	19	20	21 Rationale done
22 Week 9	23	24	25	26	27	28 Results done
29 Week 10	30 Start poster	31	01	02	03	04 Discussion done
05	06	Notes:				

2017 November

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
29 Week 10	30 Start poster	31	01	02	03	04 Discussion done
05 Week 11	06	07	08 Start presentation practice	09	10	11 Visit writing center, final edits
12 Week 12	13 Paper due this week!	14	15 Poster done	16	17 Keep practicing	18
19 Week 13	20 Post presentation #1	21	22 Refine poster	23	24 Keep practicing	25
26 Week 14	27 Final poster presentations	28	29	30	01	02 YOU MADE IT
03	04	Notes:				

6 Budget table

Item	Quantity	Location	Status	Cost
Refractometer	1	Jim McKenna	Own	n/a
pH Soil Meter	1	Jim McKenna	Own	n/a
Calibration Solution 7.01	1	Jim McKenna	Own	n/a
Calibration Solution 10.01	1	Jim McKenna	Own	n/a
Electrode Storage Solution	1	Jim McKenna	Own	n/a
KimWipes	1 box	Rogdgers Lab	Own	n/a
DI Water	1 bottle	Rodgers Lab	Own	n/a
Waterproof Data Sheets	1 pack	n/a	Purchase	$24.00

Boat time (Anbar)*	~20 hours	Waterfront	Purchase/Own	Estimated $1679.40
Institutional Housing	13 weeks	Maine Maritime Dorms	Paid for through QBC Grant	n/a
ArcGIS Software	n/a	Maine Maritime Computer Lab	Own	n/a
Project total:				$1703.40

*Actual boat time may vary, but it is required for access to most of the mudflats where sample stations are located.