Boston Harbor Islands Intertidal Bioblitz

August 18, 2008

Final Report

January 2009

Catherine Matassa, Science Coordinator

Marine Science Center, Northeastern University, Nahant, MA

Contents:

I. Sampling Locations and Protocol 2
II. Identified Taxa 5
III. Patterns of Intertidal Species Richness 10
IV. Comments from the Science Coordinator 14
V. Appendices 16

I. Sampling Locations and Protocol

Morning Field Work

Forty professionals (scientists and naturalists) sampled 6 of the 34 Boston Harbor Islands during the morning low tide (0650h, 0.0 MLLW) on August 18, 2008: Outer Brewster, Calf, Little Brewster, Peddocks, Grape, and Langlee Islands. Professionals departed EDIC Pier 10 in South Boston at 0515h aboard two landing crafts[1] and arrived at study sites on Little Brewster, Peddocks, Grape, and Langlee Islands by 0600h. Due to limited boat access at low tide, those exploring Calf and Outer Brewster Islands were deployed during mid-tide the previous day (1500h, August 17, 2008) and camped overnight on their respective islands.

Professionals explored permanent rocky outcrops and cobbles beaches on the Islands. On some of the islands, mudflats/salt marshes were also investigated (for maps and GPS coordinates of the Islands, and study sites on each island, see Appendix 1). Two groups of 3-5 professionals were deployed to each Island. Each group was equipped with a $0.25m^2$ quadrat (0.5m x 0.5m), measuring tape, nylon rope (3m), Rite-in-the-Rain® notebook, pencils, specimen containers, and ethanol preservative. Quadrats were placed haphazardly in low-, mid-, and high-intertidal areas, and three or more quadrats were sampled in each zone at each site. For each quadrat we measured rugosity by placing one end of the rope in one corner of the quadrat, laying it down along the substrate following the contours (i.e., over rocks, into crevices, etc.) along the diagonal of the quadrat to the opposite corner. This was repeated for the other diagonal as well. Dividing the length of the rope from corner to corner by the "flat" diagonal distance (0.71m for a 0.5m x 0.5m quadrat) gives the rugosity, a measure of three-dimensional structural complexity. Each quadrat was then comprehensively searched to determine the number and identity of all species present. Participants were also encouraged to search surrounding areas for species not present in the quadrat samples (exploratory sampling). These areas included anything outside the quadrats and non-rocky habitats such as salt marshes and mudflats.

After approximately three to four hours of sampling in the morning, professionals returned to Thompson Island Outward Bound Education Center (TIOBEC) to identify specimens that were not identified in the field. Unidentified specimens were given a numerical code and

[1] Rowes Wharf Water Taxi service; http://www.roweswharfwatertaxi.com/ourfleet.html#culebra, and University of Massachusetts, http://www.umb.edu/umb/marineops/landingCraft.html

either photographed or brought back to the laboratory for identification. (See Appendix 2 for the detailed protocols given to Bioblitz participants.)

Laboratory Identifications

Organisms that scientists were not able to identify in the field were brought back to the laboratory in glass jars or vials filled with seawater or ethanol. Each specimen was given a code that identified the location (Island, tidal height, and/or specific quadrat) from which it was collected. Codes were written on small tags made of waterproof paper stored in each individual vial with the specimen. Some unidentified specimens were photographed with a code tag in lieu of collection (i.e., encrusting algae).

TIOBEC and Northeastern University Marine Science Center (MSC) provided compound and dissecting microscopes for use during the Bioblitz, while the MSC and National Park Service (NPS) provided dissecting kits and invertebrate and algae identification keys. Scientists were encouraged to bring their own reference materials to aid in the identification process. The names of identified specimens and corresponding codes were written on an inventory sheet in the laboratory. As scientists identified specimens, the Science Coordinator updated the list of species found on each island and presented these data continuously on a digital map (see Appendix 3) projected on a screen in the laboratory. This allowed all visitors to track the progress of the Bioblitzers. NPS provided the digital projector.

Due to time constraints, not all specimens were identified during the Bioblitz. These specimens were returned to the MSC for future identification by the Bioblitz Science Coordinator using the same protocol and field guides.

Afternoon Field Work

Public Bioblitz participants arrived at TIOBEC as scientists worked in the laboratory to identify species from the morning fieldwork. Forty public participants (24 adults, 14 students age 14-17, and 2 children under age 10) departed EDIC Pier 10 at 1400h aboard the M/V Culebra and arrived at TIOBEC at 1430. Participants were first welcomed by Marc Albert of NPS and received a short Bioblitz training session from Dr. Jeremy Long of the MSC. Participants then toured the laboratory where scientists and naturalists were identifying specimens collected or photographed during the morning sampling effort.

Participants were given a choice of sampling location for the afternoon Bioblitz: Thompson Island or Lovells Island. With professional guides, public participants departed for Lovells Islands at 1600h to sample the cobble beach along its northern shores. The remaining participants explored the cobble beaches and salt marsh on Thompson Island with professional guides. All public participants followed the protocol described above, sampling cobble beaches using quadrats and identifying unique species outside of the quadrats in rocky and non-rocky habitats.

Data Management and Analysis

The Science Coordinator compiled a master list of the species found in each quadrat, at each tidal height, and on each Island during the bioblitz. On this spreadsheet, created with Microsoft Excel, each individual identified specimen was listed along with the quadrat from which it was sampled, the rugosity of that quadrat, the time and location (Island, tidal height, substrate type) when and where it was found, and the group who identified it in the field. Species found outside of the quadrats were entered in the same fashion but did not include quadrat information. Unidentified species were entered into the spreadsheet using their identification code (see protocol in Appendix 2). For example:

Island	**Group #**	**Habitat**	**Tidal Height**	**Quadrat #**	**Time**	**Mean Rugosity**	**Species**	**Phylum**
Calf	2	Rock	High	10	0846	1.66	*Porphyra umbilicalis*	Rhodophyta
Grape	10	Cobble	Low	1	0745	0.99	*Lepidonotus squamatus*	Annelida
Little	11	Rock	Low	1	0629	1.03	*Little-11-1-7*	Chlorophyta
Peddocks	7	Cobble	Mid	Outside	0752	N/A	*Nereis virens*	Annelida

Once all the unidentified specimens were identified, codes were substituted with actual species names. Data analysis was performed using the JMP statistical software package (SAS Institute; Cary, N.C.).

