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Natural Resource Report NPS/NETN/NRR—2010/XXX

ON THE COVER
Intertidal zone at Otter Point, Acadia NP looking towards Little Hunter and photographed March 2008. Three of the target species monitored by this protocol are visible here: Barnacles (the light brown/white layer high in the intertidal), *Ascophyllum nodosum* (the lighter, mid-intertidal seaweed in the lower right), and *Fucus* (the darker, mid-intertidal seaweed on the left). The large pool is monitored for sea stars and sea urchins using this protocol.
Photograph by: Jeremy Long

Northeast Temperate Network Long-Term Rocky Intertidal Monitoring Protocol

Natural Resource Report NPS/NETN/NRR—2010/XXX

Jeremy D. Long

Department of Biology
San Diego State University
San Diego, CA 92182

Brian R. Mitchell

National Park Service
Northeast Temperate Network
54 Elm Street
Woodstock, VT 05091

Month 2010

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

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Please cite this publication as:

Long, J. D., and B. R. Mitchell. 2010. Northeast Temperate Network Long-Term Rocky Intertidal Monitoring Protocol. Natural Resource Report NPS/NETN/NRR—2010/XXX. National Park Service, Fort Collins, Colorado.

NPS XXXXXX, Month 2010

Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.3 to 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.06 to Version 1.07) when there are minor modifications that do not affect requirements or procedures included in the protocol. Add rows as needed for each change or set of changes tied to an updated version number.

Revision History Log

Version #	Date	Revised by	Changes	Justification
1.00	March 2010	Jeremy Long and Brian Mitchell	Initial draft	N/A
1.01	May 2010	Jeremy Long and Brian Mitchell	Numerous revisions to address review comments	Internal NPS review

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Acknowledgments

Geoff Trussell welcomed Jeremy into his lab as a post-doc and supported his application to develop this protocol. Thank you for keeping things real and for assistance with plot installation at BASHAR and LITMOO. Bruce Connery, Marc Albert, David Manski, and Sara Williams all went out of their way to assist with logistics, discuss pros and cons of sampling strategies, and even scrape barnacle plots in early March. Adam Kozlowski and Jim McKenna provided comments on early drafts that greatly improved this protocol. Adam Kozlowski is also coordinating database development with North Carolina State University.

This work benefited greatly from long hours in the field by numerous volunteers, technicians, and graduate students. We are especially indebted to the assistants who braved freezing temperatures, high waves, and a stressed out advisor on repeated sampling trips. These assistants included Kimberly Banks, Eliot Cochrane, Renee Dolecal, Tania Eskin, and Chris Henry. Thank you for the laughs, bad vampire movies, and bakery runs. Jaclyn Cadwallader assisted with the project at San Diego State University. The grad students in Trussell's lab, especially Genevieve Bernatchez, Elizabeth Bryson, Meredith Doellman, Tim Dwyer, and Catherine Matassa, helped with plot installation and sampling. Special thanks go to Jeremy's Invertebrate Zoology (3 Seas) course from Fall 2008 at Northeastern University. Before the Acadia field trip, we considered sampling 5 sites in 3 days a ridiculously impossible task – but you proved us wrong. In addition to those listed above, there are numerous others who are not listed. Your efforts are appreciated too. Jeremy also recognizes the flexibility his wife, Heidi, provided to allow him to race up to Acadia for multiple day trips – often on short notice.

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Background and Objectives

Rationale for Monitoring the Rocky Intertidal Zone

Rocky intertidal zones provide habitat and food for marine and terrestrial organisms and these communities, in turn, provide important economic, scientific, educational, and recreational value for humans. It is widely recognized that these communities are naturally shaped both by natural abiotic (e.g. desiccation) and biotic factors (e.g. competition and predation; Bertness 1998). However, these communities are also affected by a variety of anthropogenic stressors including climate change, invasive species, pollution, and trampling (Bertness 1998). While the ecological consequences of some of these stressors (e.g. some invasive species) are known from short-term, within-year experiments, their effects are largely unknown over longer time periods.

Intertidal habitats in New England represent some of the best studied ecological communities, in part because the dominant species are large and grow rapidly, and the strong zonation across small spatial scales is attractive for field manipulations (Connell 1961, Paine 1966, Lubchenco 1978). The National Park Service's (NPS's) Northeast Temperate Network (NETN), part of the service's Inventory and Monitoring Program, selected the rocky intertidal zone as one of the network's "Vital Signs", or key indicators for long-term natural resource monitoring (Mitchell et al. 2006). Specifically, intertidal habitats in Acadia National Park (ACAD), Boston Harbor Islands National Recreation Area (BOHA), and the Maine Coast Islands National Wildlife Refuge (MCI) are being monitored for several reasons. The rocky intertidal zone is a unique habitat that is used by a variety of species, many of them at the edge of their physical and ecological tolerances, and thus likely to be impacted by climate change. Many of these species are important food for birds and mammals that forage along the shoreline, and several rocky intertidal species have commercial value. In addition, the National Park Service (NPS) is concerned that the popularity of the rocky shore with park visitors can lead to adverse impacts on intertidal species. In addition, there have been discussions about installing a liquefied natural gas (LNG) facility on the outer harbor islands of BOHA (esp. Outer Brewster). Long-term monitoring data is crucial for documenting the importance of the habitats that this and other development projects could impact.

Rocky intertidal monitoring has the potential to engage multiple agencies that have similar conservation objectives. The U.S. Fish and Wildlife Service's MCI refuge expressed early interest in this program and has become a full partner during the development of this protocol. Other agencies and conservation organizations in the Gulf of Maine region will probably participate in complementary monitoring efforts as this program is established. In addition, we have chosen to keep our methods comparable to the standard, or "core," procedures of the Multi-Agency Rocky Intertidal Network (MARINe) that currently surveys target species, on either an annual or semiannual basis, at 80 Pacific coast sites including six national parks. The MARINe collaboration includes the NPS, Minerals Management Service (MMS), National Marine Sanctuaries, the National Center for Ecological Analysis and Synthesis (NCEAS), and multiple universities. By adopting similar procedures, we will facilitate the ability of managers and scientists to make comparisons and predictions across coasts.

More locally, monitoring three areas (ACAD, BOHA and MCI) will allow us to determine whether future changes occur across broader scales (hundreds of kilometers versus a few to tens of kilometers) and a gradient of human visitation and management practices. This regional

approach to monitoring will vastly improve our ability to manage these resources (Miner et al. 2005). All three areas contain relatively unvisited stretches of shoreline that lack obvious impacts of collecting and trampling. These represent unique habitats, especially along the shores surrounding BOHA. Thus, there is the potential for these sites to provide refugia or propagule sources for sensitive species across larger spatial scales. At ACAD, two sites, located <1 km apart on opposing sides of Ship Harbor (named BASHAR and SHIHAR), have disparate levels of visitation – thereby allowing for the opportunity to conduct a natural experiment investigating the impacts of humans on intertidal communities in the absence of other factors. The sites at ACAD can also be compared to the nearby but much less accessible islands of MCI.

Long-term monitoring programs represent an important step towards managing resources. The protocol developed by these programs will ensure that changes detected by monitoring are occurring in nature and not simply a result of measurements taken by different people or in slightly different ways (Oakley et al. 2003). Recently, long-term monitoring protocols for rocky intertidal habitats have been developed and successfully implemented along the entire west-coast of the United States by the MARINe program. Data from these surveys were used to isolate anthropogenic impacts on rocky intertidal gastropods in southern California (Roy et al. 2003). In this study, harvesting by people decreased the body size of several gastropod species. In a second study, MARINe surveys helped document declines in black abalone along central California (Alstatt et al. 1996).

We initiated a study to develop this rocky intertidal monitoring protocol in 2007. The major focus of this study was to develop a set of procedures that would correlate changes in the abundance of ecologically important marine invertebrates and macroalgae with biotic and abiotic (e.g. water temperature) factors. Our protocol monitors rocky shores across multiple scales (biological, ecological, landscape) and across relevant disciplines (marine ecology, physical oceanography, and the study of climate change). During protocol development, we centered our efforts on preliminary data collection using the procedures we were developing. Preliminary trips served two purposes; 1) data collected on these trips guided the subsequent protocol development (e.g. sampling frequency) and 2) they revealed unexpected obstacles to protocol initiation.

Rocky substrates, especially rocky benches, dominate most of the intertidal habitat at ACAD and MCI, so studying bench habitat in these areas should be representative of most of the park's and refuge's rocky intertidal habitat. In contrast, rocky benches constitute a much lower component of BOHA habitats (<5% of all intertidal substrate in 20 of the islands; Bell et al. 2004). Thus, by focusing on rocky benches this protocol does not sample the majority of intertidal substrates within BOHA. However, these substrates are more common on the outer islands which are the focus of this protocol (see below). For example, rocky benches represent approximately 25% and 90% of substrates on Calf Island and Outer Brewster Island, respectively. A separate protocol would be needed to extend monitoring to these non-bench, intertidal habitats (e.g. cobble and boulders), since the methods and target species presented here are specific to rocky benches. In some cases (e.g. cobble beaches), standard protocols have not been adopted by marine ecologists because of the difficulty of sampling these habitats. For example, in cobble beaches and boulder fields, most invertebrates live underneath the cobble making sampling difficult.

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Measurable objectives

By focusing on dominant, zone-forming species, this protocol may fail to detect subtle changes such as the arrival of invasive species. Although invasive species can impact intertidal communities, this trade-off is necessary given limited resources (time and money) and the potentially limited taxonomic expertise of field staff. Focusing on the dominant and abundant species will still allow us to detect alterations to these communities, including changes resulting from invasive species.

Our primary objectives fall into the following categories:

Monitoring Objectives

- Determine long-term changes in population-based parameters (including density, percent cover, and elevational range) and individual-based parameters (including barnacle recruitment and predator damage to snail shells) of target invertebrate and macroalgal species (see Target and Core Species, below).

- Correlate long-term changes in intertidal population- and individual-based parameters with long-term changes in disturbance factors including abiotic (e.g. changes in water temperature, wave height, and sea level) and biotic factors (e.g. human trampling and seabirds).

- Compare long-term changes in intertidal population- and individual-based parameters across multiple spatial scales including within parks and refuges (within study areas), between study areas in New England, and between coasts of the United States.

- Correlate long-term changes in the intertidal population- and individual-based parameters with long-term changes in human visitation (Acadia National Park only).

Programatic Objectives

- Engage citizen scientists or university students.

- Keep costs within the projected NETN budget for maintaining this protocol ($26,000 for 2010).

Management Objectives

- Determine long-term trends to provide an early warning of abnormal conditions.

- Provide baseline data in case of an acute disturbance (e.g. oil spill, sewage spill, etc.).

- Provide data that could inform adaptive management practices.

Target and Core Species

Following the recommendations of MARINe, we designed this protocol to monitor target species (also called key or indicator species) that "…are species or species groups specifically chosen for long-term monitoring. They dominate particular zones or biotic assemblages in rocky intertidal habitats." Focusing on these dominant, structure forming species is advantageous because most other members of the community rely on these species in some way (Lewis 1982). Furthermore, sensitive or indicator species are largely unidentified for rocky shore communities (Murray et al.

2006). Target species have the highest priority for monitoring and are monitored at as many sites as possible. Occasionally, target species are not specifically monitored at a particular site because they do not meet the criteria for monitoring (e.g. mussel densities at many sites do not cover sufficient area to establish fixed photoplots for mussels). The criteria we used to determine target species, as recommended by MARINe, were:

- Species ecologically important in structuring intertidal communities,
- Species that have a broad distribution in the region of interest (here, the Gulf of Maine),
- Species that have been well-studied,
- Species of special human interest, and
- Species practical for long-term monitoring.

Using these criteria, we designated nine target species or species groups (Table 1). Some species were combined into species groups (e.g. *Fucus*, barnacles, and *Chondrus*/*Mastocarpus*) because of the difficulty in identifying these groups to the species level, especially by non-experts.

Table 1. Target species and species groups for rocky intertidal monitoring.

Ascophyllum nodosum
Barnacles (e.g. *Semibalanus balanoides*)
Echinoderms (especially *Asterias forbesi*, *Asterias rubens*, *Henricia sanguinea*, and *Strongylocentrotus droebachiensis*)
Fucus spp. (e.g. *Fucus vesiculosus*)
Littorina littorea
Littorina obtusata
Mussels (e.g. *Mytilus edulis*)
Nucella lapillus
Red algae (especially *Chondrus crispus* and *Mastocarpus stellatus*)

In addition to target species, we have identified "core" species as those species, species groups, or substrates that are scored in one or more of this protocol's SOPs. By definition, then, all target species are considered core species. According to MARINe, these species "must be reasonably and consistently identifiable using the designated scoring protocol." Core species (Table 2) were identified during the first two years of protocol development. Data sheets include all of the core species.

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Table 2. Core species, species groups, and substrates for rocky intertidal monitoring.

Acmaea testudinalis
Articulated corallines
Ascophyllum epibiont
Ascophyllum nodosum
Barnacles (e.g. *Semibalanus balanoides*)
Crustose algae – Coralline
Crustose algae – Non-coralline
Echinoderms (especially *Asterias forbesi*, *Asterias rubens*, *Henricia sanguinea*, and *Strongylocentrotus droebachiensis*)
Fucus epibiont
Fucus spp. (especially Fucus vesiculosus)
Kelp
Littorina littorea
Littorina obtusata
Littorina saxatilis
Metridium senile
Mussels (e.g. *Mytilus edulis*)
Nucella lapillus
Other algae – Brown
Other algae – Green
Other algae – Red
Other invertebrate
Other plant
Other substrate
Palmaria palmata
Porphyra spp.
Red algae (especially *Chondrus crispus* and *Mastocarpus stellatus*)
Rock
Sand
Tar
Ulva spp.

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Sampling Design

Rationale for Sampling Design

Fixed plots are monitored in each of four intertidal sites in ACAD, three in BOHA, and two in MCI. These plots are permanent areas that are marked with stainless steel bolts that are anchored into the bedrock. Plot sizes and shapes within a site vary and include square, rectangular, and one-dimensional transect lines. Our fixed plot approach was modeled after the protocol used by the MARINe monitoring program (Engle 2006; including sites located in Cabrillo National Monument, Channel Islands National Park, Golden Gate and Point Reyes National Parks, Redwoods National and State Parks, and Olympic National Park).

One of the major objectives of this protocol is to monitor changes in the abundances of target and core species over time. In rocky intertidal areas, the well-known spatial heterogeneity in the distribution and abundance of intertidal organisms means that randomly placing plots each year (as opposed to using fixed plots) makes it harder to detect temporal trends, because the exact placement of plots strongly affects the number of individuals present within them. Using fixed plots allows us to detect temporal trends with fewer plots, although this has the drawback of providing less information about spatial variation in the distribution of different organisms (Murray et al. 2006). In essence, we are using the fixed plots as index sites to understand temporal trends, with the assumption that other locations in the intertidal zone will show similar trends. It is impractical to randomly place plots during each monitoring visit because of the high number of replicate samples that would be needed to detect temporal change after accounting for spatial heterogeneity. In other words, fixed plots provide data about changes within the plot over time and decrease the variation in those data unrelated to temporal patterns (Murray et al. 2006). This allows the overall monitoring program to use fewer plots and makes implementation significantly less expensive.

Another advantage of the fixed plot design is the ability to incorporate these data into an established and well-tested monitoring network (MARINe). This program includes sites along the west coast and is the longest running, large scale intertidal monitoring program in North America (Engle 2006, Cox and Raimondi 2007). Furthermore, several groups monitor temporal changes via repeated sampling of fixed plots. The National Science Foundation's Long-Term Ecological Research (LTER) sites and the U.S. Forest Service's Forest Inventory and Analysis program have used fixed sampling as a model for their monitoring programs (Cox and Raimondi 2007).

A major limitation of the fixed plot approach is that, unlike random sampling, the dynamics of fixed plots cannot be extrapolated to larger areas without gathering additional information (Engle 2006; Murray et al. 2006). For this reason, random sampling designs are often preferred. However, as noted above, monitoring multiple sites in multiple parks throughout time using a truly randomized sampling design is cost-prohibitive.

Several monitoring programs have adopted the approach of monitoring a combination of fixed plots with overview photographs (Murray et al. 2006, Cox and Raimondi 2007). Overview photographs are shot of the fixed plots from set locations, and they place the changes occurring in fixed plots into a broader spatial context. These photographs can then be used to examine whether changes at the plot level are simultaneously occurring at the site level. For example, if

Fucus coverage decreases in *Fucus* photoplots, the overview photos can be examined to see if *Fucus* is decreasing outside of these plots. These overview photographs will provide useful contextual information when temporal changes are detected within fixed plots.

Site Selection

Criteria for Site Selection

The sites for rocky intertidal monitoring in ACAD, BOHA, and MCI were selected based on the following criteria:

- Areas with optimum conditions for long-term monitoring. Optimum conditions for sampling include reasonable and safe access via automobiles and hiking (ACAD) or boats (BOHA), field staff presence on site (MCI), sufficient bench rock surfaces for establishing fixed plots, sufficient abundances of target species, and minimal disturbance to sensitive resources (e.g. seabirds) (Ammann and Raimondi 2008). A sufficient abundance of target species was determined if plots could be selected where the target species represented the majority (>50%) of all species present. Sites were not excluded because of insufficient abundance of a particular target species, but within a site, some plots were not installed if the target species had a low abundance (e.g., some sites lack mussel photoplots).

- Areas with moderate to full wave exposure. Sites with moderate to full exposure to waves were selected because this characterizes the sites monitored by MARINe (Engle 2006). Additionally, these exposed habitats are the only habitats in BOHA that contain significant, flat intertidal benches. Wave exposure was estimated indirectly using biological (mussel coverage) and physical indicators (slope of bench, aspect, and presence of offshore islands that could provide a wave shadow to the site).

- Areas with similar geophysical properties as sites surveyed with the MARINe protocol.

- Areas that are geographically dispersed throughout each park or refuge.

- Areas previously studied that could provide historical data.

- Within each park or refuge island, areas with similar aspect, slope, and intertidal width. Unfortunately, we were not able to completely standardize these factors between study areas.

- Paired pristine and impacted sites with similar bedrock formations and as close to each other as possible (ACAD only).

- Areas whose intertidal zone spans a horizontal distance (or width) of at least 25 m (ACAD and MCI) and 15 m (BOHA).

ACAD, BOHA, and MCI host a diversity of intertidal habitats including sand beaches, rocky substrates, mudflats, and salt marshes. This protocol focuses on rocky benches because: 1) they are the focus of MARINe surveys, 2) they contain the greatest diversity of invertebrates and algae, 3) fixed plots can be installed and easily relocated in these habitats, 4) determining

densities and percent cover of organisms on flat benches is straightforward, and 5) flat rock benches readily collect oil and receive the greatest amount of human visitation (Murray et al. 2006). Thus, rocky benches provide the best opportunity to monitor this habitat (Ammann and Raimondi 2008). Examining similar habitats to the MARINe surveys will facilitate comparisons between the east and west coasts of the United States.

Procedures for Selecting Sampling Sites

Initially, ACAD sites were selected to embed an impact study within the monitoring study. Pristine sites (characterized by low human visitation) were paired with nearby impacted sites (characterized by high human visitation) to minimize natural variation between sites unrelated to human visitation. During site selection, we worked with park resource managers to identify sites with the highest level of human visitation using park observations and scouting surveys. Additionally, site characteristics such as intertidal width, aspect, wave-exposure, and accessibility were determined with aerial photographs, site maps, and site visits. We determined that the following sites had the highest amount of human visitation:

- Wonderland (Western Mount Desert Island [MDI])
- Seawall (Western MDI)
- Ship Harbor (Western MDI)
- Bar Island (Eastern MDI)
- Otter Point (Eastern MDI)
- Thunder Hole (Eastern MDI)
- Schoodic Point (Schoodic)

To meet the criteria of spreading sites across the park as much as possible, these sites were stratified into three different geographic groups (Western MDI, Eastern MDI, and Schoodic) and the optimum site was selected from each group based on the above criteria for site selection. Ship Harbor (SHIHAR) was selected for Western MDI because it was the closest to Bass Harbor (BASHAR; distance = 0.38 km) – a pristine site that was the focus of a previous study (Long et al. 2007). During daily surveys at Bass Harbor during June to August 2005 unrelated to this protocol, we observed a total of five people on the trail – and only three of these entered the intertidal zone. Otter Point (OTTPOI) was selected for Eastern MDI because actual visitation to the intertidal zone is believed to be higher there than Thunder Hole. Additionally, Thunder Hole was rejected because it has a very narrow intertidal zone (unlike the other sites). Bar Island was rejected because it is much more protected from waves than the other sites. The closest pristine site to Otter Point that met the above criteria was Little Hunter's Head (LITHUN; distance = 1.74 km). Finally, Schoodic Point (SCHPOI) was selected as the impacted site in the Schoodic group. Little Moose Island (LITMOO) was selected as the pristine site at Schoodic (distance = 0.83 km). Thus, there were originally six sites in ACAD (Figure 1).

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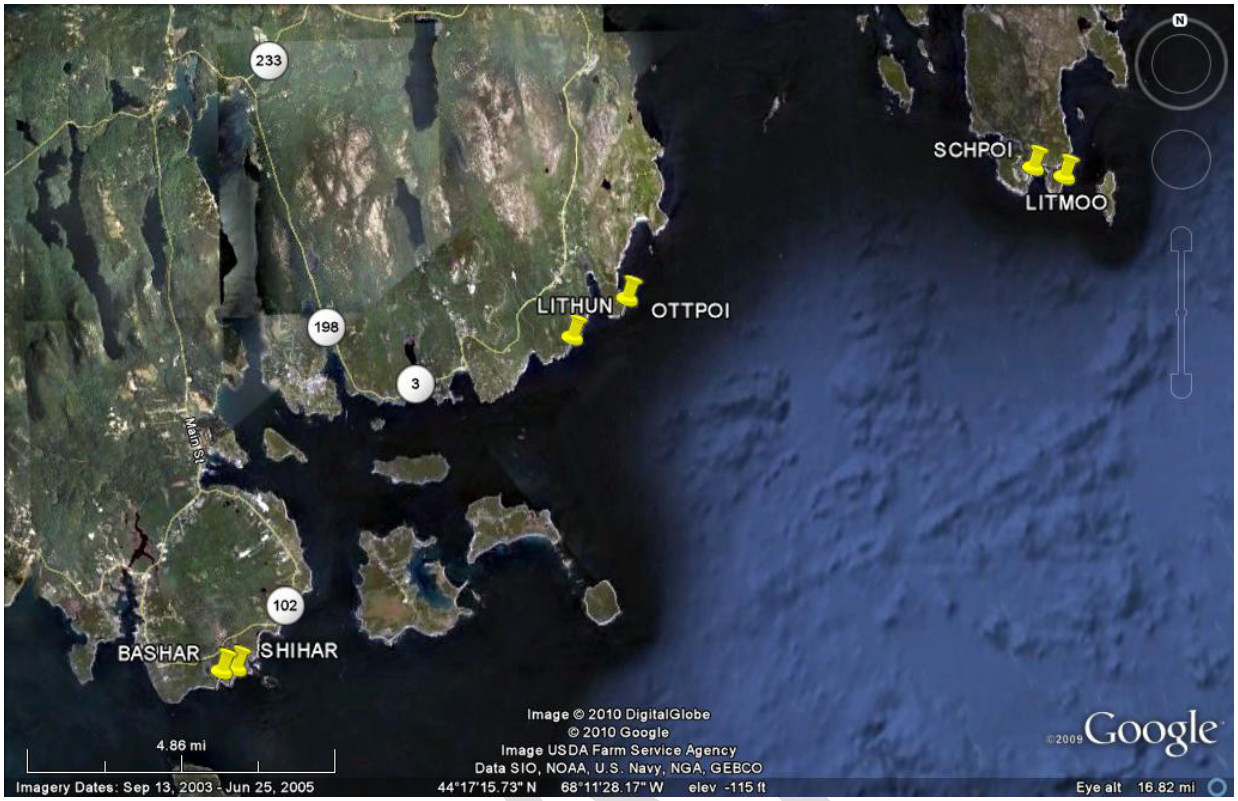

Figure 1. Map of Maine's Mount Desert Island and Schoodic Peninsula showing locations of the original six Acadia National Park sites.

It quickly became apparent that visitation was highest at Ship Harbor, and this was the only site with obvious trampling impacts (e.g. reduced barnacle coverage where people tended to walk). We decided to remove the impact study from this protocol by eliminating the Little Hunter's Head and Little Moose Island sites. These sites were removed because they were difficult to access; either requiring a hike down a steep cliff (Little Hunter's Head) or passing across a land bridge that was submerged for multiple hours between low tides (Little Moose Island). Furthermore, high wave exposure at both sites was unsafe and regularly prevented us from completing sampling. Finally, in the absence of a paired impact-pristine study, paired sites that did not receive different visitation were redundant. Although these sites were removed from this protocol, preliminary data were collected and fixed plots were left in place. It should be possible to resurvey these locations later (perhaps at five year intervals). Unfortunately, one of the effects of removing these exposed sites is that we are left with only two sites, Otter Point and Schoodic Point, in all of ACAD, BOHA, and MCI that currently monitor mussel plots.

The four remaining ACAD sites, and their six letter site codes (consisting of the first three letters of the first and second words in the full site name) are:

- Ship Harbor (SHIHAR, impacted site)
- Bass Harbor (BASHAR, pristine site)
- Otter Point (OTTPOI)

- Schoodic Point (SCHPOI)

Rock type can influence intertidal community composition via heating, small scale roughness, and water retention (Schoch and Dethier 1996, Murray et al. 2006, Littler 1980, Raimondi 1988). Thus, the paired sites on Mount Desert Island were selected, in part, because sites within each pair were found on the same bedrock formation (Gilman and Chapman 1988). The rock type at SHIHAR and BASHAR is “pink, fine grained granite with a distinctive sugary texture” and “contains abundant veins of coarser quartz and feldspar” (Gilman and Chapman 1988). The rock type at OTTPOI and LITHUN is in a “zone of intensely shattered country rock surrounding the Cadillac Mountain granite” and “near the granite contact it consists of angular blocks of dark country embedded in light gray granite” (Gilman and Chapman 1988).

SCHPOI and LITMOO “should be mostly fine grained relatively high silica granite with a lot of small relict gas pockets (called "miarolitic cavities") that have secondary mineralization by quartz, hornblende, and/or epidote” (Chris Koteas, Ph.D. Student, University of Massachusetts Geology Department, pers. comm., May 2008). At SCHPOI and LITMOO, dark gray basaltic dikes are present but none of the monitoring plots were established on these dikes.

In BOHA, a single site was selected on each of three different islands. Only 8 of the 9 outer islands (Green, Little Calf, Calf, Outer Brewster, Graves, Middle Brewster, Little Brewster, and Shags) had extensive permanent intertidal benchrock with moderate to full wave exposure (Bell et al. 2004). Great Brewster lacks significant permanent benchrock and is largely sheltered by the other outer islands. Of these 8 outer islands, four were excluded because they would be difficult to access; either because of dangerous rocks and poor anchorage (Graves, Little Brewster, and Shags) or because the Coast Guard controls access to the island (Little Brewster). The three monitoring sites (Figure 2) were randomly selected from the remaining four. The selected sites in BOHA are:

- Green Island (GREISL)
- Outer Brewster Island (OUTBRE)
- Calf Island (CALISL)

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Figure 2. Map centered on Boston Harbor's outer islands showing locations of the three Boston Harbor Islands National Recreation Area sites.

Site location on each BOHA island was determined primarily by habitat type (permanent benchrock), wave-exposure, and steepness of slope. Many of the shores are steeply sloped and would be difficult to sample (e.g. NW shores of Middle Brewster and Outer Brewster). On each of the three BOHA islands selected, sites with a northeast aspect matched the optimal criteria for site selection as defined above. Because the sites in BOHA face a more northern direction than Acadia sites (typically south to southeast aspect), sun exposure could be very different between BOHA and ACAD – even independent of latitudinal differences between the two parks.

The two criteria that were emphasized when selecting MCI islands were 1) the presence of a summer crew associated with the refuge on the island and 2) island location relevant to ACAD and BOHA. The presence of a summer crew provides more reliable access to the islands using refuge boats and also potentially provides additional volunteers during sampling. To improve the coverage of this protocol along the New England coastline, we selected an island between ACAD and BOHA, and an island to the northeast of ACAD. The selected sites in MCI (Figure 3) are:

- Metinic Island (METISL)
- Petit Manan Island (PETMAN)

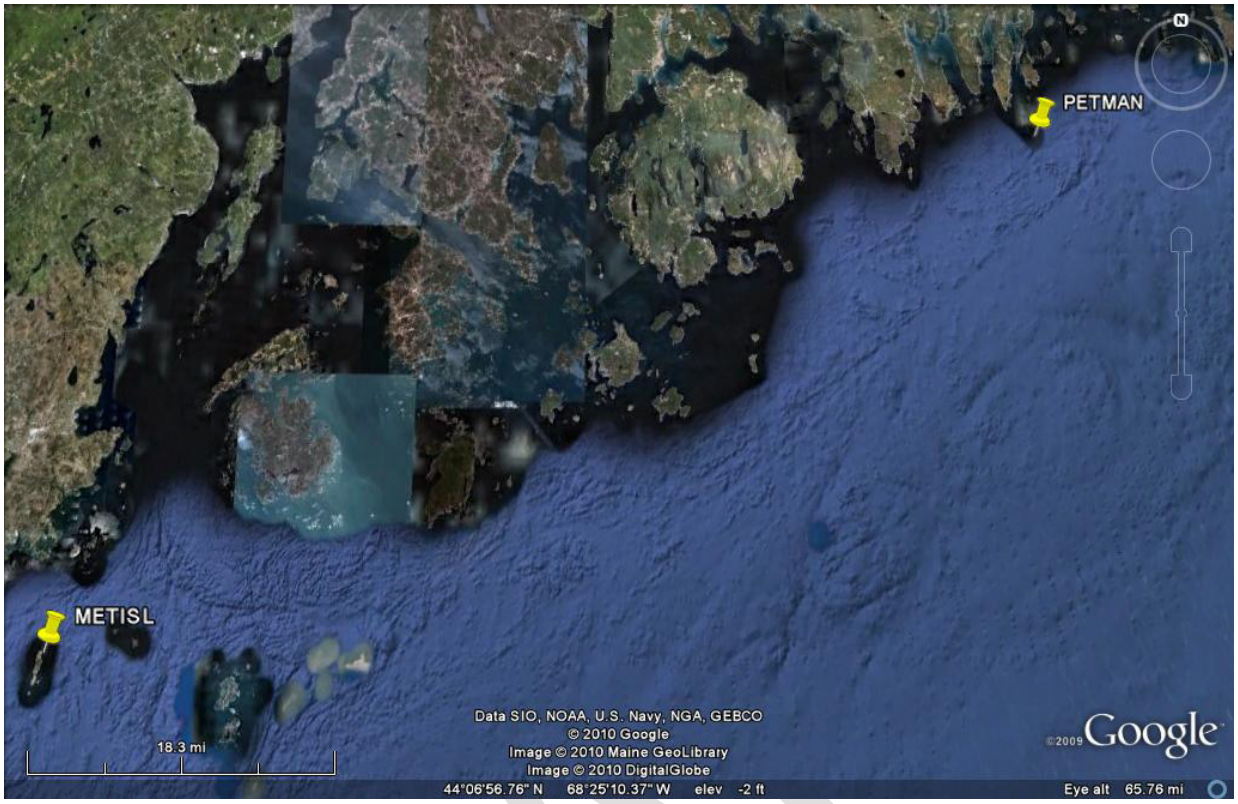

Figure 3. Map centered on the Downeast Maine coast showing locations of the two Maine Coast Islands National Wildlife Refuge sites.

Site location on each MCI island was determined primarily by habitat type (permanent benchrock) and aspect. The overall aspect of these sites is southeast, making them comparable to ACAD sites in this regard. Additionally, sites were selected with input from MCI refuge managers to minimize disturbance to nesting bird populations during site installation and sampling.

Detailed information about site locations can be found in Appendix 1.

Procedures for Selecting Sampling Plots within Sites

Although this protocol focuses on fixed plots, plot installation relies on random selection of plot locations from a user-selected pool of potential locations. Additional information can be found in SOP 2 – Plot Establishment. The current plot locations in ACAD, BOHA, and MCI (shown in Appendix 1) were installed in 2008-2009.

Sampling Frequency

Ideally, sites would be sampled repeatedly throughout each year to capture seasonally abundant species and any long-term changes in seasonality. However, there was little seasonal variation with respect to the target species of different photoquadrats (Figure 4). At any given sampling event, there was greater variation in the cover of mussels and red algae. This variation is the result of lower sample sizes due to difficulty accessing these lower intertidal sites and the difficulty of scoring these plots, which typically contain more shadows because of the structural complexity combined with dark organisms (e.g. mussels).

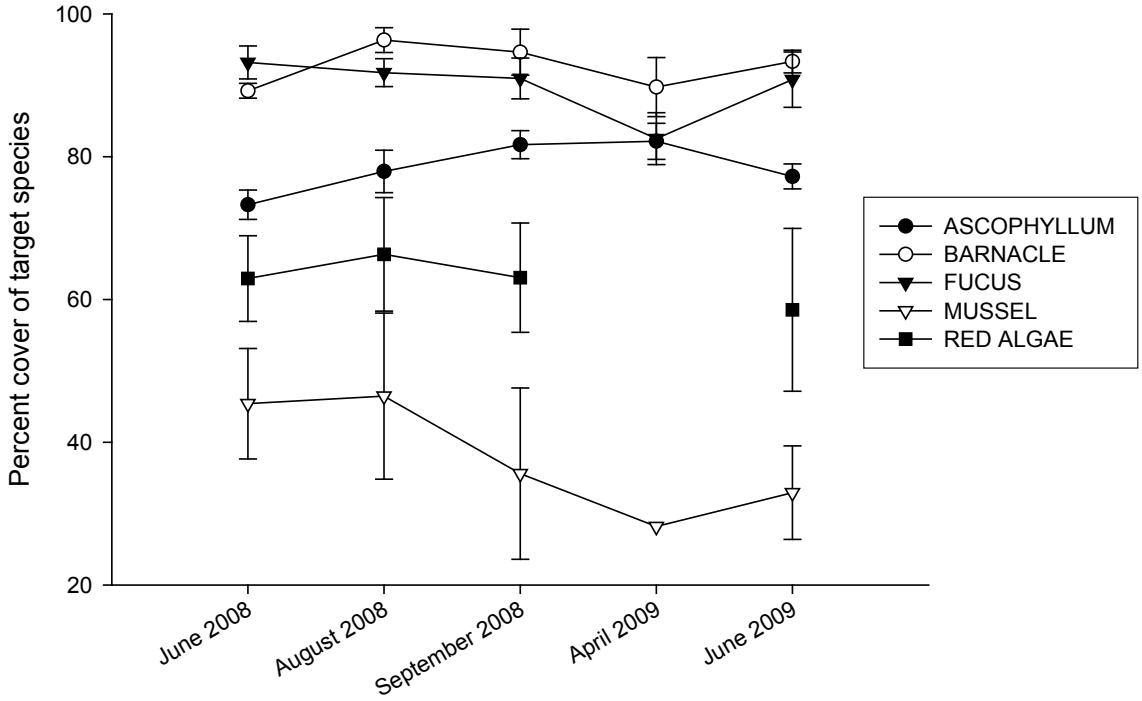

Figure 4. Percent cover of target species within the target photoplots. For example, filled circles represent the cover of *Ascophyllum nodosum* in *Ascophyllum* photoplots and open circles represent the cover of barnacles in barnacle photoplots. For a given time point and target species, percent cover is reported as the mean of the six ACAD sites. Error bars denote standard error between sites. For each site, a single mean of all five replicates was calculated.

The most striking seasonal difference we observed during the two preliminary survey years was related to barnacle coverage in settlement plots, and *Fucus* coverage in *Fucus* photoquadrats at SHIHAR. Regarding barnacle coverage, we saw a decrease in barnacle abundance and a concurrent increase in barnacle coverage from early in the summer (May and June) until late summer and fall (August and September) in settlement plots (Figure 5). This decrease in abundance likely occurred because of natural factors, including mortality from predation and competition. The increase in coverage likely resulted from growth of newly settled individuals. For these reasons, the timing of sampling will influence estimates of barnacle settlement and barnacle coverage in the photoquadrats, so varying sample dates between years may increase measurement variability.

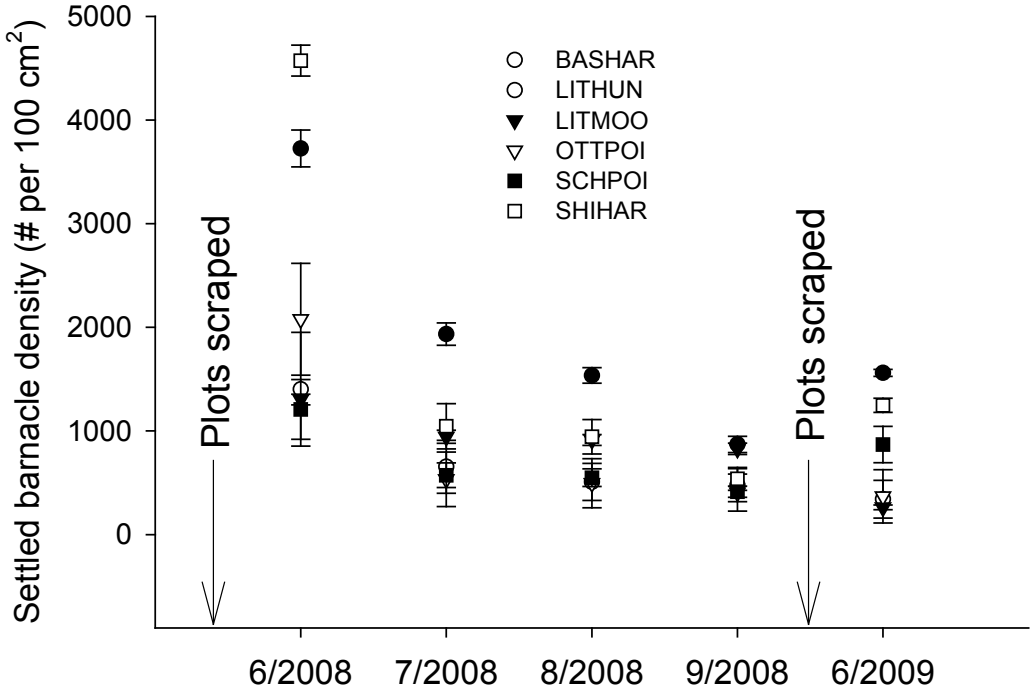

Figure 5. Barnacle density in the barnacle settlement plots at ACAD in 2008 and 2009. Plots were scraped prior to the major recruitment period during both years. The decrease in abundance at all sites from June to September 2008 likely occurred because of predation and competition. Settlement was higher at SHIHAR and BASHAR where adult densities are higher than the other sites. Settlement at these two sites in June was noticeably different between 2008 and 2009 but the June sampling also occurred two weeks later in 2009.

The second example of seasonality was a rapid loss of *Fucus* from *Fucus* plots at SHIHAR from spring to fall. We hypothesize that this decrease was largely driven by human trampling, or an interaction between trampling and some other factor. SHIHAR is the most visited of the protocol sites, and the *Fucus* photoquadrats at SHIHAR are immediately adjacent to substrate that is easy for visitors to navigate (barnacle zone). At the other sites, accessing the *Fucus* photoquadrats is much more difficult.

Initially, we are recommending sampling sites annually for multiple reasons. First, we did not detect much within-year variation in the abundance of target species (with the above exceptions). Second, the expected NPS budget (approximately $26,000 annually) is insufficient to cover monitoring, analysis, data entry, and reporting for sampling all seven NPS sites more than once per year. As a comparison, the Redwoods State and National Park intertidal protocol monitors three sites twice annually for approximately $30,000. Third, the logistics of sampling the sites in BOHA and MCI are already complicated with only an annual sampling commitment. We also recommend sampling LITMOO and LITHUN every 5 years; periodic sampling of these fairly pristine sites may provide useful information about visitor impacts on the nearby SCHPOI and OTTPOI sites that attract more visitors.

Our recommendation is to monitor the sites sometime between June and August, preferably in the same month for all sites. Given approximately one day to sample each site, this will require a full nine days of sampling. Within this range, the last week of June and first week of July are beneficial for three reasons. First, we have observed significant barnacle settlement in Acadia in early June. This suggests that sampling should occur no earlier than the last week of June. Second, as noted above, apparent barnacle settlement declines through time as barnacles grow and die. Since we are more interested in estimating barnacle settlement rather than post-settlement survival, sampling should occur as early as possible after the settlement phase. Third, ephemeral algae are more abundant earlier in the year. The major caveat to this sampling schedule is that dense populations of seagulls and cormorants nest adjacent to our sites on the outer islands of BOHA (approximately June through July, C. Trocki, pers. comm.), and birds nest near the MCI sites as well. If BOHA and MCI will be sampled after nesting season (e.g. August) to avoid disturbance to birds, then we recommend also changing Acadia sampling to August to match sampling months (although this will affect the barnacle and ephemeral algae data).

In addition to this primary sampling event, each site is currently visited in the winter (February or March) to scrape the barnacle settlement plots. These visits are quick (20 minutes per site) and, therefore, plots can be scraped at multiple sites during an individual low tide. For example, all three BOHA plots could be scraped in a single low tide. Similarly, all three ACAD sites on Mount Desert Island could be scraped during one low tide. However, accessing these sites at this time of year can be unpleasant or impossible because of storms. Therefore, future versions of this protocol should consider scraping the settlement plots after they have been photographed during the regular summer sampling. The benefit of this change is the elimination of a trip to the site during winter. The cost is that we have not tested this approach so we are uncertain what might settle in the plots that could influence barnacle recruitment the following spring. This uncertainty will inhibit our ability to use the preliminary data collected with the current protocol of scraping plots in winter if this change is made.

Sampling should occur during the month's lowest daytime tides because sampling is more efficient in daylight (Cox and Raimondi 2007). Typically, there are two periods of approximately one week in length within each summer month when tides are most favorable for sampling (e.g. tidal height ≤ 0.5 feet above Mean Low Water). Occasionally, there will be days where both daily low tides are low enough to be sampled. If sites are sampled on both low tides, this will dramatically decrease the number of days needed to sample sites. These "double tide" days can be exhausting because of the reduced preparation and down time. Although most plots within the sites may be sampled at slightly positive tides, sampling dates should occur during negative tides whenever possible. Sampling will start 3.5 to 4 hours before low tide (assuming sufficient daylight; closer to low tide in the event of large swell) and continue until the tide covers all plots or sampling is completed. Sampling may begin closer to the low tide if there are several volunteer assistants available to help. However, it is better to arrive too early (with the cost of assistants waiting for the tide to go out) than to arrive too late (with the cost of not completing sampling on a single day).

When sampling a site, it is always best to sample the lowest plots (i.e., red algae photoquadrats, tide pool band transects, point-intercept transects, and temperature sensors) as early as possible since these plots are exposed for the shortest amount of time. Higher plots can be sampled with

the flood tide. Understanding the relative placement of plot types (Figure 6) should help guide sampling events.

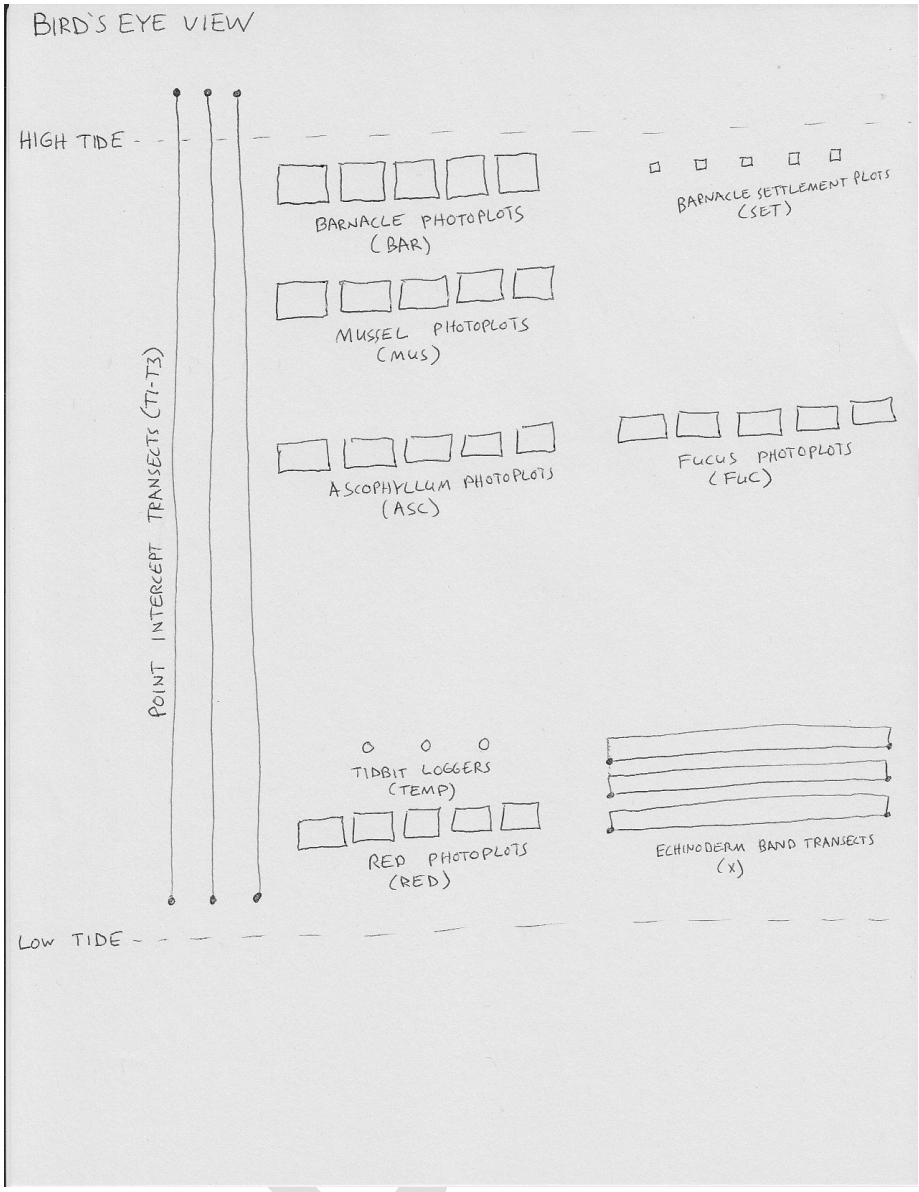

Figure 6. Schematic view showing the relative location of plot types within a site.

Replication

Each sampling site contains three point-intercept transects, three tide pool band transects, five barnacle settlement plots, three tidbit temperature sensors, and five each of up to five target species photoquadrat types (i.e., *Fucus*, *Ascophyllum*, barnacle, mussel, and red algae; up to 25 photoquadrats) (Table 3). Motile invertebrates are sampled in the photoquadrats, for up to 25 plots per site.

Table 3. Number of replicates for each fixed plot sampling type.

PARK	SITE	PHOTOQUADRATS[1]					OTHER PLOTS[2]			
		ASC	BAR	FUC	MUS	RED	SET	X	T	TEMP
ACAD	BASHAR	5	5	5	0	5	5	3	3	3
	LITHUN[3]	5	5	5	5	0	5	3	3	0
	LITMOO[3]	5	5	5	0	5[4]	5	3	3	0
	OTTPOI	5	5	5	5	5	5	3	3	3
	SCHPOI	5	5	5	5	5	5	3	3	3
	SHIHAR	5	5	5	0	5	5	3	3	3
BOHA	CALISL	5	5	5	0	5	5	3	3	3
	GREISL	5	5	5	0	5	5	3	3	3
	OUTBRE	5	5	5	0	5	5	3	3	3
MCI	METISL	5	5	5	0	5	5	3	3	3
	PETMAN	5	5	5	0	5	5	3	3	3

[1] ASC = Ascophyllum nodosum, BAR = Barnacle (Semibalanus balanoides), FUC = Fucus spp., MUS = Mussels (Mytilus edulis), RED = Red algae (mostly Chondrus crispus, Mastocarpus stellatus, and Palmaria palmata)
[2] SET = Barnacle settlement, X = Band transects in tide pools, T = Vertical point-intercept transects, TEMP = Temperature sensors (tidbits)
[3] Sampled once every 5 years
[4] The red algae plots at LITMOO are dominated by *Palmaria* rather than *Chondrus* and *Mastocarpus*. Monitoring is optional since the data will not correspond to other sites.

Detectable Level of Change

The fixed plot sampling of target species used here and for MARINe sites has high power to detect changes in the abundance of common intertidal species (Murray et al. 2006, Cox and Raimondi 2007). For example, a recent power analysis using data collected with this methodology indicated that these protocols are able to detect a 50% change in species abundance with 80% power (Murray et al. 2006, Cox and Raimondi 2007), a level that has been a reasonable goal for monitoring programs (Fairweather 1991). Dr. Penelope Pooler (NPS quantitative ecologist, Northeast Coastal and Barrier Network) conducted power analyses based on pilot data collected at Acadia and Boston Harbor Islands (Appendix 2).

The key findings from these analyses are:

- Large (greater than 50%) changes in the density of *Littorina littorea* and *L. obtusata* can be detected at a single site within 10 years in the *Fucus* zone, but not in the *Ascophyllum* zone. With five quadrats, a 50% decrease in *L. obtusata* can be detected in 4 years, and the same decrease in *L. littorea* can be detected in 7 years.

- Changes in the size of *L. obtusata* can be detected at a single site using a sample size of only 15 individuals. In either the *Ascophyllum* or the *Fucus* zone, a 50% change in the size of individuals can be detected in seven or fewer years.

- In most cases, it will be possible to detect changes in the cover of target species within photoquadrats reasonably within ten years.

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- Changes in the density of several species can be detected along point-intercept transects. A 50% change in the abundance of *Ascophyllum*, *Fucus*, and barnacles can be detected at most locations within 10 years using the current sampling interval (every 30 cm).

More details about the power analyses can be found in Appendix 2.

Field Methods

Field Work Preparation

Scheduling and logistical preparation should be arranged three to six months prior to the sampling season (SOP 3 – Pre-season Preparations). This includes travel and lodging arrangements. Park and refuge headquarters will be contacted prior to sampling events to alert park or refuge staff about the pending sampling activities, to provide an opportunity to coordinate logistics and to alert the project's lead scientist about any special circumstances (such as steps needed to reduce interference with nesting birds on BOHA). The project's lead scientist must assemble gear and test batteries well ahead of the first day of sampling, in case new equipment or fresh batteries are needed.

A field notebook will be maintained for each site that includes site maps, interplot measurements, GPS coordinates of reference bolts, and photographs of all fixed plots (preferably from a distance with quadrat frames over quadrats and an orange cone over reference bolts). This guide will help samplers locate plots, especially for plots whose corner bolts are covered by seaweed canopies (e.g. *Fucus*, *Ascophyllum*, and red algae photoplots) and for plots that are spaced far apart (e.g. the mussel photoquadrats at SCHPOI).

Summary of Field Methods

Field methods are briefly described below, and complete details can be found in the appropriate SOPs. Data forms used for sampling are reproduced in Appendix 3.

Photoquadrats

Rectangular photoquadrats (50 x 75 cm = 0.375 m^2) are used to monitor the surface cover (top layer only) of small, sessile target species. To minimize sampling time already limited by the low tides and to provide a permanent visual record of plots, the field crew takes photographs in the field and scores them afterwards in the laboratory (SOP 12 – Photoquadrats and Overview Photos and SOP 19 – Scoring Photoquadrats). The plot size has been selected to allow a comfortable camera working height and provide sufficient detail to identify target species. Following the MARINe protocol, five replicate plots per target species are monitored throughout the target species' zone of maximum abundance per site. Photoplot photos are then analyzed in the lab at a later date.

Point-intercept Transects

Transects extending from the low to the high intertidal zone (length varies by site) are used to monitor changes in the range of species with respect to intertidal height. The field crew scores what occurs every 30 cm along a transect tape extending between bolts in the low and the high intertidal zones (SOP 15 – Point-intercept Transects). Three replicate transects are monitored at each site. Although the primary purpose of these transects is to monitor target species, they also provide data on rare and non-target species. Once the heights of the transect bolts have been

surveyed, these transects will be used to determine the core species abundance (percent cover) and ranges of intertidal elevations inhabited by core species. These ranges should be particularly sensitive to climate change (e.g. warming and sea level rise) – one of the main reasons that intertidal systems are attractive for monitoring ecological consequences of climate change.

