Influence of human disturbance on marine invertebrate biodiversity in Acadia National Park's rocky intertidal community

Cassandra Lopez

OS400 Research Prep

Final Proposal

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Statement of the Problem

This field study will characterize and compare biodiversity of common invertebrate macro-fauna in the rocky intertidal zone of Acadia National Park (ANP) within low and high human visitation sites. Community biodiversity and species abundance rates will be measured using a random quadrat sample design at paired high and low visitation sites. Biodiversity indices including Shannon Weiner's Index, Simpson's Index, and Pieolou's evenness will be used to compare high and low visitation sites (Pour et al. 2013). A Mann-Whitney U statistical test will be used to determine whether human visitation has a significant impact on the macroinvertebrate community biodiversity.

Rationale

Communities with high biodiversity and species evenness thrive ecologically whereas communities with low biodiversity do not perform as well (Scrosati et al. 2011a; Scrosati et al. 2011b; Londoño-Cruz E 2014). Biodiversity is typically described as a function of two variables: species richness and evenness, where species richness refers to the total number of species present and species evenness reflects the degree of similarity in proportional abundances of the different species within the community (Scrosati et al. 2011a; Londoño-Cruz E 2014). A variety of biotic and abiotic factors such as habitat, predation, competition, and community productivity influence community biodiversity (Scrosati et al. 2011b; Londoño-Cruz E 2014; Lucas and Smith 2016). For example, according to Scrosati et al. (2011a) when ecological stress levels increase, the community biodiversity decreases because of a lack of optimal conditions. In rocky intertidal communities, trampling from human visitation may be an important ecological stressor influencing community biodiversity (Olson 2009; Pour et al. 2013).

Rocky intertidal shores experience both natural disturbances such as wave exposure, tides, and predation, as well as human disturbance (Pour et al. 2013; Long and Mitchell 2014; Long and Mitchell 2015; Lucas and Smith 2016). Human interference on beaches and accessible waterfronts can affect the biodiversity of organisms especially in the rocky intertidal zones (Keough et al. 1993; Keough and Quinn 1998; Pour et al. 2013; Bloch and Klingbeil 2016). For example two common species residing in the high zone, barnacles and periwinkles, are subject to being trampled as they are visible on the surfaces of rocks (Pour et al. 2013; Ammann et al. 2014). Common interference can include people collecting bio-fauna, bait, and rock turning, leading to disturbing communities (Keough et al. 1993; Olson 2009; Keough and Quinn 1998;

Pour et al. 2013; Bloch and Klingbeil 2016). People walk along beaches and for every six steps, 95% of an individual can be destroyed or killed (Olson 2009). Through this displacement of human disturbance, the shape and size of macro-fauna may be greatly reduced or ecosystems may be shifted if keystone species are removed (Keough et al. 1993). In the case of baiting, fisherman select for the largest mussel or limpet leaving only small organisms. Due to this size selection, the population shifts to a smaller sized base (Professor McKenna, Sarah Markwood and Mike Wise, personal communication, April 13th, 2017). As organisms are moved or disturbed by visitors in the rocky intertidal zone due to fascination, those organisms are subject to greater risks of mortality.

Little information is known regarding the biodiversity of macroinvertebrates within the rocky intertidal zone of ANP. Of the many studies done in ANP, very few of those have been done to quantify the biodiversity of macroinvertebrates within the park. Understanding the macroinvertebrate biodiversity is pertinent to management which assess needs for new protective policies, human visitation impacts, and allocation of funds. Although ANP is a protected area, anyone who pays can enter, walk the trails, and visit the rocky intertidal zone. In being so easily accessible to the general public, the environment is subject to high human disturbance.

Monitoring of the rocky intertidal shores allows for scientists to determine if the area is being maintained properly or if further protocols need to be implemented as visitors increase (Roy et al. 2003; Ammann et al. 2014; Long and Mitchell 2014; Long and Mitchell 2015). Within ANP exist three heavily visited areas: Bass Harbor Head trail, Ship Harbor Head trail and Wonderland trail which lead to the rocky shores. At all three locations, there are less visited areas which have

minimal damage due to anthropogenic factors, like trampling and rock turning. With the rate of tourism increasing especially during summertime, the biodiversity of ANP may be negatively affected.