II. Identified Taxa

On the following pages is a comprehensive list of species (and phylum or division) found via quadrat and non-quadrat (exploratory sampling) protocols on each island and within various habitats, including salt marshes (**M**), permanent rock (**R**), cobble beaches (**C**), and dock pilings (**D**). Island symbols are **CALF** (Calf), **GRAP** (Grape), **LANG** (Langlee), **LIBR** (Little Brewster), **LOVE** (Lovells), **OUBR** (Outer Brewster), **PEDD** (Peddocks), and **THOM** (Thompson). Numbers in each column indicate the number of incidences that a species was found in the corresponding habitat/Island.

		CALF		GRAP	LANG		LIBR	LOVE	OUBR	PEDD			THOM	
Phylum or Division	Species	M	R	C	C	R	R	C	R	C	D	M	C	M
Angiospermae	*Agrostis stolonifera*											1		
	Artemesia spp.													1
	Atriplex patula											1		1
	Cakile edentula													1
	Calamagrostis canadensis											1		
	Calystegia sepium											1		
	Datura stramonium													1
	Distichlis spicata	1										1		1
	Elytrigia pungens											1		
	Elytrigia repens											1		1
	Festuca rubra											1		
	Iva frutescens											1		
	Juncus gerardii											1		1
	Kochia scoparia											1		1
	Lepidium latifolium													1
	Limonium carolinianum											1		1
	Limonium nashii	1												
	Morella pensylvanica											1		
	Phragmites australis											1		1
	Puccinellia maritima											1		1
	Raphanus raphanistrum													1
	Rosa rugosa											1		
	Salicornia maritima													1
	Schoenoplectus pungens											1		
	Solidago sempervirens											1		1
	Sonchus arvensis											1		
	Spartina alterniflora	1										1		1
	Spartina patens	1										1		1

	Suaeda linearis											1		1		
	Suaeda maritima	1														
	Teucrium canadense											1				
Annelida	*Enchytraeus albidus*			1						3						
	Eteone longa			1												
	Lepidonotus squamatus		1							1						
	Nereis virens							2		1						
	Pectinaria gouldii									1						
	Polydora cornuta			1												
	Spio filiformis			1												
	Spirorbis spirorbis		1													
	Streblospio benedicti			1												
Arthropoda	*Anax junius*											1				
	Ant (unidentified species)											1				
	Anurida maritima			2	4	5	1							2	1	
	Batea catharinensis						2									
	Bombus spp.											1				
	Cancer borealis		1													
	Cancer irroratus		1													
	Caprella equilibra					1										
	Caprella penantis						2									
	Carcinus maenas		1	4	3	5	4	2	3	3		1		4	1	
	Corophium spp.								1		1					
	Cumacean (unidentified species)													1		
	Cymadusa compta								5							
	Erichthonius brasiliensis								5							
	Gammarus oceanicus			1						1						
	Hemigrapsus sanguineus			1	1		1	5	2	11				11		
	Hyale nilssoni		1				1		1							
	Idotea baltica		5													
	Idotea phosphorea		4				1		2							
	Jaera marina			1		2	1			2				4		
	Jassa marmorata		1													
	Melita nitida									2						
	Ochlerotatus sollicitans											1				
	Orchestia grillus											1				
	Pagurus acadianus		1													
	Pagurus longicarpus		2	1	2		2	6		5				2	1	
	Palaemonetes pugio											1				
	Philoscia vittata											1				
	Pontogeneia inermis						3									
	Semibalanus balanoides		12	15	5	9	9	11	15	15				11	1	
	Spider (unidentified species)											1				
	Tabanus nigrovittatus											1				

Bryozoa	*Alcyonidium polyoum*			1		6		2		11					
	Bowerbankia grivalis										1				
	Bugula simplex			1											
	Electra crustulenta		3						5						
	Electra pilosa		1	3		1		1	2	1			1		
	Membranipora membranacea		1	3	2	1				1			1		
	Membranipora tuberculata								1						
Chlorophyta	*Acrosiphonia arcta*		2												
	Chaetomorpha brachygona								1						
	Chaetomorpha linum		1	1											
	Chaetomorpha picquotiana		1												
	Cladophora rupestris		1					1							
	Pseudendoclonium submarinum			1			1		2		1		1		
	Sphacelaria arcta								2						
	Ulothrix flacca					1	2		1						
	Ulva intestinalis		1			1					1				1
	Ulva lactuca		11	4			2		9		1				1
	Ulva linza		1			1			2						
	Ulvaria obscura								1						
	Urospora penicilliformis					1									
Chordata	*Anas platyrhynchos*														1
	Anas rubripes														1
	Carpodacus mexicanus														1
	Charadrius melodus								1						
	Egretta thula														1
	Fundulus heteroclitus											1			1
	Fundulus majalis														1
	Haematopus palliatus														1
	Larus argentatus											1			1
	Larus marinus														1
	Leucophaeus atricilla														1
	Megaceryle alcyon														1
	Melospiza melodia											1			
	Menidia menidia											1			1
	Myoxocephalus scorpius					1									
	Numenius phaeopus														1
	Pluvialis squatarola											1			1
	Tachycineta bicolor											1			
	Tringa melanoleuca											1			1
	Troglodytes aedon														1
Chordata (Urochordata)	*Botrylloides diegense*								2						
	Botrylloides violeaceous		1	5	2	2	3	2	2	6					1
	Botryllus schlosseri		1			1		1	1	3					
	Styela clava		1	4	1			1		1					