Tide Pool Band Transects

The number and size of sea stars and sea urchins will be monitored with band transects between permanent bolts (SOP 14 – Tide Pool Transects). We will monitor three replicate 2 x 10 m plots per site placed in the low intertidal. If species densities become low within these transects, we will continue to monitor the transects and we may also initiate site-wide timed searches during each survey for these species.

Motile Invertebrates

We will count the number of motile invertebrates, including snails and limpets, in every photoquadrat (SOP 13 – Motile Invertebrates). Monitoring motile invertebrates within photoquadrats will facilitate our ability to correlate changes in their densities with changes in the cover of habitat-forming target species (like *Fucus*, *Ascophyllum*, red algae, barnacles, and mussels).

Barnacle Recruitment

We will monitor the recruitment of barnacles at each site (SOP 12 – Photoquadrats and Overview Photos and SOP 19 – Scoring Photoquadrats). Barnacle recruitment will be monitored using small clearings.

Water Temperature

Three "tidbit" temperature sensors are deployed in the low intertidal (i.e. red algal zone) at each site. These sensors record temperature once every hour. Data from tidbits are downloaded once per year (SOP 16 – Temperature Loggers). Tidbits are replaced every three years to prevent gaps in data. The downloaded data are then filtered to include only water temperature because of the well-known heterogeneity in air temperature in complex intertidal habitats.

Overview Photographs

A series of overlapping photographs are taken of each fixed plot (SOP 12 – Photoquadrats and Overview Photos). These are shot from the same location each time (the reference bolt) to place changes occurring within the plots into a broader spatial context.

Field Log

Information about the site-wide abiotic and biotic conditions is recorded in the field log (SOP 17 – Field Log).

End of Day Procedures

Three jobs must be completed as soon as possible after monitoring is complete: data sheet quality control, downloading and naming of digital photographs, and preparation for the next sampling date. All data sheets should be reviewed while in the field, and before the tide covers the relevant plots, to detect and correct serious errors. A more thorough review at the end of the day can uncover less serious errors associated with entering data into the sheets. Reviewing data sheets while in the field can uncover errors associated with entering data into these sheets while it is still possible to correct them. In some cases, incomplete entries may result in full or partial

losses of sampling data. Table 4 lists items that should be checked at the end of each day, since they are situations where errors are more common.

Table 4. End of day quality control check for common data errors.

Data sheet	Entry to check
All	Site name
All	Date *including the year*
All	Observer name
Tide pool band transect	Enter “0” when zero animals were found for a species.
Motile invertebrates	Plot type
Motile invertebrates	Circle area sampled
Motile invertebrates	Enter “0” when zero animals were found for a species.
Point-intercept transect	Transect number
Point-intercept transect	A single entry for each column.
Photoquadrat sketches	Plot type

Download photos immediately to a computer and rename them according to the conventions described in SOP 18 – Field Work Wrap-up. This is especially important because procedures do not currently call for use of a photolog and plots are photographed in order from 1 to 5. These photographs are likely the most valuable part of a surveying trip, so downloading and renaming them is a high priority. Also, data on digital camera storage (e.g. memory cards) should be deleted prior to the next sampling event. Skipping the photolog currently saves time and provides additional hands for shooting and shading plots.

Sampling trips often fall upon several consecutive days. Thus, gear should be maintained daily and replaced if needed; this includes regularly recharging batteries.

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Data Management, Analysis, and Reporting

Data Management

Because of the harsh nature of the rocky intertidal environment, all data will be collected on waterproof paper data sheets that are designed for accurate and complete data collection. All field data sheets will be quickly reviewed by the leader of the field data collection effort before the relevant plots are submerged, and then fully reviewed and initialed by the leader at the end of each field sampling event. As soon as possible after data collection, the data will be transcribed to an MS Access database developed by North Carolina State University and maintained by the NETN Data Manager (See SOP 8 – Data Management and QA/QC). Data entry will follow standard quality assurance and quality control (QA/QC) procedures established by NETN, including a 100% comparison of all field data sheets against the database (conducted by the project's lead scientist) and a subsequent 10% check of the data by NETN data management staff.

After data QA/QC, completed data forms will be copied onto acid-free paper and sent to the NETN office each year, while originals will be maintained by the project's lead scientist. NETN will maintain at least five years of data in the network office; older data sheets will be periodically archived at Acadia NP.

Requests for monitoring data should be directed to the NETN Data Manager (Adam_Kozlowski@nps.gov). Each request will be reviewed on a case-by-case basis, and any data on sensitive species (as defined by each park's Resource Manager or refuge staff) will be removed before data are provided to requestors outside of the NPS and USFWS.

Data Analysis

For each park or refuge, annual summaries of the monitoring data will consist of relatively simple statistical tabulations providing a "snapshot" of the intertidal community. Annual results will be compared to the mean values of previous years in order to gauge whether they are above or below "normal."

Periodically, perhaps every 5 to 10 years depending on perceived need and funding, a more detailed analysis will be conducted that will include estimates of target and core species abundance and trends, focusing on the most abundant species and those of management or conservation concern. Such an analysis will involve more sophisticated statistical modeling, and may include procedures such as estimating equations (Link and Sauer 1994), repeated measures ANOVA, hierarchical modeling, and methods for detecting non-linearities in trend data (e.g., piece-wise linear regression or Bayesian change-point analysis).

Additional information about planned data analyses can be found in SOP 21 – Data Analysis and Reporting.

Reporting

NETN recognizes the importance of effective communication and reporting to transform field data into a format that is both useful and clearly understood by park and refuge managers, scientists, the public, and policy makers. This will be accomplished by developing standard graphical and statistical summaries of vital sign measurements (see Data Analysis). While a

measure of the "ecological integrity" of these species/communities would be extremely useful, there is no agreement about what constitutes a healthy rocky shore community in New England, largely because of the significant spatial and temporal heterogeneity associated with this community. For example, a species' density that is "healthy" at one site might be "unhealthy" at a site where the species is more abundant. Thus, the best measure of the "ecological integrity" of a site will be regular comparisons of current conditions to the conditions during the first five years of monitoring.

Following each field season, an annual report will be prepared summarizing the year's work. This will include routine summaries for each measure at each sampled park and for the NPS and USFWS sites as a whole. The measures will be presented in a general framework that reflects the underlying conceptual model that the vital signs and measures are based upon. Periodically, perhaps every 5-10 years depending on perceived need and funding, a trend report will document more detailed analyses.

See SOP 21 – Data Analysis and Reporting for additional information about planned reports.

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Personnel Requirements and Training

Roles and Responsibilities

During our two year protocol development period, we learned that a lead scientist (or principal investigator [PI]) is needed who is familiar with the protocol as well as the sites. This familiarity makes time spent in the field more efficient, avoids unnecessary safety risks, and increases the reliability of the data because of proper assignment of tasks based on participant training and interest. Thus, we recommend that a single person be responsible for coordinating and organizing sampling trips and volunteers, data collection, data entry, and data management. It may help to have multiple PIs, such as separate individuals responsible for ACAD, BOHA, and MCI, in order to reduce the need for a single PI to travel between and maintain familiarity with multiple sites. A minimum of 4 assistants are recommended to assist the PI during sampling, if sampling will be completed in a single low tide sampling event. The assistants will be responsible for field sampling, sampling logistics, packing and maintaining gear, and data entry. The efficiency of these assistants will largely depend on their previous training as well as their ability to navigate around slick conditions in the intertidal. With well-trained assistants, a single site at BOHA or MCI and a full site plus part of a nearby site at ACAD can be completed during a single low tide. To reduce observer bias and facilitate temporal comparisons, a single person should be responsible for scoring the digital photographs every year. Additionally, the accuracy of this observer will be compared to a subset of images scored by the PI. Corrective measures will be taken if the observer and PI photo scoring vary by more than 5% with respect to the plot's target species (SOP 19 – Scoring Photoquadrats).

Based on these experiences, NETN is considering three potential models for protocol implementation at NPS sites. The first model is to use groups of college students who sample sites during school field trips. This approach is the most logistically difficult due to the need to schedule several fairly large groups. It is also the least safe option, since many – often inexperienced – individuals will need to be trained in safe field procedures and the logistical difficulties of scheduling field trips will make it harder to cancel trips because of inclement weather. The second model would be to use a group of dedicated volunteers in concert with the project PI. While this has value for engaging local citizens in scientific work at the park, it will be difficult to engage a dedicated group of volunteers who will be physically fit and able to commit to the rigorous field schedule. The third model is to recruit four college interns, two at ACAD and two at BOHA. The college interns would sample the rocky intertidal sites in late June or early July, take care of photo scoring and other data management tasks, and then spend the rest of their internships working on other monitoring projects (including salt marsh monitoring at both parks, and estuarine monitoring at ACAD). There would be an overall PI in charge of the rocky intertidal portion of the internships, and a separate PI who would help with logistics at the more distant park. The interns would need close supervision by one of the PI's until they could sample sites on their own, but would then work independently. While it is unlikely that the interns would be able to sample a complete site in one low tide cycle, the interns would have several weeks to sample three or four sites. NETN is currently leaning towards this third strategy, and plans to test it in 2011.

Implementation at the MCI sites will be through staff stationed on the islands with study areas. One of the permanent biologists at MCI will serve as the local coordinating PI, and may receive training (as needed) along with the ACAD interns. It may also be possible for other MCI staff to

attend training sessions, or for the ACAD interns to spend some time at the MCI study areas assisting with data collection. Scoring of MCI plot photos would likely be conducted by the BOHA or ACAD interns.

Other key individuals for this protocol include:

- NETN Program Manager – responsible for project oversight, including recruitment of project PI's and evaluating the efficacy and quality of the project.
- NETN Data Manager – responsible for ensuring the data quality of the project.
- ACAD and BOHA Resource Managers – local coordinating responsibilities, including making PI's aware of any potential conflicts with other projects, assisting with logistics, and reviewing the management implications of the monitoring data.
- MCI Biologist – serves as the PI for the USFWS sites, including handling logistics, ensuring availability of equipment, and ensuring that appropriate training is provided to field staff.

Qualifications

The overall PI should have significant experience working in the field using similar methods described in this protocol, including deployment and recovery of hardware on intertidal substrates and measuring percent cover using photographs and conducting transect-based sampling. Furthermore, the PI must have taxonomic expertise related to invertebrates and seaweeds of New England shores. This expertise will strengthen the reliability of the data. All field samplers (PI plus assistants) must be physically fit and able to carry packs with 50 lbs of equipment across uneven terrain in a variety of weather conditions including snow, ice, and rain. Photography of photoquadrats and analysis of these photos will only be conducted by experienced participants (SOP 19 – Scoring Photoquadrats).

Training

Different sampling responsibilities require different levels of expertise. Participants should be assigned to one of the three following categories based on their abilities. Depending on the implementation model used by NPS and USFWS, beginners might not be used for monitoring. It is important, however, that at least a leader and intermediate-skilled observer participate in all sampling activities.

Beginner

Beginner participants may have no marine science training and no experience with monitoring intertidal communities. Fortunately, volunteers falling into this category are often available and there are several tasks that they can be assigned. Beginner assignments include plot location, plot maintenance, plot repair, collecting motile invertebrates from photoquadrats after a brief introduction to the snails and limpets and where they tend to cluster, placing the band transect, shading photoquadrats for photos, and recording data onto datasheets that are being measured by a more experienced person.

Intermediate

Intermediate participants have some training that will help them recognize the dominant invertebrate and macroalgal species being monitored. Examples of relevant training include coursework, or a degree, in marine science or participation on previous sampling trips that imparted a similar amount of knowledge about the abundant species. Intermediate participant responsibilities include all of the Beginner tasks plus scoring the point-intercept transects; scoring the echinoderm band transects; drawing the photoquadrats; identifying, enumerating, measuring, and quantifying damage of motile invertebrates; placing the point-intercept transect; and measuring echinoderms.

Leader

The leader has excellent knowledge of the site, the methods, and the abilities of the crew. The leader will be responsible for assigning participants to their appropriate tasks, determining the order of sampling while considering the rise and fall of the tide, photographing photoquadrats, downloading temperature data from tidbits, drilling new holes for repair or new plots, completing the field log, and organizing completed data sheets. The leader will fill in for any of the Intermediate or Beginner jobs to expedite sampling.

Safety Considerations

Although the rocky shore can be a beautiful and amazing place to conduct research, there are several hazards that need to be identified and considered before any sampling event. First, many of these sites have areas that could be considered fully-exposed to big waves. Waves present a threat because of their ability to knock people over, splash people, or wash people into the ocean. Given the cold water temperatures at the monitoring sites, falling into the ocean represents a serious, potentially life-threatening hazard. To minimize risks associated with waves, check the local marine forecast. Additionally, it is wise to watch the waves for a few minutes before descending into the intertidal, to get a feel for their size, direction, and splash. However, rogue waves of significantly larger height than the average height at any time can arrive unexpectedly. It's a good idea to regularly watch and listen to the waves throughout sampling.

A second major hazard is that most surfaces, with the exception of barnacles and mussels, are extremely slick and sometimes steep. These features combined with the numerous sharp (e.g. pointy rocks, barnacles, urchin spines, etc.) and hard surfaces increase the potential for injury by falling. To minimize these risks, wear knee pads, walk carefully, and whenever possible, maintain three points of contact with the substrate.

A third hazard is lightning strikes. People are at risk because they will be the highest point in the middle of some intertidal locations and sometimes hold large metal objects (e.g. drills). If lightning is in the area, postpone sampling and seek refuge.

Finally, never use generator powered tools (e.g. drills) because of the risk of electric shock when surrounded by water. Gas and battery-powered equipment should be used instead.

Additional safety considerations are described in SOP 1 – Safety.

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Operational Requirements

Annual Workload

The annual workload for rocky intertidal monitoring at ACAD, BOHA, and MCI will depend on a variety of factors, especially the implementation model chosen (school groups, volunteers, or interns). Assuming an intern-based implementation at NPS sites, the following workloads are likely:

- Project Leader – 0.17 Full Time Equivalent (FTE) or 8 weeks. This includes time for recruiting and training field staff, participating in field work and QA/QC activities, and producing annual monitoring report.

- Field Staff – 0.25 FTE or 12 weeks. This includes field work prep, 4 person-days of field time for each of the nine sites, data entry and data management, and scoring photoquadrats.

- Local Coordinators – 0.05 FTE or 2 weeks. This includes logistical support for field activities.

- NETN Program Manager – 0.02 FTE or 1 week. This includes annual operational review, report reviews, and working with NPS contracting.

- NETN Data Manager – 0.03 FTE or 1 week. This includes participating in the annual operational review and QA/QC.

Schedule of Events

The following is a rough schedule of annual monitoring activities:

- January – Begin field season planning. Organize scraping of barnacle settlement plots. Work with NPS contracting and cooperator/contractor to transfer funding.

- February and March – Hire field staff (summer interns). Scrape barnacle settlement plots.

- April and May – Complete field season planning, including equipment checks and purchasing of replacement equipment.

- June – Field staff training and initiation of field sampling.

- July – Completion of field sampling.

- July and August – Data entry and photoquadrat analysis. QA/QC of entered data.

- September and October – Data analysis and drafting of annual monitoring report.

- November and December – Completion of annual monitoring report and annual operational review.

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Facility and Equipment Needs

Most of the basic equipment needs for this protocol are covered in SOP 3 – Pre-season Preparations. Each park or refuge will probably need its own set of equipment (including camera and drill), although it may be possible to share some equipment between sites with careful scheduling. Transportation needs include a boat to access BOHA and MCI sites, a dinghy for transport to BOHA sites from the boat anchorages, and a vehicle for reaching ACAD sites. Sampling staff at ACAD and BOHA will need housing. In addition, each park or refuge sampling crew will need access to a computer with Microsoft Access and the rocky intertidal database. Any staff who will be handling the photoquadrat photograph scoring will need a license for Adobe PhotoShop. Each park or refuge will also need space to clean and dry out gear between sampling events, as well as a safe place to store sampling gear between seasons.

Startup Costs and Budget Considerations

Initial costs for this protocol include the purchase of all equipment and supplies needed for each park or refuge. The greatest expenses are for cameras setups (particularly the strobe and waterproof case) and drill. A complete set of equipment should cost approximately $6,000.

Startup costs also include time to establish plots at each monitoring site. At this time, the ACAD, BOHA, and MCI sites are established, but setting up additional sites would likely take approximately a week of the project manager or PI's time, plus assistance from one or two others.

The Northeast Temperate Network anticipates operational monitoring of the seven sites at ACAD and BOHA to cost approximately $26,000 per year. This excludes time spent by NPS staff overseeing the project and providing logistical support. The budget breaks down roughly as follows:

- $12,000 – Project manager or PI salary
- $5,000 – Field staff stipends
- $1,000 – Equipment and supplies
- $3,000 – Indirect costs
- $5,000 – Transportation and lodging

The Maine Coast Islands NWR will cover field work at their sites using existing staff resources. Data management and photoquadrat analysis for their sites will be conducted by NETN staff.

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Appendix 1. Monitoring Site Details

The figures (Figure 7 through Figure 14) document the location of each monitoring site, while the tables (Table 5 through Table 26) document reference bolts and plot locations at each site. All coordinates are UTM zone 19, NAD 1983, and all bearings are magnetic north. Declinations at the time of plot establishment were 16 degrees west for BOHA and 17 degrees west for ACAD and MCI.

This appendix also contains a table of plot elevations for Acadia sites (Table 27), calculated using the still-water method, and a table of plot slopes and aspects for Acadia sites (Table 28).

Acadia National Park

Bass Harbor

To reach the Bass Harbor site from park headquarters, turn left at Eagle Lake Rd/ME-233. After 3.0 miles, turn right at ME-198/ME-3/Sound Dr. After 1.4 miles, turn left at Main St/ME-102/ME-198. Obey speed limits as sections of this road are well-patrolled. After 8.6 miles, slight left at ME-102A. Continue to parking lot for Bass Harbor Lighthouse.

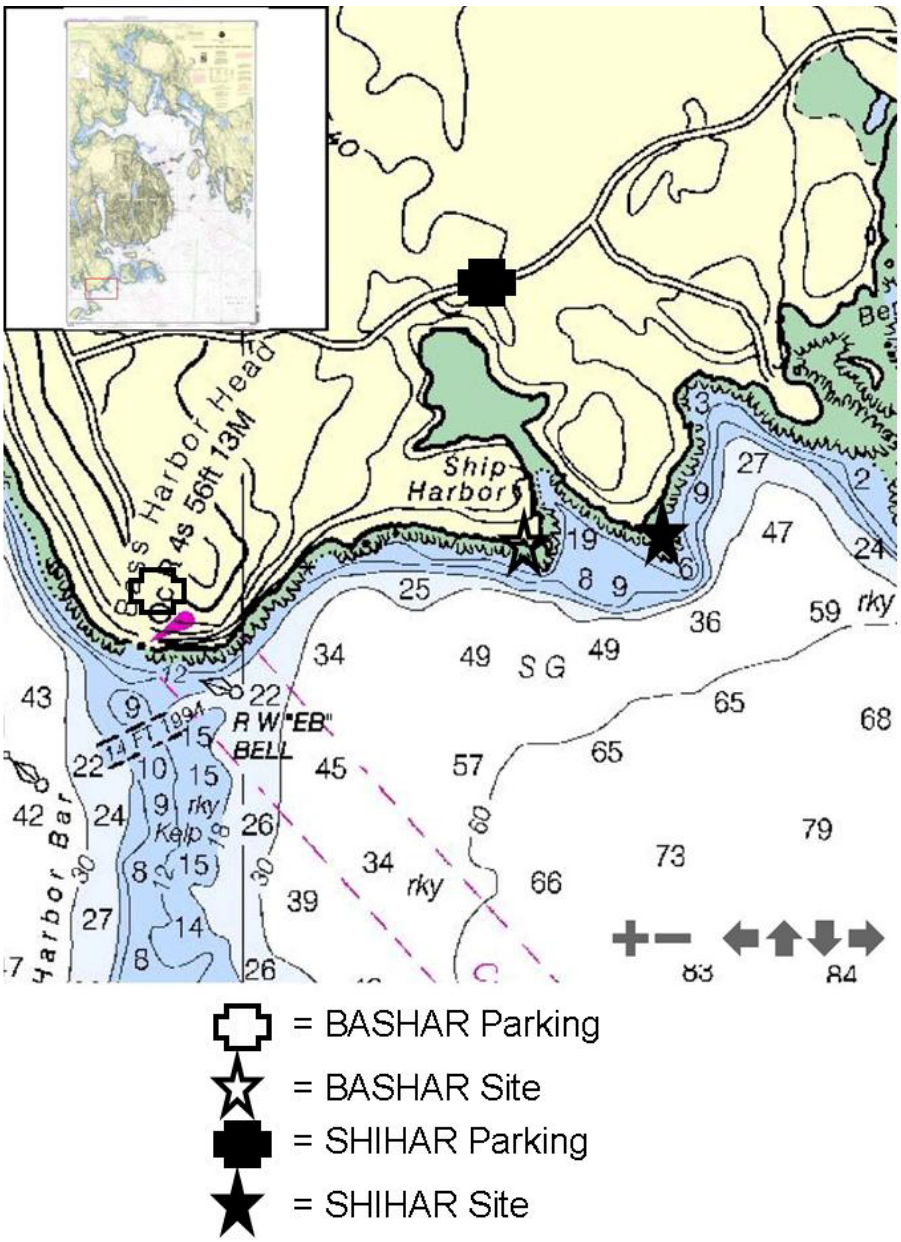

Figure 7. General location and nearby parking for the Bass Harbor (BASHAR) and Ship Harbor (SHIHAR) sites.

Table 5. Bass Harbor reference bolts. Coordinates are UTM zone 19, NAD 1983.

Name	East	North
BASHARASC	554086	4897060
BASHARBAR	554136	4897034
BASHARFUC	554133	4897025
BASHARRED	554128	4897001
BASHARTHI	554157	4897047
BASHARTLOW	554184	4897024
BASHARX3	554161	4897041

Table 6. Bass Harbor plot locations.

Plot	Plot or Bolt ID	Reference Bolt Name	Heading to Plot	Distance (m)
Ascophyllum	BASHARASC1	BASHARASC	169	9.35
Ascophyllum	BASHARASC2	BASHARASC	194	12.54
Ascophyllum	BASHARASC3	BASHARASC	197	10.40
Ascophyllum	BASHARASC4	BASHARASC	211	12.55
Ascophyllum	BASHARASC5	BASHARASC	223	12.90
Barnacle	BASHARBAR1	BASHARBAR	163	8.59
Barnacle	BASHARBAR2	BASHARBAR	173	7.28
Barnacle	BASHARBAR3	BASHARBAR	185	9.58
Barnacle	BASHARBAR4	BASHARBAR	189	6.63
Barnacle	BASHARBAR5	BASHARBAR	204	10.62
Fucus	BASHARFUC1	BASHARFUC	163	9.06
Fucus	BASHARFUC2	BASHARFUC	177	8.29
Fucus	BASHARFUC3	BASHARFUC	190	5.30
Fucus	BASHARFUC4	BASHARFUC	219	3.98
Fucus	BASHARFUC5	BASHARFUC	240	5.75
Red Algae	BASHARRED1	BASHARRED	155	8.30
Red Algae	BASHARRED2	BASHARRED	171	6.04
Red Algae	BASHARRED3	BASHARRED	184	7.61
Red Algae	BASHARRED4	BASHARRED	185	5.26
Red Algae	BASHARRED5	BASHARRED	229	6.39
Barnacle Settlement	BASHARSET1	BASHARBAR		
Barnacle Settlement	BASHARSET2	BASHARBAR		
Barnacle Settlement	BASHARSET3	BASHARBAR		
Barnacle Settlement	BASHARSET4	BASHARBAR		
Barnacle Settlement	BASHARSET5	BASHARBAR		
Band Transect	BASHARX1	BASHARFUC	146	15.40
Band Transect[1]	BASHARX1N	BASHARFUC	161	
Band Transect	BASHARX1S	BASHARFUC	195	
Band Transect	BASHARX2	BASHARFUC	213	14.25
Band Transect[1]	BASHARX2N	BASHARFUC	240	
Band Transect	BASHARX2S	BASHARFUC	269	
Band Transect	BASHARX3	BASHARX3	122	28.80
Band Transect[1]	BASHARX3N			
Band Transect	BASHARX3S			
Vertical Transect[2]	BASHART1HI	BASHARTHI		
Vertical Transect	BASHART1M	BASHARTLOW	140	25.39
Vertical Transect	BASHART1LO	BASHARTLOW	92	9.40
Vertical Transect	BASHART2HI	BASHARTHI		
Vertical Transect	BASHART2M	BASHARTLOW	145	24.54
Vertical Transect	BASHART2LO	BASHARTLOW	114	7.39
Vertical Transect	BASHART3HI	BASHARTHI		
Vertical Transect	BASHART3M	BASHARTLOW	147	24.17
Vertical Transect	BASHART3LO	BASHARTLOW	132	6.07
Tidbit	BASHARTEMP1	BASHARFUC	191	32.33
Tidbit	BASHARTEMP2	BASHARFUC	218	24.25
Tidbit	BASHARTEMP3	BASHARFUC	235	26.26

[1] Bearing from X1N to X1S = 128; X2N to X2S = 342, and X3N to X3S = TBD.
[2] Overall heading of vertical transects = TBD.

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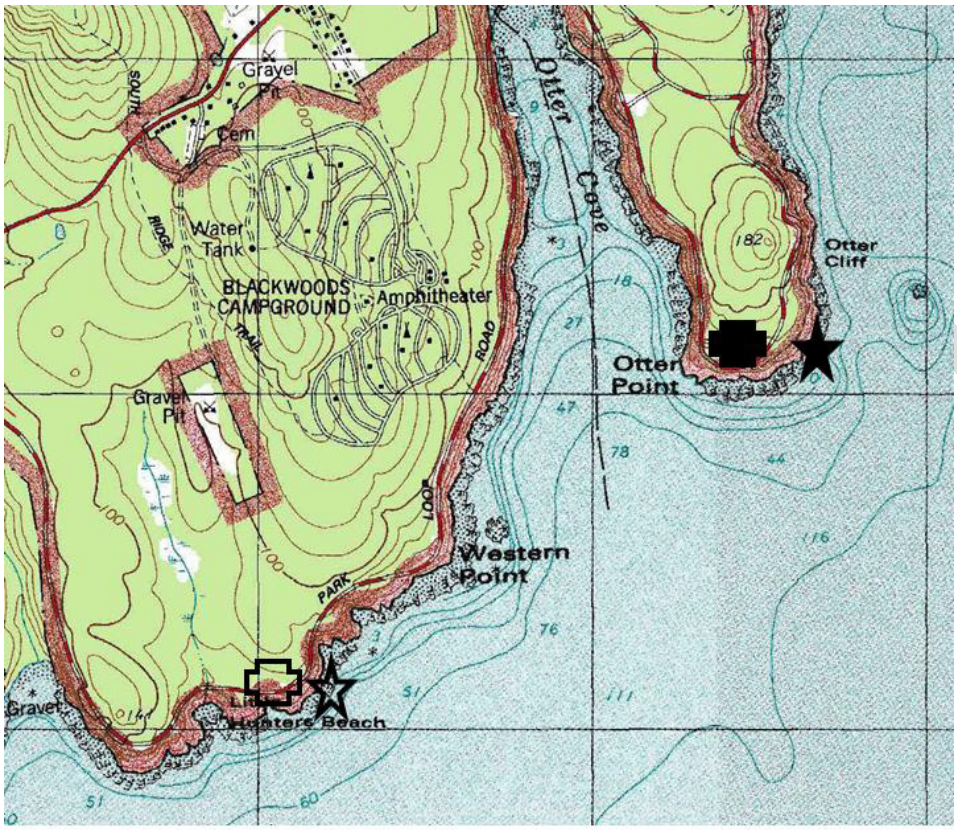
Little Hunter's Head

To reach the Little Hunter's Head site from park headquarters, turn right at Eagle Lake Rd/ME-233. After 2.1 miles, turn right at Cromwell Harbor Rd (just before golf course). After 1.2 miles, turn right at Main St/ME-3. After 3.2 miles, turn left at Otter Cliff Rd. After 1.9 miles, turn right at Park Loop Rd. Continue on Park Loop Rd ~2.5 miles. There is a turnout for parking on the left side of the road. The site is accessed by walking back from this turnout along the road and then proceeding into the trees.



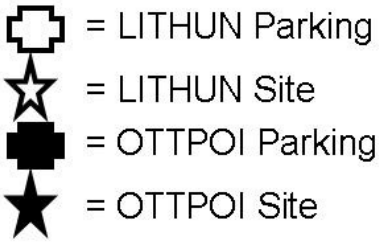


Figure 8. General location and nearby parking for the Little Hunter (LITHUN) and Otter Point (OTTPOI) sites.

Table 7. Little Hunter's Head reference bolts. Coordinates are UTM zone 19, NAD 1983.

Name	East	North
LITHUNASC	563187	4905313
LITHUNBAR	563185	4905302
LITHUNFUC	563151	4905270
LITHUNMUS	563227	4905338
LITHUNX1	563222	4905322
LITHUNX2	563192	4905305
LITHUNX3	563146	4905285
LITHUNTHI	563135	4905269

Table 8. Little Hunter's Head plot locations.

Plot	Plot or Bolt ID	Reference Bolt Name	Heading to Plot	Distance (m)
Ascophyllum	LITHUNASC1	LITHUNASC	106	9.21
Ascophyllum	LITHUNASC2	LITHUNASC	162	15.07
Ascophyllum	LITHUNASC3	LITHUNASC	198	4.4
Ascophyllum	LITHUNASC4	LITHUNASC	210	5.54
Ascophyllum	LITHUNASC5	LITHUNASC	210	6.4
Barnacle	LITHUNBAR1	LITHUNBAR	313	1.79
Barnacle	LITHUNBAR2	LITHUNBAR	311	3.59
Barnacle	LITHUNBAR3	LITHUNBAR	277	7.8
Barnacle	LITHUNBAR4	LITHUNBAR	274	9.4
Barnacle	LITHUNBAR5	LITHUNBAR	261	9.18
Fucus	LITHUNFUC1	LITHUNFUC	56	3.77
Fucus	LITHUNFUC2	LITHUNFUC	85	4.71
Fucus	LITHUNFUC3	LITHUNFUC	88	4.27
Fucus	LITHUNFUC4	LITHUNFUC	98	4.23
Fucus	LITHUNFUC5	LITHUNFUC	137	5.01
Mussel	LITHUNMUS1	LITHUNMUS	146	5.68
Mussel	LITHUNMUS2	LITHUNMUS	150	6.25
Mussel	LITHUNMUS3	LITHUNMUS	152	6.83
Mussel	LITHUNMUS4	LITHUNMUS	146	7.36
Mussel	LITHUNMUS5	LITHUNMUS	148	8.29
Barnacle Settlement	LITHUNSET	LITHUNBAR1		
Barnacle Settlement	LITHUNSET	LITHUNBAR2		
Barnacle Settlement	LITHUNSET	LITHUNBAR3		
Barnacle Settlement	LITHUNSET	LITHUNBAR4		
Barnacle Settlement	LITHUNSET	LITHUNBAR5		
Band Transect	LITHUNX1	LITHUNX1	219	8.19
Band Transect[1]	LITHUNX1N			
Band Transect	LITHUNX1S	LITHUNX1	124	4.65
Band Transect	LITHUNX2	LITHUNX2	240	1.20
Band Transect[1]	LITHUNX2N	LITHUNX2	255	1.2
Band Transect	LITHUNX2S	LITHUNX2	199	10.91
Band Transect	LITHUNX3	LITHUNX3	71	1.98
Band Transect[1]	LITHUNX3N			
Band Transect	LITHUNX3S	LITHUNX3	158	10.86
Vertical Transect[2]	LITHUNTHI1	LITHUNTHI	207	4.76
Vertical Transect	LITHUNTM1	LITHUNTHI	189	9.18

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Plot	Plot or Bolt ID	Reference Bolt Name	Heading to Plot	Distance (m)
Vertical Transect	LITHUNTLO1			
Vertical Transect	LITHUNTHI2	LITHUNTHI	224	7.08
Vertical Transect	LITHUNTM2	LITHUNTHI	204	10.43
Vertical Transect	LITHUNTLO2			
Vertical Transect	LITHUNTHI3	LITHUNTHI	232	9.8
Vertical Transect	LITHUNTM3	LITHUNTHI	215	12.32
Vertical Transect	LITHUNTLO3			
Tidbit	LITHUNTEMP1	LITHUNBAR/ASC	193	9.43
Tidbit	LITHUNTEMP2	LITHUNBAR/ASC	187	22.91
Tidbit	LITHUNTEMP3	LITHUNBAR/ASC	241	13.45
Mussel Settlement	LITHUNMSS1	LITHUNMUS	112	4.75
Mussel Settlement	LITHUNMSS2	LITHUNMUS	143	5.41
Mussel Settlement	LITHUNMSS3	LITHUNMUS	167	8.02
Mussel Settlement	LITHUNMSS4	LITHUNMUS	178	10.96
Mussel Settlement	LITHUNMSS5	LITHUNMUS	197	14.85

[1] Bearing from X1N to X1S = 72; X2N to X2S = 187, and X3N to X3S = 165.
[2] Overall heading of vertical transects = TBD.

Little Moose Island

To reach the Little Moose Island site from park headquarters, turn left at Eagle Lake RD/ME-233. After 3.0 miles, turn right at ME-198/ME-3/Sound Dr. Continue straight on ME-3. After 9.5 miles, turn right at Myrick St. After 0.4 miles, turn right at US-1. After 16.5 miles, turn right at S Goldsboro Rd/ME-186. After 6.6 miles, turn left at Main St/ME-186. After 0.6 miles, turn right on Moore Rd. After 1.4 miles, bear right at Acadia National Park. After 3.2 miles, slight left to stay on Park Loop Rd (not towards SERC). There is a slight turnoff on the right.

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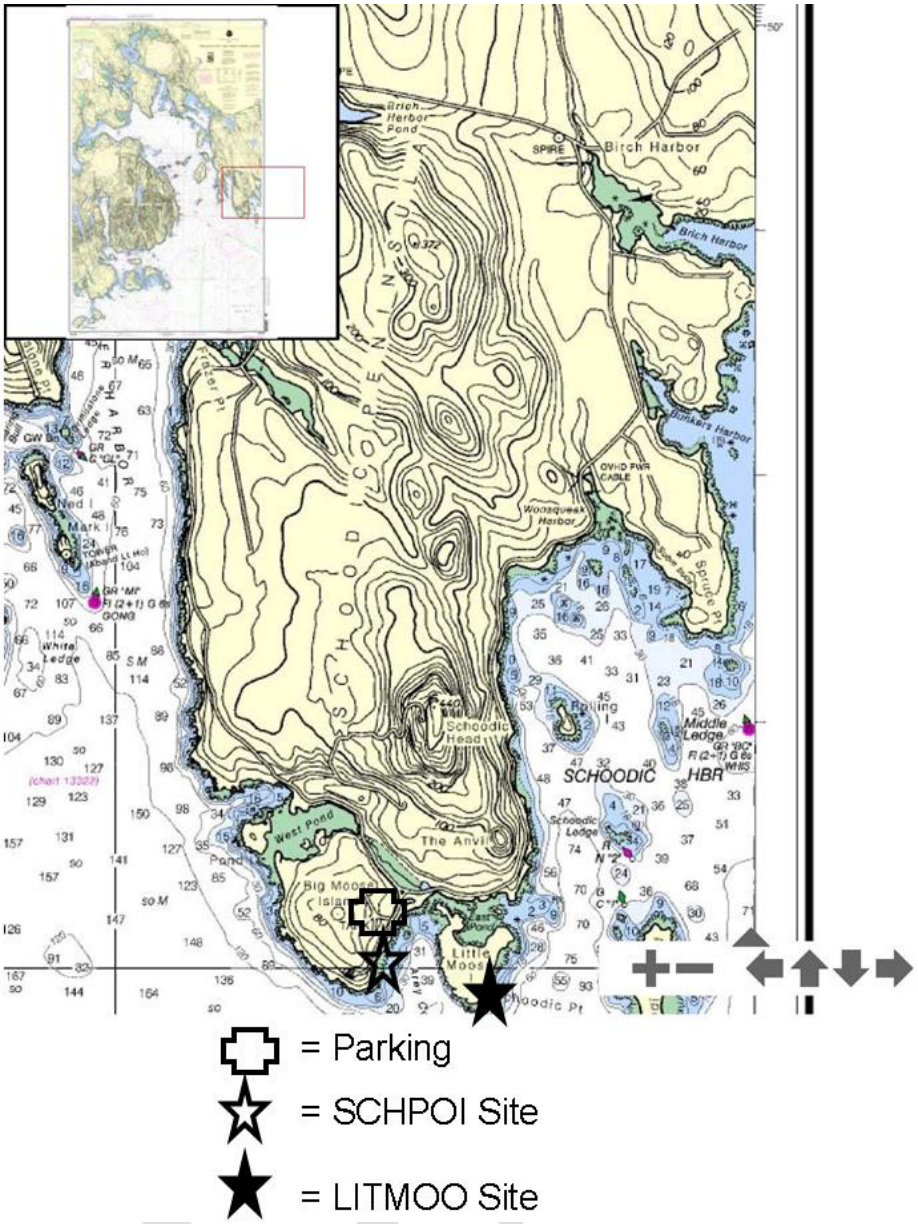

Figure 9. General location and nearby parking for the Schoodic Point (SCHPOI) and Little Moose Island (LITMOO) sites.

Table 9. Little Moose Island reference bolts. Coordinates are UTM zone 19, NAD 1983.

Name	East	North
LITMOOASC	575855	4909120
LITMOOBAR	575869	4909091
LITMOOFUC	575914	4909152
LITMOORED	575876	4909090

Table 10. Little Moose Island plot locations.

Plot	Plot or Bolt ID	Reference Bolt Name	Heading to Plot	Distance (m)
Ascophyllum	LITMOOASC1	LITMOOASC	97	4.69
Ascophyllum	LITMOOASC2	LITMOOASC	102	6.27
Ascophyllum	LITMOOASC3	LITMOOASC	134	11.75
Ascophyllum	LITMOOASC4	LITMOOASC	145	9.78
Ascophyllum	LITMOOASC5	LITMOOASC	218	5.39
Barnacle	LITMOOBAR1	LITMOOBAR	18	9.75
Barnacle	LITMOOBAR2	LITMOOBAR	27	6.07
Barnacle	LITMOOBAR3	LITMOOBAR	55	5.45
Barnacle	LITMOOBAR4	LITMOOBAR	71	7.6
Barnacle	LITMOOBAR5	LITMOOBAR	193	8.19
Fucus	LITMOOFUC1	LITMOOFUC	50	6.22
Fucus	LITMOOFUC2	LITMOOFUC	45	2.74
Fucus	LITMOOFUC3	LITMOOFUC	257	3.68
Fucus	LITMOOFUC4	LITMOOFUC	227	10.5
Fucus	LITMOOFUC5	LITMOOFUC	218	11.6
Red Algae	LITMOORED1	LITMOORED	70	11.87
Red Algae	LITMOORED2	LITMOORED	89	10.61
Red Algae	LITMOORED3	LITMOORED	94	9.08
Red Algae	LITMOORED4	LITMOORED	124	8.29
Red Algae	LITMOORED5	LITMOORED	142	8.2
Barnacle Settlement	LITMOOSET1			
Barnacle Settlement	LITMOOSET2			
Barnacle Settlement	LITMOOSET3			
Barnacle Settlement	LITMOOSET4			
Barnacle Settlement	LITMOOSET5			
Band Transect	LITMOOX1	LITMOORED	21	21.20
Band Transect[1]	LITMOOX1N			
Band Transect	LITMOOX1S			
Band Transect	LITMOOX2	LITMOORED	76	6.90
Band Transect[1]	LITMOOX2N			
Band Transect	LITMOOX2S			
Band Transect	LITMOOX3	LITMOORED	206	21.60
Band Transect[1]	LITMOOX3N			
Band Transect	LITMOOX3S			
Vertical Transect[2]	LITMOOHI1			
Vertical Transect	LITMOOM1			
Vertical Transect	LITMOOLO1	LITMOORED	89	12.67
Vertical Transect	LITMOOHI2			
Vertical Transect	LITMOOM2			
Vertical Transect	LITMOOLO2	LITMOORED	98	10.70
Vertical Transect	LITMOOHI3			
Vertical Transect	LITMOOM3			
Vertical Transect	LITMOOLO3	LITMOORED	116	9.25
Tidbits	LITMOOTEMP1	LITMOORED	55	26.11
Tidbits	LITMOOTEMP2	LITMOORED	72	16.31
Tidbits	LITMOOTEMP3	LITMOORED	98	9.00

[1] Bearing from X1N to X1S = TBD; X2N to X2S = TBD, and X3N to X3S = TBD.
[2] Overall heading of vertical transects = TBD.

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Otter Point

To reach the Otter Point site from park headquarters, turn right at Eagle Lake Rd/ME-233. After 2.1 miles, turn right at Cromwell Harbor Rd (just before golf course). After 1.2 miles, turn right at Main St/ME-3. After 3.2 miles, turn left at Otter Cliff Rd. After 1.9 miles, turn right at Park Loop Rd. Figure 8 has a map of the area with parking marked.

Table 11. Otter Point reference bolts. Coordinates are UTM zone 19, NAD 1983.

Name	East	North
OTTPOIASC	564574	4906263
OTTPOIBAR	564579	4906260
OTTPOIFUC	564602	4906269
OTTPOIMUS1	564661	4906318
OTTPOIMUS2	564629	4906313
OTTPOIMUS3	564629	4906313
OTTPOIRED	564612	4906269
OTTPOITRA	564576	4906288
OTTPOITRAM	564597	4906276
OTTPOIX1	564622	4906282

Table 12. Otter Point plot locations.

Plot	Plot or Bolt ID	Reference Bolt Name	Heading to Plot	Distance (m)
Ascophyllum	OTTPOIASC1	OTTPOIASC	108	2.70
Ascophyllum	OTTPOIASC2	OTTPOIASC	134	3.05
Ascophyllum	OTTPOIASC3	OTTPOIASC	6	4.30
Ascophyllum	OTTPOIASC4	OTTPOIASC	340	3.98
Ascophyllum	OTTPOIASC5	OTTPOIASC	228	5.78
Barnacle	OTTPOIBAR1	OTTPOIBAR	108	11.07
Barnacle	OTTPOIBAR2	OTTPOIBAR	196	5.65
Barnacle	OTTPOIBAR3	OTTPOIBAR	204	6.43
Barnacle	OTTPOIBAR4	OTTPOIBAR	208	7.50
Barnacle	OTTPOIBAR5	OTTPOIASC	260	14.10
Fucus	OTTPOIFUC1	OTTPOIX1	155	5.45
Fucus	OTTPOIFUC2	OTTPOIX1	192	4.42
Fucus	OTTPOIFUC3	OTTPOIFUC	175	4.43
Fucus	OTTPOIFUC4	OTTPOIFUC	184	4.11
Fucus	OTTPOIFUC5	OTTPOIFUC	210	4.41
Mussel	OTTPOIMUS1	OTTPOIMUS1	52	6.84
Mussel	OTTPOIMUS2	OTTPOIMUS1	25	6.01
Mussel	OTTPOIMUS3	OTTPOIMUS1	218	6.42
Mussel	OTTPOIMUS4	OTTPOIMUS2	152	3.58
Mussel	OTTPOIMUS5	OTTPOIMUS3	223	3.31
Red Algae	OTTPOIRED1	OTTPOIRED	140	9.46
Red Algae	OTTPOIRED2	OTTPOIRED	153	8.75
Red Algae	OTTPOIRED3	OTTPOIRED	185	2.65
Red Algae	OTTPOIRED4	OTTPOIRED	206	3.51
Red Algae	OTTPOIRED5	OTTPOIRED	182	7.99
Barnacle Settlement	OTTPOISET1	OTTPOIBAR		

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Plot	Plot or Bolt ID	Reference Bolt Name	Heading to Plot	Distance (m)
Barnacle Settlement	OTTPOISET2	OTTPOIBAR		
Barnacle Settlement	OTTPOISET3	OTTPOIBAR		
Barnacle Settlement	OTTPOISET4	OTTPOIBAR		
Barnacle Settlement	OTTPOISET5	OTTPOIBAR		
Band Transect	OTTPOIX1	OTTPOIX1	132	<1.0
Band Transect[1]	OTTPOIX1N	OTTPOIX1	141	2.08
Band Transect	OTTPOIX1S	OTTPOIX1	275	8.65
Band Transect	OTTPOIX2	OTTPOIASC	187	2.47
Band Transect[1]	OTTPOIX2N	OTTPOIASC	187	2.97
Band Transect	OTTPOIX2S	OTTPOIASC	218	11.95
Band Transect	OTTPOIX3	OTTPOIASC	240	12.20
Band Transect[1]	OTTPOIX3N	OTTPOIASC	240	12.3
Band Transect	OTTPOIX3S	OTTPOIASC	240	21.78
Vertical Transect[2]	OTTPOITHI1	OTTPOITRA		
Vertical Transect	OTTPOITM1	OTTPOITRAM	204	4.07
Vertical Transect	OTTPOITLO1	OTTPOIRED	170	4.16
Vertical Transect	OTTPOITHI2	OTTPOITRA		
Vertical Transect	OTTPOITM2	OTTPOITRAM	211	6.86
Vertical Transect	OTTPOITLO2	OTTPOIRED	198	5.4
Vertical Transect	OTTPOITHI3	OTTPOITRA		
Vertical Transect	OTTPOITM3	OTTPOITRAM	215	9.71
Vertical Transect	OTTPOITLO3	OTTPOIRED	210	7.69
Tidbit	OTTPOITEMP1	OTTPOIRED	116	19.20
Tidbit	OTTPOITEMP2	OTTPOIRED	105	6.53
Tidbit	OTTPOITEMP3	OTTPOIRED	193	7.96
Mussel Settlement	OTTPOIMSS1	OTTPOIMUS1	82	7.19
Mussel Settlement	OTTPOIMSS2	OTTPOIMUS1	105	5.44
Mussel Settlement	OTTPOIMSS3	OTTPOIMUS1	48	6.26
Mussel Settlement	OTTPOIMSS4	OTTPOIMUS1	33	4.20
Mussel Settlement	OTTPOIMSS5	OTTPOIMUS1	214	5.00

[1] Bearing from X1N to X1S = 274; X2N to X2S = TBD, and X3N to X3S = 257.
[2] Overall heading of vertical transects = TBD.

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Schoodic Point

To reach the Schoodic Point site from park headquarters, turn left at Eagle Lake RD/ME-233. After 3.0 miles, turn right at ME-198/ME-3/Sound Dr. Continue straight on ME-3. After 9.5 miles, turn right at Myrick St. After 0.4 miles, turn right at US-1. After 16.5 miles, turn right at S Goldsboro Rd/ME-186. After 6.6 miles, turn left at Main St/ME-186. After 0.6 miles, turn right on Moore Rd. After 1.4 miles, bear right at Acadia National Park. After 3.1 miles, take a slight right to go towards SERC. There is a slight turnoff on the right prior to the loop at the tip of Schoodic Point. Figure 9 has a map of the area with parking marked.

Table 13. Schoodic Point reference bolts. Coordinates are UTM zone 19, NAD 1983.

Name	East	North
SCHPOIASC	575130	4909445
SCHPOIBAR	575082	4909331
SCHPOIFUC	575111	4909424
SCHPOIMUS	575056	4909243
SCHPOIRED	575068	4909272
SCHPOIT	575064	4909365
SCHPOIX	575086	4909390

Table 14. Schoodic Point plot locations.

Plot	Plot or Bolt ID	Reference Bolt Name	Heading to Plot	Distance (m)
Ascophyllum	SCHPOIASC1	SCHPOIASC	52	1.95
Ascophyllum	SCHPOIASC2	SCHPOIASC	78	3.06
Ascophyllum	SCHPOIASC3	SCHPOIASC	104	4.09
Ascophyllum	SCHPOIASC4	SCHPOIASC	130	5.95
Ascophyllum	SCHPOIASC5	SCHPOIASC	130	8.77
Barnacle	SCHPOIBAR1	SCHPOIBAR	48	8.54
Barnacle	SCHPOIBAR2	SCHPOIBAR	39	7.63
Barnacle	SCHPOIBAR3	SCHPOIBAR	72	6.51
Barnacle	SCHPOIBAR4	SCHPOIBAR	118	2.53
Barnacle	SCHPOIBAR5	SCHPOIBAR	172	4.32
Fucus	SCHPOIFUC1	SCHPOIFUC	349	2.02
Fucus	SCHPOIFUC2	SCHPOIFUC	296	4.34
Fucus	SCHPOIFUC3	SCHPOIFUC	284	3.19
Fucus	SCHPOIFUC4	SCHPOIFUC	239	0.50
Fucus	SCHPOIFUC5	SCHPOIFUC	129	3.56
Mussel	SCHPOIMUS1	SCHPOIMUS	27	14.98
Mussel	SCHPOIMUS2	SCHPOIMUS	93	3.94
Mussel	SCHPOIMUS3	SCHPOIMUS	95	4.79
Mussel	SCHPOIMUS4	SCHPOIMUS	129	5.10
Mussel	SCHPOIMUS5	SCHPOIMUS	147	4.17
Red Algae	SCHPOIRED1	SCHPOIRED	114	9.52
Red Algae	SCHPOIRED2	SCHPOIRED	121	9.27
Red Algae	SCHPOIRED3	SCHPOIRED	129	10.09
Red Algae	SCHPOIRED4	SCHPOIRED	143	9.58
Red Algae	SCHPOIRED5	SCHPOIRED	146	11.39
Barnacle Settlement	SCHPOISET1			
Barnacle Settlement	SCHPOISET2			
Barnacle Settlement	SCHPOISET3			
Barnacle Settlement	SCHPOISET4			
Barnacle Settlement	SCHPOISET5			
Band Transect[1]	SCHPOIX1N	SCHPOIX	187	4.01
Band Transect	SCHPOIX1S	SCHPOIX	141	12.63
Band Transect[1]	SCHPOIX2N	SCHPOIX	117	6.57
Band Transect	SCHPOIX2S	SCHPOIX	131	16.29
Band Transect[1]	SCHPOIX3N	SCHPOIX	55	13.72
Band Transect	SCHPOIX3S	SCHPOIX	90	18.37
Vertical Transect[2]	SCHPOITHI1	SCHPOIT		

Plot	Plot or Bolt ID	Reference Bolt Name	Heading to Plot	Distance (m)
Vertical Transect	SCHPOITM1			
Vertical Transect	SCHPOITLO1			
Vertical Transect	SCHPOITHI2	SCHPOIT		
Vertical Transect	SCHPOITM2			
Vertical Transect	SCHPOITLO2			
Vertical Transect	SCHPOITHI3	SCHPOIT		
Vertical Transect	SCHPOITM3			
Vertical Transect	SCHPOITLO3			
Tidbit	SCHPOITEMP1	SCHPOIBAR	80	22.68
Tidbit	SCHPOITEMP2	SCHPOIBAR	117	23.00
Tidbit	SCHPOITEMP3	SCHPOIBAR	142	17.28
Mussel Settlement	SCHPOIMSS1	SCHPOIMUS	30	14.75
Mussel Settlement	SCHPOIMSS2	SCHPOIMUS	54	4.80
Mussel Settlement	SCHPOIMSS3	SCHPOIMUS	107	6.72
Mussel Settlement	SCHPOIMSS4	SCHPOIMUS	141	4.95
Mussel Settlement	SCHPOIMSS5	SCHPOIMUS	142	8.57

[1] Bearing from X1N to X1S = TBD; X2N to X2S = TBD, and X3N to X3S = TBD.
[2] Overall heading of vertical transects = TBD.

Ship Harbor

To reach the Ship Harbor site from park headquarters, turn left at Eagle Lake Rd/ME-233. After 3.0 miles, turn right at ME-198/ME-3/Sound Dr. After 1.4 miles, turn left at Main St/ME-102/ME-198. Obey speed limits as sections of this road are well-patrolled. After 8.6 miles, slight left at ME-102A. Ship Harbor parking lot is about 0.8 miles past the Bass Harbor Lighthouse turn-off. Figure 7 has a map of the area with parking marked.

Table 15. Ship Harbor reference bolts. Coordinates are UTM zone 19, NAD 1983.