Methods

Site Description:

Acadia National Park lies on the coast of Mount Desert Island, ME (44.3386° N, 68.2733° W). Established in 1929 and maintained by the National Park Service, ANP encompasses 47,000 acres and provides a home for birds, mammals, amphibians, invertebrates, marine fauna and flora (Park Statistics). Acadia consists of trails, beach, and rocky intertidal zones that play important biological and ecological roles (Park Statistics). Although heavily protected, ANP is a popular tourist destination with over 2 million people visiting each year most in the peak months of July, August and September (Park Statistics) ANP is home to many intertidal marine organisms, including invertebrates and algal species. The rocky intertidal zone has thick algal covers consisting of rockweed/bladder wrack (*Fucus spp./Fucus vesiculosus*), knotted wrackweed (*Ascophyllum nodosum),* dulse (*Palmaria palmata*), and coralline algae (*Corallina officinalis and Corallina spp.)*. The tidal range in ANP is over 3 m with semidiurnal high and low tides (Park Statistics). Living amongst these algae are invertebrates including smooth, rough and common periwinkles, green sea urchin, limpets, and crabs.

Three paired sample areas selected will be sampled within the western side of ANP include locations near Bass Harbor Head, Ship Head, and Wonderland (Fig. 1a&1b). Three locations will be in a heavily visited area, whereas the remaining three will be in less frequently visited

sections of ANP. For a site to qualify as low impact, I will be walking 30 minutes away from the high impact zone along the shoreline. A high impact site is defined as the rocky intertidal closest to the trail head. Due to this study focusing on the impact of human disturbance, I assume that many beachgoers will not walk ½ hour along the rocky intertidal zone justifying my use of time for distance. Selected sites will be picked that are similar in habitat, species, rock type, and wave exposure.

Sampling Procedures:

Macroinvertebrate sampling will be done in the late summer to early fall over the course of 6 days at low tide. Three sites have been picked and will be randomly sampled using a random numbers table. The numbers generated will be in respect to the number of footsteps taken as a substitute for X, Y coordinates. Using the numbers generated from the random numbers table, the X coordinate is how many steps will be taken horizontally to the shoreline whereas the Y coordinate applies to how many steps I will take down from the top of the mid intertidal where there is dense rockweed cover (Table 1; Table 2; Table 3; Fig. 2). Once I have taken the necessary steps, a 0.0625 m^2 quadrat will be used to measure all common macroinvertebrates present within the quadrat. A common invertebrate is any organism found at least 50% of the time at all locations (Zabin et al. 2013). All individuals will be identified and counted, including those attached to any substrate (Scrosati et al. 2011a). Cracked organisms, typically barnacles, will be counted if the organism is alive. Often, barnacles occur in patches of hundreds and in order to minimize the time needed to count them all, a 0.0156 m^2 quadrat will be used to subsample as needed and then multiplied by four to estimate the density of the population per the standard 0.0625m^2 quadrat.

Tides and water temperature, will be documented by using local maritime databases (Sindorf et al. 2015). In order to comply with national park regulations, it will not be possible to bring unidentified organisms back to the laboratory to be identified. For that reason, only common species of macroinvertebrates will be counted and identified. Photos will be taken of unidentified organisms for further investigation and data collection for the National Park data set.

I plan on sampling for 6 dates within late July to mid-August, arriving two hours before low tide and staying for two hours past low tide to allow for a four-hour window gap. Additional dates have been set aside in case of poor weather conditions, any mechanical malfunction, and incomplete replicates within a site. Upon arrival at the site, coordinates will be documented using a Garmin hand-held GPS. Within each site, there will be 10 replicates, and more if time allows. Overall, I will have 30 replicates each for high and low visited sites.

Statistical Tests & Analyses:

Biodiversity indices will be computed in Excel to determine the level of biodiversity across all six sample areas. Shannon Weiner index (Equation 1), Simpson's Index (Equation 2) and Pielou's indices (Equation 3) will be generated to differentiate between the species richness and evenness at the distinct locations.

Species diversity is measured by the Shannon Weiner Index which takes into account species evenness and richness:

$$H' = -\sum_{i=1}^{s}(p_i)(\ln p_i) \qquad \text{(Equation 1)}$$

where *s* is the species richness, p_i is the proportional abundance of a single species based on all present species, and H' is the Shannon-Weiner Index.

Simpson's Index is another mathematical equation that measures the amount of diversity within a community: Once the Shannon Weiner Indices are computed, I will be able to calculate Simpson's Index:

$$D = \sum_{i=1}^{S} \frac{n_i(n_i-1)}{N(N-1)} \quad \text{(Equation 2)}$$

where *s* is the species richness, n_i is the number of individuals in one species, and N is the total number of individuals in all species.

On the other end, Pielou's equation takes into account the overall sample size of the community and how evenly represented it is. Pielou's equation accesses the evenness of a population. Thus, Pielou's Evenness Index was determined:

$$J' = \frac{H\prime}{\ln S} \quad \text{(Equation 3)}$$

where H' is the sum of all Shannon Weiner indices calculated in a single community, S is the total number of species present and J' is Pielou's evenness index.