Cnidaria	*Diadumene lineata*													1
	Dynamena pumilla								2					
	Ectopleura spp.										1			
	Hydractinia echinata					1								
	Metridium senile					2			1					
	Obelia dichotoma						1							
	Obelia geniculata						1							
	Sertularia pumila		4				2		2		1			
Coniferophyta	*Juniperus virginiana*											1		
Cyanophyta	Cyanobacteria (unidentified species)			2		2	1			4				
Echinodermata	*Asterias forbesii*								2					
	Asterias vulgaris		1											
	Axiognathus squamatus									2				
	Ophiopholis aculeata		1											
	Strongylocentrotus droebachiensis		2				1		2					
Mollusca	*Acanthodoris pilosa*						2							
	Acmaea testudinalis		1	1	2		4		8	5				
	Anomia squamula								3					
	Chiton (unidentified species)							1						
	Crepidula convexa		4	1	1									
	Crepidula fornicata		1		2	1	1	4	2	7			2	
	Crepidula plana				2		2			4				
	Ensis directus								1					
	Eubranchus spp.										1			
	Hiatella arctica		3						1					
	Ilyanassa obsoleta				1									1
	Lacuna vincta		3				2		3	2				
	Littorina littorea		12	12	6	7	10	11	3	15			12	
	Littorina obtusata		5		2	10	3		6	2				
	Littorina saxatilis		7	3			3	6	10	3			3	
	Mya arenaria				2								2	
	Mytilus edulis		5	4	6	4	1	3	13	11			6	1
	Nucella lapillus		8				5		7	5				
	Onchidoris bilamellata			1										
Nematoda	unidentified species									1				
Nemertina	unidentified species									1				
Phaeophyta	*Alaria esculenta*		1						1					
	Ascophyllum nodosum		1	1	4	8	2		1					
	Desmerestia aculeata								1					
	Ectocarpus fasciculatus		5											
	Ectocarpus siliculosus			2										
	Elachistea fucicola		1	1		3	1		4	2				1
	Fucus distichus edentatus		9	2			5		10					
	Fucus spiralis		7	1		4	2		5					

	Fucus vesiculosis		6	13	3	3	3		1	10						
	Laminaria digitata								1							
	Laminaria longicruris		1													
	Laminaria saccharina		3				1		2							
	Lomentaria clavellosa								1		1					
	Pilayella littoralis		1			1	1									
	Punctaria plantaginea			1												
	Ralfsia verrucosa						1		7							
	Scytosiphon lomentaria						1									
Platyhelminthes	*Euplana gracilis*		1								1					
Porifera	*Halichondria bowerbanki*		1					2	1		1					
	Halichondria panicea		1			3				1						
	Halisarca spp.			5		1										
	Isodictya palmate			5												
Rhodophyta	*Agardhiella subulata*			6												
	Bonnemaisonia hamifera		1													
	Ceramium cimbricum		1						1							
	Ceramium rubrum		1													
	Ceramium virgatum						2		7		1					
	Champia parvula								1							
	Chondrus crispus		1	8	1	4	3	5	7	7			2			
	Corallina officinalis						1									
	Cystoclonium purpureum						2									
	Daysa baillouviana			1												
	Gracilaria tikvahiae		7													
	Grinnellia americana			2												
	Hildenbrandia rubrum		1	7	6	8	6	5	5	5			6			
	Lithothamnion glaciale		1			2		1								
	Lithothamnion variagatum								1							
	Mastocarpus stellatus		11	1			3		6							
	Neosiphonia harveyi										1					
	Palmaria palmata		2						2							
	Phymatolithon lenormandii			4		3	1		4	1			3			
	Plumaria plumosa								2							
	Polysiphonia lanosa		1				2		2							1
	Porphyra leucosticta										1					1
	Porphyra tubula										1					
	Porphyra umbilicalis								1		1					
	Stylonema alsidii		1													

III. Patterns of Intertidal Species Richness

Patterns of Species Richness in the Rocky Intertidal

The greatest rocky intertidal species richness was found on Calf and Outer Brewster Islands, each with 64 species, followed by Little Brewster (47 species), Grape (44), Langlee (40), Peddocks (36), Lovells (20), and Thompson (18) Islands (Figure 1a). A trend of increasing intertidal diversity appears to correlate with distance from the mainland, although the Outer Islands (Calf, Outer Brewster and Little Brewster) also differ from Inner Islands (Grape, Langlee, Peddocks) in that they are more wave-exposed and dominated by permanent rock habitat, while the inner Islands are composed mostly of boulder/cobble substrates[2]. Statistical analysis of quadrat data from professional samples (not including Thompson and Lovells Islands; see Figure 1b) reveals that total species richness varied between the sampled islands (ANOVA, $F_{5,77}$=2.33, p=0.05), with Calf and Outer Brewster Islands having greater species richness than Grape Island. However, this did not lead to a significant difference in species richness between the Inner and Outer Islands in general (nested ANOVA, $F_{1,4}$=3.02, p=0.15).

Figure 1a. Total number of marine species found in rocky intertidal habitats during the AM and PM Bioblitz sampling.

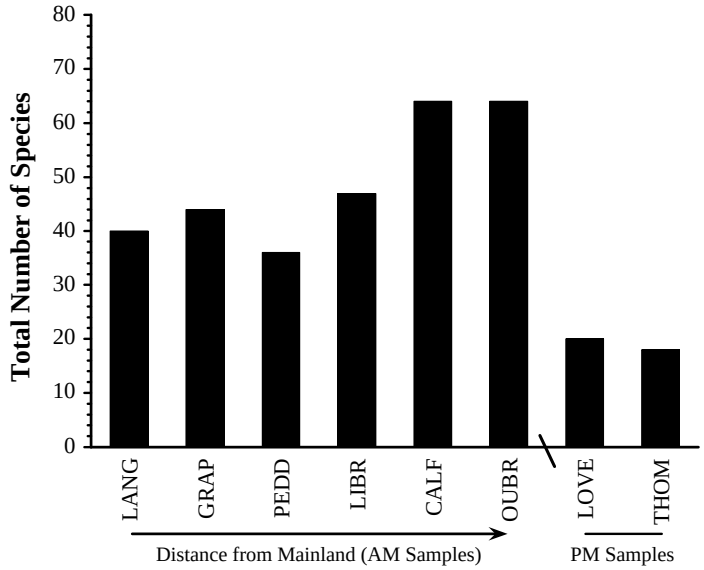
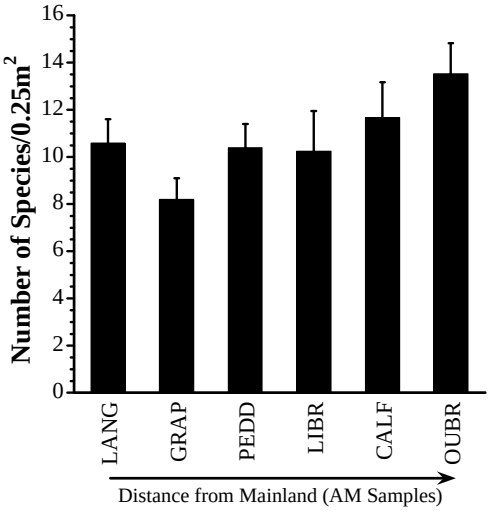


Figure 1b. Mean number of marine species found per professional quadrat sample (+/- SE) in rocky intertidal habitats.