Name	East	North
SHIHARASC	554540	4897141
SHIHARBAR	554438	4897113
SHIHARFUC	554535	4897092
SHIHARRED	554581	4897179
SHIHARSET	554406	4897123
SHIHARTRA1	554574	4897255
SHIHARTRA2	554594	4897238
SHIHARTRA3	554615	4897231
SHIHARX1	554532	4897122
SHIHARX2	554489	4897100
SHIHARX3	554454	4897107

Table 16. Ship Harbor plot locations.

Plot	Plot or Bolt ID	Reference Bolt Name	Heading to Plot	Distance (m)
Ascophyllum	SHIHARASC1	SHIHARASC	52	6.03
Ascophyllum	SHIHARASC2	SHIHARASC	352	4.24
Ascophyllum	SHIHARASC3	SHIHARASC	348	6.89
Ascophyllum	SHIHARASC4	SHIHARASC	332	6.03

Plot	Plot or Bolt ID	Reference Bolt Name	Heading to Plot	Distance (m)
Ascophyllum	SHIHARASC5	SHIHARASC	329	8.85
Barnacle	SHIHARBAR1	SHIHARBAR	171	8.34
Barnacle	SHIHARBAR2	SHIHARBAR	165	5.89
Barnacle	SHIHARBAR3	SHIHARBAR	245	3.83
Barnacle	SHIHARBAR4	SHIHARBAR	273	5.47
Barnacle	SHIHARBAR5	SHIHARBAR	276	6.82
Fucus	SHIHARFUC1	SHIHARFUC	45	8.38
Fucus	SHIHARFUC2	SHIHARFUC	56	7.44
Fucus	SHIHARFUC3	SHIHARFUC	60	5.26
Fucus	SHIHARFUC4	SHIHARFUC	38	4.45
Fucus	SHIHARFUC5	SHIHARFUC	56	2.66
Red Algae	SHIHARRED1	SHIHARRED	104	3.61
Red Algae	SHIHARRED2	SHIHARRED	142	3.61
Red Algae	SHIHARRED3	SHIHARRED	173	3.31
Red Algae	SHIHARRED4	SHIHARRED	189	6.12
Red Algae	SHIHARRED5	SHIHARRED	195	8.54
Barnacle Settlement	SHIHARSET1	SHIHARSET	171	8.34
Barnacle Settlement	SHIHARSET2	SHIHARSET	165	5.89
Barnacle Settlement	SHIHARSET3	SHIHARSET	245	3.83
Barnacle Settlement	SHIHARSET4	SHIHARSET	273	5.47
Barnacle Settlement	SHIHARSET5	SHIHARSET	276	6.82
Band Transect[1]	SHIHARX1N	SHIHARX1	22	6.12
Band Transect	SHIHARX1S			
Band Transect[1]	SHIHARX2N	SHIHARX2	123	5.54
Band Transect	SHIHARX2S			
Band Transect[1]	SHIHARX3N	SHIHARX3	200	4.92
Band Transect	SHIHARX3S			
Vertical Transect	SHIHARTRAHI1			
Vertical Transect	SHIHARTRAM1	SHIHARTRA?	70	10.17
Vertical Transect	SHIHARTRALO1	SHIHARTRA?	54	8.69
Vertical Transect	SHIHARTRAHI2			
Vertical Transect	SHIHARTRAM2	SHIHARTRA?	82	7.81
Vertical Transect	SHIHARTRALO2	SHIHARTRA?	61	6.02
Vertical Transect	SHIHARTRAHI3			
Vertical Transect	SHIHARTRAM3	SHIHARTRA?	94	5.81
Vertical Transect	SHIHARTRAL3	SHIHARTRA?	85	3.71
Tidbit	SHIHARTEMP1	SHIHARRED	232	26.9
Tidbit	SHIHARTEMP2	SHIHARRED	228	35.41
Tidbit	SHIHARTEMP3	SHIHARRED	70	18.47

[1] Bearing from X1N to X1S = TBD; X2N to X2S = TBD, and X3N to X3S = TBD.
[2] Overall heading of vertical transects = TBD.

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Boston Harbor Islands National Recreation Area
Calf Island

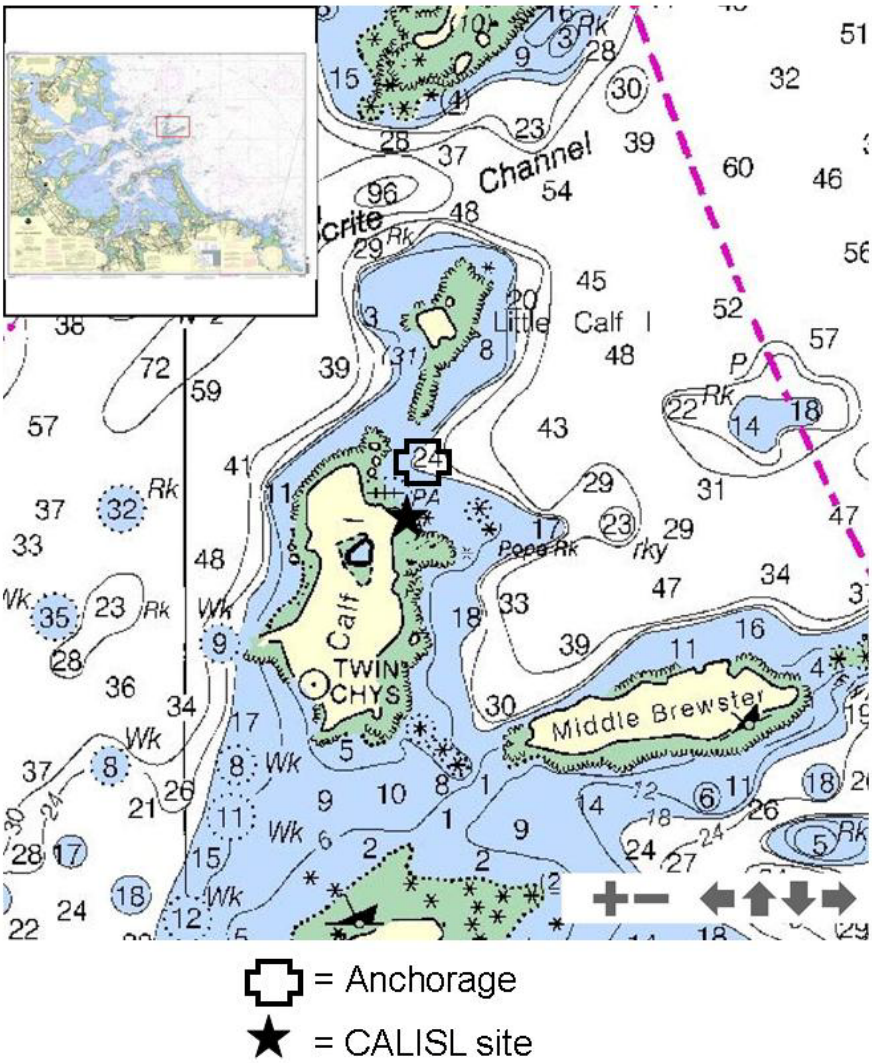

Figure 10. General location and nearby anchorage for the Calf Island (CALISL) site.

Table 17. Calf Island reference bolts. Coordinates are UTM zone 19, NAD 1983.

Name	East	North
CALISLASC	343914	4689532
CALISLSET	343919	4689593
CALISLTRAR	343911	4689550
CALISLX	343940	4689510

Table 18. Calf Island plot locations.

Plot	Plot or Bolt ID	Reference Bolt Name	Heading to Plot	Distance (m)
Ascophyllum	CALISLASC1	CALISLASC	78	7.0
Ascophyllum	CALISLASC2	CALISLASC	60	6.48
Ascophyllum	CALISLASC3	CALISLASC	63	6.34
Ascophyllum	CALISLASC4	CALISLASC	59	2.17
Ascophyllum	CALISLASC5	CALISLASC	131	3.32
Barnacle	CALISLBAR1	CALISLSET	312	6.48
Barnacle	CALISLBAR2	CALISLSET	347	5.36
Barnacle	CALISLBAR3	CALISLSET	360	4.7
Barnacle	CALISLBAR4	CALISLSET	210	1.97
Barnacle	CALISLBAR5	CALISLSET	80	3.56
Fucus	CALISLFUC1	CALISLSET	359	6.29
Fucus	CALISLFUC2	CALISLSET	12	6.15
Fucus	CALISLFUC3	CALISLSET	41	7.42
Fucus	CALISLFUC4	CALISLSET	9	2.97
Fucus	CALISLFUC5	CALISLSET	120	13.02
Red Algae	CALISLRED1	CALISLSET	3	8.03
Red Algae	CALISLRED2	CALISLSET	11	8.97
Red Algae	CALISLRED3	CALISLSET	19	8.5
Red Algae	CALISLRED4	CALISLSET	46	9.6
Red Algae	CALISLRED5	CALISLSET	69	13.89
Barnacle Settlement	CALISLSET1	CALISLSET	358	6.36
Barnacle Settlement	CALISLSET2	CALISLSET	24	4.88
Barnacle Settlement	CALISLSET3	CALISLSET	335	5.07
Barnacle Settlement	CALISLSET4	CALISLSET	43	3.4
Barnacle Settlement	CALISLSET5	CALISLSET	199	2.2
Band Transect[1]	CALISLX1N	CALISLX	150	1.73
Band Transect	CALISLX1S	CALISLX	156	11.3
Band Transect[1]	CALISLX2N	CALISLX	237	2.44
Band Transect	CALISLX2S	CALISLX	181	11.07
Band Transect[1]	CALISLX3N	CALISLX	205	12.88
Band Transect	CALISLX3S	CALISLX	167	16.86
Vertical Transect[2]	CALISLTRAHI1	CALISLTRAR		
Vertical Transect	CALISLTRAM1	CALISLSET	47	6.04
Vertical Transect	CALISLTRALO1	CALISLSET	63	12.87
Vertical Transect	CALISLTRAHI2	CALISLTRAR		
Vertical Transect	CALISLTRAM2	CALISLSET	67	5.93
Vertical Transect	CALISLTRALO2	CALISLSET	61	13.71
Vertical Transect	CALISLTRAHI3	CALISLTRAR		
Vertical Transect	CALISLTRAM3	CALISLSET	91	6.87
Vertical Transect	CALISLTRALO3	CALISLSET	79	13.83
Tidbit	CALISLTEMP1			
Tidbit	CALISLTEMP2			
Tidbit	CALISLTEMP3			

[1] Bearing from X1N to X1S = TBD; X2N to X2S = TBD, and X3N to X3S = TBD.
[2] Overall heading of vertical transects = 65.

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Green Island

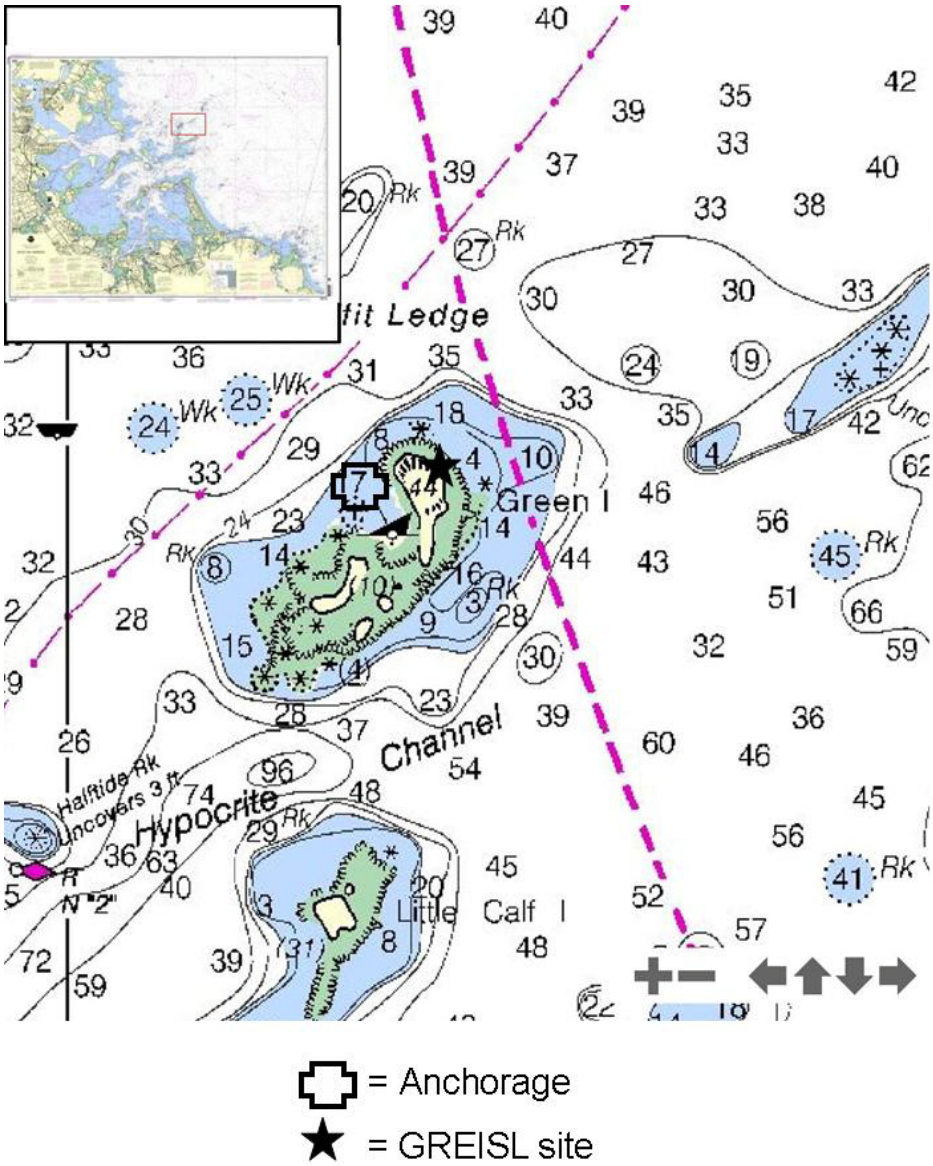

Figure 11. General location and nearby anchorage for the Green Island (GREISL) site.

Table 19. Green Island reference bolts. Coordinates are UTM zone 19, NAD 1983.

Name	East	North
GREISLASC	344211	4690754
GREISLFUC	344151	4690785
GREISLRED	344168	4690779
GREISLSET	344168	4690777
GREISLTRAN	344195	4690772

Table 20. Green Island plot locations.

Plot	Plot or Bolt ID	Reference Bolt Name	Heading to Plot	Distance (m)
Ascophyllum	GREISLASC1	GREISLASC	10	6.73
Ascophyllum	GREISLASC2	GREISLASC	54	4.59
Ascophyllum	GREISLASC3	GREISLASC	75	4.83
Ascophyllum	GREISLASC4	GREISLASC	130	5.17
Ascophyllum	GREISLASC5	GREISLASC	153	5.78
Barnacle	GREISLBAR1	GREISLSET	323	22.8
Barnacle	GREISLBAR2	GREISLSET	46	7.31
Barnacle	GREISLBAR3	GREISLSET	59	5.75
Barnacle	GREISLBAR4	GREISLSET	53	11.43
Barnacle	GREISLBAR5	GREISLSET	80	12.4
Fucus	GREISLFUC1	GREISLFUC	108	9.53
Fucus	GREISLFUC2	GREISLFUC	101	8.48
Fucus	GREISLFUC3	GREISLFUC	80	4.24
Fucus	GREISLFUC4	GREISLFUC	67	3.84
Fucus	GREISLFUC5	GREISLFUC	231	7.69
Red Algae	GREISLRED1	GREISLRED	47	16.81
Red Algae	GREISLRED2	GREISLRED	41	17.45
Red Algae	GREISLRED3	GREISLRED	31	17.55
Red Algae	GREISLRED4	GREISLRED	27	16.82
Red Algae	GREISLRED5	GREISLRED	13	20.27
Barnacle Settlement	GREISLSET1	GREISLSET	3	9.52
Barnacle Settlement	GREISLSET2	GREISLSET	18	10.43
Barnacle Settlement	GREISLSET3	GREISLSET	41	8.9
Barnacle Settlement	GREISLSET4	GREISLSET	44	8.07
Barnacle Settlement	GREISLSET5	GREISLSET	52	6.12
Band Transect[1]	GREISLX1N	GREISLFUC	313	13.53
Band Transect	GREISLX1S	GREISLFUC	272	14.02
Band Transect[1]	GREISLX2N	GREISLFUC	285	10.66
Band Transect	GREISLX2S	GREISLFUC	213	5.46
Band Transect[1]	GREISLX3N	GREISLRED	331	6.85
Band Transect	GREISLX3S	GREISLRED	61	7.75
Vertical Transect	GRETRANHI1	GREISLTRAN		
Vertical Transect	GREISLTRAM1	GREISLTRAN	333	7.04
Vertical Transect	GREISLTRALO1	GREISLTRAN	27	11.44
Vertical Transect	GRETRANHI2	GREISLTRAN		
Vertical Transect	GREISLTRAM2	GREISLTRAN	338	6.06
Vertical Transect	GREISLTRALO2	GREISLTRAN	32	11.07
Vertical Transect	GRETRANHI3	GREISLTRAN		
Vertical Transect	GREISLTRAM3	GREISLTRAN	11	2.6
Vertical Transect	GREISLTRALO3	GREISLTRAN	47	9.88
Tidbit	GREISLTEMP1			
Tidbit	GREISLTEMP2			
Tidbit	GREISLTEMP3			

[1] Bearing from X1N to X1S = TBD; X2N to X2S = TBD, and X3N to X3S = TBD.
[2] Overall heading of vertical transects = 65.

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Outer Brewster

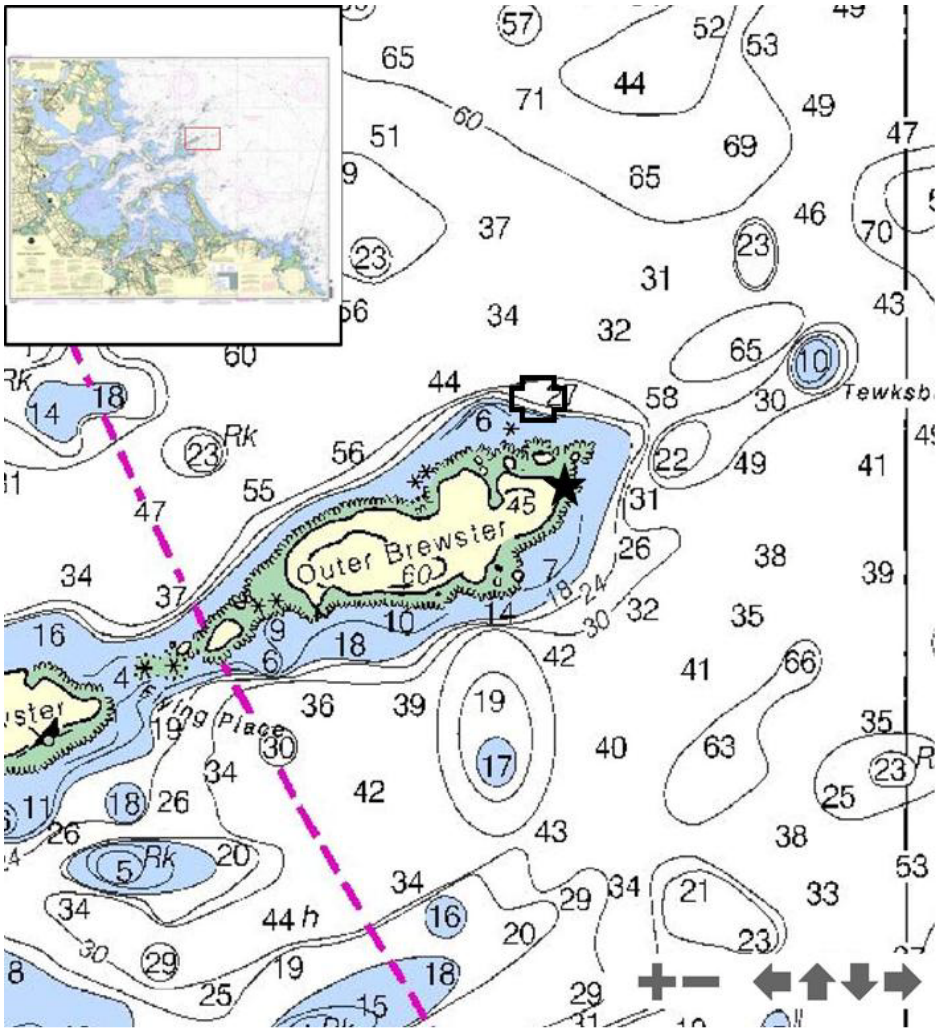

Figure 12. General location and nearby anchorage for the Outer Brewster (OUTBRE) site.

Table 21. Outer Brewster reference bolts. Coordinates are UTM zone 19, NAD 1983.

Name	East	North
OUTBREASC	345554	4689566
OUTBREBAR	345584	4689556
OUTBREFUC	345584	4689556
OUTBRERED	345595	4689542
OUTBRESET		
OUTBRESET1		
OUTBRESET2		
OUTBRESET3		
OUTBRETRAH	345586	4689540
GREISLTRAN	344195	4690772

Table 22. Outer Brewster plot locations.

Plot	Plot or Bolt ID	Reference Bolt Name	Heading to Plot	Distance (m)
Ascophyllum	OUTBREASC1	OUTBREASC	45	8.26
Ascophyllum	OUTBREASC2	OUTBREASC	42	6.7
Ascophyllum	OUTBREASC3	OUTBREASC	20	6.69
Ascophyllum	OUTBREASC4	OUTBREASC	350	4.91
Ascophyllum	OUTBREASC5	OUTBREASC	326	5.84
Barnacle	OUTBREBAR1	OUTBREBAR	317	19.67
Barnacle	OUTBREBAR2	OUTBREBAR	323	7.36
Barnacle	OUTBREBAR3	OUTBREBAR	329	2.6
Barnacle	OUTBREBAR4	OUTBREBAR	349	1.83
Barnacle	OUTBREBAR5	OUTBREBAR	250	2.1
Fucus	OUTBREFUC1	OUTBREFUC	7	15.95
Fucus	OUTBREFUC2	OUTBREFUC	8	8.36
Fucus	OUTBREFUC3	OUTBREFUC	31	4.61
Fucus	OUTBREFUC4	OUTBREFUC	53	5.61
Fucus	OUTBREFUC5	OUTBREFUC	45	7.85
Red Algae	OUTBRERED1	OUTBRERED	85	2.03
Red Algae	OUTBRERED2	OUTBRERED	156	2.76
Red Algae	OUTBRERED3	OUTBRERED	154	4.35
Red Algae	OUTBRERED4	OUTBRERED	148	5.69
Red Algae	OUTBRERED5	OUTBRERED	203	4.29
Barnacle Settlement	OUTBRESET1			
Barnacle Settlement	OUTBRESET2			
Barnacle Settlement	OUTBRESET3			
Barnacle Settlement	OUTBRESET4			
Barnacle Settlement	OUTBRESET5			
Band Transect[1]	OUTBREX1N		7	7.74
Band Transect	OUTBREX1S		86	8.28
Band Transect[1]	OUTBREX2N	OUTBREFUC	6	12.25
Band Transect	OUTBREX2S	OUTBREFUC	315	4.57
Band Transect[1]	OUTBREX3N		110	7.95
Band Transect	OUTBREX3S		287	2.44
Vertical Transect[2]	OUTBRETRAHI1			
Vertical Transect	OUTBRETRAM1	OUTBRESET1	56	13.57
Vertical Transect	OUTBRETRALO1	OUTBRERED	21	8.05
Vertical Transect	OUTBRETRAHI2			
Vertical Transect	OUTBRETRAM2	OUTBRESET2	64	13.48
Vertical Transect	OUTBRETRALO2	OUTBRERED	34	6.85
Vertical Transect	OUTBRETRAHI3			
Vertical Transect	OUTBRETRAM3	OUTBRESET3	69	13.58
Vertical Transect	OUTBRETRALO3	OUTBRERED	45	6.35
Tidbit	OUTBRETEMP1	OUTBREFUC	50	15.73
Tidbit	OUTBRETEMP2	OUTBREFUC	69	6.25
Tidbit	OUTBRETEMP3	OUTBREFUC	123	12.3

[1] Bearing from X1N to X1S = TBD; X2N to X2S = TBD, and X3N to X3S = TBD.
[2] Overall heading of vertical transects = 70.

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Maine Coast Islands National Wildlife Refuge
Metinic Island

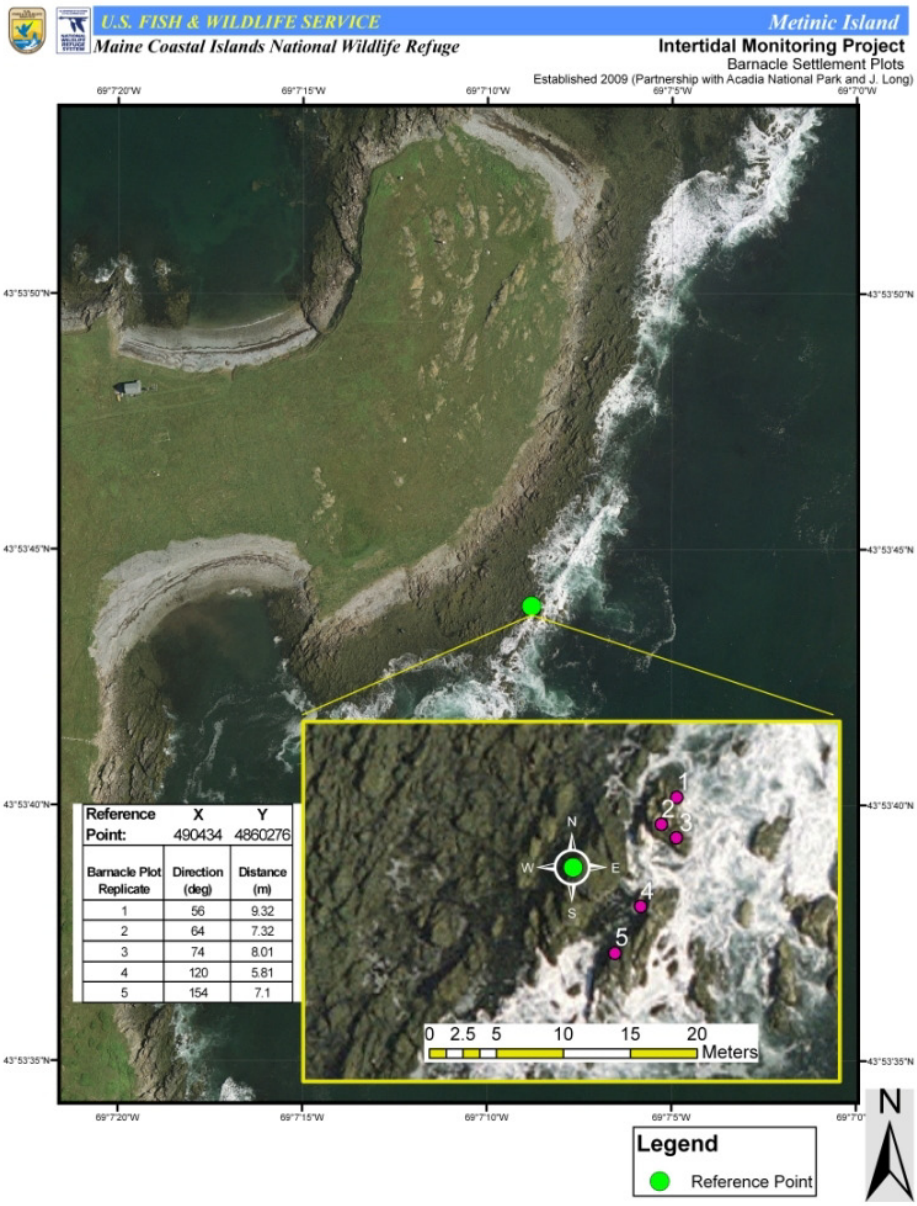

Figure 13. General location for the Metinic Island (METISL) site. Inset shows locations of barnacle settlement plots.

Table 23. Metinic Island reference bolts. Coordinates are UTM zone 19, NAD 1983.

Name	East	North
METISLBAR	490434	4860276
METISLFUC	490433	4860294
METISLRED	490461	4860306
METISLTRAHI		
METISLTRAM		
METISLTRALO		

Table 24. Metinic Island plot locations.

Plot	Plot or Bolt ID	Reference Bolt Name	Heading to Plot	Distance (m)
Ascophyllum	METISLASC1	METISLBAR	342	10.04
Ascophyllum	METISLASC2	METISLBAR	326	9.64
Ascophyllum	METISLASC3	METISLBAR	322	13.36
Ascophyllum	METISLASC4	METISLBAR	282	7.43
Ascophyllum	METISLASC5	METISLBAR	292	15.65
Barnacle	METISLBAR1	METISLBAR	94	14.26
Barnacle	METISLBAR2	METISLBAR	64	7.13
Barnacle	METISLBAR3	METISLBAR	78	7.71
Barnacle	METISLBAR4	METISLBAR	124	6.44
Barnacle	METISLBAR5	METISLBAR	140	6.22
Fucus	METISLFUC1	METISLFUC	80	23.38
Fucus	METISLFUC2	METISLFUC	81	9.01
Fucus	METISLFUC3	METISLFUC	86	6.66
Fucus	METISLFUC4	METISLFUC	141	4.52
Fucus	METISLFUC5	METISLFUC	140	8.87
Red Algae	METISLRED1	METISLRED	80	9.08
Red Algae	METISLRED2	METISLRED	98	8.1
Red Algae	METISLRED3	METISLRED	118	6.99
Red Algae	METISLRED4	METISLRED	190	8.33
Red Algae	METISLRED5	METISLRED	202	13.12
Barnacle Settlement	METISLSET1	METISLBAR	56	9.32
Barnacle Settlement	METISLSET2	METISLBAR	64	7.32
Barnacle Settlement	METISLSET3	METISLBAR	74	8.01
Barnacle Settlement	METISLSET4	METISLBAR	120	5.81
Barnacle Settlement	METISLSET5	METISLBAR	154	7.1
Band Transect[1]	METISLX1N	METISLRED	39	37.87
Band Transect	METISLX1S	METISLRED	38	28.02
Band Transect[1]	METISLX2N	METISLRED	40	24.28
Band Transect	METISLX2S	METISLRED	52	14.83
Band Transect[1]	METISLX3N	METISLRED		
Band Transect	METISLX3S	METISLRED		
Vertical Transect[2]	METISLTRAHI1			
Vertical Transect	METISLTRAM1			
Vertical Transect	METISLTRALO1			
Vertical Transect	METISLTRAHI2			
Vertical Transect	METISLTRAM2			
Vertical Transect	METISLTRALO2			
Vertical Transect	METISLTRAHI3			
Vertical Transect	METISLTRAM3			
Vertical Transect	METISLTRALO3			
Tidbit	METISLTEMP	METISLRED	66	13.25
Tidbit	METISLTEMP	METISLRED	110	8.17
Tidbit	METISLTEMP	METISLRED	185	8.91

[1] Bearing from X1N to X1S = TBD; X2N to X2S = TBD, and X3N to X3S = TBD.
[2] Overall heading of vertical transects = TBD.

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Petit Manan Island

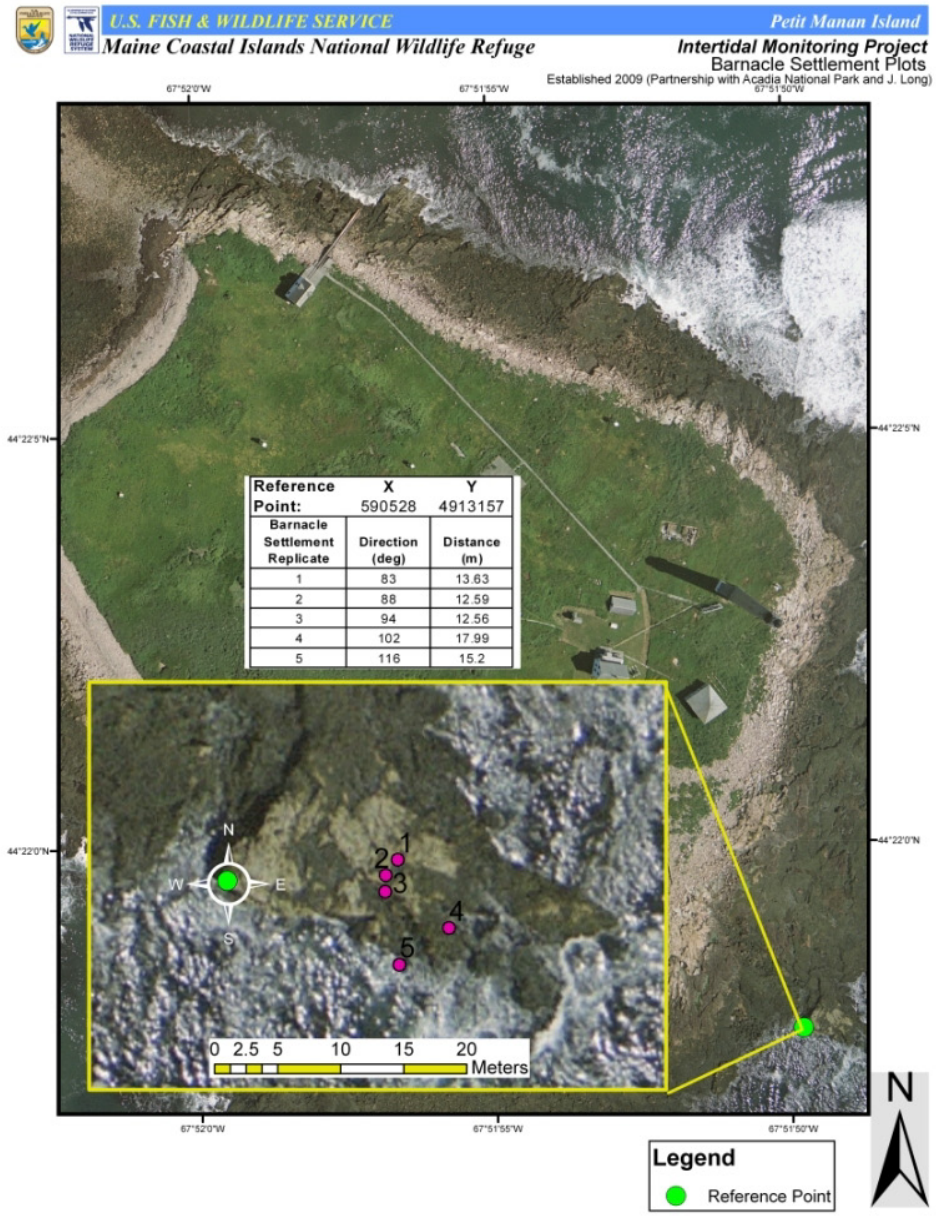

Figure 14. General location for the Petit Manan Island (PETMAN) site. Inset shows locations of barnacle settlement plots.

Table 25. Petit Manan Island reference bolts. Coordinates are UTM zone 19, NAD 1983.

Name	East	North
PETMANASC	590526	4913190
PETMANFUC	590494	4913147
PETMANRED	590545	4913078
PETMANTRA	590474	4913181
PETMANTRAL	590528	4913157

Table 26. Petit Manan Island plot locations.

Plot	Plot or Bolt ID	Reference Bolt Name	Heading to Plot	Distance (m)
Ascophyllum	PETMANASC1	PETMANASC	137	15.79
Ascophyllum	PETMANASC2	PETMANASC	142	12.9
Ascophyllum	PETMANASC3	PETMANASC	151	7.49
Ascophyllum	PETMANASC4	PETMANASC	176	5.03
Ascophyllum	PETMANASC5	PETMANASC	219	10.9
Barnacle	PETMANBAR1	PETMANTRAL	76	9.91
Barnacle	PETMANBAR2	PETMANTRAL	113	9.99
Barnacle	PETMANBAR3	PETMANTRAL	114	9.59
Barnacle	PETMANBAR4	PETMANTRAL	116	4.68
Barnacle	PETMANBAR5	PETMANTRAL	106	2.63
Fucus	PETMANFUC1	PETMANFUC	23	17.03
Fucus	PETMANFUC2	PETMANFUC	41	3.43
Fucus	PETMANFUC3	PETMANFUC	72	2.53
Fucus	PETMANFUC4	PETMANFUC	262	7.54
Fucus	PETMANFUC5	PETMANFUC	242	9.89
Red Algae	PETMANRED1	PETMANRED	93	13.14
Red Algae	PETMANRED2	PETMANRED	152	16
Red Algae	PETMANRED3	PETMANRED	156	11.15
Red Algae	PETMANRED4	PETMANRED	204	13.95
Red Algae	PETMANRED5	PETMANRED	218	13.32
Barnacle Settlement	PETMANSET1	PETMANTRAL	83	13.63
Barnacle Settlement	PETMANSET2	PETMANTRAL	88	12.59
Barnacle Settlement	PETMANSET3	PETMANTRAL	94	12.56
Barnacle Settlement	PETMANSET4	PETMANTRAL	102	17.99
Barnacle Settlement	PETMANSET5	PETMANTRAL	116	15.2
Band Transect[1]	PETMANX1N	PETMANRED	102	13.19
Band Transect	PETMANX1S	PETMANRED	106	22.55
Band Transect[1]	PETMANX2N	PETMANRED	249	8.48
Band Transect	PETMANX2S	PETMANRED	167	7.4
Band Transect[1]	PETMANX3N	PETMANRED	250	12.9
Band Transect	PETMANX3S	PETMANRED	225	20.02
Vertical Transect[2]	PETMANTRAHI1	PETMANTRAL	290	8.03
Vertical Transect	PETMANTRAM1	PETMANTRAL	290	8.03
Vertical Transect	PETMANTRALO1	PETMANTRAL	277	6.5
Vertical Transect	PETMANTRAHI2	PETMANTRAL	281	8.5
Vertical Transect	PETMANTRAM2	PETMANTRAL	281	8.5
Vertical Transect	PETMANTRALO2	PETMANTRAL	274	7.26
Vertical Transect	PETMANTRAHI3	PETMANTRAL	277	9.05
Vertical Transect	PETMANTRAM3	PETMANTRAL	277	9.05
Vertical Transect	PETMANTRALO3	PETMANTRAL	265	8.06
Tidbit	PETMANTEMP1	PETMANTRAL	118	7.96
Tidbit	PETMANTEMP2	PETMANTRAL	204	11.45
Tidbit	PETMANTEMP3	PETMANTRAL	241	16.38

[1] Bearing from X1N to X1S = TBD; X2N to X2S = TBD, and X3N to X3S = TBD.
[2] Overall heading of vertical transects = 324.

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Table 27. Elevation measurements and elevation above mean low water (tidal elevation) of Acadia National Park plots. Elevations were derived via the still-water method (see SOP 2 – Plot Establishment).

Site	Plot	Date	Recorder	X (m)	Y (m)	Z (m)	Z (time)	Tidal Elevation (m)
BASHAR	ASC1	9/21/2008	Rebecca Isquith	2.43	4.02	1.0	7:36	2.59
BASHAR	ASC2	9/21/2008	Rebecca Isquith	2.87	4.02	1.0	7:36	2.15
BASHAR	ASC3	9/21/2008	Rebecca Isquith	3.6	4.02	1.0	7:36	1.42
BASHAR	ASC4	9/21/2008	Rebecca Isquith	3.19	4.02	1.0	7:36	1.83
BASHAR	ASC5	9/21/2008	Rebecca Isquith	3.25	4.02	1.0	7:36	1.77
BASHAR	BAR1	9/21/2008	Rebecca Isquith	2.29	4.02	1.0	7:36	2.73
BASHAR	BAR2	9/21/2008	Rebecca Isquith	2.91	4.02	1.0	7:36	2.11
BASHAR	BAR3	9/21/2008	Rebecca Isquith	3.06	4.02	1.0	7:36	1.96
BASHAR	BAR4	9/21/2008	Rebecca Isquith	2.83	4.02	1.0	7:36	2.19
BASHAR	BAR5	9/21/2008	Rebecca Isquith	2.83	4.02	1.0	7:36	2.19
BASHAR	FUC1	9/21/2008	Rebecca Isquith	4.2	4.02	1.0	7:36	0.82
BASHAR	FUC2	9/21/2008	Rebecca Isquith	4.12	4.02	1.0	7:36	0.90
BASHAR	FUC3	9/21/2008	Rebecca Isquith	4.09	4.02	1.0	7:36	0.93
BASHAR	FUC4	9/21/2008	Rebecca Isquith	4.05	4.02	1.0	7:36	0.97
BASHAR	FUC5	9/21/2008	Rebecca Isquith	4.12	4.02	1.0	7:36	0.90
BASHAR	RED1	9/21/2008	Rebecca Isquith	4.78	4.02	1.0	7:36	0.24
BASHAR	RED2	9/21/2008	Rebecca Isquith	4.69	4.02	1.0	7:36	0.33
BASHAR	RED3	9/21/2008	Rebecca Isquith	4.78	4.02	1.0	7:36	0.24
BASHAR	RED4	9/21/2008	Rebecca Isquith	4.73	4.02	1.0	7:36	0.29
BASHAR	RED5	9/21/2008	Rebecca Isquith	4.8	4.02	1.0	7:36	0.22
BASHAR	SET1	9/21/2008	Rebecca Isquith	3.06	4.02	1.0	7:36	1.96
BASHAR	SET2	9/21/2008	Rebecca Isquith	3.12	4.02	1.0	7:36	1.90
BASHAR	SET3	9/21/2008	Rebecca Isquith	2.95	4.02	1.0	7:36	2.07
BASHAR	SET4	9/21/2008	Rebecca Isquith	2.89	4.02	1.0	7:36	2.13
BASHAR	SET5	9/21/2008	Rebecca Isquith	2.96	4.02	1.0	7:36	2.06
BASHAR	X1	9/21/2008	Rebecca Isquith	4.42	4.02	1.0	7:36	0.60
BASHAR	X2	9/21/2008	Rebecca Isquith	4.64	4.02	1.0	7:36	0.38
BASHAR	X3	9/21/2008	Rebecca Isquith	4.58	4.02	1.0	7:36	0.44
BASHAR	TEMP1	9/21/2008	Rebecca Isquith	4.55	4.02	1.0	7:36	0.47
BASHAR	TEMP2	9/21/2008	Rebecca Isquith	4.71	4.02	1.0	7:36	0.31
BASHAR	TEMP3	9/21/2008	Rebecca Isquith	4.61	4.02	1.0	7:36	0.41
LITMOO	ASC1	9/20/2008	Unknown	3.3	5.035	0.35	9:46	2.09
LITMOO	ASC2	9/20/2008	Unknown	3.44	5.035	0.35	9:46	1.95
LITMOO	ASC3	9/20/2008	Unknown	3.44	5.035	0.35	9:46	1.95
LITMOO	ASC4	9/20/2008	Unknown	3.31	5.035	0.35	9:46	2.08
LITMOO	ASC5	9/20/2008	Unknown	3.52	5.035	0.35	9:46	1.87
LITMOO	BAR1	9/20/2008	Unknown	1.94	5.035	0.35	9:46	3.45
LITMOO	BAR2	9/20/2008	Unknown	2.34	5.035	0.35	9:46	3.05
LITMOO	BAR3	9/20/2008	Unknown	2.8	5.035	0.35	9:46	2.59
LITMOO	BAR4	9/20/2008	Unknown	2.82	5.035	0.35	9:46	2.57
LITMOO	BAR5	9/20/2008	Unknown	2.14	5.035	0.35	9:46	3.25
LITMOO	FUC1	9/20/2008	Unknown	3.33	5.035	0.35	9:46	2.06
LITMOO	FUC2	9/20/2008	Unknown	3.35	5.035	0.35	9:46	2.04
LITMOO	FUC3	9/20/2008	Unknown	3.345	5.035	0.35	9:46	2.04
LITMOO	FUC4	9/20/2008	Unknown	3.74	5.035	0.35	9:46	1.65
LITMOO	FUC5	9/20/2008	Unknown	4.12	5.035	0.35	9:46	1.27
LITMOO	RED1	9/20/2008	Unknown	4.55	5.035	0.35	9:46	0.84

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Site	Plot	Date	Recorder	X (m)	Y (m)	Z (m)	Z (time)	Tidal Elevation (m)
LITMOO	RED2	9/20/2008	Unknown	4.54	5.035	0.35	9:46	0.85
LITMOO	RED3	9/20/2008	Unknown	4.6	5.035	0.35	9:46	0.79
LITMOO	RED4	9/20/2008	Unknown	4.54	5.035	0.35	9:46	0.85
LITMOO	RED5	9/20/2008	Unknown	4.52	5.035	0.35	9:46	0.87
LITMOO	SET1	9/20/2008	Unknown	2.14	5.035	0.35	9:46	3.25
LITMOO	SET2	9/20/2008	Unknown	2.3	5.035	0.35	9:46	3.09
LITMOO	SET3	9/20/2008	Unknown	2.43	5.035	0.35	9:46	2.96
LITMOO	SET4	9/20/2008	Unknown	2.62	5.035	0.35	9:46	2.77
LITMOO	SET5	9/20/2008	Unknown	2.25	5.035	0.35	9:46	3.14
LITMOO	X1	9/20/2008	Unknown					
LITMOO	X2	9/20/2008	Unknown					
LITMOO	X3	9/20/2008	Unknown					
LITMOO	TEMP1	9/20/2008	Unknown					
LITMOO	TEMP2	9/20/2008	Unknown					
LITMOO	TEMP3	9/20/2008	Unknown					
OTTPOI	ASC1	9/22/2008	Ysharda Clement	3.56	3.96	1.5	7:55	1.90
OTTPOI	ASC2	9/22/2008	Ysharda Clement	3.66	3.96	1.5	7:55	1.80
OTTPOI	ASC3	9/22/2008	Ysharda Clement	2.87	3.96	1.5	7:55	2.59
OTTPOI	ASC4	9/22/2008	Ysharda Clement	2.67	3.96	1.5	7:55	2.79
OTTPOI	ASC5	9/22/2008	Ysharda Clement	3.43	3.96	1.5	7:55	2.03
OTTPOI	BAR1	9/22/2008	Ysharda Clement	2.99	3.96	1.5	7:55	2.47
OTTPOI	BAR2	9/22/2008	Ysharda Clement	2.07	3.96	1.5	7:55	3.39
OTTPOI	BAR3	9/22/2008	Ysharda Clement	2.09	3.96	1.5	7:55	3.37
OTTPOI	BAR4	9/22/2008	Ysharda Clement	2.27	3.96	1.5	7:55	3.19
OTTPOI	BAR5	9/22/2008	Ysharda Clement	2.7	3.96	1.5	7:55	2.76
OTTPOI	FUC1	9/22/2008	Ysharda Clement	3.78	3.96	1.5	7:55	1.68
OTTPOI	FUC2	9/22/2008	Ysharda Clement	3.72	3.96	1.5	7:55	1.74
OTTPOI	FUC3	9/22/2008	Ysharda Clement	3.32	3.96	1.5	7:55	2.14
OTTPOI	FUC4	9/22/2008	Ysharda Clement	3.14	3.96	1.5	7:55	2.32
OTTPOI	FUC5	9/22/2008	Ysharda Clement	3.23	3.96	1.5	7:55	2.23
OTTPOI	MUS1	9/22/2008	Ysharda Clement					
OTTPOI	MUS2	9/22/2008	Ysharda Clement					
OTTPOI	MUS3	9/22/2008	Ysharda Clement					
OTTPOI	MUS4	9/22/2008	Ysharda Clement					
OTTPOI	MUS5	9/22/2008	Ysharda Clement					
OTTPOI	RED1	9/22/2008	Ysharda Clement	4.52	3.96	1.5	7:55	0.94
OTTPOI	RED2	9/22/2008	Ysharda Clement	4.5	3.96	1.5	7:55	0.96
OTTPOI	RED3	9/22/2008	Ysharda Clement	4.47	3.96	1.5	7:55	0.99
OTTPOI	RED4	9/22/2008	Ysharda Clement	4.42	3.96	1.5	7:55	1.04
OTTPOI	RED5	9/22/2008	Ysharda Clement	4.58	3.96	1.5	7:55	0.88
OTTPOI	SET1	9/22/2008	Ysharda Clement	3.14	3.96	1.5	7:55	2.32
OTTPOI	SET2	9/22/2008	Ysharda Clement	2.78	3.96	1.5	7:55	2.68
OTTPOI	SET3	9/22/2008	Ysharda Clement	2.07	3.96	1.5	7:55	3.39
OTTPOI	SET4	9/22/2008	Ysharda Clement	2.26	3.96	1.5	7:55	3.20
OTTPOI	SET5	9/22/2008	Ysharda Clement	2.41	3.96	1.5	7:55	3.05
OTTPOI	X1	9/22/2008	Ysharda Clement	4.34	3.96	1.5	7:55	1.12
OTTPOI	X2	9/22/2008	Ysharda Clement	4.14	3.96	1.5	7:55	1.32
OTTPOI	X3	9/22/2008	Ysharda Clement	4.55	3.96	1.5	7:55	0.91
OTTPOI	TEMP1	9/22/2008	Ysharda Clement	4.65	3.96	1.5	7:55	0.81

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Site	Plot	Date	Recorder	X (m)	Y (m)	Z (m)	Z (time)	Tidal Elevation (m)
OTTPOI	TEMP2	9/22/2008	Ysharda Clement	4.88	3.96	1.5	7:55	0.58
OTTPOI	TEMP3	9/22/2008	Ysharda Clement	4.53	3.96	1.5	7:55	0.93
SCHPOI	ASC1	9/20/2008	Unknown	2.03	4.25	0.1	8:22	2.32
SCHPOI	ASC2	9/20/2008	Unknown	2.125	4.25	0.1	8:22	2.23
SCHPOI	ASC3	9/20/2008	Unknown	2.12	4.25	0.1	8:22	2.23
SCHPOI	ASC4	9/20/2008	Unknown	2.34	4.25	0.1	8:22	2.01
SCHPOI	ASC5	9/20/2008	Unknown	2.52	4.25	0.1	8:22	1.83
SCHPOI	BAR1	9/20/2008	Unknown	2.14	4.6	0.3	7:49	2.76
SCHPOI	BAR2	9/20/2008	Unknown	2.25	4.6	0.3	7:49	2.65
SCHPOI	BAR3	9/20/2008	Unknown	2.415	4.6	0.3	7:49	2.49
SCHPOI	BAR4	9/20/2008	Unknown	1.92	4.6	0.3	7:49	2.98
SCHPOI	BAR5	9/20/2008	Unknown	2	4.6	0.3	7:49	2.90
SCHPOI	FUC1	9/20/2008	Unknown	1.81	5	0.1	8:36	3.29
SCHPOI	FUC2	9/20/2008	Unknown	1.615	5	0.1	8:36	3.49
SCHPOI	FUC3	9/20/2008	Unknown	1.64	5	0.1	8:36	3.46
SCHPOI	FUC4	9/20/2008	Unknown	1.62	5	0.1	8:36	3.48
SCHPOI	FUC5	9/20/2008	Unknown	1.83	5	0.1	8:36	3.27
SCHPOI	MUS1	9/20/2008	Unknown	1.735	4.02	0.7	7:02	2.99
SCHPOI	MUS2	9/20/2008	Unknown	1.53	4.02	0.7	7:02	3.19
SCHPOI	MUS3	9/20/2008	Unknown	1.61	4.02	0.7	7:02	3.11
SCHPOI	MUS4	9/20/2008	Unknown	1.82	4.02	0.7	7:02	2.90
SCHPOI	MUS5	9/20/2008	Unknown	1.72	4.02	0.7	7:02	3.00
SCHPOI	RED1	9/20/2008	Unknown					
SCHPOI	RED2	9/20/2008	Unknown					
SCHPOI	RED3	9/20/2008	Unknown					
SCHPOI	RED4	9/20/2008	Unknown					
SCHPOI	RED5	9/20/2008	Unknown					
SCHPOI	SET1	9/20/2008	Unknown	2.2	4.6	0.3	7:49	2.70
SCHPOI	SET2	9/20/2008	Unknown	2.42	4.6	0.3	7:49	2.48
SCHPOI	SET3	9/20/2008	Unknown	1.92	4.6	0.3	7:49	2.98
SCHPOI	SET4	9/20/2008	Unknown	1.84	4.6	0.3	7:49	3.06
SCHPOI	SET5	9/20/2008	Unknown	1.94	4.6	0.3	7:49	2.96
SCHPOI	MSS1	9/20/2008	Unknown	1.81	4.02	0.7	7:02	2.91
SCHPOI	MSS2	9/20/2008	Unknown	1.435	4.02	0.7	7:02	3.29
SCHPOI	MSS3	9/20/2008	Unknown	2.03	4.02	0.7	7:02	2.69
SCHPOI	MSS4	9/20/2008	Unknown	1.74	4.02	0.7	7:02	2.98
SCHPOI	MSS5	9/20/2008	Unknown	1.93	4.02	0.7	7:02	2.79
SCHPOI	X1	9/20/2008	Unknown					
SCHPOI	X2	9/20/2008	Unknown					
SCHPOI	X3	9/20/2008	Unknown					
SCHPOI	TEMP1	9/20/2008	Unknown					
SCHPOI	TEMP2	9/20/2008	Unknown					
SCHPOI	TEMP3	9/20/2008	Unknown					
SHIHAR	ASC1	9/21/2008	Rebecca Isquith	2.52	4.39	0.5	10:43	2.37
SHIHAR	ASC2	9/21/2008	Rebecca Isquith	2.78	4.39	0.5	10:43	2.11
SHIHAR	ASC3	9/21/2008	Rebecca Isquith	2.57	4.39	0.5	10:43	2.32
SHIHAR	ASC4	9/21/2008	Rebecca Isquith	2.03	4.39	0.5	10:43	2.86
SHIHAR	ASC5	9/21/2008	Rebecca Isquith	2.03	4.39	0.5	10:43	2.86
SHIHAR	BAR1	9/21/2008	Rebecca Isquith	3.19	4.82	1.1	11:50	2.73

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Site	Plot	Date	Recorder	X (m)	Y (m)	Z (m)	Z (time)	Tidal Elevation (m)
SHIHAR	BAR2	9/21/2008	Rebecca Isquith	3.39	4.82	1.1	11:50	2.53
SHIHAR	BAR3	9/21/2008	Rebecca Isquith	3.59	4.82	1.1	11:50	2.33
SHIHAR	BAR4	9/21/2008	Rebecca Isquith	3.12	4.82	1.1	11:50	2.8
SHIHAR	BAR5	9/21/2008	Rebecca Isquith	3.31	4.82	1.1	11:50	2.61
SHIHAR	FUC1	9/21/2008	Rebecca Isquith	3.51	4.39	0.5	10:43	1.38
SHIHAR	FUC2	9/21/2008	Rebecca Isquith	3.56	4.39	0.5	10:43	1.33
SHIHAR	FUC3	9/21/2008	Rebecca Isquith	3.67	4.39	0.5	10:43	1.22
SHIHAR	FUC4	9/21/2008	Rebecca Isquith	3.36	4.39	0.5	10:43	1.53
SHIHAR	FUC5	9/21/2008	Rebecca Isquith	3.65	4.39	0.5	10:43	1.24
SHIHAR	RED1	9/21/2008	Rebecca Isquith	4.05	4.39	0.5	10:43	0.84
SHIHAR	RED2	9/21/2008	Rebecca Isquith	3.95	4.39	0.5	10:43	0.94
SHIHAR	RED3	9/21/2008	Rebecca Isquith	4.31	4.39	0.5	10:43	0.58
SHIHAR	RED4	9/21/2008	Rebecca Isquith	4.39	4.39	0.5	10:43	0.5
SHIHAR	RED5	9/21/2008	Rebecca Isquith	4.28	4.39	0.5	10:43	0.61
SHIHAR	SET1	9/21/2008	Rebecca Isquith	3.27	4.82	1.1	11:50	2.65
SHIHAR	SET2	9/21/2008	Rebecca Isquith	3.62	4.82	1.1	11:50	2.3
SHIHAR	SET3	9/21/2008	Rebecca Isquith	3.54	4.82	1.1	11:50	2.38
SHIHAR	SET4	9/21/2008	Rebecca Isquith	3.22	4.82	1.1	11:50	2.7
SHIHAR	SET5	9/21/2008	Rebecca Isquith	3.38	4.82	1.1	11:50	2.54
SHIHAR	X1	9/21/2008	Rebecca Isquith	3.65	4.39	0.5	10:43	1.24
SHIHAR	X2	9/21/2008	Rebecca Isquith	3.84	4.39	0.5	10:43	1.05
SHIHAR	X3	9/21/2008	Rebecca Isquith	2.58	4.39	0.5	10:43	2.31
SHIHAR	TEMP1	9/21/2008	Rebecca Isquith	4.2	4.39	0.5	10:43	0.69
SHIHAR	TEMP2	9/21/2008	Rebecca Isquith	4.42	4.39	0.5	10:43	0.47
SHIHAR	TEMP3	9/21/2008	Rebecca Isquith	4.53	4.39	0.5	10:43	0.36

Table 28. Aspect and slope of Acadia National Park plots.

