

Two-year baseline characterization of benthic and demersal assemblages inside the University of Maine deepwater wind test sites off Monhegan Island, Maine

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Introduction

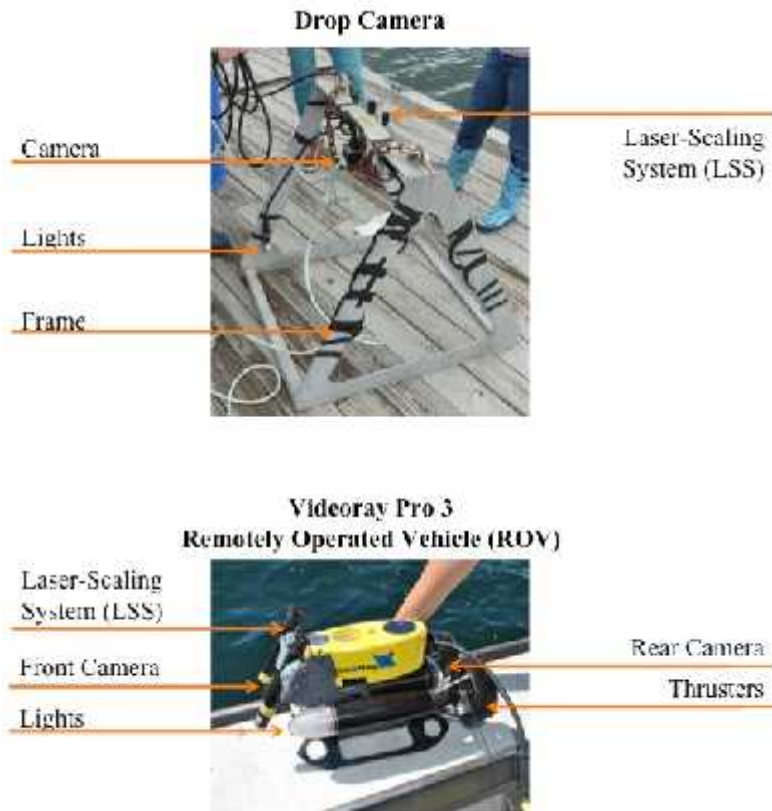
Wind-power development has become cost-competitive in areas with the most favorable wind regimes. However, high transmission costs and concerns for sight and sound disruption make land-based turbine deployment controversial. Offshore wind development in the Gulf of Maine (GoM) could be beneficial to all because the GoM has consistently high wind potential (156 GW) at an optimal distance from coastal residents (Schwartz *et al.* 2010). The University of Maine, as an emergent leader in the engineering of floating offshore wind platforms, seeks to harness this energy by deploying the first operational test-scale turbine by the end of 2013. Yet, offshore wind is just one of many valuable natural resources in the Gulf of Maine.

Organisms living on or near the seafloor are also vitally important to New England. The GoM is a relatively wide, shallow and well-mixed extension of the continental shelf, which sustains high rates of pelagic and benthic primary productivity (Townsend 1991). Since phytodetritus rains to the benthos relatively rapidly, diverse communities of invertebrates proliferate and ultimately support a high carrying capacity for large demersal fishes. Historically, the commercial harvest of these species, including Atlantic cod, haddock and flounder, has provided a livelihood for fishermen and shaped the culture of coastal communities in Maine. In the late 1980's, many demersal, or groundfish, populations in the GoM collapsed from overharvesting, leaving Maine's economy reliant on a few benthic invertebrate species (Steneck *et al.* 2011). In particular, the American lobster now comprises 85% of Maine's harvested marine resource value.

Given the inherent ecological, economic and cultural value of benthic megafauna, the University of Maine-led DeepCwind Consortium considers potential impacts from turbine deployment to be of the highest importance. For this reason, we have undertaken extensive video surveys to quantify patterns of benthic megafaunal abundance before, during and after deployment of the test turbine. In order to evaluate the population densities we observed within the potential deployment area, we also conducted surveys in coastal control sites. These data allow us to evaluate trends in population density, biomass, species diversity and megafauna

community structure with distance from shore, depth and substrate type. This report summarizes our results.