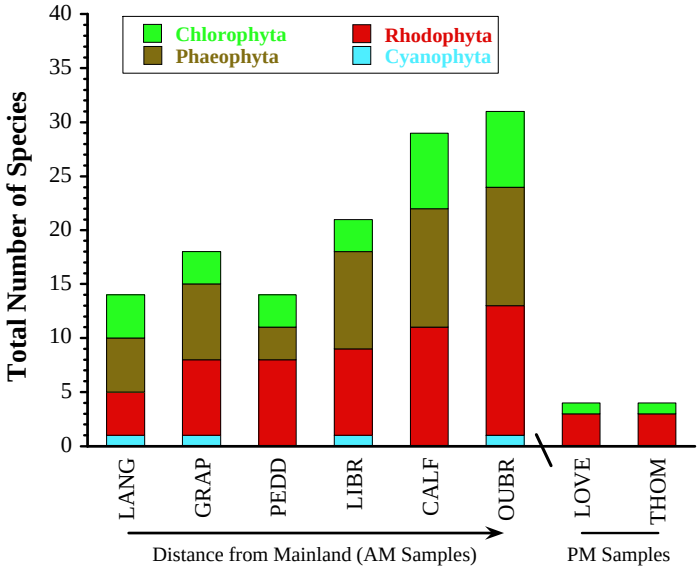


Despite the greater structural complexity (rugosity) of cobble substrates (ANOVA,

[2] Langlee Island has both permanent rock and cobble substrates.

$F_{1,81}$=11.17, p=0.001), permanent rock habitats contained more species (12.0 ± 0.7 vs. 9.3 ± 0.6 species per 0.25m^2, mean ± SE; ANOVA, $F_{1,81}$=7.42, p=0.01). However, because both habitats rarely occurred on the same island, this result is likely an artifact of the differences between islands. This conclusion is supported by the absence of a significant relationship between the rugosity and number of species in a quadrat (Linear Regression, r^2=0.03, $F_{1,81}$=2.11, p=0.15) and by the lack of habitat effects on Langlee Island, where both permanent rock and cobble habitats were sampled (ANOVA, $F_{1,13}$=1.91, p=0.2).

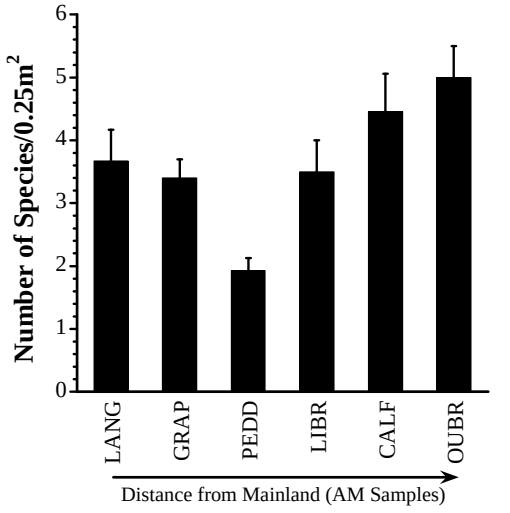
Figure 2a. Total number of algal species, belonging to four major phyla, found in rocky intertidal habitats on each Island during the Bioblitz.



Algae in the Rocky Intertidal

A total of 53 algal species were identified during the Bioblitz. Thirteen chlorophytes (green algae), 17 phaeophytes (brown algae), and 22 rhodophytes (red algae) were identified. Cyanophytes (cyanobacteria) were also found on several of the islands but were not identified beyond phylum, so they are all grouped together for a conservative measure of diversity.

Figure 2b. Mean number of algal species found per professional quadrat sample (+/- SE) in rocky intertidal habitats.



There appears to be a positive relationship between species richness and distance from the mainland (Figure 2a), but statistical analysis revealed that algal species richness did not differ between Outer and Inner Islands (Nested ANOVA, $F_{1,4}$=3.36, p=0.14). The number of algal species present in quadrats did vary from island to island (ANOVA, $F_{5,77}$=6.54, p<0.001), with fewer species on Peddocks Island compared to all other Islands (Linear Contrast, $F_{1,77}$=23.00, p<0.001). Algal diversity was also

significantly greater on permanent rock than in cobble habitats (ANOVA, $F_{1,81}$=26.99, p<0.0001), but this pattern, like total species richness, is probably an artifact of inter-island differences.

Marine Invertebrates in the Rocky Intertidal

A total of 86 marine invertebrates were identified in rocky intertidal habitats during the Bioblitz. Arthropods and mollusks were most diversely represented on the Islands, with 23 and 18 species, respectively. Ten annelid worms, 6 bryozoans, 4 urochordates (a subphylum of the Chordata), 7 cnidarians, 5 echinoderms, and 4 poriferan sponges were identified. A single nematode, nermertean, and flatworm (platyhelminthes) were found (included as "Other" in Figure 3a). The greatest number of marine invertebrate species, were found on Calf (35 species) and Outer Brewster (34 species) Islands. Thirty species were found on Peddocks Island, while Langlee, Grape and Little Brewster Islands each had 26 species. Sixteen species were found on Lovells and 14 on Thompson Island (see Figure 3a).

Figure 3a. Total number of marine invertebrate species, belonging to several major phyla, found during the Bioblitz in rocky intertidal habitats.