Site	Plot	Date	Recorder	Slope (deg.)	Aspect (deg.)
BASHAR	ASC1	9/20/2004	Austin Gallagher	13.5	18
BASHAR	ASC2	9/20/2004	Austin Gallagher	15.6	20
BASHAR	ASC3	9/20/2004	Austin Gallagher	13.6	354
BASHAR	ASC4	9/20/2004	Austin Gallagher	9.2	120
BASHAR	ASC5	9/20/2004	Austin Gallagher	12.7	170
BASHAR	BAR1	9/20/2004	Austin Gallagher	12.1	175
BASHAR	BAR2	9/20/2004	Austin Gallagher	5.1	194
BASHAR	BAR3	9/20/2004	Austin Gallagher	9.0	146
BASHAR	BAR4	9/20/2004	Austin Gallagher	10.7	272
BASHAR	BAR5	9/20/2004	Austin Gallagher	5.2	58
BASHAR	FUC1	9/20/2004	Austin Gallagher	10.5	210
BASHAR	FUC2	9/20/2004	Austin Gallagher	27.8	205
BASHAR	FUC3	9/20/2004	Austin Gallagher	31.6	220
BASHAR	FUC4	9/20/2004	Austin Gallagher	40.1	305
BASHAR	FUC5	9/20/2004	Austin Gallagher	21.9	225
BASHAR	RED1	9/20/2004	Austin Gallagher	14.2	180
BASHAR	RED2	9/20/2004	Austin Gallagher	9.5	210
BASHAR	RED3	9/20/2004	Austin Gallagher	15.1	354
BASHAR	RED4	9/20/2004	Austin Gallagher	11.9	210
BASHAR	RED5	9/20/2004	Austin Gallagher	19.0	230

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Site	Plot	Date	Recorder	Slope (deg.)	Aspect (deg.)
BASHAR	SET1	9/20/2004	Austin Gallagher	8.7	180
BASHAR	SET2	9/20/2004	Austin Gallagher	7.0	170
BASHAR	SET3	9/20/2004	Austin Gallagher	5.2	128
BASHAR	SET4	9/20/2004	Austin Gallagher	6.8	138
BASHAR	SET5	9/20/2004	Austin Gallagher	10.5	140
LITMOO	ASC1	9/20/2004	Rebecca Isquith	32.4	0
LITMOO	ASC2	9/20/2004	Rebecca Isquith	18.5	6
LITMOO	ASC3	9/20/2004	Rebecca Isquith	13.4	9
LITMOO	ASC4	9/20/2004	Rebecca Isquith	14.9	19
LITMOO	ASC5	9/20/2004	Rebecca Isquith	26.8	180
LITMOO	BAR1	9/20/2004	Rebecca Isquith	3.9	40
LITMOO	BAR2	9/20/2004	Rebecca Isquith	9.9	0
LITMOO	BAR3	9/20/2004	Rebecca Isquith	5.7	36
LITMOO	BAR4	9/20/2004	Rebecca Isquith	20.3	320
LITMOO	BAR5	9/20/2004	Rebecca Isquith	10.8	346
LITMOO	FUC1	9/20/2004	Rebecca Isquith	2.5	260
LITMOO	FUC2	9/20/2004	Rebecca Isquith	17.0	358
LITMOO	FUC3	9/20/2004	Rebecca Isquith	19.7	205
LITMOO	FUC4	9/20/2004	Rebecca Isquith	18.7	172
LITMOO	FUC5	9/20/2004	Rebecca Isquith	14.0	356
LITMOO	RED1	9/20/2004	Rebecca Isquith	17.5	352
LITMOO	RED2	9/20/2004	Rebecca Isquith	7.2	64
LITMOO	RED3	9/20/2004	Rebecca Isquith	0.5	286
LITMOO	RED4	9/20/2004	Rebecca Isquith	14.0	270
LITMOO	RED5	9/20/2004	Rebecca Isquith	12.9	30
LITMOO	SET1	9/20/2004	Rebecca Isquith	6.1	342
LITMOO	SET2	9/20/2004	Rebecca Isquith	6.3	348
LITMOO	SET3	9/20/2004	Rebecca Isquith	7.7	330
LITMOO	SET4	9/20/2004	Rebecca Isquith	18.6	341
LITMOO	SET5	9/20/2004	Rebecca Isquith	14.4	6
OTTPOI	ASC1	9/21/2004	Andy Shantz	13.9	108
OTTPOI	ASC2	9/21/2004	Andy Shantz	13.4	180
OTTPOI	ASC3	9/21/2004	Andy Shantz	29.5	150
OTTPOI	ASC4	9/21/2004	Andy Shantz	12.1	200
OTTPOI	ASC5	9/21/2004	Andy Shantz	7.6	124
OTTPOI	BAR1	9/21/2004	Andy Shantz	27.0	170
OTTPOI	BAR2	9/21/2004	Andy Shantz	14.4	178
OTTPOI	BAR3	9/21/2004	Andy Shantz	16.8	180
OTTPOI	BAR4	9/21/2004	Andy Shantz	17.1	188
OTTPOI	BAR5	9/21/2004	Andy Shantz	22.3	210
OTTPOI	FUC1	9/21/2004	Andy Shantz	16.9	356
OTTPOI	FUC2	9/21/2004	Andy Shantz	17.6	0
OTTPOI	FUC3	9/21/2004	Andy Shantz	40.0	16
OTTPOI	FUC4	9/21/2004	Andy Shantz	45.1	18
OTTPOI	FUC5	9/21/2004	Andy Shantz	44.9	10
OTTPOI	MUS1	9/21/2004	Andy Shantz	11.5	120
OTTPOI	MUS2	9/21/2004	Andy Shantz	5.6	31
OTTPOI	MUS3	9/21/2004	Andy Shantz	11.0	170
OTTPOI	MUS4	9/21/2004	Andy Shantz	16.7	178
OTTPOI	MUS5	9/21/2004	Andy Shantz	4.6	350

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Site	Plot	Date	Recorder	Slope (deg.)	Aspect (deg.)
OTTPOI	RED1	9/21/2004	Andy Shantz	23.5	340
OTTPOI	RED2	9/21/2004	Andy Shantz	13.6	326
OTTPOI	RED3	9/21/2004	Andy Shantz	14.5	38
OTTPOI	RED4	9/21/2004	Andy Shantz	12.8	148
OTTPOI	RED5	9/21/2004	Andy Shantz	20.7	192
OTTPOI	SET1	9/21/2004	Andy Shantz	22.8	182
OTTPOI	SET2	9/21/2004	Andy Shantz	35.1	170
OTTPOI	SET3	9/21/2004	Andy Shantz	19.3	180
OTTPOI	SET4	9/21/2004	Andy Shantz	17.2	222
OTTPOI	SET5	9/21/2004	Andy Shantz	13.4	192
SCHPOI	ASC1	9/19/2004	Rebecca Isquith	11.7	178
SCHPOI	ASC2	9/19/2004	Rebecca Isquith	11.8	190
SCHPOI	ASC3	9/19/2004	Rebecca Isquith	3.6	184
SCHPOI	ASC4	9/19/2004	Rebecca Isquith	10.6	184
SCHPOI	ASC5	9/19/2004	Rebecca Isquith	13.3	188
SCHPOI	BAR1	9/19/2004	Rebecca Isquith	6.4	1
SCHPOI	BAR2	9/19/2004	Rebecca Isquith	9.2	18
SCHPOI	BAR3	9/19/2004	Rebecca Isquith	3.4	11
SCHPOI	BAR4	9/19/2004	Rebecca Isquith	10.0	22
SCHPOI	BAR5	9/19/2004	Rebecca Isquith	8.8	28
SCHPOI	FUC1	9/19/2004	Rebecca Isquith	8.9	18
SCHPOI	FUC2	9/19/2004	Rebecca Isquith	10.3	332
SCHPOI	FUC3	9/19/2004	Rebecca Isquith	14.4	59
SCHPOI	FUC4	9/19/2004	Rebecca Isquith	8.2	201
SCHPOI	FUC5	9/19/2004	Rebecca Isquith	11.2	41
SCHPOI	MUS1	9/19/2004	Rebecca Isquith	2.7	1
SCHPOI	MUS2	9/19/2004	Rebecca Isquith	8.3	354
SCHPOI	MUS3	9/19/2004	Rebecca Isquith	6.7	6
SCHPOI	MUS4	9/19/2004	Rebecca Isquith	21.7	8
SCHPOI	MUS5	9/19/2004	Rebecca Isquith	9.7	38
SCHPOI	RED1	9/19/2004	Rebecca Isquith	22.5	344
SCHPOI	RED2	9/19/2004	Rebecca Isquith	18.1	342
SCHPOI	RED3	9/19/2004	Rebecca Isquith	20.2	340
SCHPOI	RED4	9/19/2004	Rebecca Isquith	19.1	344
SCHPOI	RED5	9/19/2004	Rebecca Isquith	23.8	340
SCHPOI	SET1	9/19/2004	Rebecca Isquith	4.8	333
SCHPOI	SET2	9/19/2004	Rebecca Isquith	3.9	21
SCHPOI	SET3	9/19/2004	Rebecca Isquith	16.9	32
SCHPOI	SET4	9/19/2004	Rebecca Isquith	7.0	352
SCHPOI	SET5	9/19/2004	Rebecca Isquith	3.2	14
SHIHAR	ASC1	9/20/2004	Ashwin Bandiwhad	13.2	315
SHIHAR	ASC2	9/20/2004	Ashwin Bandiwhad	32.0	110
SHIHAR	ASC3	9/20/2004	Ashwin Bandiwhad	17.3	130
SHIHAR	ASC4	9/20/2004	Ashwin Bandiwhad	18.2	158
SHIHAR	ASC5	9/20/2004	Ashwin Bandiwhad	22.7	245
SHIHAR	BAR1	9/20/2004	Ashwin Bandiwhad	7.2	95
SHIHAR	BAR2	9/20/2004	Ashwin Bandiwhad	10.6	270
SHIHAR	BAR3	9/20/2004	Ashwin Bandiwhad	11.9	310
SHIHAR	BAR4	9/20/2004	Ashwin Bandiwhad	17.5	310
SHIHAR	BAR5	9/20/2004	Ashwin Bandiwhad	14.6	235

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Site	Plot	Date	Recorder	Slope (deg.)	Aspect (deg.)
SHIHAR	FUC1	9/20/2004	Ashwin Bandiwhad	11.0	146
SHIHAR	FUC2	9/20/2004	Ashwin Bandiwhad	11.0	126
SHIHAR	FUC3	9/20/2004	Ashwin Bandiwhad	19.4	102
SHIHAR	FUC4	9/20/2004	Ashwin Bandiwhad	30.0	142
SHIHAR	FUC5	9/20/2004	Ashwin Bandiwhad	22.2	142
SHIHAR	RED1	9/20/2004	Ashwin Bandiwhad		
SHIHAR	RED2	9/20/2004	Ashwin Bandiwhad		
SHIHAR	RED3	9/20/2004	Ashwin Bandiwhad		
SHIHAR	RED4	9/20/2004	Ashwin Bandiwhad		
SHIHAR	RED5	9/20/2004	Ashwin Bandiwhad		
SHIHAR	SET1	9/20/2004	Ashwin Bandiwhad	16.7	310
SHIHAR	SET2	9/20/2004	Ashwin Bandiwhad	7.6	150
SHIHAR	SET3	9/20/2004	Ashwin Bandiwhad	4.1	210
SHIHAR	SET4	9/20/2004	Ashwin Bandiwhad	5.0	140
SHIHAR	SET5	9/20/2004	Ashwin Bandiwhad	13.3	230

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Appendix 2. Power Analyses

Several power analyses were conducted using pilot monitoring data to explore whether sample sizes selected for this protocol are sufficient to detect trends related to important species within a reasonable period of time. These power analyses will be supplemented in a few years with additional analyses using several years of complete monitoring data. It is typically not possible to choose an optimum sample size for all species being monitored, due to natural variation in species abundance and spatial distribution. However, power analyses can detect when sample sizes are too low for most species, and can be useful for determining if there are some species that cannot be monitored effectively.

The power analyses addressed the following questions:

- How long will it take to detect trends in the density of *Littorina littorea* and *L. obtusata* on *Ascophyllum* and *Fucus* plots?
- How long will it take to detect trends in the size of *Littorina littorea* and *L. obtusata* on *Ascophyllum* and *Fucus* plots?
- How long will it take to detect trends in the percent cover of target species on photoquadrats?
- How long will it take to detect trends in the abundance of species on point-intercept transects?

Analyses were conducted by Dr. Penelope Pooler (NPS quantitative ecologist for the Northeast Coastal and Barrier Network) in TRENDS version 3.0. This software is available from the NOAA Southwest Fisheries Science Center at http://swfsc.noaa.gov/textblock.aspx?Division=PRD&ParentMenuId=228&id=4740. The program is described in Gerrodette (1987, 1991, 1993). All analyses used a significance level of 0.05, two-tailed significance tests, a power of 0.80, rate of change expressed as overall change (as opposed to change per time step), coefficient of variation proportional to the square root of abundance, and equal intervals between sampling occasions.

The snail density analysis was based on data for one site with ten quadrats in the *Ascophyllum* zone and 10 in the *Fucus* zone. The data were bootstrapped to simulate different numbers of quadrats (3, 5, and 7). The snail size analysis was also based on data for one site. Thirty individuals of each species measured from the *Ascophyllum* zone, and 30 individuals of each species were measured from the *Fucus* zone. For the point-intercept analysis, data was only available for 5 transects, so the coefficient of variation for larger sample sizes was estimated by assuming that the mean and the distribution of sample data would stay constant as sample size increased. For each species or cover type and sample size, the time to detect a trend was calculated for each combination of three factors: trend direction (positive or negative), trend size (50% or 25%), and functional form (linear or exponential population change).

Large changes in the density of *Littorina littorea* and *L. obtusata* can be detected at a single site in a reasonable length of time in the *Fucus* zone, but not in the *Ascophyllum* zone (Table 29).

With five *Fucus* zone quadrats, a 50% decrease in *L. obtusata* can be detected in 4 years, and the same decrease in *L. littorea* can be detected in 7 years. This power could be increased by combining data from multiple sites (e.g., all Acadia sites, or all Boston Harbor Islands sites), unless there is substantial variation between sites. This analysis indicates that the number of quadrats does not matter, but the counts were highly variable (typically ranging over almost an order of magnitude for each species within a zone), and it is possible that there was not enough raw data for the bootstrapping procedure to effectively model the conditions at a site. This analysis will be repeated in a few years, when more data is available.

Changes in the size of *L. obtusata* can be detected at a single site using a sample size of only 15 individuals. In either the *Ascophyllum* or the *Fucus* zone, a 50% change in the size of individuals can be detected in seven or fewer years (Table 30). Changes in the size of *L. littorea* cannot be detected within a reasonable length of time, but power would likely be improved by combining data from multiple sites. This analysis indicates that there is no benefit to doubling the sample size from 15 to 30. However, the distribution of snail sizes within a habitat is generally bimodal rather than normal. It is possible that the sample size was too small to accurately reflect the distribution of snail sizes, or that sizes are non-normally distributed (e.g., there are different age cohorts that are different sizes). In the first case, more raw data would be needed for an effective bootstrap simulation, and the second case would require changes to the power analysis methods. This analysis will also be repeated in a few years, when more data is available.

Changes in the cover of target species within photoquadrats should be detected reasonably quickly in most cases (Table 31). At Acadia, pilot data indicates that a 50% decline in *Ascophyllum*, barnacles, and *Fucus* could be detected within ten years. At Boston Harbor Islands, pilot data indicates that a 50% decline in *Ascophyllum*, *Fucus*, and *Chondrus/Mastocarpus* could be detected within ten years.

Changes in the density of several species can be detected along point-intercept transects, using sample sizes for MCI (5 or 6 total transects), Boston Harbor Islands (9 transects), and Acadia (12 transects). A 50% change in the abundance of *Ascophyllum*, *Fucus*, and barnacles can be detected at most locations within 10 years using the current sampling interval (every 30 cm) (Table 32). This is only one of the ways that the point-intercept data will be analyzed; once the transects are surveyed for elevation, analyses will also explore changes in range, minimum elevation, and maximum elevation of species and cover types.

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Table 29. Number of years needed to detect changes in the density of two species of motile invertebrates at a single site, within the *Ascophyllum* or *Fucus* zone. The analysis used a power of 0.8, alpha of 0.05, and a two-tailed significance test. Empty cells indicate that greater than 50 years is needed to detect a trend.

							Number of Years Needed to Detect Change							
							50% Linear[2]		50% Exponential		25% Linear		25% Exponential	
Zone	**Species**	**Mean**	**Var[1]**	**SD**	**CV**	**N**	**+**	**–**	**+**	**–**	**+**	**–**	**+**	**–**
Ascophyllum	*Littorina littorea*	2.07	2.07	1.44	0.70	3								
Ascophyllum	*Littorina littorea*	2.08	2.08	1.44	0.69	5								
Ascophyllum	*Littorina littorea*	2.07	2.08	1.44	0.70	7								
Ascophyllum	*Littorina obtusata*	3.10	0.66	0.81	0.26	3	33	21	33	20				
Ascophyllum	*Littorina obtusata*	3.10	0.66	0.81	0.26	5	33	21	33	20				
Ascophyllum	*Littorina obtusata*	3.10	0.66	0.81	0.26	7	33	21	33	20				
Fucus	*Littorina littorea*	4.94	0.52	0.72	0.15	3	12	7	12	7	37	28	37	29
Fucus	*Littorina littorea*	4.94	0.52	0.72	0.15	5	12	7	12	7	37	28	37	29
Fucus	*Littorina littorea*	4.94	0.52	0.72	0.15	7	12	7	12	7	37	28	37	29
Fucus	*Littorina obtusata*	4.83	0.10	0.32	0.07	3	5	4	5	4	8	7	8	7
Fucus	*Littorina obtusata*	4.82	0.11	0.33	0.07	5	5	4	5	4	8	7	8	7
Fucus	*Littorina obtusata*	4.82	0.11	0.32	0.07	7	5	4	5	4	8	7	8	7

[1] Var = variance; SD = standard deviation; CV = coefficient of variation; N = sample size (number of quadrats per site)
[2] 50% and 25% refer to the percentage change in population size, based on either a linear or exponential trend. “+” indicates a positive trend, while “–“ indicates a negative trend.

Table 30. Number of years needed to detect changes in the size of two species of motile invertebrates at a single site, within the *Ascophyllum* or *Fucus* zone. The analysis used a power of 0.8, alpha of 0.05, and a two-tailed significance test. Empty cells indicate that greater than 50 years is needed to detect a trend.

							Number of Years Needed to Detect Change							
							50% Linear[2]		50% Exponential		25% Linear		25% Exponential	
Zone	**Species**	**Mean (cm)**	**Var[1]**	**SD**	**CV**	**N**	**+**	**–**	**+**	**–**	**+**	**–**	**+**	**–**
Ascophyllum	*Littorina littorea*	1.41	0.20	0.45	0.32	15	48	29	46	28				
Ascophyllum	*Littorina littorea*	1.46	0.20	0.44	0.30	30	44	27	42	26				
Ascophyllum	*Littorina obtusata*	1.04	0.01	0.11	0.11	15	7	6	7	6	21	16	20	16
Ascophyllum	*Littorina obtusata*	1.03	0.01	0.11	0.11	30	7	6	7	6	21	16	21	16
Fucus	*Littorina littorea*	1.62	0.18	0.42	0.26	15	31	20	31	19				
Fucus	*Littorina littorea*	1.60	0.14	0.37	0.23	30	27	17	26	16				
Fucus	*Littorina obtusata*	0.98	0.01	0.10	0.10	15	7	5	7	5	19	15	18	15
Fucus	*Littorina obtusata*	1.08	0.06	0.23	0.22	30	23	14	23	15				

[1] Var = variance; SD = standard deviation; CV = coefficient of variation; N = sample size (number of motile invertebrates measured per site)
[2] 50% and 25% refer to the percentage change in population size, based on either a linear or exponential trend. “+” indicates a positive trend, while “–“ indicates a negative trend.

Table 31. Number of years needed to detect changes in cover of target species within photoquadrats. The target species are only considered within photoquadrats set up to detect them (e.g., barnacles with barnacle photoquadrats only). The analysis used a power of 0.8, alpha of 0.05, and a two-tailed significance test. Empty cells indicate that greater than 50 years is needed to detect a trend.

							Number of Years Needed to Detect Change							
							50% Linear[2]		50% Exponential		25% Linear		25% Exponential	
Park	**Target Species**	**Mean**	**Var[1]**	**SD**	**CV**	**N**	**+**	**–**	**+**	**–**	**+**	**–**	**+**	**–**
ACAD	*Ascophyllum*	75	173	13.2	0.18	20	15	10	15	10				
ACAD	Barnacles	89	22	4.7	0.05	20	4	4	4	4	7	6	7	6
ACAD	*Fucus*	95	27	5.2	0.05	20	4	4	4	4	7	6	7	6
ACAD	Mussels	38	83	9.1	0.24	10	28	17	27	17				
ACAD	*Chondrus/Mastocarpus*	67	271	16.5	0.25	20	29	18	29	17				
BOHA	*Ascophyllum*	92	62	7.8	0.09	15	6	5	6	5	13	11	13	10
BOHA	Barnacles	60	241	15.5	0.26	15	33	20	31	19				
BOHA	*Fucus*	91	13	3.5	0.04	15	4	4	4	4	5	5	5	5
BOHA	*Chondrus/Mastocarpus*	85	107	10.4	0.12	15	9	6	9	6	26	21	25	21

[1] Var = variance; SD = standard deviation; CV = coefficient of variation; N = sample size

[2] 50% and 25% refer to the percentage change in population size, based on either a linear or exponential trend. “+” indicates a positive trend, while “–“ indicates a negative trend.

Table 32. Number of years needed to detect changes in density of selected species and substrates on point-intercept transects. The analysis used a power of 0.8, alpha of 0.05, and a two-tailed significance test. Empty cells indicate that greater than 50 years is needed to detect a trend.

							Number of Years Needed to Detect Change							
							50% Linear[2]		50% Exponential		25% Linear		25% Exponential	
Species or Substrate	**Interval[1]**	**Mean**	**Var**	**SD**	**CV**	**N**	**+**	**–**	**+**	**–**	**+**	**–**	**+**	**–**
Ascophyllum	10	94.8	48.3	6.9	0.07	5	5	4	5	4	10	8	10	8
Ascophyllum	10	94.8	48.3	6.9	0.05	9	4	4	4	4	7	6	7	6
Ascophyllum	10	94.8	48.3	6.9	0.04	12	4	4	4	4	6	5	6	5
Ascophyllum	30	31.6	16.0	4.0	0.13	5	9	7	9	7	27	22	27	21
Ascophyllum	30	31.6	16.0	4.0	0.09	9	7	4	7	4	19	10	18	10
Ascophyllum	30	31.6	16.0	4.0	0.7	12	6	4	6	4	12	7	12	7
Fucus	10	49.6	35.3	5.9	0.12	5	9	6	9	6	25	20	25	19
Fucus	10	49.6	35.3	5.9	0.08	9	7	4	7	4	16	9	17	9
Fucus	10	49.6	35.3	5.9	0.07	12	6	4	6	4	12	7	12	7
Fucus	30	16.5	11.6	3.4	0.21	5	21	13	20	13				
Fucus	30	16.5	11.6	3.4	0.15	9	16	6	16	5	46	22	45	22
Fucus	30	16.5	11.6	3.4	0.12	12	12	5	12	5	32	16	30	15
Chondrus/Mastocarpus	10	3.4	3.2	1.8	0.52	5								
Chondrus/Mastocarpus	10	3.4	3.2	1.8	0.37	9		25		19				
Chondrus/Mastocarpus	10	3.4	3.2	1.8	0.30	12		18		13				
Chondrus/Mastocarpus[3]	30	1.1	0.9	0.9	0.47	12								
Barnacles	10	32.2	25.7	5.1	0.16	5	12	9	12	9	42	33	43	33
Barnacles	10	32.2	25.7	5.1	0.11	9	11	5	10	5	28	13	26	13
Barnacles	10	32.2	25.7	5.1	0.09	12	8	4	7	4	18	10	19	9
Barnacles	30	10.7	8.4	2.9	0.27	5	33	21	34	21				
Barnacles	30	10.7	8.4	2.9	0.19	9	28	8	26	7				
Barnacles	30	10.7	8.4	2.9	0.16	12	19	6	18	6		26		25
Rock	10	4.2	3.7	1.9	0.46	5								
Rock	10	4.2	3.7	1.9	0.32	9		20		15				
Rock	10	4.2	3.7	1.9	0.26	12		13	48	11				
Rock[3]	30	1.4	0.9	0.9	0.38	12								

[1] Interval = spacing (in cm) between samples; Var = variance; SD = standard deviation; CV = coefficient of variation; N = sample size
[2] 50% and 25% are change in population size, based on linear or exponential trend. "+" indicates positive trend, while "–" indicates negative trend.
[3] *Chondrus*/*Mastocarpus*: CV = 0.82 when N = 5, and CV = 0.58 when N = 9. Rock: CV = 0.66 when N = 5, and CV = 0.47 when N = 9.

Appendix 3. Data Forms

The following pages contain copies of all data forms.

Form 1: Photoquadrat Drawings

Site:_____Date:_____Time:_____
Photographer:_____Observer:_____Target Species:_____
Directions: Draw species cover in approximately 1 minute per photoquadrat. Label with species codes at the bottom of the form. If species are mixed, delineate the mixed area, and divide into approximate area for each species.

Purpose	Color	Date	Initials
Field Review	N/A		
Entered to DB	☐		
100% Check	☐		
10% Check	☐		
Validation	☐		
	☐		

Plot 1 Notes:_____

Plot 2 Notes:_____

Plot 3 Notes:_____

Green Algae:	**UE** = Ulva/Enteromorpha; **OG**=Other Green
Brown Algae:	**AS** = *Ascophyllum*; **FU** = *Fucus*; **KE** = Kelp; **OB**=Other Brown
Red Algae:	**AC**=Articulated Corallines; **CC**=Crustose Corallines; **CM** = *Chondrus crispus* or *Mastocarpus stellatus*; **PA** = *Palmaria palmate*; **PO** = *Porphyra* spp; **OR**=Other Reds
Algae/Plants:	**CN** = Crustose Non-Coralline; **OP**=Other Plants
Barnacles:	**BA**=Barnacles
Mollusks:	**MU**=Mussels; **CI**=Chitons
Invertebrates:	**OI** = Other Invertebrates
Substrates:	**RO** = Rock; **SA** = Sand; **TA** = Tar; **OS** = Other Substrate

Form 1: Photoquadrat Drawings

Site:_____Date:_____Time:_____
Photographer:_____Observer:_____Target Species:_____
Directions: Draw species cover in approximately 1 minute per photoquadrat. Label with species codes at the bottom of the form. If species are mixed, delineate the mixed area, and divide into approximate area for each species.

Purpose	Color	Date	Initials
Field Review	N/A		
Entered to DB	☐		
100% Check	☐		
10% Check	☐		
Validation	☐		
	☐		

Plot 4 Notes:_____

Plot 5 Notes:_____

Plot Notes:_____

Green Algae:	**UE** = Ulva/Enteromorpha; **OG**=Other Green
Brown Algae:	**AS** = *Ascophyllum*; **FU** = *Fucus*; **KE** = Kelp; **OB**=Other Brown
Red Algae:	**AC**=Articulated Corallines; **CC**=Crustose Corallines; **CM** = *Chondrus crispus* or *Mastocarpus stellatus*; **PA** = *Palmaria palmate*; **PO** = *Porphyra* spp; **OR**=Other Reds
Algae/Plants:	**CN** = Crustose Non-Coralline; **OP**=Other Plants
Barnacles:	**BA**=Barnacles
Mollusks:	**MU**=Mussels; **CI**=Chitons
Invertebrates:	**OI** = Other Invertebrates
Substrates:	**RO** = Rock; **SA** = Sand; **TA** = Tar; **OS** = Other Substrate

Form 2: Photo Log (Optional)

Site:_____Date:_____Time:_____

Photographer:_____Recorder:_____

Directions: Record Plot (or Overview Type) and notes about all pictures. The Photo # refers to the order of photographs taken during the field sampling event.

Purpose	Color	Date	Initials
Field Review	N/A		
Entered to DB	☐		
100% Check	☐		
10% Check	☐		
Validation	☐		
	☐		

Photo #	Plot/Area Photographed (if area, indicate viewpoint)	Notes
1		
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12		
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44		

Plot/Area Codes: ASC = *Ascophyllum*; BAR = barnacles; FUC = *Fucus*; MUS = mussels; RED = red algae, SET = settlement. Follow the code with the replicate number or "O" for overview. Examples: MUS1 = Mussel rep 1 and SETO = settlement overview

Form 2: Photo Log (Optional)

Site:_____Date:_____Time:_____

Photographer:_____Recorder:_____

Directions: Record Plot (or Overview Type) and notes about all pictures. The Photo # refers to the order of photographs taken during the field sampling event.

Purpose	Color	Date	Initials
Field Review	N/A		
Entered to DB	☐		
100% Check	☐		
10% Check	☐		
Validation	☐		
	☐		

Photo #	Plot/Area Photographed (if area, indicate viewpoint)	Notes
45		
46		
47		
48		
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57		
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Plot/Area Codes: ASC = *Ascophyllum*; BAR = barnacles; FUC = *Fucus*; MUS = mussels; RED = red algae, SET = settlement
Follow the code with the replicate number or "O" for overview. Examples: MUS1 = Mussel rep 1 and SETO = settlement overview

Form 3: Tide Pool Transects

Site:_____Date:_____Time:_____

Observer:_____Recorder:_____

Directions: Collect the first 10 individuals of each urchin and sea star species detected on the band transect. Count all individuals by species on the band transect and record the total number by tide pool. For each individual collected, measure diameter of urchins (across test) and radius of sea stars (center of disk to tip of longest ray/arm).

Purpose	Color	Date	Initials
Field Review	N/A		
Entered to DB	☐		
100% Check	☐		
10% Check	☐		
Validation	☐		
	☐		

Green sea urchins (STRDRO)

	Pool 1 (X1)	Pool 2 (X2)	Pool 3 (X3)
Diam. (mm)	1)	1)	1)
	2)	2)	2)
	3)	3)	3)
	4)	4)	4)
	5)	5)	5)
	6)	6)	6)
	7)	7)	7)
	8)	8)	8)
	9)	9)	9)
	10)	10)	10)
Count			

Blood stars (HENSAN)

	Pool 1 (X1)	Pool 2 (X2)	Pool 3 (X3)
Radius (mm)	1)	1)	1)
	2)	2)	2)
	3)	3)	3)
	4)	4)	4)
	5)	5)	5)
	6)	6)	6)
	7)	7)	7)
	8)	8)	8)
	9)	9)	9)
	10)	10)	10)
Count			

Common sea star (orange-red, ASTRUB)

	Pool 1 (X1)	Pool 2 (X2)	Pool 3 (X3)
Radius (mm)	1)	1)	1)
	2)	2)	2)
	3)	3)	3)
	4)	4)	4)
	5)	5)	5)
	6)	6)	6)
	7)	7)	7)
	8)	8)	8)
	9)	9)	9)
	10)	10)	10)
Count			

Northern sea star (yellow, ASTFOR)

	Pool 1 (X1)	Pool 2 (X2)	Pool 3 (X3)
Radius (mm)	1)	1)	1)
	2)	2)	2)
	3)	3)	3)
	4)	4)	4)
	5)	5)	5)
	6)	6)	6)
	7)	7)	7)
	8)	8)	8)
	9)	9)	9)
	10)	10)	10)
Count			

Form 4: Point Intercept Transect Data Sheet

Site:_____Date:_____Time:_____Observer:_____Recorder:_____Transect:_____

Directions: Record point-intercept code every 0.3 m (30 cm) along variable length transect lines.

Purpose	Color	Date	Initials
Field Review	N/A		
Entered to DB	☐		
100% Check	☐		
10% Check	☐		
Validation	☐		
	☐		

Species/Taxa/Substrate	0.0	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.3	3.6
AS: *Ascophyllum*													
CM: *Chondrus/Mastocarpus*													
FU: *Fucus*	3.9	4.2	4.5	4.8	5.1	5.4	5.7	6.0	6.3	6.6	6.9	7.2	7.5
KE: Kelp													
PA: *Palmaria*													
PO: *Porphyra*	10.2	10.5	10.8	11.1	11.4	11.7	12.0	12.3	12.6	12.9	13.2	13.5	13.8
UE: *Ulva/Enteromorpha*													
EA: epibiont, *Ascophyllum*													
EF: epibiont, *Fucus*	16.5	16.8	17.1	17.4	17.7	18.0	18.3	18.6	18.9	19.2	19.5	19.8	20.1
CC: Crustose Coralline													
CN: Crustose Non-Coralline													
AC: Articulated Corallines	22.8	23.1	23.4	23.7	24.0	24.3	24.6	24.9	25.2	25.5	25.8	26.1	26.4
OR: Other red algae													
OB: Other brown algae													
OG: Other green algae	29.1	29.4	29.7	30.0	30.3	30.6	30.9	31.2	31.5	31.8	32.1	32.4	32.7
OP: Other plant													
MU: Mussels													
BA: Barnacles	35.4	35.7	36.0	36.3	36.6	36.9	37.2	37.5	37.8	38.1	38.4	38.7	39.0
OI: Other Invertebrates													
RO: Rock													
SA: Sand	41.7	42.0	42.3	42.6	42.9	43.2	43.5	43.8	44.1	44.4	44.7	45.0	45.3
TA: Tar													
OS: Other Substrate													
UN: Unidentified	48.0	48.3	48.6	48.9	49.2	49.5	49.8	50.1	50.4	50.7	51.0	51.3	51.6

3.9	4.2	4.5	4.8	5.1	5.4	5.7	6.0	6.3	6.6	6.9	7.2	7.5	7.8	8.1	8.4	8.7	9.0	9.3	9.6	9.9
10.2	10.5	10.8	11.1	11.4	11.7	12.0	12.3	12.6	12.9	13.2	13.5	13.8	14.1	14.4	14.7	15.0	15.3	15.6	15.9	16.2
16.5	16.8	17.1	17.4	17.7	18.0	18.3	18.6	18.9	19.2	19.5	19.8	20.1	20.4	20.7	21.0	21.3	21.6	21.9	22.2	22.5
22.8	23.1	23.4	23.7	24.0	24.3	24.6	24.9	25.2	25.5	25.8	26.1	26.4	26.7	27.0	27.3	27.6	27.9	28.2	28.5	28.8
29.1	29.4	29.7	30.0	30.3	30.6	30.9	31.2	31.5	31.8	32.1	32.4	32.7	33.0	33.3	33.6	33.9	34.2	34.5	34.8	35.1
35.4	35.7	36.0	36.3	36.6	36.9	37.2	37.5	37.8	38.1	38.4	38.7	39.0	39.3	39.6	39.9	40.2	40.5	40.8	41.1	41.4
41.7	42.0	42.3	42.6	42.9	43.2	43.5	43.8	44.1	44.4	44.7	45.0	45.3	45.6	45.9	46.2	46.5	46.8	47.1	47.4	47.7
48.0	48.3	48.6	48.9	49.2	49.5	49.8	50.1	50.4	50.7	51.0	51.3	51.6	51.9	52.2	52.5	52.8	53.1	53.4	53.7	54.0

54.3	54.6	54.9	55.2	55.5	55.8	56.1	56.4	56.7	57.0

Mid Bolt

Low Bolt

Form 5: Motile Invertebrates

Site:_____Date:_____Time:_____
Observer:_____Recorder:_____ Target Species:_____
Directions: Use 20 x 20 cm frame to determine if subsampling is needed.
Collect the first 10 individuals of each species (7 mm or larger) separately.
Examine all for damage, and record number damaged and undamaged.
Record length (nearest mm) of first 10 individuals of each species.

Purpose	Color	Date	Initials
Field Review	N/A		
Entered to DB	☐		
100% Check	☐		
10% Check	☐		
Validation	☐		
	☐		

	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5
Subsample?	Y N	Y N	Y N	Y N	Y N

COUNTS	Damage	No Damage	Damage	No Damage	Damage	No Damage	Damage	No Damage	Damage	No Damage
Littorina littorea										
Littorina obtusata										
Littorina saxatilis										
Nucella lapillus										
Acmaea testudinalis										

SIZES	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5
Littorina littorea	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)
Littorina obtusata	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)
Littorina saxatilis	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)
Nucella lapillus	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)
Acmaea testudinalis	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)	1) 6) 2) 7) 3) 8) 4) 9) 5) 10)

Purpose	Color	Date	Initials
Field Review	N/A		
Entered to DB	☐		
100% Check	☐		
10% Check	☐		
Validation	☐		
	☐		

Form 6: Photoquadrat Scoring

Site:_____ Sampling Date:_____

Scoring Date:_____

Scorer:_____ Target Species:_____

Directions: This data form has an embedded Excel worksheet to calculate totals for each replicate. Double-click in the table to activate the worksheet. Record number of points with each species under the appropriate replicate column with the form open on a computer. If you complete the replicate and the total does not equal 100, score the replicate again. Once all five replicates are completed, print this form out. Make sure to complete the information at the top of the page.

Species/Taxa/Substrate		1	2	3	4	5
Ascophyllum nodosum						
Chondrus/Mastocarpus						
Fucus spp.						
Palmaria palmata						
Porphyra spp.						
Ulva spp.						
Kelp						
Ascophyllum epibiont						
Fucus epibiont						
Crustose	Coralline					
Algae	Non-Coralline					
Articulated Corallines						
Other Algae	Red					
	Brown					
	Green					
Other Plant						
Metridium senile						
Mussels						
Barnacles						
Asterias spp.						
Other Invertebrates						
Rock						
Sand						
Tar						
Other Substrate						
Unidentified						
Total (must add up to 100):		0	0	0	0	0

Form 7: Field Log

Site:_____Date:_____Start Time:_____
End Time:_____Recorder:_____
Directions: Complete this form at the end of the field sampling day, based on observations over the course of the sampling effort. This should be a rapid and qualitative assessment. See SOP 17 – Field Log for additional guidance.

Purpose	Color	Date	Initials
Field Review	N/A		
Entered to DB	☐		
100% Check	☐		
10% Check	☐		
Validation	☐		
	☐		

Fill in all blanks.: ---=No Data; 0=None; L=Low; M=Med; H=High; or Actual Value

Participants:_____
_____

Weather and Sea Conditions (affecting quality of sampling)(use codes listed above)
Swell/Surge:_____ Wind:_____ Rain:_____ Recent Rain:_____
Substratum Changes (sediment=sand, gravel, cobble) (magnitude at site)
Sediment Level:_____ Scour:_____ Rock Movement:_____
Debris and Pollutants (magnitude at site):
Plant Wrack:_____ Driftwood:_____ Shells:_____ Dead Animals:_____ Trash:_____ Oil/Tar:_____
Notes on Physical Conditions:_____
_____
_____
_____
_____
_____

Birds and Mammals (maximum # seen at any one time during the sampling)(see bird/mammal list for other species)

Pelican		Snowy Egret		
Cormorant		Lg Shorebird		
Gull		Sm Shorebird		
Tern		Other Birds		
Oystercatcher		Seal		
Blue Heron		Dog		
Great Egret				

Bird/Mammal Notes:_____
_____

Humans (maximum # seen at any one time in the intertidal zone during sampling; note behavior) #:_____
_____

Plot Marker Loss/Repair Notes:_____
_____
_____

Other Notes:_____
_____
_____
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Form 7: Field Log

Site:_____Date:_____Start Time:_____

End Time:_____Recorder:_____

Directions: Complete this form at the end of the field sampling day, based on observations over the course of the sampling effort. This should be a rapid and qualitative assessment. See SOP 17 – Field Log for additional guidance.

Purpose	Color	Date	Initials
Field Review	N/A		
Entered to DB	☐		
100% Check	☐		
10% Check	☐		
Validation	☐		
	☐		

Site-Wide Species Conditions

Species	Abundance	Appearance	Recruitment	Notes
Target Species shown in bold.	-----=No Data 0=Absent R=Rare U=Uncommon P=Present C=Common A=Abundant	-----=No Data √=Typical (healthy) F=Fertile Flowers B=Bleached D=Damaged L=Low level M=Med level H=High level	-----=No Data 0=Absent L=Low level M=Med level H=High level	
Ascophyllum nodosum				
Chondrus/Mastocarpus				
***Fucus* spp.**				
Palmaria palmata				
Porphyra spp.				
Ulva spp.				
Crustose coraline				
Crustose noncoraline				
Articulated Corallines				
***Asterias* spp.**				
Cancer spp.				
Carcinus maenus				
Hemigrapsus sanguineus				
Littorina littorea				
Littorina obtusata				
Littorina saxatilis				
Metridium senile				
***Mytilus* spp.**				
Nucella lapillus				
Barnacles				
Tar				

Form 7: Field Log

Site:_____Date:_____Start Time:_____
End Time:_____Recorder:_____
Directions: Complete this form at the end of the field sampling day, based on observations over the course of the sampling effort. This should be a rapid and qualitative assessment. See SOP 17 – Field Log for additional guidance.

Purpose	Color	Date	Initials
Field Review	N/A		
Entered to DB	☐		
100% Check	☐		
10% Check	☐		
Validation	☐		
	☐		

Codes

No Data (----): Draw a horizontal line through any blank area to indicate that this category was not evaluated or does not apply.

None (0): None were found within the defined site boundaries.

Low (L): Relatively few or low levels were found within the defined site boundaries.

Med (M): Medium numbers or moderate levels were found within the defined site boundaries.

High (H): High numbers or high levels were found within the defined site boundaries.

Weather and Sea Conditions

Swell/Surge: L/M/H relative levels of water movement over seaward portion of site.

Wind: L = ≤10 knots M = 11-20 knots H => 20 knots

Rain: L/M/H relative amounts of precipitation at the site during the survey.

Recent Rain: Evidence or knowledge of L/M/H amounts rain at the site within the past few days.

Water Temp: Actual seawater temperature (°C) or L: ≤14°C (57°F) M: 15-18°C H: >18°C (64°F).

Substratum Changes

Sediment Level: L/M/H relative levels of unconsolidated sand/gravel/cobble along reef/sediment interfaces.

Scour: L/M/H relative extent of scoured reef surfaces within the defined site boundaries.

Rock Movement: L/M/H relative extent of overturned boulders or bedrock breakouts.

Debris and Pollutants

Plant Wrack: L/M/H levels of unattached algae or other drift plants within the site.

Driftwood: L/M/H levels of sticks, branches, and logs within the site.

Shells: L/M/H levels of dead shells, especially mussel shells.

Dead Animals: L/M/H levels of dead invertebrates, fish, birds, or mammals.

Trash: L/M/H levels of human debris including cans, bottles, plastics, and metal items.

Oil/Tar: L/M/H relative extent of fresh or weathered oil/tar within the site.

Site-Wide Species Conditions

Abundance: Relative numbers of individuals or cover of species, in 5 levels, with "Present" representing the middle level.

Appearance: Checkmark indicates typical "healthy" non-reproductive appearance. If appearance is not typical, pair noted appearance codes with level codes (FL, FM, FH, BL, BM, BH, DL, DM, DH). Score L/M/H relative levels of reproductive appearance (F) (plants showing evidence of fertility), bleaching (B) (plants only: e.g., appearing pale or translucent or red algae appearing greenish), or damage (D) (plants & animals: e.g., abraded, torn, broken, withered, diseased, injured, or dead individuals). It is possible to record multiple entries (e.g., *Silvetia* = FL, BL, & DM).

Recruitment: For appropriate species when evident, score L/M/H relative levels of recruit abundances (settlers that have become obvious since the previous sampling)

SOP 1 – Safety

Version 1.00 (May 1, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	5/1/2010	B. Mitchell	Based on Safety SOP v1.04 in the NETN Forest Health protocol	Original	1.00

Overview

This Standard Operating Procedure (SOP) describes basic safety procedures that should be followed during rocky intertidal field sampling at ACAD, BOHA, and MCI. Personal safety is the number one priority at all times. Staff should never participate in operations that appear dangerous or risky. The intertidal zone is an inherently dangerous place, and travel and work in the intertidal, particularly on rocky shores which are encrusted with slippery organisms, requires careful, methodical movement. Awareness of weather, swell, and waves is crucial to safe coastal conduct.

The Northeast Temperate Network (NETN) considers the occupational health and safety of its employees, cooperators, and volunteers to be of utmost importance, and is committed to ensuring that all seasonal crews receive adequate training on National Park Service (NPS) safety procedures, incident reporting, and emergency response prior to field work. This SOP and supporting appendices were designed to provide a summary of safety issues that should be covered during the pre-season training, and to serve as a first reference in case of an incident. Topics covered include emergency procedures and contacts, incident reporting, field preparation, safe field procedures, vehicle safety, and workers compensation procedures. This SOP does not cover first aid.

Responding to an Incident

Life-Threatening Medical Emergency

1. **Call 9-1-1 or park/refuge emergency number. If available, use an NPS or FWS radio to contact dispatch (Table 33).**

Table 33. Emergency contacts and procedures for each site.

Site	Contact	Phone	Radio	Notes
ACAD	Dispatch	(207) 288-8791	“Dispatch”	When in the park, Dispatch is able to coordinate emergency responses (i.e. Search and Rescue, Ambulance, Police, etc.) faster than by dialing 911. Calling Dispatch by radio is the most reliable means, as cell coverage is poor throughout most of the park.
BOHA	DCR HQ	781-740-1605 x201	“NPS1”	Researchers with non-911 emergency needs can call either DCR (island-owners) headquarters or NPS1 or NPS Stewardship Manager (currently Marc Albert 978-

				360-0421)
MCI-METISL	Brian Benedict, Deputy Refuge Manager	207-557-7812	Channel 16 for emergencies or distress	Work cell phone. If refuge staff cannot be reached in the event of an island emergency, call the U.S. Coast Guard. Emergency: 207-244-5121, Non-emergency: 207-244-5517.
MCI-PETMAN	Jim Fortier (small craft operator)	207-460-1102		Work cell phone. If refuge staff cannot be reached in the event of an island emergency, call the U.S. Coast Guard. Emergency: 207-244-5121, Non-emergency: 207-244-5517.

2. As soon as it is practical to do so, inform your supervisor and the park's emergency contact.

3. Complete Worker's Compensation paperwork (procedures are detailed in the current NETN Forest Health protocol Safety SOP, available at http://science.nature.nps.gov/im/units/NETN/monitor/monitor.cfm).

Non-Emergency Incidents

1. Contact supervisor immediately after incident.

2. Complete Worker's Compensation paperwork (must be done within 48 hours of incident; procedures are detailed in the current NETN Forest Health protocol Safety SOP, available at http://science.nature.nps.gov/im/units/NETN/monitor/monitor.cfm).

NOTE: Never discard original paperwork related to workers compensation claims (including information from doctor's visits, CA-1, CA-2, CA-16 or CA-17 forms).

Field Preparation

All staff are responsible for maintaining a safe work environment for themselves and their coworkers.

First Aid Kits

Every project vehicle should have a first aid kit that is to remain with the vehicle at all times. In addition to the vehicle first aid kit, a backpacking first aid kit should be with the crew at all times while in the field. An inventory of first aid kits should be performed prior to each field season to ensure that all medical supplies are in sufficient quantity and haven't expired. Each first aid kit will have an inventory list of the supplies it should contain. Items in first aid kits that are used should be promptly replaced.

Daily Communication and Planning

Staff are expected to carry a charged cell phone or radio at all times while in the field. These items should be stored in a waterproof container (e.g. Ziploc bag). Staff must plan their sample locations before going into the field. A trip plan must be filed with a supervisor or other responsible party. At a minimum, the plan must contain:

- Date and purpose of trip,

- Name of all people on trip,

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- Destination and route,
- Time of departure and estimated time of return,
- Radio frequency or cell phone number, and
- Type of watercraft, if applicable.