Data will be entered into Excel and SPSS for analyses. Data will be standardized number of individuals per m^2. Shannon Weiner Indices will be tested for normality using Shapiro-Wilk's and Levene's test of homogeneity in SPSS. A Mann Whitney U test will be completed to determine if there is a significant difference in the biodiversity observed within the high impact and low impact sites. Each individual Shannon-Weiner index will be calculated and averaged for a site then compared within the areas of high and low impact.

Table 1. The location of each site with how many steps it takes from the rockweed cover to the low intertidal zone (Y coordinate) and the steps required along the shoreline (X coordinate).

Location	X coordinate (steps)	Y Coordinate (steps)
Ship Head Harbor (High)	0-1000	0-25
Ship Head Harbor (Low)	0-1000	0-30
Wonderland (High)	0-1000	0-25
Wonderland (Low)	0-1000	0-25
Bass Harbor Head (High)	0-1000	0-25
Bass Harbor Head (Low)	0-1000	0-25

Table 2. The (X, Y) coordinates of sample locations within a site were determined using a random numbers generator for the high visitation sites.

Location	(X,Y) Coordinates
Ship Harbor Head (High)	(298,20); (356,2); (712,2); (971,25); (308,16); (819,1); (771,23); (625,19); (635;19); (368; 3)
Wonderland (High)	(552,16); (30,24); (962,6); (531,11); (270,7); (296,15); (310,3); (60,9); (167,17); (842,9)
Bass Harbor Head (High)	(446,9); (970,24); (562,16); (404,21); (744,19); (936,11); (305,13); (337,24); (603,24); (961,8)

Table 3. The (X, Y) coordinates of sample locations within a site were determined using a random numbers generator for the high visitation sites.

Location	(X,Y) Coordinates
Ship Harbor Head (Low)	(118,6); (176,13); (3,29); (867,4); (303,16); (595,21); (426,27); (808,24); (234,5); (470,1)
Wonderland (Low)	(921,19); (747,19); (599,17); (586,15); (447,26); (382,26); (508,20); (935,10); (465, 10); (553,12)
Bass Harbor Head (Low)	(616,19); (154, 15); (400,27); (26,27); (587,8); (879,17); (209,23); (117,19); (102,28); (207,30)

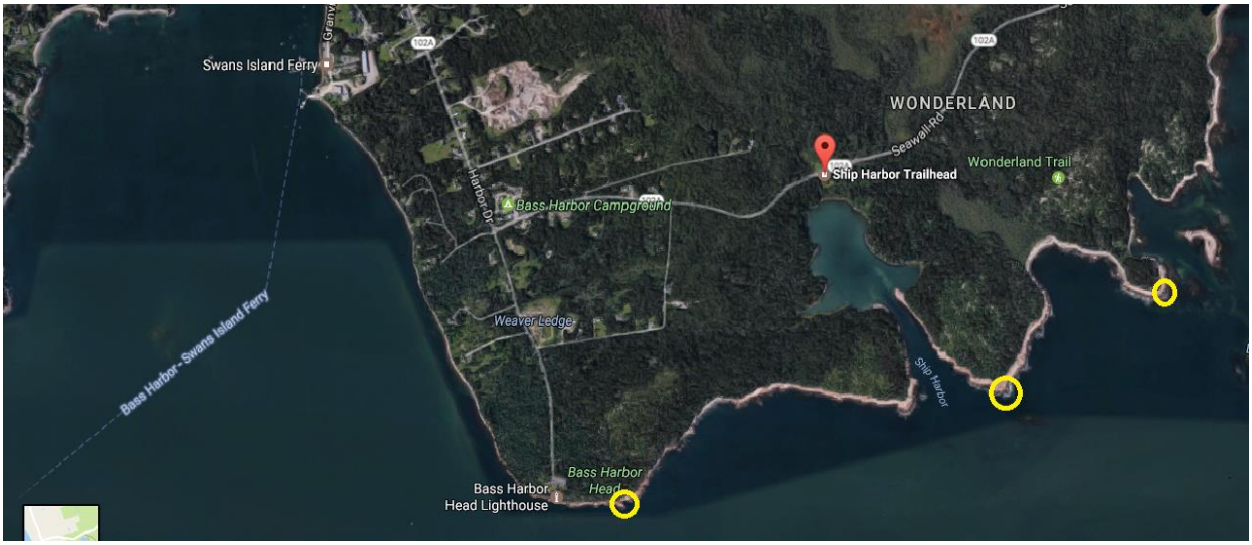

Fig. 1a and 1b. Maps showing Mount Desert Island (MDI) and a second map showing the sites that will be used for sampling.