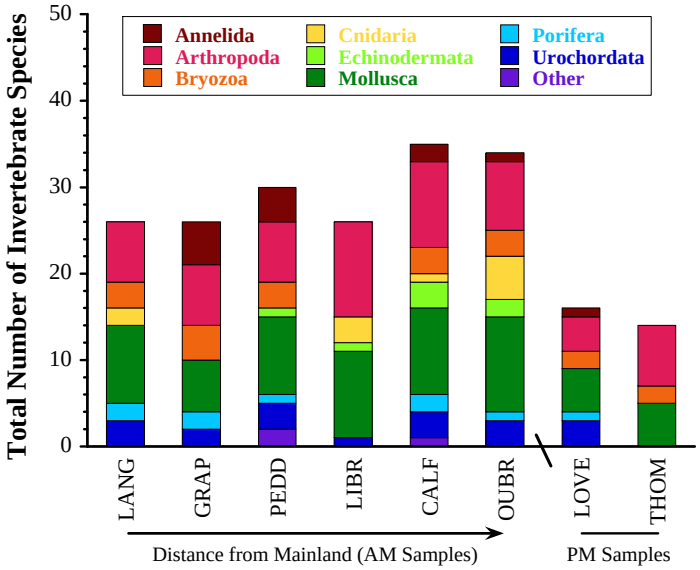
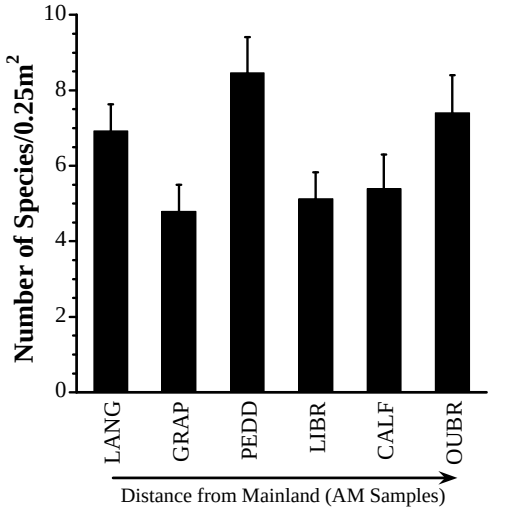


Figure 3b. Mean number of marine invertebrate species found per professional quadrat sample (+/- SE) in rocky intertidal habitats.



The trend for increasing invertebrate richness with increasing distance from the mainland does not appear as strong as that for algae or for total species richness. In fact, invertebrate richness did not differ between Outer and Inner Islands (Nested ANVOVA, $F_{1,4}$=0.33, p=0.6), nor were there any habitat effects (ANOVA, $F_{1,81}$=0.18, p=0.7). The only statistically significant difference detected was between

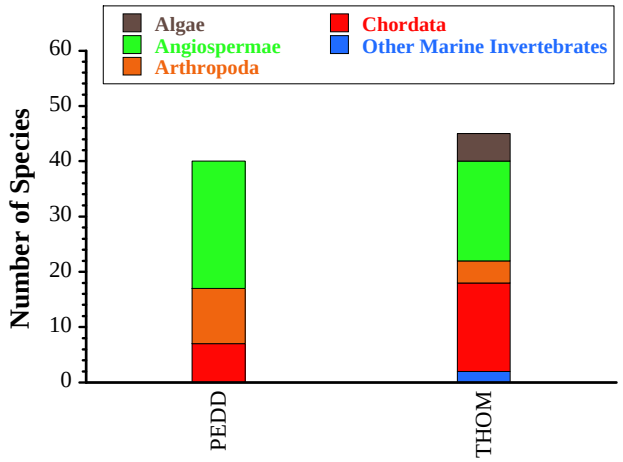
Peddocks and Grape Islands (Linear Contrast, $F_{1,77}$=9.84, p=0.002) .

Biodiversity in Other Intertidal Habitats: Salt Marshes and Fouling Communities

Salt marshes on Peddocks and Thompson Islands, and a small inland marsh on Calf Island, were explored during the Bioblitz using the non-quadrat protocol. A total of 31 flowering plants (Angiospermae), 1 conifer, and 18 vertebrates (fish and sea birds) were unique to the marsh habitats, which included bordering mudflats and tidal channels. Of the thirteen arthropods found in the marsh habitats, 7 were marine species.

Dock pilings on Peddocks Island were also opportunistically sampled during the morning tide. Eight species of marine algae, three of which were unique to this habitat, and nine invertebrates, four of which were also unique to the dock pilings, were identified (see the comprehensive list of identified species, pages 3-8).

Figure 4. Total number of species, belonging to several major phyla, found during the Bioblitz in salt marshes on Peddocks and Thompson Islands.



IV. Comments from the Science Coordinator

Some Recommendations for Future Bioblitzes

Time and Planning

Planning the Bioblitz in only six months was a challenge. More time researching previous Bioblitzes would have been helpful, perhaps contacting other science coordinators, and getting a better understanding of the kinds of quantitative data that could feasibly be obtained via a Bioblitz. Perhaps because this was my first experience with a Bioblitz, I did not know what to expect, but I think talking to other scientists who had been involved in previous Bioblitzes would have been valuable.

Quantifying and Comparing Biodiversity

Measuring diversity typically involves measuring both species richness and species evenness, which requires, at least, a relative measure of abundance for each species present. One of the biggest challenges in designing the scientific protocol was developing a way to standardize search effort, or the amount of time or area that is sampled, because each island was sampled by different people, some inherently more thorough than other or with an eye for a particular phylum.

I think using the quadrats to designate a fixed search area was a simple and effective way to standardize our measures of species richness from island to island. Unfortunately, we did not collect enough useful information about species abundances within the quadrats to calculate evenness, so I have only presented results and analyses of species richness.

One of the scientific goals at the outset of the Bioblitz was to determine if species richness was affected by habitat type: permanent bedrock substrates versus cobble beaches. Because the islands that have permanent rock substrates are typically the most exposed, these islands differ from those consisting of cobble substrates, which are more protected within the harbor, in ways other than substrate type, including wave exposure, water flow, and anthropogenic impacts. Unfortunately disentangling substrate type from these other factors was not completely possible due to logistical constraints of the Bioblitz (i.e., island accessibility, limited time and researchers, etc.). The inability to properly assess habitat effects on diversity and the challenge of standardized sampling were scientific shortcomings of the Bioblitz.