Figure 1: Images of drop camera and small remotely operated vehicle (ROV) used in 2010 and 2011, respectively. The drop camera consists of a metal frame and a 500-line resolution camera. The Video Ray is propelled by four thrusters (two horizontal, two vertical), controlled from surface console and collects live video with a 570-line resolution camera. Both units illuminated the seafloor with Halogen lights and allowed us to collect size measurements using a laser-scaling system. Both years, the laser scaling system measured approximately a 10.4 cm diameter.



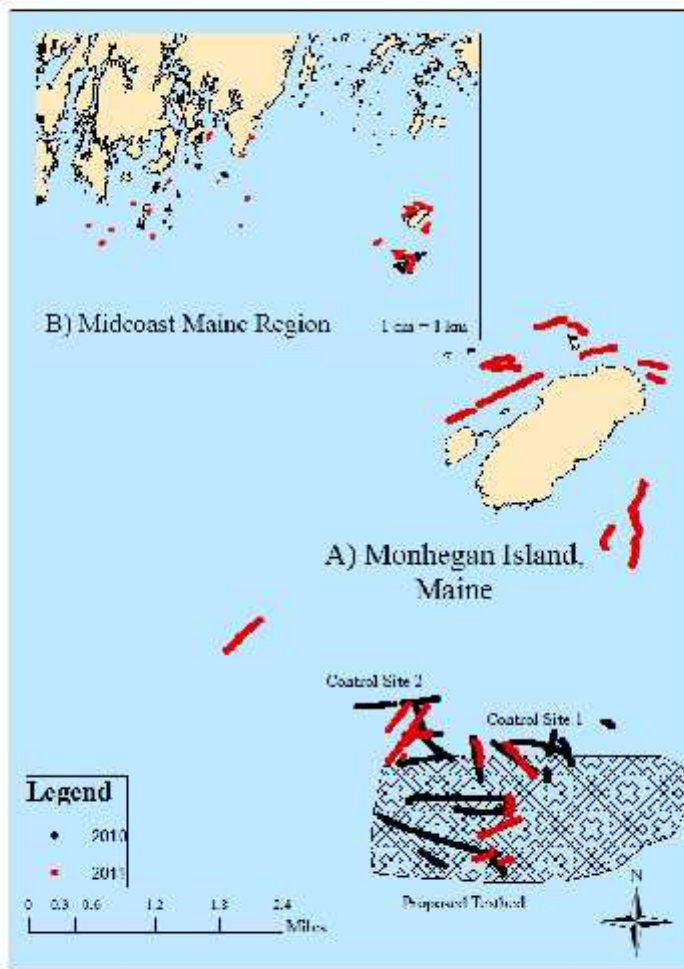
Methods

Survey Methods

During the summer of 2010 and 2011, the Steneck Lab used a drop-camera and a small Videoray Pro 3 remotely operated vehicle (ROV) to characterize bottom habitats and communities in the midcoast Maine region (Figure 1). Initially we intended to collect one year of “before deployment” data and one year of “after deployment” data, but due to delays in deployment we have collected two years of baseline data. During this time, we conducted over 100 geo-referenced, laser-scaled underwater video surveys between the Boothbay and Monhegan Island, Maine (10-100m water depth) (Figure 2). Twenty-seven transects characterize the

proposed testbed and two adjacent control sites near Monhegan (a total of 27 transects) prior to turbine deployment and approximately 73 transects (from 28 sites) characterize the benthos from coastal controls sites.

Figure 2: Map of sites surveyed at Mohegan Island (A) and within Midcoast Maine (B). The hash-marked area denotes the area of potential deployment for the University of Maine’s test floating offshore wind turbine. Black and red lines denote transects conducted using a drop camera in 2010 and a small Videoray remotely operated vehicle (ROV) in 2011, respectively.