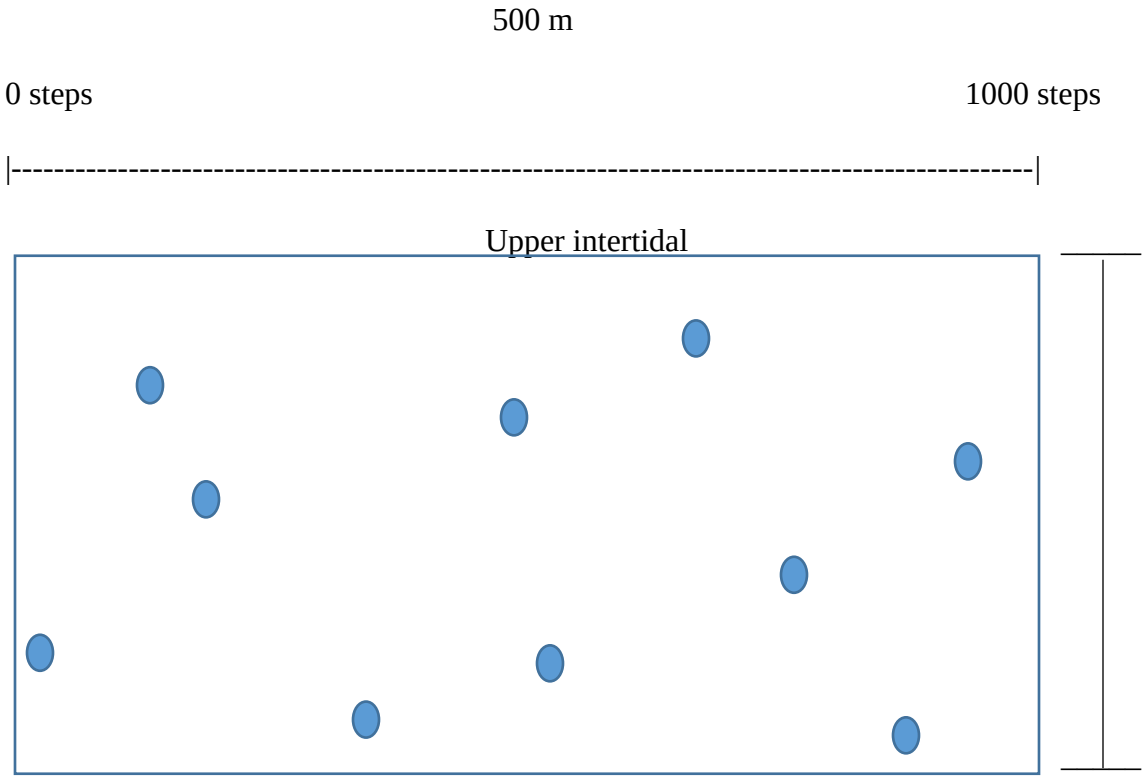

Fig. 2. A sample of how the sample site will be set up. The horizontal line is how many steps I will take for the "X" coordinate while the vertical lines indicate the amount of steps for the "Y" coordinate and where I will sample. The steps range 0-1000 for the horizontal since it takes approximately that many to walk 500 m. The step range of the vertical distribution is undetermined thus far and will be counted April 24th, 2017.

Budget

No costs are associated with any of the materials needed, our department has access to all of it.

Items in Ocean Studies inventory				
Item	**Quantity**	**Location**	**Dates needed**	**Notes**
Field guide	1		4/27/17	Currently in possession
Medium plastic bags	20		4/27/17	
Sharpie	1		4/27/17	
Gray bins	3		4/27/17	Currently in possession
White bucket with handle	1		4/27/17	
GPS (Handheld)	1		4/27/17	
Waterproof paper	40 sheets		4/27/17	
Quadrat	1		4/27/17	Currently in possession

Timeline

Calendars have been created (July-October) giving the timeline of the project which starts in late July and is finalized in Week 12 of OS401. Each day is assigned a task and each portion of the research report is given a week to write with the remaining seven weeks used for editing and finalizing my poster.