For future Bioblitzes, I would recommend making a clear statement of both the scientific and public relations goals and thinking of creative ways to meet this goals. For example, one way in which scientist-citizen interactions and the quality of data from this Bioblitz could have been improved may have involved abandoning the structure of a single-day Bioblitz. Instead, people could sign up for "Blitzdays," weekly or biweekly outings where 2-3 of scientists take out a small group (5-10) of citizens to thoroughly inventory and quantify biodiversity on a single island. Blitzdays could occur throughout the summer and all of the participants could gather with other interested citizens (those who perhaps could not participate in a Blitzday) in August to share their findings on a "host" island (e.g. TIOBEC, Thompson Island). Scientists and citizens who participated in Blitzdays could lead groups of untrained citizens to investigate the host island, and their findings could be shared and compared to other islands at the end of the day. A scheme like this would provide greater opportunity for and quality of scientist-citizen interactions and allow for quicker identification of species and less back-up of unidentified specimens.

Summary of Science Coordinator Work Hours

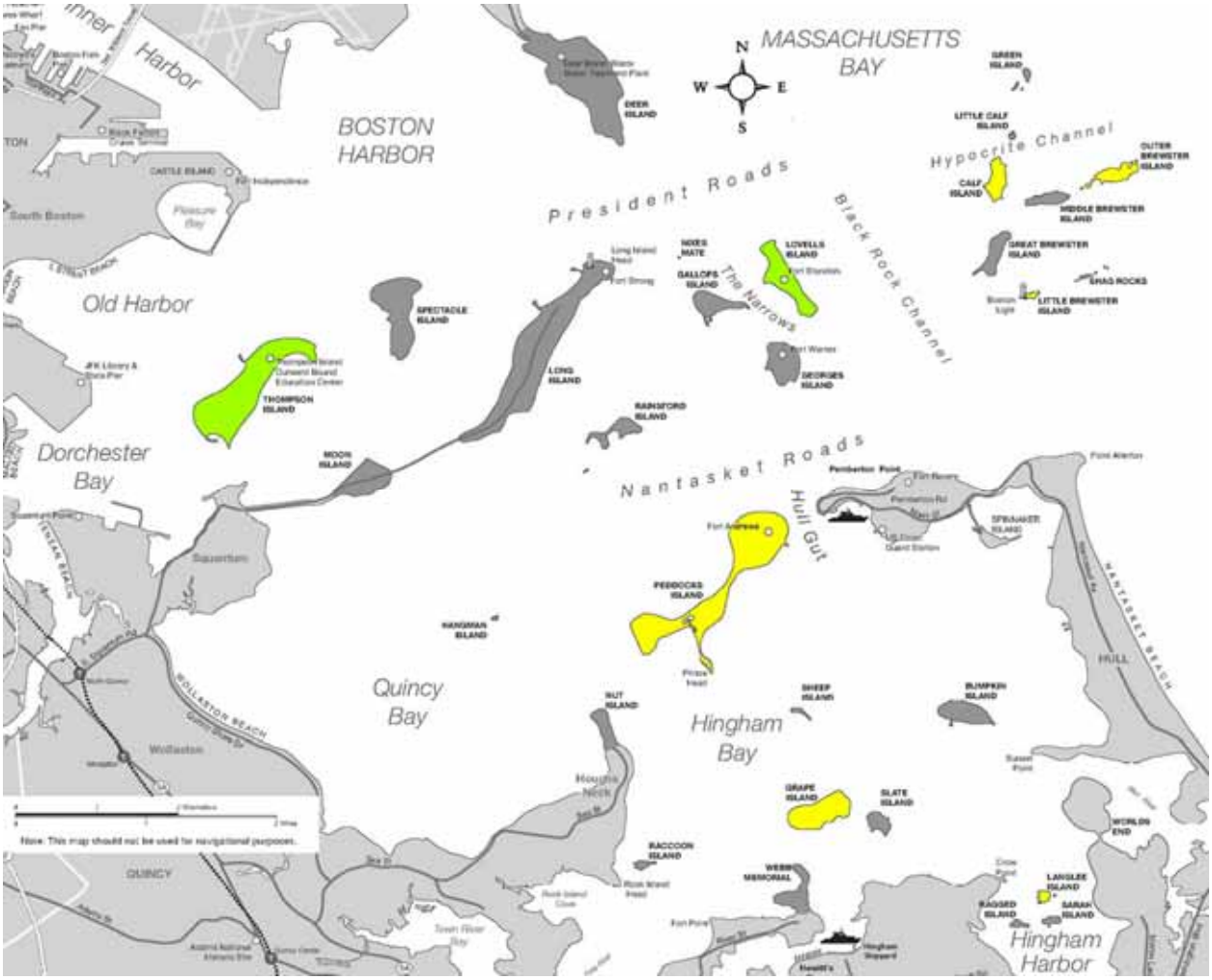
Stage	Activity	Estimated Hours
Planning (before 8/18/08)	Communicating with and registering participants	30
	Designing scientific sampling protocol and schedule	40
	Scouting for study sites	20
	Meetings with NPS staff	20
	Ordering, gathering, and preparing equipment	20
	Preparing TIOBEC laboratory	8
Bioblitz Day (8/18/08)	Registration of professional participants at EDIC	2
	Field work	4
	Laboratory work	4
	TIOBEC laboratory clean-up	4
	Misc.	4
Data/Reports (after 8/18/08)	Identifying remaining specimens	40
	Data entry	20
	Data analysis	16
	Preparing graphics	8
	Preparing draft report	40
	Preparing final report	32

Total hours dedicated to intertidal biodiversity at the Boston Harbor Islands national park area: 312

V. Appendices

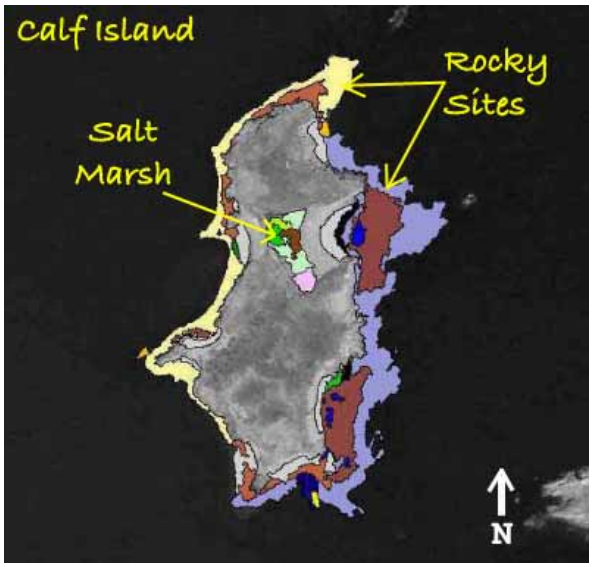
Appendix 1.