If the plan changes while in the field, staff must notify the individual they left their trip plan with immediately. At the end of the day, staff must notify the person with their trip plan that they have returned from the field.

Personal Gear

Each person is responsible for ensuring he/she is wearing field appropriate clothing and footwear such as long pants, a hat and boots. Dress in layers as the temperature and wind can change dramatically. For example, warm clothing may be needed during sunrise hikes to ACAD sites or during boat rides to the BOHA and MCI sites. However, once at the site, the weather may be very different. Most people are okay wearing the shoes or boots they intend to wear in the intertidal all day. Knee-high rubber boots are good for sampling and stepping in pools. Depending on the weather, rain gear or warm clothing should be taken into the field and it is recommended that an extra set of clothing be kept in the vehicle. Staff should take care to avoid over exposure to the sun by wearing sunscreen and/or protective clothing. Everyone should always carry ample water (2-3 liters) and food when working in the field. Dehydration is a serious condition that can lead to more serious conditions if untreated, and should be avoided. It is important to drink liquid frequently to maintain hydration on a warm day, even if you don't feel thirsty.

Field Safety

Slip, Trip, Fall Prevention

Uneven terrain, slippery rocks, dense brush, and fatigue are all hazards that could result in a slip, trip, or fall. The rocks and seaweeds in the rocky intertidal zone are particularly slippery, and are the most common source of injury in the intertidal zone. The following guidelines should be obeyed by crew members to avoid injury from slips, trips, or falls:

- Always wear appropriate footwear such as sturdy hiking boots
- Pay attention to where you are going, and remain alert of potential hazards
- When in the intertidal zone, always keep at least one hand free, and always test your footing before putting your full weight down.
- Walk at an appropriate pace and adjust pace for changes in terrain (e.g., slow down and take smaller steps on slippery surfaces)
- When hiking long distances, take breaks to avoid fatigue

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- When navigating to a location off trail, choose the safest route (this may not be the shortest route). Avoid river crossings, excessively steep terrain and sudden drop-offs. Always be careful when navigating over piles of scree, and alert others of falling rocks.

Proper use of Backpacks

Staff will be expected to carry ≥35 pound packs over uneven terrain on a daily basis, and it is important for crew members to understand appropriate ways to pack, lift and carry a heavy backpack to avoid serious back, neck and shoulder injuries. Follow these guidelines:

- Use a sturdy field pack with padded and adjustable hip and shoulder straps.
- Pack heavy items in the center of the pack and close to your back.
- Make sure weight is evenly distributed from side to side.
- Once equipment is packed, tighten the compression straps to minimize movement inside the pack during travel.
- When picking up a heavy pack, use your legs to do the lifting, and use slow, smooth movements. Keep your back straight, and keep the pack close to your body. Do not twist or bend at the waist, and do not swing the pack quickly over one shoulder.
- Always carry a pack with both shoulder straps and with the hip belt and chest straps secured.
- The pack should be positioned near the center of the back, and most of the weight should rest on your hips.
- Keep your pack organized, and only carry the necessary equipment, food and water to reduce weight.

Waves and Tides

Waves are a significant threat in the intertidal zone, even on relatively calm days. Large waves tend to arrive in sets, or groups, but rogue waves can also occur. Always be aware of the ocean, and work facing the sea whenever possible. Be constantly vigilant of the tide level, and make sure that you can always safely retreat to higher ground on short notice.

Wading

The band transects require wading. Even on hot summer days, the ocean water is extremely cold, and hypothermia is a real possibility. Wear synthetic (non-cotton) clothing, and make sure that a partner is nearby when you are wading. Plan ahead by bringing a towel or dry clothes if you will be sampling tide pools.

Kneeling

Much of the rocky intertidal sampling will be done while kneeling. Rubber knee pads should be worn while sampling, and staff should stretch regularly.

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Weather

Weather conditions in the eastern U.S. can be hazardous and can change quickly. Staff are responsible for planning their day according to the local weather forecast and for being aware of their surroundings and changing conditions.

Thunderstorms

Storms that produce strong winds and lightning are dangerous and should be avoided in the field. If caught in a lightning storm, seek shelter in a building or car as soon as possible. If no shelter is available, spread out and move to an open space. Squat low to the ground on the balls of your feet with your hands on your knees (do NOT lie flat on the ground). Avoid high elevations, conductive materials, and tall structures such as trees or telephone poles. If you are in the open and feel your hair stand on end (indicating lightning is about to strike), immediately make yourself the smallest target possible and minimize contact with the ground.

NOTE: A person struck by lightning can often be revived by prompt administration of CPR and oxygen.

Excessive Heat and Sun

Over exposure to heat and sun can cause dehydration, heat exhaustion, or heat stroke. All are serious conditions that can be life threatening, and should be avoided. When working in hot weather, be sure to drink plenty of water and eat foods that can replace electrolytes. Wear loose and light colored clothing, including a hat to block the sun's rays. It may help to shift the field schedule to avoid working outside during the hottest part of the day.

WARNING: Signs of heat stroke include hot, red or spotted (usually dry) skin, and the sufferer may be mentally confused, delirious, having convulsions, or unconscious. If heat stroke is suspected, seek immediate medical attention!

Poor Air Quality

Summer ozone and particulate matter levels occasionally exceed federal health standards. Young children, seniors, and those suffering from asthma, chronic bronchitis, chronic obstructive pulmonary disease or heart problems are especially sensitive to poor air quality and should minimize outdoor activity when poor air quality warnings are posted. The risks of occasional exposure to ozone and fine particulate matter are minimal for healthy individuals.

When poor air quality warnings occur, it is advisable to avoid overly strenuous activity during the hottest part of the day (pollution levels tend to be lowest early in the morning).

To check local air quality forecasts, or learn more about health risks of air pollution, visit the AIRNow intergovernmental agency website: http://www.airnow.gov/.

Boats

Boats are required to access sites at BOHA and MCI, and boats will be piloted by a licensed captain. Follow all instructions from the captain to ensure your safety.

Deer ticks and Lyme Disease

Several species of ticks are commonly encountered in eastern U.S. parks while working in the field. This includes the deer tick (*Ixodes scapularis*), which is a known vector of Lyme disease and Ehrlichiosis. Lyme disease is not common in Maine or the Boston area, but staff should consider the following precautions:

- Clothes treated with permethrin have been found to be fairly effective tick repellant. Carefully follow the application instructions on the spray bottles to ensure your safety. The repellent will remain active for several weeks and through several washings.

- Tuck pants in socks and tuck in shirts. Wearing long sleeves and gaiters has been found to help.

- Check clothes and skin for ticks at the end of every field day. Ticks typically need to be embedded for at least 24 hours for disease transmission to occur; therefore, the earlier ticks are found and removed, the lower your chances are of acquiring a tick-borne illness.

- If you find a tick that is already embedded, use fine-tipped tweezers to firmly grasp the tick close to your skin. Slowly and steadily pull the tick's body away from your skin. Be careful not to crush the tick's body to minimize the chances of it regurgitating fluids into the wound. Clean the bite area once the tick is removed with soap and water.

- If you start to notice symptoms of Lyme disease, file a workers compensation report as soon as possible.

- Keep an eye out for any early symptoms of tick borne diseases. Symptoms may include a bull's eye rash around the tick bite (doesn't always occur), tingling or numbness in extremities, a spotted rash on extremities, bad headaches, high fever, joint aches, stiff neck, fatigue, or swollen glands. If you develop a combination of these symptoms soon after a tick bite, seek medical attention.

Poisonous Plants and Animals

Both for safety and protection of park resources, it is never advisable for staff to eat wild plants while working in a National Park or National Wildlife Refuge, regardless of their confidence in plant identification. Keep a safe distance from wildlife and never handle potentially dangerous wildlife.

Poison Ivy

Poison ivy (*Toxicodendron* spp.) is present at ACAD and BOHA, and can be very abundant in localized areas. When working in areas with poison ivy, it is advisable to take precautions to avoid skin contact with any part of the poison ivy plant.

Poisonous Snakes

The only poisonous snake that could be found in the project area is the timber rattlesnake (*Crotalus horridus*), which is listed as "critically imperiled" in Massachusetts. The best course of action is to avoid all snakes by keeping them at a safe distance. When in poisonous snake

country, pay attention to where you put your hands and feet, and be aware around rock piles and bedrock outcrops. Should you receive a snake bite from a potentially poisonous snake, wash the bite area and dress the wound. Immobilize the bite area with a splint, and immediately seek medical attention. Of these snakes, the rattlesnake is the most likely to have a life-threatening bite. If bitten by a venomous snake, immediately move to a safe location and use a venom extractor (must be used within the first couple of minutes to be effective). Remain calm, and if emergency services cannot reach you, walk slowly to a place where you can be picked up. Note that many snake bites are purely defensive, and contain no venom. Bites from immature snakes are much more likely to contain a more dangerous amount of venom than bites from adult snakes.

Vehicle Safety

Responsibilities of Vehicle Operators

Staff are responsible for inspecting their vehicles before every use to ensure the vehicles are in safe working condition. This includes visually checking tire pressure, adjusting mirrors, and making sure equipment is secure. Crew members must perform preventative maintenance in a timely manner (e.g., having oil changed by a qualified mechanic), and report any potential hazards or needed repairs to their supervisor.

Rules that must be followed when operating a federal vehicle:

- Everyone in a government vehicle is required to wear a seat belt.
- Texting or any other cell phone use is strictly prohibited while driving.
- Only federal employees or authorized cooperators and contractors are allowed to operate a government vehicle.
- Passengers who are not federal employees or authorized cooperators and contractors are forbidden from riding in a government vehicle.
- Drivers must adhere to all federal and state vehicle regulations, including all posted speed limits.

Procedures for reporting a motor vehicle accident

1. Seek medical attention if needed.
2. Follow the Northeast Region accident/incident reporting guidelines listed in the current NETN Forest Health protocol Safety SOP, available at http://science.nature.nps.gov/im/units/NETN/monitor/monitor.cfm. A copy of these guidelines and the corresponding forms (SF 91 and SF94) should be located in the glove compartment of every federal vehicle at all times.

Contact Information

Northeast Temperate Network:

Brian Mitchell, NETN Program Manager

54 Elm Street, Woodstock, VT 05091

(802) 457-3368 x37

brian_mitchell@nps.gov

Literature Cited

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SOP 2 – Plot Establishment

Version 1.01 (May 4, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	1/16/2009	J. Long	---	Original	1.00
1.00	5/4/2010	B. Mitchell and J. Long	Added Appendix 1 and 2, moved plot maintenance info to the plot maintenance SOP, added tidbit info, minor edits	Protocol revision	1.01

This Standard Operating Procedure (SOP) provides information regarding establishing new intertidal monitoring plots or transects and maintaining plots. The Rocky Intertidal Monitoring Protocol at ACAD, BOHA, and MCI is designed using a fixed-plot approach, meaning that repeated measurements are taken from the same locations through time. Fixed plots are permanent areas of rocky intertidal habitat defined by bolt markers. Fixed plots may be variable in size and shape, including rectangular, irregular, or transect lines. Monitoring methods for specific plot types are discussed in separate SOPs.

Appendix 1 provides the reference bolt locations and plot locations relative to reference bolts for existing plots; if new plots are added in the future, their locations will be added to the appendix.

Establishing New Plots

Fixed Photoplots

Fixed plots or transects are typically established during initial site set-up. However, they may be added at an existing site (e.g. a historic plot is lost or the substrate is destroyed). Each plot chosen for monitoring should have a high coverage (>50% cover) of the target species (barnacles, mussels, *Ascophyllum*, *Fucus* or red algae) and needs to be relatively flat, though not necessarily horizontal. Photos of photoplots will be easier to score in the laboratory if the entire plot falls into a narrow field of focus with no heavy shadows from rock cracks or boulders. Additionally, estimates of organism densities will be more accurate from flat plots. Reflections on pools may obscure what is below. The frame of the quadrapod should be able to rest on the plot. For photoplots, five plots that are representative of each target species are established. To select these plots, ten 50x75 cm quadrats are haphazardly placed in each target species zone. These 10 quadrats are placed at least 50 cm apart to facilitate plot relocation using a single reference bolt. From these 10 quadrats, 5 are randomly selected as the final locations for the fixed photoplots.

1. Locate plot positions following the above guidelines.

2. Scrape the substrate in an area of about 5 cm x 5 cm below each quadrat corner using scrapers and wire brushes. Additionally, scrape another 5 cm x 5 cm area approximately 10 cm from the expected location of the upper left bolt. This area will be for the plot label. The standard convention for choosing the upper left is to view the plot with one's back to the ocean.

3. Plots are marked with stainless steel bolts (3" length, 1/4" diameter) in each corner. Holes must be at least 2" deep. After drilling holes (5/16" diameter), insert blue polyethylene anchors (1 3/8" length) with a hammer so that the anchor is flush with the substrate. Using an impact driver, insert bolts 2" into hole so that the bolt sticks up from the substrate 1".

4. The plot label is installed by drilling a 2" hole (5/16" diameter) and inserting a blue polyethylene anchor (1 3/8" length) with a hammer. Plot labels consist of a 1 1/2" stainless steel washer with the identification label stamped into the washer. The identification label consists of a letter and a number. The letter identifies the plot type (A=Ascophyllum photoplot, F=Fucus photoplot, B=Barnacle photoplot, M=Mussel photoplot, R=Red algae photoplot, X=Band transect, T=Point-intercept transect, S=Barnacle settlement) and the number indicates the replicate number. Identification labels should be stamped prior to deployment. The washer is placed over the anchor and a 1" stainless steel bolt is passed through the washer and drilled into the anchor.

Band Transects (Sea Star and Sea Urchin Monitoring)

1. Locate all of the tidepools with the following criteria: 1) pools with at least one linear dimension greater than or equal to 10 m and 2) pools with kelp (Laminaria saccharina) growing in them. Unfortunately, many pools have a maximum linear dimension less than 10 m. In these cases, select the pools with the longest linear dimension. In ACAD, all low pools contained kelp. In BOHA, kelp was absent from many pools. If kelp is absent, select pools below the top of the Fucus zone.

2. Lay a transect line across the pool so that the endpoints are outside of the pool and are 10 m apart. The final transect will be monitored by recording organisms falling within one horizontal meter of the transect line. Thus, position the transect line with the following two criteria: 1) close to walls within pools that are preferred habitats for echinoderms and 2) to maximize the amount of pool area sampled with this band transect. A total of 3 pools must be selected. If more than 3 potential pools are present at a site, then the pools should be randomly selected.

3. Scrape the substrate for an area of about 10 cm x 10 cm below each transect endpoint using scrapers and wire brushes.

4. Mark the endpoints of the band transect with stainless steel bolts (3" length, 1/4" diameter). Holes must be at least 2" deep. After drilling holes (5/16" diameter), insert blue polyethylene anchors (1 3/8" length) with a hammer so that anchor is flush with the substrate. Using an impact driver, insert bolts 2" into hole so that bolt sticks up from the substrate 1".

5. The transect label is installed by drilling 2" holes (5/16" diameter) adjacent (5 cm) to both endpoint bolts and inserting a blue polyethylene anchor (1 3/8" length) with a hammer. Plot

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labels consist of a 1 1/2" stainless steel washer with the identification label stamped into the washer. The identification label consists of two letters and a number. The first letter identifies the plot type (X=Band transect), the second letter indicates whether the endpoint is the northern or southern (N or S) end of the transect, and the number indicates the replicate number. The washer is placed over the anchor and a 1" stainless steel bolt is passed through the washer and drilled into the anchor.

Point-Intercept (Vertical) Transects

1. Locate a wide swath of bedrock, approximately 6 m in width, that extends from the high intertidal above the barnacle zone to the low intertidal (red algae zone). Flat swaths are preferred because detecting elevational range shifts in the distribution of species, a goal of this protocol, will be easier on flatter transects.

2. Lay out an along-shore transect along the high intertidal. This transect should be at least one meter higher, vertically, than the upper edge of the barnacle zone. Divide this transect into whole meters (e.g. If the swath is 6 m, divide the transect into 0, 1, 2, 3, 4, 5, and 6). Randomly select three of these numbers. These three numbers will be the positions of the top bolts of the point-intercept transects.

3. Scrape the substrate for an area of about 10 cm x 10 cm below each of these locations of the top bolts.

4. Mark the top of each transect with stainless steel bolts (3" length, ¼" diameter). Holes must be at least 2" deep. After drilling holes (5/16" diameter), insert blue polyethylene anchors (1 3/8" length) with a hammer so that anchor is flush with the substrate. Using an impact driver, insert bolts 2" into hole so that bolt sticks up from the substrate 1".

5. Attach a transect line to each of the three top bolts. Extend the transect line vertically (down to the low intertidal) following the flat swath of substrate. Note: the priority here is to follow the swath rather than following the shortest possible distance from high to low intertidal. The bottom of the transect lines should be in an area that will be accessible during most low tides. Typically, this is approximately 1 m (vertical) below the upper edge of the red algae zone. With another transect line, extend the transect along-shore along this low intertidal zone. Line up the transect lines so they are spaced as they are at the upper bolts.

6. Place a single mid-bolt along each transect line (following the procedures of steps 3-4). This bolt will allow for the upper portion of the transect lines to be scored prior to low tide. Thus, they should be approximately in the middle of the transect with respect to the vertical dimension (note that this will not necessarily mean that they are in the middle of the horizontal dimension of the transects).

7. Place a single low bolt at the bottom of each of the three high-low transect lines (following the procedures of steps 3-4).

8. Place an identification label 5 cm from each high, mid, and low bolt of each transect line. This will help locate the permanent transects on subsequent trips. Each label is installed by drilling a 2" hole (5/16" diameter) and inserting a blue polyethylene anchor (1 3/8" length) with a hammer. Labels consist of a 1 ½" stainless steel washer with the identification label

stamped into the washer. The identification label consists of a letter and a number. The letter identifies the plot type (in this case, T=Point-intercept transect) and the number indicates the replicate number (1-3). The washer is placed over the anchor and a 1" stainless steel bolt is passed through the washer and screwed into the anchor.

Barnacle Settlement Plots

1. Barnacle settlement plots should be installed at locations within the barnacle zone with the highest density of adult barnacles for that site. Typically, this will be roughly in the middle of the barnacle zone. Potential sites need to be relatively flat, though not necessarily horizontal. Photos will be easier to score in the laboratory if the entire plot falls into a narrow field of focus with no heavy shadows from rock cracks or boulders. Reflections on pools may obscure what is below. There should be no obstruction between the plot and approximately 0.5 m perpendicular to the plot to allow adequate distance for photography. To select settlement plots, ten 20x20 cm frames are haphazardly placed in each target species zone. These 10 frames are placed at least 50 cm apart to facilitate plot relocation using a single reference bolt. From these 10 frames, 5 are randomly selected as the final location for the fixed barnacle settlement plots.

2. Scrape the entire substrate underneath each randomly selected frame using scrapers and wire brushes. Additionally, scrape the width of a scraper blade about 7 cm) around the outside edge of each frame. It is critical to remove all macro-organisms from the scraped area for the following reasons. First, barnacles not removed during scraping may be incorrectly counted as new recruits during subsequent surveys. Second, other organisms may influence barnacle recruitment. To check scraping effectiveness, brush off all of the scraped material from the substrate and examine for missed barnacles and other organisms.

3. After this area has been scraped, place the 20x20 cm frame in the center of the plot. Plots are marked with stainless steel bolts (3" length, 1/4" diameter) in the upper left and lower right corners of this frame. The standard convention for choosing the upper left is to view the plot with one's back to the ocean. Holes must be at least 2" deep. After drilling holes (5/16" diameter), insert blue polyethylene anchors (1 3/8" length) with a hammer so that anchor is flush with the substrate. Using an impact driver, insert bolts 2" into hole so that bolt sticks up from the substrate 1".

4. Install a plot label exterior to the upper left bolt. The plot label is installed by drilling a 2" hole (5/16" diameter) and inserting a blue polyethylene anchor (1 3/8" length) with a hammer. Plot labels consist of a 1 1/2" stainless steel washer with the identification label stamped into the washer. The identification label consists of a letter and a number. The letter identifies the plot type (in this case, S=Barnacle settlement) and the number indicates the replicate number (1-5). The washer is placed over the anchor and a 1" stainless steel bolt is passed through the washer and screwed into the anchor.

5. Remove the frame.

Tidbits

1. Prior to entering the field, prepare the tidbit shelters (Figure 15). The LEDs on each tidbit are susceptible to breakage. Thus, the tidbits must be protected (e.g. from rocks, ice, trampling)

in order to prevent data loss. Each tidbit is covered with a protective PVC shelter. Shelters consist of a 10 cm length of 2” Schedule 40 (white) PVC that has been cut in half lengthwise (thus, each 10 cm length of pvc produces two shelters). Two 5/16” holes are placed through each shelter approximately 7 cm apart on the top of the shelter (centered along length of shelter). Bolts will pass through these holes and anchor the shelter to the substrate.

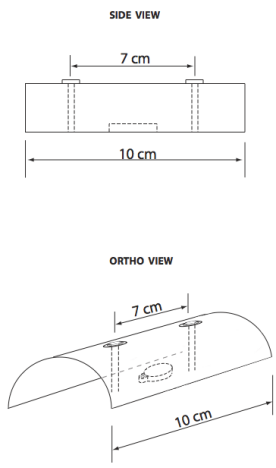

Figure 15. Protective PVC shelter for tidbit temperature loggers showing bolt placement.

2. The three tidbits are placed in the red algae zone. Tidbits are placed 10-15 m apart. At each location, scrape the substrate clean for an area of about 15 x 15 cm.

3. Place shelter in center of scraped area and drill through the shelters and into the substrate at least 2” deep. After drilling holes (5/16” diameter), insert blue polyethylene anchors (1 3/8” length) with a hammer so that the anchor is flush with the substrate.

4. Remove shelter. Drill a 2” hole (3/16” diameter) in line with the two 5/16” holes. This smaller hole should be between the two larger holes and approximately 1 cm from one of the larger holes. After drilling this small hole, insert a blue polyethylene anchor (#6 x 7/8”) with a hammer so that anchor is flush with the substrate.

5. Attach tidbit with a stainless steel screw (6 x 1 ½” Phillips head pan). Record the identification number on the side of the tidbit and the replicate (either TEMP1, TEMP2, or TEMP3). The identification number will be downloaded with the data later. This provides a simple way to manage tidbit data.

6. The plot label is installed by drilling a 2” hole (5/16” diameter) and inserting a blue polyethylene anchor (1 3/8” length) with a hammer. Plot labels consist of a 1 ½” stainless steel washer with the identification label stamped into the washer. Unlike other plot types, tidbit labels are only marked with a number because the proximity to shelters makes their

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identity obvious. The washer is placed over the anchor and a 1" stainless steel bolt is passed through the washer and drilled into the anchor.

7. Attach tidbit shelter with two 1/4" stainless steel hex bolts (lag screws). Place a single stainless steel washer (1" OD) between each of the bolts and the shelter.

Recording plot location

1. After a plot is installed, document its location with respect to a reference bolt. A reference bolt is placed in a prominent location, preferably on a substrate with no macro-organisms covering it or with low lying organisms (i.e. not seaweed). The reference bolt is a stainless steel bolt (3" length, 1/4" diameter). The hole must be at least 2" deep. After drilling the hole (5/16" diameter), insert a blue polyethylene anchor (1 3/8" length) with a hammer so that anchor is flush with the substrate. Using an impact driver, insert bolt 2" into hole so that bolt sticks up from the substrate 1".

2. Install a reference bolt for each plot type unless multiple plot types are in close enough proximity that a single reference bolt would suffice.

3. Record the GPS coordinates of each reference bolt. Be sure to record coordinates in UTM with NAD83 as the reference datum.

4. Record the distance in meters from the reference bolt to the identification label of each replicate with a transect line. A single person can do this by hooking the starting edge of the tape around the reference bolt. Before recording this distance, be sure that the line is taught. The measurement is the distance from the reference bolt to the actual label (this typically won't be a perfectly horizontal line).

5. While the distance is being measured, record the compass heading from the reference bolt to the identification label.

6. After all distances and headings have been recorded, place an orange cone over the reference bolt. Place quadrat frames over photoplots and place transect tapes over band transects and point-intercept transects. Take multiple photographs of each plot/transect to clarify locations and orientations at future sampling events.

7. Compile this information (GPS coordinates of reference bolt, distance and heading from the reference bolt to each identification label [Appendix 1], and plot photographs). Place these sheets in clear, plastic envelopes and put these in a single notebook for each site that can be brought into the field during future sampling events to assist with plot relocation.

Appendix 1 contains overview maps of all the sites, including recommended anchorages at the BOHA sites and parking locations at ACAD. Appendix 1 also contains directions to ACAD sites from park headquarters (McFarland Hill).

Slope, Aspect, and Elevation

This section summarizes the procedures for measuring the slope, aspect, and elevation of the photoquadrats and barnacle settlement plots, and the elevation of the tidbit temperature loggers. All three variables are important drivers of community structure. It will be useful to correlate

long-term changes with these abiotic properties of the plots. Initial measurements were completed at most of the ACAD sites in 2008 (Appendix 1). Initial measurements are needed for remaining plots at ACAD and all plots at BOHA and MCI. After this, however, the only variable that will need to be tracked is the current sea level because slope and elevation should not change and elevation can be transformed between times of known sea levels.

Procedure for Measuring Plot Slope

1. For each fixed photoquadrat and barnacle settlement plot, determine the dominant slope of the plot visually. Note that the center of the plot may not be representative of the dominant slope.

2. Place an inclinometer (available at Home Depot) along this slope, from high point to low point, to determine the angle of inclination (or slope). A perfectly flat plot has a slope of 0o. A perfectly vertical plot has a slope of 90o. A plot may have a slope greater than 90o if the plot is under an overhang. Record the slope to the nearest five degrees. Be careful because some inclinometers do not go past 90o but some of the plots are on overhangs and have slopes > 90o (e.g. some of the BOHA barnacle photoplots and settlement plots). Also, the predominant slope need not be parallel to the sides of the plot.

Appendix 1 (Table 28) contains plot slopes calculated according to this method. As more slopes are measured, they will be added to the appendix.

Procedure for Measuring Plot Aspect

1. The aspect is the direction in which the plot faces (360o along a plane parallel to earth's surface).

2. For each fixed photoquadrat and barnacle settlement plot, determine the dominant slope of the plot visually. Note that the center of the plot may not be representative of the dominant slope.

3. Draw an imaginary line from the top of the slope to the bottom of this slope. Place a compass so that it is perpendicular to this line.

4. Keeping the compass pointed in the same direction, lower the compass so that it is level.

5. Record the compass heading to the nearest five degrees. This is the aspect.

Appendix 1 (Table 28) contains plot aspects calculated according to this method. As more aspects are measured, they will be added to the appendix.

Procedure for Measuring Plot Elevation

NOTE: An alternative and more accurate approach to measuring elevation of plots is through the use of an RTK GPS unit. This equipment is expensive and requires significant training, but equipment and staff time may be available in the next few years to allow surveying of the existing rocky intertidal plots.

1. Tidal elevation is determined using still water measurements and is referenced as distance above or below the mean low water mark. Using surveying equipment that can be purchased

at Home Depot (including a tripod, a leveled scope, and a large measuring stick), tidal elevation can be calculated.

2. Set up the tripod so that the top of the tripod is higher than all plots.

3. Level the scope on top of tripod (see instructions). If the tripod is moved for any reason after leveling (e.g. tripod is bumped or tripod is moved between plot types), repeat steps 2-5. This is because the tripod may no longer be level or at the same elevation it was originally.

4. Determine the elevation from the still sea level (the waterline, or "Y" on Figure 16) to the scope by placing measuring stick at the water line and reading the height through the scope. IMPORTANT: RECORD THE TIME, DATE, AND LOCATION OF THIS MEASUREMENT AS ALL HEIGHT CALCULATIONS WILL RELY ON THESE DATA.

5. Determine the elevation from the plot to the scope ("X" on Figure 16) by placing measuring stick on the center of the plot and reading the height through the scope.

6. Repeat for all plots within a site.

7. Determine the tidal height above mean low water for each waterline measurement ("Z" on Figure 16, may be only one per site). To determine tidal height, use the date, time, and location to locate the measured tidal height at NOAA's Tides and Currents (http://tidesandcurrents.noaa.gov). For ACAD sites, select Maine>Mount Desert Island>Southwest Harbor (Station ID: 8413320). For BOHA sites, select Massachusetts>Boston Harbor>Boston Light (Station ID: 8444162). For PETMAN (MCI), select Maine>Cobscook Bay>Green Island, Petit Manan Bar (Station ID: 8412568). For METISL (MCI), select Maine>Eggemoggin Reach>Matinicus Harbor, Wheaton Island (Station ID: 8414876).

8. Plot elevation is calculated with the formula Y+Z-X where; Y = the waterline height measured in the field, Z = the sea level elevation above mean low water that was calculated from the tide charts in step 1, and X is the plot height measured in the field.

Appendix 1 (Table 27) contains plot elevations calculated according to this method. As more elevations are measured, they will be added to the appendix.

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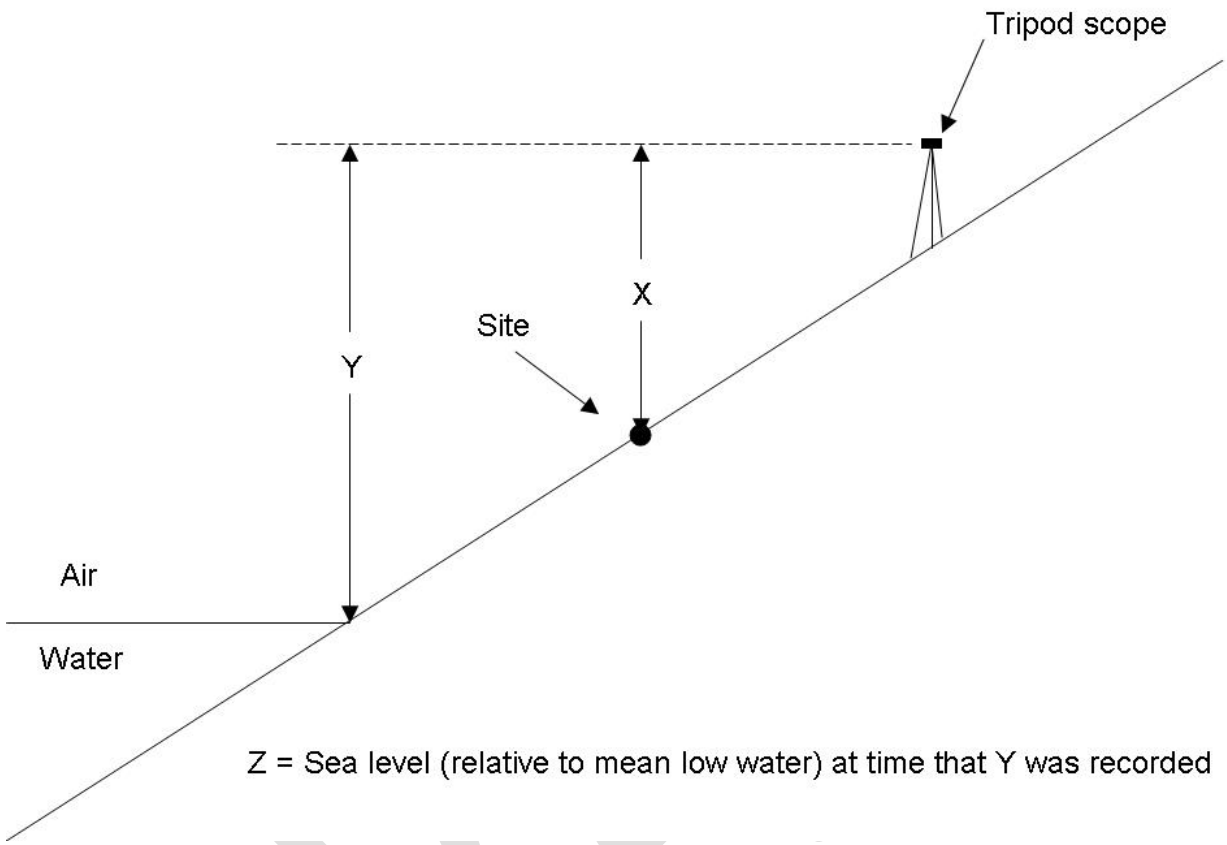

Figure 16. Diagram showing the measurements needed to determine plot elevation.

SOP 3 – Pre-season Preparations

Version 1.01 (May 1, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	1/16/2009	J. Long	---	Original	1.00
1.00	5/1/2010	A. Kozlowski, B. Mitchell, and J. Long	Reorganized and edited to provide additional detail. Some info moved to other SOPs.	Protocol update	1.01

This Standard Operating Procedure (SOP) describes planning and preparing for sampling trips to rocky intertidal monitoring sites at ACAD, BOHA, and MCI. Because of the intense field sampling procedures, scheduling and logistical preparation should be arranged three to six months prior to the sampling season. Here, we provide details on factors affecting scheduling, as well as information on housing, transportation, and equipment required to conduct the sampling.

Scheduling Considerations

Timing

Sampling of rocky intertidal sites is conducted annually between June and August. Low tide series with a duration of one week and tidal heights of ≤ 0.5 feet above Mean Low Water are required to insure reasonable access to all of the fixed plots and tidepools. Days with the lowest negative tides during daylight hours should be given priority. Tide predictions for each sampling site can be found at NOAA's Tides and Currents website http://tidesandcurrents.noaa.gov/tide_predictions.shtml (Table 34).

Table 34. NOAA tide stations most closely associated with NETN Rocky Intertidal Monitoring sampling sites.

Sampling Site(s)	NOAA Station ID	Station Path (website)
ACAD – all	8413320	Maine>Mount Desert Island>Southwest Harbor
BOHA – all	8444162	Massachusetts>Boston Harbor>Boston Light
MCI – PETMAN	8412568	Maine>Cobscook Bay>Green Island, Petit Manan Bar
MCI – METISL	8414876	Maine>Eggemoggin Reach>Matinicus Harbor, Wheaton Island

Sampling days are extremely busy and require adequate preparation and properly trained personnel to completely sample a site in a single day. Typically, 4 days are required to complete the 4 ACAD sites, 3 days for the 3 BOHA sites, and 2 days for the 2 MCI sites. Occasionally, two low tides may occur during daylight hours. On these days, if the team is extremely efficient, it may be possible to sample more than one site in a day. Alternatively, it may be necessary to use both low tides to completely sample a single site, especially during days when low tides occur near dawn or dusk. Additionally, sampling trips to MCI sites are dependent upon MCI boat schedules and may require overnight stays on islands even if sampling can be completed in less than a day.

Sampling occurs during daylight hours for safety and sampling efficiency reasons.

Sampling will start 3.5 to 4 hours before low tide (assuming sufficient daylight; closer to low tide in the event of large swell) and continue until the tide covers all plots or sampling is completed. Sampling may begin closer to the low tide if there are several volunteer assistants available to help.

If sampling of a site is cancelled for any reason, it should be rescheduled for the next possible low tide series – even if this new series causes the site to be sampled outside the preferred months (June to August).

Weather and Safety

Waves can significantly reduce the accessibility of all of these sites. Additionally, large waves can be dangerous for personnel (see SOP 1 – Safety). Certain sites are more wave-exposed than others (Table 35). Thus, exposure and short-term weather forecasts should be factors in determining the order to sample sites. For example, if the swell is small at the start of a sampling period, the exposed sites should be sampled first in case the swell increases. Alternatively, less-exposed sites should be sampled first if the swell is high at the start of the sampling period. Exposure is similar at both MCI sites.

Table 35. Relative exposure of NETN Rocky Intertidal Sampling sites to weather and wave events.

	ACAD	BOHA
More exposed	Otter Point	Outer Brewster
	Schoodic Point	Green Island
	Ship Harbor	Calf Island
Less exposed	Bass Harbor	

Lodging

There are several lodging options near both ACAD and BOHA. For the ACAD sites on Mount Desert Island, the apartment units at Acadia Park Headquarters are within a 30 minute drive from these sites. For the ACAD sites at Schoodic, the lodging units at the Schoodic Environmental Research Center (SERC) are less than 5 minutes from these sites. Information about SERC can be found at: http://www.acadiapartners.org/. Near BOHA, limited housing is available at Northeastern University's Marine Science Center: http://www.marinescience.neu.edu/.

Limited lodging may be available at MCI and should be coordinated through the refuge managers.

Site Access

Park and refuge headquarters will be contacted prior to sampling events. This contact will alert parks and the refuge about the field sampling and provide an opportunity to coordinate logistics and alert the project's lead scientist about any special circumstances (such as steps needed to reduce interference with nesting birds [BOHA] or to acquire parking passes for research vehicles [ACAD]).

A boat is needed to access the BOHA and MCI sites. Water transportation (boat and captain) for accessing MCI sites will typically be provided by the U.S. Fish and Wildlife Service. Given the

high cost of chartering boats in Boston, we recommend that this project charter boats through UMASS Boston or Northeastern University to access BOHA sites.

The advantages of chartering from UMASS is that their boat is stored in the water (thereby removing time required for launches and recoveries) and the current captain, Russ Bowles, has significant experience working around the Boston Harbor islands. The current rates are $55 per hour. Information about this vessel can be found at: http://www.umb.edu/umb/marineops/landingCraft.html.

The main advantage of the Northeastern vessel is that it probably is cheaper to charter (though rates are currently changing). The 21' SteigerCraft at Northeastern's Marine Science Center has been successfully used to make sampling trips. Given the time required to deploy this vessel, we recommend that it be deployed once per sampling series and kept in the water overnight. The Northeastern vessel should be launched from the ramp at the beginning of the Nahant causeway, adjacent to the Lynn rotary. Although there is a ramp closer to the Marine Science Center, it is more degraded and should not be used at lower tides. Currently, this vessel is captained by a Marine Science Center employee. Overnight slips can be purchased from the Seaport Landing Marine in Lynn for approximately $20 per night. This vessel can accommodate 6 persons. Equipment can be stored in the hold.

Conducting a shore landing on BOHA islands directly from the UMASS or Northeastern boat is unsafe, so a dinghy is required regardless of which boat is chartered. Once the primary boat has been anchored safely offshore near the sampling site, the dinghy is used to row ashore. Although this approach is the safest method to land on these islands, it requires additional time because only two people and some of the gear can fit in the dinghy at once. Therefore, multiple trips are required to shuttle the entire crew and gear from boat to shore. Appendix 1 shows the BOHA sites and the suggested anchorage and landing sites. If needed, the dinghy used during protocol development is available at Northeastern University's Marine Science Center.

Organizing Field Equipment

After sampling trips have been scheduled and any necessary lodging has been arranged, the last step in preparation is to organize the equipment needed to sample a site. Because of limitations relating to personnel, losing a low tide because of broken or missing equipment is unacceptable. Thus, be thorough when preparing the equipment and pack extra items (e.g. batteries, transect tapes, settlement grids, etc.). Especially in ACAD and MCI, the remoteness of sites and irregular hours of samplings (mornings, evenings, weekends, holidays) will make replacement of key items difficult and could delay sampling for many days. When possible, each sampling crew should be outfitted with its own complete set of equipment. This will allow multiple sites to be sampled simultaneously on a single day when multiple sampling crews are available.

Prior to the sampling season:

1. In January, make arrangements with park and refuge staff to ensure that barnacle settlement plots will be scraped between February 1 and March 14 (see SOP 4 – Barnacle Settlement Plot Scraping). Because the weather is usually unpredictable in February, this will likely occur in early March.

2. At least 6 weeks before the first summer sampling event, compile an equipment list and organize the equipment. If needed, create or repair a photostand (photoquadrapod; see Appendix 4). Table 36 is an example checklist of field equipment necessary for sampling rocky intertidal sites. Remember to print maps and datasheets on water proof paper.

3. Check all equipment on the list to make sure it is in good operating condition. Repair or replace damaged/missing items well in advance of sampling (specifications are in Table 37). Check the database to obtain a list of data loggers that will need their batteries replaced and procure these batteries.

4. Read through all sites' previous sampling notes to determine if special equipment or sampling will be needed. If there were damaged or lost plots, then appropriate equipment (e.g. rock hammer drills) and hardware (especially pre-stamped washers) must be transported to the site.

5. Download the tidal schedules for all the monitoring sites and develop a sampling schedule. Contact relevant park and refuge staff to help review the schedule for conflicts and to arrange for housing as necessary. Make arrangements to charter a boat to access BOHA and MCI sites.

6. Organize a training session for all field staff participating in the survey (SOP 5 – Training).

Download tidal height data for all sites

Tidal height information for each site can be obtained from J-tide, a free tide prediction program (http://www.arachnoid.com/JTides/). Site-specific tidal heights are used to filter the tidbit data to only include temperature measurements that were taken when the data loggers were completely submerged.

Process steps for downloading tidal heights from J-Tides:

1. Before downloading any tidal heights first check the latest version of the NETN Rocky Intertidal Monitoring Database to see that tidal data have not already been uploaded for the time period of interest for your location (tbl_Tides).

2. If the most recent tidal data are missing from the database, open the J-Tides program, select the Site Explorer (Site Menu → Site Explorer), and navigate to the J-tide site most closely associated with your plot of interest (Tide Stations → America…).

   a. ACAD – Bar Harbor, Frenchman Bay, Maine

   b. BOHA – Boston, Massachusetts

   c. MCI (PETMAN) – Bar Harbor, Frenchman Bay, Maine

   d. MCI (METISL) – Port Clyde, Maine

3. Once you have selected your site, use the Configuration Dialog (Site Menu → Configure/Data) to set up the export file.

   a. Configuration Tab: Set time zone to "Use site time zone." Set display time to 24 hr. Set daylight time handling to "Compute daylight time." Set display units to "Meters" (Figure 17).

   b. Text Database Tab: Set the start and end time to complement what is missing from the database. Set the Tide/Current interval to 1 hour (Figure 17).

   c. Click 'Create' when finished. A tab delimited .csv file will be created in the location of your choice.

Note that the Tidbit temperature loggers that will be used with tide data automatically correct for daylight savings time provided that the computer that is used to launch the logger is set to automatically adjust for daylight savings.

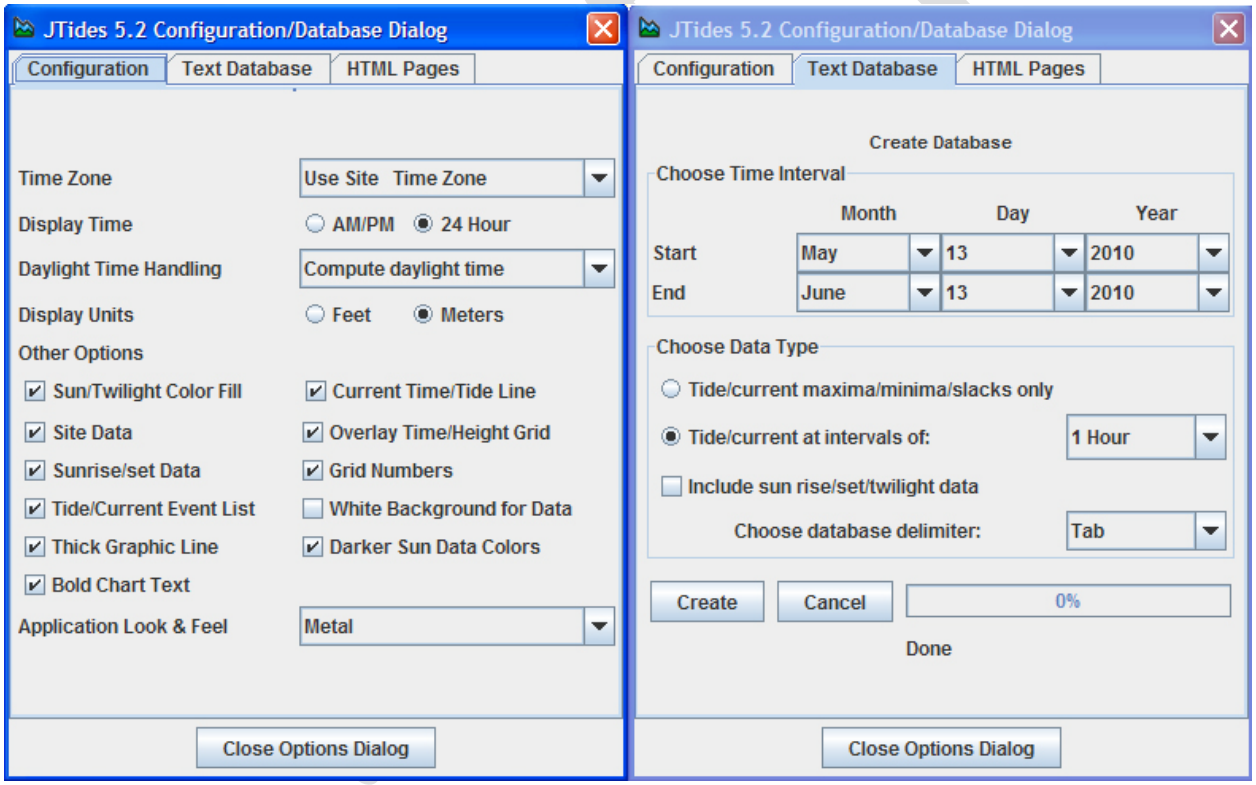

Figure 17. Screen shots of J-Tides configuration dialog settings required when downloading tidal height information.

Process steps for uploading tidal heights fils from J-Tides into the database:
This section will be completed when the database is finished.

Table 36. Rocky intertidal sampling and personal equipment checklists.

Quantity	Item
	Plot repairs and installation
1	Rotary Hammer Drill
1	Gas can for drill
1	Gas for drill
1	Mix oil for drill
Variable	SS lag bolts (3” length, 1/4” diameter). Site installation requires approximately 150/site.
Variable	SS lag bolts (1” length, 1/4” diameter) Site installation requires approximately 60/site.
1	Complete set of pre-stamped stainless steel washers (1.5” OD)
Variable	Blue anchors (1/4” lag screw size). Site installation requires approximately 200/site
Variable	Blue anchors (6-10 screw size). Site installation requires 3/ site.
1	Impact wrench/Nut Driver with 5/16” wrench
1	Spare batteries for impact wrench
1	Paint scraper with wire brush
1	Hammer
Variable	Drill bits (5/16”). Site installation usually requires 5-10/ site.
Variable	Drill bits (3/16”). Site installation usually requires 2/ site.
	Plot location and Overview Photos
6	PVC 50 x 75 cm quadrat
1	Orange cone
1	GPS unit with plot locations in memory
1	Notebook with heading and distances from reference bolts to plots.
1	Photographs of plot overviews
3	Fiberglass transect tape (50 m)
1	Compass
	Photoplot monitoring
1	PVC photoquadrat camera frame (“quadrapod”) with 4 legs and camera mount
1	Nikon Digital Camera with underwater housing, spare batteries, memory card, + moisture muncher
1	Strobe
1	Car shade for shading plots
1/person	Knee pads
	Motile invertebrates and size frequencies
4	Forceps
30	Containers for invertebrates (Yogurt containers or Ziploc baggies)
2	Plastic calipers
3	20 x 20 cm sub-sampling quadrat
	Tidepool band transects
1	1 m long PVC pipe
2	Handheld tally counter
1	Container for holding urchins prior to measurement (e.g. yogurt tub)
3	50 m transect tapes
	Point-intercept transects
4	50 m transect tapes

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Quantity	Item
	Barnacle Settlement
2	Metric ruler for scale in photographs
2	7.5” x 7.5” frame
	Data Collection
4	Clipboard
5	Mechanical pencil
	Datasheets (on RITE IN RAIN PHOTOCOPIER PAPER)
3	Point-intercept transects (Need 3 complete sets per site. Note that lengths vary between sites)
Up to 5	Motile invertebrate (density, size, proportion damaged)
1	Tidepool band transect
Up to 5	Photoplot drawings
1	Photolog
	Personal Equipment
1	First Aid Kit
1/person	Backpack
1/person	Sun protection (sunscreen, sunglasses, hat)
1/person	Shoes or boots (that can get wet and have good traction)
1/person	Multiple layers of clothing (including raingear)
2/person	Filled waterbottle
1/person	Food

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Table 37. Specifications, product number and supplier of special equipment used to sample rocky intertidal monitoring sites.

Item	Company	Product ID	2007/2008 Cost (-shipping)
SD/SDHC Memory Card Reader	B&H	GGI GGGRSDHCU2.0	$14.95
4 GB SDHC Memory Card	B&H	LESDP24GB	$68.95
1400 grey pelican case	B&H	PE1400FS	$60.50
1450 yellow pelican case	B&H	PE1450FY	$78.37
Nikon MH-61 Battery charger	B&H	NIMH61	$24.95
Nikon EN-EL5 Lithium-Ion Battery	B&H	NIENEL5	$65.85
Nikon Coolpix P5100 Digital Camera	B&H	NICPP5100	$339.95
Ikelite Tray with handle	B&H	IK9523.31	$52.95
Ikelite DS-125 package with TTL Sync Cord	B&H	IK3944.75	$859.95
Ikelite TTL Underwater Housing	B&H	IK6182.50	$449.95
SDS Shank Rotary Hammer Drill bit 5/16", 4" drilling depth	McMaster-Carr	8948A14	$6.15
18-8 SS Hex head lag screw, 1/4" diameter, 3" length, pack of 10	McMaster-Carr	92351A554	$7.70
18-8 SS Hex head lag screw 1/4" diameter, 1" length, pack of 50	McMaster-Carr	92351A542	$11.03
Blue polyethylene conical screw anchor, no. 14-16, 1/4" lag screw size, 1-3/8" length, pack of 100	McMaster-Carr	97068A140	$5.81
18-8 SS Large OD Flat Washer 1/4" screw size, 9/32" ID, 1-1/2" OD, .052"-.072" thick, pack of 25	McMaster-Carr	90313A109	$10.34
18-8 SS Pan head phillips sheet metal screw no. 6 size, 1-1/2" length, pack of 100	McMaster-Carr	92470A157	$6.65
Polyethylene conical screw anchor no. 6-10 screw size, 7/8" length, pack of 100	McMaster-Carr	97068A120	$2.61
SDS Shank Rotary Hammer Drill bit 3/16", 2" drilling depth	McMaster-Carr	8948A49	$4.84
Practice Cones Color: Orange, 15	Sator soccer		$11.25
50m Fiberglass tape, Keson open-type fiberglass long tape, metric, pack of 5	Amazon	OTR50M	$224.75
30m Fiberglass tape, Keson open-type fiberglass long tape, metric, pack of 5	Amazon	OTR30M	$124.95
LL Bean White Mountain pack	LL Bean	TC55608	$149.00
Garmin GPS Map 76S Handheald GPS Navigator	Amazon		$199.99
Impact Driver 12 V, Dewalt	Grainger	1EC29	$177.00
Batteries for 12 V Dewalt Impact Drivers	Grainger	4GA68	$59.36
PVC Gloves with lining	Seattle Marine	ATS495	$16.06
Rite in Rain Journaled Stapled Notebook (4 5/8" x 7")	Rite in the Rain	391	$39.00
Hand Stamp set 1/4	Grainger	1F113	$102.24
Electronic calipers	Home Depot	38728014702	$34.96
Dial caliper	Home Depot	38728441454	$24.96
Map source, trip, and waypoint manager software	Garmin	010-10215-04	$29.99
Access, USB to serial cable for GPS	Garmin	010-10310-00	$59.99
Rite in Rain photocopier paper	Forestry Suppliers	49247	$25.95
250GB Buffalo Ministation turboUSB USB 2.0 Portable Hard Drive	B&H	BUHDPS25OU2	$114.95
Forceps	VWR	25601-134	$2.72
HOBO Waterproof shuttle for tidbits	Onset	U-DTW-1	$219.00
Temperature tidbits	Onset	UTBI-001	$116.00

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Item	Company	Product ID	2007/2008 Cost (-shipping)
HOBOware Pro for Windows v2.5.0	Onset	BHW-PC	$99.00
Level Rod 7.6m	Forestry Suppliers	43483	$140.90
Sealife big moisture muncher	Divers Direct	10061316, M101	$5.99
Aquamesh (1.5" mesh, 36" wide, 100' roll)	Friendship Trap Co.		$235.14
Gas Rotary/Hammer Drill w/ Chipper	D&D Metal Detectors	DD118N SDS	$995.00

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Appendix 4. Preparing a Photostand (i.e. Photoquadrapod)

1. Cut 1/2" Sch. 40 white PVC to make the photoquadrapod. The critical dimensions are the bottom quadrat (50 x 75 cm) and the lengths of the legs (long enough so that the entire bottom quadrat can be viewed and fills the field of view when the camera is mounted to the photoquadrapod). Although example dimensions are shown in Figure 1, these will not necessarily work for each individual type of camera. Thus, you should make cuts specific to your particular camera. For example, the lengths of the legs may be longer/shorter for your camera.