Each transect involved deploying the unit from a small vessel (usually a lobster boat), lowering it to approximately 0.5 to 1m above the seafloor and drifting with the current for 40 to 1000m. The lengths of each transect varied depending on the direction of the currents, the wind speed, and the presence of lobster gear. Where surveys could be completed without obstacles, we

surveyed continuously for up to an hour per transect. However in locations where interruptions occurred more frequently, we conducted a higher number of transects for a shorter period of time per transect (usually adding up to one to two hours total).

Video Analyses

In the lab, we reviewed the videos and sub-divided each transect into roughly 50m² segments to standardize our dataset. Then, we analyzed each segment to quantify patterns species composition, population density (#/100m²), dominance, and diversity (Shannon-Weiner Index). We also calculated body sizes for any organisms we observed using the onscreen laser distance. Together, these metrics of benthic community structure and biodiversity allow us to describe baseline communities of invertebrates and groundfishes in the midcoast Maine region. To minimize variance between sites and reveal the habitat preferences of organisms, we stratified our data by depth and substrate type (Table 1).

Table 1: Samples sizes by habitat strata. Video data was collected using a drop camera and a small Videoray Pro3 ROV in 2010 and 2011 from sites across the midcoast Maine region (from Monhegan Island to Boothbay Harbor, Maine.)

HABITAT STRATA							
	Depth (m)						
Substrate Type	10	20	30	40	50	60	100
<i>Boulder</i>	x	10	27	10	3	10	x
<i>Cobble</i>	x	4	9	8	7	7	x
<i>Gravel</i>	x	7	23	7	2	4	x
<i>Ledge</i>	10	60	36	10	7	3	17
<i>Mud</i>	20	7	32	12	4	30	142
<i>Sand</i>	2	6	8	x	x	x	x
<i>Silt</i>	x	x	3	x	x	x	x

Results

Area and Habitats Surveyed

Between 2010 and 2011, we characterized a substantial area of the midcoast Maine coastal shelf (i.e. the area between Mohegan, Island and Boothbay Harbor, ME). Within the potential deployment area, we surveyed 4595m² of the proposed testbed, as well as 3532m² and 3640m² of the adjacent control sites, 1 and 2 respectively (a total of 7922 m² and 3846m² by year) (Figure 2A). We also characterized approximately 18,812 m² of benthic habitat across the near shore midcoast region (Figure 2B), allowing us to collect video from a wide array of habitats. From these surveys, we observed that substrate and depth profiles are exceptionally

heterogeneous in this area. Near shore and shallow habitats in the region (above 60m) consist predominantly of ledge, boulder and cobble areas with fewer soft-bottom habitats occurring between outcroppings; whereas mud habitat pervasively dominates deeper areas (below 60m) of the coast where the test turbine is proposed for deployment (J. McHenry and R. Steneck, personal observation).

Table 2: List of species identified from the midcoast Maine region (from Monhegan Island to Boothbay Harbor, Maine) from laser-scaled, geo-referenced video surveys conducted in 2010 and 2011. Seventy-one species are presented below by taxonomic grouping.