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
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24	25	Bass Harbor Head (High) Low tide: 7:13 a.m. Estimated time: 8.5 h 26	Bass Harbor Head (Low) Low tide: 8:03 a.m. Estimated time: 9 h 27	Wonderland Trail (High) Low tide: 8:54 a.m. Estimated time: 8 h 28	Wonderland Trail (Low) Low tide: 9:45 a.m. Estimated time: 8.5 h 29	Ship Head Harbor (High) Low tide: 10:37 a.m. Estimated time: 8 h 30
Ship Head Harbor (Low) Low tide: 11:30 a.m. Estimated time: 8.5 h 31						

JULY

2017

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JUNE 2017

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AUGUST 2017

NOTES:

These are the proposed dates unless weather is too dangerous for sampling.

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
	Writing: Methods (Site Description) 1	Writing: Methods (Sampling Procedure) 2	Writing: Methods (Sampling Procedure) 3	Writing Methods (Statistical Test and Analyses) 4	Writing: Methods (Statistical Test and Analyses) 5	6
7	8	9	10	Bass Harbor Head (High) Low tide: 7:13 a.m. Estimated time: 8.5 h 11	Bass Harbor Head (Low) Low tide: 8:03 a.m. Estimated time: 9 h 12	Wonderland Trail (High) Low tide: 8:54 a.m. Estimated time: 8 h 13
Wonderland Trail (Low) Low tide: 9:45 a.m. Estimated time: 8.5 h 14	Ship Head Harbor (High) Low tide: 10:37 a.m. Estimated time: 8 h 15	Ship Head Harbor (Low) Low tide: 11:30 a.m. Estimated time: 8.5 h 16	17	18	19	20
21	22	Bass Harbor Head (High) Low tide: 7:13 a.m. Estimated time: 8.5 h 23	Bass Harbor Head (Low) Low tide: 8:03 a.m. Estimated time: 9 h 24	Wonderland Trail (High) Low tide: 8:54 a.m. Estimated time: 8 h 25	Wonderland Trail (Low) Low tide: 9:45 a.m. Estimated time: 8.5 h 26	Ship Head Harbor (High) Low tide: 10:37 a.m. Estimated time: 8 h 27
Ship Head Harbor (Low) Low tide: 11:30 a.m. Estimated time: 8.5 h 28	CLASSES START 29	30	31			

AUGUST

2017

JULY 2017

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SEPTEMBER 2017

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NOTES:

First set of proposed makeup dates

Second set of proposed makeup dates

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
28	Input Data into Excel 29	Input Data into Excel 30	Input Data into Excel 31	Input Data into Excel 1	2	3
Biodiversity Indices: Bass Harbor Head 4	Biodiversity Indices: Bass Harbor Head 5	Biodiversity Indices: Wonderland Trail 6	Biodiversity Indices: Wonderland Trail 7	Biodiversity Indices: Ship Head Harbor 8	Biodiversity Indices: Ship Head Harbor 9	10
Statistical analysis: Mann Whitney U 11	Review Results (Mann Whitney U) 12	Review Results (Mann Whitney U) 13	Review Results 14	Review Results 15	Writing: Rationale Section/ Review Results (first paragraph rationale) 16	Writing: Rationale Section/ Review Results (second paragraph rationale) 17
Writing: Rationale Section (third paragraph rationale) 18	Writing: Rationale Section (third paragraph rationale) 19	Writing: Results Section (Compare Simpson's Indices) 20	Writing: Results Section (Compare Pielou's indices) 21	Writing: Results Section (Mann Whitney U results paragraph) 22	Writing: Results Section (Mann Whitney U results paragraph) 23	24
Writing: Discussion Section (First paragraph) 25	Writing: Discussion Section (Second paragraph) 26	Writing: Discussion Section (Third paragraph) 27	Writing: Discussion Section (Fourth paragraph) 28	Writing: Discussion Section (Fifth paragraph) 29	30	

SEPTEMBER 2017

AUGUST 2017

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OCTOBER 2017

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NOTES:

Proposed dates for tasks to accomplish

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
Make Poster 16	Make Poster 17	Make Poster 18	19	20	21	22
23	24	25	26	27	28	29
30	31					

Review Final Research Paper

Review Final Research Paper

Review Final Research Paper

OCTOBER

2017

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SEPTEMBER 2017

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NOVEMBER 2017

NOTES:

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
			FACULTY MEMBERS REVIEW 1	2	3	4
FACULTY MEMBERS REVIEW 5	6	7	8	9	10	11
12	FINAL RESEARCH PAPER DUE 13	14	15	16	17	18
19	Poster Presentation to Course instructor 20	Refine Poster after comments 21	Practice Poster Presentation 22	23	24	25
26	POSTER PRESENTATION OCEAN STUDIES DEPARTMENT 27	28	29	30		

NOVEMBER

2017

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OCTOBER 2017

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17	18	19	20	21	22	23
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DECEMBER 2017

NOTES:

Literature Cited

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