2. The bottom frame and the bottom legs should be spray painted black once fully assembled. This serves two functions. First, it reduces glare in photographs. Second, it can provide a check in the field that the quadrapod is properly assembled (e.g., all pvc is inserted properly and the dimensions of the bottom quadrat are 50 x 75 cm).

3. The top frame needs to be modified to hold the camera. The goal is to have the center of the camera in the center of the top frame. Two holes must be drilled into the crossbar PVC of the top frame. These holes should be separated by a distance equal to the two holes in the bottom of the Ikelite camera housing. Upon assembly, the camera and housing will be mounted to the top frame.

4. A small notch (Figure 1) should be cut into the upper left of the top frame. This is where the strobe arm will rest.

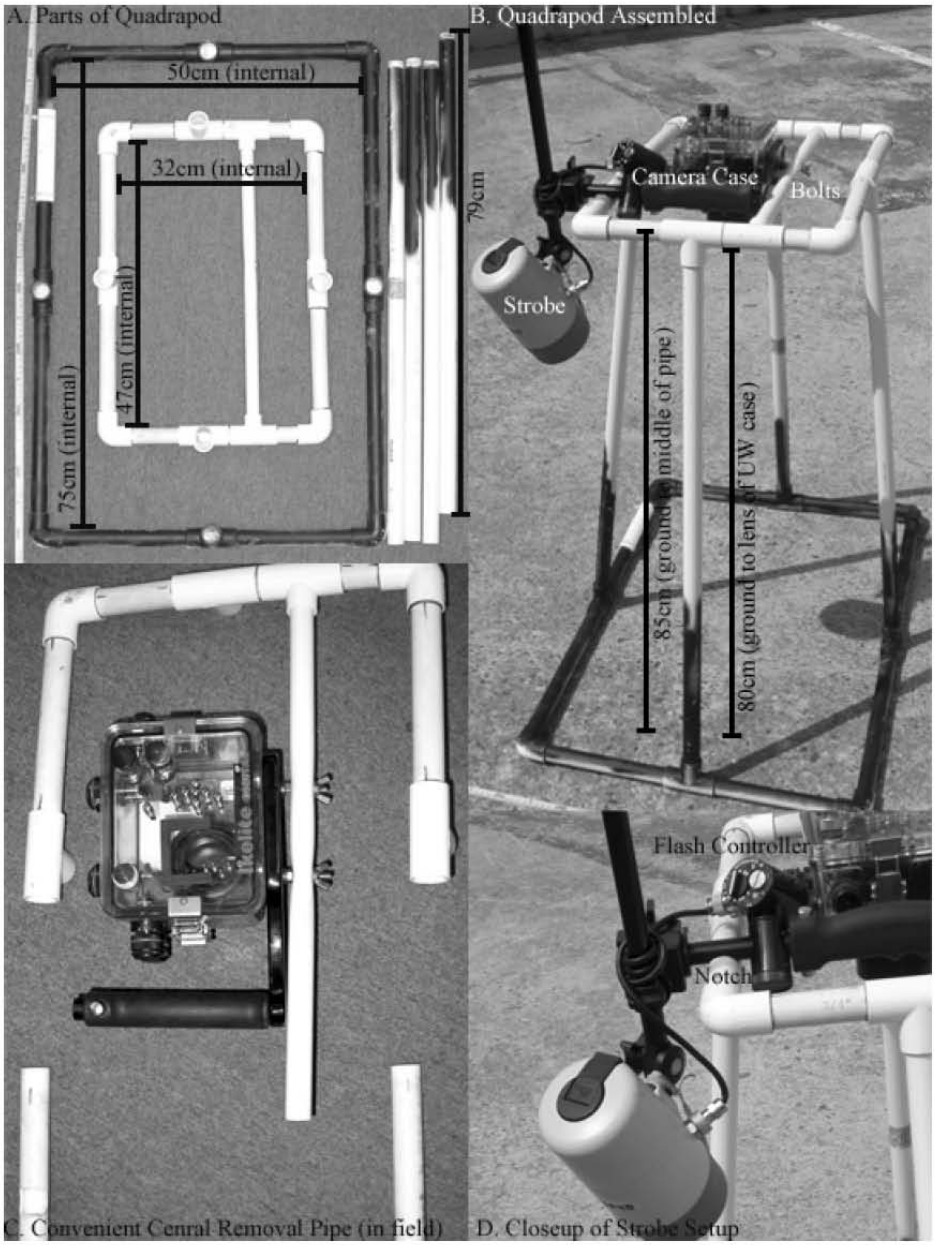

Figure 18. PVC photo framer, or "quadrapod," for photographing the fixed 50 x 75 cm photoquadrats. Photographs from Becker (2006).

SOP 4 – Barnacle Settlement Plot Scraping

Version 1.01 (May 3, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	2/10/2010	J. Long	---	Original	1.00
1.00	5/3/2010	B. Mitchell	Minor edits, including placing quadrats over barnacle photoplots	SOP Update	1.01

This Standard Operating Procedure (SOP) provides information regarding scraping the barnacle settlement plots. Barnacle settlement is measured by counting the number of barnacles settling on scraped, fixed plots in the barnacle zone. As barnacle settlement typically occurs from late March to late May, plots should be scraped between February 1 and March 14 (but a future revision may allow plots to be scraped at the end of the last monitoring date of the prior year). New England is notorious for unpredictable and sometimes harsh winter weather at this time of the year. Ice and snow may cover access trails and intertidal substrates. Nor'Easters can bring significant wave heights. Always exercise caution and only sample when it's safe. When in doubt, don't go out.

Scraping the Plots

1. Locate Settlement plot #1 (S1). Use GPS coordinates, measurements and headings from reference bolts, etc. Each plot should be marked by two stainless steel hex bolts that stick up ~1" from the substrate. Because these bolts are easy to see, once the general area of plots is located, plots typically can be found with a quick visual search. Additionally, a stamped stainless steel washer label should be positioned near each upper left bolt. These washers are stamped with an "S" (for settlement plots) and replicate number (1-5). See Figure 19 for an example (note that the ruler and black frame will not be present when you visit the plots). TAKE CARE TO NOT STEP ON THE OTHER FIXED PLOTS, ESPECIALLY THE BARNACLE PHOTOQUADRATS THAT ARE USUALLY ADJACENT TO THE SETTLEMENT PLOTS. It may help to bring out five 50 x 75 cm quadrats to place over the barnacle photoquadrats. Plots were typically arranged from North to South, S1 to S5.

Figure 19. Barnacle settlement plot prior to scraping.

2. Scrape S1. BEFORE SCRAPING, CONFIRM THAT YOU ARE NOT LOOKING AT A BARNACLE PHOTOPLOT (labeled B1, B2, B3, etc.). DO NOT SCRAPE BARNACLE PHOTOPLOTS. Because barnacles display aggregative settlement, the same sized area should be scraped for all settlement plots. To do this, place a frame (7.5 x 7.5") over the two diagonal bolts of S1. The frame can be made of aquamesh with the inner mesh cut out to leave a frame. Scrape the entire substrate underneath the frame using paint scrapers first, followed by wire brushes (Figure 20). Scrapers with a handle and a knob are preferred. It is critical to remove all macro-organisms from the scraped area because barnacles not removed during scraping may be incorrectly counted as new settlers during subsequent surveys. Pay particular attention to cracks, crevices, and the area around bolts, as last year's barnacle class may have settled in these locations.

<u>Paint Scraper</u>

<u>Wire Brush</u>

Figure 20. Tools for scraping barnacle plots.

3. Scrape a border around the frame the width of a scraper blade (7 cm).

4. Check for thorough scraping. Using the wire brush, brush off all of the scraped material from the substrate and examine for missed barnacles and other organisms. It may be helpful to remove the frame.

5. Repeat steps 1-5 for S2-S5.

Needed Materials

- Compass
- 30 m transect line
- Site notebook (containing plot overview photos and coordinates)
- 7.5 x 7.5” frame (aquamesh)
- 50 x 75 m quadrats (5, for marking barnacle photoplots)
- Paint scraper (2)
- Wire brush (2)
- Knee pads (for comfort while scraping)

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SOP 5 – Training

Version 1.00 (May 3, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	5/3/2010	B. Mitchell	---	Initial draft, based on training section of the Preparation and Equipment List SOP (v. 2.07) in the NETN forest health protocol.	1.00

Prior to commencement of each field season, all field personnel must fully understand this protocol through participating in a training session. Crew preparation should involve careful review and discussion of all procedures, in addition to hands-on sessions led by designated personnel in which training plots are set up and measured. Crew must be given sufficient time to read the entire protocol thoroughly. It may be useful to divide the training into discrete "phases"—so that a particular SOP or set of SOPs can be read, learned and practiced before moving on to the next. Some discussion of how the data will be used to assess the condition of the rocky intertidal zone should also be included to help the crew better understand the process.

Training should cover:

- safety hazards such as slippery rocks and waves;
- safe field practices to avoid injury such as how to properly pack and wear a field pack;
- personal equipment needed for field sampling;
- emergency procedures;
- introduction to rocky intertidal ecosystems;
- review of common rocky intertidal species, and test to ensure proper species identifications;
- identification of invasive exotic species;
- proper use of all equipment including GPS and digital camera;
- proper use of compasses, especially declination settings;

- practice using field notebooks to locate plots from reference bolts;
- plot layout and maintenance;
- procedures for each field method (photoquadrats, motile invertebrates [including use of calipers to measure shell thickness], sea star and sea urchin transects, and point-intercept transects);
- procedures for scoring photoplots (especially for staff who will be doing this work);
- practice using procedures for careful data collection described in the Data Management and QA/QC SOP;
- procedures to minimize plot trampling; and
- expectations of crew behavior;

Training should include both demonstration of all measurements by trainers, and hands-on practice of all measurements by trainees. Training groups should be small to ensure that all trainees have sufficient opportunity to practice measurements thoroughly and question the trainer as needed. Training should thoroughly demonstrate how to enter data onto data sheets and into the rocky intertidal database for each SOP. Training materials should include screen captures of each form in the database.

Training must emphasize the critical importance of careful, accurate and steady data collection to this long-term monitoring program. Trainers must stress the importance of exact adherence to SOP instructions to prevent bias in measurements among years, which will inhibit the networks' ability to detect long-term trends. Trainees should be encouraged to discuss with supervisors any concerns that arise over field procedures or the datasheet or database recording systems during training or later during the field season—the crew should never deviate from established protocols or alter the datasheet or database without first taking this step.

Training must emphasize the critical importance of careful behavior to minimize plot trampling. Packs should be put down and unloaded above the intertidal zone. Crew should not enter the area with plots without an explicit reason to do so. Crew should arrange the taking of measurements to minimize disturbance. Crew should plan ahead to retrieve all gear needed for a particular set of measurements at once, rather than taking extra trips back and forth across the intertidal zone. Extra care must be taken to avoid trampling in or around plots and transects.

During training, one crew member from each crew should be designated as the GPS lead, and another should be the camera lead. The GPS lead should receive extra training in the use of the GPS unit, and should carefully study the GPS SOP and the Garmin manual. The camera lead should receive extra training on how to take suitable pictures.

Network staff must decide what location provides sufficient logistical support for the initial training session. SERC at Acadia NP is probably the best location for training, because lodging

is inexpensive and an extra site has been established within a short walk that can be sampled during training.

Appendix 5 contains a general diagram of plots that may be useful during training.

Appendix 6 contains a quick photographic guide to the main intertidal species that may be useful during training.

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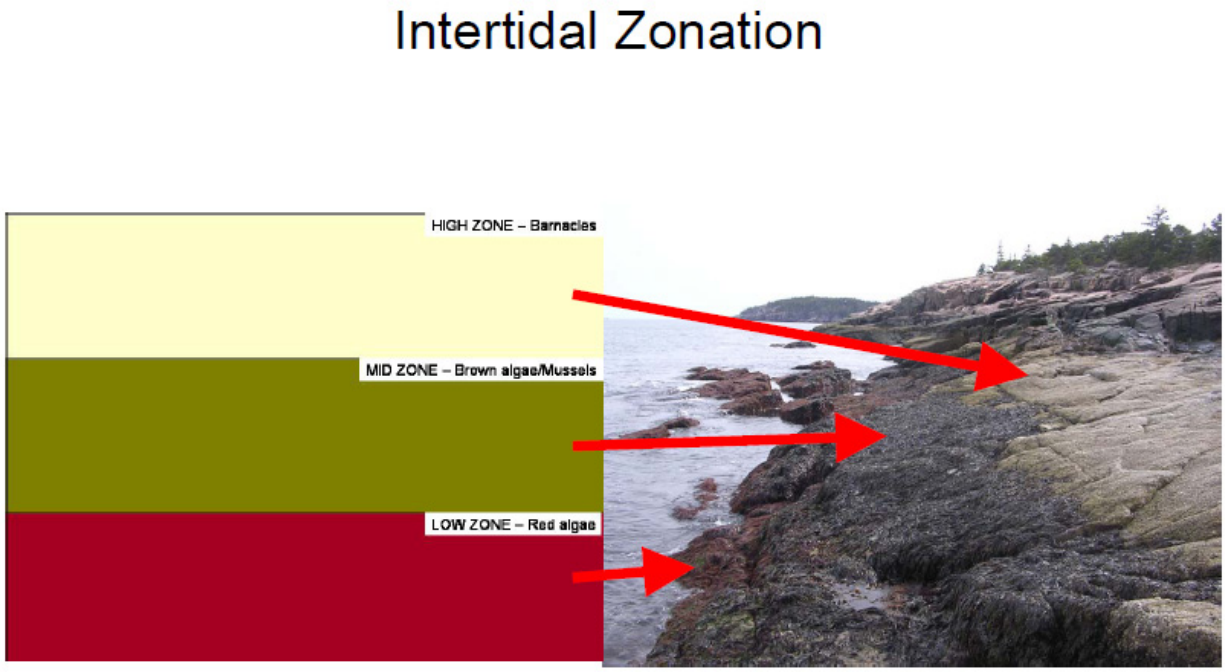
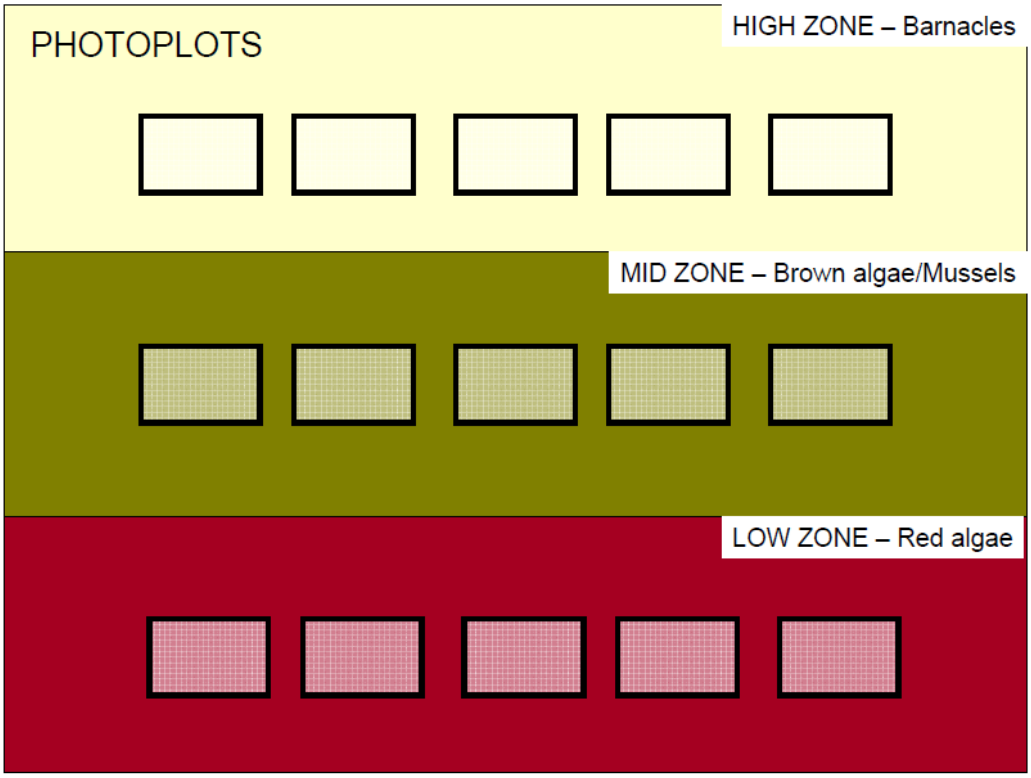
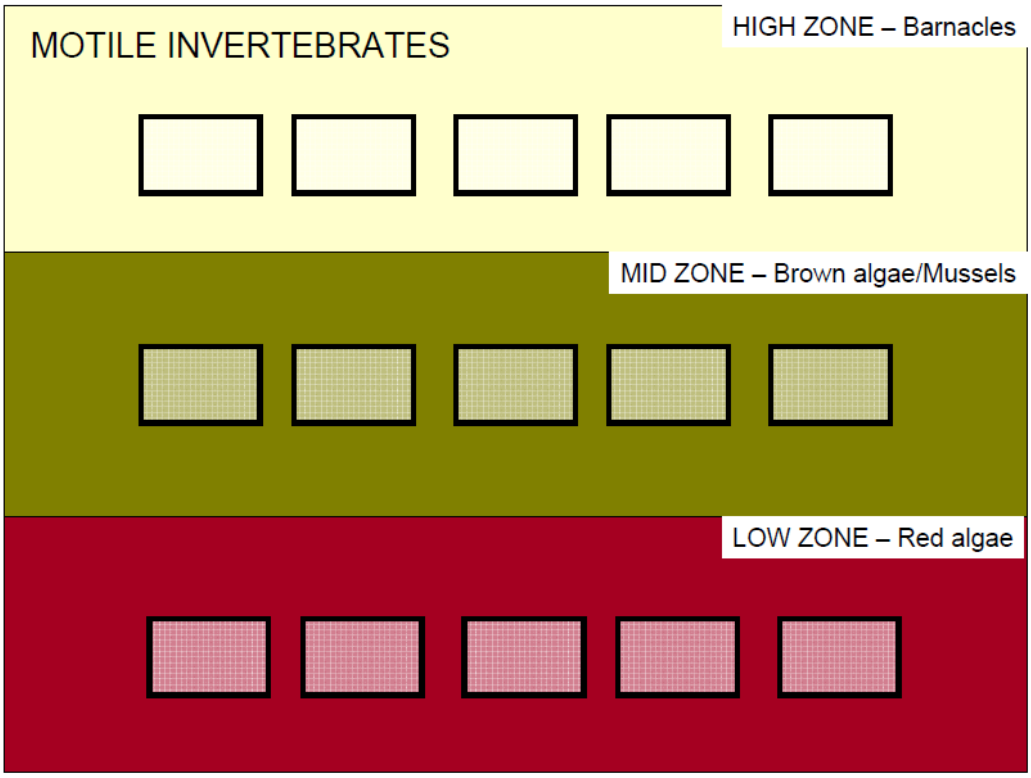
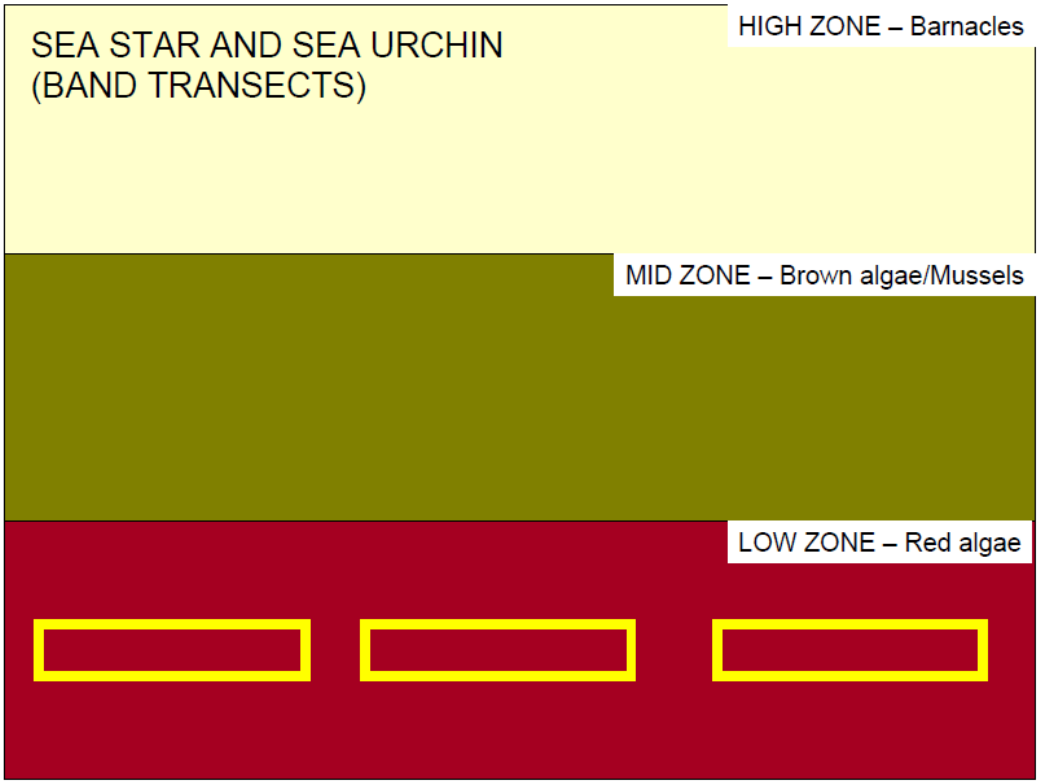
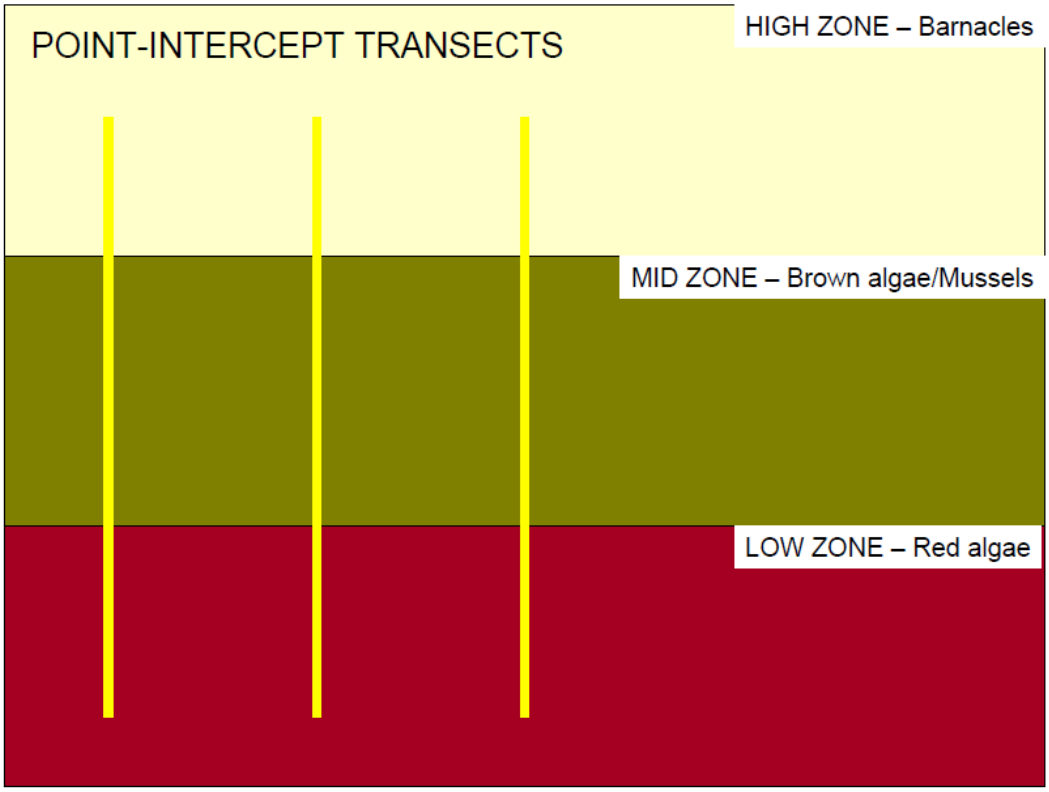
Appendix 5. Rocky Intertidal Plot Diagrams

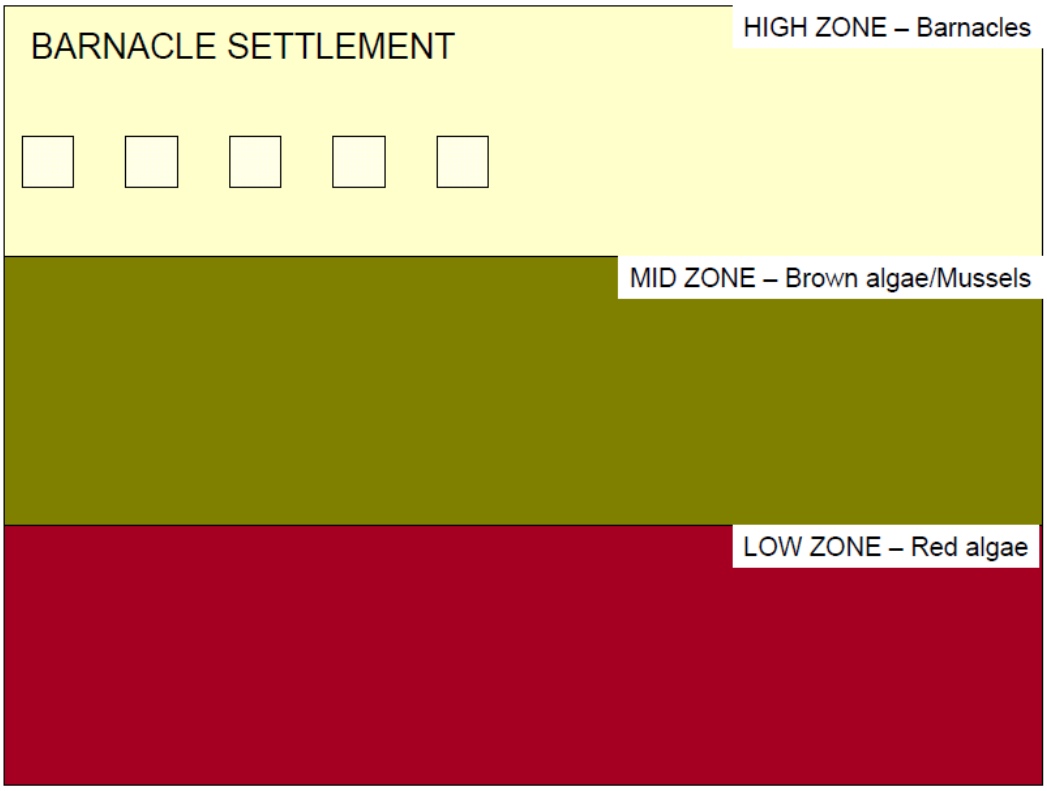





MOTILE INVERTEBRATES
HIGH ZONE – Barnacles
MID ZONE – Brown algae/Mussels
LOW ZONE – Red algae


SEA STAR AND SEA URCHIN
(BAND TRANSECTS)
HIGH ZONE – Barnacles
MID ZONE – Brown algae/Mussels
LOW ZONE – Red algae


POINT-INTERCEPT TRANSECTS
HIGH ZONE – Barnacles
MID ZONE – Brown algae/Mussels
LOW ZONE – Red algae


BARNACLE SETTLEMENT
HIGH ZONE – Barnacles
MID ZONE – Brown algae/Mussels
LOW ZONE – Red algae

Appendix 6. Photographic Guide to Intertidal Species

Quick Guide to the Intertidal

Invertebrates

Littorina littorea
(Common periwinkle)

Littorina obtusata
(Smooth periwinkle)

Littorina saxatilis
(Rough periwinkle)

Hemigrapsus sanguineus
(Asian shore crab)

Carcinus maenas
(Green crab)

Cancer spp. (Cancer crab)

Asterias spp.
(Sea star)

Mytilus edulis
(Blue mussel)

Semibalanus balanoides
(Northern acorn barnacle)

Strongylocentrotus droebachiensis
(Green sea urchin)

Nucella lapillus (Atlantic dogwhelk)

Acmaea testudinalis
(Atlantic plate limpet)

Quick Guide to the Intertidal

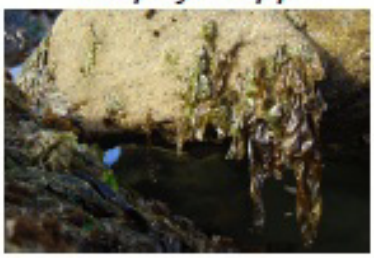
Algae

Ascophyllum nodosum

Fucus spp.

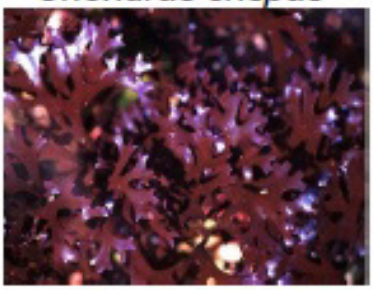
Ulva spp.

Porphyra spp.



Kelp

Chondrus crispus



Mastocarpus stellatus

Fucoid epiphyte

Palmaria palmata

Articulated coralline

Crustose non-coralline

Crustose coralline

SOP 6 – Camera

Version 1.01 (May 29, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	5/3/2010	B. Mitchell	---	Initial outline	1.00
1.00	5/29/2010	J. Long	Write SOP	Write SOP	1.01

Users of the digital cameras, underwater housings, and strobes should all be familiar with the general operation of these products. Consult the respective manuals for additional details. This SOP describes specific settings for and use of the Nikon Coolpix P5100 digital camera, Ikelite DS-125 strobe, and Ikelite underwater housing.

Camera Settings

1. File size: To adjust the file size, press the "MENU" button (Figure 21). Scroll to "Image size" using either the command dial (Figure 22) or the multiselector. Press "OK" on the multiselector. Scroll to appropriate image size (either 5M or 8M depending on photograph type). Press "MENU" to exit.

Figure 21. Back of the Ikelite camera housing showing the buttons associated with the camera's multiselector (cluster of buttons on the right). The "menu" button is the 2nd from the bottom on the left.

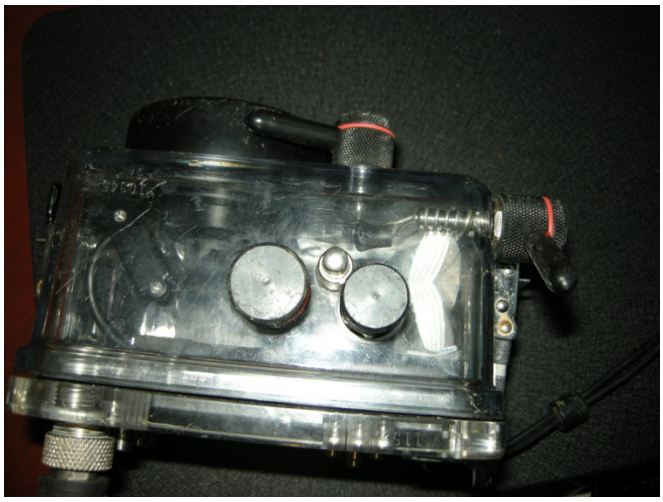


Figure 22. Top of the Ikelite camera housing. The command dial is the large black knob on the right.

2. Flash settings: To set flash to the on position, press the flash button on the multiselector. Scroll to the appropriate flash setting (always on) using either the command dial or the multiselector.

3. Set the "Mode" dial to "P."

Strobe Settings

1. Strobe dials should be turned to the "On" and "TTL" settings (Figure 23).

Figure 23. Strobe settings during photography. The "Ready Light" should illuminate.

Camera and Strobe Assembly

1. Attach camera to the back of the camera housing.

    A. Slide the "hot shoe connector" of the camera housing into the accessory shoe at the top of the camera (**Figure 24**).

Figure 24. Back of the Ikelite camera housing showing the hot shoe connector that attaches to the camera's accessory shoe.

B. Using a coin (preferably a penny), screw the screw at the base of the housing into the bottom of the camera.

C. While maintaining the position of the moisture muncher inside the housing (Figure 25), connect the two housing pieces together using the clasps on the sides. Be careful that the o-ring on the housing is clean and in place. The o-ring and shafts can be lightly lubricated for the best seal.

Figure 25. Front of camera housing showing correct placement of the moisture muncher.

2. Attach strobe to the camera housing.

A. After aligning the pins, insert the strobe cable into the external strobe connector on the housing. Screw the connector into place (Figure 26).

Figure 26. Photograph showing the connection location of the strobe to the camera.

IV. Tips for Taking Good Pictures

- Shading: Whenever possible, plots should be shaded from direct sunlight to avoid glare. The entire plot and any area outside the plot that appears in the camera's viewfinder should be shaded.

- Steady Hands: Try not to move while taking photographs. Movement can lead to blurry photos that can be difficult to score.

- Depth of field: The depth of field can be changed by adjusting the camera's f-stop. Higher numbers indicate a broader range where there will be sharp focus.

- Housing Lens Cap: Always replace the lens cap on the housing. This will prevent damage to the housing surface that covers the lens. The cap can also keep this surface dry during rainy conditions.

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SOP 7 – GPS

Version 1.00 (May 3, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	5/3/2010	B. Mitchell	---	Initial SOP, based on the Using the GPS SOP v. 2.01 from the NETN forest health protocol	1.00

Overview

This Standard Operating Procedure explains the methods that all observers should follow to learn to use Global Positioning System (GPS) with the Garmin GPSMAP 60CSX (or similar) unit. Rocky intertidal crews use GPS to help navigate to and locate reference bolts.

Suggested Reading

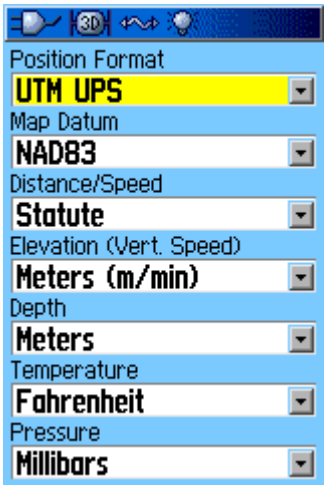
Garmin GPSMAP 60CSX Owner's Manual

Setting Up and Using the GPS Unit in the Field

Global positioning system equipment is used in the field to navigate to monitoring sites and locate reference bolts. Detailed steps for setting up and using the GPS unit are presented below.

Setting up the GPS Unit

1. Make sure the GPS is set to UTM NAD83.



   a. Go to the Main Menu by pressing 'Menu' twice.

   b. Toggle to 'Setup' and press 'ENTR'.

   c. Toggle to 'Units' and press 'ENTR'.

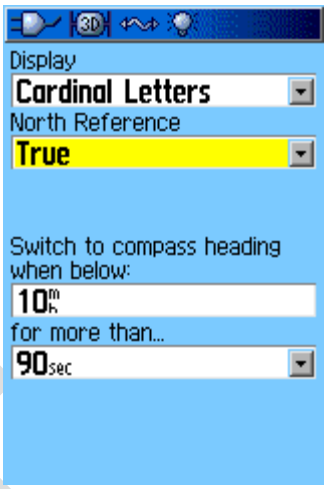
   d. Set the 'Position Format' to '**UTM UPS'** and the 'Map Datum' to '**NAD83'**. To change these, highlight the field press 'ENTR'. Then toggle to the appropriate setting and press 'ENTR' again.

   e. To get back to the Setup menu press 'QUIT'.

2. Make sure the GPS is set to True North.

   a. Toggle to ‘Heading’ on the Setup menu and press ‘ENTR’.

   b. Set the ‘North Reference’ to ‘**True**’.

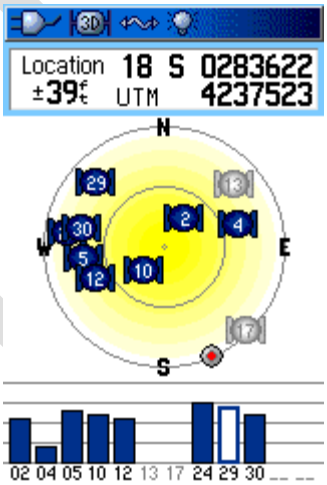


Note: These settings will be saved on the GPS and should not have to be re-entered each time the unit is turned on.

3. <u>Be sure to carry at least one full replacement of batteries</u> for the GPS receiver.

4. As soon as you turn the unit on, it starts to look for satellites. You can track the status of the satellites by pressing ‘Page’ until you reach the Satellite screen. The GPS is most accurate when it has at least four satellites and a 3D position. The location of satellites in the sky changes from day to day and thus sometimes satellite reception is more difficult to achieve. Openings in the canopy of the forest can increase the strength of satellite signals reaching the GPS unit.

5. The current estimated accuracy of the receiver is also displayed on this page. The accuracy fluctuates as satellite signals are gained and lost. An accuracy of +/– 10 m (30 ft) or better is desirable to precisely document location.



Navigating to a Site

After the receiver is turned on and has adequate reception, press the ‘FIND’ button, highlight ‘Waypoints’ and press ‘ENTR’.

Use the keypad to enter the first number or two and then press ‘QUIT’ to get out of the keypad. Now you can scroll to the appropriate waypoint and press ‘ENTR’.

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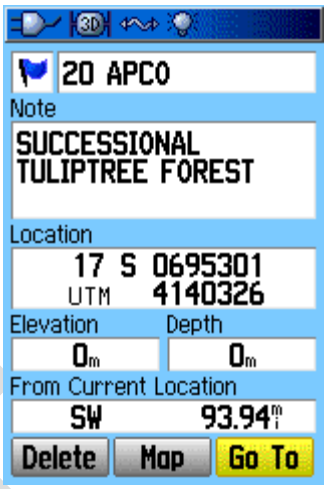
The waypoint screen will give you detailed information about the waypoint including the Note field and the distance to the point. 'Go To' should already be highlighted so press 'Enter'.



At the top of the Map Page, the distance and bearing to the waypoint will be displayed. The Map Page, Compass Page or Highway Page can be used to navigate to the waypoint. As the distance to the waypoint decreases, the bearing and distance numbers will begin to jump around as the accuracy varies. As the waypoint nears, the use of a hand compass and measurement by pacing will help locate the point.

Selecting a Waypoint Symbol

1. Waypoint symbols are a way to group waypoints on your GPS unit. The default symbol for waypoints uploaded to the unit from a computer is the Flag (Blue). The default symbol for waypoints collected in the field is the Parachute Area.

2. It is a good idea to pick a new symbol to distinguish individual and/or groups of waypoints that you collect in the field. This will make it easier to manage, download and delete waypoints on your GPS unit. An example is using a car symbol for a waypoint at the car before you wander into the forest.

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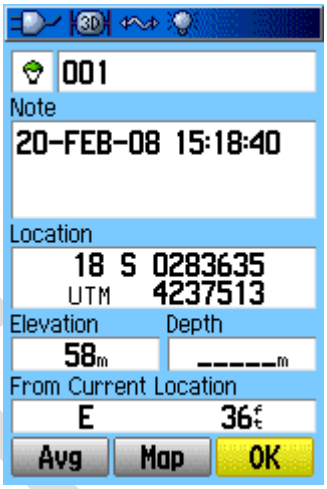
Marking a Waypoint

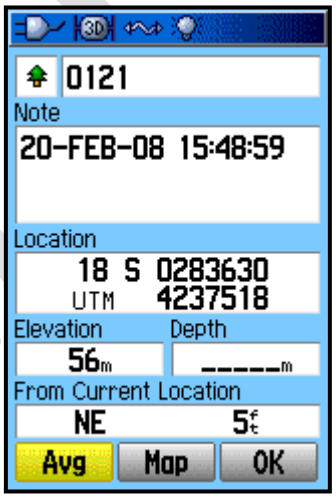
1. Press 'MARK' and the Mark Waypoint screen appears.



2. Toggle up to the symbol and press 'ENTR' for the Waypoint Symbols screen.

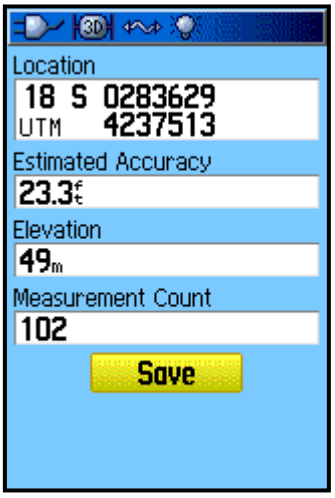
3. Toggle to the symbol you want to use and press 'ENTR'.

4. The default name of a waypoint is a sequential number starting with '001'. To change the default name toggle to the number and press 'ENTR'.



5. Toggle up and down through the numbers and letters and left and right between characters. Once the last letter or digit has been selected, toggle to 'OK' and press 'ENTR' to save the name and highlight the whole name field. Reference bolts should have waypoints created based on their 6-letter site code plus bolt name (e.g. BASHARASC for the *Ascophyllum* reference bolt at the Bass Harbor Head site).

6. The most accurate way to document a location is to collect a waypoint position that averages at least 100 points. After you have named the waypoint. Toggle to 'Avg' at the lower left corner and press 'ENTR'.



7. The 'Average Location' screen appears and measurement counts automatically begin. After the 'Measurement Count' reaches 100, highlight 'Save' and press 'ENTR' to return to the Map Page.

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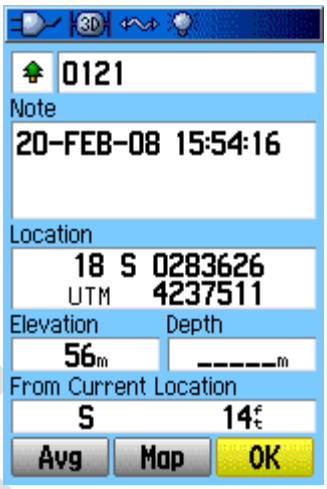
8. **You still need to highlight 'OK' and press 'ENTR' on the map page to save the point.**

9. Before leaving the point, make sure that it has been recorded. Press 'FIND' and toggle to 'Waypoints' and press 'ENTR'. Does the new waypoint appear on the list?



Navigating

You can navigate using the Map Page, Compass Page or Highway Page. When navigating using the GPS, remember that directional signals you receive from GPS are only valid while you are moving. Unlike a compass, if you stop and turn to face a different direction, the GPS will not reposition until you move again. A compass must be used to determine the correct direction to continue after stopping, and care must be taken to hold the compass sufficiently far from the GPS handheld unit to avoid influencing the compass needle.

Connecting the Garmin 60CSX Unit to a Computer

1. Connect the Garmin 60CSX unit to a computer using a USB cable.

2. Turn the unit on.

3. There are two ways to open DNR Garmin. You should be using version 5.3.2 or higher.

    a. Open DNR Garmin from the Start menu or

    b. Open DNR Garmin from the DNR Garmin toolbar in ArcMap. If the toolbar is not loaded, select View > Toolbars > DNR Garmin Toolbar from the ArcMap menu.

4. Confirm that DNR Garmin recognizes the unit.

    a. If the unit is not recognized, 'Not Connected' will appear in the lower left corner (Figure 27).

    b. If the unit is recognized, 'Connected' will appear in the lower left corner and the GPS unit information should appear on the screen (Figure 28).

5. If the unit is not recognized, make sure the Port is set to USB by selecting GPS > Set Port > USB. To refresh the connection, select GPS > Open. Note: this will only work if the GPS is not connected.

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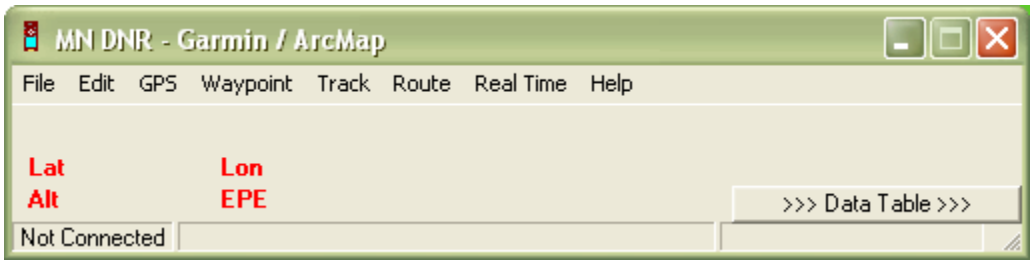

Figure 27. MN DNR—Garmin/ArcMap with GPS not connected.

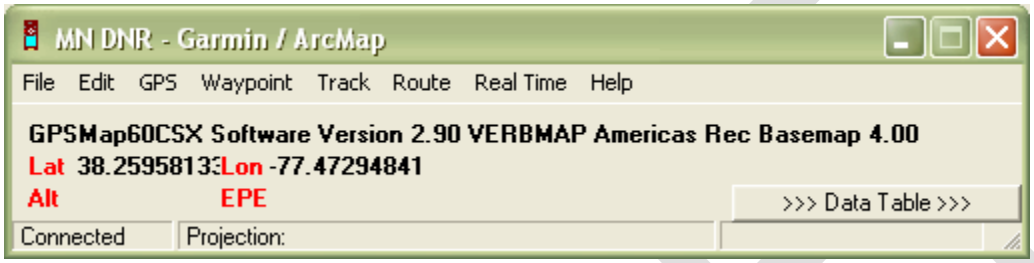

Figure 28. MN DNR—Garmin/ArcMap with Garmin unit GPSmap 60CSX connected.

6. Set the default projection to NAD 83, UTM Zone 19N. To open the DNR Garmin Properties window (Figure 29); select File > Set Projection. You will need to set the projection three times.

    a. Select ESRI on the Projection tab and select 'NAD_1983_UTM_Zone_19N' from the Datums/Projections drop-down box. You may want to type some of it in to narrow the options.

    b. On the bottom of the same tab, click the 'Load PRJ' button and navigate through 'Projected Coordinate Systems', 'UTM', 'Nad 1983', and then select 'NAD 1983 UTM Zone 19N'.

    c. At the top of the same tab, select ArcMap, click the 'Load PRJ' and navigate to the same projection file as in the last step. Click 'Ok'.

The Projection will now appear at the bottom center of the main MN DNR—Garmin/ArcMap screen (Figure 30).

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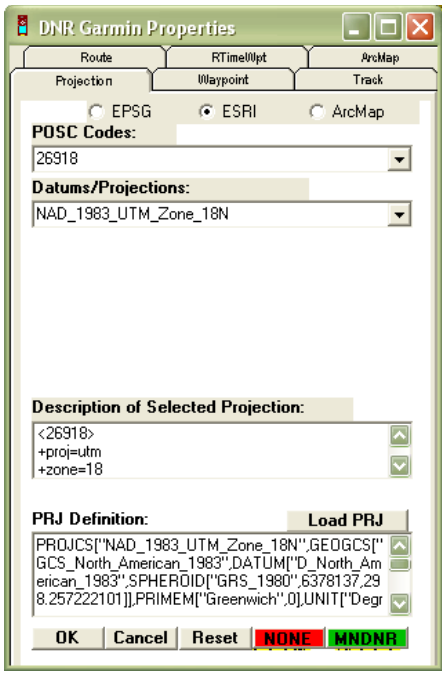


Figure 29. DNR Garmin Properties window with projection set to NAD 1983, UTM Zone 18N.

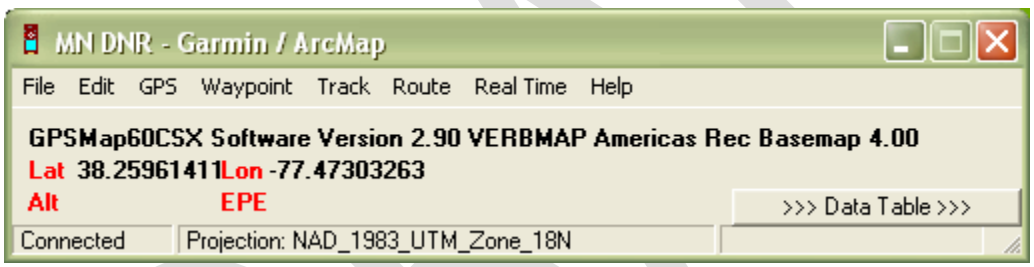


Figure 30. MN DNR—Garmin/ArcMap with Garmin unit GPSmap 60CSX connected and projection set to NAD 1983, UTM Zone 18N.

Uploading Waypoints to the Garmin Unit

In order to navigate to existing reference bolts, waypoints with plot Universal Transverse Mercator (UTM) coordinates must be uploaded from a GIS layer to the GPS receiver. The steps for this procedure are as follows:

1. Turn on the computer and open the current ArcGIS map document with the GIS layer loaded. Make sure the GIS layer you want to upload is active. It should be highlighted (Figure 31).

2. Connect the GPS unit to the computer using the USB cable and turn the unit on.

3. Open MN DNR Garmin.

4. Select File > Load From > ArcMap > Layer. The Identify Fields dialog box will appear and you will need to select an Ident and Comment field. *Note: If the shapefile already has a comment field, MN DNR Garmin will default to the existing comment field and*

ignore the field selected. You will need to either copy the field you want to use into the existing comment field or delete it.

5. To upload the waypoints to the GPS unit. Select Waypoint > Upload.

6. The GPS will beep when the upload is complete and a small box on the computer screen will read 'Transfer Complete. Waypoints uploaded.' Click OK. Now, you are ready to take the GPS into the field.

7. Note that the default symbol for uploaded waypoints is a blue flag. Press 'FIND' on the Garmin unit and select 'Waypoints' and then press 'ENTR' to see the waypoints that you just uploaded.

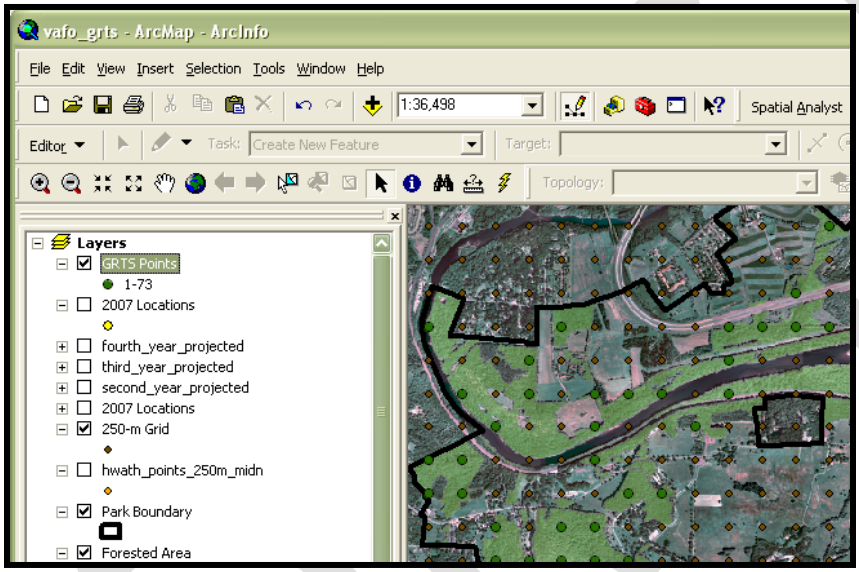


Figure 31. ArcMap screenshot, showing that the GRTS Points layer is active in the Table of Contents.

Downloading Waypoints

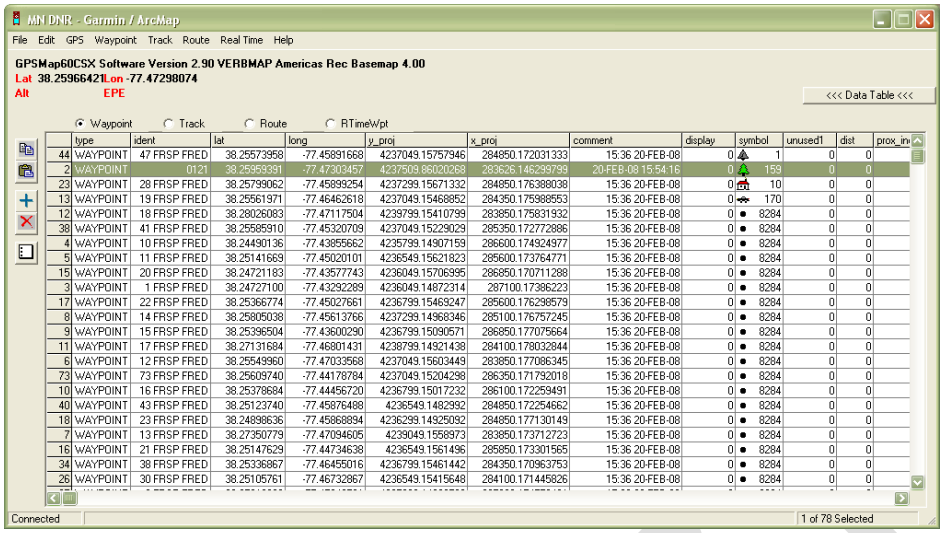
Waypoints for newly established reference bolts as well as updated waypoints for plots with inaccurate GPS locations need to be downloaded onto the computer upon return to the office from the field.