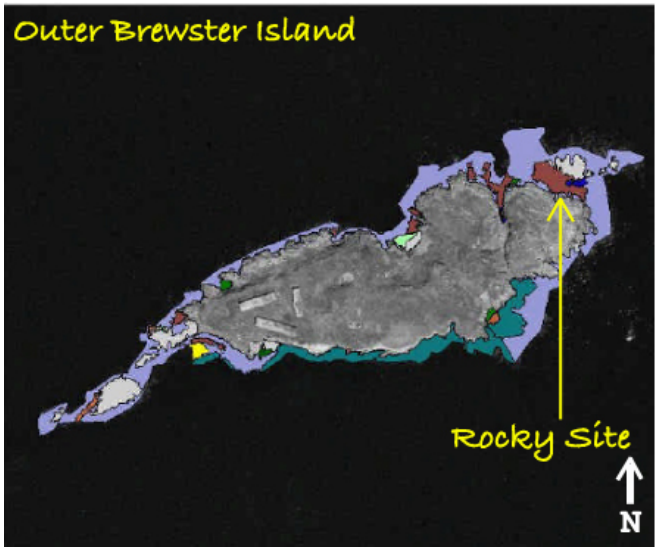
A. Map of Islands sampled during the Boston Harbor Islands Intertidal Bioblitz. Yellow islands were sampled by scientists and professional naturalists during the AM low tide. Green islands were samples by public Bioblitz participants with professional guides during the PM low tide.