TAXONOMIC GROUPINGS	
	SPECIES NAME
Demersal Fishes	Atlantic cod (<i>Gadus morhua</i>), pollock (<i>Pollachius virens</i>), cusk (<i>Brosme brosme</i>), silver hake (<i>Merluccius bilinearis</i>), red hake (<i>Urophycis chuss</i>), spotted hake (<i>Urophycis regius</i>), white hake (<i>Urophycis tenuis</i>), cunner (<i>Tautoglabrus adspersus</i>), tautog (<i>Tautoga onitis</i>), black sea bass (<i>Centropristis striata</i>), searobin (<i>Prionotus evolans</i> , other <i>Prionotus</i> sp.), longhorn sculpin (<i>Myoxocephalus octodecemspinosus</i>), shorthorn sculpin (<i>Myoxocephalus scorpius</i>), grubby (<i>Myoxocephalus aeneus</i>), Acadian rockfish (<i>Sebastes fasciatus</i>), American eel (<i>Anguilla rostrata</i>), rock gunnel (<i>Pholis gunnellus</i>), Atlantic hagfish (<i>Myxine glutinosa</i>), snakeblenny (<i>Lumpenus lumpraeformis</i>), daubed shanny (<i>Lumpenus maculatus</i>), radiated shanny (<i>Ulvaria subbifurcata</i>), winter flounder (<i>Pseudopleuronectes americanus</i>), American plaice (<i>Hippoglossoides platessoides</i>), summer flounder (<i>Paralichthys dentatus</i>), Atlantic halibut (<i>Hippoglossus hippoglossus</i>), lumpfish (<i>Cyclopterus lumpus</i>), ocean pout (<i>Zoarces americanus</i>), and alligator fishes (<i>Aspidophoroides monopterygius</i>).
Decapods	Northern shrimp (<i>Pandalus borealis</i> , other <i>Pandalus</i> sp.), American lobster (<i>Homarus americanus</i>), Jonah crab (<i>Cancer borealis</i>), Atlantic rock crab (<i>Cancer irroratus</i>) and Arctic lyre crab (<i>Hyas araneus</i>).
Bivalves	Horse mussel (<i>Modiolus modiolus</i>) and giant sea scallop (<i>Placopectan magellanicus</i>).
Anemones	Northern cerianthid anemone (<i>Cerianthus borealis</i>), northern red anemone (<i>Urticina felina</i>), frilled anemone (<i>Metridium senile</i>), swimming anemone (<i>Stomphia coccinea</i>) and rugose anemone (<i>Hormathia nodosa</i>).
Echinoderms	Blood seastar (<i>Henricia sanguinolenta</i>), northern seastar (<i>Asterias rubens</i>), Forbes' seastar (<i>Asterias forbesi</i>), spiney sunstar (<i>Crossaster papposus</i>), smooth sunstar (<i>Solaster endeca</i>), horse seastar (<i>Hippasteria phrygiana</i>), common sand dollar (<i>Echinarachnius parma</i>), Psolus cucumber (<i>Psolus fabricii</i>), orange footed sea cucumber (<i>Cucumaria frondosa</i>) and brittle stars (<i>Ophirudiae</i> sp.)
Brachiopods	Northern lampshell (<i>Terebratulina septentrionalis</i>)
Sponges	Fig sponge (<i>Suberites ficus</i>), breadcrumb sponge (<i>Halichondria panicea</i>), finger sponge (<i>Haliclona oculata</i>), palmate sponge (<i>Isodictya palmate</i>), <i>Iophon</i> sp., boring sponge (<i>Cliona celata</i>), red beard sponge (<i>Microciona prolifera</i>), <i>Polymastia</i> sp. and warty sponge (<i>Melonanchora elliptica</i>).
Tunicates	Crust (<i>Didemnum</i> spp., <i>Botrylloides diegensis</i>) and solitary tunicates (<i>Mogula</i> sp.)
Polychaetes	Sabellid sp.
Bryozoans	<i>Bugula turrata</i>

Benthic Assemblages from Coastal Maine to Monhegan Island

From the Boothbay to Monhegan Island, we observed a total of 71 species (Table 2). Throughout the region, we found that the species composition, population densities (#/100m²) and species diversity of megafaunal communities vary with substrate and depth. Overall, rocky habitats were more diverse and sustained higher population densities than soft bottom habitats (Figure 3). We also found that the species composition and the diversity of communities changed drastically with depth depending on the substrate type. On soft bottom habitats, assemblages of cerianthid anemones and euphausiids dominated the shallow (30m) to intermediate (60m) depth sites, while northern shrimp become more abundant in deeper areas (100m) (Figure 3). However on rocky habitats, average population densities and species diversity for megafauna were highest at intermediate depths (60m). For examples, brachiopods, horse mussels and cunner dominated shallow sites (30m) and Acadian redfish and northern red anemones dominated deep sites (100m). However at intermediate depths (60m), diverse assemblages of Acadian redfish, cunner, northern red anemones, cerianthid anemones, four sponges species and two tunicate species persisted. Lastly, we found that the population densities for many valuable species, including American lobsters, Jonah crabs, northern shrimp, and pollock all decrease from shallow to deeper sites (Figure 4). The only commercially valuable species to increase drastically in abundance near the testbed were Acadian redfish and northern shrimp (Figure 4B).

Figure 4: Average population density (#/100²) of demersal fishes (A) and decapods (B). Abundance data was collected using a drop camera and a small Videoray Pro3 ROV in 2010 and 2011.

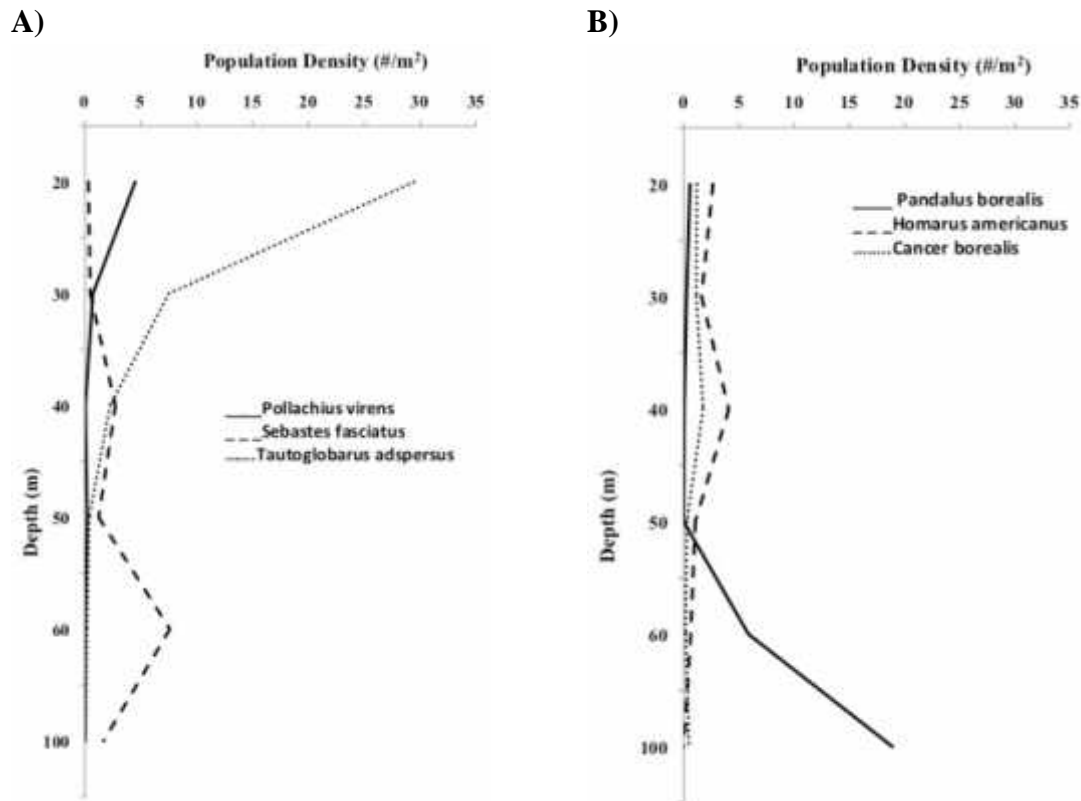


Table 4: List of species identified within the deployment test site and two control sites off of Monhegan, Maine from laser-scaled, geo-referenced video surveys conducted in 2010 and 2011. Thirty-two species are presented below by taxonomic grouping.

TAXONOMIC GROUPINGS	SPECIES NAME
Demersal Fishes	Silver hake (<i>Merluccius bilinearis</i>), red hake (<i>Urophycis chuss</i>), spotted hake (<i>Urophycis reguis</i>) white hake (<i>Urophycis tenuis</i>), cunner (<i>Tautoglabrus adspersus</i>), longhorn sculpin (<i>Myoxocephalus octodecemspinosus</i>), shorthorn sculpin (<i>Myoxocephalus scorpius</i>), Acadian rockfishes (<i>Sebastes fasciatus</i>), rock gunnel (<i>Pholis gunnellus</i>), Atlantic hagfish (<i>Myxine glutinosa</i>), snakeblenny (<i>Lumpenus lumpretaeformis</i>), daubed shanny (<i>Lumpenus maculates</i>), radiated shanny (<i>Ulvaria subbifurcata</i>), winter flounder (<i>Pseudopleuronectes americanus</i>), American plaice (<i>Hippoglossoides platessoides</i>), summer flounder (<i>Paralichthys dentatus</i>), Atlantic halibut (<i>Hippoglossus hippoglossus</i>), lumpfish (<i>Cyclopterus lumpus</i>), ocean pout (<i>Zoarces americanus</i>) and alligatorfish (<i>Aspidophoroides monopterygus</i>).
Decapods	Northern shrimp (<i>Pandalus borealis</i>), American lobster (<i>Homarus americanus</i>), Jonah crab (<i>Cancer borealis</i>) and Arctic lyre crab (<i>Hyas araneus</i>).
Bivalves	Giant sea scallop (<i>Placopectan magellanicus</i>)
Anemones	Northern cerianthid anemone (<i>Cerianthus borealis</i>), northern red anemone (<i>Urticina felina</i>), rugose anemone (<i>Hormathia nodosa</i>).
Echinoderms	Blood seastar (<i>Henricia sanguinolenta</i>)
Brachiopods	Northern lampshell (<i>Terebratulina septentrionalis</i>)
Sponges	Breadcrumb sponge (<i>Halichondria panicea</i>), <i>Iophon</i> sp.

Benthic Assemblages within the Potential Deployment Area

Compared to shallower sites, the potential deployment area at Mohegan Island has only 32 species (Table 3). In 2010 and 2011, benthic assemblages observed in the proposed testbed, control site 1 and control site 2 differed between mud and ledge habitats. As stated above, Acadian redfish and northern red anemones dominate the deeper hard bottom ledge habitats whereas northern shrimp and other panda lid shrimp species dominate the mud areas within the area of potential deployment (Figure 5, Figure 6). Species diversity is also much lower in areas with mud compared to areas with ledge (Table 5).

Discussion and Conclusions

The potential deployment area is relatively species depauperate and provides habitat for comparatively low densities of benthic megafauna. Most ecologically and economically valuable species, including American lobster, crabs and pollock all decrease in abundance to zero at 100m depth. Even within the proposed testbed, our ROV surveys confirm that the mud dwelling communities are considerably less diverse than the surrounding ledge habitats. Since mud habitats are so expansive near the deployment area, we conclude that the impacts to valuable species from deployment will likely be minimal within this area. Northern shrimp and Acadian

redfish populations do persist within the testbed and control sites. However we do not expect drastic impacts to either of these species.

Figure 5: Population density (#/100m²) of dominant benthic and demersal organisms within the potential deployment area near Monhegan Island, Maine in 2010. Abundance data was collected using a drop camera from mud and ledge habitats at 100m water depth within the proposed deployment site, control site 1 and control site 2. Error bars denote +/- 1 standard error.

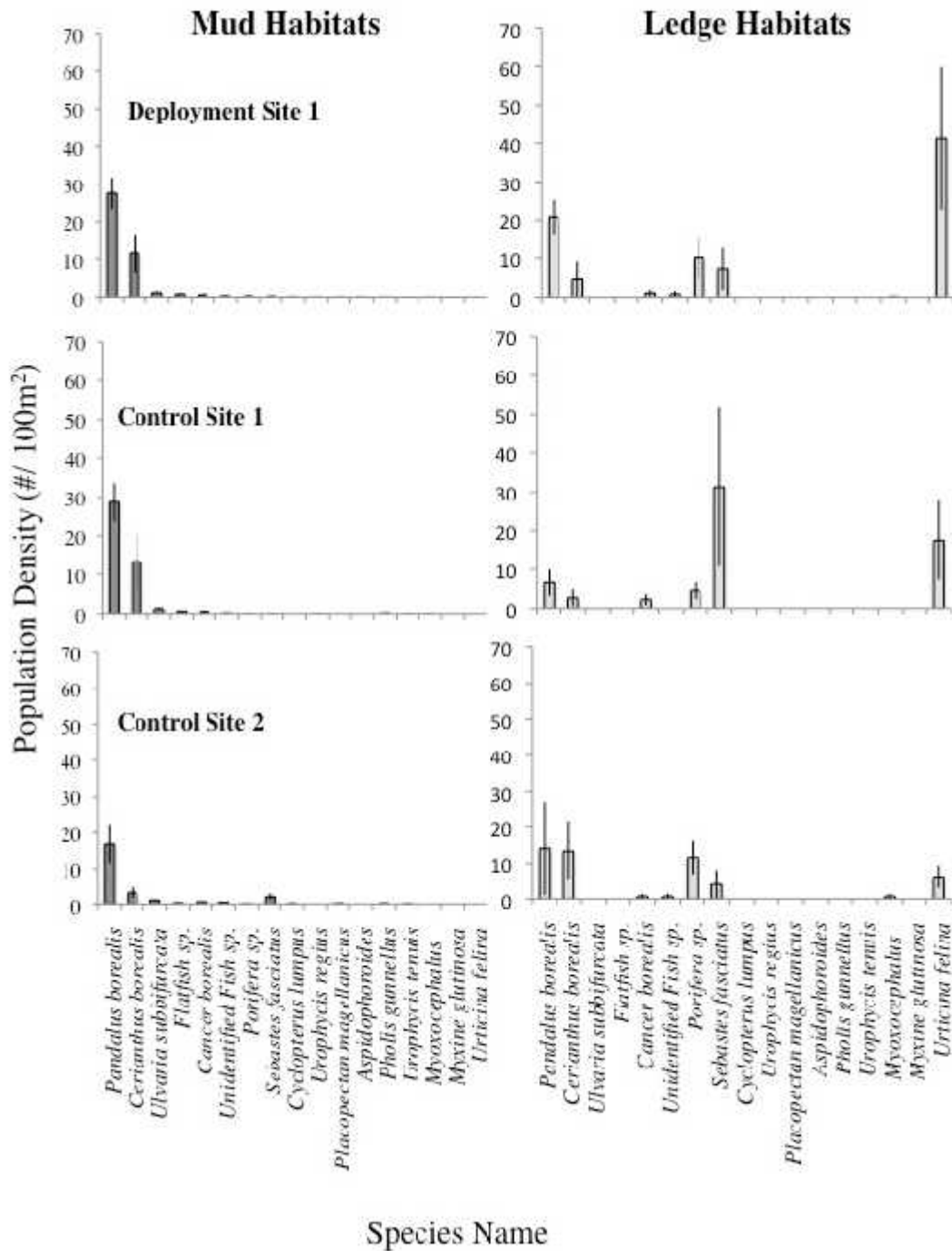


Figure 6: Population density (#/100m²) of dominant benthic and demersal organisms within the potential deployment area near Monhegan Island, Maine in 2011. Abundance data was collected using a small Videoray Pro 3 ROV from mud and ledge habitats at 100m water depth within the proposed deployment site, control site 1 and control site 2. Error bars denote +/- 1 standard error.

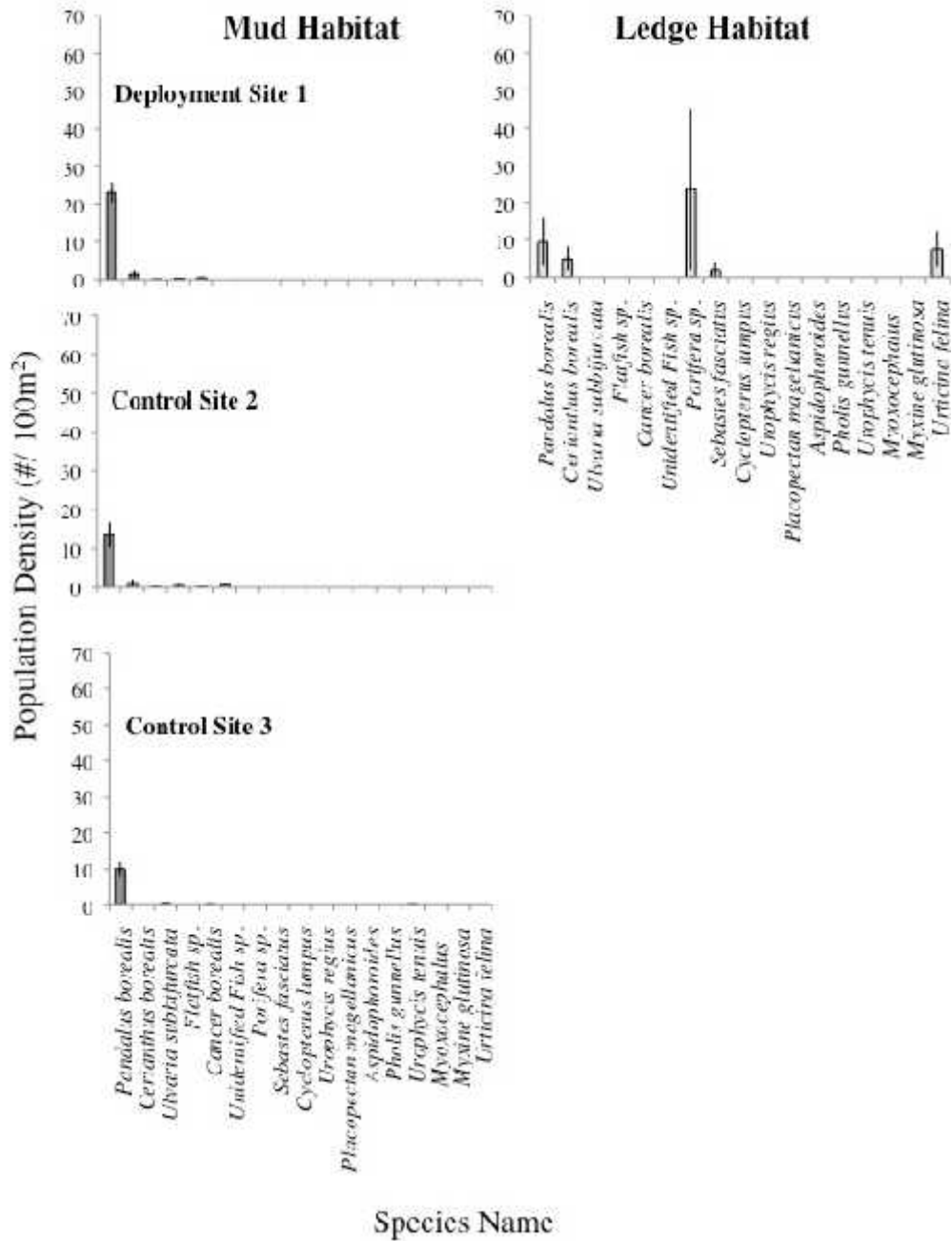


Table 5: Differences in Shannon Weiner species diversity and richness by substrate in the Monhegan testbed and two adjacent controls. Benthic abundance data was collected using a drop camera and a small Videoray Pro3 ROV in 2010 and 2011.

SHANNON WEINER DIVERSITY INDEX FOR MONHEGAN SITES								
	Proposed Testbed		Control Site 1		Control Site 2		Average SW Index	
Year	Ledge	Mud	Ledge	Mud	Ledge	Mud	Ledge	Mud
2010	2.15	1.49	2.06	1.37	2.52	1.69	2.25	1.51
2011	2.36	0.79	-	0.94	-	1.06	2.36	0.93

Future surveys

The next phase of the permitting process will involve siting for subsea transmission lines between Mohegan Island and the cable’s point of landfall (a site to be determined). Since population densities and species diversity are relatively higher on hard substrate habitats (i.e. ledge, boulder and cobble) and hard substrate habitats are more common in the near shore area, we will commence extensive ROV surveys between Mohegan Island and land in early 2013. Ecosystem models that incorporate past data from 2010, 2011, 2012 (in prep.) and 2013 will be used to help select the most appropriate path for transmission lines that ensures the lowest impact to benthic communities.

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