1. Open the ArcGIS map document with the relevant files.

2. Connect the GPS unit to the computer with a USB cable and turn it on.

3. Open DNR Garmin and verify that the GPS is acknowledged and that the projection is set to NAD 83, UTM Zone 19N. If you need help, see the section above on setting up DNR Garmin.

4. To download waypoints, select Waypoint > Download. The saved waypoints from the GPS will now appear in the table (Figure 32).



	type	ident	lat	long	y_proj	x_proj	comment	display	symbol	unused1	dist	prox_in
44	WAYPOINT	47 FRSP FRED	38.25573958	-77.45891668	4237049.15757946	284850.172031333	15:36 20-FEB-08	0	1	0	0	
2	WAYPOINT	0121	38.25959391	-77.47303457	4237509.86020268	283626.146299799	20-FEB-08 15:54:16	0	159	0	0	
23	WAYPOINT	28 FRSP FRED	38.25799062	-77.45899254	4237299.15671332	284850.176388038	15:36 20-FEB-08	0	10	0	0	
13	WAYPOINT	19 FRSP FRED	38.25561971	-77.46462618	4237049.15468852	284350.175988553	15:36 20-FEB-08	0	170	0	0	
12	WAYPOINT	18 FRSP FRED	38.28026083	-77.47117504	4239799.15410799	283850.175831932	15:36 20-FEB-08	0	8284	0	0	
38	WAYPOINT	41 FRSP FRED	38.25585910	-77.45320709	4237049.15229029	285350.172772886	15:36 20-FEB-08	0	8284	0	0	
4	WAYPOINT	10 FRSP FRED	38.24490136	-77.43855662	4235799.14907159	286600.174924977	15:36 20-FEB-08	0	8284	0	0	
5	WAYPOINT	11 FRSP FRED	38.25141669	-77.45020101	4236549.15621823	285600.173764771	15:36 20-FEB-08	0	8284	0	0	
15	WAYPOINT	20 FRSP FRED	38.24721183	-77.43577743	4236049.15706995	286850.170711288	15:36 20-FEB-08	0	8284	0	0	
3	WAYPOINT	1 FRSP FRED	38.24727100	-77.43232289	4236049.14872314	287100.17398223	15:36 20-FEB-08	0	8284	0	0	
17	WAYPOINT	22 FRSP FRED	38.25366774	-77.45027661	4236799.15463247	285600.176298579	15:36 20-FEB-08	0	8284	0	0	
8	WAYPOINT	14 FRSP FRED	38.25805038	-77.45613766	4237299.14968346	285100.176757245	15:36 20-FEB-08	0	8284	0	0	
9	WAYPOINT	15 FRSP FRED	38.25396504	-77.43600290	4236799.15090571	286850.177075664	15:36 20-FEB-08	0	8284	0	0	
11	WAYPOINT	17 FRSP FRED	38.27131684	-77.46801431	4238799.14921438	284100.178032844	15:36 20-FEB-08	0	8284	0	0	
6	WAYPOINT	12 FRSP FRED	38.25549960	-77.47033568	4237049.15603449	283850.177086345	15:36 20-FEB-08	0	8284	0	0	
73	WAYPOINT	73 FRSP FRED	38.25609740	-77.44178784	4237049.15204298	286350.171792018	15:36 20-FEB-08	0	8284	0	0	
10	WAYPOINT	16 FRSP FRED	38.25378684	-77.44456720	4236799.15017232	286100.172259491	15:36 20-FEB-08	0	8284	0	0	
40	WAYPOINT	43 FRSP FRED	38.25123740	-77.45876498	4236549.1482992	284850.172254662	15:36 20-FEB-08	0	8284	0	0	
18	WAYPOINT	23 FRSP FRED	38.24898636	-77.45868894	4236299.14925092	284850.177130149	15:36 20-FEB-08	0	8284	0	0	
7	WAYPOINT	13 FRSP FRED	38.27350779	-77.47094605	4239049.1558973	283850.173712723	15:36 20-FEB-08	0	8284	0	0	
16	WAYPOINT	21 FRSP FRED	38.25147629	-77.44734638	4236549.1561496	285850.173301565	15:36 20-FEB-08	0	8284	0	0	
34	WAYPOINT	38 FRSP FRED	38.25336867	-77.46455016	4236799.15461442	284350.170963753	15:36 20-FEB-08	0	8284	0	0	
26	WAYPOINT	30 FRSP FRED	38.25105761	-77.46732867	4236549.15415648	284100.171445826	15:36 20-FEB-08	0	8284	0	0	

Figure 32. Data table in the MN DNR – Garmin/ArcMap application displaying downloaded waypoints.

5. Note that all the waypoints on the GPS are downloaded. You can sort through these by clicking on any of the column headings. For example, click on 'symbol' to sort the waypoints by their symbol.

6. You can either save all the waypoints or select specific waypoints to save. What you choose to do may depend on the project you are working on. If you do not highlight any of the waypoints, they will all be saved. To highlight waypoints, click on the row identifier. In Figure 32, clicking on '2' highlighted the row which is Plot 0121.

7. These waypoints need to be saved twice, once as a text file and once as a shapefile.

    a. To <u>save as a text file</u>, select File > Save To > File…

    For rocky intertidal plots and reference bolts, the text file should be saved in the '**backup_gps_text_files**' folder. The naming convention should include the date the file was downloaded, the GPS brand and model number, and the type of data following the format "**20080220_Garmin_60CSX_waypoints.txt**".

    b. To <u>save as a shapefile</u>, select File > Save To > ArcMap > Shapefile Layer...

    For rocky intertidal plots and reference bolts, the shapefile should be saved in the '**backup_gps_shapefiles**' folder. The naming convention should include the date the file was downloaded, the GPS brand and model number, and the type of data following the format "**20080220_Garmin_60CSX_waypoints.shp**".

8. This file will automatically appear in the Table of Contents of the ArcGIS Map Document that you have open.

9. Close DNR Garmin and verify the contents of the new shapefile in the map document to ensure that your data were properly transferred.

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Deleting Waypoints from the GPS Unit

The GPS receiver can hold up to 500 waypoints, but it is advisable to delete the downloaded waypoints from the GPS periodically to keep it from becoming full while in the field. You have three options for deleting waypoints on the GPS receiver.

1. Deleting a single waypoint:

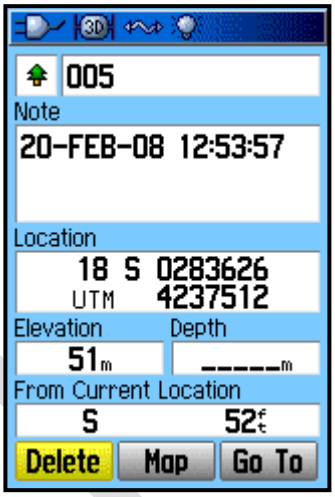
   a. Press 'Find' to open the Find screen.

   b. Select 'Waypoints' to open the Waypoints screen.

   c. Toggle to highlight the waypoint you would like to delete and Press 'ENTR' to open the Waypoint screen.

   d. Toggle to highlight 'Delete' in the lower left corner and press 'ENTR'

   e. When prompted 'Do you really want to delete waypoint xxx?' highlight 'Yes' and press 'ENTR'



2. Deleting all waypoints:

   a. Press 'Find' to open the Find screen.

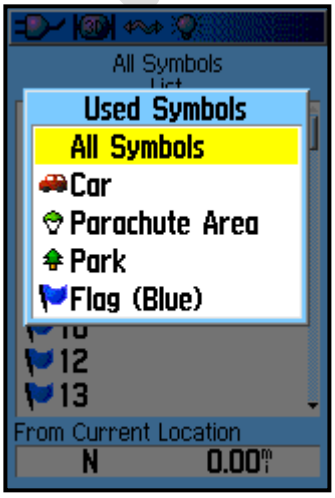
   b. Select 'Waypoints' to open the Waypoints screen.

   c. Press 'MENU' to open the Menu screen.

   d. Highlight 'Delete' and press 'ENTR'

   e. Highlight 'All Symbols' and press 'ENTR'

   f. Confirm that you really want to delete all waypoints and press 'ENTR'



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3. Deleting all waypoints represented by the same symbol

   a. Press ‘Find’ to open the Find screen.

   b. Select ‘Waypoints’ to open the Waypoints screen.

   c. Press ‘MENU’ to open the Menu screen.

   d. Highlight ‘Delete’ and press ‘ENTR’

   e. Highlight the symbol representing the group of waypoints that you want to delete and press ‘ENTR’

   f. Confirm that you really want to delete all the waypoints with the selected symbol by highlighting ‘Yes’ and press ‘ENTR’

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SOP 8 – Data Management and QA/QC

Version 1.00 (May 3, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	5/3/2010	B. Mitchell	---	Initial SOP, based on the Data Management and QA/QC SOP v. 2.10 from the NETN forest health protocol	1.00

Overview

Careful, accurate collection of data as directed in these SOPs is critical to the success of Vital Signs monitoring. This SOP describes quality assurance/quality control (QA/QC) procedures for accurate data collection, transcription and stewardship, and assessment of data quality. For rocky intertidal monitoring, crews will collect field data on paper datasheets and later transcribe the sheets into a database. The rocky intertidal database (currently being developed) will contain forms for entry of laboratory photo analysis data, so these data will be entered directly into the database. Appendix 7 is a quick-reference guide to QA/QC procedures.

Field Procedures

Staff shall use the following procedures to record data in the field:

- To measure distance using a measuring tape, do as follows. When ready, the measurer shall alert the crew member holding the tape origin by calling "mark." The crew member holding the tape origin will then hold the tape securely and directly over the starting location, and reply "mark" to signal readiness. The measurer then pulls the tape taught and reads the measurement.

- To record data, do as follows. The measurer shall clearly call out a data value to be recorded. The recorder shall clearly repeat the value aloud as it is recorded, to ensure the value was heard and recorded accurately. If the measurer does not hear a response from the recorder, the measurer shall repeat calling out the measurement until a response is obtained.

Datasheets

The crew must always bring datasheets copied onto Rite-in-Rain paper into the field. Datasheets will contain as much preprinted project information as possible with designated labels for specific data elements, including general data such as date and collectors' names. Datasheets will clearly identify all required information, using examples where needed to ensure that the proper data are recorded. After paper datasheets have been initialed in the field check box as having

been filled out in their entirety, a complete set of working copies will be made (see Data Stewardship section below). Most post-field collection data entry notes and remarks shall be made only on the copies, not to the original datasheets. Post-field collection remarks added to either the original (e.g., unknown species identifications) or copies of the datasheets should be written using a different colored pencil. Using the template at the top of the datasheet, all network staff members (including the crew) who make modifications to the datasheet shall indicate their identity (initials), date of modifications, purpose of their review, and the color used to provide comments or make changes (Figure 33).

Purpose	Color	Date	Initials
Field Review	N/A		
Entered to DB	☐		
100% Check	☐		
10% Check	☐		
Validation	☐		
	☐		

Figure 33. Verification log found at the top of paper datasheets. Log is used to track changes and record the verification and validation status of datasheets for each plot.

Data Verification

Data quality and verification involve checking the accuracy of field data at each stage it is transcribed from its original source. To minimize the possibility of carrying entry errors forward into analysis, the data quality and verification process for this protocol involve multiple checks. After computerized data are verified to accurately reflect the original field data (i.e., the entered data match the collected data), the paper forms will be archived and remaining data manipulation shall be done in the database.

Field Data Transcribed to Paper Datasheets

- Datasheets should be protected within an enclosed clipboard.
- All information added to a datasheet must be printed using pencil and clearly legible.
- While manually recording data, the crew member entering the data will verbally double check all field values for accuracy and completeness with the crew member collecting/announcing the data. All discrepancies will be corrected prior to moving to the next data field.
- Information shall never be erased and incorrect or older information shall never be overwritten.
- Revisions shall be accomplished by crossing-out the erroneous data with a single line.
- Upon completing data collection at each site, original datasheets shall be reviewed and checked for legibility and completeness. The crew member responsible for completing this field verification will initial the datasheet in the appropriate location.

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Paper Data Transcribed to Computer

During the process of transcribing data from paper datasheets into the database, the crew member will double check all entries and correct discrepancies prior to advancing to the next datasheet.

Following data entry into the computer, a crew member shall review 100% of the records entered to ensure that values present on field forms were accurately and completely transcribed into digital form. All efforts should be made to prevent the same crew member who originally entered the data from conducting the 100% verification check. Notes or changes made to the datasheets should only be made on the complete set of copies made for this purpose.

Ten percent of records are reviewed a second time by either the data manager or other designated network staff. All comments and changes should be recorded on the copies of the datasheets. If a significant transcription error (e.g., incorrect values or missing records) is found in one out of 10 datasheets during the 10% review, then the entire data set will be verified again (i.e., repeat the 100% and subsequent 10% checks until the data manager is satisfied with the data quality). In cases where the transcription errors detected follow a pattern, then a subset of the datasheets following that pattern will be checked, instead of the entire set of datasheets.

Data Validation

Although data may be correctly transcribed from the original field forms, their values may not always be accurate or logical. As often as possible, components of the data validation process have been built into the database (e.g., value range restrictions, separate species pick-lists for different procedures, etc.). Although many validation problems can be addressed by a well designed database, the rocky intertidal project manager must also review and validate the data after verification is complete. The rocky intertidal project manager is the authority on the methodologies and species involved.

Once the verification process has been completed, statistics should be used to evaluate the data present in the database. The project manager should generate range and average values to help identify outliers.

Data Stewardship

Good data stewardship practices play a critical role in long term data security and help prevent irretrievable loss of information.

- Datasheets should be copied onto acid-free paper within one week of collection, and shall be checked to ensure that all original data are present and legible. Once produced, photocopies of the datasheets should be affixed as coversheets to their corresponding originals and used for all computer data entry and verification procedures. All post-field corrections and remarks should be recorded on the copies. All post-field corrections and remarks should be annotated with the date and initials of the person making the changes. Datasheets must always be stored in a safe location.

- The database should be backed up weekly, with a backup copy stored in a different physical location from the working copy. Sequential backups should be used so that old versions of the data are stored; this can be useful if data is inadvertently deleted.

- Electronic data (Hobo tidbit files and photos) should also be backed up weekly, and stored with the database in a safe location.

- Once the computerized data are verified as accurately reflecting the original field data and validation is complete, the paper field forms shall be delivered to the network data manager. The electronic version of the data is used for all subsequent data activities.

Field QA/QC

One randomly selected site will be resampled each year to determine reliability and repeatability of field data collection (with 9 sites, this is an 11% resample rate). Field QA/QC will occur as close as possible to original sample date of the plot to reduce seasonal variability. Field staff for remeasurement must not include members of the field crew that originally measured the plot

The field QA/QC team can consist of several combinations of staff. Crews working at a different location can travel to the QA/QC site to resample it, or the rocky intertidal project manager can lead the resampling effort with network staff and volunteers. The QA/QC team must not include anyone who was present at the original sampling event.

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Appendix 7. QA/QC steps quick-reference.

Data Collection	For each measurement, verbally verify its value with crew member before recording it.
Data Entry	Never overwrite or erase incorrect information; cross out erroneous data with a single line. After each site, verify with your initials that each form was completed in its entirety. At the end of each day, verify that completed forms exist for each site visited.
Back-up Data	Weekly: make a complete set of copies for all paper datasheets Store all datasheets in a safe location.
Verify Data	A crew member will transcribe all paper records into the computer database. A different crew member will conduct a 100% review of all transcribed records. All corrections/remarks should be recorded on copies of the datasheets. Log of all post-field data corrections should be recorded on top of each paper datasheet. Project Manager or Data Manager will conduct 10% review of all transcribed records. Verification steps will be repeated until Project and Data Managers are satisfied.
Validate Data	Project Manager will check data for data logic errors not prevented by database design.
Data Stewardship	After all verification and validation procedures are completed all paper datasheets will be delivered to the Network Data Manager and prepared for archiving. The electronic version of the data is used for all subsequent data activities.

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SOP 9 – Field Work Preparation

Version 1.00 (May 3, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	5/3/2010	B. Mitchell	---	Original	1.00

The following items must be attended to prior to each sampling event:

- The day prior to sampling, review the equipment list thoroughly and conduct operational checks of all equipment.
- Charge equipment batteries and spare batteries.
- Verify that copies of all necessary site maps, site descriptions, GPS coordinates, and paper data sheets are included with the sampling equipment.
- Review the safety procedures (SOP 1 – Safety) with all staff that will be conducting surveys, verify that each member of the group knows what to do in case of an emergency, and verify that crew members have brought the proper personal equipment to safely work in the rocky intertidal zone.
- Review weather report, and cancel the sampling event if the weather will be severe (high seas or significant rain)
- File a trip plan with the rocky intertidal project manager or a designated park or refuge staff member at the site being monitored.

SOP 10 – In the Field

Version 1.00 (May 4, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	5/4/2010	B. Mitchell and J. Long	---	Original	1.00

This SOP describes procedures for locating plots in the field and the typical schedule of field activities during a sampling event.

Locating Plots

Previous experience with this monitoring protocol at the specific site is the most efficient way to relocate plots. If an experienced person is unavailable, GPS coordinates and overview photographs from previous trips are useful for finding the general location (+/- 15 m of most replicates). Mussel and barnacle plots are easily found with the naked eye because bolts are exposed. When plots are not obvious to the naked eye, then the reference bolt should be found and the previously recorded distance and headings of plots (Appendix 1) should be used to relocate plots (These are kept in binders marked with the site name and plot type).

To locate plots from a found reference bolt, first extend a 30 m transect tape from the reference bolt to the distance of that specific plot, in the general direction of the plot. Then, carefully orient the transect tape along the heading of the plot. This technique can be used to get within 50 cm of the plot's label. Note that a single person can do this by using the compass in reverse from the free end (non-reference bolt end) of the transect tape. To find plots covered with a thick seaweed canopy, use the previous techniques and then press straight down on the algae in the most likely area of the plot to try and feel the bolts with a flat hand.

Scheduling

In general, work as low in the intertidal as possible first. Lower plots are exposed for shorter time periods. Higher plots can be sampled later. A typical field day begins with arrival at the site about 3 hours prior to the low tide, so it makes sense to work at higher plots as you wait for the tide to recede.

In a typical field day, the crew will arrive on site about 3 hours before low tide, and be able to sample until 3 hours after low tide. The recommended sampling schedule is found in Table 38.

Table 38. Recommended sampling schedule for a typical field day.

Time	Activity[1]
3.0 to 1.5 hours before low tide	Barnacle/*Fucus*/*Ascophyllum* photoquadrats: photograph and sample motile invertebrates. Photograph barnacle settlement plots.
1.5 to 0.5 hours before low tide	Mussel photoquadrats: photograph and sample motile invertebrates. Point intercept transects (maybe only from high to mid bolts).
0.5 hours before to 0.5 hours after low tide	Upload temperature data from loggers. Red algae photoquadrats: photograph and sample motile invertebrates. Complete point-intercept transects.
0.5 to 1.5 hours after low tide	Complete the activities not completed above. Work from low to high as the tide floods.
1.5 to 3.0 hours after low tide	Complete the activities not completed above. Work from low to high as the tide floods.

[1] Note that this is a recommended schedule. As indicated in the text, the priority should be to sample as low in the intertidal as possible at any given time because of the reduced exposure times of low intertidal substrates.

Some field days will be early (i.e., low tide will occur near sunrise). On these days, the recommended sampling schedule is found in Table 39.

Table 39. Recommended sampling schedule for an early field day.

Time	Activity[1]
1.5 to 0.5 hours before low tide	Mussel photoquadrats: photograph and sample motile invertebrates. Point intercept transects (maybe only from high to mid bolts).
0.5 hours before to 0.5 hours after low tide	Upload temperature data from loggers. Red algae photoquadrats: photograph and sample motile invertebrates. Complete point-intercept transects.
0.5 to 1.5 hours after low tide	Complete the activities not completed above. Work from low to high as the tide floods.
1.5 to 3.0 hours after low tide	Barnacle/*Fucus*/*Ascophyllum* photoquadrats: photograph and sample motile invertebrates. Photograph barnacle settlement plots. Complete the activities not completed above. Work from low to high as the tide floods.

[1] Note that this is a recommended schedule. As indicated in the text, the priority should be to sample as low in the intertidal as possible at any given time because of the reduced exposure times of low intertidal substrates.

Some field days will be late (i.e., low tide will occur near sunset). On these days, the recommended sampling schedule is found in Table 40.

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Table 40. Recommended sampling schedule for a late field day.

Time	Activity[1]
3.0 to 1.5 hours before low tide	Barnacle/*Fucus*/*Ascophyllum* photoquadrats: photograph and sample motile invertebrates. Photograph barnacle settlement plots.
1.5 to 0.5 hours before low tide	Mussel photoquadrats: photograph and sample motile invertebrates. Point intercept transects (maybe only from high to mid bolts).
0.5 hours before to 0.5 hours after low tide	Upload temperature data from loggers. Red algae photoquadrats: photograph and sample motile invertebrates. Complete point-intercept transects.
0.5 to 1.5 hours after low tide	Complete the activities not completed above. Work from low to high as the tide floods.

[1] Note that this is a recommended schedule. As indicated in the text, the priority should be to sample as low in the intertidal as possible at any given time because of the reduced exposure times of low intertidal substrates.

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SOP 11 – Plot Maintenance

Version 1.01 (May 13, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	7/7/2009	J. Long	---	Original	1.00
1.00	5/13/2010	J. Long and B. Mitchell	Added info about replacing shelters and bolts.	Requested by NPS	1.01

This SOP covers annual maintenance of plot bolts, as well as the timing of periodic replacements (e.g., for tidbits and tidbit shelters).

Plot Bolts

Finding bolts can be a problem when organisms overgrow these bolts. After each plot has been sampled during a sampling event, clean the bolts and a 5 x 5 cm area around each bolt using a scraper and wire brush. This will increase the probability of finding the bolts on the subsequent visit.

Although bolts can readily be found with sufficient notes, measurements from reference bolts, and photographs, a metal detector could be used to find hidden bolts. If a metal detector will be used, test it with stainless steel hardware as some detectors are not sensitive to this material. We have not required a metal detector during protocol development.

All hardware placed in the intertidal is stainless steel and thus, will not need replacement because of normal weathering. Similar bolts have been placed in these systems for > 10 years. Furthermore, bolts used by Dr. Bruce Menge in the 1970s were still present around Northeastern University's Marine Science Center in 2009. The most likely causes of a lost bolt are 1) incorrect installation of anchors (e.g. not fully inserted into hole), 2) incorrect drilling of hole creates too large of a hole, or 3) erosion of substrate (that typically is apparent while drilling the initial hole).

If a bolt is lost, recreate the plot as close as possible to the original site using overview photos, GPS coordinates, distance and azimuth from reference bolts, and position relative to other plot bolts. For example, if a photoquadrat corner is lost, use a quadrat to determine correct placement of the missing bolt.

Temperature Loggers (Tidbits)

Water temperature at each site will be recorded using three tidbit temperature loggers (ONSET corporation) (SOP 16 – Temperature Loggers). Set tidbits to record water temperature every hour, but not to record battery life (see launch instructions included with tidbits). At these settings, new tidbits should record data for approximately 5 years. However, we recommend

replacing tidbits every 3 years because data is difficult to retrieve from tidbits whose batteries are expired. Tidbit shelters should be replaced every six years. See Table 41 for schedule for replacing tidbits and shelters (update this table when new tidbits are deployed). Currently, ACAD and BOHA tidbits will need to be replaced in 2011 and MCI tidbits will need to be replaced in 2012; ACAD and BOHA tidbit shelters will need to be replaced in 2014 and MCI tidbit shelters will need to be replaced in 2015.

Table 41. Tidbit temperature logger and shelter replacement schedule.

Site	Replicate	Year tidbit deployed	Year tidbit to be replaced	Year shelter deployed	Year shelter to be replaced
ACAD-BASHAR	TEMP1	2008	2011	2008	2014
	TEMP2	2008	2011	2008	2014
	TEMP3	2008	2011	2008	2014
ACAD-OTTPOI	TEMP1	2008	2011	2008	2014
	TEMP2	2008	2011	2008	2014
	TEMP3	2008	2011	2008	2014
ACAD-SCHPOI	TEMP1	2008	2011	2008	2014
	TEMP2	2008	2011	2008	2014
	TEMP3	2008	2011	2008	2014
ACAD-SHIHAR	TEMP1	2008	2011	2008	2014
	TEMP2	2008	2011	2008	2014
	TEMP3	2008	2011	2008	2014
BOHA-CALISL	TEMP1	2008	2011	2008	2014
	TEMP2	2008	2011	2008	2014
	TEMP3	2008	2011	2008	2014
BOHA-GREISL	TEMP1	2008	2011	2008	2014
	TEMP2	2008	2011	2008	2014
	TEMP3	2008	2011	2008	2014
BOHA-OUTBRE	TEMP1	2008	2011	2008	2014
	TEMP2	2008	2011	2008	2014
	TEMP3	2008	2011	2008	2014
MCI-METISL	TEMP1	2009	2012	2009	2015
	TEMP2	2009	2012	2009	2015
	TEMP3	2009	2012	2009	2015
MCI-PETMAN	TEMP1	2009	2012	2009	2015
	TEMP2	2009	2012	2009	2015
	TEMP3	2009	2012	2009	2015

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SOP 12 – Photoquadrats and Overview Photos

Version 1.01 (May 27, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	1/16/2009	J. Long	---	Original	1.00
1.00	5/27/2010	J. Long and B. Mitchell	Minor changes to procedures.	Minor edits, refine photo procedures.	1.01

This Standard Operating Procedure (SOP) provides information for taking digital photographs of the photoquadrats, barnacle settlement plots, and overviews. The images for the photoquadrats and barnacle settlement plots are analyzed in the office according to SOP 19 – Scoring Photoquadrats. General camera use and quadrapod procedures are also discussed here.

General Considerations for Digital Photography

Digital cameras provide immediate feedback on image quality and simplify data management issues such as image organization, storage, and analysis. Before departing for the field, check all cameras and associated equipment for proper functioning. Ensure that all batteries are fully-charged, memory cards are operational and empty (i.e. erased), and extra consumables like spare batteries and back-up memory cards are packed.

Fixed Photoquadrats

These photographs provide a fine-scale photographic record of the fixed photoquadrats. They are scored in the office after completing the sampling events. Additionally, these photos provide a visual record of the species composition and abundance for each plot and secure a digital image archive to allow for comparisons of temporal changes within plots (Figure 34).

1. Carefully mount camera (currently a Nikon Coolpix 5100) in waterproof housing (Ikelite, for this camera). Place a dessicant (such as a Moisture Muncher) within the waterproof housing to reduce condensation in the housing that may obscure photographs. If no dessicant is available, condensation will usually go away if the housing is left open for a couple of minutes.

2. In the field, assemble the quadrapod frame (see SOP 3 – Pre-season Preparations). Attach strobe to the camera housing and to the quadrapod. It helps to keep the base frame and the frame that attaches to the camera always assembled. Quadrapod legs are removed during transportation and storage. Confirm that the quadrapod base frame (the 50 x 75 cm rectangular at the base) is assembled tightly. The easiest way to do this is to ensure that the pvc connections all contain painted pipe and no white pipe is exposed. This step improves the precision of the frame to represent the 50 x 75 cm dimensions.

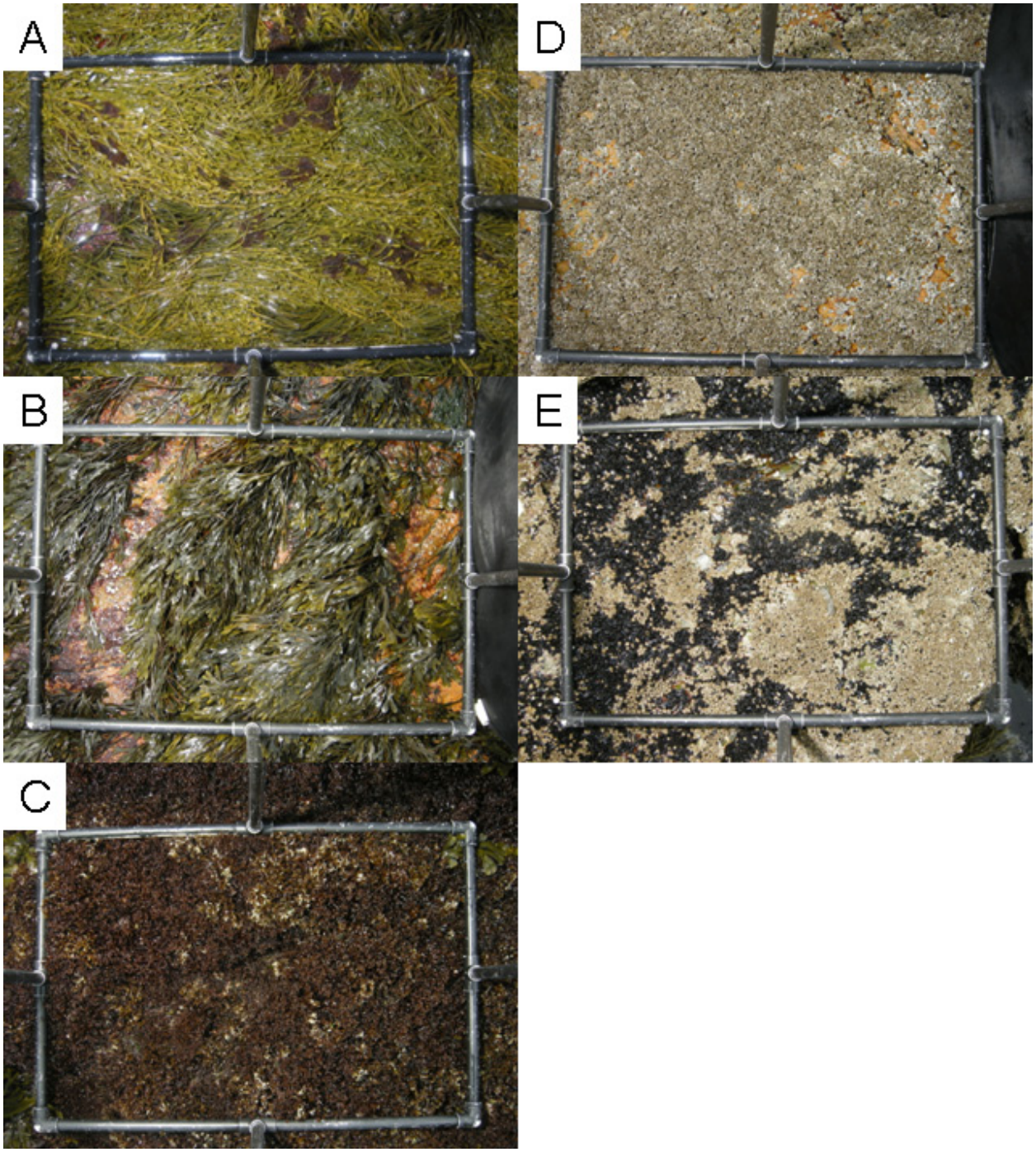

Figure 34. Sample photoquadrat photos. A) *Ascophyllum*, B) *Fucus*, C) Red algae, D) Barnacles, and E) Mussels.

3. Locate photoquadrats. It is easiest to shoot all replicates of a target species type (*Fucus*, *Ascophyllum*, red algae, barnacles, and mussels) sequentially before proceeding to another target species type.

4. Locate plot boundaries by identifying all four plot corners. These are recognizable because they are marked by bolts extending 1" above the substrate, whereas plot labels are nearly flush with the substrate. When searching for plot corners, DO NOT DISTURB THE ORIENTATION OF ANY ORGANISMS WITHIN THE PLOT. Photos should show algae or invertebrates in their original position. This is particularly important in the brown seaweed (*Fucus* and *Ascophyllum*) plots – because mussels, barnacles, and most red algae are not large or easily moved. Moving large, frondose seaweeds may alter percent cover measurements and may increase stress for sub-canopy organisms.

5. If it is necessary to move organisms while locating bolts, return them to their original positions before photographing.

6. It is usually most efficient to locate all plots of a given target species first and then to photograph these plots sequentially. Thus, when a plot is found, lay a 50 x 75 cm PVC quadrat over the plot. For each plot type, 5 quadrats are needed (one for each replicate). When the size of the monitoring team allows for the simultaneous sampling of multiple plot types, bring multiple sets of 5 quadrats into the field. These quadrats will not only be used to find the plot when it comes time to photograph them, they are also used to mark plot locations in the overview photos (described below) and for determining the motile invertebrate counts within plots (SOP 10). Thus, do not move a quadrat marking a plot until all of these tasks are completed for a given plot type.

7. Carefully remove loose drift algae and other debris from the plot that is not attached to the substrate.

8. Prior to photographing plots, draw the major plot contents (i.e. those species or substrates representing 5% or greater of the percent cover) using Form 1 (Photoquadrat Drawing Data Sheet). Each plot should be drawn in one minute or less (see Figure 35 for an example). Be sure to draw these in the proper orientation (upper left of drawing is equivalent to the upper left of plot closest to the plot label). These drawings will be used as a backup in the event that digital photographs are lost. Drawings must depict the plot as seen by the camera. In other words, only the top layer of organisms is apparent in photographs and thus, only the top layer should be drawn. Underlying organisms that are not visible without moving other organisms are not drawn. Importantly, every area of the drawing should have a unique species or substrate assigned to it. It is unacceptable to label an area of the plot as multiple species. In the cases where multiple small species are distributed throughout an area, draw the perimeter of this multi-species area, estimate the relative cover of this defined area for each of the species contained in this area, and then proportion this area into appropriately sized areas for each individual species. In the event of photo loss, drawings will be used to estimate percent cover. Draw all replicates of a single target species before photographing them.

9. Turn strobe to the "ON" and "TTL" settings. Check that the strobe is pointed at the center of the plot and oriented to minimize the shadow created by the quadrapod legs.

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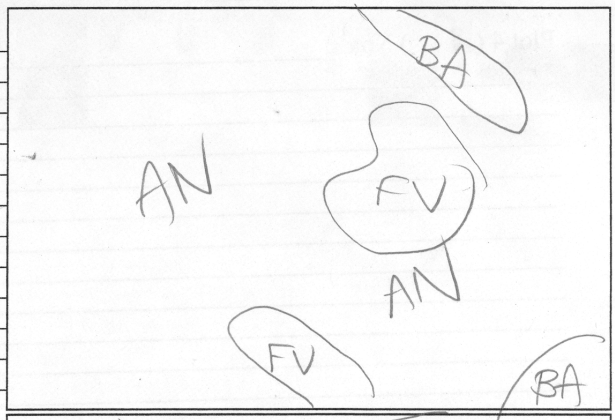
Prototype Eastern MARINe Rocky Intertidal Photoplot Sketch Data Sheet

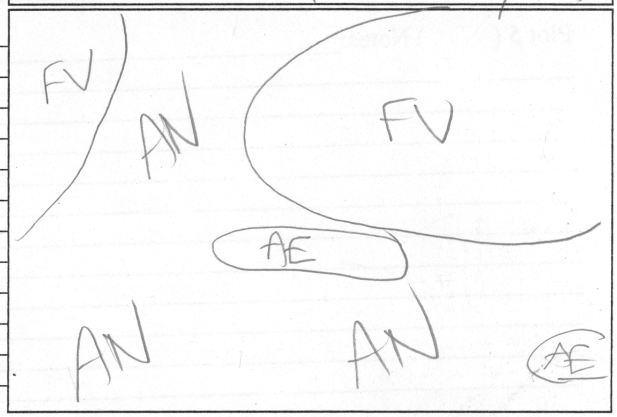
Site: BASHAR Date: 6/22/09 Photographer: CK

Target Species: ASC Observer: RED

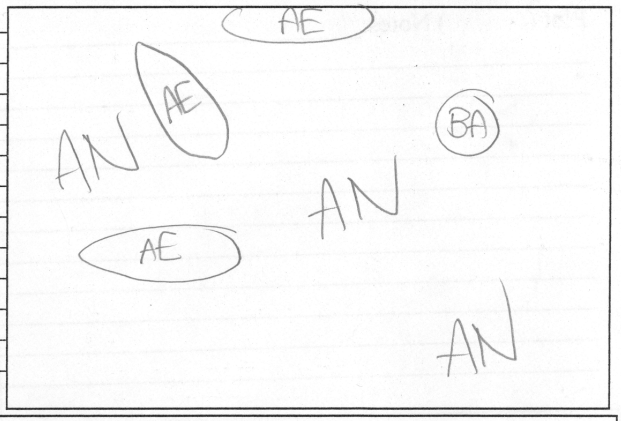
Plot 1 ( ) Notes:



Plot 2 ( ) Notes:



Plot 3 ( ) Notes:



Green Algae: **UE** = Ulva/Enteromorpha; **OG**=Other Green
Brown Algae: **AN** = Ascophyllum; **FV**=Fucus; **OB**=Other Brown
Red Algae: **AC**=Articulated Corallines; **CC**=Crustose Corallines; **CM** = Chondrus crispus or Mastocarpus stellatus; **PP** = Palmaria palmate; **PS**=Porphyra spp;; **OR**=Other Reds
Algae/Plants: **NC**=Non-Coralline Crusts; **OP**=Other Plants
Barnacles: **BA**=Barnacles
Mollusks: **MY**=Mytilus; **LI**=Limpets; **CI**=Chitons
Invertebrates: **AS**=Asterias spp.; **OI**=Other Invertebrates
Substrates: **R**=Rock, **S**=Sand, **T**=Tar

Figure 35. Example data sheet with photoquadrat drawings.

10. Turn camera on and to the P (Programmed auto) setting. This setting allows camera to set the shutter speed and aperture for optimal exposure. Using this setting, the camera will typically select an f stop between f2.7 and f3.4. Although the low f stop reduces depth of field, larger f stops typically are not useful because of the distance of the camera from the substrate and the relatively small depth of field of the plots. Confirm that "Image Size" setting is at 5M (final pictures will be 2592 x 1944 pixels). The camera's flash should be on.

11. Adjust zoom so that the quadrapod frame is maximized within the field of view.

12. Temporarily remove the quadrat and place the quadrapod frame over the four plot bolts. While viewing the frame through the camera's LCD screen, position the quadrapod so that all frame corners are within the photograph's edge. Remember to orient the frame so that the upper left corner of the plot (marked with a stamped identification label and typically recorded as the "upper left" when standing with your back to the ocean) is located in the upper left corner of the cameras field of view. Although the protocol does not currently analyze the location of species within plots, taking photos in this standard orientation will allow this capability in the future.

13. Currently, a visual record of site name, plot type, and date in each photo is not required. This is acceptable if replicates are photographed in order (1-5) and they are downloaded and renamed the same day. If this is not possible, the following directions should be followed: Site code and date are recorded in each photo on an erasable square slate attached to the quadrapod frame, at the start of that day's sampling. The plot type and replicate is also recorded on the erasable slate (e.g. A2 = *Ascophyllum* plot #2). The slate provides a backup of plot identification in the event that a photo is incorrectly named after being downloaded to an office computer.

14. On sunny days, plots are shaded to prevent overexposure and to standardize light levels across the plot. The best shades are car shades that can be compacted to a smaller size via twisting. If these are unavailable, clothing (e.g. jackets and sweaters) and people can be used as shades.

15. Hold the quadrapod steady and press the camera's shutter release.

16. Take a 2nd photograph after adjusting the command dial of the camera to use an f-stop three stops higher. The function of the second photo is to have photos shot at different settings so that the best image can be analyzed later in the office.

17. After photographing each photoquadrat, return the PVC quadrat to its original position over the bolts as these quadrats are necessary for the overview photos and motile invertebrate counts.

18. *Optional Step*: Record the sequence of photos and notes on the optional Photo Log (Form 2). This information is used for labeling photos in the office. This step is not necessary if a) it is obvious what the target species is within plots, b) all replicates within a target species are shot together, c) replicates within a target species are shot in order from 1-5, and d) photos are downloaded and named immediately after sampling.

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19. Move onto the next replicate and repeat steps 12-18.

20. After all replicates of a plot type have been photographed, take the overview photos for this plot type (see below) and then proceed to the next plot type and repeat steps 3-19.

21. After all photoquadrats have been photographed, disassemble quadrapod (remove camera, housing, and tray and take apart the legs) and store camera and housing in a pelican case.

Overview Photos

These photos provide an overview of the target species at each site. They allow the changes occurring within the fixed plots to be placed into a broader spatial context. Overlapping overview photographs can be stitched together manually or with a digital photography program (Figure 36).

Figure 36. Sample overview photographs of the barnacle zone at SCHPOI. Images have been overlayed manually. Note the white pvc quadrats that are marking the barnacle photoquadrats. Also, the orange cone marks the position of the reference bolt for these photoquadrats.

1. Overview photos are taken of all photoquadrats and the point-intercept transects. No overviews are photographed for barnacle settlement plots and band transects, because overview photographs would not provide precise data related to the focal species of these plot types. Overview photos are a series of panoramic shots from the reference bolt for that particular set of plots. It is useful to have a second camera (one that is not connected to the quadrapod) that can be used exclusively for overview photos. This additionally provides a backup for photoquadrats in case the quadrapod photoplot camera malfunctions. Alternatively, the quadrapod camera and top frame of the quadrapod can be disconnected from the quadrapod legs for overview photos – though this step increases sampling time.

2. Locate reference bolt, if not previously found and temporarily marked. These bolts are always placed in obvious places and are never completely covered with algae. Site familiarity will greatly facilitate relocation of reference bolts. Additionally, GPS coordinates and measurements from the reference bolt to the plots can be useful. Finally, plot notebooks with photographs are extremely helpful.

3. Standing directly above the reference bolt, photograph all of the target plots using multiple photographs that can later be stitched together using software (Camera set to automatic

landscape mode with image size set to 5M; final pictures will be 2592 x 1944 pixels). This can be completed by taking multiple overlapping photos while rotating the camera in a clockwise motion. Photos should overlap each other by 1/3 of the next photograph.

4. Try to minimize shooting the sky or sea as this may create exposure problems.

Barnacle Settlement Plot Photos

Barnacle settlement is measured by counting the number of barnacles settling on scraped rocks in the barnacle zone (Figure 37). Recruits are counted using images of these plots. Recruitment is highest late March to early June. Note that apparent barnacle settlement is highest just after peak recruitment. Thus, we recommend sampling plots in June (or July). If these plots are scored later in the summer (e.g. August or September), then apparent settlement will be lower because of intraspecific competition and the fact that larger barnacles begin to obscure smaller barnacles below them.

Figure 37. Sample barnacle settlement plot showing newly recruited barnacles in June.

1. Locate Settlement plot #1 (S1). Use GPS coordinates, measurements and headings from reference bolts, etc. Plots should be photographed in order from 1-5.

2. Remove overlying drift algae and motile invertebrates. Place frame (7.5 x 7.5”) over the two diagonal bolts of S1. The frame can be made of aquamesh with the inner mesh cut out to leave a frame.

3. Place metric ruler face-up, flat on rock adjacent to the frame. This ruler will provide a scale for analyzing these photographs.

4. Turn strobe on to "ON" and the "TTL" settings. Check that the strobe is pointed at the center of the plot.

5. Turn camera on and to the P (Programmed auto) setting. This setting allows camera to set the shutter speed and aperture for optimal exposure. Using this setting, the camera will typically select an f stop between f2.7-f3.2. Although the low f stop reduces depth of field, larger f stops typically are not useful because of the distance of the camera from the substrate and the relatively small depth of field of the plots. Confirm that "Image Size" setting is at 8M (final pictures will be 3264 x 2448 pixels). NOTE THAT THESE IMAGES ARE LARGER THAN EITHER THE PHOTOPLOTS OR THE OVERVIEW PHOTOGRAPHS. LARGER IMAGES ARE NECESSARY TO IDENTIFY TINY BARNACLE RECRUITS. The camera's flash should be on.

6. Orient the frame so that the upper left corner of the plot (marked with a stamped identification label and typically recorded as the "upper left" when standing with your back to the ocean) is located in the upper left corner of the camera's field of view. Although the protocol does not currently analyze the location of barnacle recruits within plots, taking photos in this standard orientation will allow this capability in the future.

7. Adjust distance from frame so that frame is maximized within the camera's LCD screen. Do not zoom the camera; use the normal setting and move physically closer to the plot to fill the screen.

8. Photograph plots while holding the camera perpendicular to the plot surface. Holding the camera in this way increases the accuracy of density estimates of barnacles. Hold the camera steady and press the camera's shutter trigger.

9. On sunny days, plots will be need to be shaded to prevent too much contrast. The best shades are car shades that can be compacted to a smaller size via twisting. If these are unavailable, use clothing (e.g. jackets and sweaters) and people as shades.

10. Take a 2nd photograph after adjusting the command dial of the camera to use an f-stop three stops higher. The function of the second photo is to have photos shot at different settings so that the best image can be analyzed later in the office.

11. Repeat steps 1-10 for S2-S5.

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SOP 13 – Motile Invertebrates

Version 1.01 (May 27, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	7/7/2009	J. Long	---	Original	1.00
1.00	5/27/2010	J. Long and B. Mitchell	Clarify procedures, add figure of shell damage	Revisions requested by NPS.	1.01

This Standard Operating Procedure (SOP) summarizes the procedures for conducting motile invertebrate monitoring. This monitoring will be conducted during every full sampling trip. Motile invertebrates will be enumerated and measured in each of the fixed photoquadrats (monitored with SOP 12 – Photoquadrats and Overview Photos). This SOP focuses on herbivorous and carnivorous gastropods that dominate the motile invertebrate community and exert well-known control of invertebrate (e.g. barnacles and mussels for predatory whelks) and algal prey (e.g. ephemeral algae for herbivorous periwinkles). Estimating invertebrate population size within the photoquadrats should provide insight into the community dynamics within the plots.

General Considerations

Because small snails can be difficult for non-experts to identify (e.g. juvenile *Littorina littorea* vs. *Littorina saxatilis*) and find, this protocol examines snails equal to or greater than 0.7 cm, approximately the width of a pencil, in length.

Procedure for Collecting Motile Invertebrates:

1. Because monitoring motile invertebrates disturbs the positioning of some target species within plots, motile invertebrate monitoring within photoquadrats occurs AFTER the photoquadrats have been drawn and photographed (SOP 12 – Photoquadrats and Overview Photos).

2. For each target species photoquadrat, label two small bags/containers for each plot number (e.g. B1 for Barnacle photoquadrat 1). Thus, there will be a total of 10 bags for each target species. Half of these are used to place the first 10 individuals of a species encountered for measurements and the other half are collected to determine abundance.

3. Starting from one side of the photoplot, systematically look through the plot and collect all snails (*Littorina obtusata, Littorina littorea, Littorina saxatalis, Nucella lapillus*) and limpets (*Acmaea testudinalis*) with a length greater than or equal to 0.7 cm (approximately the width of a pencil). Use care when extracting *Acmaea testudinalis* and *Nucella lapillus* as their

shells can be very fragile, especially juvenile stages. Separate the first 10 individuals of each species as these will be later measured for shell length.

4. For plots with many cracks and crevasses, such as barnacle and mussel plots, forceps are helpful in removing snails. For plots containing foliose algae (e.g. *Ascophyllum* and *Fucus* plots), look through all layers of algae thoroughly. To begin, scan the top layer for any snails, then continue to search by working from one side of the photoplot to the other, checking the entire length of algal pieces, and paying special attention to holdfasts and crevasses. Motile invertebrates should only be collected from the area outlined with the quadrat, no area outside is to be considered. Plants extending past the quadrat may be moved for better visibility, but snails located outside the quadrat on these plants should not be collected.

5. Place invertebrates in their designated bag/containers counting and measuring after collection.

6. If the snail count appears very high, it may be necessary to subsample the plot. To determine if subsampling is needed, count the most abundant motile invertebrate species within a 20 x 20 cm quadrat placed in the upper left corner of the 50 x 75 cm photoquadrat. If there are more than 10 of an individual species, the plot should be subsampled. Photoquadrats are subsampled by placing three 20 x 20 cm quadrats within the plot (upper left corner, middle, and lower right corner). Subsampling reduces sampling time.

Procedure for Counting and Measuring Motile Invertebrates

1. To maximize efficiency with smaller sampling groups, motile invertebrates can be counted and measured at the end of the day. However, counting and measuring should be done in the field to allow for the return of invertebrates to their site.

2. Enter the initial information on the motile invertebrates data sheet (Form 5, Motile Invertebrates Data Sheet) with the appropriate headings: site, plot type, observer, date, collection time, and area sampled. IT IS CRITICAL TO CIRCLE THE CORRECT AREA SAMPLED. OTHERWISE, THE COUNTS CAN NOT BE USED TO CALCULATE DENSITIES.

3. For each photoquadrat type, count all individuals for each species collected within each plot and inspect for damage. Counts are divided into “damaged” and “undamaged.” For this protocol, damage refers to snails showing signs of repair after damage by a crab (center shell in Figure 38). This type of damage is indicative of failed crab predation. It consists of a notch of the shell lip that was previously removed by a crab and where this portion of the shell has regrown (Figure 38). Although it is an indirect measure, the abundance and proportion of damaged to undamaged snails provides an estimate of crab predation.

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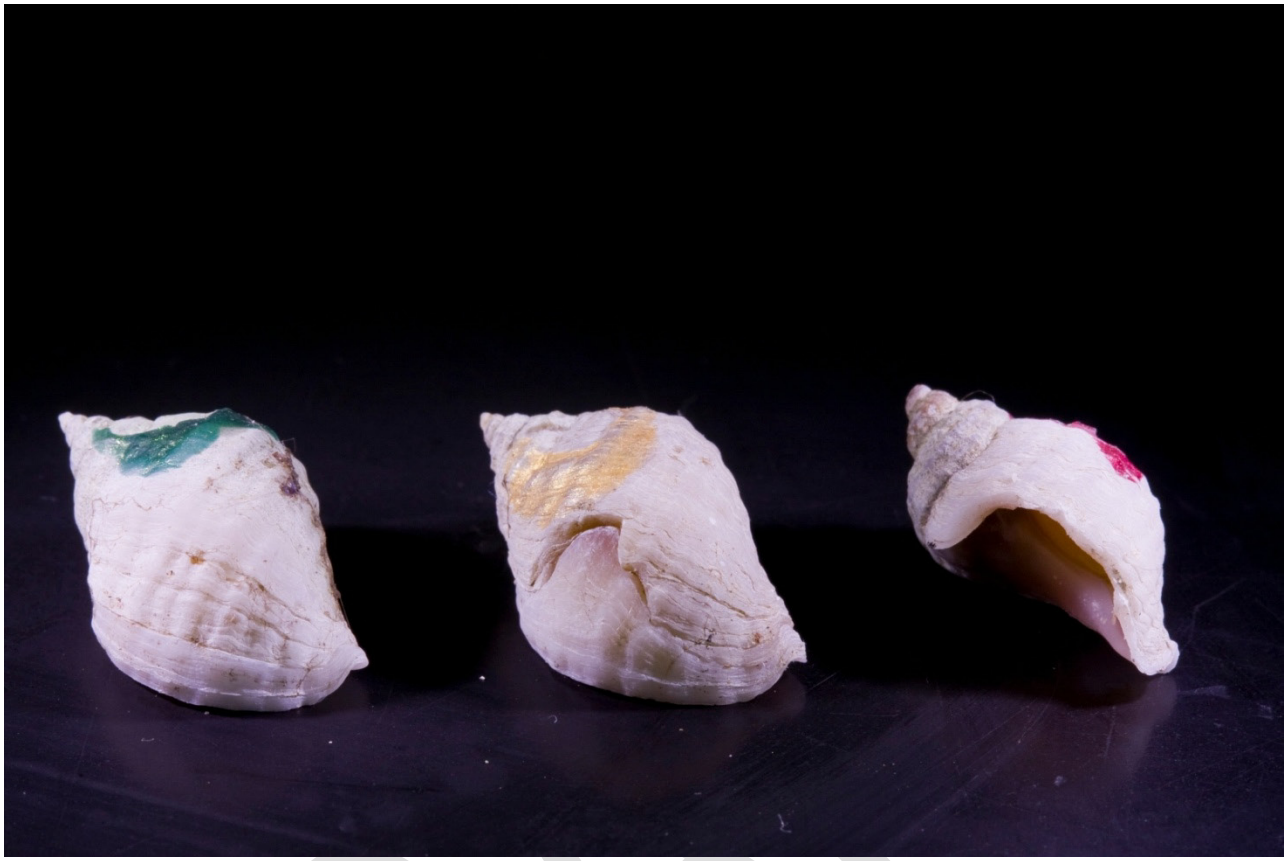

Figure 38. Representative shells of *Nucella lapillus* showing an undamaged shell (left), a damaged and repaired shell (center), and a recently damaged and unrepaired shell (right). Note the large chip that was previously removed from the center shell.