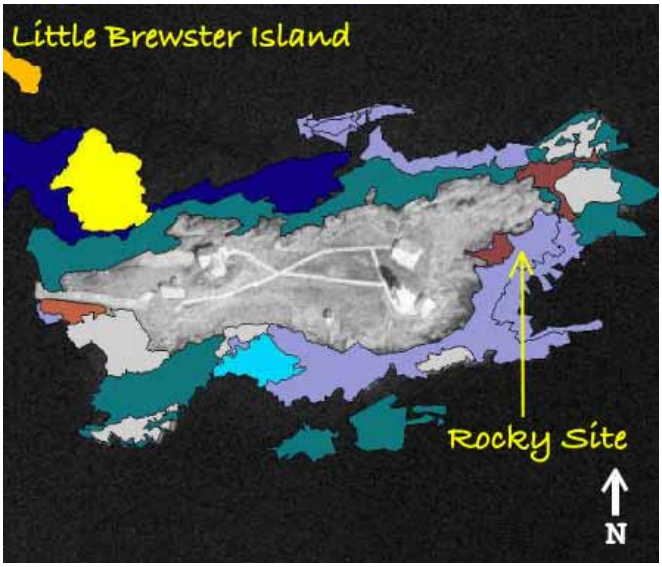


B. Maps of individual islands and study sites.

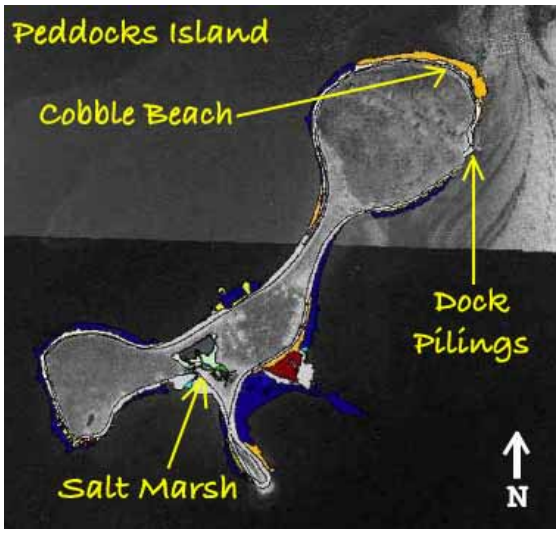
Outer Islands

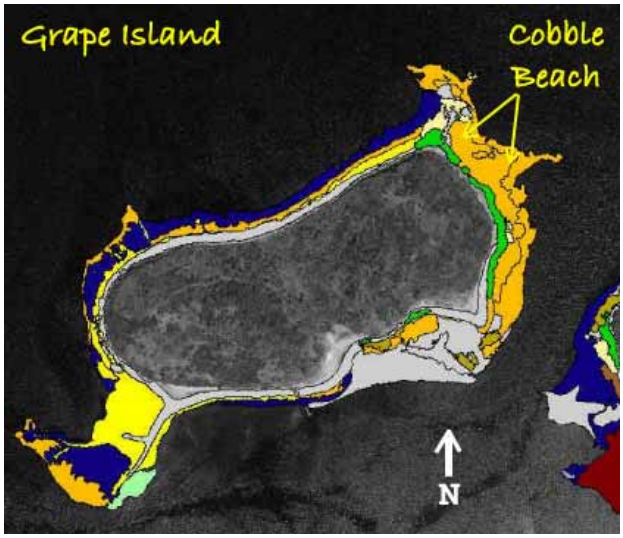


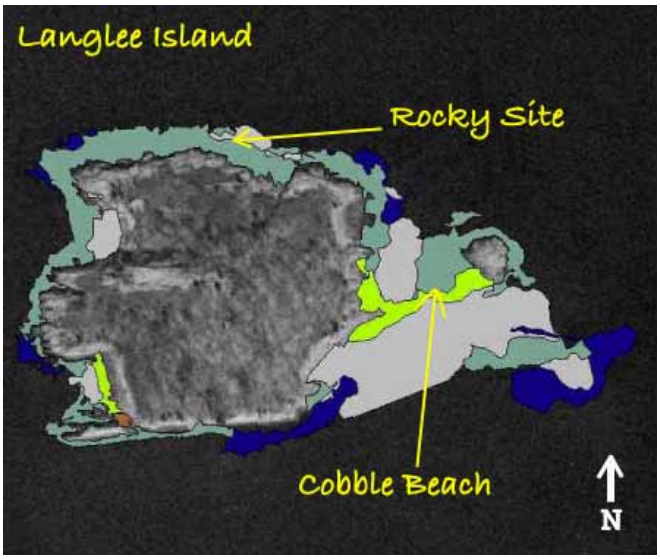


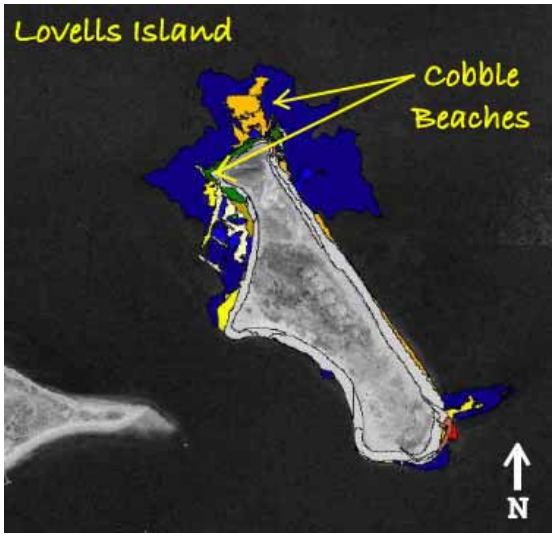


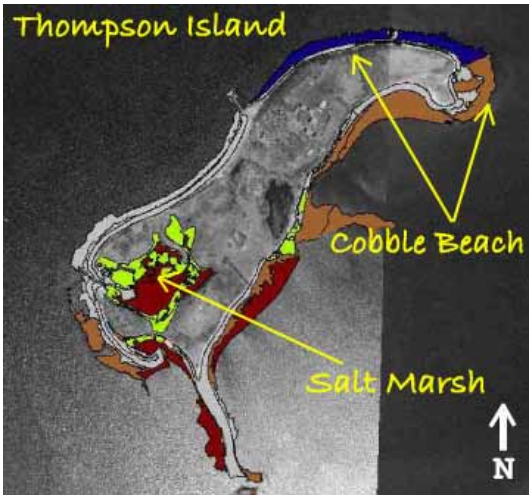
Inner Islands











C. GPS Coordinates for Islands investigated during the Bioblitz. Coordinates for Outer Brewster, Calf, and Little Brewster are from actual study sites. Other coordinates are from the centers of the respective Islands and were obtained from www.bostonharborislands.org.

Island	**Latitude**	**Longitude**
Outer Brewster	42°20’34.157” N	70°52’28.059” W
Calf	42°20”34.606” N	70°53’41.317” W
Little Brewster	42°19’48.456” N	70°53’19.519” W
Peddocks	42°17’32.6” N	70°56’21.6” W
Grape	42°16’10.10” N	70°55’00.07” W
Langlee	42°15’52.0” N	70°53’15.4” W
Lovells	42°19’45.6” N	70°55’48.5” W
Thompson	42°18’53.6” N	71°00’53.3” W

Appendix 2.

Detailed protocol given to Bioblitz participants.

Quadrat Protocol for Permanent Rock and Cobble/Boulder Habitats:

- In your notebook, record the names of all team members.
- Sample at least 5 quadrats at each intertidal elevation (low, mid, high) in each available habitat on your island. Island Leaders will know the specific sites on each island under investigation.
- Start at the low tide mark and working your way up to the mid and high zones as the tide rises.
- Start a new page for every new quadrat, and make sure to fill out necessary information on pre-labeled sheets in the notebook.
- Contact Catherine Matassa with issues as they arise if you have cell phone service: 516.250.5799

1. Place the quadrat in the low, mid or high zone in either the rocky or cobble/boulder habitat.
2. Record the quadrat # (1,2,3, etc.), time (0704, 1825, etc.), habitat (rocky or cobble), and approximate tidal height (low, mid or high) in the pre-labeled section of a new page in your notebook.
3. Take 2 rugosity (a measure of 3D complexity) measurements along the diagonals of the quadrat. To do this, place one end of the rope in one corner of the quadrat and lay it down along the substrate following the contours (i.e., over rocks, into crevices…) along the diagonal of the quadrat to the opposite corner. Record the length of the rope from corner to corner in centimeters. Repeat this along the other diagonal.
4. Begin searching the quadrat and generating a species list. Record the names of each species present in the quadrat and estimate percent cover of sessile species to one of the following values: <10%, 25%, 50%, 75%, >90%.
5. **Photograph Samples**: As you encounter new species in your quadrats, take a photograph of them (only 1 photo of each species please!). When you photograph a species from one of your quadrats, place a star * next to it in the species list. Fill out a sample card and include this card in the photograph (place it next to the specimen). When you get back to Thompson Island, download the photographs to the science coordinator's laptop.
6. **Unidentified species**: If you encounter a species that cannot be readily identified in the field (e.g. filamentous red algae), remove it from the quadrat and bring it back to Thompson Island. Include it in your species list for that quadrat by calling it Unidentified Sample #1 (or 2, 3, 4 etc.). Place it in a small sample jar with ethanol or a Ziploc bag with seawater. Fill out a sample card and include it in the container with the specimen. Record any remarkable information about the specimen in your notebook at the end of the species list for that quadrat, for example, "UnID #3, found in a crevice under *Ascophyllym*" or "unID #7, encrusting alga, may be *Ralfsia verrucosa*, need microscope to determine" or "unID#23, encrusting alga, looks similar to unID#7, but unsure if same species," etc.

Non-Quadrat Sampling (Rocky and Non-rocky Habitats):

You may, and are encouraged to, sample for species outside of the quadrats in any intertidal habitat on the islands. Use blank pages at the end of your notebook to record information about each species found. Use the same photograph (5) and unidentified species (6) protocols listed above to catalog/collect specimens (not including quadrat #, obviously) or mud samples (cores, sieves, etc.). Record the following data for each sample:

1. Species name, unidentified species #, or core #, etc.
2. Habitat from which the specimen was collected (marsh, mudflat, pebble beach, rock, cobble, etc.)
3. Approximate tidal elevation (low, mid, high, supralittoral, splash zone, etc.)
4. Any pertinent remarks (e.g. "bryozoan on *Chondrus crispus* in tidepool, unknown species name")

Photographers- Please remember to get some interesting photographs of the habitats, organisms, and the scientists in action! Download all of your photographs, particularly those from the quadrat samples, to the science coordinator's laptop upon your return to the lab at Thompson Island.

Appendix 3.

Map with continuously updated data projected in the laboratory during the Bioblitz.