4. Record counts of damaged and undamaged invertebrates per species and per replicate on Form 5.

5. Using calipers, measure the length of the first 10 individuals encountered in the plot of each motile invertebrate species. Measure the length of limpets along the widest axis of the shell to the nearest 0.1 cm. For periwinkles and whelks, length is measured from the tip of the spire to the opposing shell edge to the nearest 0.1 cm. Enter measurements on Form 5.

6. Return all invertebrates to the intertidal zone.

Quality Control and Datasheet Management

1. While still at the site, check data sheet for missing information and legibility. Any questions should be clarified immediately with the recorder. Any variation to normal procedures or other observations should be noted briefly on the data sheet and on the daily log. The recorder will initial the data sheet at the appropriate location to indicate that the field check is complete.

2. File Form 5 with all other datasheets from the monitoring event in the appropriate binder.

SOP 14 – Tide Pool Transects

Version 1.01 (May 27, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	4/6/2009	J. Long	---	Original	1.00
1.00	5/27/2010	J. Long and B. Mitchell	Clarified procedures and added figure.	Changes requested by NPS.	1.01

This Standard Operating Procedure (SOP) summarizes the procedures for conducting sea star and sea urchin monitoring (Figure 39). This monitoring will be conducted during every full sampling trip. The species that are targeted by this SOP are echinoderms - the sea stars (*Asterias rubens* and *Asterias forbesii*) and the green sea urchin (*Strongylocentrotus droebachiensis*). However, all other sea stars and urchins will also be recorded. This SOP summarizes procedures for conducting the surveys and completing the data sheet.

Figure 39. Band transect for monitoring sea star and sea urchin abundance and size.

General Survey Considerations

Sea stars are important predators of invertebrates, especially mussels. Sea urchins are important herbivores, especially of kelp. Although both species will forage on rocky shores during high tide, they are most commonly found in the subtidal zone and in deep pools low in the intertidal zone (e.g. typically around red algae). Thus, we do not expect abundances of these echinoderms to correlate well with the target species in the photoquadrats that are higher in the intertidal zone. The primary goal of this SOP is to monitor changes in abundances and sizes of these echinoderms.

Unlike west coast sea stars like *Pisaster* spp., New England species are rarely observed out of the water. Thus, we will monitor these species in intertidal pools (maximum depth approximately 50 cm) that are low in the intertidal zone. The plots are not intended to quantify overall densities within a site, but rather to quantify the change in abundance and size of these organisms within fixed pools over time.

Procedures for counts and measurements

1. To survey a plot, wait until sea level is below the pool's water level. These pools are typically uncovered after the brown algae photoquadrats (*Fucus* and *Ascophyllum*) are uncovered, so the sea star and sea urchin monitoring will typically occur after the sampling of these plots. Of course, with very large sampling teams, this procedure can be carried out simultaneously with other procedures. When the pool is accessible, lay a transect tape between the two bolts. These bolts are spaced 10 m apart. Echinoderms will only be surveyed along a band transect between these bolts. Thus, for pools that are longer than 10m that continue beyond these bolts, echinoderms will not be surveyed beyond bolts.

2. Starting on one side of the transect tape, count every sea star and sea urchin falling below a one meter long pvc pipe held with one hand and extending perpendicular from the transect tape across the width of the pool. The observer should have boots (knee-high or waders) to allow him or her to walk along the shallow portions of the pool. The pvc pipe can also be used to push aside large kelp that obscures the pool's bottom and to collect echinoderms in deeper parts of the pools. Particular emphasis should be placed on searching for echinoderms in pool crevices and walls. Because water in pools can be very cold, a pair of fisherman or diving gloves makes this sampling more comfortable but may make collecting echinoderms for measurements more difficult.

3. While counting stars and urchins, collect the first 10 individuals of each species encountered for measurements.

4. In some pools (e.g. OTTPOI X3, aka "the cave of wonders"), sea urchin abundance may exceed 200. In these cases, it is useful to have a handheld tally counter. If these are used, be sure to check them prior to sampling as they are prone to malfunction after rusting.

5. Repeat the count of sea stars and sea urchins along the other side of the transect tape. Thus, the final area that is searched is at most 10 x 2 m (20 m^2). However, in many cases, pools are smaller than this area. In these cases, it is unnecessary to search for echinoderms in areas that are outside of the pools because these echinoderms are not found out of the pools. These counts should take approximately 15-20 minutes per pool with one sampler. Allocate search

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time accordingly so that the entire pool is sampled within this time frame. Note that sea urchins often display a clumped distribution. Record counts on the Sea Star and Sea Urchin Data Sheet (Form 3). For any species where zero individuals were found, be sure to record a zero on the datasheet. Otherwise, the pool will be considered incomplete/not sampled.

6. After counting, measure the previously set aside (step 3) stars and urchins to the nearest mm using a plastic pair of calipers. Sea stars are measured from the center of the disc to the tip of the longest ray (arm). Sea urchins are measured from one side of the test to the other (the diameter of the urchin, measured from side to side, excluding the spines). Record sizes on data sheet (Form 03).

7. Sampling time can be reduced by assigning one person to measure and one person to record measurements.

8. Return measured organisms to the pool.

Quality Control and Datasheet Management

1. While still at the site, check data sheet for missing information and legibility. Any questions should be clarified immediately with the recorder. Any variation to normal procedures or other observations should be noted briefly on the data sheet and on the daily log. The recorder will initial the data sheet at the appropriate location to indicate that the field check is complete.

2. File Form 3 with all other datasheets from the monitoring event in the appropriate binder.

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SOP 15 – Point-intercept Transects

Version 1.01 (May 27, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	7/7/2009	J. Long	---	Original	1.00
1.00	5/27/2010	J. Long and B. Mitchell	Clarified procedures	Requested by NPS	1.01

This Standard Operating Procedure (SOP) summarizes the procedures for monitoring point-intercept transects (Figure 40). This monitoring will be conducted during every full sampling trip. Each site contains three of these transects that extend from the high intertidal to the low intertidal. The species or substrates along these transects is recorded every 0.3 m. Data collected with this SOP will allow for an across-shore estimate of species cover and an estimate of the elevational range for each species detected. Both of these estimates should be particularly sensitive to factors related to climate change, including increasing temperatures and sea level rise.

Figure 40. Three point-intercept transects extending from the high intertidal (foreground) to the low intertidal (background).

General Considerations

The bolts for these transects were initially installed to range from the red algae zone (in the low intertidal zone) to above the high intertidal (approximately 1 m vertically, in areas that are typically dry during the high tide).

Because different sites have different slopes, maintaining this "vertical" distance will result in different numbers of points between sites. For example, even under a similar tidal regime, a gently sloping shore will have a longer transect, and therefore more points between high and low bolts, than a steep shore. This design was chosen to minimize the amount of site-specific information, e.g. sampling distances along transect tapes, needed during monitoring. Furthermore, the fixed plot nature of this protocol focuses on within-site changes through time rather than between-site differences. Although some MARINe protocols sample every 0.1 m along 10 m transects (e.g. surfgrass), we chose to sample every 0.3 m because many organisms can grow longer than 0.2 m (e.g. fucoid algae). A greater distance between sampling points should be less susceptible to natural variation in how these organisms are positioned on any given sampling date.

Procedures

1. Attach the starting clip (at zero) of a 50 m transect to the uppermost bolt of T1.

2. Extend the transect from the uppermost bolt to the two other T1 bolts (located in the mid- and low-intertidal, respectively). Bolts and tags are often covered or encrusted with algae and may be difficult to find, even with reference coordinates. Two or more people should aid in bolt location to assure it is done in a timely manner. If the transect bolts are not easily found (e.g. if observers are unfamiliar with the site), locate the reference bolts using the site coordinates. Once the area is identified, locate transect bolts using the reference distances and compass headings. Minimize disturbance when laying out meter tapes. If vegetation must be moved to locate marker bolts, return it to its original position.

3. Note that point-intercept transect monitoring will often begin before the tide has fully receded. When placing out the transect tape, if the tide is above the lowest bolt, stop at the mid bolt, score the transect to this point, and continue later to the low bolt. If the low bolt still cannot be located, or the waves are too large to continue, lay the tape out as accurately as possible, lining up with the lower bolt, extending the tape to the waters edge (tape may be washed away if laid out further). Continue to lay out the tape in small portions while surveying until reaching the low bolt.

4. Return to the top bolt. While walking along the length of the tape from high to low, position the tape along its length so that 1) the numbers are facing up to expedite scoring and 2) it follows a straight line (as viewed from above) connecting the high, mid, and low bolts while following the contour of the substrate. For example, the transect should move up walls and there should not be large sections of the tape that are lifted off the substrate. During windy conditions, it may be necessary to hold down the upper section of the tape as it is scored. Wave surge can rearrange algae along the transect depending on the extent of low tide and sea conditions. Try to survey the entire transect during a period when the tape is undisturbed.

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5. For transects extending over a pool, lay the tape across the surface rather than following the submerged topographic complexity of the pool.

6. Enter the following information into the Point Intercept Data Sheet (Form 4): site, date, recorder, observer, time, and transect number.

7. Starting with 0, identify the organism or substrate that lies at the top of the tape (the top of the tape is determined by an observer orienting themselves so that the numbers on the tape are right-side up) and directly perpendicular to tape marks every 0.3 m until the low bolt is reached. Score dead barnacle tests, dead mollusk shells, and other non-living substrates that are not "rock" or "sand" as "other substrates." Epoxy corner markers and bolts should be scored as "rock". When sand is present along the transect, score "sand" whenever the sand cover is 2 cm or deeper; otherwise score "rock" or the underlying core species. This is determined by probing with the index finger, with 2 cm roughly being the distance from the fingertip to the first joint. Note that this definition is different from the photoplot definition of sand.

8. Observers should be able to easily identify all of the species, species groups, and substrates found on Form 4.

9. Mark the corresponding two character code in the box under the appropriate number heading on the data sheet. Although there may be multiple organisms at a given point, it is important to only record the first species/substrate encountered (e.g. the top layer only). Algal epiphytes and encrusting algae are considered top layer organisms and should be recorded when present, not the host they cover. Each box should only have one species or substrate.

10. Record the location (distance from 0) of the mid- and low bolts on the data sheet. The mid-bolt location can be useful when the upper portion (high to mid bolt) is recorded prior to the tide receding to allow access to the low bolt. The tape can then be repositioned later when the lower portion is scored so that this distance falls exactly on the mid bolt.

11. On days with a lot of wind and/or waves, it is helpful to have two people work on a single transect line. While one person records, the other should follow the transect line, making sure it stays in line with the bolts and contours the ground as close as possible.

12. Repeat steps 1-11 for the remaining transects (T2, T3).

13. Take an overview photograph with transect lines in position.

Quality Control and Datasheet Management

1. While still at the site, check data sheet for missing information and legibility. Any questions should be clarified immediately with the recorder. Any variation to normal procedures should be noted briefly on the data sheet and on the daily log. After review, the reviewer will initial the appropriate line at the top of the data sheet.

2. File Form 4 with all other datasheets from the monitoring event in the appropriate binder.

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SOP 16 – Temperature Loggers

Version 1.01 (May 4, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	4/6/2009	J. Long	---	Original	1.00
1.00	5/27/2010	A. Kozlowski, B. Mitchell, and J. Long	Multiple changes to clarify procedures; several sections moved to other SOPs	Protocol update	1.01

Temperature is one of the dominant structuring forces in rocky shore communities. For most intertidal species, temperature and associated factors (such as desiccation) limit their upper distribution. Air temperature is known to be especially important to the survival of intertidal species. Unfortunately, the heterogeneity of air temperature at rocky shore sites is significant – primarily because of variability in shading, wind protection, ocean spray, and canopy density. Thus, air temperature is currently too expensive to monitor in an ecologically informative way. However, ocean water temperature can also influence the distribution of intertidal species and can be monitored cheaply because it is much more homogeneous within sites and even between sites within a location (but note that tidepool water temperature, in contrast to ocean water temperature, can be quite variable).

This protocol uses tidbit temperature loggers set to record temperature every hour. These relatively inexpensive temperature loggers provide a continuous temperature record of local water temperature (during high tides) and air temperature (during low tides). Recorded temperatures will be filtered using tide information to exclude temperatures outside of high tides (i.e. when the tidbits were recording air temperature). Additionally, these temperatures recorded by tidbits can be compared to temperatures recorded by offshore buoys. However, because the local temperature conditions may vary markedly from other available temperature stations (tide stations and buoys for water data, and weather stations for air temperature), local temperature data determined with tidbits may be valuable for interpreting other rocky intertidal information.

Tidbit deployment

1. Water temperature at each site will be recorded using three tidbit temperature loggers (ONSET corporation). Set tidbits to record water temperature every hour, but not to record battery life (See launch instructions included with tidbits). At these settings, new tidbits should record data for ~5 years. However, we recommend replacing tidbits every 3 years because data is difficult to retrieve from tidbits whose batteries are expired. See SOP 11 – Plot Maintenance, for schedule for replacing tidbits.

2. Data should be downloaded from tidbits once per year using a HOBO Waterproof Shuttle (Onset Corporation, U-DTW-1) with the corresponding coupler attached (COUPLER2-D; see instructions included with the shuttle). To download data, remove the shelter. Clean the tidbit with a finger or toothbrush so that the tidbit surface is clear of debris and organisms. We have not needed to unscrew the tidbit from the substrate to download data in the field. However, this can be done if necessary. Follow instructions for data download provided with the data logger. A single shuttle has space for downloading data from 63 tidbits. Care should be taken to not disconnect the shuttle from the coupler during data download. Data can be downloaded while the tidbit and shuttle are submerged.

Data processing

1. Upload temperature data from shuttle to computer (see instructions with shuttle).

2. Import tidbit data, into database. The database is currently being developed (contact Brian Mitchell or Adam Kozlowski). The database will filter these data to only show temperatures when the tidal height was greater than +2 m. This focuses the data on the times when the tidbits were submerged and recording water temperature. This section will be added to significantly as the front-end components of the database are developed to handle the import and the filtering of tidbit temperature data.

A note about tidbit data

During protocol development, an individual sensor provided two anomalous readings. During a cold February, this sensor indicated an unusually warm temperature in February (15°C warmer than the other two tidbits at the site) and an unusually cold temperature in September (below freezing while the other tidbits provided normal readings). When asked about this, the makers of tidbits (ONSET) did not provide a reasonable explanation to account for these anomalous readings (their hypotheses included sabotage, hard contact, and lightning strikes). Otherwise, this tidbit provided temperatures similar to the other two tidbits at the site. This is probably not a major concern because this is just one measurement from two separate days. However, this problem suggests that temperature data should be inspected. In these cases, the outliers were extremely obvious.

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SOP 17 – Field Log

Version 1.01 (May 27, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	7/7/2009	J. Long	---	Original	1.00

This Standard Operating Procedure (SOP) summarizes the procedures for completing the field log. This form summarizes the site-wide conditions at the time of sampling. These conditions may influence some of these species monitored with these protocols (e.g. motile invertebrates). Thus, these data may be critical to distinguishing variation surrounding these factors versus long-term change. This field log is a modification of the field log used by MARINe (Engle 2006) that reflects the change in species from the west coast to New England. An annual check should be performed of the MARINe form to determine if changes have been made to their protocol that might also be changed in this protocol.

Completing the Field Log

1. The Field Log Data Sheet (Form 7) should be completed as close to the end of sampling as possible. Preferably, it should be completed with the input of as many observers as possible.

2. The first page of Form 7 includes spaces to describe "Weather and Sea Conditions," "Substratum Changes," and "Debris and Pollutants." Refer to the third page of Form 7 for guidance about different categories of each.

3. Because birds and mammals are not explicitly quantified with these protocols, and therefore it may be impossible to recognize individuals, only record the maximum number seen at any one time during sampling. Record bird species if known.

4. Report any plot marker or repair on page 1.

5. On page 2, categorize the abundance, health, and recruitment of the dominant species (per instructions on page 3). During protocol development, we found that we were only able to comment on recruitment for barnacles – probably because it was watched with specific protocols.

MARINe Guidelines for Completing the Field Log

The rest of the text in this section, from Engle (2006; pages 18-20), describes the current MARINe guidelines for completing the Field Log. This text should be updated annually to reflect changes in the MARINe protocol

3.1.1 Completing the Field Log and Conducting Site-Wide Reconnaissance

Core Procedure: Field log information and site reconnaissance characterization are recorded on the two-page field log data form (Form 1a,b,c: Prototype MARINe Rocky Intertidal Field Log). Field log **data that must be recorded (required by database) include site, date, survey time, low tide time and height, and names of survey participants.** Core physical data that should be recorded include weather and sea conditions (swell/surge, wind, rain, recent rain, and water temperature), substratum changes (sediment level, scour, rock movement), and debris/ pollutants presence (plant wrack, driftwood, shells, dead animals, trash, and oil/tar). Relevant biological features that should be recorded include site-wide presence of birds, marine mammals, or humans; and abundance, appearance, and recruitment of target species (primary emphasis) and other core species (secondary consideration). To facilitate standardization and data management, many data entries are restricted to specific category codes (e.g., low, med, high). These codes and other terms are defined in Form 1c. Any additional information can be written as notes. All **data entry blanks on the field log should be filled in with a code, actual value, notes, or a dashed line indicating "no data".**

Physical Conditions: Emphasis is placed on **conditions that could affect quality of sampling**. Some physical conditions recorded in previous years (e.g., cloud cover) were deemed not relevant because the site is visited only 2 days a year. Water temperature can be useful to compare with satellite sea surface temperature records or buoy/thermister data.

Birds and Mammals: Core categories are listed and should be scored. Record maximum number seen at any one time during the sampling, preferably upon arrival at site prior to sampler disturbance. Other more specific categories or species may be added; however, this requires specifying a core taxon for "lumping" the more specific entry during database entry unless the species/higher taxon has officially been designated as an "optional species" (see above for optional species discussion). For example, a bird recorded as "crow" would be lumped with "other birds" during database entry unless the monitoring group designated "crow' as an optional species. Only score species within the defined site, either onshore or within 50 m of shore. Note relevant behaviors.

Humans: Record **maximum number of people seen at any one time during the sampling**. Especially check at low tide. Separate counts for people on the site reef and on nearby sand beach. Note relevant behaviors.

Species Conditions: Give **highest priority to scoring target species**, particularly those monitored at the site. Core species should be scored if possible or indicate "no data". Other species can be added for scoring if desired; however, they will not be entered in the MARINe database unless they have been designated as "optional species" (see above). To score, **consider the site-wide condition of the species within its optimum zone(s).** It is not practical to score for turf or other non-discrete algae and most small invertebrates where determination would be too time-consuming.

Guidelines:

On a descending tide, it may be practical to start the field log and site reconnaissance upon first arrival at the site because many observations can be recorded before the tide is low enough for performing other tasks. Additional notes can be added later during the monitoring, or even afterwards, when more time is available to organize thoughts or confer with others. The **reconnaissance may take 30-60 min by 1 person** (less time if 2 or more persons participate), depending on site layout and complexity. If time is short, jot notes on blank paper, then transcribe to the data sheet shortly after the survey.

Useful things to note include: general appearance of algae and encrusting animals, damaged patches of reef, signs of disease, **changes observed since last visit**, absence of animals or algae that might occur at the site, whether anything was done different from the standard methods, and problems encountered with equipment or locating plots.

Variations from and Additions to Core Procedures:

Plot Marker Loss/Repair and Other Notes: These are **optional categories** that provide for additional information as desired. For example, under plot markers, note any problems with lost markers or difficult to find plots, record any repairs completed or newly installed bolts or plots. Identify problems that need to be fixed on the next visit. This section does not need to be entered in database, but can be checked when planning the next sampling trip. Notes on physical and biological conditions will contain useful information that should be entered in the database (as text entries) if possible.

Quality Control and Datasheet Management

1. While still at the site, check data sheet for missing information and legibility. Any questions should be clarified immediately with the recorder. Any variation to normal procedures or other observations should be noted briefly on the data sheet and on the daily log. The recorder will initial the data sheet at the appropriate location to indicate that the field check is complete.

2. File Form 7 with all other datasheets from the monitoring event in the appropriate binder.

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SOP 18 – Field Work Wrap-up

Version 1.00 (May 3, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	5/3/2010	B. Mitchell and J. Long	---	Original, plus incorporates former digital photo management SOP	1.00

The following items must be attended to immediately after each sampling event:

- Contact the individual with your trip plan to notify them that you have safely returned from the field.
- Download data from camera cards and Hobo shuttle to a computer not going into the field. Remove any completed paper datasheets from clipboards and store them together in a non-field location.
- Complete the digital photo file management procedures (see below).
- The following items should be rinsed with freshwater and allowed to air dry: digital camera housing (especially the surface covering the lens, the dial knobs, the clasps, and the surface covering the display), transect tapes (especially the buckle at the start of the tape), and the Hobo shuttle. Failure to properly rinse equipment may lead to failure (e.g. rusting buckle on transect tapes).
- Remember to make scheduled maintenance and periodic operational checks of equipment between sampling events. Clean, count, and repair or replace damaged/missing items. For equipment that cannot be repaired, adequately mark it as 'broken' so that it is not accidentally brought into the field.
- Recharge batteries for camera, strobes, impact driver, and GPS units.
- Verify that the field equipment includes a sufficient number of blank data forms and that maps and coordinate lists have been organized for the next site.

Digital Photo File Management

1. Photos should be labeled immediately upon returning from the field.

2. For photoquadrats and barnacle settlement plots, each file should be named so that the site, plot type, and sampling date are identified. This will facilitate analysis and storage. Images are named according to the following:

   Sitename_plottypeandreplicate#_monthandyearofmonitoringandimageidentifier

   Where the 6 letter code is used for site name, a three letter code is used for plot type (asc=*Ascophyllum*, bar=barnacles, fuc=*Fucus*, mus=mussels, red=red algae, and set=barnacle settlement), replicate # is 1-5, the first three letters of the month sampled, the full year of monitoring, and image identifier is either a or b. Each plot is photographed twice using different settings. This provides a choice of two images to be scored at a later data. When labeling the images, the best image is assigned the identifier "a" and the other photo is assigned a "b."

   An example of an image name is:

   greisl_asc4_jun2009a.jpg

3. For overview photos, images are named as follows:

   Sitename_plottype_monthandyearofmonitoringandimageidentifier

   There are two differences between how these are named compared to the photoplots. First, replicate # is not informative for overview photos so it is not recorded. Second, the image identifier now refers to where in the sequence of overview photos of a specific plot type an image was recorded (in alphabetical order). An example of an image name for overview photos is:

   greisl_asc_jun2009e.jpg

   In this case, this would be the fifth overview photo (e=5th letter) of the *Ascophyllum* plots.

4. After naming all images, move these to their appropriate folder. Currently, the photos are stored on external hard drives. Photos are stored in the folder labeled "Photos." Within this folder, they are filed according to the following hierarchy:

   Barnacle Settlement Photos:

   Year/Sitename_year/Barnacle Settlement

   Photoquadrats:

   Year/Sitename_year/Photoquadrats/Plot type

   Overviews:

   Year/Sitename_year/Overviews

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SOP 19 – Scoring Photoquadrats

Version 1.01 (May 4, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	7/7/2009	J. Long	---	Original	1.00

Scoring Photoplot Photographs

1. Open photograph to be scored in Adobe Photoshop. Note that each plot should have two photographs because it was shot twice. The clearer photograph should have been identified during file management (SOP 18 – Field Work Wrap-up) by placing the letter "a" at the end of the file name. For example, the photograph with the following name:

   greisl_asc4_jun2009a.jpg

   was previously determined to be better quality than the photograph with the following name:

   greisl_asc4_jun2009b.jpg

   However, if the second image is clearer, then the file names should be swapped, and the new "a" file should be scored.

2. While in Adobe Photoshop, also open the file "rectanglegrid.psd." This file is on the NETN network drive, at Z:\PROJECTS\MONITORING\Rocky_Intertidal\5_Data\Data_Files\201002_From_Jeremy\ACAD\TEMPLATES. The file contains an image of a yellow grid consisting of framed 10 x 10 lines that creates 100 intersection points.

3. Copy the grid (Select>All, Edit>Copy) and paste the grid onto the photograph to be scored.

4. Transform the grid layer so that the corners of the grid align with the inner corners of the quadrapod quadrat seen in the photograph to be scored. To transform the layer, select: Edit>Transform>Skew. Then, drag each grid corner to the respective quadrat corner.

5. The above instructions create a photoshop document with two layers: the plot image layer and the grid layer. The grid consists of 100 intersecting points. The primary goal of this SOP is to identify the species or substrate below each point.

6. To facilitate scoring, it is useful to highlight the grid with Adobe Photoshop's magic wand tool, and then to hide the grid layer. This creates an outline of the grid and can make it easier to see what lies directly beneath the intersection points.

7. Using Form 6 (or the data entry form in the database, when it becomes available), record the species present under each point. It is useful to print out this form and put check marks next to each species each time it is encountered.

8. After an image is scored, confirm that the number of species/substrates identified add up to 100. If it does, proceed to the next step. If not, the image must be rescored. Because rescoring an entire photo because of a missed point is extremely time consuming, it is useful to score the intersection points in rows of 10, confirming that 10 species/substrates were identified in each row. Using this technique, a missed point would require rescoring an individual row (10 points) rather than the entire photo (100 points).

9. Save the Photoshop document just created (plot image + grid) as a jpeg image with both layers visible. This may be useful to help people understand exactly where the points that were sampled were located. The image should be saved with a "g" (for grid) at the end of the name in the same folder as the original plot photo. For example, the file from above would be relabeled:

   greisl_asc4_jun2009g.jpg

Scoring Barnacle Settlement Plots

1. Open photograph to be scored in Adobe Photoshop. Note that each plot should have two photographs because it was shot twice. The clearer photograph should have been identified during file management (SOP 18 – Field Work Wrap-up) by placing the letter "a" at the end of the file name. For example, the photograph with the following name:

   greisl_set4_jun2009a.jpg

   was previously determined to be better quality than the photograph with the following name:

   greisl_set4_jun2009b.jpg

   However, if the second image is clearer, then the file names should be swapped, and the new "a" file should be scored.

2. While in Adobe Photoshop, also open the file labeled "barnaclebox.psd." This file is on the NETN network drive, at Z:\PROJECTS\MONITORING\Rocky_Intertidal\5_Data\Data_Files\201002_From_Jeremy\ACAD\TEMPLATES. The file contains an image of a red box.

3. Copy the box (Select>All, Edit>Copy) and paste it onto the photograph to be scored.

4. Transform the box layer. Move and rotate the box so that an edge of the box is parallel and directly adjacent to the ruler in the image. Scale the box (Edit>Transform>Scale) so that this edge of the box is 10 cm in length.

5. Rotate the box so that it is parallel to the black frame that is around the two bolts in the photograph.

6. Place the box in the center of the settlement plot.

7. Barnacle counting is facilitated by hiding the area of the image outside of the box. To do this, select the box with the magic wand tool. Then choose the inverse of this selection. Switch over to the main layer containing the settlement plot image. Fill in the area around the box by choosing Edit>Fill. Then, hide the layer containing the barnacle box. These steps will create a 10 x 10 cm square in the center of the plot where the barnacles can be counted.

8. In a new layer, place a dot over each of the barnacles within the 10 x 10 cm box. As with any quadrat sampling, only place dots (count) over barnacles that are more than 50% within the box.

9. Save the dot layer as a jpeg with the following naming scheme:

   greisl_set4_jun2009dots.jpg

10. Open the dot image in ImageJ (a free program available at http://rsbweb.nih.gov/ij/).

11. Convert the image in ImageJ to binary, black and white (select Process>Binary>Make Binary).

12. Count the dots using ImageJ. Select Analyze>Analyze Particles.

13. Record dot density as the number of barnacles per 100 cm2 (10 x 10 cm area).

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SOP 20 – Season Wrap-up

Version 1.00 (May 3, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	5/3/2010	J. Long, A. Kozlowski, and B. Mitchell	---	Original	1.00

Equipment Cleaning and Storage

As soon as possible after the last site is sampled, equipment with metallic parts should be thoroughly cleaned to prevent rusting. This cleaning should include spraying sensitive parts with a lubricant like WD40. Lubricant should be applied to buckles on transect tapes, bolts on scrapers, and exposed screws/bolts on drills and nut drivers. In addition, for safety purposes, the drill should be drained of the gas/oil mixture.

Data Sheet Management

1. Hole punch all data sheets for placement in a three-ringed binder.

2. Arrange data sheets in the following order: Field Log (Form 7), Photoquadrat drawings (Form 1), Motile Invertebrates (Form 5), Point Intercept (Form 4), and Band Transect (Form 3). Additionally, the photoquadrat drawings and the Motile Invertebrates should be in alphabetical order (ASC, BAR, FUC, MUS, RED). The Point-Intercept and Band Transect sheets should be in numerical order. This arrangement will make it easier to find specific data sheets at a later date.

Temperature Data Management

Download surface temperature data annually from each site's corresponding buoy on the Gulf of Maine Ocean Observing System (GoMOOS) website (www.gomoos.org/data/recent.html). Buoy data will provide temperature data that may be important to invertebrate recruitment for species with larval dispersal (e.g. barnacles, mussels, and some periwinkle snails). The nearest buoys to each NETN Rocky Intertidal Monitoring site are listed in Table 42. GoMOOS also reports water temperature at coastal tide stations at Bar Harbor and Boston, but the offshore data will likely be more useful for understanding conditions encountered by larvae.

Table 42. Nearest oceanographic data buoy to each Rocky Intertidal Monitoring site.

Monitoring Site	Buoy Location	Buoy Code
All BOHA sites	Boston Harbor	NOAA44013
All ACAD sites	Eastern Maine Shelf	GoMOOS I01
MCI-METISL	Central Maine Shelf	GoMOOS E01
MCI-PETMAN	Eastern Maine Shelf	GoMOOS I01

Process steps for downloading surface temperatures from GoMOOS website:

1. Before downloading any buoy data first check the latest version of the NETN Rocky Intertidal Monitoring Database to see that surface temperature data have not already been uploaded for the time period of interest for your location (tbl_Temp_Buoy).

2. Navigate to the Buoy Conditions Graphing and Download page of the GoMOOS website (http://www.gomoos.org/gnd/)

3. Introduction Tab: 'Click here to begin' button.

4. Data Types Tab: Use dropdown menus to populate the available fields with the following values:

5. Data Type = Water Temperatures

6. Specify = Hourly

7. Unit = Degrees Centigrade

8. 'Add Data Type' button → Continue

9. Time Periods Tab:

10. Output time zone = Eastern Time EST / EDT

11. Enter time interval or custom time to obtained desired time interval

12. 'Add Selection ' button → Continue

13. Locations Tab: Select the buoys from Table 1. For the GMOOS buoys, only check the 1m depth box and click the 'Update Selection' button.

14. Click 'Create report now' button

15. Select a format for your report = Text File – CSV

16. Click 'View report now' button and choose a file name and location to save it

Process steps for uploading surface temperature data from buoys into the database:

DETAILS ABOUT BRINGING THIS FILE INTO THE DATABASE WILL BE ADDED AFTER THE DATABASE IS COMPLETED.

Ensure that tidbit data, buoy data, time of measurement, and tidal height data are all imported into the database. The database is currently being developed (contact Brian Mitchell or Adam Kozlowski). The database will filter the data to only show tidbit temperatures when the tidal

height was greater than +2 m. This focuses the data on the times when the tidbits were submerged and recording water temperature.

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SOP 21 – Data Analysis and Reporting

Version 1.00 (May 4, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	5/3/2010	B. Mitchell and J. Long	---	Original, Based on KLMN Rocky Intertidal Data Analysis and Report Writing SOP v.1.00	1.00

This Standard Operating Procedure (SOP) gives important guidelines for completing reports for the Rocky Intertidal Monitoring Program. This SOP discusses annual reports and trend reports and includes procedures on when, where and to whom the reports should be electronically submitted.

General Considerations for Writing Reports

Annual reports are the responsibility of the Project Manager. The reports' main purpose is to archive the data and procedures for the year(s). Analysis and Synthesis or Trend reports are written every five years and are meant to be a multiyear summary showing data relevance. Trend reports will also be the responsibility of the Project Manager with assistance from the NETN Program Manager or other designated staff. Annual reports and trend reports are subject to a thorough peer review process that includes park staff.

It is a recent objective of the National Park Service (NPS) Inventory and Monitoring (I&M) Program to streamline annual reporting; best efforts should be made to comply with new policies. Annual reports and trend analysis reports will use the NPS Natural Resource Publications template, a preformatted Microsoft Word template document based on current NPS formatting standards. Both reports should be completed using the Natural Resource Technical Report template. This template and documentation of the NPS publication standards are available at: http://www.nature.nps.gov/publications/NRPM/index.cfm.

Procedures for Annual Reporting

1. Complete the annual report in a totally digital format. The annual report will be published as a technical report for the NETN and therefore should follow the standard, accepted format for a national technical report. If the report has pages generated as Access reports, you will need to run the report while in Access and **save it with a .snp file extension**.

2. Files should follow the NETN file naming conventions: Title_YYYYMMDD. Subsequent versions of the document should change the date extension.

4. Collate document together, with appendices (use of templates posted on the NRPM web site is highly recommended), and submit draft manuscript and the NRPM Manuscript Submittal Form and Checklist via email to the NETN Program Manager.

5. The NETN Program Manager or NPS Key Official (if not the NETN Program Manager) determines whether or not additional peer review is necessary based on the manuscript content and the quality of the initial reviews, and if deemed appropriate, arranges for and oversees additional peer review. The NPS Key Official determines whether or not a management review is necessary, and if so, selects an appropriate reviewer who can verify consistency with NPS policy, clear and appropriate relation to NPS policy, and appropriate treatment to sensitive issues.

6. Once the Key Official is satisfied that reviewer comments have been adequately incorporated and the report meets the minimum standards for the series, the NETN Science Communication Specialist will review the formatting of the report and make technical editing suggestions.

7. Once all technical edits have been addressed, the report is approved for publication in one of the series and the NETN Science Communication Specialist obtains a report number as well as an NPS Technical Information Center (TIC) identification number following the guidance on the NRPM web site.

8. Once the report numbers are added, the NETN Science Communication Specialist will produce a portable document format (PDF) version of the publication, order printed copies, and post it on the NETN web site. A record for the report will be created in NatureBib. Species listed in the annual report will be compared to park species lists in NPSpecies to ensure all species are included on the lists.

Procedures for Trend Reporting

1. Complete a trend report every five years (or when analyses are warranted), again using a totally digital format. The trend report, like the annual report, will be published as a technical report for the network and therefore should follow a standard, accepted format for a national technical report. The use of templates posted on the NRPM web site is highly recommended.

2. The Project Manager is responsible for ensuring standard NPS font and graphic guidelines are followed and for checking report accuracy and completeness. If report pages are generated as Access reports, run the report while in Access and save it with a .snp file extension. This will assist when it comes times to save the entire report in PDF format.

3. The report is written at a general audience level and uses a graphic presentation of the data where possible. Since the data have already been tabularized and summarized in the annual report, trend reports should concentrate on important issues and changes observed since the monitoring program began.

4. Naming conventions for trend reports should follow a similar format to the annual report described above.

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5. After an initial review by internal staff and incorporation of revisions/comments, submit trend report for review to the NETN Program Manager, and any additional experts that could provide critical input to the report.

6. Once reviews are complete, follow steps 3 to 7 under the annual reporting section of this document.

Components of Annual and Trend Reports

The general outline of the annual and trend reports should include:

1. A brief Introduction section describing the project along with the goals and objectives.

2. A Methods section detailing data collection procedures and analytical techniques; this may change little from year to year but should still be included as part of each year's report. The section should highlight any changes from previous methods. For annual reports, describe any logistic problems that were encountered and provide suggestions for preventing or coping with similar problems in the future.

3. A Results section that describes the content of the summary tables and figures (see data analysis in next section).

4. For annual reports, graphs or tables showing current values compared to the average results from previous years. For trend reports, include graphs showing trends in the mean counts of the most common species detected.

5. A brief Discussion section that highlights and interprets any notable findings, such as detections of unexpected or invasive species, unexpectedly large changes in species abundance patterns (>50% change), or factors such as unusual oceanic conditions that might have affected results.

6. An Acknowledgements section thanking individuals and organizations who contributed to the field season or the report.

Data Analysis

To examine variation in the abundance of target species in space and time, summary statistics (mean and standard error of the mean) for all sites and sample periods are calculated and graphically plotted. Linear modeling (regression, ANOVA, ANCOVA, as appropriate) procedures are used to assess temporal patterns of abundance for each of the target species at each site (Miner et al. 2005). In the models, time (sample) is included as a covariate. An alternative statistical model that is probably more appropriate for time series data is a random effects (hierarchical) model, where each site is considered a random effect. Comparisons of the community dynamics among the sites are used to track changes within each park or refuge, and can potentially be integrated within the broader sampling efforts of MARINe. This collaboration provides more power to evaluate local changes in the context of a broader system, which is able to consider large-scale changes in the environment such as geographic variation in climate.

Statistical analysis for the status and trend reports will initially be similar to the trend reports completed for Cabrillo National Monument's rocky intertidal program (Becker 2006). Details of

these analyses can be found in the Cabrillo National Monument Trend Report and are paraphrased as follows. The same number of fixed plots is established in each zone using a random, stratified experimental design appropriate to the highly patchy habitat (Miller and Ambrose 2000). Basic trends of percent cover, averaged by plot type, are graphed for all target species for photoplots (e.g., barnacles, mussels, *Ascophyllum*, *Fucus*, and red algae), and band and point-intercept transects. In order to minimize variability, photoquadrat target types are not pooled when analyzed. For example, the percent cover of mussels is considered only in mussel plots. Photoquadrats and line transects are all "fixed," or measured in the same location every season.

The benefit of this sampling design is that it limits some of the natural variability in the system that can obscure important trends in the data. However, the tradeoff is that it is not possible to extrapolate trends in the plots to the whole area without using additional information about the area (Miller and Ambrose 2000, Murray et al. 2006). In addition, data from the same place at different times are not statistically independent and therefore the types of statistical analyses appropriate for this study are limited (Murray et al. 2006). In order to determine if there are differences between plots in zones, or between the trends in the plots in zones (a "Zone x Time" interaction effect), a repeated measures ANOVA will be conducted on all of the trends. The analysis is conducted using time as the within-subject variable (dependents), zones as the between-subject variable (factors) and cover as the response variable (independents). If a zone/time interaction is found, the zone and time analyses become meaningless (Underwood 2002).

If there is no significant ($p < 0.10$) zone effect or zone/time interaction for a given species, all plots from all zones are averaged into a single trend for the whole park. If there is a significant difference in the time effect among the zones, the trends for each zone are considered separately. This method has a potential shortcoming, in that lack of a significant result is not evidence of a lack of interaction. An alternative and more defensible approach would be the use of a statistical equivalence test. Trends are examined using a regression analysis. For each taxon, the goodness of fit (r^2) of the linear, second, and third-order polynomial are determined. The regression descriptive statistics (slopes and intercepts) are also reported. The log-likelihood and Akaike's Information Criterion (AIC) should be computed for each model, and the appropriate model selected according to model selection guidelines (Burnham and Anderson 2002). Alternative trend detection methods, particularly non-linear methods like piece-wise regression and SiZer (Sondregger et al. 2009), should also be considered.

Creating Summary Charts

Create annual summaries for the park and refuge sites for:

- Photoquadrats (species cover)
- Motile invertebrates (including mean numbers and mean sizes, with standard errors)
- Sea stars and sea urchins (mean numbers and mean sizes, with standard errors)
- Barnacle recruitment

- Point-Intercept data (standardized range, median, and 25th and 75th percentiles for key species). Range is standardized such that the lower bolt is 0.0 and the upper bolt is 1.0. This standardization permits comparisons of range within site across time. However, because the bolts were placed at each site with respect to the dominant species zones and rock topography, this standardization alone does not provide information about the absolute range of each species.

- Sea temperature data (weekly or monthly mean, standard error, max, and min.)

Summary Table and Trend Graph Examples

Below are examples of a photoquadrat summary (Table 43) and a summary of motile invert counts and size frequency (Table 44). Example trend graphs of acorn barnacles from the MARINe program (Figure 41) and from Redwoods (Figure 42) are also included.

Table 43. Photoplot summary of the mean percent cover by zone at Scorpion Rock, Santa Cruz Island, Spring 2004 (five plots/zone). (Channel Islands National Park rocky intertidal monitoring data excerpt.)

Zone	Bare Rock	Barnacle	Tetra-clita	Endo-cladia	Hespero-phycus	Silvetia	Mussels	Turf-weed	Leaf Barnacle	Misc Algae	Misc Animal	Other
Barnacle	36.4	17.2	0.0	25.8	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.4
Endocladia	28.4	4.0	0.4	53.8	0.0	0.2	1.4	0.0	1.4	10.0	0.2	0.2
Mussels	24.2	10.4	16.4	2.6	0.0	0.0	29.4	1.0	0.2	12.8	1.8	1.2
Tetraclita	55.4	3.6	11.4	3.8	0.0	0.0	13.4	0.0	3.0	7.2	1.6	0.6
Hespero-phycus	40.4	0.4	0.0	23.8	20.8	11.0	0.8	0.0	0.2	2.6	0.0	0.0

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Table 44. Motile invertebrate (A) size frequency measurements (mm) and (B) counts for Scorpion Rock, Santa Cruz Island, Spring 2004. (Channel Islands National Park rocky intertidal monitoring data excerpt.)

A.

	Nucella emarginata	*Acanthina spp.*	*Tegula funebralis*	*Ceratostoma nuttali*	*Ocenebra circumtexta*	*Lottia gigantea*
Count	8	19	4	1	84	8
Average size	17	16	17	29	12	41
Minimum size	11	7	15	29	4	12
Maximum size	22	22	19	29	36	63

B.

Zone	**Barnacle**					**Endocladia**				
Plot #	**801**	**802**	**803**	**804**	**805**	**806**	**807**	**808**	**809**	**810**
Lepidochitona spp.							2	1		
Nuttalina spp.								1		
Fissurella volcano										
Pachygrapsis					4			3	2	
Pagurus spp.										
large limpets(>15mm)										
S. purpuratus									1	
Amphissa versicolor										
Nucella emarginata	1						3			
Acanthina spp.			1		3			1	2	
Tegula funebralis						1				
Ceratostoma nuttali										
Ocenebra circumtexta			1			2	2	3	5	8
Lottia gigantea										
Pisaster ochraceus										
Littorina spp.	325	2563	413	1363	938	253	197	253	344	1225
subsample1	3	94	18	48	18	41	24	56	75	37
subsample2	9	77	11	31	24	16	20	22	14	42
subsample3	14	34	4	30	33	24	19	3	21	19

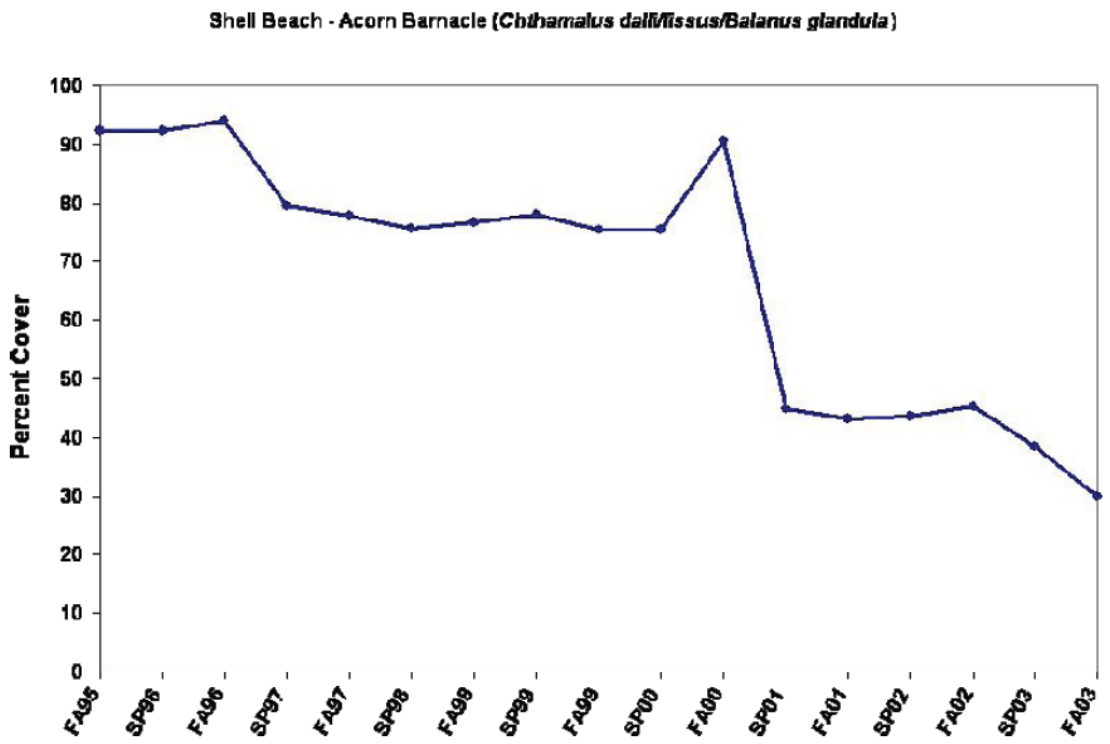

Figure 41. Example trend graphs from nine years of MARINe data for Acorn Barnacles *Chthamalus dalli/fissus/Balanus glandula* at Shell Beach in San Louis Obisbo County (from http://www.marine.gov/).

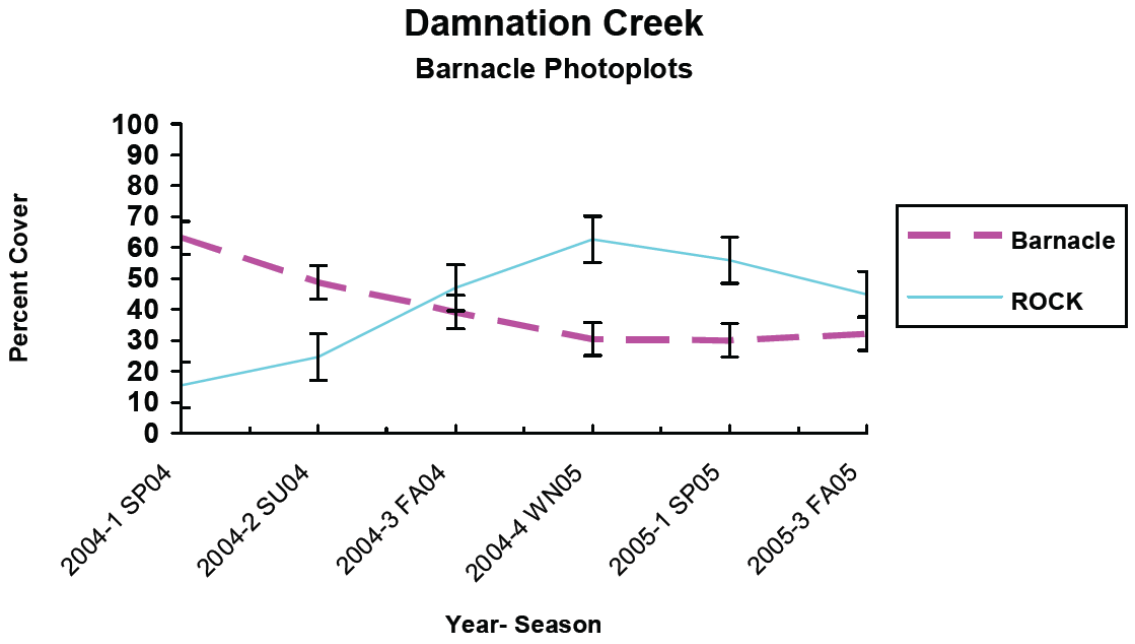

Figure 42. Example graph from two years of percent cover data for Acorn Barnacles *Chthamalus dalli/fissus/Balanus glandula* at Damnation Creek, RNSP.

Literature Cited

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SOP 22 – Procedures for Future Consideration

Version 1.01 (May 27, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	5/5/2010	B. Mitchell	---	Original	1.00
1.00	5/27/2010	J. Long and B. Mitchell	Revised to incorporate suggestions from J. Long	Protocol revision	1.01

This SOP documents procedures that have been considered or are being considered for future implementation as part of the Rocky Intertidal protocol, but are not incorporated at this time.

Procedures Being Considered for Future Implementation

Enhanced Point-Intercept Transect

The point-intercept transect method was selected because of the time constraints associated with this protocol (e.g. a desire to sample a site during a single low tide). If time no longer constrains monitoring, perhaps because of increased volunteer participation or because sites are sampled on multiple days, then a more sophisticated approach could be adopted. For example, the protocol would be improved by any technology (e.g. RTK-GPS) that would allow a more precise determination of specific points that could be revisited on subsequent sampling trips. Pete Raimondi is currently using this approach to monitor elevational ranges of intertidal species using his "SWAT" group.

Alternatively additional bolts could be added to all point-intercept transects to make the measurements more repeatable. Bolts every 5 m should produce a more consistent sample. In addition, more bolts in the lower portion of the transect will reduce the amount of data lost when the bottom bolt cannot be reached.

RTK-GPS Surveying

Use of RTK-GPS to survey the exact location and height of all bolts every 5-10 years will provide valuable data for studying how changing sea level affects the plots (and particularly the point-intercept transects).

Timed Search – Invasives and Other Species

Adding a timed search (15 to 30 minutes) for invasive species and other species not sampled in the protocol (e.g., crabs) would provide useful presence/absence data as well as semi-quantitative data on abundance. A list of timed search target species (e.g., invasive and native crabs) would need to be developed, and crew training would need to cover identification and likely habitats for each target species.

Crab Monitoring

Crabs are an important component of rocky shore communities given their direct and indirect effects on sessile (e.g. mussels) and motile (e.g. gastropods) invertebrates. Some possibilities to consider would be either 1) trapping experiments to determine how the number of crabs caught changes through time or 2) tethering experiments to examine the mortality of crab prey through time. Crab monitoring could also be part of a timed search, but it is unclear whether a timed search will give consistent results for crabs.

Understory Species

The protocol currently does not assess or monitor understory species, like crustose and coralline algae. Possible methods include moving algae to expose maximum understory and taking and analyzing another photoquadrat picture, or adding a grid sampler to get 25-50 points of species ID's (keeping this to recognizable target species and groups). The MARLIN program (http://www.marlin.ac.uk/bacs.php) may have some useful methods.

Procedures That Will Not Be Implemented

Mussel Recruitment

Use of an artificial substrate left in the field for a year at a time (or deployed when barnacle plots are scraped) can be used to gather data about mussel recruitment. However, the consensus is that this approach is not effective at catching mussel recruitment. Researchers who have used "tuffy" balls replace them weekly due to the extremely high post-settlement mortality.

Shell Thickness

Measuring the shell thickness of one or more species of motile invertebrate molluscs would be interesting given the potential for this trait to be altered by temperature, chemical cues from crab predators, and ocean acidification. However, because all of these variable are expected to change, it may be difficult to identify single responsible factors. In addition, this measurement is time consuming. Some snail thickness measurements were made at ACAD and BOHA in 2008.

Ocean Acidity:

Deploying plaster blocks of uniform size and shape (deployed when barnacle plots are scraped, and collected when plots are sampled) could provide an estimate of effects of increasing ocean acidity on wildlife. Blocks would be weighed and/or measured before and after deployment to determine loss of mass. However, the effects of wave action and temperature and small variations in composition of the plaster could affect the results. This would be more effective as a laboratory study using seawater collected from different locations.

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The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS XXXXXX, Month 2010

National Park Service
U.S. Department of the Interior

Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov