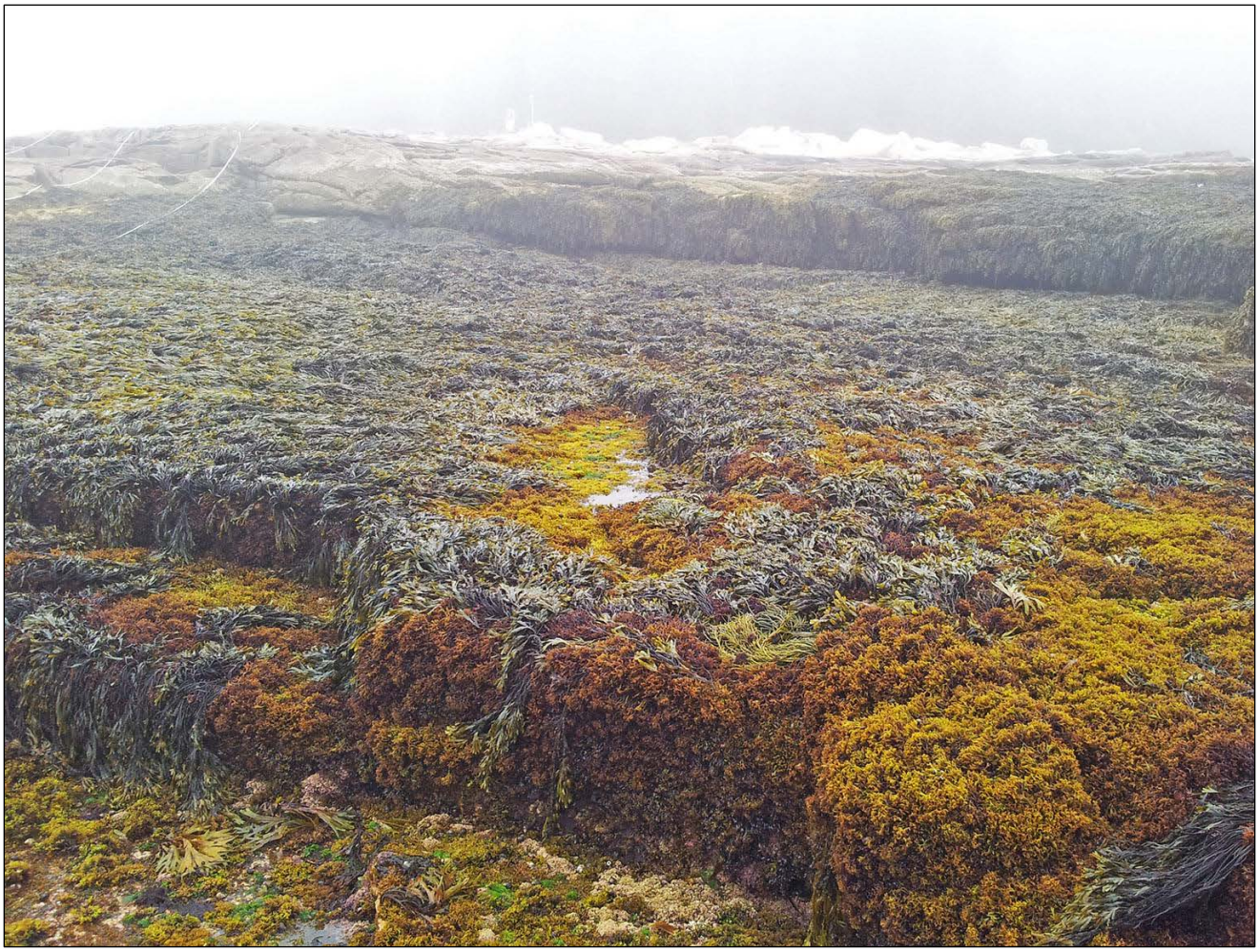
National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Northeast Temperate Network Long-Term Rocky Intertidal Monitoring Protocol

2015 Revision

Natural Resource Report NPS/NETN/NRR—2015/922



ON THE COVER
Intertidal zone in Acadia NP photographed August 2012. Several target species monitored by this protocol are visible, including: Fucus (the dark green, mid-intertidal seaweed), Ulva (the bright green algae in the bottom- middle of the photo), and several red algae species throughout the intertidal zone. Three point-intercept transects are also visible in the upper left of the photo.
Photograph by: Ed Sharron

Northeast Temperate Network Long-Term Rocky Intertidal Monitoring Protocol

2015 Revision

Natural Resource Report NPS/NETN/NRR—2015/922

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

February 2015

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate comprehensive information and analysis about natural resources and related topics concerning lands managed by the National Park Service. The series supports the advancement of science, informed decision-making, and the achievement of the National Park Service mission. The series also provides a forum for presenting more lengthy results that may not be accepted by publications with page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available from the Northeast Temperate Network, (http://science.nature.nps.gov/im/units/NETN/monitor/monitor.cfm) and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/NRPM). To receive this report in a format optimized for screen readers, please email irma@nps.gov.

Please cite this publication as:

Long, J. D., and B. R. Mitchell. 2015. Northeast Temperate Network long-term rocky intertidal monitoring protocol: 2015 revision. Natural Resource Report NPS/NETN/NRR—2015/922. National Park Service, Fort Collins, Colorado.

NPS 962/127984, February 2015

Revision History

Version numbers will be incremented by a whole number (e.g., Version 1.30 to 2.00) 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
1.02	September 2010	Brian Mitchell and Jeremy Long	Numerous revisions to address review comments. See "Rocky Intertidal Response to Reviewers_20100903.docx" for details.	External review
1.03	December 2010	Brian Mitchell	Additional revisions to address peer review manager comments. See "Rocky Intertidal Response to Reviewers_ 20101216.docx" for details. Revised personnel section to remove assumption of sharing crew with salt marsh and estuary monitoring protocols.	External review
1.04	January 2012	Brian Mitchell and Adam Kozlowski	LITMOO and LITHUN sites will no longer be included in a regular monitoring rotation. Clarified definition of non-coralline crustose algae and noted that this group is not comparable to MARINe categories. Monitoring site details (Appendix A) substantially enhanced and improved. Appendix A was removed from protocol and produced as a stand-alone document that now includes RTK GPS coordinates, better photos, enhanced vertical transects, and summer-scraped barnacle recruitment plots. Include info about 2011 installation of additional barnacle recruitment plots Additional power analysis delayed one year Clarified that one site can be sampled per low tide Clarified that NETN and parks may assist with volunteer recruitment and staff may help with monitoring, but PI should be able to implement the protocol without this assistance. Updated Data Form 4 in Appendix B NOTE: This revision received internal NPS review, but no formal external peer review	Too expensive to maintain Clarification needed Site details were inadequate. Test summer scraping Implementation delayed one year Erroneous suggestion that part of a second site could be sampled at ACAD Potential contractors were confused by the original text Revised due to new procedures

Version #	Date	Revised by	Changes	Justification
1.05	June 2013	B. Mitchell	Update species names (*Acmaea* to *Tectura*, *H. sanguinea* to *H. sanguinolenta*)	Taxonomic changes and corrections
1.06	January 2014	B. Mitchell	Update field forms to versions for the 2014 field season.	Annual review
1.07	January 2015	B. Mitchell	Update field forms to versions for the 2015 field season.	Annual review
			SUM plots are now Summer/Fall barnacle scraping plots.	Scraping will be fall rather than summer starting in 2015.

Contents

Page

Figures vii

Tables vii

Appendices ix

Standard Operating Procedures xi

Acknowledgments xii

Background and Objectives 1

- Purpose and Organization of the Protocol 1
- Rationale for Monitoring the Rocky Intertidal Zone 1
- Protocol Development 3
- Measurable objectives 4
  - Monitoring Objectives 4
  - Programmatic Objectives 5
  - Management Objectives 5
- Target and Core Species 5

Sampling Design 9

- Rationale for Sampling Design 9
- Site Selection 10
  - Criteria for Site Selection 10
  - Procedures for Selecting Sampling Sites 11
  - Procedures for Selecting Sampling Plots within Sites 15
- Sampling Frequency 16
- Replication 19
- Detectable Level of Change 20

Field Methods 23

- Field Work Preparation 23
- Summary of Field Methods 23
  - Photoplots 23
  - Point-intercept Transects 23

Tide Pool Band Transects 24
Motile Invertebrates 24
Barnacle Recruitment 24
Water Temperature 24
Overview Photographs 24
Field Log 24
End of Day Procedures 24
Data Management, Analysis, and Reporting 27
Data Management 27
Data Analysis 27
Reporting 27
Personnel Requirements and Training 29
Roles and Responsibilities 29
Qualifications 30
Training 30
Beginner 30
Intermediate 31
Leader 31
Safety Considerations 31
Operational Requirements 33
Annual Workload 33
- Project Leader 33
- Field Staff 33
- Local Coordinators 33
- NETN Program Manager 33
- NETN Data Manager 33

Schedule of Events 33
Facility and Equipment Needs 34
Startup Costs and Budget Considerations 34
Literature Cited 35

Figures

Page

Figure 1. Map of Maine's Mount Desert Island and Schoodic Peninsula showing locations of the original six Acadia National Park sites. 12

Figure 2. Map centered on Boston Harbor's outer islands showing locations of the three Boston Harbor Islands National Recreation Area sites. 14

Figure 3. Map centered on the Downeast Maine coast showing locations of the two Maine Coastal Islands National Wildlife Refuges sites. 15

Figure 4. Percent cover of target species within the target photoplots 16

Figure 5. Barnacle density in the barnacle recruitment plots at ACAD in 2008 and 2009. 17

Figure 6. Schematic view showing the relative location of plot types within a site. 19

Tables

Page

Table 1. Target species and species groups for rocky intertidal monitoring. 6

Table 2. Core species, species groups, and substrates for rocky intertidal monitoring. 7

Table 3. Number of replicates for each fixed plot sampling type. Note that LITHUN and LITMOO were established, but are not sampled as part of this protocol. 20

Table 4. End of day quality control check for common data errors. 25

Appendices

Page

Appendix A. Power Analyses 37

Appendix B. Data Forms 45

Appendix S1.A. Green-Amber-Red Risk Assessment 65

Appendix S1.B. Job Safety Analysis 69

Appendix S2.A. Plot Slope and Aspect 88

Appendix S3.A. Preparing a Photostand (i.e. Photoquadrapod) 105

Appendix S5.A. Rocky Intertidal Plot Diagrams 115

Appendix S9.A. QA/QC steps quick-reference. 157

Standard Operating Procedures

Page

SOP 1 – Safety 53
SOP 2 – Plot Establishment 77
SOP 3 – Pre-season Preparations 95
SOP 4 – Barnacle Recruitment Plot Scraping 107
SOP 5 – Training 111
SOP 6 – Camera 119
SOP 7 – GPS 125
SOP 8 – Using a Nikon DTM-322 Total Station to Survey Sites 137
SOP 9 – Data Management and QA/QC 151
SOP 10 – Field Work Preparation 159
SOP 11 – In the Field 161
SOP 12 – Plot Maintenance 165
SOP 13 – Using the HHGA 169
SOP 14 – Photoplots and Overview Photos 171
SOP 15 – Motile Invertebrates 179
SOP 16 – Tide Pool Transects 183
SOP 17 – Point-intercept Transects 187
SOP 18 – Temperature Loggers 191
SOP 19 – Field Log 195
SOP 20 – Field Work Wrap-up 199
SOP 21 – Scoring Photoplots 203
SOP 22 – Season Wrap-up 215
SOP 23 – Data Analysis and Reporting 221
SOP 24 – Deviations and Summary of Major Changes 231
SOP 25 – Procedures for Future Consideration 233

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 five 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.

Background and Objectives

Purpose and Organization of the Protocol

This document describes the rationale and methods used by the National Park Service (NPS) Northeast Temperate Network (NETN) and U.S. Fish and Wildlife Service (USFWS) Maine Coastal Islands National Wildlife Refuges (MCI) for long-term monitoring of rocky intertidal habitats. The monitoring effort will collect data for key metrics representing the ecological health of the intertidal zone, and over time it will provide an indication of the trend of these metrics. The monitoring is not intended to be a comprehensive assessment of the ecosystem or the factors contributing to changes in condition; rather it is intended to provide an early warning when problematic changes are occurring. This narrative portion of the protocol provides background and justification for the monitoring effort, as well as brief descriptions of data collection methods and operational procedures. The Standard Operating Procedures (SOPs) that follow the narrative contain the detailed instructions for implementing the protocol. SOPs are organized to be maximize their usability by staff implementing the protocol, with general SOPs about safety, training, and equipment; then specific guidelines for pre-season, field work, and post-season; and ending with activities like data analysis and reporting. The narrative and SOPs are organized and written according to the NPS protocol guidelines (Oakley et al. 2003).

Rationale for Monitoring the Rocky Intertidal Zone

Rocky intertidal communities are dominated by sessile (immobile) invertebrates and seaweeds that, in turn, provide habitat and food for a diversity of motile invertebrates (such as snails and crabs) as well as sessile epibiotic species (i.e., species that live on other species). The species assemblages within these communities are determined by the interplay of both abiotic (e.g. intertidal elevation and emersion time, wave-disturbance, slope, aspect, substrate color, and wave spray) and biotic factors (e.g. predation and competition; Bertness 1998). Furthermore, humans may disturb these environments through a variety of mechanisms including trampling, collecting, oil spills, coastal development, and climate change (Bertness 1998). While the ecological consequences of some of these stressors (e.g. some invasive species) are known from short-term, within-year experiments, lack of baseline data make their effects largely unknown over longer time periods. With respect to climate change, these communities are ideal for sampling because two factors that are predicted to change over the next few decades – sea level and temperature – are critical to determining the elevational range of intertidal species. These changes, combined with the short distances across which these changes occur and the growth and turnover rates of these species, make the intertidal a model community for examining consequences of climate change.

The diversity of factors shaping rocky intertidal communities and their spatial variation creates heterogeneity across these communities on small scales (meters or less). Despite this variation, rocky intertidal communities are characterized by well-known zones of dominant species that can cover up to 100% of the substrate. The relative positions of these zones are often consistent between locations. In general, the upper distribution of intertidal species is limited by abiotic factors (e.g. thermal stress and desiccation) whereas the lower distribution is limited by biotic factors (e.g. predation and competition).

Intertidal habitats in New England are well studied, 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 zonation extends from the high to the low intertidal. The highest dominant species are barnacles, primarily *Semibalanus balanoides*. Lower elevation motile invertebrates, especially crabs and dogwhelks (*Nucella lapillus*), are the dominant barnacle predators although birds and fish might also be important. Newly recruited barnacles are especially susceptible to trampling mortality. The next major zone contains three dominant species groups: two dominant fucoid seaweeds (*Ascophyllum nodosum*, and *Fucus* spp.) and mussels (dominated by *Mytilus edulis*). Mussels are extremely sensitive to thermal stress and therefore restricted to lower elevations but they can extend higher when growing beneath seaweed canopies or in areas receiving wave surge or splash. These species are mobile as juveniles and are preyed upon by predators similar to the ones that prey on barnacles. With respect to the fucoid seaweeds, *Ascophyllum* is typically higher than *Fucus*. However, there are many exceptions to this pattern because *Ascophyllum* is restricted to wave-protected areas (e.g. behind ridges) since it grows slowly and lives for long periods (tens of years). The fucoids are grazed by littorine snails, especially *Littorina obtusata* and *Littorina littorea*. *L. obtusata* is thought to be a more important fucoid grazer because it is a specialist on this kind of seaweed. In contrast, *L. littorea* is assumed to graze fucoids opportunistically when ephemeral species are unavailable. On a site-wide basis, ephemeral seaweeds are rare with respect to perennial fucoids, so *L. littorea* can also be an important grazer. The lowest zone is the red algae zone that is dominated by *Mastocarpus stellatus* and *Chondrus crispus*. The algal diversity in this zone is higher than the others, presumably because of reduced abiotic stress.

The Northeast Temperate Network, a division of the National Park Service's Inventory and Monitoring Program, selected the rocky intertidal zone as one of the network's "Vital Signs." A Vital Sign is an indicator of the condition of natural resources that is suitable for long-term monitoring (Mitchell et al. 2006). Specifically, intertidal habitats in Acadia National Park (ACAD), Boston Harbor Islands National Recreation Area (BOHA), and the Maine Coastal Islands National Wildlife Refuges 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. Climate change, energy development and oil spills could threaten these resources. In addition, the NPS is concerned that the popularity of rocky shores with park visitors can lead to adverse impacts on intertidal species. Long-term monitoring data are crucial for documenting the status and importance of the rocky intertidal zone so that threats can be addressed in a timely manner.

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, NETN has chosen to keep its methods comparable to the standard, or "core," procedures of the Multi-Agency Rocky Intertidal Network (MARINe; http://www.marine.gov/) that currently surveys target species, on

either an annual or semiannual basis, at over 100 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 (Engle 2008). Adopting similar procedures 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 NETN 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 can contribute to management decision-making for coastal 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. Natural experiments certainly have drawbacks, since they lack rigorous controls, but long-term monitoring has the potential to suggest processes and contributing factors that can be tested with manipulative experiments.

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). 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 (Allstatt et al. 1996).

Protocol Development

Northeastern University and NETN 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. This protocol monitors rocky shores across multiple scales (biological, ecological, landscape) and across relevant disciplines (marine ecology, physical oceanography, and the study of climate change). Protocol development centered on preliminary data collection using procedures from MARINe or new procedures. Preliminary trips served two purposes; 1) data collected on these trips guided the subsequent protocol development (e.g. sampling frequency) and 2) pilot field sampling allowed for testing of operational and logistical procedures, and they revealed unexpected obstacles to protocol implementation. This protocol development study was needed because the Atlantic species and community structure differ from the

Pacific, and MARINe methods were not always suitable. This protocol closely follows some MARINe methods, such as photoplots (SOP 14 – Photoplots and Overview Photos) and motile invertebrate counts within the photoplots (SOP 15 – Motile Invertebrates). The methods for taking overview photos (SOP 14 – Photoplots and Overview Photos), sampling band transects (SOP 16 – Tide Pool Transects) and point-intercept transects (SOP 17 – Point-Intercept Transects), and using temperature loggers (SOP 18 – Temperature Loggers) are all either modified from MARINe or are new sampling methods.

NETN decided to focus protocol development on rocky substrates, especially rocky benches, which dominate most of the intertidal habitat at ACAD and MCI. 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). However, these substrates are more common on the outer islands (for example, rocky benches represent ~25% and 90% of substrates on Calf Island and Outer Brewster Island, respectively). Thus, by focusing on rocky benches this protocol will not represent the majority of intertidal substrates within BOHA, but it will represent the intertidal areas of the outer islands. A separate protocol would be needed to extend monitoring to these non-bench, intertidal habitats (e.g. cobble beaches and boulder fields), since the methods and target species presented here are specific to rocky benches. In some cases 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.

Measurable objectives

By focusing on dominant, large, zone-associated 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.

The 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) and between study areas in New England. Although it is beyond the scope of this protocol, the full

MARINe data set (including New England data) could also be used to compare 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 (ACAD only).

Programmatic 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 or sewage spill).
- Provide data that could inform adaptive management practices.

Target and Core Species

Following the recommendations of MARINe, Northeastern University 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" (Engle 2008). Focusing on these dominant, zone-associated 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 used to determine target species, as recommended by MARINe, were:

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

Using these criteria, Northeastern University and NETN 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.

In addition to target species, Northeastern University and NETN have identified "core" species as those species, species groups, or substrates that are recorded using 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 2 years of protocol development. Data sheets include all of the core species. In most cases, target and core species are comparable between MARINe and the NETN protocol. The exception is non-coralline crustose algae, which in NETN includes microalgae that MARINe classifies as rock.

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

Target Species
Common periwinkle (*Littorina littorea*)
Dogwelk (*Nucella lapillus*)
Knotted wrackweed (*Ascophyllum nodosum*)
Smooth periwinkle (*Littorina obtusata*)
Target Species Groups
Barnacle (e.g. Semibalanus balanoides)
Echinoderm (Asterias forbesi, Asterias rubens, Henricia sanguinolenta, and Strongylocentrotus droebachiensis)
Mussel (e.g. Mytilus edulis)
Red algae (Chondrus crispus and Mastocarpus stellatus)
Rockweed (Fucus spp., e.g. Fucus vesiculosus)

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

Core Species
Common periwinkle (*Littorina littorea*)
Dogwelk (*Nucella lapillus*)
Frilled anemone (*Metridium senile*)
Knotted wrackweed (*Ascophyllum nodosum*)
Rough periwinkle (*Littorina saxatilis*)
Sea lettuce (*Palmaria palmata*)
Smooth periwinkle (*Littorina obtusata*)
Tortoise-shell limpet (*Tectura testudinalis*)
Core Species Groups
Articulated coralline
Barnacle (e.g. *Semibalanus balanoides*)
Crustose algae – Coralline
Crustose algae – Non-coralline (encrusting, non-calcareous micro and macro algae)
Echinoderm (*Asterias forbesi*, *Asterias rubens*, *Henricia sanguinolenta*, and *Strongylocentrotus droebachiensis*)
Kelp (e.g., *Laminaria* and *Alaria*)
Knotted wrackweed (*Ascophyllum*) epibiont
Mussel (e.g. *Mytilus edulis*)
Red algae (*Chondrus crispus* and *Mastocarpus stellatus*)
Red algae (*Porphyra*) spp.
Rockweed (*Fucus*) epibiont
Rockweed (*Fucus*) spp. (*Fucus vesiculosus*)
Sea lettuce (*Ulva*) spp.
Other algae – Brown
Other algae – Green
Other algae – Red
Other invertebrate
Other plant
Substrates
Rock
Sand
Tar
Other substrate (e.g., shell hash, cobble, boulder)

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 representative of the community or zone being sampled and 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. The fixed plot approach was modeled after the protocol used by the MARINe monitoring program (Engle 2008; including sites located in Cabrillo National Monument, Channel Islands National Park, Golden Gate National Recreation Area, Point Reyes National Seashore, 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, NETN is 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 (Cox and Raimondi 2007, Engle 2008). 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 compared to random sampling is that the dynamics of fixed plots cannot be extrapolated to larger areas without gathering additional information (Murray et al. 2006, Engle 2008). 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. A hybrid design that uses some fixed plots and some random plots was considered but is not being implemented. The hybrid design makes data analysis more complicated, and would require reducing the number of fixed plots so that random plots could be installed without increasing implementation costs. This approach would decrease the number of fixed

plots below the minimum needed for trend detection without adding enough random plots to characterize spatial variability.

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 qualitatively 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, 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 each target species was determined if plots could be selected where that 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 2008). 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, these factors could not be completely standardized 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 a great 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 explicit evaluation of visitor impacts within the monitoring design. 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, Northeastern University and NETN 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. 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. Their six letter site codes consist of the first three letters of the first and second words in the full site name. 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, one of the protocol authors (Long) 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).

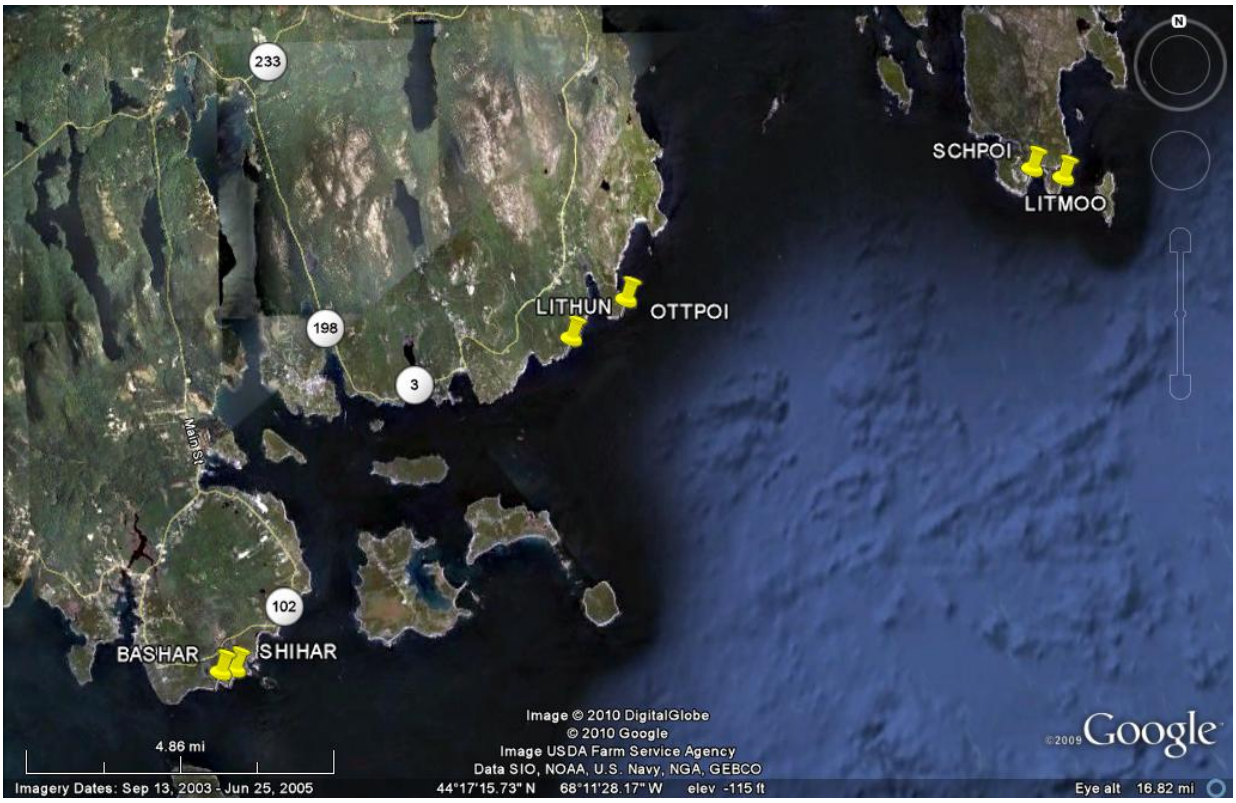


Figure 1. Map of Maine's Mount Desert Island and Schoodic Peninsula showing locations of the original six Acadia National Park sites.

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). Northeastern University and NETN decided to remove the visitor impact comparison from this protocol by eliminating the Little Hunter's Head (LITHUN) and Little Moose Island (LITMOO) sites. These sites were removed from sampling at the end of 2009 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 made them unsafe and regularly prevented us from completing sampling. Finally, in the absence of a paired impact-pristine design, 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. Funding permitting, these sites

could be resurveyed occasionally to provide a periodic assessment of potential visitor impacts on heavily visited sites. An unfortunate effect of removing these exposed sites is that there are 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 are:

- Ship Harbor (SHIHAR, heavily visited site)
- Bass Harbor (BASHAR, minimally visited site)
- Otter Point (OTTPOI, moderately visited site)
- Schoodic Point (SCHPOI, moderately visited site)

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. All ACAD site locations may be viewed in NETN’s Acadia National Park Google Earth module (http://science.nature.nps.gov/im/units/netn/googleMaps/parkMaps_GoogleEarth.cfm).

In BOHA, a single site was selected on each of three different islands. Only eight of the nine 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 eight 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)



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. This may affect comparisons between the parks, particularly concerning algal cover. All BOHA site locations may be viewed in NETN's Boston Harbor Islands National Park Area Google Earth module (http://science.nature.nps.gov/im/units/netn/googleMaps/parkMaps_GoogleEarth.cfm).

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, Northeastern University and MCI 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)

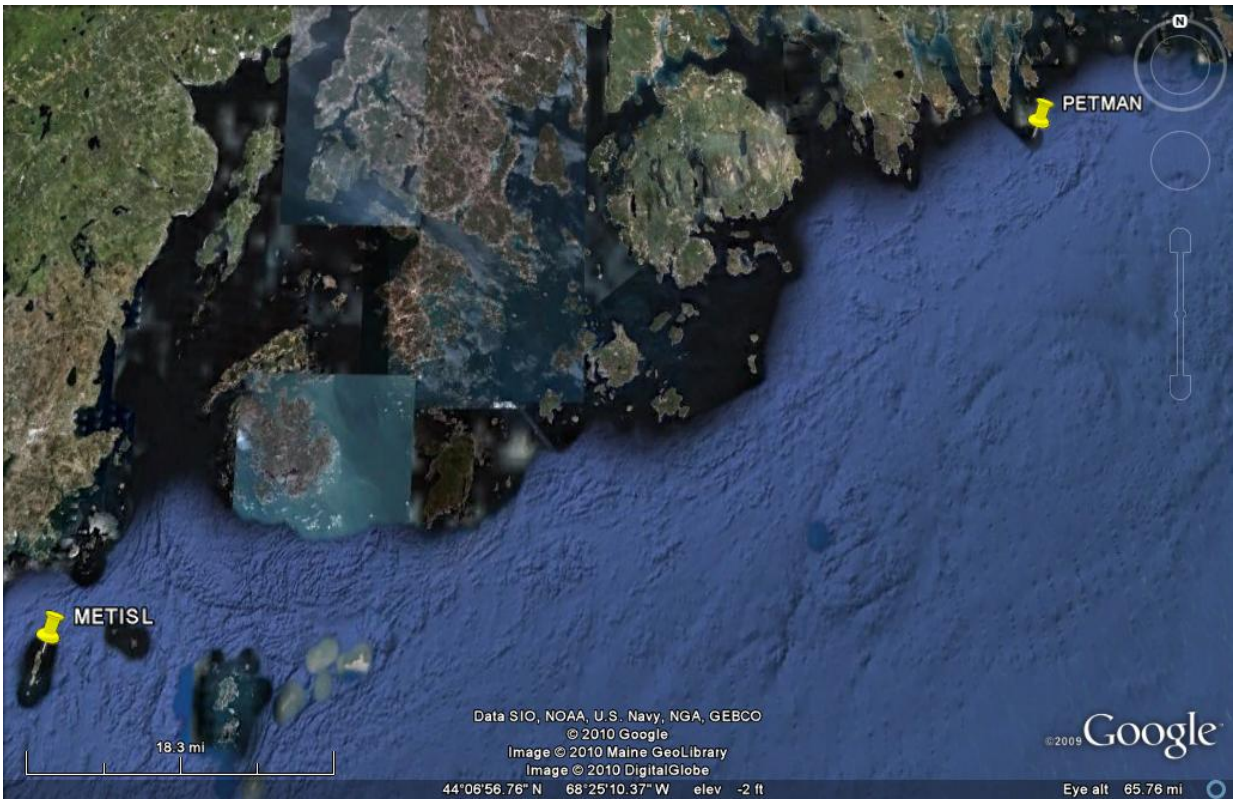


Figure 3. Map centered on the Downeast Maine coast showing locations of the two Maine Coastal Islands National Wildlife Refuges sites.

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. All MCI site locations may be viewed in NETN's Acadia National Park Google Earth module (http://science.nature.nps.gov/im/units/netn/googleMaps/parkMaps_GoogleEarth.cfm).

Detailed information about site locations can be found in the companion document to this protocol, "Rocky Intertidal Monitoring Site Information".

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 the companion document, "Rocky Intertidal Monitoring Site Information") were installed in 2008-2009. In 2011 additional barnacle recruitment plots were installed at three ACAD and two BOHA sites; these plots are paired with the existing plots and scraped in the summer to explore whether summer scraping can be used instead of winter scraping.

Sampling Frequency

Ideally, sites would be sampled repeatedly throughout each year to capture seasonally abundant species and any long-term changes in seasonality. However, data collected during protocol development at ACAD showed little seasonal variation in percent cover with respect to the target species of different photoplots (50 x 75 cm plots established for photographic monitoring; SOP 14 – Photoplots and Overview Photos, Figure 4). At any given sampling event, there was greater variation in the cover of mussels and red algae. This variation is partially the result of lower sample sizes due to difficulty accessing these lower intertidal sites; in other words there were often less than six sites sampled for these target species. These plots were also more difficult to score, since they contained more shadows because of the structural complexity combined with dark organisms (e.g. mussels).

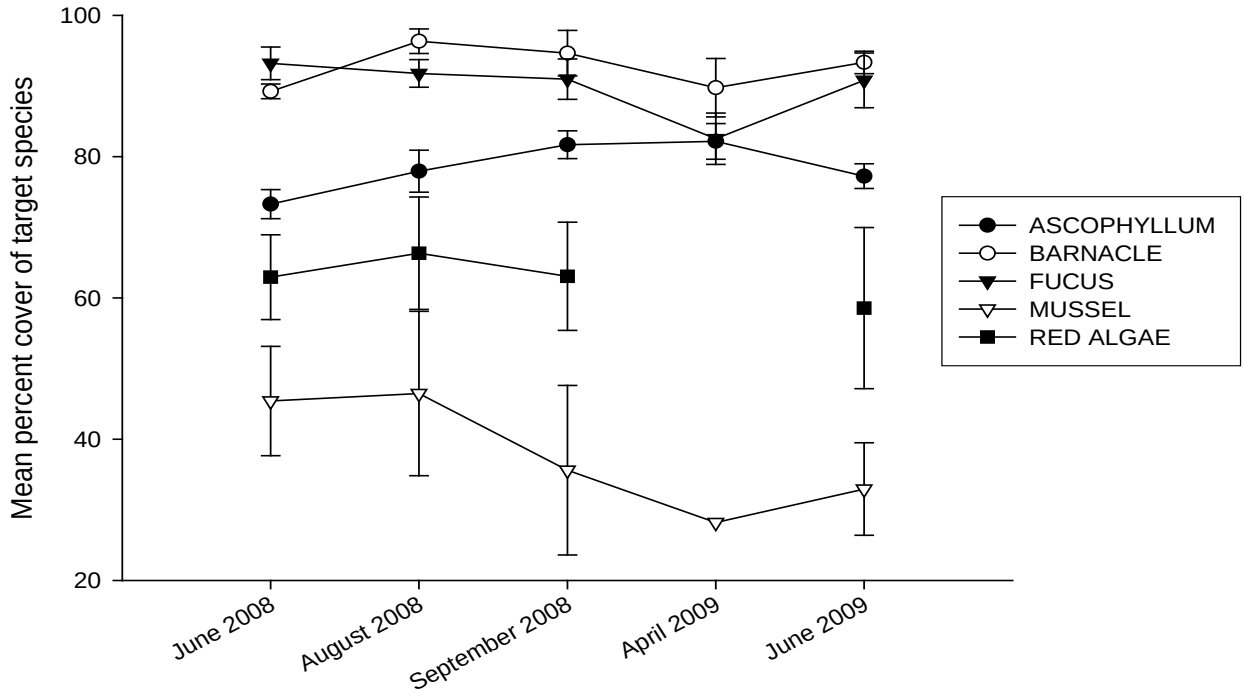


Figure 4. Percent cover of target species within the target photoplots. For example, filled circles represent the cover of Ascophyllum nodosum in Ascophyllum photoplots, open circles represent the cover of barnacles in barnacle photoplots, and so on. For a given time point and target species, percent cover is reported as the mean of up to six ACAD sites, although in many cases fewer sites were sampled for red algae and mussels. Error bars denote standard error between sites. For each site, a single mean of all five replicates was calculated.

The most striking seasonal difference observed during the 2 years of protocol development at ACAD was related to barnacle coverage in the 10 x 10 cm centers of recruitment plots (SOP 14 – Photoplots and Overview Photos), and Fucus coverage in Fucus photoplots at SHIHAR. Regarding barnacle coverage, there was a decrease in barnacle abundance (Figure 5) and a concurrent increase in barnacle coverage (Figure 4) from early in the summer (May and June) until late summer and fall

(August and September) in recruitment plots. The decrease in abundance likely occurred because of natural factors, including mortality from predation and competition, although manipulative experiments would be needed to prove this. The increase in coverage likely resulted from growth of newly settled individuals. For these reasons, the timing of sampling will influence estimates of barnacle recruitment and barnacle coverage in the photoplots, so varying sample dates between years may increase measurement variability.

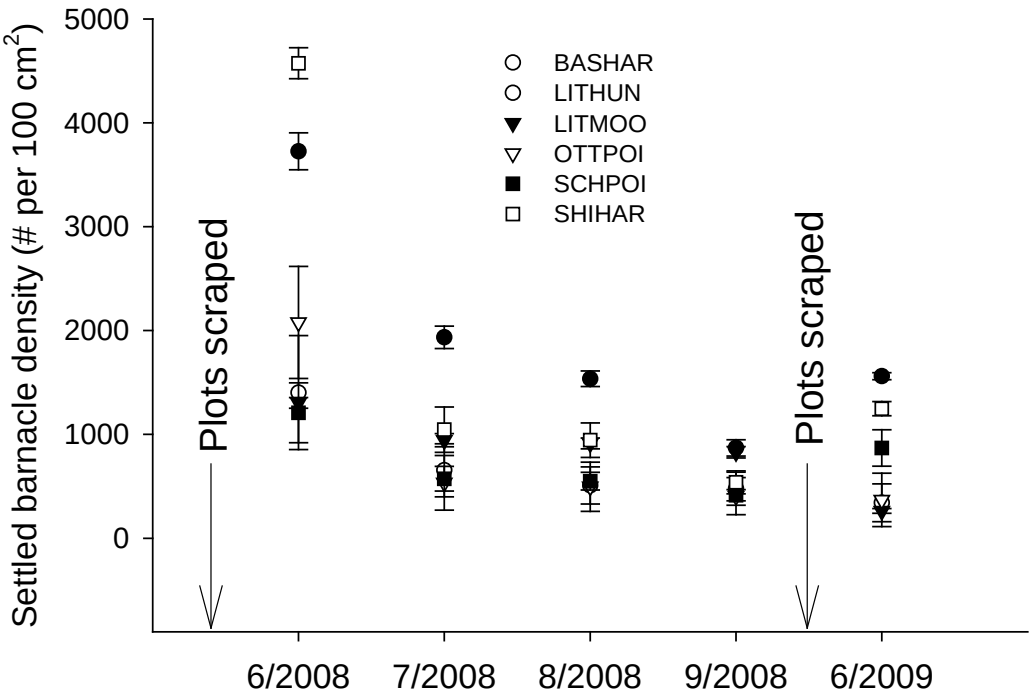


Figure 5. Barnacle density in the barnacle recruitment plots at ACAD in 2008 and 2009. Plots were scraped down to the rock prior to the major recruitment period during both years (SOP 4 – Barnacle Recruitment Plot Scraping). Recruitment was higher at SHIHAR and BASHAR where adult densities are higher than the other sites. Recruitment 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 at ACAD was a rapid loss of *Fucus* from *Fucus* plots at SHIHAR from spring to fall; percent cover declined from 93% to 80%, although the 95% confidence intervals overlapped. This decrease may have been driven by human trampling, or an interaction between trampling and some other factor (such as water flow rates, predation intensity, or thermal stress). SHIHAR is the most visited of the protocol sites, and the *Fucus* photoplots at SHIHAR are immediately adjacent to substrate that is easy for visitors to navigate (barnacle zone). At the other sites, accessing the *Fucus* photoplots is much more difficult.

Initially, all sites (except LITMOO and LITHUN at ACAD) will be sampled annually for multiple reasons. First, there was not much within-year variation detected 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. LITMOO and LITHUN will be sampled 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.

Sites should be monitored 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 9 days of sampling. Within this range, the last week of June and first week of July are beneficial for three reasons. First, there is significant barnacle recruitment 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 recruitment declines through time as barnacles grow and die. Ideally, the barnacle recruitment plots would be sampled as close as possible to the peak in barnacle settlement in June, so that initial settlement of new recruits is measured rather than a combination of settlement and post-settlement mortality. 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 the 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 Acadia sampling should also be changed 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 recruitment 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 recruitment 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 drawback is that this approach is untested, and there may be some settlement of different species in the plots that could influence barnacle recruitment the following spring. This uncertainty will inhibit the use of data collected with the current protocol. In 2011, five new barnacle recruitment plots were installed at each of five sites in order to evaluate the difference between winter and summer (after photographing) scraping. A comparison between the two methods will be conducted after 2-4 years of sampling, and at that time a decision will be made about whether to change the scraping season.

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 photoplots, 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.

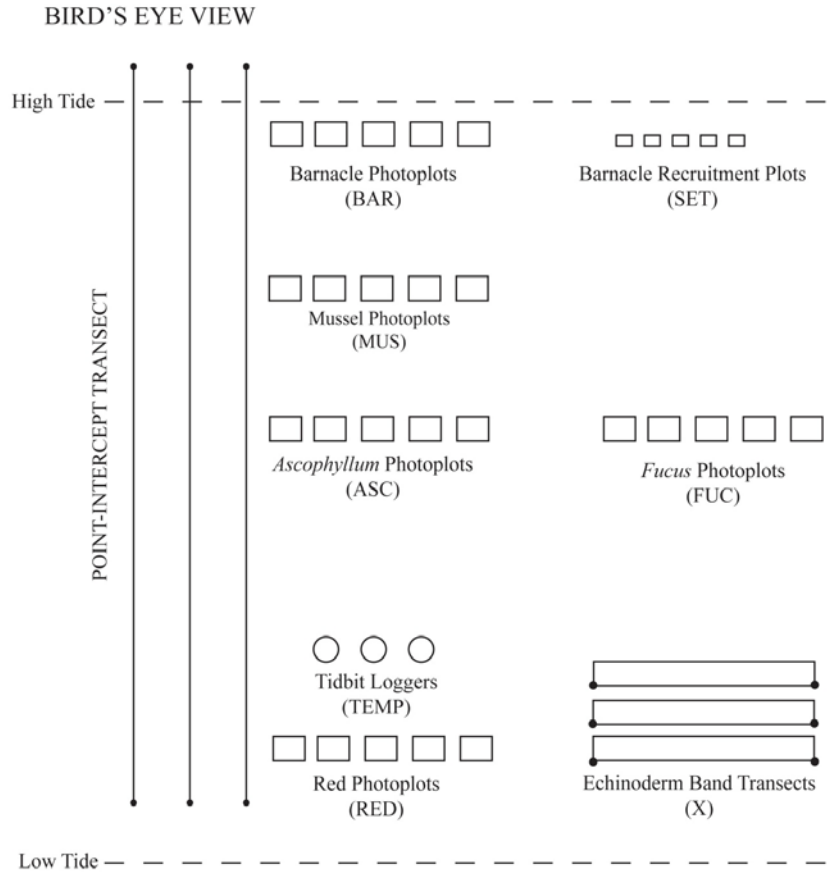


Figure 6. Schematic view showing the relative location of plot types within a site.

Replication

Each sampling site contains three point-intercept transects extending from the high to the low intertidal zone (SOP 17 – Point-intercept Transects), three 2 x 10 m tide pool band transects (SOP 16 – Tide Pool Transects), five barnacle recruitment plots, where recruitment photos of the central 10 x 10 cm are taken (SOP 14 – Photoplots and Overview Photos), three tidbit temperature sensors to

record water and air temperatures in the low intertidal zone (SOP 18 – Temperature Loggers), and five each of up to five target species 50 x 75 cm photoplot types (i.e., *Fucus*, *Ascophyllum*, barnacle, mussel, and red algae; up to 25 photoplots; SOP 14 – Photoplots and Overview Photos) (Table 3). Motile invertebrates (snails) are sampled in the photoplots, for up to 25 plots per site (SOP 15 – Motile Invertebrates). The level of replication was chosen to balance the need for sufficient data against the overall cost of the monitoring program. The sample sizes are commensurate with sample sizes for the MARINe program.

Table 3. Number of replicates for each fixed plot sampling type. Note that LITHUN and LITMOO were established, but are not sampled as part of this protocol.

PARK	SITE	PHOTOPLOTS[1]					OTHER PLOTS[2]				
		ASC	BAR	FUC	MUS	RED	SET	SUM	X	T	TEMP
ACAD	BASHAR	5	5	5	0	5	5	5	3	3	3
	LITHUN[3]	5	5	5	5	0	5	0	3	3	0
	LITMOO[3]	5	5	5	0	5[4]	5	0	3	3	0
	OTTPOI	5	5	5	5	5	5	0	3	3	3
	SCHPOI	5	5	5	5	5	5	5	3	3	3
	SHIHAR	5	5	5	0	5	5	5	3	3	3
BOHA	CALISL	5	5	5	0	5	5	5	3	3	3
	GREISL	5	5	5	0	5	5	5	3	3	3
	OUTBRE	5	5	5	0	5	5	0	3	3	3
MCI	METISL	5	5	5	0	5	5	0	3	3	3
	PETMAN	5	5	5	0	5	5	0	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 recruitment, SUM = Summer/Fall scraping barnacle recruitment, X = Band transects in tide pools, T = Vertical point-intercept transects, TEMP = Temperature sensors (tidbits)

[3] Established sites, but not sampled as part of this protocol

[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 A).

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 7 or fewer years.

- In most cases, it will be reasonably possible to detect changes in the cover of target species within photoplots within 10 years.

- 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).

NETN believes that the ability to detect significant changes within 10 years is a reasonable power for an intertidal monitoring program. Many intertidal species have a high reproductive rate and long-distance dispersal, and would be expected to recover quickly from levels of decline that can be detected by this protocol. More details about the power analyses can be found in Appendix A. NETN will conduct an additional power analysis by 2014, using multiple years of data collected with the full protocol, to ensure that there is sufficient power to detect change in the measurements collected with this protocol. Where power is low, procedures will be modified or dropped so that the network does not spend time and resources collecting poor quality data.

Field Methods

Field Work Preparation

Scheduling and logistical preparation should be arranged 3 to 6 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, GPS coordinates of bolts, distances and bearings of plots from reference bolts, overview maps and photographs of all fixed plots (preferably from a distance with quadrat frames over quadrats and an orange cone over reference bolts). This information should be excerpted from the protocol companion document, "Rocky Intertidal Monitoring Site Information". The site notebooks 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 photoplots 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 B.

Photoplots

Rectangular photoplots (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 14 – Photoplots and Overview Photos and SOP 21 – Scoring Photoplots). 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 canopy species with respect to intertidal height. The field crew scores the uppermost species, species group, or substrate every 30 cm along a transect tape extending between bolts in the low and the high intertidal zones (SOP 17 – Point-Intercept Transects). Three replicate transects are monitored at each site; this is the minimum number of transects needed to calculate within-site variance, and our power analysis (Appendix A) indicated that this level of replication is sufficient for detecting change over time. Although the primary purpose of these transects is to monitor canopy cover and vertical range of target species, they also provide data on

rare and non-target species. These transects will be used to determine the core species canopy abundance (percent cover) and ranges of intertidal elevations where core species are in the canopy. 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 16 – Tide Pool Transects). NETN will monitor three replicate 2 x 10 m plots per site placed in the low intertidal. If species densities become low within these transects, NETN will continue to monitor the transects and may also initiate site-wide timed searches during each survey for these species.

Motile Invertebrates

NETN will count the number of motile invertebrates, including snails and limpets, in every photoplot (SOP 15 – Motile Invertebrates). Monitoring motile invertebrates within photoplots will facilitate NETN's ability to correlate changes in their densities with changes in the cover of zone-associated target species (like *Fucus*, *Ascophyllum*, red algae, barnacles, and mussels).

Barnacle Recruitment

NETN will monitor the recruitment of barnacles at each site (SOP 14 – Photoplots and Overview Photos and SOP 21 – Scoring Photoplots). 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 18 – Temperature Loggers). Tidbits are replaced every 3 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 14 – Photoplots 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 19 – 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 no animals were found for a species.
Motile invertebrates	Plot type
Motile invertebrates	Circle area sampled
Motile invertebrates	Enter "0" when no animals were found for a species.
Point-intercept transect	Transect number
Point-intercept transect	A single entry for each column.
Photoplot sketches	Plot type

Download photos immediately to a computer and rename them according to the conventions described in SOP 20 – 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 occur on several consecutive days. Thus, gear should be maintained daily and replaced if needed; this includes regularly recharging batteries. In between sampling trips equipment should be cleaned and stored properly to prevent corrosion due to exposure to salt water. 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, if a gas drill is used it should be drained of the gas/oil mixture. The Ikelite camera housing and strobe should be maintained according to the manufacturer's instructions, including lubricating the O-rings with an approved silicone lubricant.

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 9 – 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 5 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."

Every 5 years 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 23 – 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 another 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 5 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 23 – Data Analysis and Reporting for additional information about planned reports.

Personnel Requirements and Training

Roles and Responsibilities

During the 2 year protocol development period, NETN 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, a single person must 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 four 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 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 21 – Scoring Photoplots).

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 up to four college interns or other seasonal staff. The field crew would sample the rocky intertidal sites at the appropriate time and take care of photo scoring and other data management tasks. The interns would need close supervision by the PI until they could sample sites on their own, but would then work independently. Four interns would be able to sample a complete site in one low tide cycle, while fewer interns would likely need multiple trips to each site. The interns would have several weeks to sample seven sites (although multiple visits will increase transportation costs, particularly at BOHA).

NETN is currently leaning towards this third strategy for NPS sites, but the final decision rests with the contractor or cooperator conducting the monitoring. Parks may be able to help with finding volunteers to assist with field work and photo scoring, and park staff may participate in monitoring activities if their schedules permit (assuming adequate training in safety and field methods). In particular, having park staff and volunteers participate for multiple years will help develop some institutional memory regarding site layout and methods. BOHA has committed to providing two staff

members to assist with annual monitoring at BOHA, but the contractor or cooperator implementing the protocol should not count on the availability of volunteers or park staff at ACAD.

Implementation at the MCI sites will be through staff stationed on the islands with study areas. A permanent biologist at MCI will serve as the local coordinating PI, and may receive training (as needed) along with the field crew. It may also be possible for other MCI staff to attend training sessions. Scoring of MCI plot photos will be conducted by the team that monitors the NPS sites.

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 photoplots and analysis of these photos will only be conducted by experienced participants (SOP 21 – Scoring Photoplots).

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 photoplots after a brief introduction to

the snails and limpets and where they tend to cluster, placing the band transect, shading photoplots 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, 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 in addition to scoring the point-intercept transects; scoring the echinoderm band transects; identifying, enumerating, measuring, and quantifying damage of motile invertebrates; placing the point-intercept transect; measuring echinoderms; and scoring photoplots in the lab.

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 photoplots, 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 with the potential to be 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, field staff should check the local marine forecast prior to field work, and wear a life vest while in the lower intertidal zone. 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 often be the highest point at some intertidal locations and will at times be holding 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.

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 photoplots.
- ***Local Coordinators*** (Park or Refuge Resource Managers) – 0.05 FTE or 2 weeks. This includes logistical support for field activities, reviewing and distributing reports, and public communications about the project.
- ***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 recruitment plots. Work with NPS contracting and cooperator/contractor to transfer funding.
- February and March – Hire field staff (summer interns). Scrape barnacle recruitment 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 photoplot 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.

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 photoplot 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 camera 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 Coastal Islands NWR will cover field work at their sites using existing staff resources, including entering and checking data in the NETN database. Data management and photoplot analysis for their sites will be conducted by NETN staff.

Literature Cited

Allstatt, J. M., R. F. Ambrose, J. M. Engle, P. L. Haaker, K. D. Lafferty, and P. T. Raimondi. 1996. Recent declines of black abalone *Haliotis cracherodii* on the mainland coast of central California. Marine Ecology Progress Series 142: 185-192.

Ammann, K. N. and P. T. Raimondi. 2008. Long-term monitoring protocol for rocky intertidal communities of Redwoods National and State Parks, California. Natural Resource Report NPS/KLMN/NRR-2008/034. National Park Service, Fort Collins, Colorado.

Bell, R., M. Chandler, R. Buchsbaum, and C. Roman. 2004. Inventory of intertidal habitats: Boston Harbor Islands, a national park area. Technical Report NPS/NERBOST/NTR-2004/1, National Park Service, Northeast Region, 15 State Street, Boston, MA. 138 pp.

Bertness, M. D. 1998. The ecology of Atlantic shores. Sinauer Associates, Inc. 417 pp.

Connell, J. C. 1961. The influence of interspecific competition and other factors on the distribution of the barnacles *Chtamalus stellatus*. Ecology 42: 710-723.

Cox, K. and P. Raimondi. 2007. Long-term monitoring protocol for rocky intertidal communities of Redwood National and State Parks. U.S. Department of the Interior, National Park Service Inventory and Monitoring Program. Protocol version 1.0.

Engle, J. M. 2008. Unified monitoring protocols for the multi-agency rocky intertidal network. U.S. Department of the Interior, Minerals Management Service, Pacific OCS Region. Santa Barbara, CA. 84 pp.

Fairweather, P. G. 1991. Statistical power and design requirements for environmental monitoring. Australian Journal of Marine and Freshwater Research 42: 555-567.

Gerrodette, T. 1987. A power analysis for detecting trends. Ecology 68:1364-1372.

Gerrodette, T. 1991. Models for power of detecting trends – a reply to Link and Hatfield. Ecology 72:1889-1892.

Gerrodette, T. 1993. Trends: software for a power analysis of linear regression. Wildlife Society Bulletin 21:515-516.

Gilman, R. A. and C. A. Chapman. 1988. Bedrock geology of Mount Desert Island. Bulletin 38, Maine Geological Survey, Augusta, ME.

Lewis, J. R. 1982. The composition and functioning of benthic ecosystems in relation to the assessment of long-term effects of oil pollution. Philos. Trans. R. Soc. Lond. Ser. B Biol. Sci. 297: 257-267.

Link, W. A., and J. R. Sauer. 1994. Estimating equations estimates of trends. Bird Populations 2:23-32.

Littler, M. M. 1980. Overview of the rocky intertidal systems of Southern California. *in* Power, D. M., Editor. The California Islands: proceedings of a multidisciplinary symposium. Santa Barbara Museum of Natural History, Santa Barbara, California, USA. pp. 265-306.

Long, J. D., R. S. Hamilton, and J. L. Mitchell. 2007. Asymmetric competition via induced resistance: specialist herbivores indirectly suppress generalist preference and populations. Ecology 88(5): 1232-1240.

Lubchenco, J. 1978. Plant species diversity in a marine intertidal community: importance of herbivore food preference and algal competitive abilities. American Naturalist 112: 23-39.

Miner, C. M., P. T. Raimondi, R. F. Ambrose, J. M. Engle, and S. N. Murray. 2005. Monitoring of rocky intertidal resources along the central and southern California mainland: comprehensive report (1992-2003) for San Luis Obispo, Santa Barbara, Ventura, Los Angeles, and Orange Counties. OCS Study, MMS-2005-071.

Mitchell, B. R., W. G. Shriver, F. Dieffenbach, T. Moore, D. Faber-Langendoen, G. Tierney, P. Lombard, and J. Gibbs. 2006. Northeast Temperate Network vital signs monitoring plan. Technical Report NPS/NER/NRTR--2006/059. National Park Service, Northeast Temperate Network, Woodstock, Vermont.

Murray, S. N., R. F. Ambrose, and M. N. Dethier. 2006. Monitoring Rocky Shores. Berkeley, University of California Press. 220 pp.

Oakley, K. L., L. P. Thomas, and S. G. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bulletin 31(4):1000-1003.

Paine, R. T. 1966. Food web complexity and species diversity. American Naturalist 100: 65-75.

Raimondi, P. T. 1988. Rock type affects settlement, recruitment, and zonation of the barnacle Chthamalus-anisopoma Pilsbury. Journal of Experimental Marine Biology and Ecology 123: 253-267.

Roy, K. , A. G. Collins, B. J. Becker, E. Begovic, and J. M. Engle. 2003. Anthropogenic impacts and historical decline in body size of rocky intertidal gastropods in southern California. Ecology Letters 6: 205-211.

Schoch, G. C. and M. N. Dethier. 1996. Scaling up: the statistical linkage between organismal abundance and geomorphology on rocky intertidal shorelines. Journal of Experimental Marine Biology and Ecology 201: 37-72.

Appendix A. 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* photoplots?
- How long will it take to detect trends in the size of *Littorina littorea* and *L. obtusata* on *Ascophyllum* and *Fucus* photoplots?
- How long will it take to detect trends in the percent cover of target species on photoplots?
- 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 near Northeastern University's lab in Nahant, Massachusetts, with ten quadrats in the *Ascophyllum* zone and ten 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 were only available for five 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 (16 to 48 years, Table A.1). 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 using a hierarchical modeling approach or 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 were 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 are 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 A.2). 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 are available.

Changes in the cover of target species within photoplots should be detected reasonably quickly in most cases (Table A.3). At Acadia, pilot data indicate that a 50% decline in *Ascophyllum*, barnacles, and *Fucus* could be detected within 10 years. At Boston Harbor Islands, pilot data indicate that a 50% decline in *Ascophyllum*, *Fucus*, and *Chondrus/Mastocarpus* could be detected within 10 years.

Changes in the density of several species can be detected along point-intercept transects, using sample sizes for MCI (five or six total transects), Boston Harbor Islands (nine 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 A.4). This is only one of the ways that the point-intercept data will be analyzed; once transects are surveyed for elevation, analyses (e.g., regression, ANOVA, and nonlinear methods) will also explore changes in range, minimum elevation, and maximum elevation of species and cover types.

These initial power analyses serve to demonstrate that the methods and sample sizes chosen for rocky intertidal monitoring have the potential to detect biologically meaningful changes in species abundance and size. They were based on a small amount of pilot data, and the analyses need to be repeated in 2-3 years, once several years of data are available and once NETN has standardized the key metrics that will be regularly analyzed (since these metrics will inform the power analysis). Future analyses will use the change per time step option (rather than overall change), since the overall change option can be hard to interpret. An alternative approach to this analysis would be to determine what annual rate of change could be detected within 10 years. In addition, future analyses

will consider the sensitivity of the choice of alpha and power; the alpha for this analysis (0.05) is conservative. A separate analysis will investigate whether there is sufficient power to detect differences between the paired (high versus low) visitation sites at ACAD.

Table A.1. 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[1] (#/m^2)	Var	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] All values are calculated based on transformed (ln + 1) data. 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 A.2. 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 A.3. Number of years needed to detect changes in percent cover of target species within photoplots. The target species are only considered within photoplots set up to detect them (e.g., barnacles with barnacle photoplots 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 (the number of photoplots at the park)

[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 A.4. Number of years needed to detect changes in percent cover of selected canopy 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	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	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[3]	30	1.1	0.9	0.9	0.47	12								
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[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 B. Data Forms

The following pages contain copies of all data forms. Note that Form 2 is no longer used and is excluded from the Appendix.

Form 1: Field Log (version 1.02)

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: ND = No Data; 0 = None; L = Low; M = Med; H = High; or Actual Value

Participants (full names and initials):_____

_____

_____

Weather and Sea Conditions (affecting quality of sampling; use codes listed above)

Swell/Surge:_____ Wind:_____ Rain:_____ Recent Rain:_____

Substratum Changes (magnitude at site; sediment = sand, gravel, cobble)

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 on site or within 50 m of shore at any one time during the sampling; note behavior)

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

Plot Marker Loss/Repair Notes:_____

_____

_____

_____

_____

Tidbits: Temp1 SN:_____ Temp2 SN:_____ Temp3 SN:_____

Tidbit Notes:_____

_____

Other Notes:_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Form 1: Field Log (version 1.02)

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			Notes
Target Species shown in bold.	ND=No Data 0=Absent R=Rare U=Uncommon P=Present C=Common A=Abundant	F=Fertile/Flowers B=Bleached D=Damaged ND=No Data –=Absent/Healthy L=Low level M=Med level H=High level			
		F	B	D	
Knotted Wrack (*A. nodosum*)					
Ascophyllum epibiont					
Rockweed (*Fucus*) spp.					
Fucus epibiont					
Kelp (e.g., *Laminaria / Alaria*)					
Sea lettuce (*Ulva* spp.)					
Grass kelp (*Enteromorpha* spp.)					
Irish Moss (*Chondrus/Mastocarpus*)					
Dulse (*Palmaria palmate*)					
Laver (*Porphyra* spp.)					
Articulated Corallines					
Crustose coraline					
Crustose non-coraline					
Common periwinkle (*L. littorea*)					
Smooth periwinkle (*L. obtusata*)					
Rough periwinkle (*L. saxatilis*)					
Dogwhelk (*Nucella lapillus*)					
Limpet (*Tectura testudinalis*)					
Mussel (e.g., *Mytilus edulis*)					
Sea stars (*Asterias* spp.)					
Blood star (*Henricia sanguinolenta*)					
Sea urchin (*S. droebachiensis*)					
Sea anemone (*Metridium senile*)					
Barnacle (e.g., *S. balanoides*)					
Edible crab (*Cancer* spp.)					
Green crab (*Carcinus maenus*)					
Asian shore crab (*H. sanguineus*)					

Form 1: Field Log (version 1.02)

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	☐		
	☐		

General Code Definitions

No Data (ND): Use "ND" to indicate that this category was not evaluated or does not apply.

Absent/Healthy (--): For species appearance only (Page 2), use to indicate no fertile fronds/eggs and absence of bleaching or damage.

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

Low (L): Relatively few or low levels were found within the defined site boundaries; usually up to 5% cover.

Med (M): Medium numbers or moderate levels were found within the defined site boundaries; usually 5-20% cover.

High (H): High numbers or high levels were found within the defined site boundaries; usually 20-100% cover.

Weather and Sea Conditions

Swell/Surge: 0/L/M/H relative levels of water movement over seaward portion of site.

Wind: 0 = <2 knots L = 3-10 knots M = 11-20 knots H => 20 knots

Rain: 0/L/M/H relative amounts of precipitation at the site during the survey. 0 = none, L = Drizzle or fog, M = Showers to light rain, and H = Moderate to heavy rain.

Recent Rain: Evidence or knowledge of 0/L/M/H amounts rain at the site within the past few days.

Substratum Changes

Sediment Level: 0/L/M/H relative levels of unconsolidated sand/gravel/cobble along reef/sediment interfaces.

Scour: 0/L/M/H relative extent of scoured reef surfaces within the defined site boundaries.

Rock Movement: 0/L/M/H relative extent of overturned boulders or bedrock breakouts.

Debris and Pollutants

Plant Wrack: 0/L/M/H levels of unattached algae or other drift plants within the site.

Driftwood: 0/L/M/H levels of sticks, branches, and logs within the site.

Shells: 0/L/M/H levels of dead shells, especially mussel shells.

Dead Animals: 0/L/M/H levels of dead invertebrates, fish, birds, or mammals.

Trash: 0/L/M/H levels of human debris including cans, bottles, plastics, and metal items.

Oil/Tar: 0/L/M/H relative extent of fresh or weathered oil/tar within the site.

Site-Wide Species Conditions

Abundance: Abundance (animals) or percent cover (algae) of species in appropriate habitat at the site. For animals, abundance is relative to typical sites and years (e.g., 100 sea stars seen would be "Abundant", but 100 dog whelks would likely rate an "Uncommon"). For algae cover: 0 = None, Rare = <1% cover, Uncommon = 1-5% cover, Present = 5-10% cover, Common = 10-20% cover, and Abundant = 20-100% Cover.

Appearance: If appearance is not typical, enter an "L", "M", or "H" in the appropriate column(s). Score ND/--/L/M/H relative levels of reproductive appearance (F) (plants showing evidence of fertility, crabs in berry), 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). Shaded cells indicate a situation where observations are not required.

Form 3: Motile Invertebrates (version 1.03)

Site:_____Date:_____Time:_____

Observer:_____Recorder:_____ Target Species:_____

Directions: Collect first 10 individuals of each species (7 mm or larger) to me
Examine all for damage, and record number damaged and undamaged.
Record length (nearest mm); widest point (limpet) or spire to base (others).

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
Photographer					
Collector					

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

SIZES	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5
Common periwinkle (*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)
Smooth periwinkle (*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)
Rough periwinkle (*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)
Dogwhelk (*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)
Limpet (*Tectura 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)

Form 4: Point Intercept Transect Data Sheet (version 1.12)

Site:_____ Date:_____ Time:_____ Observer:_____ Recorder:_____ Transect:_____

Directions: In the top 10 rows, record point-intercept code every 0.3 m (30 cm) along variable length transect lines.
In the bottom two rows, record the distance (in m, to the nearest cm) at each bolt that you encounter.

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

Species/Taxa/Substrate
AS: *Ascophyllum*
AE: *Ascophyllum* epibiont
FU: *Fucus*
FE: *Fucus* epibiont
KE: Kelp
OB: Other Brown
UL: *Ulva*
EN: *Enteromorpha*
OG: Other Green
CM: *Chondrus/Mastocarpus*
PA: *Palmaria*
PO: *Porphyra*
AC: Articulated corallines
CC: Crustose corallines
OR: Other Red
CN: Crustose non-coralline
OP: Other Plant
BA: Barnacle
MU: Mussel
OI: Other Invertebrate
RO: Rock
WA: Water
SA: Sand
TA: Tar
BL: Bolt
OS: Other substrate
UN: Unidentified

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

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	57.3	57.6	57.9	58.2	58.5	58.8	59.1	59.4	59.7	60.0	60.3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0.00														

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

Form 5: Tide Pool Transects (version 1.03)

Site:_____ Date:_____ Time:_____

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	☐		
	☐		

	Pool 1 (X1)	Pool 2 (X2)	Pool 3 (X3)
Observer(s)			
Recorder			

Pool 1 (X1)

	Green Sea Urchin (*S. droe-bachiensis*)	Blood Star (*H. sangui-nolenta*)	Common sea star (*A. rubens*)	Northern sea star (*A. forbesi*)
Diam. (mm) for GSU Radius (mm) for sea stars	1) 2) 3) 4) 5) 6) 7) 8) 9) 10)	1) 2) 3) 4) 5) 6) 7) 8) 9) 10)	1) 2) 3) 4) 5) 6) 7) 8) 9) 10)	1) 2) 3) 4) 5) 6) 7) 8) 9) 10)
Count				

Pool 2 (X2)

Green Sea Urchin (*S. droe-bachiensis*)	Blood Star (*H. sangui-nolenta*)	Common sea star (*A. rubens*)	Northern sea star (*A. forbesi*)
1)	1)	1)	1)
2)	2)	2)	2)
3)	3)	3)	3)
4)	4)	4)	4)
5)	5)	5)	5)
6)	6)	6)	6)
7)	7)	7)	7)
8)	8)	8)	8)
9)	9)	9)	9)
10)	10)	10)	10)

Pool 3 (X3)

	Green Sea Urchin (*S. droe-bachiensis*)	Blood Star (*H. sangui-nolenta*)	Common sea star (*A. rubens*)	Northern sea star (*A. forbesi*)
Diam. (mm) for GSU Radius (mm) for sea stars	1) 2) 3) 4) 5) 6) 7) 8) 9) 10)	1) 2) 3) 4) 5) 6) 7) 8) 9) 10)	1) 2) 3) 4) 5) 6) 7) 8) 9) 10)	1) 2) 3) 4) 5) 6) 7) 8) 9) 10)
Count				

A. rubens has bumps (pedicellaria) in row along each arm, and stalked eye spots near tip of arms (underside).
A. forbesi has bumps (pedicellaria) randomly along each arm and unstalked eye spots.
H. sanguinolenta has no bumps (pedicellaria)

SOP 1 – Safety

Version 2.03 (January 20, 2015)

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
1.00	9/3/2010	B. Mitchell	Field staff should not wear cotton clothes in the field. Added requirement for life vest and throw rope. Other minor changes.	External review	1.01
1.01	2/17/2012	B. Mitchell	Minor edit to wading – bring towel and dry clothes. Edits to reflect new NETN safety procedures. Addition of JSA and GAR	Clarification Network-wide safety review	2.00
2.00	2/22/2012	B. Mitchell	Incorporate revisions based on review by John Karish	Internal / supervisory review	2.01
2.01	2/13/2014	B. Mitchell	Add space blanket to safety gear and add section on potential for hypothermia	Suggestion from Marc Albert (BOHA)	2.02
2.02	1/20/2015	B. Mitchell	Personnel who cannot swim must identify themselves, and must wear a life vest in the intertidal	Safety	2.03

Overview

This Standard Operating Procedure (SOP) describes basic safety procedures that should be followed during rocky intertidal field sampling at Acadia NP (ACAD), Boston Harbor Islands NRA (BOHA), and Maine Coastal Islands NWR (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, contractors, and volunteers ("monitoring staff") to be of utmost importance, and is committed to ensuring that all monitoring staff 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. A Green, Amber, Red risk assessment (GAR) has been conducted for this protocol and is included as an appendix (Appendix S1.A). Additionally, a Job Safety Analysis (JSA), which documents hazards

associated with this protocol and recommends approaches to mitigate these hazards, is included as an appendix (Appendix S1.B) to this SOP. The JSA must be read and signed by all monitoring staff who conduct field work for this protocol. This SOP does not cover procedures specific to the US Fish and

Wildlife Service (USFWS), and may need to be modified to accommodate procedures relevant to the MCI sites. 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 S1.1). At ACAD, if unable to make contact by phone or radio, activate the emergency Personal Locator Beacon (PLB), and use the SPOT transmitter's emergency function as a backup. Administer first aid to the best of your knowledge, ability, and training. If appropriate, transport to emergency room.

2. As soon as it is safe and practical to do so, inform your supervisor and the park's emergency contact. If your supervisor is not an NPS employee, the supervisor must contact the NETN Program Manager as soon as it is practical to do so.

3. For NPS staff and volunteers, 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). For contractors and cooperators, follow your organization's procedures for documenting accidents, and notify the NETN program manager with details of the incident.

Table S1.1. 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	1) Park Ranger	N/A 617-740-7820	N/A	1) Park staff member with radio will be primary contact for emergency response communication.
	2) MA State Police Marine Unit	617-343-4911	N/A	2) 7 AM to 11:30 PM
	3) Boston Emergency Response	617-223-3201	N/A	3) If after hours, or if unsuccessful reaching 1 or 2
	4) US Coast Guard Marine Emergency		N/A	4) If after hours, or if unsuccessful reaching 1 – 3 Additional Notes: Massachusetts DCR owns all rocky intertidal monitoring islands (781-740-1605 x201 for emergencies). Researchers with non-911 emergency needs can call either DCR (island-owners) headquarters 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	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.

Non-Emergency Incidents

1. Contact supervisor immediately after incident. If your supervisor is not an NPS employee, the supervisor must contact the NETN Program Manager as soon as it is practical to do so.

2. For NPS staff and volunteers, 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 https://irma.nps.gov/App/Reference/Profile/2193689?lnv=true). For contractors and cooperators, follow your organization's procedures for documenting accidents, and notify the NETN program manager with details of the incident.

3. Seek medical attention, if needed.

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

Field Preparation

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

Job Safety

An important tool used to promote safe conduct is the Job Safety Analysis (JSA; sometimes called a Job Hazard Analysis or JHA). This approach is consistent with NPS Directors Order 50 and Reference Manual 50B for Occupational Health and Safety. The JSA process is to (1) identify hazards associated with field and laboratory settings, and (2) as appropriate, develop approaches to mitigate those hazards. All monitoring staff for this protocol (including individuals who are observing or only participating for a short time) must read and sign the JSA in Appendix S1.A. In addition, monitoring staff must read the entire Safety SOP (including appendices S1.A and S1.B) during training week.

First Aid Kits and Training

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.

At the beginning of every field season the monitoring staff will receive basic first aid and CPR training if they do not already have current certifications. Having a crew member with Wilderness First Aid or Wilderness First Responder certification is strongly encouraged.

Daily Communication and Planning

Monitoring staff are expected to carry a functioning primary and secondary mode of communication at all times while in the field. Unless they are water proof, these items should be stored in a water resistant or water proof container (e.g. Ziploc bag). At BOHA, a park employee with a radio will be part of the monitoring team, and a cell phone can be the secondary mode of communication. At ACAD, the park will not be able to loan a radio to the monitoring team, but if an NPS staff member is observing or participating they will likely have a radio that would become the primary mode of emergency communication. Since cell phone reception is poor in the park, NETN will loan a Personal Locator Beacon (PLB) and SPOT GPS Messenger to the monitoring staff at ACAD to support check-ins and emergency response. All monitoring staff must be familiar with the operation and capabilities of the communication devices.

Monitoring staff must notify the NETN Program Manager and the appropriate park resource manager with expected dates of field work. On each monitoring day, they must know which site they will be monitoring and how they will get there before going into the field. A trip plan must be filed with a supervisor or other designated office staff (DOS) who will not be in the field. The DOS must be made cognizant of the absolute necessity of checking in with the team. If the team fails to check in on or before the planned check-in time for completion of field work, the DOS will immediately try to reach the team by all available methods. If the crew has not been reached within 30 minutes, the DOS must notify emergency services and initiate a search.

At ACAD, when the NETN PLB and SPOT GPS Messenger are being borrowed by the monitoring staff the trip plan must also be provided to the NETN staff members responsible for tracking messages from the devices. NETN must also be provided with the DOS name, phone number, and e-mail, and the DOS must be provided with contact information for NETN staff. At a minimum, the trip plan must contain the:

- date and purpose of trip;
- names of all people on trip;
- vehicle license plate number(s) and parking location;
- destination and route, including map with the sampling location clearly marked;
- time of departure from lodging or rendezvous point and estimated time of return to lodging or rendezvous point;
- check-in time for completion of field work;
- radio frequency or cell phone number (for all phones in group); and
- type of watercraft, if applicable.

If the trip is cancelled or if the plan changes while in the field, staff must notify the DOS immediately. At the end of the day, staff must notify the DOS that they have returned from the field. At ACAD, the SPOT Messenger can be used to notify NETN that more time is needed in the field or that field work is completed; NETN staff will relay this message to the DOS. If NETN staff are not contacted, they will assume that the monitoring staff checked in directly with the DOS.

All monitoring staff are responsible for being aware of the time and ensuring that end of day check-ins occur on schedule; the DOS will call emergency services if the crew misses their check in and cannot be located within 30 minutes of the check-in time.

Personal Gear

Each person is responsible for ensuring he/she is wearing field appropriate clothing (no cotton or cotton blends) 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, but may not have good traction on slippery intertidal rocks. The monitoring project will supply all participants with knee pads and traction devices (e.g., “Stabilicers”). 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 overexposure 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 must be avoided. It is important to drink liquid frequently to maintain hydration on a warm day, even if you don't feel thirsty. At least one space blanket (or similar item) should be carried with the other safety gear in case a member of the sampling team gets wet and cold.

Field Safety

Teamwork

No one may work by themselves in the intertidal zone, no matter how experienced they are. When conducting sampling, all monitoring staff in the intertidal zone must be in visual contact with at least one other person. For example, one member of the monitoring team can be above the tide line counting snails collected in quadrats, and another team member can be sampling intertidal quadrats, as long as the higher team member is keeping regular tabs on the individual in the intertidal zone. If the field crew separates into multiple teams, the teams must periodically check in with each other regarding the status of sampling and where on the site they will be located. Emergency gear (e.g., throw rope, life vests, personal locator beacon) must be placed in a central location above the tide line that is known to all monitoring staff.

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 must be obeyed by monitoring staff 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, wear knee pads, always keep at least one hand free, and always test your footing before putting your full weight down. The black algae zone in the high intertidal zone is extremely slick if it is at all wet, and macroalgae can shift unpredictably underfoot. Move at a slow, steady pace when working in the intertidal zone.
- 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.
- 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

Monitoring staff will occasionally need to carry ≥35 pound packs over uneven terrain, and it is important for everyone to understand appropriate ways to pack, lift and carry a heavy backpack to

avoid serious back, neck and shoulder injuries; and to avoid becoming unstable when wearing a heavy pack. 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.

Carrying Other Gear

In addition to backpacks, some gear will be hand-carried (e.g., Hilti drill, pelican case with camera and strobe). Whenever possible, put heavier items (e.g., drill batteries) into backpacks. If you must hand-carry heavy items, remember to slow down and rest frequently to avoid hand and arm fatigue. Any person hand-carrying a heavy item should always have one hand free for balance, and so that the item can be shifted between hands.

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 wear a life vest in the low intertidal, 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. A throw rope must be kept with the field gear for use if someone is washed into the water, and all monitoring staff must practice using it during training.

Any personnel who do not know how to swim – i.e., unable to float, tread water, and travel at least 50 meters using a crawl or breast stroke – must tell the protocol lead. Non-swimmers will need to wear a life jacket while in the intertidal zone.

Hypothermia

Hypothermia is a potential risk, particularly during spring barnacle scraping trips or during cool or rainy weather. Always be alert for signs of hypothermia, particularly in people who sample tidepools

or are otherwise wet. Keep at least one space blanket (or similar item) in the field with the safety gear.

Wading

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

Kneeling

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

Weather

Weather conditions in the eastern U.S. can be hazardous and can change quickly. Monitoring 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 and who is without a pulse 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.

NOTICE! 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 will be piloted by a licensed captain. Follow all instructions from the captain to ensure your safety. Some BOHA sites will require use of a row boat. Life vests are mandatory in the row boat. When someone is entering or exiting the row boat, at least one other person should be helping to stabilize the boat. Take care when getting on and off the row boat; keeping your center of gravity low and stay to the center of the boat as much as possible. The boat must not be overloaded and people in the boat must never stand in the boat while it is in motion. If any monitoring staff are inexperienced with rowing, they should receive guidance from a more experienced rower, and they should avoid fatigue by trading off rowing duties with other staff.

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 monitoring 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 claim 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.

Additional information on this topic can be found in the Safety SOP of the current Northeast Temperate Network Long-Term Forest Monitoring Protocol, available at http://science.nature.nps.gov/im/units/NETN/monitor/monitor.cfm.

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.

Poison Ivy

Poison ivy (*Toxicodendron* spp.) is present at ACAD and BOHA, and can be very abundant in localized areas. Monitoring staff must learn how to recognize this plant. 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.

Venomous Snakes

The only venomous snake that could be found in the project area is the timber rattlesnake (*Crotalus horridus*), which is listed as "critically imperiled" in Massachusetts and is very rare. The timber rattlesnake does not occur in Maine, and it has never been observed on the Boston Harbor Islands. The best course of action is to avoid all snakes by keeping them at a safe distance. When in venomous 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 venomous snake, wash the bite area and dress the wound. Immobilize the bite area with a splint, and immediately seek medical attention. If bitten by a venomous snake, immediately move to a safe location and use a venom extractor if you have one (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.

Bees, Wasps, and Yellow Jackets

Bees, wasps, and yellow jackets could be encountered while traveling to monitoring sites, but are not a significant risk. See the JSA (Appendix S1.B) for appropriate actions to mitigate risk from stings.

Black Bears

Black bears occur within ACAD but are not a significant risk. See the JSA (Appendix S1.B) for appropriate actions to mitigate risk from bear encounters.

Vehicle Safety

Responsibilities of Vehicle Operators

Monitoring 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. Monitoring staff 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 vehicle:

- Everyone in a government vehicle is required to wear a seat belt, and when using other vehicles seat belts are mandatory where required by law, and strongly recommended in all situations.
- Texting or any other cell phone use is strictly prohibited while driving a government vehicle and in some states, and it is strongly recommended that monitoring staff avoid use of cell phones while driving any vehicle.
- Only federal employees or authorized volunteers, cooperators and contractors are allowed to operate a government vehicle.
- Passengers who are not federal employees, volunteers, 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.

Because government vehicles are self-insured, damage resulting from government vehicle accidents are generally paid by the driver's program (e.g., NETN or MIDN). However, in cases of severe negligence, the driver found at fault for the accident may be personally liable.

Procedures for reporting a motor vehicle accident.

1. Seek medical attention if needed.
2. If the incident involves a government vehicle, 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. If the incident involves a contractor or cooperator vehicle, follow your organization's procedures for documenting accidents, and notify the NETN program manager with details of the incident.

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

Acadia National Park. 2008. Acadia National Park Health and Safety Program Plan. Internal Document # A7619(ACAD-PB). U.S. Department of Interior, National Park Service, Acadia National Park, Bar Harbor, Maine.

American Lyme Disease Foundation. 2000. Tick ID Card. Tim Peters and Company Inc., Peapack, New Jersey.

Cass, W. 2007. Shenandoah National Park Long Term Ecological Monitoring System. SOP #2, version 1.2. U.S. Department of Interior, National Park Service, Shenandoah National Park, Luray, Virginia.

Sonoran Desert Network, National Park Service. 2008. SODN Field Safety Plan. Version 6.00. U.S. Department of Interior, National Park Service, Sonoran Desert Network Office, Tucson, Arizona.

Appendix S1.A. Green-Amber-Red Risk Assessment

This appendix describes application of the GREEN-AMBER-RED (GAR) Risk Assessment Model as outlined in the NPS Operational Leadership Student Manual (Version 2; July 2011) to the NETN Rocky Intertidal Monitoring Protocol. This GAR was written by the NETN Program Manager (Brian Mitchell) on 17 February 2012 and approved by the NPS Northeast Region I&M Program Manager (John Karish) on 22 February 2012.

The GAR model allows for a general assessment of a task or operation and generates communication concerning the risks of an activity (in this case, conducting the field-based activities of the NETN Rocky Intertidal Monitoring Protocol). The most important part of the process is the team discussions leading to an understanding of the risks and how they will be managed.

The GAR is a seven step process. Each step is defined and explained in the context of the NETN Rocky Intertidal Monitoring Protocol below.

Step 1: Define the Mission or Task

The NETN Rocky Intertidal Monitoring protocol includes several field-based monitoring activities: tide pool transects, vertical transects, photoquadrats and motile invertebrate tasks, as well as other tasks in the rocky intertidal zone. Monitoring staff are part of a team, and may work in multiple pairs when conducting the monitoring activities. The activity is conducted on remote islands (BOHA) and away from roads and trails (ACAD), and the intertidal zone where monitoring occurs has a number of innate safety hazards. Potential safety hazards (along with mitigation measures) have been identified in a Job Safety Analysis (JSA; Appendix S1.B). Of specific concern is that monitoring staff will regularly be working on uneven and extremely slippery surfaces immediately adjacent to the ocean. A fatality through drowning or a severe slip and fall is possible and is the most significant risk encountered when conducting this activity.

Step 2: Define the Threats

The threats/hazards for this activity along with mitigation measures are described in the associated JSA (Appendix S1.B).

Step 3: Assess Risk and Assign a Numerical Value

The numerical ranks (Table S1.A.1) were assigned by Brian Mitchell, the NETN Program Manager and the NPS project leader for the NETN Rocky Intertidal Monitoring Protocol. NETN staff had substantial input and discussion into the values chosen, since this protocol was used as an example during Operational Leadership Training. It should be noted that at the time final numerical values were assigned (February 17, 2012) the protocol had been in development for several years and considerable time and effort had already gone into evaluating and mitigating risks.

The GAR process is described in NPS Operational Leadership Student Manual (Version 2; July 2011).The activity risk can be visualized using the colors of a traffic light. If the total risk value falls in the GREEN ZONE (1-35), risk is rated as low. If the total risk value falls in the AMBER ZONE (36-60), risk is moderate and you should consider adopting procedures to minimize the risk. If the

total value falls in the RED ZONE (61-80), you should implement measures to reduce the risk prior to starting the event or evolution.

The ability to assign numerical values or "color codes" to hazards using the GAR Model is not the most important part of risk assessment. What is critical to this step is team discussions leading to an understanding of the risks and how they will be managed.

Table S1.A.1. NETN Rocky Intertidal Monitoring Protocol assigned risk codes of 0 (For No Risk) through 10 (For Maximum Risk) to each of the eight Green-Amber-Red Risk Assessment elements.

Element	Rating
Supervision	3
Planning	2
Communication	2
Contingency Resources	4
Team Selection	4
Team Fitness	2
Environment	7
Event/Evolution Complexity	6
Total Risk Score	30

Step 4: Identify Risk Control Options

Supervision

The NETN Rocky Intertidal Protocol clearly identifies personnel, roles and responsibilities, and a chain of command. A supervisor (the contracted principal investigator) is on site with 2-5 monitoring staff, and the staff often works in teams of two, with periodic check-ins between teams. The supervisor has many tasks to accomplish, so is not always focusing only on supervision. Nobody is allowed to work solo and out of sight of at least one other team member. A score of 3 was assigned due to on-site supervision and the fact that the team is not large, and work is conducted in pairs with regular check-ins.

Planning

The NETN Rocky Intertidal Protocol includes numerous SOPs that explain hiring, training, personal safety, emergency communication (equipment and contacts), and appropriate field activities. Crew members are required to review these materials during training, and crew members are required to have first aid and CPR training. Due to this advance planning, written documentation, and training procedures, a low score (2) was assigned.

Communication

Routine and emergency communication equipment and procedures are explained in the relevant SOPs. This includes coordination with park natural resource managers, rangers, and dispatch. It also includes a daily check-out/check-in procedure for the crew to ensure that a responsible party knows if someone has not returned from the field activity in a timely manner. Due to this advance planning, written documentation, and training procedures, a low score (2) was assigned.

Appendix S1.A. Green-Amber-Red Risk Assessment (continued).

Contingency Resources

Contingency resources include communication equipment and procedures that explicitly involve park rangers, park dispatch, and 9-1-1. Crew members always have at least two modes of communication (park radio and cell phones at BOHA; Personal Locator Beacon and SPOT GPS Messenger and cell phones at ACAD). The crew is instructed to place all safety gear (communication devices, throw rope, etc.) at a central location (the exception would be radio of a BOHA ranger). Notification of emergency services should happen within minutes of an incident, but emergency services may not be able to reach the crew quickly due to the remoteness of some sites (especially BOHA sites and the Bass Harbor site at ACAD). A score of 4 was assigned instead of a lower score because of the potential delay before emergency services could reach the crew.

Team Selection

The monitoring protocol clearly identifies the essential skills and abilities required to execute this protocol in a competent manner. Prior experience is required for most team members. All team members should have basic first aid and CPR skills. A score of 4 was assigned (instead of a lower score) because some crew members may have limited experience, and may not have advance training in the particular safety issues that can arise in the intertidal zone. While some of these skills can be worked on during monitoring staff training, there is no substitute for experience.

Team Fitness

Team selection should ensure an overall high level of initial team fitness. Monitoring staff are only in the field for approximately six hours per day (not including drive times). Although sampling "double tides" (essentially a split shift with sampling in the morning and evening) is permitted by the protocol, it is discouraged and conditions are not often appropriate for implementing two sampling periods per day. Sampling always occurs during daylight hours. A score of 2 was assigned because the shifts are not long, even though the work can be strenuous. Monitoring staff must be diligent about adequate rest and nourishment to ensure that fatigue does not become a factor.

Environment

Environment was assigned a higher score (7) primarily because of the inherent dangers associated with the rocky intertidal environment. Activities occur during a variety of weather conditions immediately adjacent to the sea, and rogue waves and high surf are a concern. The intertidal zone is also a very uneven and slippery substrate, and extreme caution is needed to avoid slipping and falling in this environment. ACAD experiences a visitor fatality every 2-3 years and numerous visitor injuries each year that can be directly attributed to falls in the intertidal zone. Despite training, working in pairs, and using a life vest in the lower intertidal zone or any other time the tide is near, the possibility exists for an individual to slip and be rendered unconscious, potentially leading to drowning.

Incident Complexity

Incident complexity was also assigned a higher score (6) mostly because daily field conditions change due to weather and the ocean conditions can change unpredictably. Individual monitoring staff must use judgment and experience to respond appropriately.

Appendix S1.A. Green-Amber-Red Risk Assessment (continued).

Step 5: Evaluate Risk vs. Gain

The NETN Program Manager has determined that the activity, if carried out in accordance with all SOPs, has an acceptable level of risk.

Step 6: Execute Decision

The decision made by the NETN Program Manager is to conduct the activity in accordance with NETN Rocky Intertidal Monitoring Protocol Standard Operating Procedures (SOPs).

Step 7: Supervise – Watch for Change

The NETN Program Manager continually solicits feedback from the contractor and NPS staff on safe execution of the protocol including risk control options not considered thus far.

Appendix S1.B. Job Safety Analysis

JOB SAFETY ANALYSIS: Rocky Intertidal Field Work and Travel to, from, and within Parks	**JOB TITLE:** Rocky Intertidal Crew Members **DEPARTMENT:** Northeast Temperate Network **ANALYSIS BY:** Brian R. Mitchell, NETN Program Manager	☒ **NEW** ☐ **REVISED** ☒ **REVIEWED** John Karish, NER I&M Program Manager
Required and/or Recommended Personal Protective Equipment: Required: Two modes of communication (i.e., radio and cell phone or Personal Locator Beacon and SPOT GPS Messenger), life vests, throw rope, knee pads, first aid kit, driver's license, Recommended as appropriate: rain gear, condition-appropriate footwear and clothing, hat, dry change of clothes, sufficient food and water.		

Tasks	**Potential Hazards**	**Recommended Action or Procedure**
Planning and Communi-cation	Not being prepared and following plan/itinerary. Communication breakdowns.	• Plan ahead. Know where you and each crew member will be going, particular hazards associated with travel routes, and sites to be visited that day. Check expected weather, tide, and surf conditions for day and sites to be visited. • Understand itinerary of planned trip and follow carefully. Coordinate drop-off and pick-up times (or return times) and locations precisely. • Check in with Designated Office Staff (DOS) prior to field work with a trip plan, and after field work to confirm crew safety. If return will be delayed, contact DOS before agreed-upon check-in time to establish a new check-in time. Always carry two methods of communication with full charges.

Appendix S1.B. Job Safety Analysis (continued).

Tasks	**Potential Hazards**	**Recommended Action or Procedure**
Emergency Preparedness	Not knowing emergency procedures. Not having emergency supplies.	• Know who to contact and how to reach them in the event of a life-threatening or non-life-threatening emergency. • Have current CPR and first aid certification, and know the certification status of co-workers. • Keep a well-maintained first aid kit in each vehicle and with the field team. • Place safety equipment at a central location at the monitoring site that is known to all crew members and that is above the tide line.
Teamwork	Lack of awareness of other team members leading to delayed incident response	• Make sure that no crew member works alone and out of sight of other crew members; i.e., work in groups of two at a minimum. • It is particularly important to never have someone working solo and out of sight while in the intertidal zone. • If crew splits up into multiple pairs, the pairs should periodically check in with each other.
General foot travel	Falling or tripping due to wet areas, poor footing, uneven terrain, loose/rolling rocks and heavy pack.	• Use caution at all times. Walk carefully, watching footing. • Wear appropriate boots for conditions. Stay aware of your feet. Address blisters and hot spots promptly. • Avoid carrying excessive weight loads or unbalanced loads. • When walking on a steep slope, lean upslope. Ensure that stems and vines are alive and can support your weight before relying on them. • Use extreme caution traversing wet rocks, streams, steep slopes or blowdown areas.
Movement in the intertidal zone	Falling or tripping due to extremely slick, uneven, and unstable surfaces	• The black algae intertidal zone is *extremely* slick if it is at all wet; virtually no boot sole will gain traction on wet black algae. Use extreme caution moving in this zone. • The lower algae zones can also be treacherous, with long slippery algal fronds and unstable and uneven rocks. • Always keep your center of gravity as low as possible and always keep at least one hand free and be prepared to lose your footing.
Work by the ocean	Waves, rogue waves, and falling into ocean	• Wear a life vest in the low intertidal zone or any time you are near the ocean. • Work in pairs and make sure that at least one person is keeping an eye on the water and can warn the other of approaching waves. • Move carefully and deliberately, and ensure you have solid footing before using both hands for any task.

Appendix S1.B. Job Safety Analysis (continued).

Tasks	**Potential Hazards**	**Recommended Action or Procedure**
Wading and collecting echinoderms in tide pools	Cuts from rocks and marine organisms, exposure/ hypothermia and slipping	• Wear knee boots or waders if working in tide pools; some tide pools are thigh-deep, and most pools require reaching into the pool beyond the elbow. • Carry a towel and change of clothes into the field if you will be sampling tide pools; even on warm days the ocean water is frigid. • When searching for echinoderms, feel carefully in crevices for animals; you may not be able to see where you put your hands, so move carefully and avoid sudden movements. No tide pool animals in MA or ME bite or sting, but rocks and sea urchin spines can cut or puncture. • A thin neoprene work glove may help protect against cuts and abrasions without hampering the ability to detect sea urchins and sea stars by feel.
Working outdoors during storms	Being struck by falling trees or branches; being struck by lightning	• Listen to the weather forecast each morning (park radio and/or internet). • Plan or adjust field work to avoid being out in thunderstorms. • Postpone work if safety will be compromised by storm conditions. If you see or hear a thunderstorm coming, retreat from high ground and exposed areas. Go inside a sturdy building or vehicle, if possible. • If you can't get inside and if you feel your hair stand on end, lightning is about to strike. • Make yourself the smallest target possible and minimize contact with the ground. • Crouch down on your pack on the balls of your feet and keep your feet close together. Place your hands on your knees and lower your head. • During a thunderstorm, members of the crew should stay separated by at least ten feet.
Poisonous plants, especially poison ivy	Contamination/toxicity from contact with poisonous plants	• Learn to identify poison ivy in its many growth forms. • Wear long sleeves and pants. • Be aware of poison ivy and avoid coming in direct contact with it. • Thoroughly wash hands, equipment, and clothes with Tecnu or similar specialized soap if you come into contact with poison ivy.

Appendix S1.B. Job Safety Analysis (continued).

Tasks	**Potential Hazards**	**Recommended Action or Procedure**
Working in bear territory	Black bear encounter	• A bear encounter is highly unlikely for this project; bears do occur within ACAD. • Work in teams. • Be especially alert near dawn or dusk. • Be especially aware of mother bears with cubs. Never approach cubs or come between a mother bear and her cubs. • Face the animal, continually make noise – do not freeze or remain silent. • Appear larger by standing tall, waving arms or jacket over your head. • Slowly back away – do not approach a bear. • Never run from a bear. • Throw things and shout loudly. • Fight back aggressively.
Bee, wasp, or yellow-jacket stings	Multiple stings from disturbing or stepping into nest areas	• Bees, wasps, or yellow-jackets may be encountered while hiking to monitoring sites. • Be alert to hives in brush, ground holes, or hollow logs. Watch for insects traveling in and out of one location. • If you or anyone you are working with is known to have allergic reactions to be stings, tell the rest of the crew and your supervisor. Make sure you carry emergency medication with you at all times and that your co-workers know where you keep it. • Wear long sleeve shirts and trousers, tuck in shirt. Bright colors and metal objects may attract bees or wasps. • If you are stung, a cold compress may bring relief. • If stinger is left behind, scrape it off of skin. Do not use tweezer as this squeezes the venom sack, worsening the injury. • If the victim develops hives, asthmatic breathing, tissue swelling or a drop in blood pressure, seek medical help immediately.
Bites from mosquitoes, black flies, and other insects	Itchy reactions to multiple bites	• Wear long sleeves and pants. • Avoid sitting on the ground or on logs, especially in dry sunny grassy areas. • Use insect repellants. Do not apply Permethrin, Permanone, or greater than 30% DEET directly to skin, only to clothing. • Carry after-bite medication to reduce skin irritation.

Appendix S1.B. Job Safety Analysis (continued).

Tasks	**Potential Hazards**	**Recommended Action or Procedure**
Ticks	Contracting diseases transmitted from ticks	• Use tick avoidance precautions, including pre-treating clothing with permethrin, tucking pants into socks and shirt into pants when hiking to and from intertidal sites. • Wear clothes (including pants and long-sleeved shirts) that are light colored and check for ticks on clothing after traveling through vegetation. • Conduct a thorough tick check every evening after completing field work. • Know how to identify tick life forms, and the signs & symptoms of tick-borne diseases.
Walking through thick vegetation	Cut, scratched, or bruised by vegetation; eye or ear injuries	• Shield your eyes and face with your hands, glasses, or hat when moving through tall thick brush. Keep your head and eyes pointed somewhat downward so your head hits obstacles before your eyes. • Wear pants and long-sleeved shirts to protect bare skin. • Look before you grab vegetation to avoid grasping thorny stems. • Do not follow closely behind other people to avoid having branches snap back and hit you.
Working in heat, humidity, or cold	Heat exhaustion, sunburn, dehydration, hypothermia	• Evaluate the weather forecast each morning and plan field work accordingly. • Carry and drink plenty of water. • Take extra breaks during extreme weather events. Adjust the work routine to minimize exposure to extreme heat and humidity. • Take adequate garments for all possible weather conditions. Choose clothing that will keep you warm even if it gets wet.
Hazard trees	Being struck by falling trees or branches	• Look up. Be alert for widow-makers, storm damaged trees with large broken limbs, and unstable standing dead trees. • Do not spend extended time in an area with hazard trees.
Carrying a pack and other equipment	Injuries from improper packing, adjustment, and lifting of backpacks. Injuries from improper carrying of gear	• Learn how to properly pack, adjust, lift, and carry a pack. • When hand-carrying gear, keep one hand free. • If carrying long equipment, be aware of other people and never swing around quickly. Avoid allowing a long piece of equipment to project up and behind you, where you cannot see it.

Appendix S1.B. Job Safety Analysis (continued).

Tasks	**Potential Hazards**	**Recommended Action or Procedure**
Riding in landing craft or other small boat	Injuries from tripping while getting on and off boat; injuries from crossing waves/wakes; exposure to wind, sun, and rain	• Obey all instructions from the boat captain. • If unsure of footing, have someone help you on or off of boat. • Pass gear between people on boat and land rather than carrying the gear onto the boat. • When the boat is in motion, stay flexible and try to move with the boat motion; avoid bracing yourself rigidly. • Bring a jacket, even on warm days, since it is cooler on the water. • Check the weather and be prepared with hat, sunscreen, and rain gear.
Using row boat to transport gear and personnel	Injuries and loss of equipment from capsizing, injuries from tripping while getting on and off boat, injuries from improper rowing technique	• Always wear a life vest in the row boat. • Get on and off the boat carefully, keeping center of gravity low and staying to the center of the boat as much as possible. • When someone is entering or exiting the row boat, at least one other person should be helping to stabilize the boat. • Do not overload the row boat and never stand in the boat while it is in motion. • Consider wearing gloves while rowing to protect from blisters. • If you are inexperienced with rowing, take turns with other crew or let a more experienced crew member row.

Appendix S1.B. Job Safety Analysis (continued).

Tasks	**Potential Hazards**	**Recommended Action or Procedure**
General operation of a vehicle	Injuries from vehicle accident; Damage to vehicle	• Perform pre-operational check of vehicle (oil, tire pressure, tire condition, fluids, wipers, brakes, lights, gas, etc.). Report all needed repairs to the crew leader or supervisor promptly. • Do not use the vehicle if it is unsafe. • Wear seat belts with shoulder harnesses whenever vehicle is in motion. • Do not use cell phones or text while driving. • Only NPS employees, volunteers or authorized cooperators and contractors are allowed to operate or ride in a government vehicle. • Ensure full visibility from all windows and mirrors. Clean windshield regularly. • Always ride inside the vehicle. • Properly store and secure all tools, equipment, and cargo so that they will not shift during sudden starts or stops. • Plan your travel before you start. Know your route. • Practice defensive driving; be alert to potential hazards. • Obey all traffic laws and speed limits. • Adjust speed to changing weather or traffic conditions • Allow adequate following/stopping distance. • Avoid distractions such as eating while driving. • Be alert for pedestrians or bicyclists using roadways. • Be watchful for wildlife crossing roads, especially at early morning, dusk, and after dark. • Do NOT drive if fatigued. Stay alert!

SOP 2 – Plot Establishment

Version 1.12 (January 8, 2015)

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 A and B, moved plot maintenance info to the plot maintenance SOP, added tidbit info, minor edits	Protocol revision	1.01
1.01	9/3/2010	B. Mitchell	Recruitment plots should be interspersed with barnacle photoplots whenever possible. Minor edits, including renaming barnacle settlement plots to barnacle recruitment plots.	External review	1.02
1.02	1/9/2012	B. Mitchell	Update procedures for establishing vertical transects. Include procedures for establishing summer scraping barnacle recruitment plots. Revise methods for recording plot location to emphasize use of surveying equipment. Plot aspect should be relative to true north. Remove reference to Appendix A, and update references to refer to the companion document, “Rocky Intertidal Monitoring Site Information”. Add Appendix S2.A, containing known slopes and aspects and placeholders for unknowns.	Improved procedures Procedure needed to test effect of scraping season Higher accuracy needed Clarify procedure Remove site details from protocol document. Store info from former Appendix A	1.10
1.10	6/3/2013	B. Mitchell	Bolts for labels should be 2” lag bolts, not 1” lag bolts	Reduce lost labels	1.11
1.11	1/8/2015	B. Mitchell	Labeled washers should be use to label vertical transect bolts.	Facilitate finding bolts and scoring transect	1.12

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.

The companion document, "Rocky Intertidal Monitoring Site Information," provides the reference bolt locations and plot locations relative to reference bolts for existing plots, as well as photos and overview maps. If new plots are added in the future, their locations will be added to the companion document.

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 50 x75 quadrats are haphazardly scattered 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, five 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 x 5 cm below each quadrat corner using scrapers and wire brushes. Additionally, scrape another 5 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 recruitment) and the number indicates the replicate number. Identification labels should be stamped prior to deployment. The washer is placed over the anchor and a 2" 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 on either side 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 three pools must be selected. If more than three potential pools are present at a site, then the pools should be randomly selected.

3. Scrape the substrate for an area of about 10 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 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 2” 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 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 in this low intertidal zone, and parallel to the upper along-shore transect. Line up the vertical transects so they are spaced identically to 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 2" stainless steel bolt is passed through the washer and screwed into the anchor.

9. Add additional bolts to fill in the contours of each transect. Additional bolts should be at high points, low points, or large changes in slope of each transect. Bolts should not be installed below water; if there is a tidepool along a transect install bolts at the points where the transect intersects the edges of the pool. If there is a long stretch of constant slope, the new bolts should be spaced no farther apart than every 3.0 m. The purpose of these bolts is to provide for more consistent data collection, as well as locations with known elevation (once they are surveyed) for monitoring sea level rise. Install the bolts using the procedures in steps 3 and 4.

10. Once the total number of bolts on each transect is known, install a labeled 1 ¼" stainless steel washer on each bolt (use the impact driver to unscrew the bolt, insert it through the washer,

and then reinstall the bolt in the existing anchor). Bolts are labeled with "N-1" at the top, where N is the transect number. 1 ¼" washers are used because they are large enough for stamping numbers, but narrower than the transect tape.

Barnacle Recruitment Plots

1. Barnacle recruitment 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 recruitment plots, ten 20 x 20 cm frames are haphazardly scattered 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, five are randomly selected as the final location for the fixed barnacle recruitment plots. Whenever possible, the barnacle recruitment plots should be interspersed with the barnacle photoplots to ensure that the recruitment data will be relevant to the photoplots information.

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 20 x 20 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 recruitment) and the number indicates the replicate number (1-5). The washer is placed over the anchor and a 2" stainless steel bolt is passed through the washer and screwed into the anchor.

5. Remove the frame.

Summer Scraping Barnacle Recruitment Plots

1. If installing summer scraping recruitment plots (to compare the difference between scraping barnacles in the winter and summer), use these procedures. The plot must have >50% barnacle cover and be relatively flat, and should not be within 20 cm of an existing barnacle settlement plot or barnacle photoplot. The first choice of location is two 20 x 20 cm frame lengths to the left (with back to the ocean) of each existing barnacle recruitment plot. If that location is not suitable, go to the right, then above, then below, and then extend an additional frame length and repeat, until a suitable location is found.

2. Scrape the entire substrate underneath each 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 because barnacles not removed during scraping may be incorrectly counted as new recruits during subsequent surveys, and because 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 20 x 20 cm frame in the center of the plot. Plots are marked with stainless steel bolts (3" length, 1/4" diameter) just inside 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, U=Summer Scraping Barnacle Recruitment) and the number indicates the replicate number (1-5). The washer is placed over the anchor and a 2" stainless steel bolt is passed through the washer and screwed into the anchor.

Tidbits

1. Prior to entering the field, prepare the tidbit shelters (Figure S2.1). 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

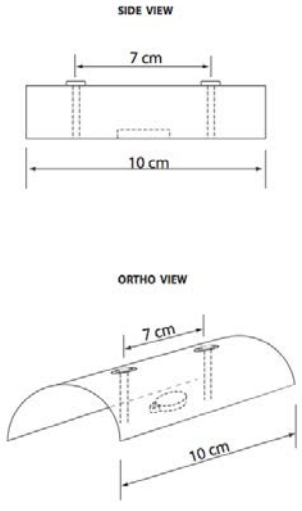


Figure S2.1. Protective PVC shelter for tidbit temperature loggers showing bolt placement.

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.

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 identity obvious. The washer is placed over the anchor and a 2” 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

After a plot is installed, use surveying equipment (RTK-GPS or a total station that can be referenced to a surveyed location or reference bolt) to record the location and elevation of each bolt to within 5 cm horizontal accuracy. Accurate locations are crucial for facilitating relocation of plots that are encrusted by marine organisms, and for documenting the effects of sea level rise.

If surveying equipment is not available, document plot location as follows:

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.

Once the bolt locations have been recorded, collect photographic documentation of the plot(s) as follows:

1. 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.

2. Compile this information (GPS coordinates of reference bolt, distance and heading from the reference bolt to each identification label [see “Rocky Intertidal Monitoring Site Information,”], 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.

The protocol companion document, “Rocky Intertidal Monitoring Site Information” contains overview maps of all the sites, including recommended anchorages at the BOHA sites and parking locations at ACAD. “Rocky Intertidal Monitoring Site Information”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 photoplots and barnacle recruitment 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 slope and aspect measurements were completed at most of the ACAD sites in 2008 (Appendix S2.A). 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 photoplot and barnacle recruitment 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 most hardware/home improvement stores) 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 0°. A perfectly vertical plot has a slope of 90°. A plot may have a slope greater than 90° if the plot is under an overhang. Record the slope to the nearest five degrees. Be careful because some inclinometers do not go past 90° but some of the plots are on overhangs and have slopes > 90° (e.g. some of the BOHA barnacle photoplots and recruitment plots). Also, the predominant slope need not be parallel to the sides of the plot.

Appendix S2.A 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 (360° along a plane parallel to earth's surface).
2. For each fixed photoplot and barnacle recruitment 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 (relative to true north) to the nearest five degrees. This is the aspect.

Appendix S2.A 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 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 hardware/home improvement stores (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 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 S2.2) 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 S2.2) 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 S2.2, 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.

The protocol companion document, "Rocky Intertidal Monitoring Site Information," contains plot elevations calculated using RTK-GPS or according to this method. As more elevations are measured, they will be added to the document.

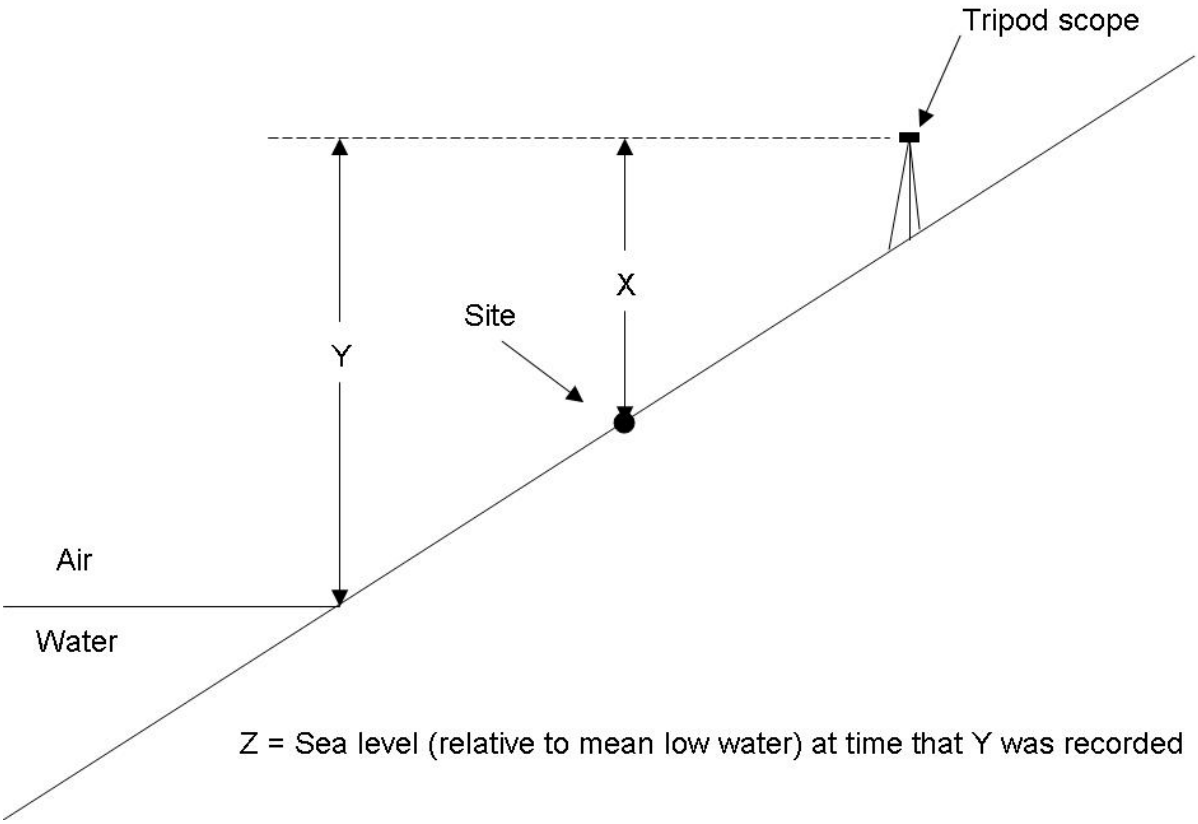


Figure S2.2. Diagram showing the measurements needed to determine plot elevation.

Appendix S2.A. Plot Slope and Aspect

Plot aspects in this appendix dated 2008 may be relative to magnetic north rather than true north. Aspects should be verified and adjusted to be relative to true north if necessary.

Park	Site	Plot	Date	Recorder	Slope (deg.)	Aspect (deg.)
ACAD	BASHAR	ASC1	9/20/2008	Austin Gallagher	13.5	18
ACAD	BASHAR	ASC2	9/20/2008	Austin Gallagher	15.6	20
ACAD	BASHAR	ASC3	9/20/2008	Austin Gallagher	13.6	354
ACAD	BASHAR	ASC4	9/20/2008	Austin Gallagher	9.2	120
ACAD	BASHAR	ASC5	9/20/2008	Austin Gallagher	12.7	170
ACAD	BASHAR	BAR1	9/20/2008	Austin Gallagher	12.1	175
ACAD	BASHAR	BAR2	9/20/2008	Austin Gallagher	5.1	194
ACAD	BASHAR	BAR3	9/20/2008	Austin Gallagher	9.0	146
ACAD	BASHAR	BAR4	9/20/2008	Austin Gallagher	10.7	272
ACAD	BASHAR	BAR5	9/20/2008	Austin Gallagher	5.2	58
ACAD	BASHAR	FUC1	9/20/2008	Austin Gallagher	10.5	210
ACAD	BASHAR	FUC2	9/20/2008	Austin Gallagher	27.8	205
ACAD	BASHAR	FUC3	9/20/2008	Austin Gallagher	31.6	220
ACAD	BASHAR	FUC4	9/20/2008	Austin Gallagher	40.1	305
ACAD	BASHAR	FUC5	9/20/2008	Austin Gallagher	21.9	225
ACAD	BASHAR	RED1	9/20/2008	Austin Gallagher	14.2	180
ACAD	BASHAR	RED2	9/20/2008	Austin Gallagher	9.5	210
ACAD	BASHAR	RED3	9/20/2008	Austin Gallagher	15.1	354
ACAD	BASHAR	RED4	9/20/2008	Austin Gallagher	11.9	210
ACAD	BASHAR	RED5	9/20/2008	Austin Gallagher	19.0	230
ACAD	BASHAR	SET1	9/20/2008	Austin Gallagher	8.7	180
ACAD	BASHAR	SET2	9/20/2008	Austin Gallagher	7.0	170
ACAD	BASHAR	SET3	9/20/2008	Austin Gallagher	5.2	128
ACAD	BASHAR	SET4	9/20/2008	Austin Gallagher	6.8	138
ACAD	BASHAR	SET5	9/20/2008	Austin Gallagher	10.5	140
ACAD	BASHAR	SUM1				
ACAD	BASHAR	SUM2				
ACAD	BASHAR	SUM3				
ACAD	BASHAR	SUM4				
ACAD	BASHAR	SUM5				
ACAD	OTTPOI	ASC1	9/21/2008	Andy Shantz	13.9	108
ACAD	OTTPOI	ASC2	9/21/2008	Andy Shantz	13.4	180
ACAD	OTTPOI	ASC3	9/21/2008	Andy Shantz	29.5	150
ACAD	OTTPOI	ASC4	9/21/2008	Andy Shantz	12.1	200
ACAD	OTTPOI	ASC5	9/21/2008	Andy Shantz	7.6	124
ACAD	OTTPOI	BAR1	9/21/2008	Andy Shantz	27.0	170
ACAD	OTTPOI	BAR2	9/21/2008	Andy Shantz	14.4	178
ACAD	OTTPOI	BAR3	9/21/2008	Andy Shantz	16.8	180
ACAD	OTTPOI	BAR4	9/21/2008	Andy Shantz	17.1	188
ACAD	OTTPOI	BAR5	9/21/2008	Andy Shantz	22.3	210
ACAD	OTTPOI	FUC1	9/21/2008	Andy Shantz	16.9	356
ACAD	OTTPOI	FUC2	9/21/2008	Andy Shantz	17.6	0
ACAD	OTTPOI	FUC3	9/21/2008	Andy Shantz	40.0	16

Appendix S2.A. Plot Slope and Aspect (continued).

Park	Site	Plot	Date	Recorder	Slope (deg.)	Aspect (deg.)
ACAD	OTTPOI	FUC4	9/21/2008	Andy Shantz	45.1	18
ACAD	OTTPOI	FUC5	9/21/2008	Andy Shantz	44.9	10
ACAD	OTTPOI	MUS1	9/21/2008	Andy Shantz	11.5	120
ACAD	OTTPOI	MUS2	9/21/2008	Andy Shantz	5.6	31
ACAD	OTTPOI	MUS3	9/21/2008	Andy Shantz	11.0	170
ACAD	OTTPOI	MUS4	9/21/2008	Andy Shantz	16.7	178
ACAD	OTTPOI	MUS5	9/21/2008	Andy Shantz	4.6	350
ACAD	OTTPOI	RED1	9/21/2008	Andy Shantz	23.5	340
ACAD	OTTPOI	RED2	9/21/2008	Andy Shantz	13.6	326
ACAD	OTTPOI	RED3	9/21/2008	Andy Shantz	14.5	38
ACAD	OTTPOI	RED4	9/21/2008	Andy Shantz	12.8	148
ACAD	OTTPOI	RED5	9/21/2008	Andy Shantz	20.7	192
ACAD	OTTPOI	SET1	9/21/2008	Andy Shantz	22.8	182
ACAD	OTTPOI	SET2	9/21/2008	Andy Shantz	35.1	170
ACAD	OTTPOI	SET3	9/21/2008	Andy Shantz	19.3	180
ACAD	OTTPOI	SET4	9/21/2008	Andy Shantz	17.2	222
ACAD	OTTPOI	SET5	9/21/2008	Andy Shantz	13.4	192
ACAD	SCHPOI	ASC1	9/19/2008	Rebecca Isquith	11.7	178
ACAD	SCHPOI	ASC2	9/19/2008	Rebecca Isquith	11.8	190
ACAD	SCHPOI	ASC3	9/19/2008	Rebecca Isquith	3.6	184
ACAD	SCHPOI	ASC4	9/19/2008	Rebecca Isquith	10.6	184
ACAD	SCHPOI	ASC5	9/19/2008	Rebecca Isquith	13.3	188
ACAD	SCHPOI	BAR1	9/19/2008	Rebecca Isquith	6.4	1
ACAD	SCHPOI	BAR2	9/19/2008	Rebecca Isquith	9.2	18
ACAD	SCHPOI	BAR3	9/19/2008	Rebecca Isquith	3.4	11
ACAD	SCHPOI	BAR4	9/19/2008	Rebecca Isquith	10.0	22
ACAD	SCHPOI	BAR5	9/19/2008	Rebecca Isquith	8.8	28
ACAD	SCHPOI	FUC1	9/19/2008	Rebecca Isquith	8.9	18
ACAD	SCHPOI	FUC2	9/19/2008	Rebecca Isquith	10.3	332
ACAD	SCHPOI	FUC3	9/19/2008	Rebecca Isquith	14.4	59
ACAD	SCHPOI	FUC4	9/19/2008	Rebecca Isquith	8.2	201
ACAD	SCHPOI	FUC5	9/19/2008	Rebecca Isquith	11.2	41
ACAD	SCHPOI	MUS1	9/19/2008	Rebecca Isquith	2.7	1
ACAD	SCHPOI	MUS2	9/19/2008	Rebecca Isquith	8.3	354
ACAD	SCHPOI	MUS3	9/19/2008	Rebecca Isquith	6.7	6
ACAD	SCHPOI	MUS4	9/19/2008	Rebecca Isquith	21.7	8
ACAD	SCHPOI	MUS5	9/19/2008	Rebecca Isquith	9.7	38
ACAD	SCHPOI	RED1	9/19/2008	Rebecca Isquith	22.5	344
ACAD	SCHPOI	RED2	9/19/2008	Rebecca Isquith	18.1	342
ACAD	SCHPOI	RED3	9/19/2008	Rebecca Isquith	20.2	340
ACAD	SCHPOI	RED4	9/19/2008	Rebecca Isquith	19.1	344
ACAD	SCHPOI	RED5	9/19/2008	Rebecca Isquith	23.8	340
ACAD	SCHPOI	SET1	9/19/2008	Rebecca Isquith	4.8	333
ACAD	SCHPOI	SET2	9/19/2008	Rebecca Isquith	3.9	21
ACAD	SCHPOI	SET3	9/19/2008	Rebecca Isquith	16.9	32
ACAD	SCHPOI	SET4	9/19/2008	Rebecca Isquith	7.0	352
ACAD	SCHPOI	SET5	9/19/2008	Rebecca Isquith	3.2	14
ACAD	SCHPOI	SUM1				

Appendix S2.A. Plot Slope and Aspect (continued).

Park	Site	Plot	Date	Recorder	Slope (deg.)	Aspect (deg.)
ACAD	SCHPOI	SUM2				
ACAD	SCHPOI	SUM3				
ACAD	SCHPOI	SUM4				
ACAD	SCHPOI	SUM5				
ACAD	SHIHAR	ASC1	9/20/2008	Ashwin Bandiwhad	13.2	315
ACAD	SHIHAR	ASC2	9/20/2008	Ashwin Bandiwhad	32.0	110
ACAD	SHIHAR	ASC3	9/20/2008	Ashwin Bandiwhad	17.3	130
ACAD	SHIHAR	ASC4	9/20/2008	Ashwin Bandiwhad	18.2	158
ACAD	SHIHAR	ASC5	9/20/2008	Ashwin Bandiwhad	22.7	245
ACAD	SHIHAR	BAR1	9/20/2008	Ashwin Bandiwhad	7.2	95
ACAD	SHIHAR	BAR2	9/20/2008	Ashwin Bandiwhad	10.6	270
ACAD	SHIHAR	BAR3	9/20/2008	Ashwin Bandiwhad	11.9	310
ACAD	SHIHAR	BAR4	9/20/2008	Ashwin Bandiwhad	17.5	310
ACAD	SHIHAR	BAR5	9/20/2008	Ashwin Bandiwhad	14.6	235
ACAD	SHIHAR	FUC1	9/20/2008	Ashwin Bandiwhad	11.0	146
ACAD	SHIHAR	FUC2	9/20/2008	Ashwin Bandiwhad	11.0	126
ACAD	SHIHAR	FUC3	9/20/2008	Ashwin Bandiwhad	19.4	102
ACAD	SHIHAR	FUC4	9/20/2008	Ashwin Bandiwhad	30.0	142
ACAD	SHIHAR	FUC5	9/20/2008	Ashwin Bandiwhad	22.2	142
ACAD	SHIHAR	RED1				
ACAD	SHIHAR	RED2				
ACAD	SHIHAR	RED3				
ACAD	SHIHAR	RED4				
ACAD	SHIHAR	RED5				
ACAD	SHIHAR	SET1	9/20/2008	Ashwin Bandiwhad	16.7	310
ACAD	SHIHAR	SET2	9/20/2008	Ashwin Bandiwhad	7.6	150
ACAD	SHIHAR	SET3	9/20/2008	Ashwin Bandiwhad	4.1	210
ACAD	SHIHAR	SET4	9/20/2008	Ashwin Bandiwhad	5.0	140
ACAD	SHIHAR	SET5	9/20/2008	Ashwin Bandiwhad	13.3	230
ACAD	SHIHAR	SUM1				
ACAD	SHIHAR	SUM2				
ACAD	SHIHAR	SUM3				
ACAD	SHIHAR	SUM4				
ACAD	SHIHAR	SUM5				
BOHA	CALISL	ASC1				
BOHA	CALISL	ASC2				
BOHA	CALISL	ASC3				
BOHA	CALISL	ASC4				
BOHA	CALISL	ASC5				
BOHA	CALISL	BAR1				
BOHA	CALISL	BAR2				
BOHA	CALISL	BAR3				
BOHA	CALISL	BAR4				
BOHA	CALISL	BAR5				
BOHA	CALISL	FUC1				
BOHA	CALISL	FUC2				
BOHA	CALISL	FUC3				
BOHA	CALISL	FUC4				

Appendix S2.A. Plot Slope and Aspect (continued).

Park	Site	Plot	Date	Recorder	Slope (deg.)	Aspect (deg.)
BOHA	CALISL	FUC5				
BOHA	CALISL	RED1				
BOHA	CALISL	RED2				
BOHA	CALISL	RED3				
BOHA	CALISL	RED4				
BOHA	CALISL	RED5				
BOHA	CALISL	SET1				
BOHA	CALISL	SET2				
BOHA	CALISL	SET3				
BOHA	CALISL	SET4				
BOHA	CALISL	SET5				
BOHA	CALISL	SUM1				
BOHA	CALISL	SUM2				
BOHA	CALISL	SUM3				
BOHA	CALISL	SUM4				
BOHA	CALISL	SUM5				
BOHA	GREISL	ASC1				
BOHA	GREISL	ASC2				
BOHA	GREISL	ASC3				
BOHA	GREISL	ASC4				
BOHA	GREISL	ASC5				
BOHA	GREISL	BAR1				
BOHA	GREISL	BAR2				
BOHA	GREISL	BAR3				
BOHA	GREISL	BAR4				
BOHA	GREISL	BAR5				
BOHA	GREISL	FUC1				
BOHA	GREISL	FUC2				
BOHA	GREISL	FUC3				
BOHA	GREISL	FUC4				
BOHA	GREISL	FUC5				
BOHA	GREISL	RED1				
BOHA	GREISL	RED2				
BOHA	GREISL	RED3				
BOHA	GREISL	RED4				
BOHA	GREISL	RED5				
BOHA	GREISL	SET1				
BOHA	GREISL	SET2				
BOHA	GREISL	SET3				
BOHA	GREISL	SET4				
BOHA	GREISL	SET5				
BOHA	GREISL	SUM1				
BOHA	GREISL	SUM2				
BOHA	GREISL	SUM3				
BOHA	GREISL	SUM4				
BOHA	GREISL	SUM5				
BOHA	OUTBRE	ASC1				
BOHA	OUTBRE	ASC2				

Appendix S2.A. Plot Slope and Aspect (continued).

Park	Site	Plot	Date	Recorder	Slope (deg.)	Aspect (deg.)
BOHA	OUTBRE	ASC3				
BOHA	OUTBRE	ASC4				
BOHA	OUTBRE	ASC5				
BOHA	OUTBRE	BAR1				
BOHA	OUTBRE	BAR2				
BOHA	OUTBRE	BAR3				
BOHA	OUTBRE	BAR4				
BOHA	OUTBRE	BAR5				
BOHA	OUTBRE	FUC1				
BOHA	OUTBRE	FUC2				
BOHA	OUTBRE	FUC3				
BOHA	OUTBRE	FUC4				
BOHA	OUTBRE	FUC5				
BOHA	OUTBRE	RED1				
BOHA	OUTBRE	RED2				
BOHA	OUTBRE	RED3				
BOHA	OUTBRE	RED4				
BOHA	OUTBRE	RED5				
BOHA	OUTBRE	SET1				
BOHA	OUTBRE	SET2				
BOHA	OUTBRE	SET3				
BOHA	OUTBRE	SET4				
BOHA	OUTBRE	SET5				
MCI	METISL	ASC1				
MCI	METISL	ASC2				
MCI	METISL	ASC3				
MCI	METISL	ASC4				
MCI	METISL	ASC5				
MCI	METISL	BAR1				
MCI	METISL	BAR2				
MCI	METISL	BAR3				
MCI	METISL	BAR4				
MCI	METISL	BAR5				
MCI	METISL	FUC1				
MCI	METISL	FUC2				
MCI	METISL	FUC3				
MCI	METISL	FUC4				
MCI	METISL	FUC5				
MCI	METISL	RED1				
MCI	METISL	RED2				
MCI	METISL	RED3				
MCI	METISL	RED4				
MCI	METISL	RED5				
MCI	METISL	SET1				
MCI	METISL	SET2				
MCI	METISL	SET3				
MCI	METISL	SET4				
MCI	METISL	SET5				

Appendix S2.A. Plot Slope and Aspect (continued).

Park	Site	Plot	Date	Recorder	Slope (deg.)	Aspect (deg.)
MCI	PETMAN	ASC1				
MCI	PETMAN	ASC2				
MCI	PETMAN	ASC3				
MCI	PETMAN	ASC4				
MCI	PETMAN	ASC5				
MCI	PETMAN	BAR1				
MCI	PETMAN	BAR2				
MCI	PETMAN	BAR3				
MCI	PETMAN	BAR4				
MCI	PETMAN	BAR5				
MCI	PETMAN	FUC1				
MCI	PETMAN	FUC2				
MCI	PETMAN	FUC3				
MCI	PETMAN	FUC4				
MCI	PETMAN	FUC5				
MCI	PETMAN	RED1				
MCI	PETMAN	RED2				
MCI	PETMAN	RED3				
MCI	PETMAN	RED4				
MCI	PETMAN	RED5				
MCI	PETMAN	SET1				
MCI	PETMAN	SET2				
MCI	PETMAN	SET3				
MCI	PETMAN	SET4				
MCI	PETMAN	SET5				

SOP 3 – Pre-season Preparations

Version 1.07 (January 6, 2015)

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
1.01	9/3/2010	B. Mitchell	Added monitoring timeline section and table, and reference to maintenance of Ikelite equipment. Updated equipment list and equipment specifications. Minor edits, including use of barnacle recruitment instead of settlement.	External review	1.02
1.02	12/16/2010	B. Mitchell	Remove assumption that there will be coordination with estuary and salt marsh monitoring. New procedures for downloading tide predictions.	Programmatic change	1.03
1.03	1/6/2012	B. Mitchell	Tidal height should be less than 0.3 ft (0.1 m) and negative if seas are > 1 foot; otherwise some plots may not be reachable. Update UMASS landing craft rate and web site, and info about BOHA dinghy. BOHA staff availability for sampling better in July than June. Removed reference to multiple sampling crews. Update info on equipment list and specs.	Original recommendation (0.5 ft) was not sufficient Update info Clarify availability Extraneous info Update info	1.04
1.04	7/2/2013	B. Mitchell	Replace 1” lag bolts with 2” lag bolts (for labels) Add info about FWS site access Add stretch cord to equipment list	Reduce lost labels Limited access to PETMAN Streamline gear (replaces quadrats)	1.05
1.05	2/13/2014	B. Mitchell	Add information about BOHA gull and cormorant colonies Add space blanket to personal gear	Planning needs to reduce impact on breeding birds Suggestion from Marc Albert (BOHA)	1.06
1.06	1/6/2015	B. Mitchell	Updated equipment checklist (Table S3.3).	Old version outdated.	1.07

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 3 to 6 months prior to the sampling season. This SOP provides details on factors affecting scheduling, as well as information on housing, transportation, and equipment required to conduct the sampling.

Scheduling Considerations

Monitoring Timeline

Table S3.1 provides a timeline of annual monitoring activities, including pre-season and post-season deadlines. The table assumes sampling in late June or early July, and should be adjusted if sampling will occur later in the season (acceptable dates extend through the end of August).

Field Work Timing

Low tide series with a duration of 1 week and tidal heights of ≤ 0.3 feet (0.1 m) above Mean Low Water are required to insure reasonable access to all of the fixed plots and tide pools. 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 website (Obtaining Tidal Schedules, below). If the seas are greater than one foot, negative tidal heights will likely be needed for the lowest plots to be reachable.

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 four ACAD sites, 3 days for the three BOHA sites, and 2 days for the two 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. Note that the availability of BOHA staff can best be assured if sampling at BOHA is scheduled for July.

BOHA sampling should be scheduled for as late in the season as possible to minimize disturbance to gull and cormorant breeding colonies (while still ensuring adequate weather make-up days). Access to the Calf and Green Island sites requires walking through gull colonies, and there is a cormorant colony above the monitoring site on Green Island. BOHA may wish to schedule a boat trip by the breeding colonies prior to and a week after the sampling to document potential impacts. Gulls are not particularly sensitive to disturbance and are unlikely to be significantly affected by the traffic through the colonies, but cormorants are more sensitive and the cormorant colony should be avoided.

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.

Table S3.1. Timeline of annual monitoring tasks, including pre-season and post-season deadlines.

Date	Responsible Individual	Task
January 1	NETN Program Manager	Ensure that cooperative agreement or contract for the project manager is in place.
January 15	Project Manager	Make arrangements with park and refuge staff for barnacle scraping trips.
February 1 to March 14	NPS and USFWS Staff	Barnacle plot scraping
February 15	Project Manager	Recruit summer interns.
March 15	Project Manager	Review tide schedule to select sampling dates, coordinate with park and refuge staff regarding transportation, landowner notification (BOHA) and volunteer recruitment.
April 15	Project Manager, NPS, and USFWS Staff	Check and maintain all equipment; repair and replace as needed.
May 1	Project Manager	Review plot notes from previous season, produce list of plots needing repair work, produce list of sites needing new tidbits, and prepare any equipment (e.g., plot labels) that need to be installed.
June 7 to June 22	Project Manager and Field Staff	Training (likely a few days within this time window)
June 22 to July 15	Project Manager and field staff	Field sampling, including one QC (repeat) plot
July 16	Field Staff	Clean and maintain all equipment for storage, and report any equipment problems.
July 20	Field Staff	Enter all field data into database.
July 27	Project Manager and Field Staff	Complete 100% check of field data.
August 5	Project Manager and Field Staff	Complete photoplot scoring and data entry.
September 15	NETN Staff	Complete 10% check of database.
November 15	Project Manager	Draft annual report due
December 1	NPS and USFWS Staff	Comments returned to Project Manager
December 15	Project Manager, NPS and USFWS staff	Final report due, and annual protocol review meeting

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 S3.2). 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 S3.2. 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. In order to access Petit Manan, USFWS boats must be launched from Milbridge or Jonesport more than two hours before or two hours after low tide (typically not a problem since sampling takes more than four hours). Given the high cost of chartering boats in Boston, NETN recommends 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 $60 per hour. Information about this vessel can be found at: http://www.umb.edu/marineops/vessels/landing_craft/.

The main advantage of the Northeastern vessel is that it is most likely 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, it should 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 three people and some of the gear can fit in the BOHA dinghy at once. Therefore, multiple trips are required to shuttle the entire crew and gear from boat to shore. The protocol companion document, "Rocky Intertidal Monitoring Site Information," shows the BOHA sites and the suggested anchorage and landing sites.

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, recruitment 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.

Prior to the sampling season:

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

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 S3.A). Table S3.3 is an example checklist of field equipment necessary for sampling rocky intertidal sites. Remember to print maps and datasheets on water proof paper.

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 S3.4). Maintain the Ikelite camera housing and strobe according to the directions that came with the equipment (including lubricating all O-ring seals). Check the database to obtain a list of data loggers that will need their batteries replaced and procure these batteries.

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.

Download the tidal schedules for all the monitoring sites and develop a sampling schedule (Obtaining Tidal Schedules, below). 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.

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

Table S3.3. Rocky intertidal sampling and personal equipment checklists.

Quantity	Item
	Plot repairs and installation
1	Rotary Hammer Drill capable of drilling into granite (e.g., Hilti TE 7-A)
1	Spare battery for drill
Variable	SS lag bolts (3" length, 1/4" diameter). Site installation requires approximately 150/site.
Variable	SS lag bolts (2" length, 1/4" diameter). Site installation requires approximately 60/site.
1	Complete set of pre-stamped stainless steel washers (1.5" OD) & vertical transect washers (1.25")
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 7/16" nut driver
1	Spare battery for impact driver
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.
	General
1	Site guide with detailed maps and photos
1	Metal detector
1	Set of data sheets (see below)
3	Clipboard
4	Mechanical pencils
4	Paint scraper
4	Wire brush
	Photo plot location and overview photos
6	PVC 50 x 75 cm quadrat or stretch cords and one quadrat for plots with missing bolts
5	Orange cone for marking plot for photo when tide/waves affects quadrat
	Photoplot monitoring
1	PVC photoplot camera frame ("quadrapod") with 4 legs and camera mount
1	Digital Camera with underwater housing, spare batteries, memory card, and moisture muncher
1	Strobe
1	Car shade for shading plots
	Motile invertebrates and size frequencies
2	Forceps
30	Containers for invertebrates (yogurt containers and labeled Ziploc baggies)
2	Plastic calipers
	Temperature loggers
1	Data shuttle
1	Impact driver with phillips head and 7/16" nut driver
1	Spare anchors, bolts, and shelter
	Tidepool band transects
2	1 m long PVC pipe
2	Handheld tally counter
1	Container for holding urchins prior to measurement (e.g. yogurt tub)
3	30 m transect tapes

Table S3.3. Rocky intertidal sampling and personal equipment checklists (continued).

Quantity	Item
	Point-intercept transects
3	50 m transect tapes
	Barnacle Recruitment
2	Metric ruler for scale in photographs
2	7.5”x7.5” frame
1	PVC camera frame (sized for close-up of 7.5” frame)
1	Car shade for shading plots
	Data sheets (on RITE IN RAIN PHOTOCOPIER PAPER)
1	Form 1 (Field Log)
4 or 5	Form 3 (Motile Invertebrates)
3	Form 4 (Point-intercept Transect)
1	Form 5 (Tidepool Band Transect)
	Personal Equipment
1	First Aid Kit
1	Throw Rope
1-2	Space blanket
2/person	Knee pads
2/person	Stabilicers
1/person	Life vest
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 water bottle
1/person	Food

Table S3.4. Specifications, product number and supplier of special equipment used to sample rocky intertidal monitoring sites.

Item	Company	Product ID	2010 Cost (without shipping)
SD/SDHC Memory Card Reader	B&H	ALAUCR202F	$11.79
4 GB SDHC Memory Card	B&H	KISDHC44GB	$9.95
1400 grey pelican case	B&H	PE1400FS	$69.29
1450 yellow pelican case	B&H	PE1450FY	$78.99
Battery charger (AA)	B&H	ANP5	$45.99
AA 4-packs, x 2	B&H	ANAANM42850	$35.98
Canon SX20 IS Digital Camera (or similar)	B&H	CAPSSX20	$399.99
Ikelite Tray with handle	B&H	IK9523.31	$49.95
Ikelite DS-125 package with TTL Sync Cord	B&H	IK3944.90	$1,044.95
Ikelite TTL Underwater Housing	B&H	IK6148.01	$699.99
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	$5.36
18-8 SS Hex head lag screw 1/4" diameter, 2" length, pack of 25	McMaster-Carr	92351A550	$8.94
Blue polyethylene conical screw anchor, no. 14-16, 1/4" lag screw size, 1-3/8" length, pack of 100	McMaster-Carr	97068A140	$5.80
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	$9.18
18-8 SS Pan head phillips sheet metal screw no. 6 size, 1-1/2" length, pack of 100	McMaster-Carr	92470A157	$6.52
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	SA-6200	$11.25
50m Fiberglass tape, Keson open-type fiberglass long tape, metric, pack of 5	Amazon	OTR50M	$164.95
30m Fiberglass tape, Keson open-type fiberglass long tape, metric, pack of 5	Amazon	OTR30M	$99.99
LL Bean White Mountain pack	LL Bean	TC55608	$159.00
Garmin GPS Map 76S Handheld GPS Navigator	Amazon		$139.99
Impact Driver 18 V, Dewalt	Grainger	DC825B	$129.00
Batteries for 18 V Dewalt Impact Drivers	Grainger	4GA70	$95.00
Charger for 18 V Dewalt batteries	Grainger	2AEX1	$79.00
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	$3.95
Hand Stamp set 1/4	Grainger	2CDY2	$105.35
Plasti-cal Digital Caliper	Forestry Suppliers	59598	$52.50
Plastic dial caliper	Forestry Suppliers	59591	$24.96
Map source, trip, and waypoint manager software	Amazon	010-10215-04	$23.43
Access, USB to serial cable for GPS	Garmin	010-10310-00	$59.99

Table S3.4. Specifications, product number and supplier of special equipment used to sample rocky intertidal monitoring sites (continued).

Item	Company	Product ID	2010 Cost (without shipping)
Rite in Rain photocopier paper	Forestry Suppliers	49247	$28.95
250GB Buffalo Ministation Metro USB 2.0 Portable Hard Drive	B&H	BUHDPX250U2R	$74.95
Forceps	VWR	25601-134	$5.35
HOBO Waterproof shuttle for tidbits	Onset	U-DTW-1	$230.00
Temperature tidbits	Onset	UTBI-001	$133.00
HOBOware Pro for Windows v2.5.0	Onset	BHW-PC	$89.00
Level Rod 7.6m	Forestry Suppliers	43483	$158.50
Sealife big moisture muncher	Divers Direct	10061316, M101	$9.95
Aquamesh (1.5" mesh, 12.5 gauge, ten 7.5" x 7.5" squares)	Friendship Trap Co.	FW1515125360	$26
Hilti TE 7-A Rotary Hammer Drill premium kit (drill, charger, case, 2 batteries)	Hilti	3476239	$1,224.13

Obtaining Tidal Schedules

Tidal height predictions for each site can be obtained from the National Oceanic and Atmospheric Administration's (NOAA) Center for Operational Oceanographic Products & Services (CO-OPS). Tidal predictions should be used to fine tune sampling schedules to maximize the amount of productive survey time on each site.

Process steps for obtaining tidal schedules from NOAA:

1. Navigate to the Tides and Currents page of NOAA's website (http://tidesandcurrents.noaa.gov/gmap3/index.shtml?type=PreliminaryData&region)
2. In the 'Require Data Type' dialog box on the top-right of the page, choose "Tide Predictions"
3. Type the station ID (Table S3.5) into the 'Search for Station' dialog box (top of page)

Table S3.5. NOAA tide prediction stations most closely associated with NETN Rocky Intertidal Monitoring sampling sites.

Sampling Site(s)	NOAA Station ID	Station Name
ACAD – MDI	8413564	Southwest Harbor
ACAD - Schoodic	8413079	Winter Harbor, Frenchman Bay
BOHA – all	8444162	Boston Light
MCI – PETMAN	8412568	Green Island, Petit Manan Bar
MCI – METISL	8414876	Matinicus Harbor, Wheaton Island

4. In the pop-up window for the station select 'Tide Predictions'
5. Use the Tides & Currents webpage interface to refine the data being returned

a. Basic settings: Begin Date, Time Range (monthly), Time Zone (LST/LDT), Units (meters)

b. Advanced options: Datum (MLLW; this is the only option for the stations in Table S3.5), Time Units (AM/PM or 24 hour), Data Interval (High/Low or Low only)

6. Print or download the data as a text file using the tools provided in the upper right of the screen (Figure S3.1).

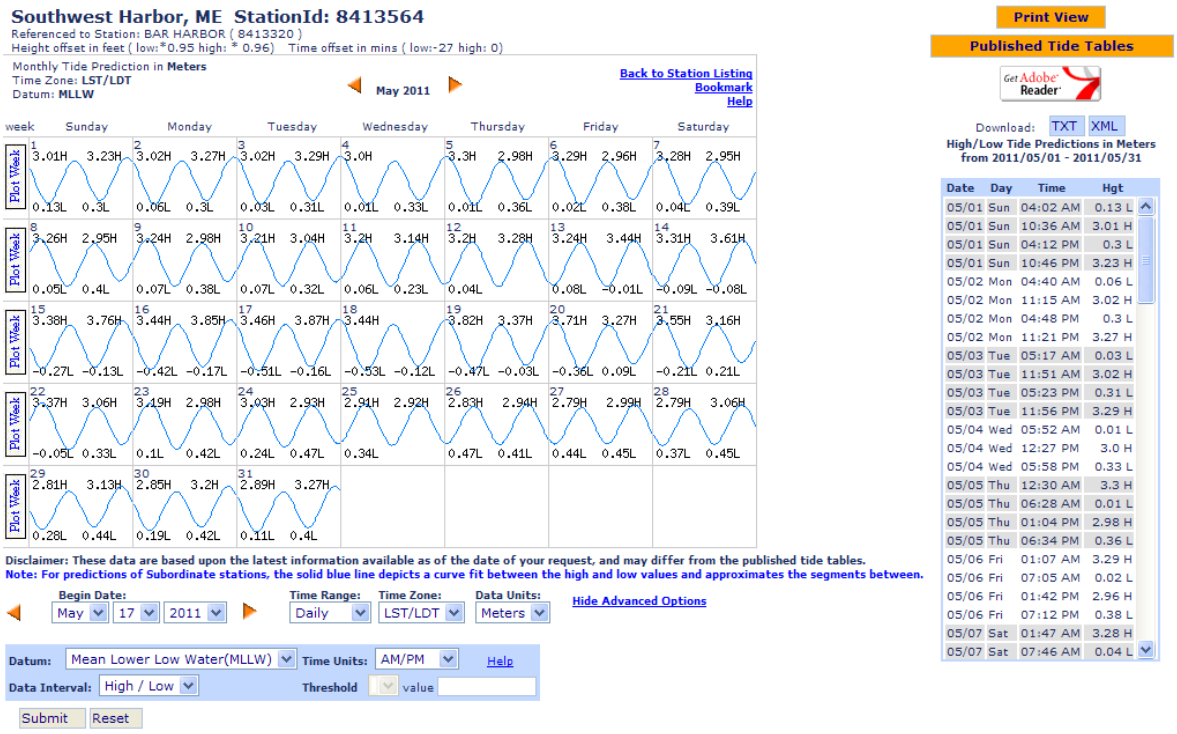


Figure S3.1. Screen shot of NOAA's Currents and Tides webpage with typical configuration of dialog settings required when obtaining predicted tidal height information.

Appendix S3.A. 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 S3.A.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 S3.A.1) should be cut into the upper left of the top frame. This is where the strobe arm will rest.

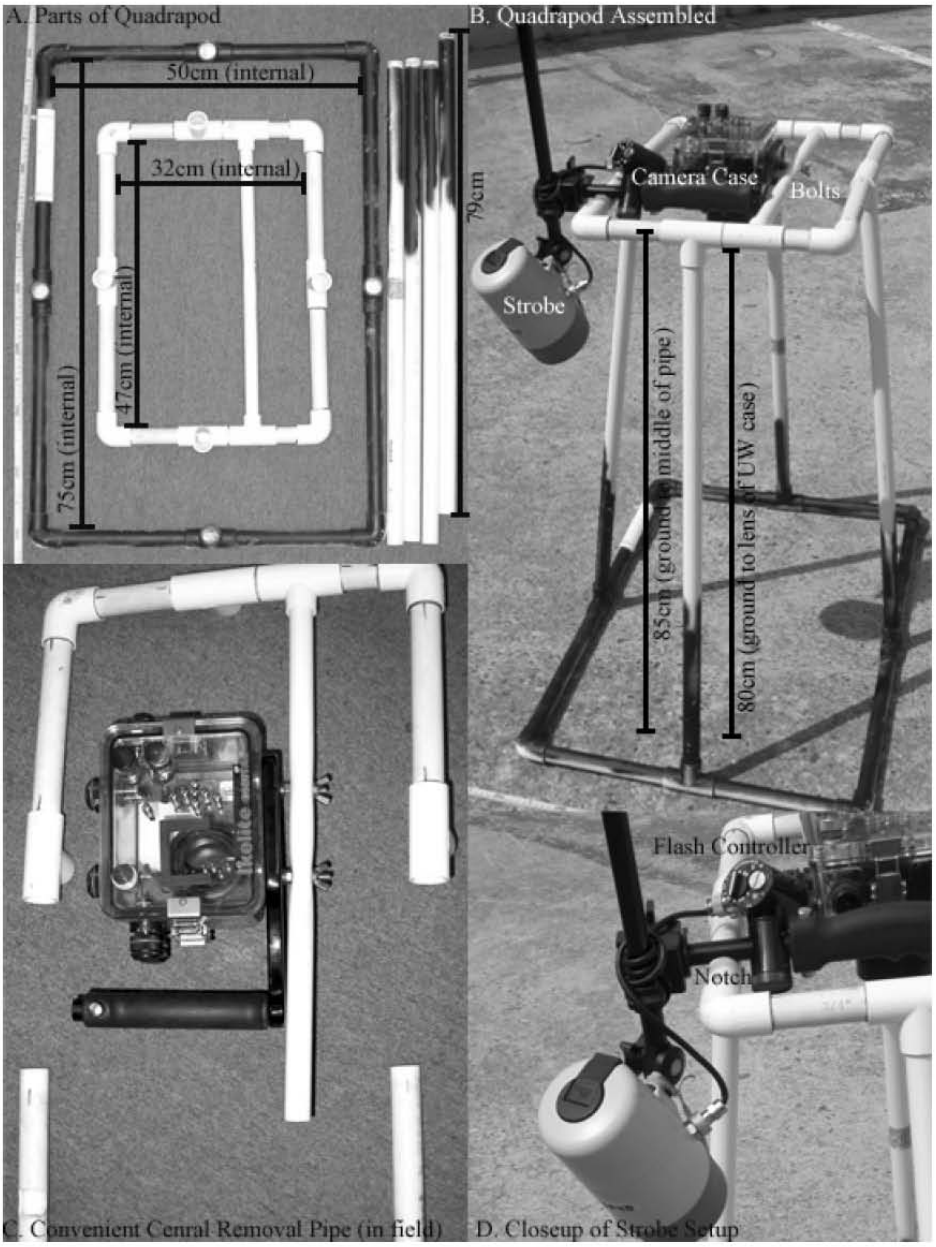


Figure S3.A.1. PVC photo framer, or "quadrapod," for photographing the fixed 50 x 75 cm photoplots. Photographs from Becker (2006).

SOP 4 – Barnacle Recruitment Plot Scraping

Version 1.13 (January 20, 2015)

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
1.01	9/3/2010	B. Mitchell	Barnacle settlement plots are now recruitment plots. Added requirement to photograph plots prior to scraping. Other minor edits.	External review	1.02
1.02	12/16/2010	B. Mitchell	Added suggestion to download tidbits if possible.	External review	1.03
1.03	1/11/2012	B. Mitchell	Removed photographing of winter settlement plots prior to scraping. Updated with information about summer-scraping barnacle recruitment plots.	These data have not previously been collected or analyzed New plots to test effect of time of scraping	1.10
1.10	2/11/2013	B. Mitchell	Updated equipment list to remove photo gear, ruler. 50 x 75 cm quadrats are optional.	Update procedures	1.11
1.11	2/13/2014	B. Mitchell	Add safety gear to equipment list	Promote safety	1.12
1.12	1/20/2015	B. Mitchell	Summer scraping plots will now be fall scraping plots	Summer scraping not a good proxy for winter; trying fall	1.13

This Standard Operating Procedure (SOP) provides information regarding scraping the barnacle recruitment plots. Barnacle recruitment is measured by counting the number of barnacles settling on scraped, fixed plots in the barnacle zone. As barnacle recruitment typically occurs from late March to late May, the “SET” plots (labeled “S” in the field) should be scraped between February 1 and March 14. 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.

“SUM” plots, labeled “U” in the field, were initially scraped after summer monitoring. The goal was to see if summer scraping could replace winter scraping, due to logistical, personnel, and safety concerns with winter scraping. Unfortunately the summer scraping plots were not a good proxy for winter scraping, so beginning in 2015 the summer scraping plots will be scraped as late

as possible in the fall (October or November), since these dates are still preferable to winter scraping. If the plots scraped in the fall turn out to be a good proxy for winter scraping after 3 years, the winter scraping will be discontinued.

If the weather and tide permit and there is sufficient time during winter scraping visits, consider downloading the three tidbit sensors according to the procedures in SOP 18 – Temperature Loggers.

Scraping the Plots

1. Locate Recruitment plot #1 (S1) for winter scraping, or U1 for fall scraping. 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" or "U", depending on whether they are winter or fall scraping plots (historically, the "S" was for "Settlement" and "U" for "Summer") and replicate number (1-5). See Figure S4.1 for an example (note that the ruler and black frame will not be present when you visit the plots).

2. TAKE CARE TO NOT STEP ON THE OTHER FIXED PLOTS, ESPECIALLY THE BARNACLE PHOTOPLOTS THAT ARE USUALLY ADJACENT TO THE RECRUITMENT PLOTS. It may help to bring out five 50 x 75 cm quadrats to place over the barnacle photoplots. Plots were typically arranged from North to South, S1 to S5 or U1 to U5, and paired (so S2 and U2 are near each other).

3. Scrape S1 (winter) or U1 (fall). BEFORE SCRAPING, CONFIRM THAT YOU ARE NOT LOOKING AT A BARNACLE PHOTOPLOT (labeled B1, B2, B3, etc.). DO NOT SCRAPE BARNACLE PHOTOPLOTS. Also, for winter scraping, verify that you are scraping plots with "S" labels; for fall scraping, verify that the plot has "U" labels. Because barnacles display aggregative settlement, the same sized area should be scraped for all recruitment plots. To do this, place a frame (7.5 x 7.5") over the two diagonal bolts of S1 or U1. 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 S4.2). 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.



Figure S4.1. Barnacle recruitment plot prior to scraping.

Paint Scraper



Wire Brush



Figure S4.2. Tools for scraping barnacle plots.

4. Scrape a border around the frame the width of a scraper blade (7 cm).
5. 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.
6. Repeat steps 1-6 for S2-S5 (winter) or U2-U5 (fall).
7. Upon returning from the field, clean all equipment with fresh water, and download the camera according to procedures in SOP 20 – Field Work Wrap-up.

Needed Materials

- Compass and 30 m measuring tape (to facilitate locating plot from reference bolts, if needed)
- Site notebook (containing plot overview photos and coordinates)
- 7.5 x 7.5” frame (aquamesh)
- 50 x 75 cm quadrats (5, optional, for marking barnacle photoplots)
- Paint scraper (2)
- Wire brush (2)

- Knee pads (for comfort while scraping)
- Stabilicers (for traction while moving in the intertidal zone)
- Life vests (if working near the water line or conditions are rough)
- Space blanket
- First aid kit

SOP 5 – Training

Version 1.03 (January 6, 2015)

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
1.00	9/3/2010	B. Mitchell	Removed photographic field guide. Revised diagrams in Appendix S5.A.	External review	1.01
1.01	1/12/2012	B. Mitchell	Removed reference to practice site at SERC.	Site does not exist	1.02
1.02	1/6/2015	B. Mitchell	Removed reference to measuring shell thickness Database use is not part of main training Individualized training needed for photo scoring and data entry Separate training guide is available	Method not part of protocol Database not used in the field Target training to appropriate staff Focus crew on essential info	1.03

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 (photoplots, motile invertebrates [including use of calipers to measure snails], 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 for each SOP.

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 during training or later during the field season—the crew should never deviate from established protocols or alter the datasheet 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 mapping lead, and another should be the camera lead. The mapping lead should receive extra training in the use of the

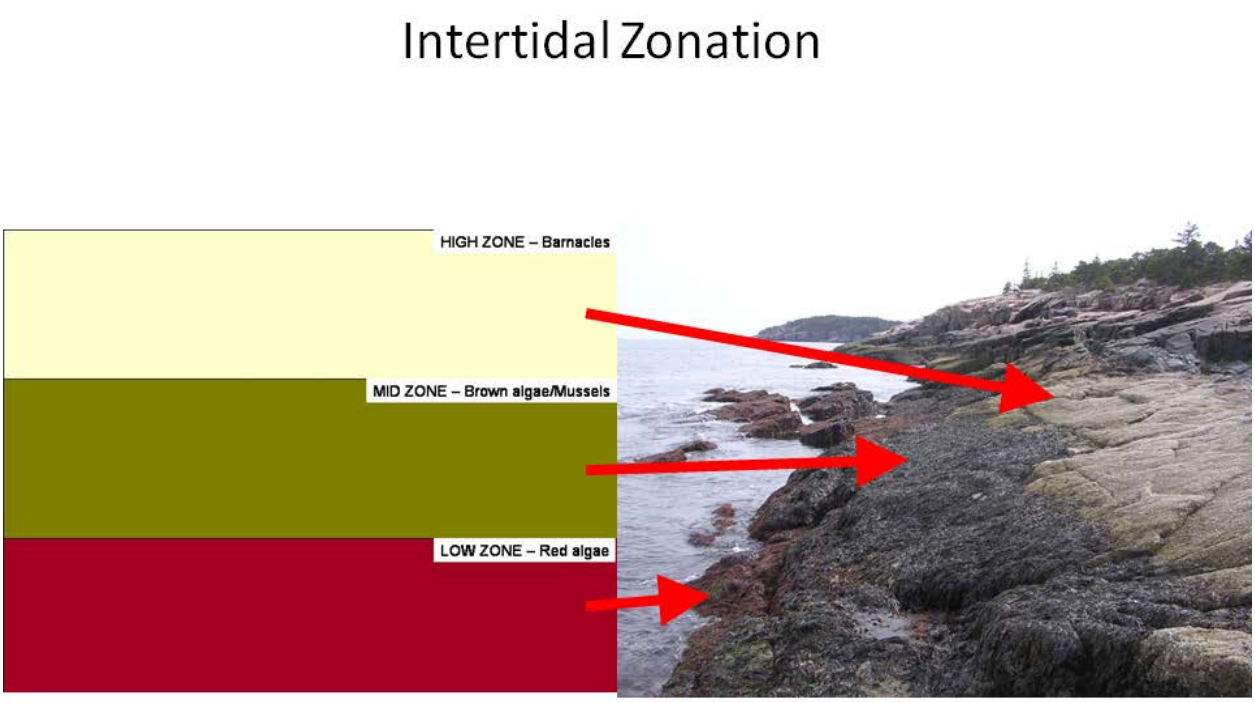
GPS unit, and how to use the site guide to locate plots. The camera lead should receive extra training on how to take suitable pictures.

Individuals who will be responsible for entering data into the database or who will be scoring photographs must receive individual training on these procedures prior to attempting the tasks. The first data entry or scored photos must be reviewed promptly by the PI to ensure that procedures were followed.

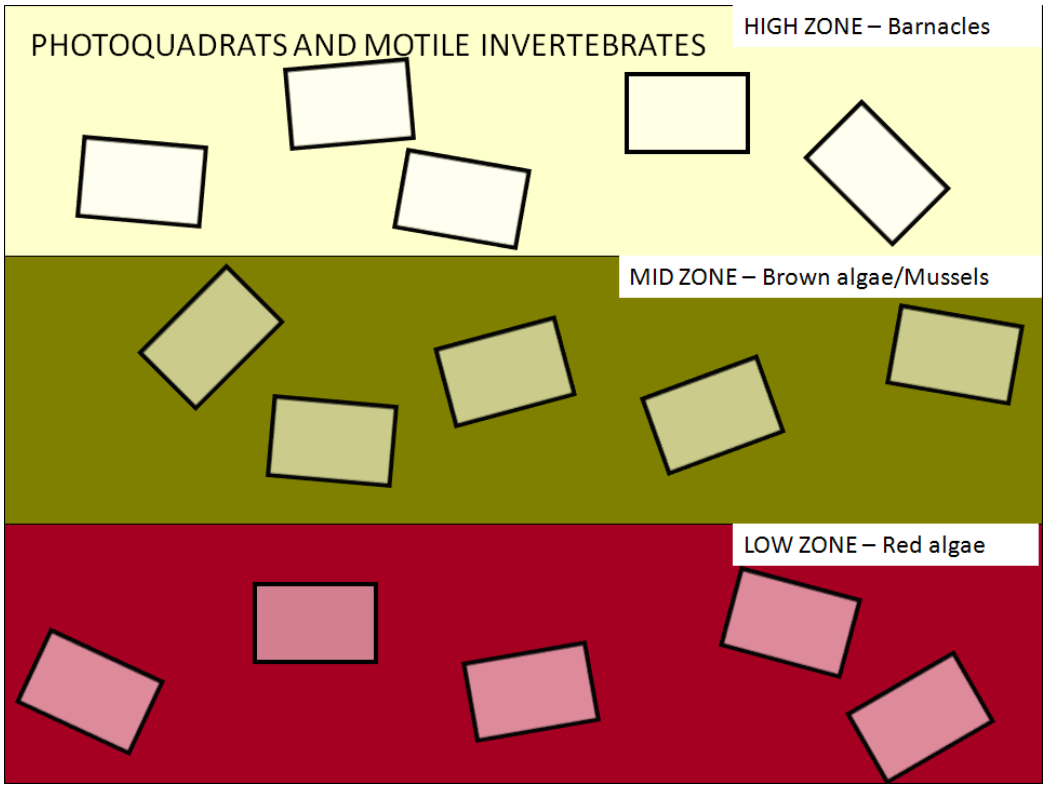
Network staff must decide what location provides sufficient logistical support for the initial training session. SERC at Acadia NP is probably the best location for training, because lodging is inexpensive and one of the monitoring sites (SCHPOI) is nearby.

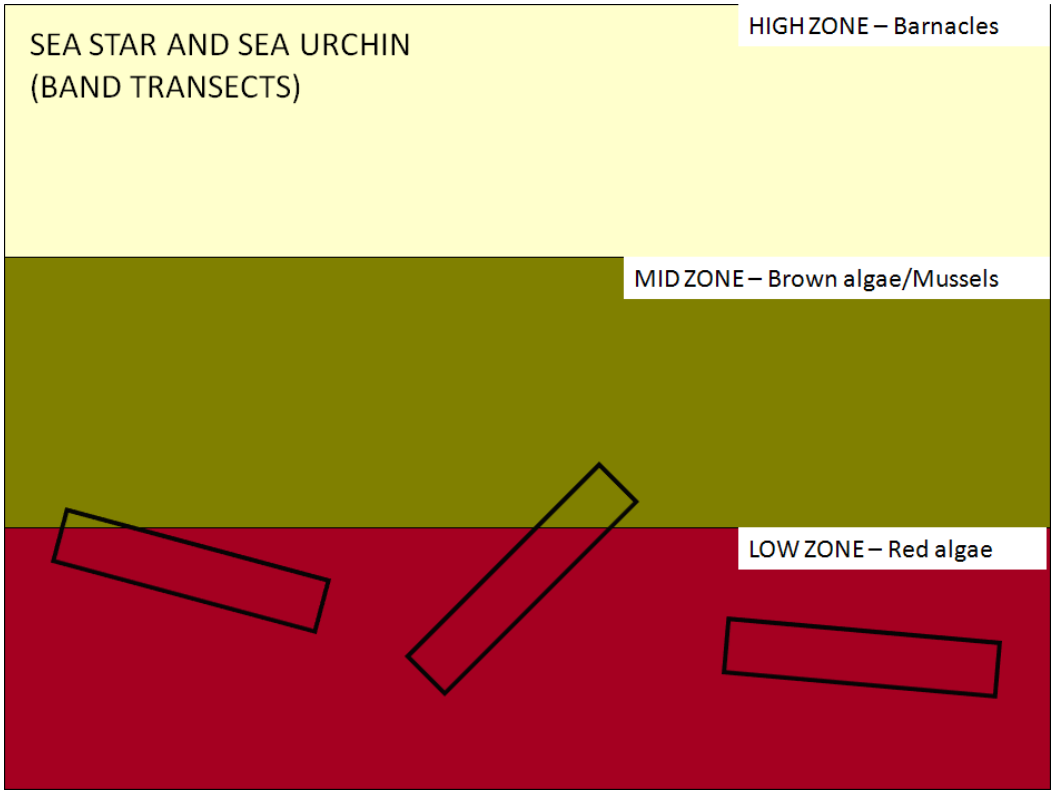
Appendix S5.A contains a general diagram of plots that may be useful during training. A training guide has been developed by NETN that is available upon request. A photographic field guide of common species and identifying characteristics will also be used to assist the crew with species identification; NETN has an example field guide that is also available upon request, but it cannot be published because some of the photos may be copyrighted.

Appendix S5.A. Rocky Intertidal Plot Diagrams

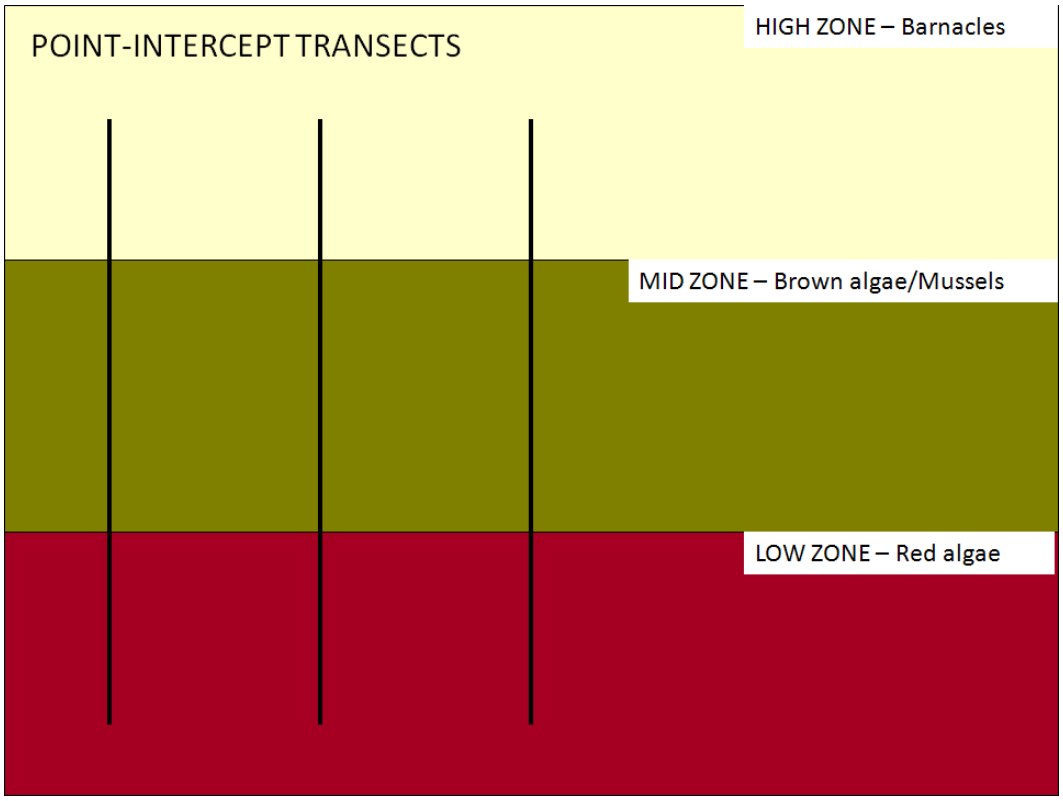


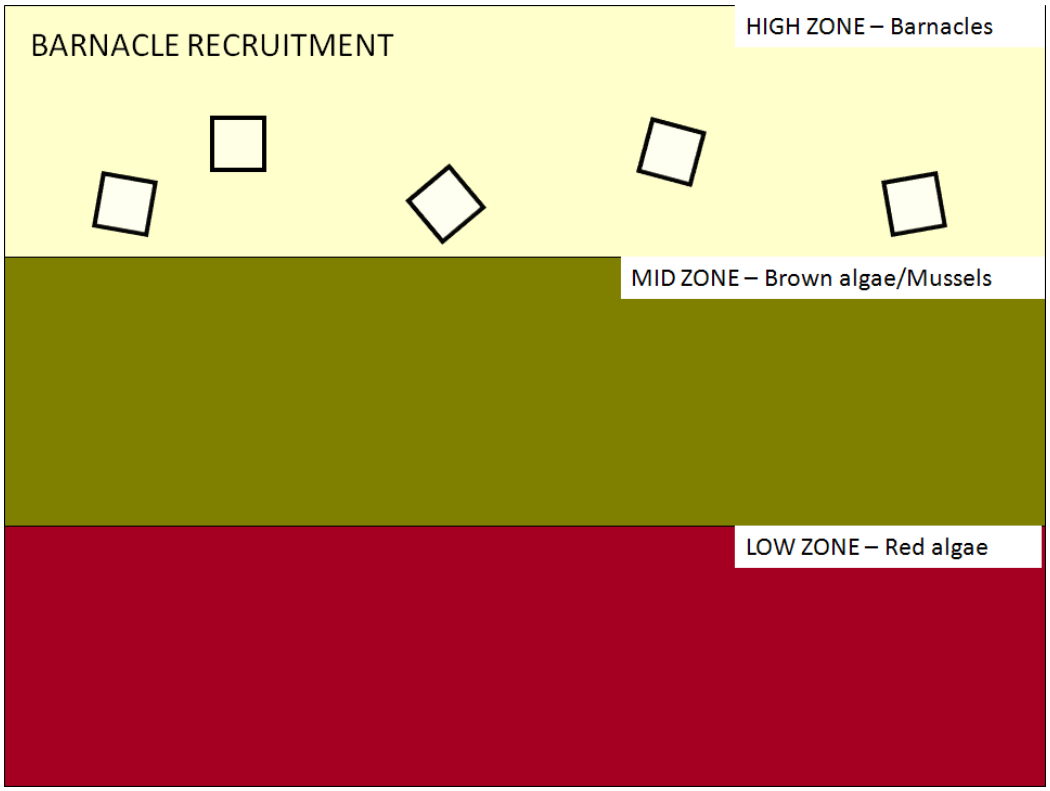
Appendix S5.A. Rocky Intertidal Plot Diagrams (continued).





Appendix S5.A. Rocky Intertidal Plot Diagrams (continued).





SOP 6 – Camera

Version 1.04 (January 5, 2015)

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
1.01	9/3/2010	B. Mitchell	Revised to include Canon SX10 (USFWS) and SX20 (BOHA) camera instructions, and DS-160 strobe (BOHA). Added check of f-stop in aperture-priority mode, and enhanced depth of field paragraph.	New equipment and external review	1.02
1.02	1/11/2012	B. Mitchell	Cameras not assigned to specific parks.	Update info	1.03
1.03	1/5/2015	B. Mitchell	Added tip about checking for condensation, water, and deposits.	Most common reasons for poor photos	1.04

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 (NPS), Canon PowerShot SX10/20 IS digital camera (USFWS/NPS), Ikelite DS-125 or DS-160 strobe, and Ikelite underwater housing.

Camera Settings

- File size (Nikon Coolpix): To adjust the file size, press the “MENU” button (Figure S6.1). Scroll to “Image size” using either the command dial (Figure S6.2) or the multiselector. Press “OK” on the multiselector. Scroll to appropriate image size (a minimum of 5M or 8M depending on photograph type). Press “MENU” to exit.

- File size (Canon Powershot): To adjust the file size, press the “Func. Set” button in the middle of the multi-selector (Figure S6.1). Scroll to “Image size”, the bottom icon on the left, using the up and down buttons above and below the “Func. Set” button. Then use the left and right buttons or the black knob to the right of the multiselector to change the file size. Choose a minimum of 5 M (the “M2” setting for the SX20 and the “M1” setting for the SX10) or 8 M (the “M1” setting for the SX20 and the “L” setting for the SX10), depending on photograph type. Press “Func. Set” to save and exit.

- Flash settings (Nikon Coolpix only): 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.

- Set the “Mode” dial to “A” (Nikon Coolpix) or “Av” (Canon PowerShot), and ensure that the maximum (highest number) f-stop is selected.

- Set the “Mode” dial to “P” (Nikon Coolpix) or “Pv” (Canon PowerShot).



Figure S6.1. Back of the Ikelite camera housing (left, Nikon Coolpix; right, Canon PowerShot) showing the buttons associated with the camera's multiselector (cluster of buttons on the right). The "menu" button for the Nikon Coolpix is the 2nd from the bottom on the left.



Figure S6.2. Top of the Ikelite camera housing (left, Nikon Coolpix; right, Canon PowerShot). The command dial is the large black knob on the right for the Nikon Coolpix. The command dial is the black knob on the left for the Nikon Coolpix. The mode dial is the left knob on the Nikon Coolpix and the right knob on the Canon PowerShot.

Strobe Settings

- Strobe dials should be turned to the “On” and “TTL” settings (Figure S6.3).



Figure S6.3. Strobe settings during photography for the DS-125 strobe. The “Ready Light” should illuminate. The DS-160 strobe uses the same settings.

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 S6.4).



Figure S6.4. Back of the Ikelite camera housing for the Nikon Coolpix showing the hot shoe connector that attaches to the camera’s accessory shoe. The Canon Powershot housing back looks similar.

    b. Using a coin (preferably a penny), turn 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 S6.5), 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 S6.5. Front of camera housing showing correct placement of the moisture muncher. The housing for the Nikon Coolpix is shown, but the moisture muncher should be in the same location in the Canon PowerShot housing.

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 S6.6).



Figure S6.6. Photograph showing the connection location of the strobe to the camera.

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.

- Condensation, water, and deposits: Check for condensation inside the housing lens and water droplets or salt deposits on the outside of the housing lens every few minutes when photographing plots. If condensation is detected (usually sunny days), crack the case to air it out and allow the condensation to evaporate. If water or deposits are discovered (rainy days

or when the case is splashed), clean the lens glass thoroughly. Re-photograph any recent plots that may have been photographed while the lens was compromised.

- 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 (while in Av mode on the command dial. Higher numbers indicate a broader range where there will be sharp focus. Because the P (Program) mode often defaults to the lowest f-stop, shots are typically taken in pairs, alternating between P mode and Av mode. The most recent f-stop set in the Av mode is retained by the camera, so switching between P and Av modes can allow you to alternate between the minimum and maximum f-stop.
- 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.

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	Based on the Using the GPS SOP v2.01 from the NETN forest health protocol	Original	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.

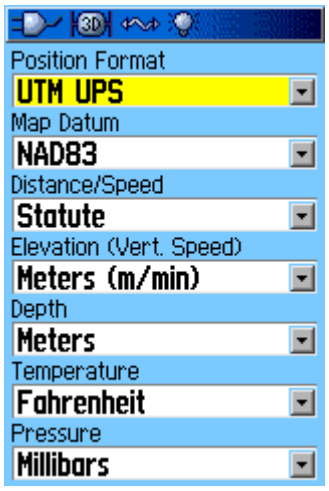
   a. Go to the Main Menu by pressing ‘Menu’ twice.

   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.

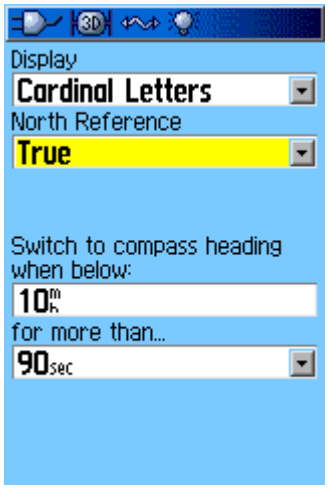
   e. To get back to the Setup menu press ‘QUIT’.



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’**.

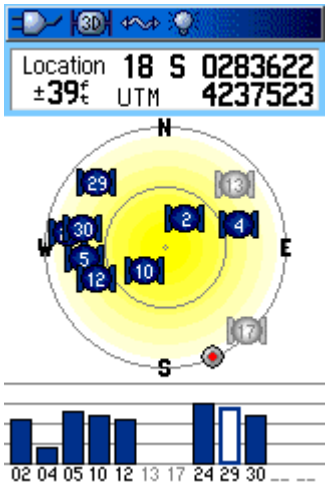


Note: These settings will be saved on the GPS and should not have to be re-entered each time the unit is turned on.

3. Be sure to carry at least one full replacement of batteries 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.



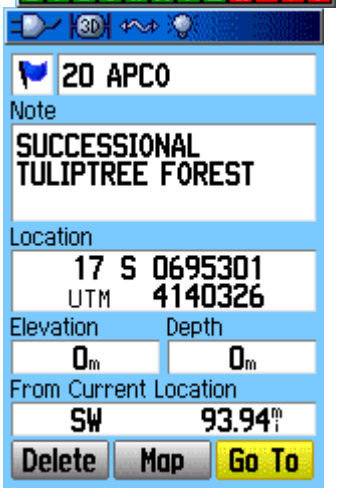
Navigating to a Site

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’.

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.

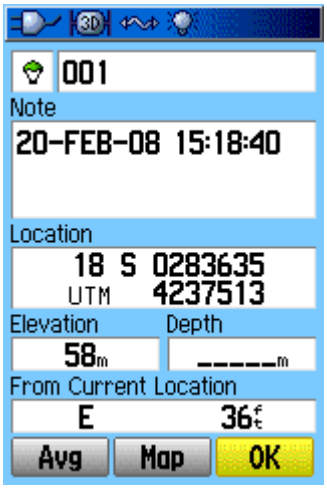


2. It is a good idea to pick a new symbol to distinguish individual and/or groups of waypoints that you collect in the field. This will make it easier to manage, download and delete waypoints on your GPS unit. An example is using a car symbol for a waypoint at the car before you wander into the forest.

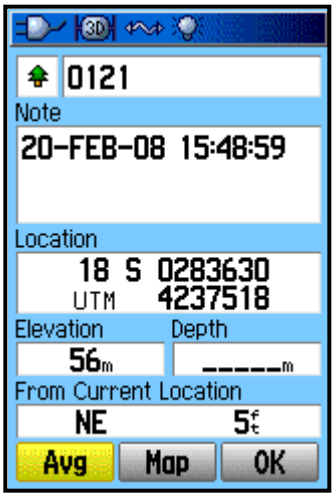


Marking a Waypoint

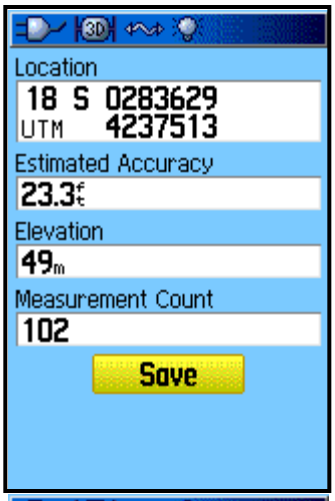
1. Press 'MARK' and the Mark Waypoint screen appears.
2. Toggle up to the symbol and press 'ENTR' for the Waypoint Symbols screen.
3. Toggle to the symbol you want to use and press 'ENTR'.
4. The default name of a waypoint is a sequential number starting with '001'. To change the default name toggle 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 six-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'.

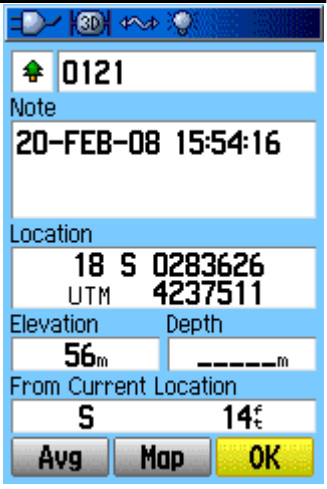


7. The ‘Average Location’ screen appears and measurement counts automatically begin. After the ‘Measurement Count’ reaches 100, highlight ‘Save’ and press ‘ENTR’ to return to the Map Page.



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 S7.1).

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 S7.2).

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.

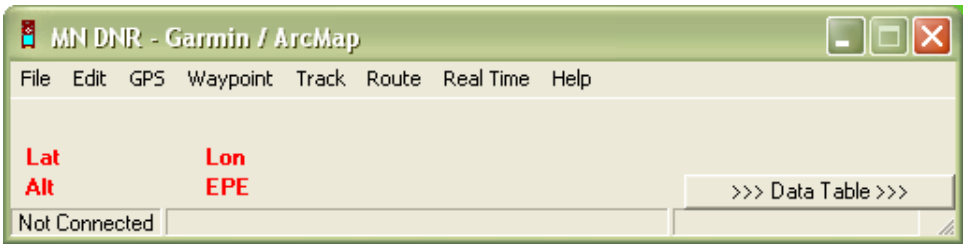


Figure S7.1. MN DNR—Garmin/ArcMap with GPS not connected.

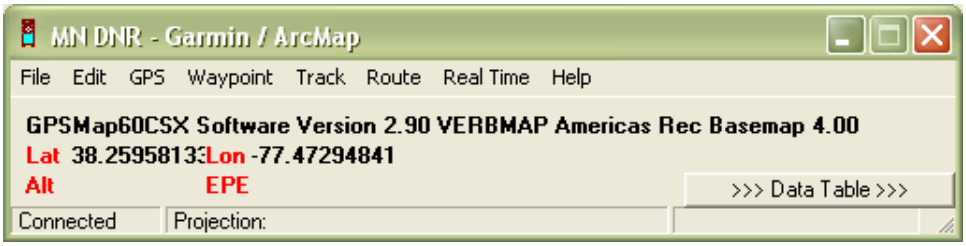


Figure S7.2. MN DNR—Garmin/ArcMap with Garmin unit GPSmap 60CSX connected.

6. Set the default projection to NAD 83, UTM Zone 19N. To open the DNR Garmin Properties window (Figure S7.3); 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 S7.4).

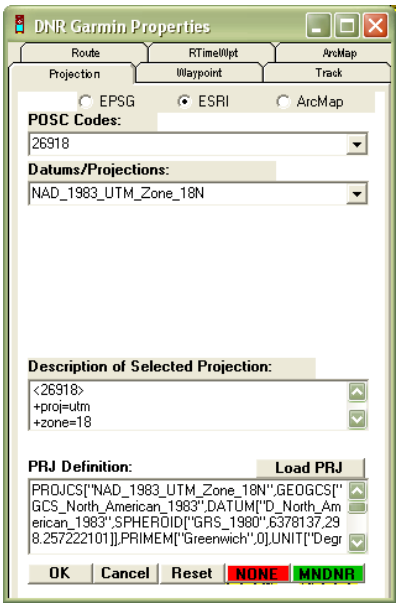


Figure S7.3. DNR Garmin Properties window with projection set to NAD 1983, UTM Zone 18N.

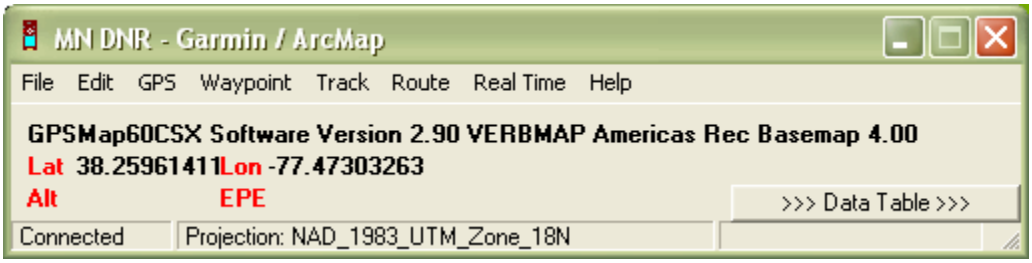


Figure S7.4. MN DNR—Garmin/ArcMap with Garmin unit GPSmap 60CSX connected and projection set to NAD 1983, UTM Zone 18N.

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 S7.5).

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.

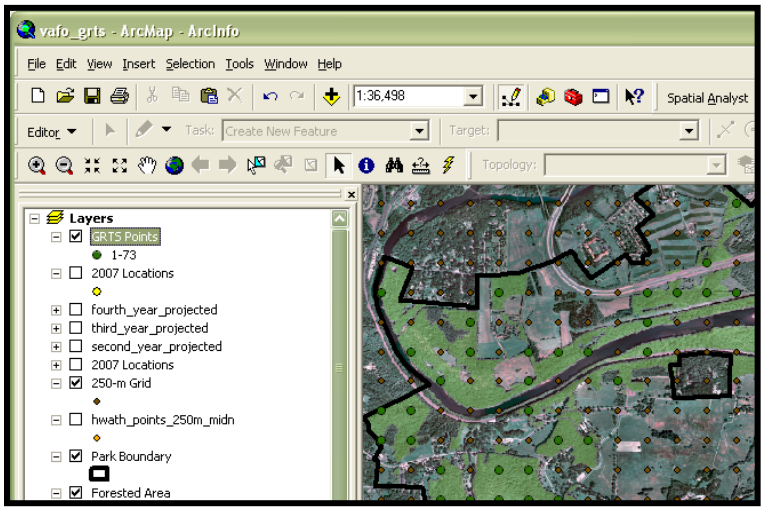


Figure S7.5. ArcMap screenshot, showing that the GRTS Points layer is active in the Table of Contents.

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 S7.6).

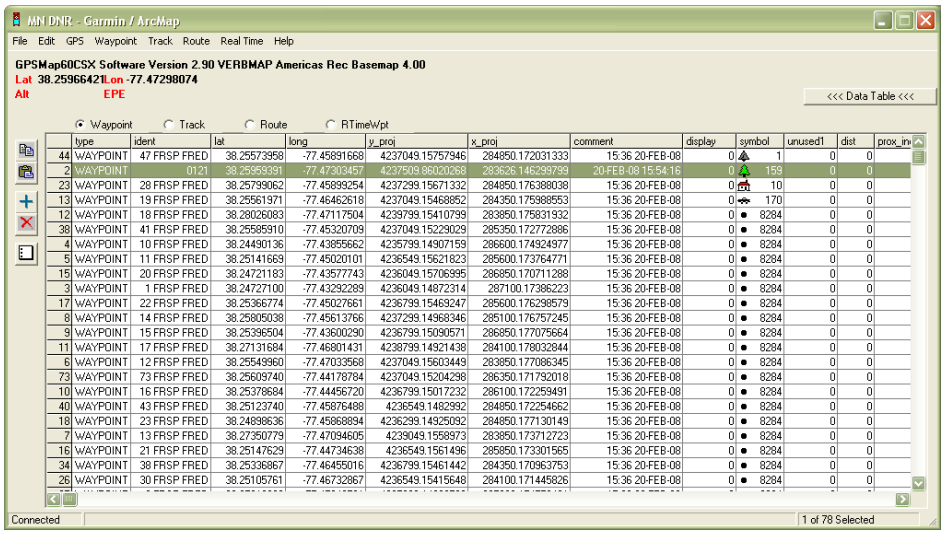


Figure S7.6. Data table in the MN DNR – Garmin/ArcMap application displaying downloaded waypoints.

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 S7.6, 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 save as a text file, 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 save as a shapefile, 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.

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:

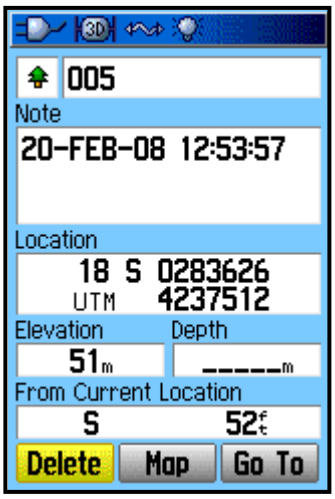
   a. Press ‘Find’ to open the Find screen.

   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.

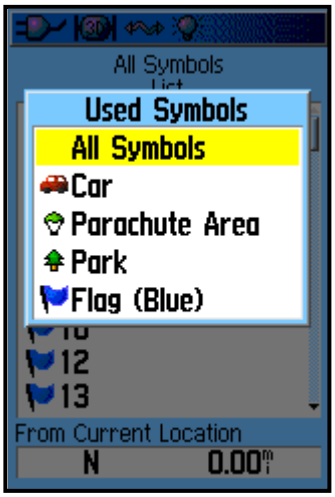
   b. Select ‘Waypoints’ to open the Waypoints screen.

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

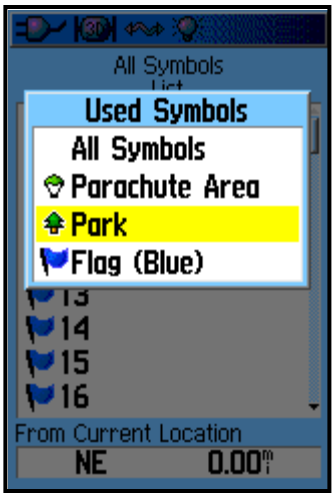
   d. Highlight ‘Delete’ and press ‘ENTR’

   e. Highlight ‘All Symbols’ and press ‘ENTR’

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



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’

SOP 8 – Using a Nikon DTM-322 Total Station to Survey Sites

Version 1.02 (January 6, 2015)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	4/1/2013	B. Mitchell	New SOP	Original	1.00
1.00	8/1/2014	B. Mitchell	Add documentation for measured baseline at MABI	Facilitate check of instrument constant	1.01
1.01	1/6/2015	B. Mitchell	Revised location of raw data files Prism height and battery change info are now their own sections	New location Highlight important info	1.02

Overview

This SOP documents the use of a Nikon DTM-322 Total Station to survey monitoring sites. The surveying process requires setting up the total station on a benchmark at known coordinates and elevation, configuring it with the help of a second benchmark (also at known coordinates and elevation), and then establishing the location of new points (e.g., bolts marking transects and plots) by calculating their relative coordinates and elevation using the distance and angles (horizontal and vertical) from the first benchmark. The error of the total station is 3mm plus 0.2 mm per 100 meters. The vertical accuracy is lower, since the height of the total station is estimated based on the height of the second benchmark.

The basic procedure for surveying monitoring sites involves carefully setting up the total station above a benchmark (e.g., a REF bolt), and at a location where another benchmark (a REF bolt or GPS bolt) can be seen. The locations to be surveyed (e.g., new bolts and other REF bolts) must also be visible from the first benchmark. After the station is centered over the benchmark and leveled (made exactly horizontal), the coordinates for the station and the backsight benchmark are entered. Then a sighting is taken on a prism stationed at the second benchmark (the backsight location). This sets the reference angle for the rest of the survey. The survey can then proceed, with sightings taken on the prism while it is stationed at each point that needs to be recorded. All data is recorded on the total station and downloaded in the office.

BOLD indicates buttons on the total station; *ITALICS* indicates menu or other items on the screen. This SOP is not intended to provide complete instructions for the use of a Nikon DTM-322 Total Station; users should review the instruction manual for additional information.

Basic Maintenance and Operation of the Total Station

- When removing the total station from the case, check the lens for dust. Clean with a lens brush and lens cleaning cloth if necessary. Alcohol can be used on a cleaning cloth.

- If leaving the total station on the tripod or a long period while not in use, cover the station with the protective vinyl cover.
- Before storing the total station in its case for any period of time, brush dirt off of the lens with a lens brush, breathe on the lens to provide some moisture, then clean the lens with a lens cleaning cloth.
- Always remove the battery if storing the total station for a period of time greater than a week.
- To turn the total station on:
    - Press the **PWR** button. The last pressure and temperature values will display.
    - If you want to initialize the horizontal angle (maintain consistency with earlier measurements, even if the station has been rotated while powered off), rotate the station horizontally until "*HA INITIALIZED*" appears (will alternate with "*TILT TELESCOPE*").
    - Rotate the telescope through the horizontal position.
- To check or change the date and time:
    - Press **MENU** then **8** (*Time*).
    - Press **ESC** if the date and time are correct.
    - Otherwise cycle through year, month, day, hour, and minute by pressing **REC/ENT**, changing any values that need to be corrected.
    - Press **ESC** again to return to the measurement screen.
- To turn the total station off, sleep, or reset the station:
    - Press the **PWR** button.
    - Press **REC/ENT** to turn off the station.
    - Press **ANG** (the *Sleep* soft key) to sleep the station. Wake the station by pressing a key, rotating the station, or tilting the telescope.
    - Press **MSR2** (the *Reset* soft key) to reboot the station.
    - Press **ESC** to cancel.
- Alternating between alphanumeric and text entry:
    - On some screens, you will see a *1* or *A* to the right, indicating alphanumeric entry (*A*) or numbers only entry (*1*).
    - Press **MODE** to switch between the two options. In alphanumeric mode, press a button repeatedly to switch between the options for that button; numbers will appear after letters (e.g., pressing **STN** repeatedly goes through A, B, C, then 7.
- Aiming the total station telescope at an object entails:
    - Loosening the vertical clamp (large knob to the right of the telescope) and the upper plate clamp (large knob to the right of the display and keyboard), and swiveling the station and telescope towards the object.
    - Sight the object through the sighting tube above the telescope.

    - Lock the two clamps, and use the tangent screws (smaller inner knobs attached to the clamps) to make fine adjustments while sighting through the telescope eyepiece.
- The leveling screws and tangent screws have lines indicating the center of their range; try to keep the screws as close as possible to these lines.
- When the prism is attached to the staff, the true staff height is the height displayed on the staff, when reading the height from the top of the bracket (with the bubble level) and the top of a black measurement line. To confirm or check the prism height:
    - Press **PRG** then **5** for *REM* (remote elevation measurement).
    - Enter 0 for the target height (*HT*) and press **REC/ENT**. Sight the target and press **MSR1**.
    - Sight the bottom of the prism pole. The height difference (*Vh*) displays. To record this as the new prism height, press **REC/ENT**. Then press **ESC** three times. The new target height displays at the bottom of the screen.
- The prism constant is +30 mm when the prism is screwed into the recessed side of the holder; it is 0 when screwed into the opposite side. The total station has been set to expect a constant of +30 mm (instruction manual, pages 17 and 45) when you use the **MSR1** key.
- When storing the total station, put the lens cap on the telescope, rotate it so that the eyepiece is up, and align the storage mark (a ▼ molded into the plastic below the battery compartment) with the ▼ mark on the leveling base clamp knob. The battery compartment will be up when the total station is properly placed in the case.
- The light on the battery charger will flash when the battery is charging, and turn steady when charging is complete.

Setting up the Tripod and Total Station

1. First set up the tripod so that it is approximately level and centered over the benchmark point; look through the center hole in the tripod head or use a plumb bob to verify the horizontal position.
2. Separate the total station from the leveling base by turning the leveling base clamp knob (marked with a ▼) and carefully lifting the station out of the base. Mount the base on the tripod. Use the bubble level on the leveling base to make sure the tripod is level, while remaining centered over the benchmark point. Shift the legs of the tripod until the bubble is exactly centered inside the central circle of the bubble level. Firmly press the tripod legs into the ground if the terrain allows. Verify again that the tripod is centered over the benchmark point and that the head is level. Place the total station on the leveling base and clamp it to the base.
3. Mount the total station on the tripod, and hand-tighten the mounting screw.
4. Center the total station over the benchmark point using the optical plummet (eyepiece on back side of total station, to the right of the faceplate cover).

   a. Turn the outer ring of the plummet out until the reticle is blurry, then turn it in until the reticle becomes sharp.
   b. Turn the inner ring of the plummet to focus.
   c. Slightly loosen the mounting screw and shift the total station within the range allowed by the tripod head. If this range does not allow you to center over the benchmark point, remove the total station from the tripod and go back to Step 2.
5. Now level the total station using the plate level (above the display).
   a. Loosen the upper plate clamp (larger inner knob to the right of the display). The station should rotate freely.
   b. Rotate the station so that the plate level is midway between two leveling screws. Rotate one of the leveling screws until the bubble is in the middle of the plate level.
   c. Rotate the total station 90 degrees, and rotate the third leveling screw until the bubble is in the middle of the level.
   d. Repeat steps 5b and 5c.
   e. Rotate the total station 180 degrees. If the bubble in the plate level moves off-center, it needs adjustment (see Checking and Adjusting the Total Station, step 1). Tighten the upper plate clamp.
6. Look through the optical plummet again. If the station is no longer centered over the benchmark point, loosen the mounting screw and shift it within the range of the tripod head. Tighten the mounting screw and go back to step 5.
7. Look through the telescope eyepiece and adjust the eyepiece diopter outwards (counter-clockwise) so that the reticle is blurry, then inwards until the point where it first becomes sharp.
8. Attach the prism to the staff. With the prism target in a stable location, focus on it (with the major telescope focus knob), and shift your eyes slightly up and down, left and right, and make sure that there is no parallax/shifting. The reticle should seem fixed on the prism target, and not shift relative to it when you move your eyes slightly. If there is a shift, go back to step 7.
9. Set the target height, temperature, and pressure.
   a. Press **HOT** (Height Of Target).
   b. Press **1** or use the arrow keys to select *HT* and press **REC/ENT**. Enter the height with the numeric keys and press **REC/ENT**. You can also press the **ANG** key (the *Stack* soft-key) and use the arrows to select a recent height. Note that the height on the prism staff is accurate when measured from the top of the bracket and the top of a black measurement line.
   c. Press **HOT** (Height Of Target).
   d. Press **2** or use the arrow keys to select *Temp-Press* and press **REC/ENT**. Enter the temperature with the numeric keys and then press ▼ and enter the pressure, then press **REC/ENT**.

10. To record data, you must create or open a job. Use the acronym for the site you are surveying plus the two digit year (e.g., BASHAR13 for surveying at Bass Harbor in 2013).
    a. Press **MENU** then **1** to enter the Job Manager.
    b. The current job has an asterisk to the left of the name. To select a different job, use the ▼ or ▲, and press **REC/ENT**.
    c. If the job you want is not present:
        i. Press **MSR1** (*Creat* soft key) to create a new one.
        ii. Enter an eight letter (max) job code using the number keys (e.g., for "C" press **7** three times). Then press **REC/ENT**.

Taking Measurements

1. The person with the prism and staff should stand so that the staff is level (use the bubble level) and then rotate the staff and tilt the prism, if necessary, to aim straight at the total station.
2. Use the sighting tube on top of the telescope to aim the total station at the prism.
3. Look through the telescope eyepiece, and adjust the focus using the large focus knob.
4. Use the tangent screws to center the prism (the point in the center where the three lines intersect) in the eyepiece reticle.
5. Signal to the person with the staff that you are ready to take a measurement. That person should verify that the staff is on the point to be surveyed and that the staff is level. Re-check alignment of the prism in the telescope eyepiece.
6. Press **MSR1** to take a measurement. An indicator at the top-right of the screen will display the signal level. The bottom row of information on the screen will display *SDx* and the slope distance to the prism.

Determining the Prism Height

When the prism is attached to the staff, the true staff height is the height displayed on the staff, when reading the height from the top of the bracket (with the bubble level) and the top of a black measurement line. To confirm or check the prism height:

- Press PRG then 5 for REM (remote elevation measurement).
- Enter 0 for the target height (HT) and press REC/ENT. Sight the target and press MSR1.
- Sight the bottom of the prism pole. The height difference (Vh) displays. To record this as the new prism height, press REC/ENT. Then press ESC three times. The new target height displays at the bottom of the screen.

Changing the Battery During a Survey

To change the battery in the middle of a survey:

1. Lock the vertical and upper plate clamps.

2. Power off the station (see Basic Maintenance and Operation of the Total Station).
3. Carefully replace the batteries; try to avoid shifting the station in the process.
4. Turn the station back on, being careful to initialize the horizontal angle prior to tilting the telescope (see Basic Maintenance and Operation of the Total Station).
5. With the prism at the backsight location, press **STN** then **5**. The current horizontal angle (*HA*) and expected backsight angle (*BS*) display.
6. If the two angles differ by more than 5 arcseconds, press **ANG** (the *Reset*) soft key. Otherwise press **ESC**.

Checking and Adjusting the Total Station

The total station needs to be checked and adjusted periodically (before use at the start of the season, after any significant shocks (e.g., rough transport by boat in Boston Harbor), or approximately monthly if it is being used regularly.

1. Check and adjust the plate level:
   a. Set the tripod up at a solid location, and level the total station.
   b. Rotate the station 180° on the tripod.
   c. The bubble should still be in the center of the vial. If it is not:
      i. Use the adjustment pin (basically a stiff wire, stored in a bag in the back-right of the case) to rotate the adjustment screw until the level moves half the distance back to the center.
      ii. Use the leveling screws to re-level the station.
      iii. Go back to step 1b.
2. Check and adjust the bubble level by taking the station off of the leveling base and verifying that the bubble is in the center of the inner circle. If it is not, use the adjustment pin to rotate the adjustment screws until the bubble is centered in the level.
3. Check and adjust the optical plummet:
   a. If the station is not set up on top of a benchmark, place a mark on a piece of paper or other object and move it under the station until it is exactly centered in the optical plummet.
   b. Rotate the station 180°, and verify that the station is still exactly over the mark. If it is not:
      i. Use the hex wrench (in the case with the adjusting pin) to turn the adjusting screws on the optical plummet until the plummet is aimed exactly half way back towards the mark.
      ii. Go back to step 3a.
4. Check for vertical angle errors:
   a. Level the station if needed.
   b. Sight a target within 45° of the horizontal plane. Record the vertical angle (*VA*).

c. Rotate the station 180° and flip the telescope (from "Face-1" or "F1" to "Face-2" or "F2"), and sight on the target again. Add the new vertical angle with the angle recorded in the last step.
d. If the angles do not sum to 360°, within 10 arcseconds, the station must be calibrated:
   i. Rotate the telescope back to F1. Press **MENU** and **7** (*Calibrat.*) to enter the calibration menu.
   ii. Sight a target on the horizon and press **REC/ENT**.
   iii. When the message *Turn to F2* displays, rotate the station 180° and flip the telescope to the F2 position
   iv. Sight again on the target and press **REC/ENT**.
   v. Press **ESC** to start over, or **REC/ENT** to accept the new calibration.
e. Repeat from step 4b.

5. Check the instrument constant. There are two ways to check the instrument constant. The first is to use a correctly measured baseline (i.e., two points with an exactly known separation that is approximately 100 m apart). This baseline could be established with the use of the station, after verifying that the instrument constant is correct with the second method:
   a. Establish points P and Q, about 100 m apart and in as flat an area as possible.
   b. Set up the station at P and the prism at Q, and measure the horizontal distance between P and Q with the station.
   c. Establish about 10 points, R1 through R10 that are between P and Q and on the same line. Use the telescope, locked for horizontal angle, to make sure the points are established exactly on the line between P and Q.
   d. Move the station to a point R and measure the distance to point P and to point Q.
   e. Sum the two distances from step 5d and then subtract the distance recorded in step 5b. Record this error value.
   f. Repeat steps 5d and 5e for all the R points, and then calculate the average error value. The average value should be within 3 mm. If it is not, duplicate the test. If the average is still greater than 3 mm, the station will need to be serviced by a dealer.

   A measured baseline has been established at Marsh-Billings-Rockefeller NHP. Two rebar rods (with caps labeled "NPS NETN") have been placed at either end of the Horse Pasture, and measured at 129.297 m horizontal distance apart. The following page has an overview map, and pictures of each rebar location.



Southern marker:



Northern marker:



Field Procedures

The total station is used to periodically check whether or not the reference (REF) bolts at each site have shifted. This check should be conducted at least every 5 years. For this check, use a consistent station and backsight (e.g., REF1 and BM or REF1 and REF2). After setting up the station, determine the coordinates of the other REF bolts. If any of the bolts have shifted more than 2.5 cm horizontally or vertically (after re-measuring), set up the station again (i.e., start again from step 1, below) and then carefully re-measure the REF bolts. If one or more bolts are still showing a shift, there has likely been a datum shift at the site. ALL bolts at the site should be resurveyed, and this should include the use of a USGS benchmark or RTK-GPS to re-establish elevation and position.

The total station is also used to survey new bolts (replacement for lost bolts or new monitoring quadrats/transects), and an initial total station survey of all bolts is suggested since the relative locations and elevations (relative to the station and backsight benchmarks) of bolts will be more accurate with a total station than with an RTK-GPS.

The detailed measurement procedure is:

1. Set up the total station on top of a benchmark point (a REF point near the points that need to be surveyed), and within line of sight of a second benchmark point (ideally the GPS benchmark, but potentially another REF point). The second benchmark is used to set the azimuth and instrument height, so it should not be so close that slight errors in holding the prism staff throw off the azimuth. Try not to use benchmarks closer together than 30 m.
2. If you haven't done so already, create or open a job with the current site acronym and year (e.g., BASHAR13 for Acadia's Bass Harbor in 2013).
3. Press **STN**. Press **1** for *Known*.
4. Enter the benchmark point name. Pressing **DSP** (the *List* soft key) will give you a list of options. Choose *INTERTIDAL*→ and then "*BOLT.R.*", add the bolt number (use 0 for the GPS bolt), and press **REC/ENT**. Note that pressing **ANG** (the *Stack* soft key) will give the most recently used point names. Also note that using ► and ◄ within a stack or list will move you forward or backward a full screen.
5. Enter the station East (*E*), North (*N*), and elevation (*Z*) coordinates, pressing **REC/ENT** after each field.
6. Enter a code (*CD*) for the point. Pressing **DSP** (the *List* soft key) will give a list of options; for a GPS benchmark or reference bolt choose *INTERTIDAL*→ and press **REC/ENT**, then select *BM.BENCHMARK* for a GPS benchmark or *REF.REFERENCE* for a reference point and press **REC/ENT** again to select it. Press **REC/ENT** to save the code. Note that pressing **ANG** (the *Stack* soft key) will give the most recently used codes.
7. Press **REC/ENT** to store an instrument height (*HI*) of 0.000 (this will be corrected later).
8. On the Backsight screen, press **1** for *Coord.*, meaning you will be providing the coordinates for the backsight. Enter the name of the backsight point (e.g., BOLT.2). See step 4 for details.
9. Enter the backsight East (*E*), North (*N*), and elevation (*Z*) coordinates, pressing **REC/ENT** after each field.
10. Enter a code (*CD*) for the point. See step 6 for details.

11. Verify the prism height (*HT*) on the next screen. Change it if needed, and press **REC/ENT**.
12. Sight on the prism and press **MSR1**. IMPORTANT: Do NOT press **REC/ENT** at this time.
13. Press **DSP** to display the vertical (*dVD:*) and horizontal (*dHD:*) error. The horizontal error should be less than 3 cm. If it is not, press **ESC** then **REC/ENT** twice, and go to step 12. The vertical error is the negative height of the station. Record the opposite of the value (e.g., if -*1.317* is displayed, record +1.317).
14. Go back to the station setup and enter the correct station height by pressing **ESC** three times, then **REC/ENT**, then enter the correct height and press **REC/ENT**.
15. On the Backsight screen, press **1** for *Coord.*, meaning you will be providing the coordinates for the backsight. Enter the name of the backsight point (e.g., BOLT.R.0). The coordinates will flash on the screen. Press **REC/ENT** when the screen returns to "*Input BS Point*".
16. Sight on the prism and press **MSR1**. IMPORTANT: Do NOT press **REC/ENT** at this time.
17. Press **DSP** to display the vertical (*dVD:*) and horizontal (*dHD:*) error. Both errors should be less than 3 cm. If they are not, press **ESC** then **REC/ENT** twice, and go to step 16. Otherwise press **REC/ENT** to save the point; both the station (ST) and backsight (F1) points are saved to the current job. F1 refers to a "Face 1" backsight measurement; other total station models have two "faces" and recording from two sides allows for additional error correction.
18. Proceed with surveying points:
    a. The person with the prism and staff moves to the first point.
    b. Sight on the point and press **MSR1**. A slope distance (*SD*) will appear after the measurement.
    c. Press **DSP** if needed to display the coordinates.
    d. If the sighting seems sound, press **REC/ENT** to save the point.
    e. Enter a point name. Note that if the previous point name ended in a number, the default value will be incremented by one over the previous point name. Pressing **DSP** (*List*) and then selecting *INTERTIDAL→* will bring up a set of standard point number prefixes (see Table 1). Select the appropriate prefix, then add a point number to the end. DO NOT repeat a point number, even if the points have different codes. For example, use BOLT.1.B1 through BOLT.1.B4 for the first barnacle quadrat, and BOLT.1.R1 through BOLT.1.R4 for the first red algae quadrat. Similarly, the labels would be LABEL.1.B1 and LABEL.1.B2.
    f. Verify the staff height. Note that the staff height can be changed if the prism can't be seen at a specific location. The new height well remain the default for future points.
    g. Enter the appropriate code. Pressing **DSP** (*List*) and then selecting *INTERTIDAL→* will bring up a set of standard codes (see Table S8.1). Select the appropriate code, then press **REC/ENT**. Recent codes can be accessed by using **ANG** (the *Stack*) soft key).
    h. Continue with the next point.

Table S8.1. Point and code labels for use with the total station.

Codes	Description	Points	Description
A.Ascophyllum	*Ascophyllum* quadrat	Bolt.1.	Bolt for quad/transect/logger 1
B.Barnacle	Barnacle quadrat	Bolt.2.	Bolt for quad/transect/logger 2
BM.Benchmark	GPS benchmark	Bolt.3.	Bolt for quad/transect/logger 3
F.Fucus	*Fucus* quadrat	Bolt.4.	Bolt for quadrat 4
M.Mussel	Mussel quadrat	Bolt.5.	Bolt for quadrat 5
R.Red.Algae	Red algae quadrat	Bolt.R.	Ref/GPS bolt (GPS is BOLT.R.0)
REF.Reference	Reference bolt	Bolt.	Other bolts
S.Winter.Recruit	Barnacle recruit (winter scrape)	Label.1.	Label for quad/transect/logger 1
T.Vertical.Trans	Vertical transect	Label.2.	Label for quad/transect/logger 2
TEMP.Temperature	Temperature logger	Label.3.	Label for quad/transect/logger 3
U.Summer.Recruit	Barnacle recruit (summer scrape)	Label.4.	Label for quadrat 4
X.Tidepool	Tidepool transect	Label.5.	Label for quadrat 5
		Label.End.	Label for end of vertical transect
		Label.Mid.	Label for middle of vertical transect
		Label.Start.	Label for bottom of vertical transect
		Label.	Other labels

Data Management

To view the stored data in the total station:

1. Press **MENU**, then **4** for *Data*.
2. To view coordinate data:
   a. Select **2** for *XYZ data*.
   b. The most recent point is highlighted. The info for each point is a point type, the point name, and the point code. You should see the following point types:
      i. *MP* is a manual point (user-entered, in our case the station and backsight benchmarks).
      ii. *SS* is a sideshot point (all of our survey points will be SS points).
   c. Press **REC/ENT** to view the coordinates for the selected point.
3. To view the raw data:
   a. Select **1** for *RAW data*.
   b. The most recent point is highlighted. As with coordinate data, the info for each point is a point type, the point name, and the point code. You should see the following point types:
      i. *ST* is the station benchmark.
      ii. *F1* is the backsight "Face 1" benchmark.
      iii. *CO* is a comment (e.g., temperature and pressure, or whether a backsight check was conducted to reset the horizontal angle)
      iv. *SS* is a sideshot point (all of our survey points will be SS points).
   c. Press **REC/ENT** to view the information for the selected point. The information shown will vary depending on the point type. A SS or F1 point will include the horizontal and vertical angles and slope distance, while a station record will include instrument height, backsight point, and backsight azimuth.
4. Note that the data menu provides functions for deleting and editing points. You can edit the point name, point code, and prism height of a RAW point record. If you edit the prism height,

the Z coordinate is recalculated. You can also edit the point name, point code, and coordinates of coordinate records, but this is NOT recommended since it will create a mismatch between the total station RAW data and the coordinates. If you want to completely delete a point, delete the RAW record and the associated coordinate record will be deleted.

Upon returning from the field, download the job data via the download cable and terminal (communication) software. Note that a *Leveling* screen may appear on the total station with a bubble level figure; this appears when the station is out of level and beyond what the station can compensate for. Just press **ESC** to close the screen.

1. Verify the computer COM port settings:
   a. If using a serial port, the port will be COM1.
   b. If using a serial-to-USB adapter, make sure the adapter driver is installed. Then open the Device Manager on the computer, and select "Ports (COM & LPT)". The port number will be listed next to "USB Serial Port".
   c. Right-click the entry for the correct port, and select "Properties". Then click on "Port Settings" and verify the following:
      i. Bits per second: 4800
      ii. Data bits: 8
      iii. Parity: None
      iv. Stop bits: 1
      v. Flow control: Xon/Xoff
2. Now open the terminal program (terminal.exe, on the NETN Z:drive at Z:\LIBRARY\SOFTWARE\Utilities\Nikon_DTM322_Total_Station or online at https://sites.google.com/site/terminalbpp/. Verify the settings:
   a. COM Port: Select appropriate
   b. Other settings at top of screen: Same as in step 1c.
   c. In the "Receive" section of the program window, the "ASCII" radio button should be on, and all check boxes should be off.
   d. Click "Connect" at the top-left.
3. Now send the data from the total station:
   a. Press **MENU**, then **5** for *Comm*. then **1** for *Download.*
   b. If the job you want to download is not displayed, select a new one by pressing **MSR1** (the *Job* soft key) and selecting the correct job, then press **REC/ENT**.
   c. Press **REC/ENT** to select *Nikon* format.
   d. Press **REC/ENT** to select *RAW* format.
   e. Press **ANG** (the *Go* soft key) to send the data.
   f. Job metadata and survey data should appear in the computer's terminal window.
   g. Press **ESC** to prevent the station from deleting the job.
   h. Repeat steps 3a through 3g, EXCEPT at step 3d press ► then **REC/ENT** to select *Coord* data. This time, only survey point coordinate data (without metadata) will be sent to the terminal window.

4. In the terminal window, select all the exported data clicking and dragging over it with the mouse, and then press Ctrl-C. Open a notepad window and press Ctrl-V. Find the first "→" in the pasted information (at the end of the RAW data output), and press return between the arrow and the station benchmark point name to create a line break. Save the notepad file as "SSSSSS_YYYYMMDD.txt", where SSSSSS is the 6-letter site name.
5. When you are certain that the data for a job has been downloaded and saved, you can delete the job:
   a. Pressing **MENU** then **1** for *Job*.
   b. Use the arrow keys to highlight the job you want to delete, and then press **MSR2** (the *DEL* soft key). Press **REC/ENT** to confirm deletion, or **ESC** to abort deletion.
6. The comma-delimited data file can be imported into Excel, and the coordinate data at the bottom of the file can then be reformatted for import into a database or ArcGIS. The original data file must be archived at Z:\PROJECTS\MONITORING\Rocky_Intertidal\5_Data\Spatial_Data\Raw_Survey_Data.

To add, edit, or delete codes or point names to the code and point lists:

1. Press **MENU** then **4** (*Data*).
2. Press **4** (*PT name List*) or **5** (*Code List*), as appropriate.
3. To add a new layer (group of points or codes), press **ANG** (the *Layer* soft key) and press **REC/ENT**, type in the layer name, and press **REC/ENT**.
4. To work on the entries within a layer, highlight the layer name and press **REC/ENT**. Layers have an "→" after their name.
5. To delete an entry, use the arrow keys to highlight the entry and press **MSR1** (*DEL*) to delete an entry. Press **ANG** (*Yes*) if you are sure you want to delete, otherwise press **ESC** or **MSR1** (*No*).
6. To edit or add an item, press **MSR2** (*Edit*) or **DSP** (*Add*) and press **REC/ENT**. Type in the label or code and press **REC/ENT**. Type in the revised or new label or code and press **REC/ENT**. Note that for Codes, there will be a *CD* field and a *REC* field. *CD* is the code that displays on the station, and *REC* is the value that is recorded. If you leave *REC* blank, the value for *CD* will be used.
7. When finished, press **ESC** until you get to the main measurement screen.

SOP 9 – Data Management and QA/QC

Version 1.04 (January 24, 2014)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	5/3/2010	B. Mitchell	Based on the Data Management and QA/QC SOP v2.10 from the NETN forest health protocol	Original	1.00
1.00	9/3/2010	B. Mitchell	Minor edits, including reference to field QC in Appendix S8.A.	External review	1.01
1.01	12/15/2010	A. Kozlowski	Added data sheet handling steps	Database finalization	1.02
1.02	1/11/2012	B. Mitchell	Reduced and clarified requirements for field QA/QC (repeat site measurement), including allowance for the same personnel to be present if they perform different tasks.	Optimize costs/benefits of QA/QC data	1.03
1.03	1/24/2014	B. Mitchell	Removed reference to Form 2 (plot drawings)	Form no longer used	1.04

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 "Rite in Rain" paper datasheets and later transcribe the sheets into an MS Access database. The rocky intertidal database contains forms for entry of laboratory photo analysis data, so these data will be entered directly into the database. Appendix S9.A is a quick-reference guide to data 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.

Data Sheet Management

- 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. Field staff are responsible for reviewing the datasheets for completeness and legibility before leaving a survey site. Staff responsible for the review will initial the completed forms (Figure S9.1). A complete set of working copies of the datasheets will be made upon returning from the field (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 S9.1).

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

Figure S9.1. 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), all paper forms will be sent to the network data manager to 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.
- Arrange data sheets in the following order: Field Log (Form 1), Motile Invertebrates (Form 3), Point Intercept (Form 4), and Band Transect (Form 5). Additionally, 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.

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 network 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.

- Original data sheets should be copied onto acid-free paper within one week of collection. Photocopies 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 will be backed up weekly, with a backup copy stored in a different physical location from the working copy. Sequential backups will be used so that old versions of the data are maintained; these previous versions can be useful if data are 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, all paper field forms (copies and originals) shall be delivered to the network data manager. The electronic version of the data is used for all subsequent data activities.

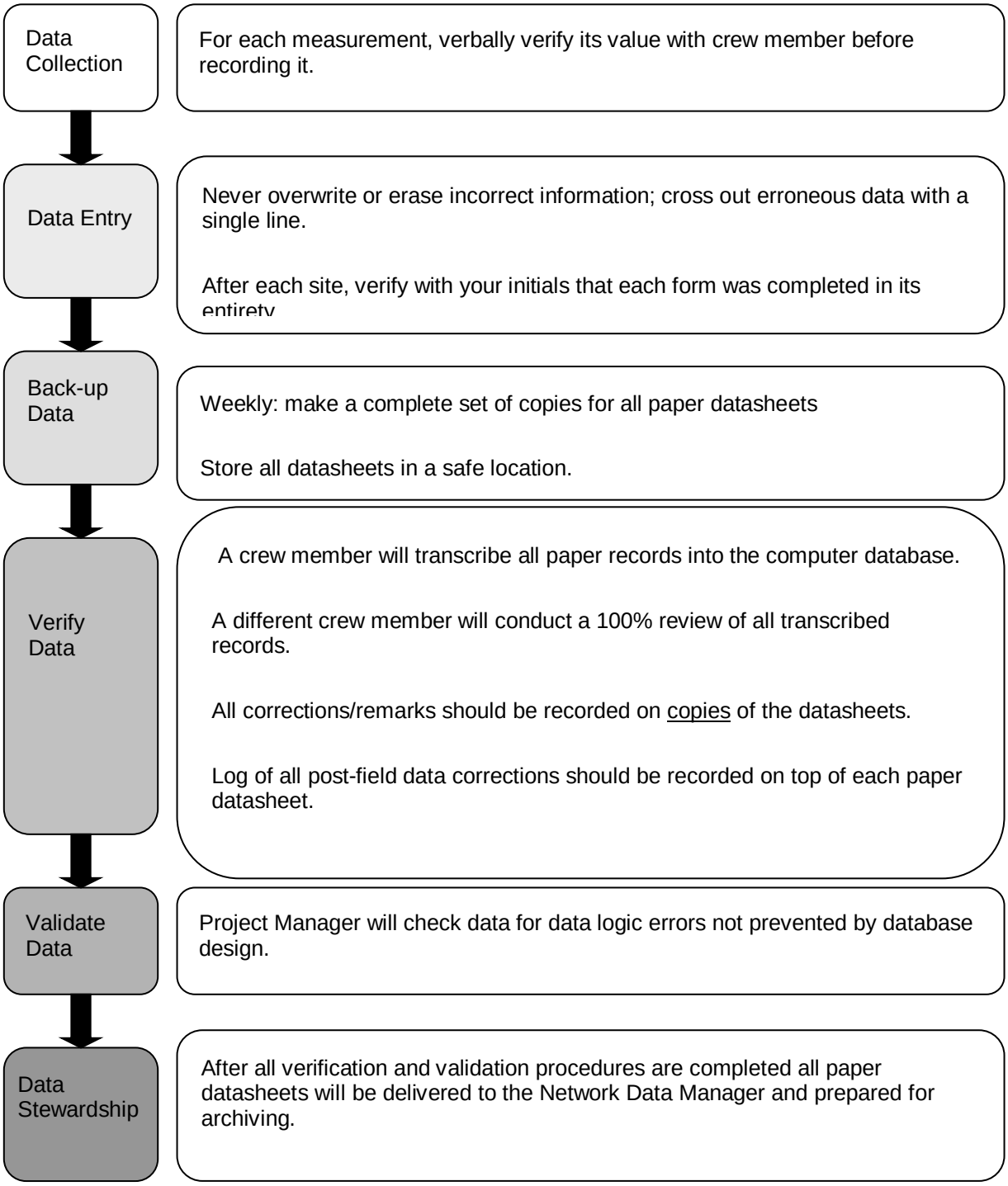
Field QA/QC

One randomly selected site will be resampled each year to determine reliability and repeatability of field data collection (with seven sites, this is a 14% resample rate). Field QA/QC will occur as close as possible to original sample date of the plot to reduce seasonal variability. If field staff for re-measurement includes some of the same people who conducted the initial measurements, they must collect different data during the QA/QC visit. For example, the person who collected transect data could be the data recorder for transect data, but not the observer, and the person who photographed plots must have a different task during QA/QC.

For the QA/QC visit, it is not necessary to sample all the plots. Three out of 5 of each type of photo quadrat should be photographed, and two out of three tide pool and vertical transects should be sampled. The plots and transects to be sampled must be chosen randomly. Motile invertebrates do not

need to be sampled, since these observations may be affected by removal of individuals during initial sampling. Temperature tidbits do not need to be downloaded during a QA/QC visit.

Appendix S9.A. QA/QC steps quick-reference.



SOP 10 – Field Work Preparation

Version 1.01 (September 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
1.00	9/3/2010	B. Mitchell	Must have confirmation that trip plan was received.	External review	1.01

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, and get verbal or written confirmation that the plan was received

SOP 11 – In the Field

Version 1.04 (January 7, 2015)

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
1.00	9/3/2010	B. Mitchell	Barnacle settlement plots are now recruitment plots	External review	1.01
1.01	1/12/2012	B. Mitchell	Updated info about finding plots. Add band transects to suggested schedules. Removed reference to Appendix A and replaced with reference to site information document.	Reflect improved site documentation Accidental omission Site information is now separate	1.02
1.02	2/4/2014	B. Mitchell	Add information about gull and cormorant colonies on BOHA.	Minimize disturbance to breeding bird colonies	1.03
1.03	1/7/2015	B. Mitchell	Revised methods for locating plots to note use of triangulation from nearby mapped bolts, and use of metal detector.	New procedure possible with better equipment and documentation	1.04

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, detailed maps based on RTK-GPS data, site documentation panoramas, GPS coordinates and overview photographs from previous trips (see the companion document to this protocol, “Rocky Intertidal Monitoring Site Information”) are useful for finding plot locations. Mussel and barnacle plots are usually easily found with the naked eye because bolts are exposed. When plots are not obvious to the naked eye and not found based on the maps and other site documentation, then the location of the bolt should be triangulated based on distance and bearing from nearby bolts. This can be done roughly, from the mapped locations of bolts, or based on calculations using bolt coordinates. For sites without RTK-GPS or total station mapping, a reference bolt should be found and the previously recorded distance and bearings to plots should be used to relocate plots (these should be kept in binders marked with the site name).

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 use a metal detector or 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 S11.1.

Table S11.1. Recommended sampling schedule for a typical field day.

Time	Activity[1]
3.0 to 1.5 hours before low tide	Barnacle/*Fucus*/*Ascophyllum* photoplots: photograph and sample motile invertebrates. Photograph barnacle recruitment plots.
1.5 to 0.5 hours before low tide	Mussel photoplots: 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 photoplots: photograph and sample motile invertebrates. Complete point-intercept transects.
0.5 to 1.5 hours after low tide	Band transects. 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 S11.2.

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 S11.3.

Table S11.2. Recommended sampling schedule for an early field day.

Time	Activity[1]
1.5 to 0.5 hours before low tide	Mussel photoplots: 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 photoplots: photograph and sample motile invertebrates. Complete point-intercept transects.
0.5 to 1.5 hours after low tide	Band transects. Complete the activities not completed above. Work from low to high as the tide floods.

Time	Activity[1]
1.5 to 3.0 hours after low tide	Barnacle/*Fucus*/*Ascophyllum* photoplots: photograph and sample motile invertebrates. Photograph barnacle recruitment 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.

Table S11.3. Recommended sampling schedule for a late field day.

Time	Activity[1]
3.0 to 1.5 hours before low tide	Barnacle/*Fucus*/*Ascophyllum* photoplots: photograph and sample motile invertebrates. Photograph barnacle recruitment plots.
1.5 to 0.5 hours before low tide	Mussel photoplots: 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 photoplots: photograph and sample motile invertebrates. Complete point-intercept transects.
0.5 to 1.5 hours after low tide	Band transects. 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.

A Note about Cormorants and Gulls at BOHA

Accessing the Calf and Green Island sites at BOHA requires walking through breeding gull colonies, often at a time of year (June and early July) when unfledged chicks are present. In addition, there is a cormorant colony above the Green Island monitoring site. Sampling at BOHA should be scheduled for as late in the season as possible to avoid disturbing the birds, but it will often be necessary to sample during the breeding season. Take extreme care when walking through the gull colony, to avoid trampling cryptic unfledged gull chicks. When working on Green Island, give the cormorants as much distance as possible to minimize disturbance.

SOP 12 – Plot Maintenance

Version 1.04 (January 7, 2015)

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
1.01	9/3/2010	B. Mitchell	Minor edits	External review	1.02
1.02	1/12/2012	B. Mitchell	Some bolts are lost due to storm-related factors. Maps are now available to assist with locating plots. Update tidbit replacement schedule.	Update based on field experience Improved site documentation Reflect 2011 replacements	1.03
1.03	1/7/2015	B. Mitchell	Updated tidbit replacement schedule	Reflect 2014 replacements	1.04

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 them. After each plot has been sampled during a sampling event, clean the bolts and a 5 x 5 cm area around each bolt (outside the plot only), 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 maps, notes, measurements from reference bolts, and photographs, a metal detector could be used to locate difficult to find bolts. If a metal detector will be used, test it with stainless steel hardware as some detectors are not sensitive to this material. Field staff did not need 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 creates too large of a hole, 3) erosion of substrate (that typically is apparent while drilling the initial hole), or 4) storm-related natural factors including shifting of rocks that the bolt is embedded in, large rocks being deposited on top of the bolt, or impact of rocks on the bolt's head.

If a bolt is lost, recreate the plot as close as possible to the original site using maps, overview photos, GPS coordinates, distance and azimuth from reference bolts, and position relative to other plot bolts.

For example, if a photoplot corner is lost, use a quadrat to determine correct placement of the missing bolt.

Temperature Loggers (Tidbits)

Water temperature at each site is recorded using three tidbit temperature loggers (ONSET corporation) (SOP 18 – 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. Because battery life varies, replace tidbits every 3 years because data are difficult to retrieve from tidbits whose batteries are expired. Tidbit shelters should be replaced every 6 years. See Table S12.1 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 2017 and MCI tidbits will need to be replaced in 2015 or 2016; ACAD and BOHA tidbit shelters will need to be replaced in 2020 and MCI tidbit shelters will need to be replaced in 2015.

Table S12.1. 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	2014	2017	2014	2020
	TEMP2	2014	2017	2014	2020
	TEMP3	2014	2017	2014	2020
ACAD-OTTPOI	TEMP1	2014	2017	2014	2020
	TEMP2	2014	2017	2014	2020
	TEMP3	2014	2017	2014	2020
ACAD-SCHPOI	TEMP1	2014	2017	2014	2020
	TEMP2	2014	2017	2014	2020
	TEMP3	2014	2017	2014	2020
ACAD-SHIHAR	TEMP1	2014	2017	2014	2020
	TEMP2	2014	2017	2014	2020
	TEMP3	2014	2017	2014	2020
BOHA-CALISL	TEMP1	2014	2017	2014	2020
	TEMP2	2014	2017	2014	2020
	TEMP3	2014	2017	2014	2020
BOHA-GREISL	TEMP1	2014	2017	2014	2020
	TEMP2	2014	2017	2014	2020
	TEMP3	2014	2017	2014	2020
BOHA-OUTBRE	TEMP1	2014	2017	2014	2020
	TEMP2	2014	2017	2014	2020
	TEMP3	2014	2017	2014	2020
MCI-METISL	TEMP1	2009	2015	2009	2015
	TEMP2	2009	2015	2009	2015
	TEMP3	2009	2015	2009	2015
MCI-PETMAN	TEMP1	2013	2016	2009	2015
	TEMP2	2013	2016	2009	2015
	TEMP3[1]	2009	2015	2009	2015

[1]Temp3 at PETMAN was not located in 2013 or 2014.

SOP 13 – Using the HHGA

Version 1.00 (January 7, 2015)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	1/7/2015	B. Mitchell	New SOP	New SOP	1.00

And now for something completely different…

If you have made it this far through the protocol, you are probably ready for a break. Here is a transcript of a favorite scene of ours from the movie Monty Python and the Holy Grail (1975).

Instructions for the Operation of the Holy Hand Grenade of Antioch

From The Book of Armaments 2:9-21

...And Saint Attila raised the hand grenade up on high, saying, “O LORD, bless this Thy hand grenade that with it Thou mayest blow Thine enemies to tiny bits, in Thy mercy.” And the LORD did grin and the people did feast upon the lambs and sloths and carp and anchovies and orangutans and breakfast cereals, and fruit bats and large chu...

[At this point, the friar is urged by Brother Maynard to “skip a bit, brother”]...

And the Lord spake, saying,

1. First shalt thou take out the Holy Pin.
2. Then, shalt thou count to three, no more, no less.
3. Three shalt be the number thou shalt count, and the number of the counting shalt be three.
4. Four shalt thou not count, nor either count thou two, excepting that thou then proceed to three.
5. Five is right out.
6. Once the number three, being the third number, be reached, then lobbest thou thy Holy Hand Grenade of Antioch towards thy foe, who being naughty in my sight, shall snuff it.

SOP 14 – Photoplots and Overview Photos

Version 1.05 (January 8, 2015)

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
1.01	9/3/2010	B. Mitchell and J. Long	Use modeling light of strobe to ensure it is aimed correctly, and revise procedures to include Canon PowerShot cameras. Take two photos at different f-stops by switching between program and aperture modes. Identify "other" species in drawings when >5% of a plot. Minor edits, including changing name of barnacle settlement plots to recruitment plots.	Update and external review	1.02
1.02	1/12/2012	B. Mitchell	Add procedures for photographing summer scraping barnacle plots. Add reference to improved site data – maps and photos.	New plot type Improved site info	1.03
1.03	1/30/2014	B. Mitchell	Removed information about drawing photoplots (using Form 2). This method is time consuming and does not produce useable data in the event of lost photos. Adjusted the procedures to reflect allowable use of stretch cord to mark photoplots. Add option to use an iPhone or similar camera for panoramas. Increase resolution of photoplot photos; identification of species can be difficult with the lower resolution photos.	Streamline field procedures Reduce errors in photoplot scoring	1.04
1.04	1/8/2015	B. Mitchell	Camera lens should be checked for condensation, water droplets, and deposits before each photoplot or overview. Use a shorter photoquadrupod for photographing settlement plots. U plots no longer scraped after photography	Most common causes of unusable photos Reduce image variability Scraping is now done in the fall	1.05

This Standard Operating Procedure (SOP) provides information for taking digital photographs of the photoplots, barnacle recruitment plots, and overviews. The images for the photoplots and barnacle recruitment plots are analyzed in the office according to SOP 21 – Scoring Photoplots. 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 backup memory cards are packed.

Fixed Photoplots

These photographs provide a fine-scale photographic record of the fixed photoplots. 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 S14.1).

1. Carefully mount camera (a Nikon Coolpix 5100 at ACAD and a Canon PowerShot SX10 or SX20 IS at MCI and BOHA) in waterproof housing (Ikelite, for this camera). Place a desiccant (such as a Moisture Muncher) within the waterproof housing to reduce condensation that may obscure photographs. If no desiccant is available, condensation will usually evaporate 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. Use the “Lite” setting on the strobe to turn on the test light and ensure that the strobe is aimed at the center of the quadrapod base, and then tighten the adjustment knobs on the strobe so that its position does not shift.

3. Locate photoplots. 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.

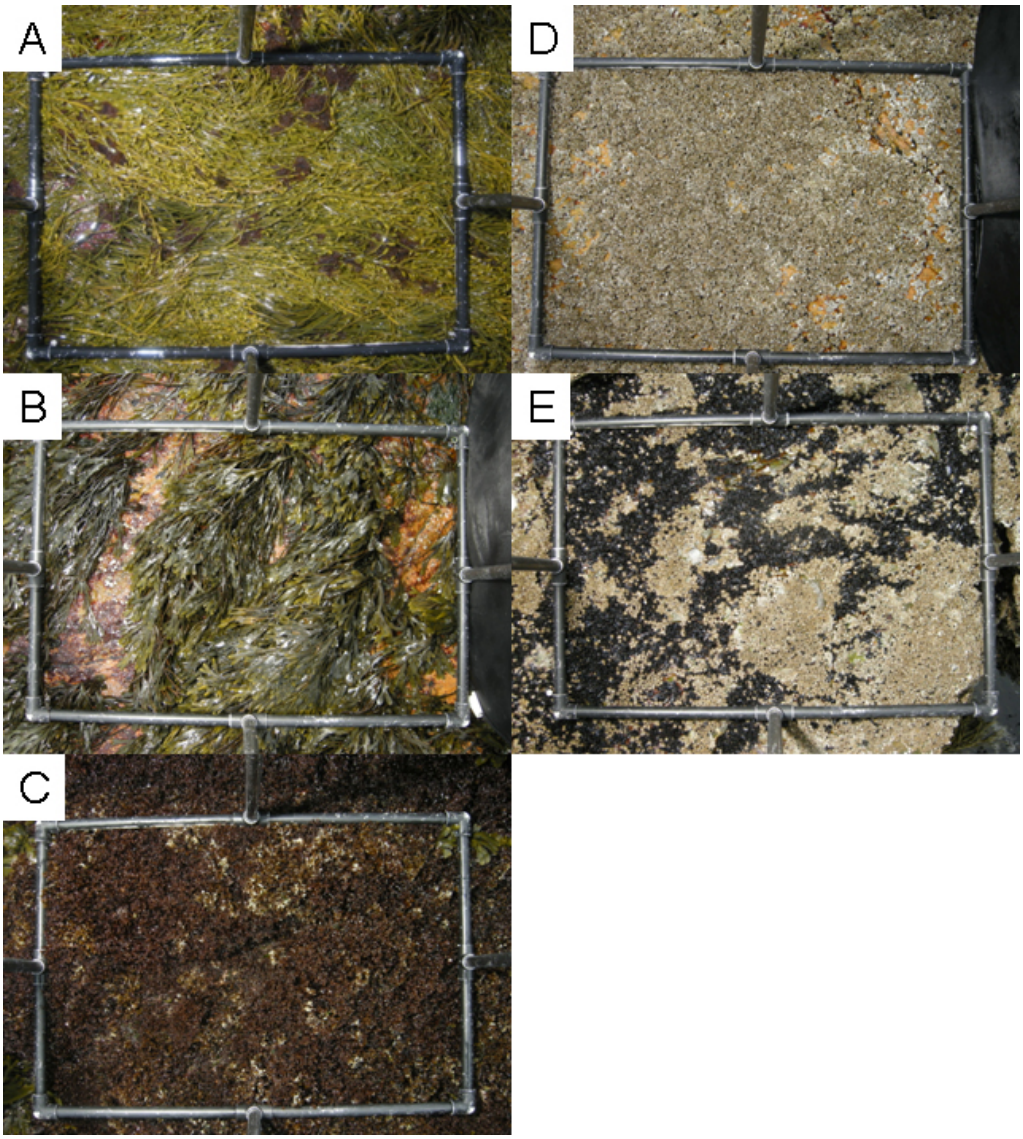


Figure S14.1. Sample photoplot photos. A) *Ascophyllum*, B) *Fucus*, C) Red algae, D) Barnacles, and E) Mussels.

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. Stretch cord can also be used if all 4 plot bolts are present. For each plot type, five quadrats or sets of stretch cord 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 five quadrats or stretch cord into the field. These quadrats and cords 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 15 – Motile Invertebrates). Thus, do not move a

quadrat or stretch cord 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. 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 (use the "Lite" setting to verify this).

9. 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 are often not needed because of the distance of the camera from the substrate and the relatively small depth of field of the plots. Nevertheless, a second photo will be taken at a higher f-stop. Confirm that "Image Size" setting is at least 8M (final pictures will be 3264 x 2448 pixels); use the highest resolution available. If using the Canon PowerShot SX10, use at least the 10M ("L") setting, and preferably the highest resolution available. The camera's flash should be on.

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

11. Before photographing each plot, check the housing for condensation inside the lens and water droplets or deposits (salt or other debris) on the outside of the lens. Clean the lens if necessary or open the case to allow condensation to evaporate.

12. Temporarily remove the quadrat and place the quadrapod frame over the four plot bolts. If using stretch cord, the cord can remain in place. 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 second photograph after adjusting the mode dial to A (Nikon) or Av (Canon) and ensuring that the maximum f-stop is selected. 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 photoplot, return the PVC quadrat (if used) 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 7). 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.

19. Move onto the next replicate and repeat steps 11-18.

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 photoplots 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 S14.2). Alternatively, an iPhone or similar camera that can create panoramas instantly may be used.



Figure S14.2. Sample overview photographs of the barnacle zone at SCHPOI. Images have been overlaid manually. Note the white PVC quadrats that are marking the barnacle photoplots. Also, the orange cone marks the position of the reference bolt for these photoplots.

1. Overview photos are taken of all photoplots and the point-intercept transects. No overviews are photographed for barnacle recruitment 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 panorama or series of adjacent 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 photoplots 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 installed in obvious places and are never completely covered with algae. Site familiarity will greatly facilitate relocation of reference bolts. Additionally, maps, site photos, 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, no flash or strobe). If using the Canon PowerShot SX10, use the 6M (“M1”) setting. This can be completed by taking multiple overlapping photos while rotating with the camera in a clockwise motion. Photos should overlap each other by 1/3 of the next photograph. Alternatively, an iPhone or similar camera that can generate panoramas instantly may be used.

4. Try to minimize shooting the sky or sea as this may create exposure problems, and make sure to check the camera lens for condensation, water droplets, or deposits that will lower the image quality.

Barnacle Recruitment Plot Photos

Barnacle recruitment is measured by counting the number of barnacles settling on scraped rocks in the barnacle zone (Figure S14.3). Barnacle recruitment is a major force that determines succession after disturbance (e.g. trampling and winter storms), and monitoring recruitment may provide insight into long-term changes in the barnacle photoplots. Barnacle recruitment also encompasses changes that happen beyond intertidal habitats because larvae disperse away from these habitats. Monitoring recruitment may give us a glimpse of consequences of long-term changes beyond the intertidal (e.g. changes in planktonic primary production, ocean temperature, or oceanic circulation).

Recruits are counted using images of barnacle recruitment plots. Recruitment is highest late March to early June. Note that apparent barnacle recruitment is highest just after peak settlement. Thus, sample plots in June (or July). If these plots are scored later in the summer (e.g. August or September), then

apparent recruitment will be lower because of intraspecific competition, predation, larger barnacles obscuring smaller barnacles below them, and other factors.

Recruitment photographs are facilitated by using a shorter version of the photoquadrupod designed so that the bottom frame is several centimeters larger than the plot size (7.5” x 7.5”), and with legs sized so that the camera’s field of view is just larger than the plot when the photoquadrupod is assembled. This facilitates maintaining a consistent distance from the recruitment plot, and reduces errors due to not holding the camera directly over the plot. However, some recruitment plots are located in areas that cannot be photographed with a frame due to nearby rocks; in these cases photos should be taken “free-form”.

1. Locate recruitment 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 to provide scale when the photograph is analyzed.

4. Turn strobe to “ON” and “TTL” settings. Check that the strobe is pointed at the center of the plot (use the “Lite” setting if needed).



Figure S12.3. Sample barnacle recruitment plot showing newly recruited barnacles in June.

5. Turn camera on and set to 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 are often not needed because of the distance of the camera from the substrate and the relatively small depth of field of the plots. Nevertheless, a second photo will be taken at a higher f-stop. Confirm that "Image Size" setting is at least 8M (final pictures will be 3264 x 2448 pixels), and preferably the highest resolution available. If using the Canon PowerShot SX10, use at least the 10M ("L") setting, and preferably the highest resolution available. This is the same setting that is used for the photoplots, so no adjustment should be needed. The camera's flash should be on.

6. Before photographing each plot, check the housing for condensation inside the lens and water droplets or deposits (salt or other debris) on the outside of the lens. Clean the lens if necessary or open the case to allow condensation to evaporate.

7. 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.

8. 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.

9. 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.

10. 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.

11. Take a second photograph after adjusting the mode dial to A (Nikon) or Av (Canon) and ensuring that the maximum f-stop is selected. 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.

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

13. For sites with summer scraping barnacle recruitment plots, repeat steps 1-12 for plots U1-U5.

SOP 15 – Motile Invertebrates

Version 1.04 (January 8, 2015)

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
1.01	6/6/2013	B. Mitchell	*Acmaea* is now *Tectura*	Update taxonomy	1.02
1.02	1/27/2014	B. Mitchell	Update and clarify procedures for handling snails.	Streamline procedures	1.03
1.03	1/8/2015	B. Mitchell	Remove option to subsample plots	Rarely used and potentially introduces problems in data analysis stage	1.04

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 photoplots (monitored with SOP 14 – Photoplots 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 photoplots 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 photoplots occurs AFTER the photoplots have been photographed (SOP 14 – Photoplots and Overview Photos).

2. For each photoplot in the *Ascophyllum*, *Fucus*, and mussel zones, label one small bag/container for each plot number (e.g. F1 for Fucus photoplot 1). Thus, there will be a total of 5 bags for each target species per zone. For zones that typically have very few snails (barnacle and red algae), a single bag can be used for each photoplot (all five target snail species are placed in the single bag). There will be a total of 60 bags for sites without mussel plots, and 85 bags for sites with mussel plots.

3. Enter the initial information on the motile invertebrates data sheet (Form 3, Motile Invertebrates Data Sheet) with the appropriate headings: site, plot type, date, collection time, photoplot photographer, and snail collector. The "Observer" and "Recorder" are filled in later; these are the people measuring and writing down snail data.
4. Put some water in the bag(s) or container(s) for the photoplot you are working in. 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 (*Tectura testudinalis*) with a length greater than or equal to 0.7 cm (approximately the width of a pencil). Use care when extracting *Tectura testudinalis* as their shells are very fragile. It is preferable to leave *Tectura testudinalis* individuals in place, measuring them with calipers and recording the data as you work.
5. 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.
6. Place invertebrates in their designated bag/containers for counting and measuring after collection.
7. Store the bags in the shade until the snails can be measured and counted. *Fucus* and *Ascophyllum* photoplot snails should always be saved for later. There are typically few enough barnacle, red algae, and mussel zone snails that they can be measured and recorded immediately after collection.

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. Verify the initial information on the motile invertebrates data sheet (Form 3, Motile Invertebrates Data Sheet). Add the observer (person measuring snails) and recorder (person writing the data) names.
3. For each photoplot 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 S15.1). 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 S15.1). Although it is an indirect measure, the abundance and proportion of damaged to undamaged snails provides an estimate of crab predation.



Figure S15.1. 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 3.

5. Using calipers, measure the length of 10 randomly chosen individuals of each motile invertebrate species from each plot. When there are more than 10 individuals of a species, take care to select individuals without biasing towards small or large individuals. For example, gently shake the bag (with water in it) to sort the snails along the bottom, and choose the first 10 from the left or right side of the bag. 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 3.

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

SOP 16 – Tide Pool Transects

Version 1.03 (January 27, 2014)

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
1.01	9/3/2010	B. Mitchell	Minor edits, and suggestion of analysis exploring number of individuals measured.	External review	1.02
1.02	1/27/2014	B. Mitchell	Added possibility of having two people survey the same tidepool, one on each side of the transect line.	Streamline procedures	1.03

This Standard Operating Procedure (SOP) summarizes the procedures for conducting sea star and sea urchin monitoring (Figure S16.1). 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. Currently, only 10 individuals of each species are sampled per tide pool. A power analysis will help determine whether this sample is sufficient to detect biologically meaningful changes in size.



Figure S16.1. 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, abundances of these echinoderms may not correlate well with the target species in the photoplots 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, NETN 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 photoplots (*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 that are spaced 10 m apart. Echinoderms will only be surveyed along the band transect between these bolts. Thus, echinoderms occurring beyond the 10 m transect will not be surveyed.

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, many pools are smaller than this area. In such cases, it is unnecessary to search for echinoderms in areas that are outside of the pools because they do not occur there. The counts should take approximately 15-20 minutes per pool with one sampler. Allocate search 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 5). 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 5).

7. Sampling time can be reduced by assigning one person to measure and one person to record measurements, or by having two people sample by each taking one side of the transect.

8. Return measured organisms to the pool.

Quality Control and Datasheet Management

- 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.

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

SOP 17 – Point-intercept Transects

Version 1.06 (1/8/2015)

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
1.01	9/3/2010	B. Mitchell and J. Long	Identify any species that falls into an "other" category and is found on 5 points in any transect, and notify PI. Minor edits.	External review	1.02
1.02	12/15/2010	B. Mitchell	Edits to emphasize that this SOP evaluates canopy cover, not overall abundance	External review	1.03
1.03	1/12/2012	B. Mitchell	Update procedures to accommodate enhanced transects (with >10 surveyed bolts). Add code for "bolt". Clarified how to distinguish rock from non-coralline crustose algae.	Enhanced transects in 2011. More often encountered with enhanced transects. Clarification needed.	1.04
1.04	6/6/2013	B. Mitchell	All transects have been enhanced at ACAD and BOHA.	Completed transect upgrades.	1.05
1.05	1/9/2015	B. Mitchell	Added numbered washers to BOHA and ACAD transects. Clarified procedures for locating bolts.	Facilitate locating missing bolts Revised based on field experience	1.06

This Standard Operating Procedure (SOP) summarizes the procedures for monitoring canopy species cover along point-intercept transects (Figure S17.1). 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 top-most species or substrates along the transects are recorded at every 0.3 m. Data collected with this SOP will allow for an across-shore estimate of canopy species cover and an estimate of the elevational range for each canopy species detected. Both estimates should be particularly sensitive to factors related to climate change, including increasing temperatures and sea level rise.

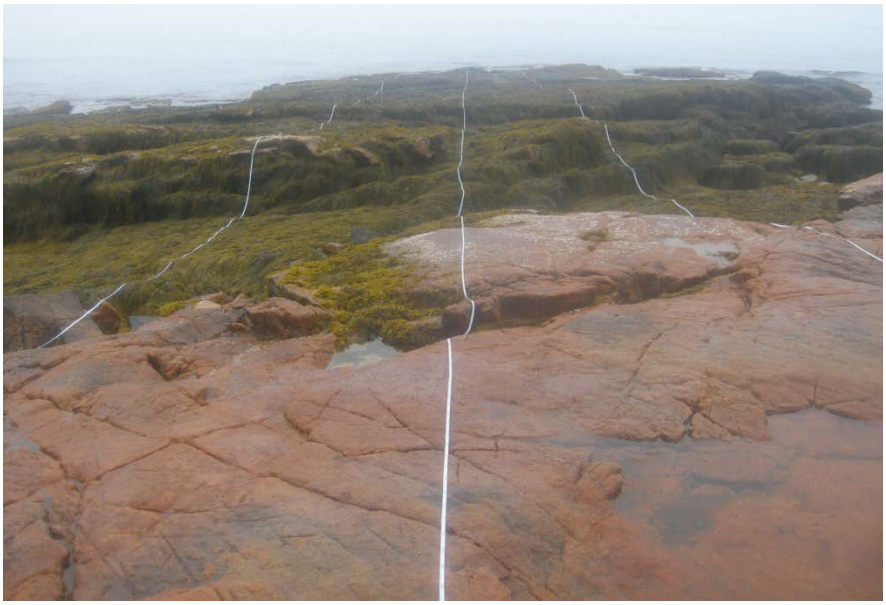


Figure S17.1. Three point-intercept transects extending from the high intertidal (foreground) to the low intertidal (background).

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 varying 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), NETN will 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.

In 2011 through 2013, all transects at BOHA and ACAD were upgraded with the installation of additional bolts, and bolts were surveyed using RTK GPS or a total station. The additional bolts provide more consistent guidance to samplers about the locations to sample, and will facilitate analysis of changes in species distribution due to sea level changes. In 2014 (BOHA) and 2015 (ACAD), numbered washers were added to facilitate locating missing bolts and allow for surveying partial transects (i.e., allow sampling when the mid-bolt or end-bolt is covered).

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 and along the other T1 bolts (generally located every few meters and at local high and low points down to the low intertidal). The upper bolt, mid-bolt (by elevation, not distance) and bottom bolt are the only bolts with separate, labeled bolts, but bolts at ACAD and BOHA will have numbered washers (e.g., 2-8 for the eighth bolt along transect 2). Bolts and tags are often covered or encrusted with algae and may be difficult to find, even with reference coordinates and maps. 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), triangulate on the bolt location using maps and coordinates, and use a metal detector, if available. Minimize disturbance when laying out transect tapes. If vegetation must be moved to locate 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 lowest accessible 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 to the lowest accessible bolt and make note of it on the data sheet. For transects that have not been upgraded with additional bolts, extend the tape as accurately as possible to the water's edge.

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, 2) it passes to the right of each bolt (when your back is to the water), and 3) it follows a straight line (as viewed from above) connecting each bolt 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.

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. Refer to the transect map to determine how many bolts should be found between the upper and mid bolt and between the mid and lower bolt, and make sure all bolts are located prior to surveying a section of the transect.

7. Starting with zero, identify the organism or substrate that lies at the top of the tape (determined by an observer orienting themselves so that the numbers on the tape are right-side up) and directly perpendicular and to the right of the 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 "bolt" (BL). If you are unsure whether the substrate is non-coralline crustose algae or rock, scrape the rock with a fingernail. If dark pigmented material comes off, it is algae. Non-coralline crustose algae includes any color encrusting algae that is too

small to identify, such as green algae with barely visible filaments (< 0.5 cm). Whenever sand cover is 2 cm or deeper along the transect, score “sand”; otherwise score “rock” or the underlying core species. Sand depth 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. If more than five points along the transect have a species that falls in the “other” category, record the species name (to the lowest taxonomic resolution possible) and the number of points on the form. Alert the project PI, so that a decision can be made about including this species in future monitoring. *Spongomorpha* and similar algae are classified as “Other Green”, and *Ceramium* and similar algae are classified as “Other Red” since there are multiple taxa with very similar morphology.

11. Record the locations (distance from zero) of all bolts on the bottom two rows of the data sheet as you encounter them. For transects that have not been upgraded with numbered washers for each bolt (or intermediate bolts), place an asterisk next to the number corresponding to the mid-bolt location. 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.

12. 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.

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

14. 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.

SOP 18 – Temperature Loggers

Version 1.11 (January 12, 2012)

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
1.01	9/3/2010	B. Mitchell	Air and water temps are of interest. Minor edits.	External review	1.02
1.02	12/15/2010	A. Kozlowski	Added data handling steps for tidbits.	Database finalization	1.10
1.11	1/12/2011	B. Mitchell	Minor edits	Clarification	1.11

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 separate temperatures into water temperatures (near high tide) and air temperatures (near low tide). Additionally, the 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

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, NETN will replace tidbits every 3 years because data are difficult to retrieve from tidbits whose batteries are expired. Check the NETN Rocky Intertidal database or SOP 12 – Plot

Maintenance to obtain the schedule of data loggers that will need replacement. Note that the Tidbit temperature loggers will 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.

Data processing

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). Upon returning from the field, temperature data files are moved from the shuttle to a computer so that they can be imported into the database. Once in the database, tide data are used to identify readings of air (exposed) and water water (submerged) temperatures. Make sure to follow procedures in the Tidal Data Management section of SOP 22 – Season Wrap-up before importing tidbit data into the NETN Database; this will ensure that the data are available to determine whether tidbit data are air or water temperatures.

Retrieving Data from a Tidbit in the Field

1. Locate the tidbit and remove the shelter. It should not be necessary to unscrew the tidbit from the substrate to download data in the field, but this can be done if needed.

2. Clean the tidbit with a finger or toothbrush so that the tidbit surface is clear of debris and organisms.

3. Follow instructions provided with the shuttle to move temperature data from the tidbit to the HOBO Waterproof Shuttle. 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.

4. Repeat Steps 1 through 3 for each tidbit anchored at the site (normally three).

Preparing Tidbit Files for Import into the NETN Rocky Intertidal Database

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

2. Open a new, temporary Access database

3. External Data → Import → Text File

4. Browse to the .csv file you are importing

5. Maintain standard import settings → OK

6. Choose ‘Delimited’ format → Next

7. Choose ‘Comma’ delimited; Choose ‘First Row Contains Field Names’ → Next

8. Field 1: check ‘Do not import field’

9. Rename Field 2 as Date; Field 3 as Time; Field 4 as Temp_C
10. Check ‘Do not import field’ for remaining columns --> Next.
11. Select ‘No primary key’ --> Next
12. Name the table (something logical) --> Finish
13. Open the table to verify a clean import. Delete row 1 and 2 (header information).
14. Repeat steps 2 through 10 until all files you wish to import are in the temporary database.

Importing Processed Tidbit Data into the NETN Rocky Intertidal Database

1. Open the NETN Rocky Intertidal Database
2. From the Main Menu select ‘Import Data Files’
3. Follow the instructions given on the Import Data Files form
4. Check to make sure all files uploaded correctly (e.g. check record count)
5. Check to make sure that the Temp_Source column was fully populated (e.g. water or air)
6. Delete all temporary text and database files generated during this process.

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 (15^{o}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.

SOP 19 – Field Log

Version 1.03 (January 9, 2015)

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	9/3/2010	B. Mitchell and J. Long	Clarified methods for evaluating changes. Staff should be quiet on arrival to look for birds and mammals. Abundant non-target species should be identified and noted. Defined L / M / H and R / U / P / C / A to apply to specific percentage covers. Updated field form, including separating health evaluation into multiple columns.	External review	1.01
1.01	1/27/2014	B. Mitchell	Minor edits, plus minor changes to reflect revised field form.	Annual review	1.02
1.02	1/9/2015	B. Mitchell	Edits to reflect revised field form	Annual review	1.03

This Standard Operating Procedure (SOP) summarizes the procedures for completing the field log (Form 1). This form summarizes the site-wide conditions at the time of sampling. Conditions may influence some of the 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

The Field Log Data Sheet (Form 1) 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. When the form asks for comparisons to previous visits, staff should do as much as they can with the evidence at the site, supplemented by site photos and memory (if anyone at the site has sampled it previously).

The first page of Form 1 includes spaces to describe “Weather and Sea Conditions,” “Substratum Changes,” and “Debris and Pollutants.” Refer to the third page of Form 1 for guidance about different categories of each. In general, “0” means none, “L” means up to5% cover, “M” means 5-20% cover, and “H” means 20% and higher percent cover. For rain, “L” means drizzle or fog, “M” means showers or light rain, and “H” means moderate to heavy rain. Substratum changes will primarily be based on evidence visible during the site visit. For example, has a rock shifted onto a photoplot? Is there sediment in a tidepool? Are areas that would normally be covered by seaweed scoured bare?

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. Animals must be on the site (i.e., within the intertidal zone) or within 50 m of shore. Note that arrival to the site should be quiet and staff should attempt an initial count upon arrival. Record bird species if known.

Report any plot marker loss, installation, or repair on page 1.

Report any non-target species that are abundant, particularly if they are recorded in one of the "other" categories during sampling.

On page 2, categorize the abundance and appearance of the dominant species (per instructions on page 3). Abundance of animals is relative to typical sites and years (e.g., 100 sea stars seen would be "Abundant", but 100 dog whelks would likely rate as "Uncommon"). For algae cover, use the following categories: 0 = None, Rare = <1% cover, Uncommon = 1-5% cover, Present = 5-10% cover, Common = 10-20% cover, and Abundant = 20-100% Cover. Gray blocks on the form do not need to be filled in.

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 one person** (less time if two 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

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.

File Form 1 with all other datasheets from the monitoring event in the appropriate binder.

SOP 20 – Field Work Wrap-up

Version 1.03 (January 23, 2014)

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.	Original	1.00
1.00	9/3/2010	B. Mitchell	Minor edits; barnacle settlement plots are now recruitment plots.	External review	1.01
1.01	1/12/2012	B. Mitchell	Add label for summer scraping barnacle recruitment plots ("sum").	New plot type	1.02
1.02	1/23/2014	B. Mitchell	Revise photo name format to be compatible with the bulk rename utility, and added instructions for using the rename utility. Added network server location for photos.	Facilitate data management	1.03

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 photoplots and barnacle recruitment 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_PlotType_Replicate#andImageIdentifier_Date

   Where the six 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, SET=barnacle recruitment, and SUM=summer scraping barnacle recruitement), replicate # is 1-5, and date is in YYYYMMDD format. The 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 date. When initially labeling the images, the first image is assigned the identifier "a" and the other photo is assigned a "b." Later the designation may be switched if photo "b" is noticeably better than "a".

   An example of an image name is:

   GREISL_ASC_4A_20090621.jpg

3. For overview (panoramic) photos, images are named as above, with a "P" instead of the replicate, and as many image identifier letters as are needed to get overviews of all the photoplots:

   GREISL_ASC_PA_20090621.jpg

4. To speed up the renaming process and reduce errors when renaming photoplot and barnacle recruitment photos, use the bulk file renaming utility (on the NETN server at Z:\LIBRARY\SOFTWARE\Utilities\Bulk Rename Utility). You will also need the two settings files that are configured for the rocky intertidal monitoring program ("rename_ri_1.bru" and "rename_ri_2.bru"). These files are located at Z:\PROJECTS\MONITORING\Rocky_Intertidal\5_Data\Photos.

   a. Technical Note 1: The settings files are configured to look for photos in C:\Temp. You can navigate to the photo location using the GUI, or change the default path by editing the configuration file. Open the file in Notepad and change the Path= line (second line) to the desired path.

   b. Technical Note 2: The renaming process occurs in two steps; the first step handles most of the renaming, but can't handle producing unique alphanumeric codes for a photo based on the order in which the photo was taken (e.g., 2A for the third photo). So the first step assigns a numeric code (from 00 to 09) for the ten photos, and then the second step searches for and replaces the numbers with the correct codes (1A to 5B). To alter the search and replace (e.g., to use the renaming utility for a different protocol), open the second configuration file in notepad and edit the "[Character Translation]" section at the bottom. This section contains the text in the file name that is searched for and the text to

replace it with. The format is awkward since each character is separated by a comma, but to change a "_12_" to "_7A_" you would insert the following line:

Pair N= "_,1,2,_=_,7,A,_"

Where N is the next number not already used as a pair number.

5. With the photos to be renamed in C:\Temp, double-click the rename_ri_1.bru file. This should open the Bulk Rename Utility GUI. In the "Add (7)" section, enter the correct site name and plot type (e.g., "BASHAR_ASC_". Select the 10 photos to be renamed, and verify that the "New Name" column has the correct new file names. Click "Rename" at the bottom-right of the GUI. Repeat for all the other plot types from the same site. Then close the Bulk Rename Utility.

6. Double-click on the rename_ri_2.bru file to open the Bulk Rename Utility with the new settings. Select all ten photos of the first plot type, and verify that the "New Name" column has the correct final file names. Click "Rename" at the bottom-right of the GUI. Repeat for all the other plot types from the same site. Then close the Bulk Rename Utility.

7. Manually rename the overview (panoramic) photos and any other photos taken at the site.

8. After renaming all images, move these to their appropriate folder. While in the field, use a separate folder for each site, named with the 6 character site code. In the office, move each folder to the network server: Z:\PROJECTS\MONITORING\Rocky_Intertidal\5_Data\Photos\Protocol_Photos\YYYY where YYYY is the year. All photos for the site in a given year are stored within the same folder.

SOP 21 – Scoring Photoplots

Version 1.05 (October 10, 2014)
Revision History Log

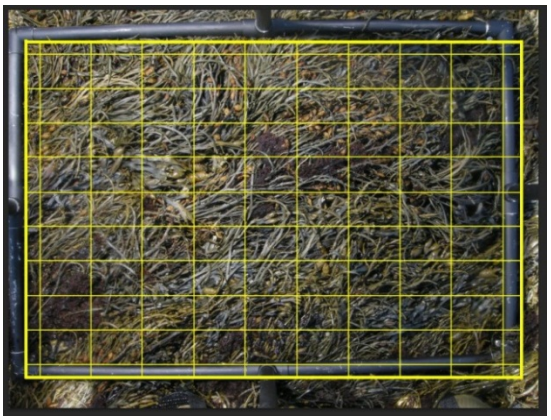
Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	7/7/2009	J. Long	---	Original	1.00
1.00	9/3/2010	B. Mitchell and J. Long	Any species classified as "other" with more than 5 points in a photo should be identified and reported to the PI. Minor edits, including use of barnacle recruitment instead of settlement.	External review	1.01
1.01	12/15/2010	A. Kozlowski	Added detail about where photo scoring data is to be stored in the database	Database finalization	1.02
1.02	7/22/2013	B. Mitchell	Updated barnacle scoring procedures with increased detail	Facilitate scoring by technicians and improve quality control	1.03
1.03	1/24/2014	B. Mitchell	Revise photo data management procedures Clarify that tests of dead barnacles and other similar non-living items are "other substrate"	Facilitate data management Standardize procedures	1.04
1.04	10/10/2014	B. Mitchell	Clarify PhotoShop and database procedures for scoring photoplot photos	Additional experience and new database	1.05

Scoring Photoplot Photographs

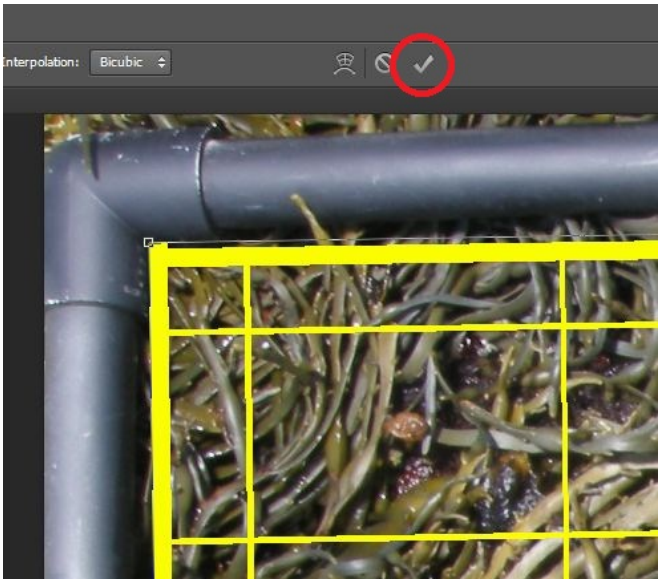
1. Open a photograph to be scored in Adobe Photoshop (these directions are written for Photoshop CS6). Note that each plot should have two photographs because it was shot twice; one is labeled with an "A" after the plot type and replicate number, and the other has a "B". If the "B" photo is noticeably better than the "A" photo, rename them so that the "A" photo is the better photo. See SOP 20 – Field Work Wrap-up for the photo naming conventions.

2. While in Adobe Photoshop, also open the file "rectanglegrid.psd." This file contains an image of a yellow grid consisting of framed 10 x 10 lines that creates 100 intersection points, and it can be obtained from NETN staff.

3. Copy the grid (Ctrl-A, then Ctrl-C) and paste it onto the photograph to be scored (Ctrl-V). Your image should look like this:

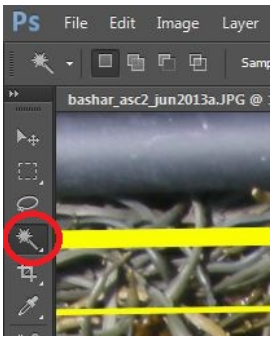


4. Transform the grid layer so that the corners of the grid are immediately inside the inner corners of the quadrapod quadrat seen in the photograph to be scored. To transform the layer, select: Edit>Transform>Skew. Then, drag each grid corner to the respective quadrat corner. Zoom in or out using Ctrl-+ or Ctrl--. Once you are satisfied, click the check in the middle of the top toolbar.

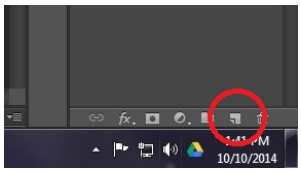


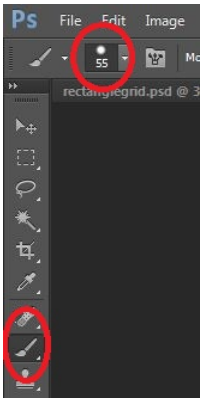
5. The above instructions create a Photoshop document with two layers: the plot image layer and the grid layer. The grid consists of 100 intersecting points. The primary goal of this SOP is to identify the species or substrate below each point.

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 (Layer… Hide Layers). This creates an outline of the grid and can make it easier to see what lies directly beneath the intersection points.



7. To make it easier to track points that have been scored, it may help to create a new layer, and use the brush tool to put dots on the intersections that have been scored. Click the "Create a new layer" icon at the bottom-right of the window (A), then click on the new layer name ("Layer 2") and rename it "done dots". Make sure this layer is highlighted, and turn on the Brush tool and set a brush size of around 50 pixels (B). As points are tallied, just click at the intersection of the grid lines to create a colored dot. The color of the dot is set by clicking the foreground color icon and choosing a color from the palette (C).

A) 

B) 

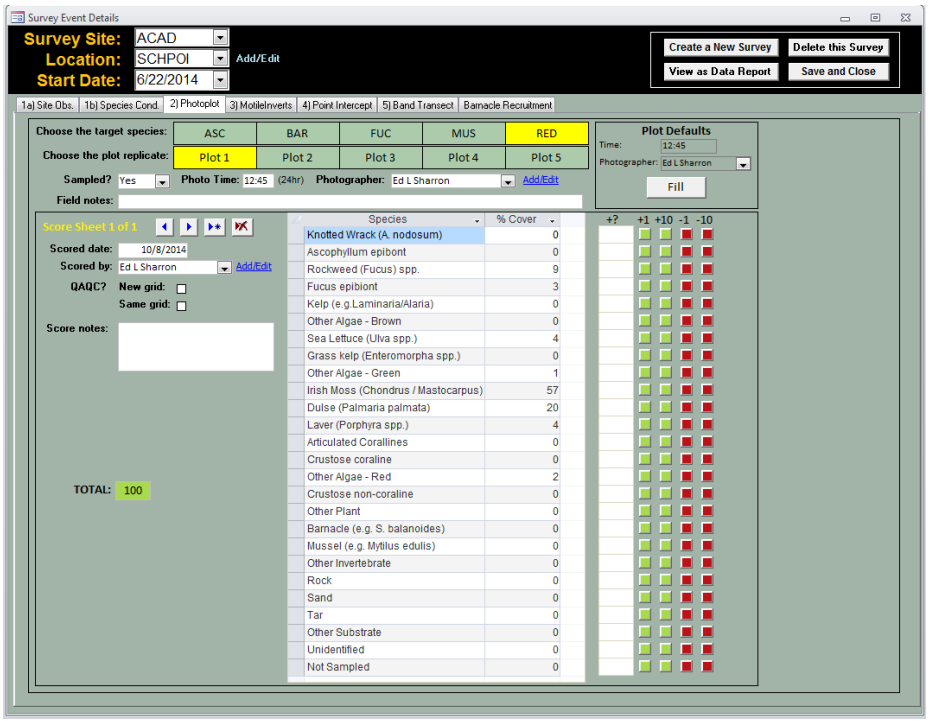
C) 

8. Using the data entry form in the database, record the date, scorer name, and whether the scoring is for QC (i.e., a repeat scoring of the same photo; do not check a QC category just because the photo was taken at a QC site), record the species present under each point. Use the columns to the right of the "% Cover" field to enter data; any value entered in the "+?" column is added to the tally in the % Cover column, and the columns of buttons can be used to add or subtract 1 or 10 to the % Cover value.

   If a bolt or other object blocks the view of a point, mark the point as "Not Sampled". If a point is shadowed or blurred, it may be possible to classify the point based on what is surrounding it. However, if the point is deeply shadowed, shadowed and surrounded by a variety of species, or so blurred it is impossible to determine what target species is at the point, mark the point as "Not Sampled". If water is covering species, try to identify the first target species below the water; if reflections prevent an identification, mark the point as "Not Sampled". In the comments, record the number of points and reason for any points not sampled.

It may be possible to adjust the image to help make an identification at shadowed locations in a photo. Make sure to turn the highlighted grid off (or the adjustment will be limited to the grid itself) and click the "Background" layer on. Choose Image… Adjustments… Shadows/Highlights and adjust the slider with the "Preview" checkbox selected. Cancel out rather than saving the adjustment when you are finished. Then make sure to use the Magic Wand tool to highlight the grid again, and select the "done dots" layer, before proceeding.

If more than five points in a photoplot have a species that fall in the "unidentified" category or one of the "other" categories, record the species name (to the lowest taxonomic resolution possible) and the number of points in the comments field for the photoplot in the database. Alert the project PI, so that a decision can be made about including this species in future monitoring. Score dead barnacle tests, dead mollusk shells, and other non-living substrates that are not "rock" or "sand" as "other substrates." *Spongomorpha* and similar species should be scored as "Other Green", while *Ceramium* and similar species should be scored as "Other Red".



9. 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. Rescoring an entire photo because of a missed point is extremely time consuming, so 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).

10. Save the Photoshop document to the same directory as the photo. Use the same file name, with the .psd extension. Also save the Photoshop document just created (plot image + grid) as

a jpeg image with all 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, if the photo being scored is GREISL_ASC_4A_20090621.jpg, then the file would be named:

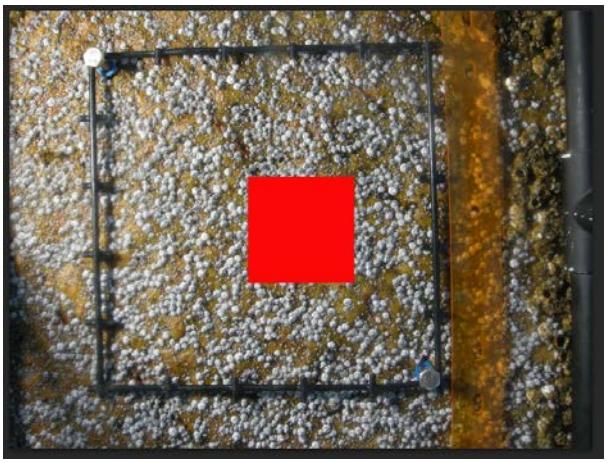
GREISL_ASC_4G_20090621.jpg

Scoring Barnacle Recruitment Plots

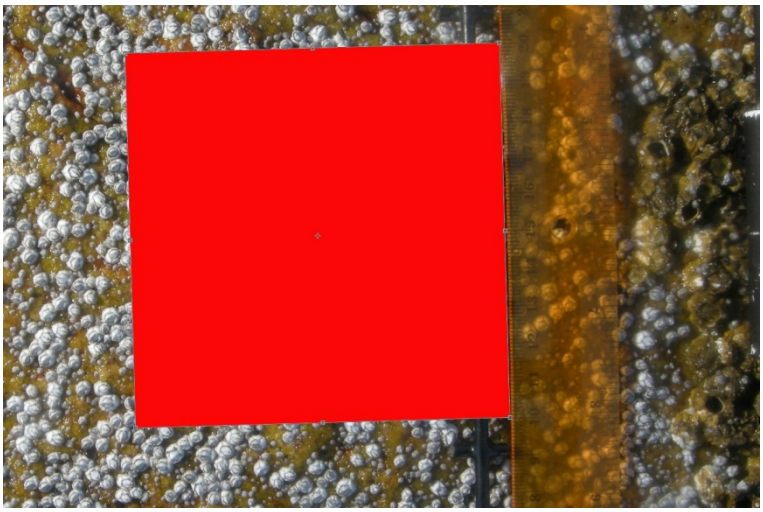
1. Open photograph to be scored in Adobe Photoshop (these directions are written for Photoshop CS6). Note that each plot should have two photographs because it was shot twice; one is labeled with an "A" after the plot type and replicate number, and the other has a "B". If the "B" photo is noticeably better than the "A" photo, rename them so that the "A" photo is the better photo. See SOP 20 – Field Work Wrap-up for the photo naming conventions.

2. While in Adobe Photoshop, also open the file labeled "barnaclebox.psd." This file contains an image of a red box, and can be obtained from NETN staff.

3. Copy the box (Ctrl-A, Ctrl-C) and paste it (Ctrl-V) onto the photograph to be scored. Your image should look similar to this:

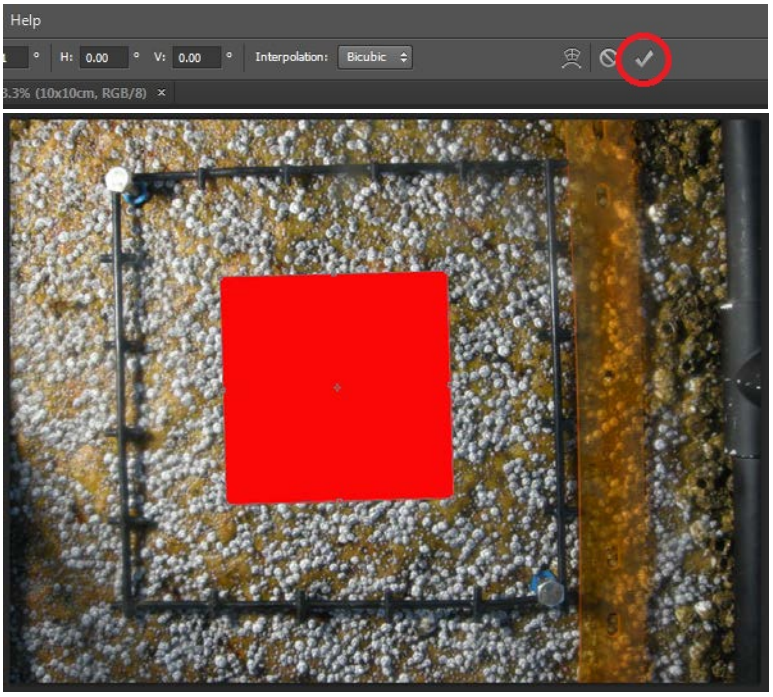


4. Transform the box layer. Move and rotate the box so that an edge of the box is parallel and directly adjacent to the ruler in the image. Scale the box (Edit>Transform>Scale) so that this edge of the box is exactly 10 cm in length (variation in box size is the largest source of error in this process; the box size must be within 1 mm of 10 cm). Hold down the Shift key while scaling to ensure that the box stays exactly square. Zoom in and out (Ctrl-+ and Ctrl--) as needed to be accurate. Also, once the box is selected, right-clicking gives access to the scale and the rotate functions.

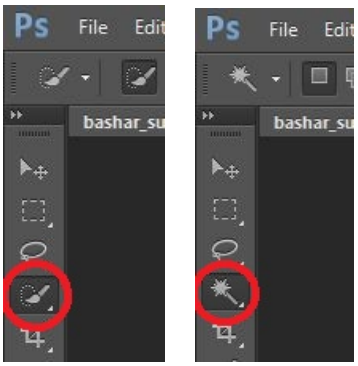


5. Rotate the box (Edit>Transform>Rotate) so that it is parallel to the black frame that is around the two bolts in the photograph. The frame is not exactly square, so move the red square to each corner and get at close as possible to parallel.

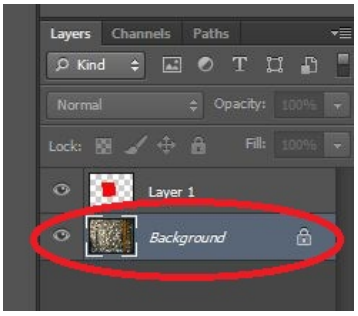
6. Place the box in the center of the recruitment plot and accept the transformation by clicking the check mark near the top-center of the screen.



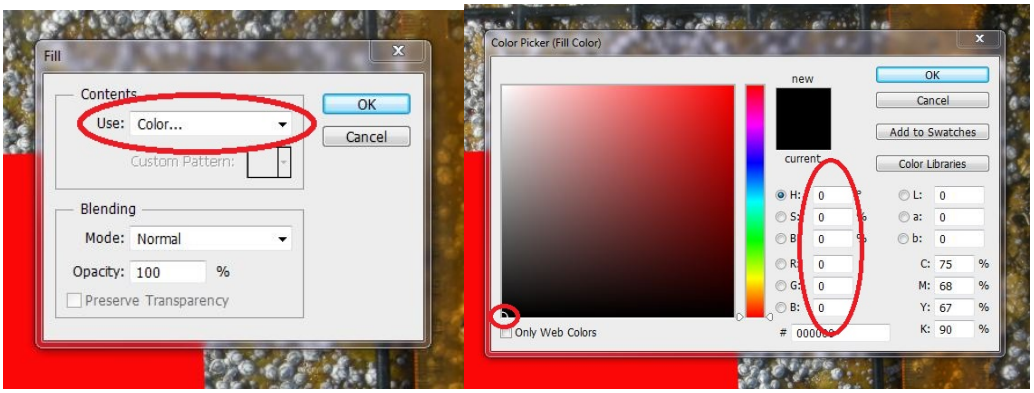
7. Barnacle counting is facilitated by hiding the area of the image outside of the box. To do this, select the box with the magic wand tool (left-click on the "Quick Selection Tool", 4th from the top, and then select the wand tool).



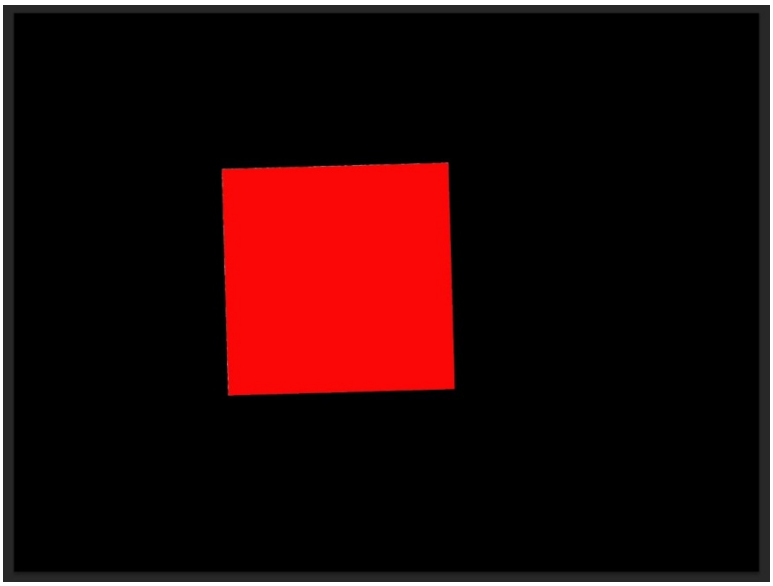
Then choose the inverse (Ctrl+Shift+I) of this selection. Switch over to the main layer containing the recruitment plot image (in the “Layers” panel on the right, select “Background”).



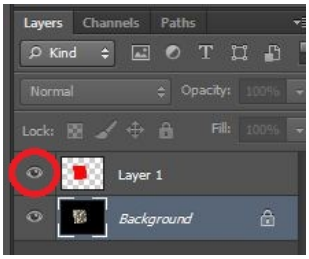
Fill in the area around the box by choosing Edit>Fill. In “Contents”, choose Use: “Color…” and choose the bottom left corner of the pallet (H, S, B, R, G, and B will be 0).



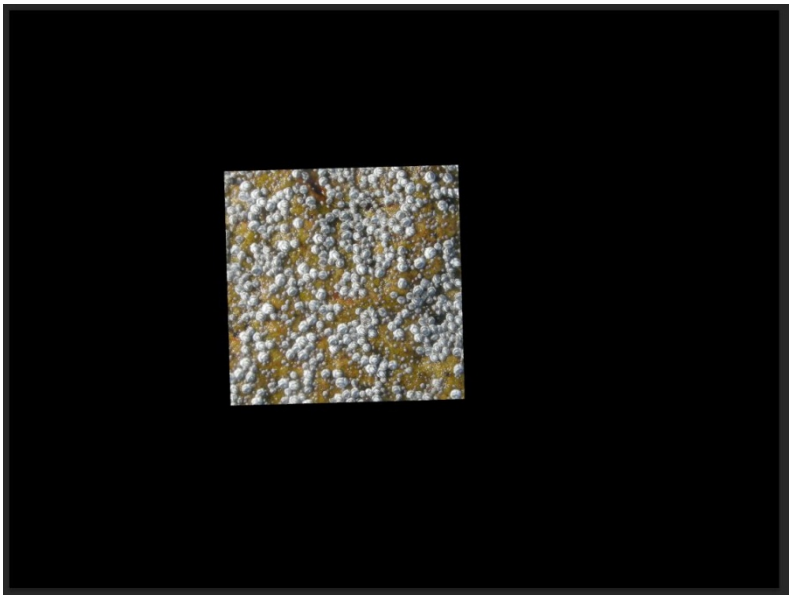
Your image should look like this:



Then, hide the layer containing the barnacle box (click the eye icon next to the layer name in the "Layers" panel). These steps will create a 10 x 10 cm square in the center of the plot where the barnacles can be counted.



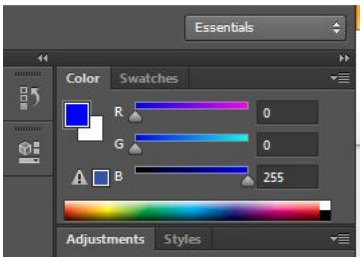
Your image should look like this:



8. Activate the "Brush Tool", 8th icon from the top. After selecting the tool, click the size and hardness selector (in the top context toolbar this is the second icon), and set hardness to 100% and size to 10 pixels.

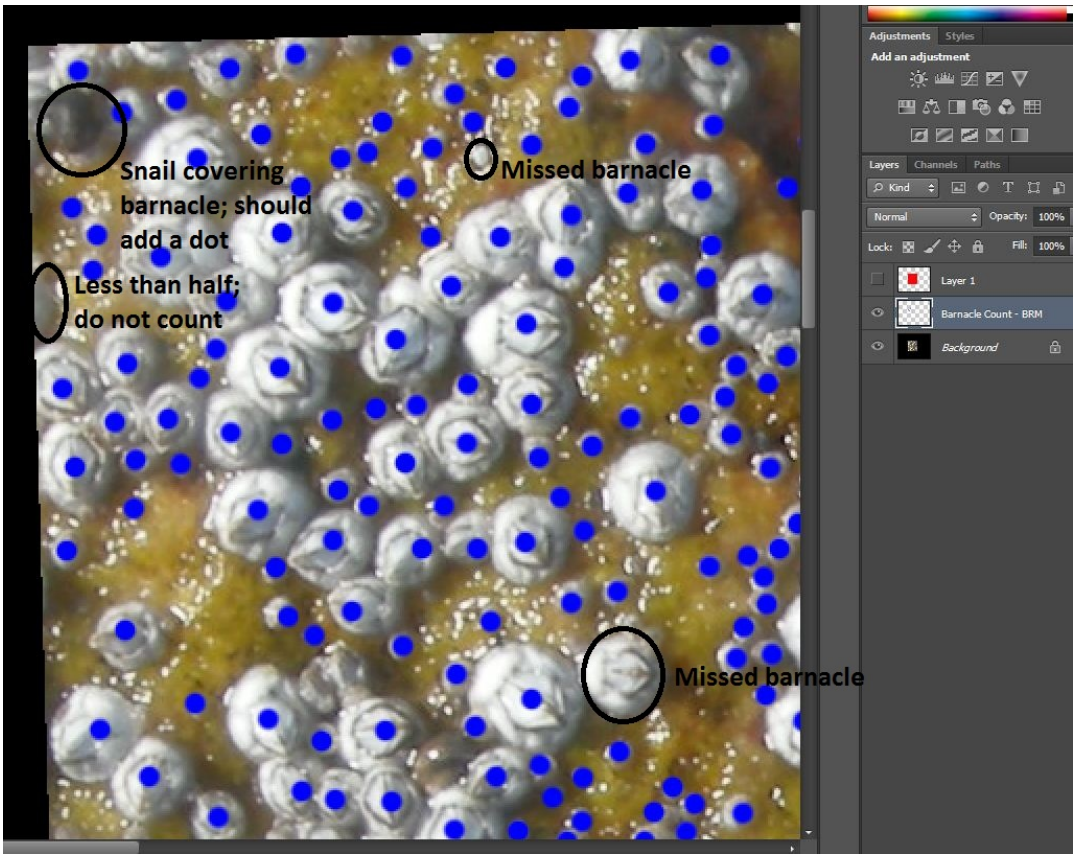


Change the color to something easy to see (e.g., blue) using the sliders on the "Color" panel.



9. Create a new layer (Ctrl+Shift+N) and name it "Barnacle Count – XXX", where "XXX" is the observer's initials.

10. Zoom to a comfortable level (use Ctrl-+ or Ctrl--); 200% generally works well for this task. 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. Do not count dead barnacles (no operculum). Do not count snails, but do count barnacles under snails if you can see part of them. Make sure that dots do not overlap since this will prevent an accurate count later. A portion of the image will look something like this:



11. Save the photoshop file (File… Save As) and give the file the initial file name plus the observer's initials (instead of "XXX"). For example:

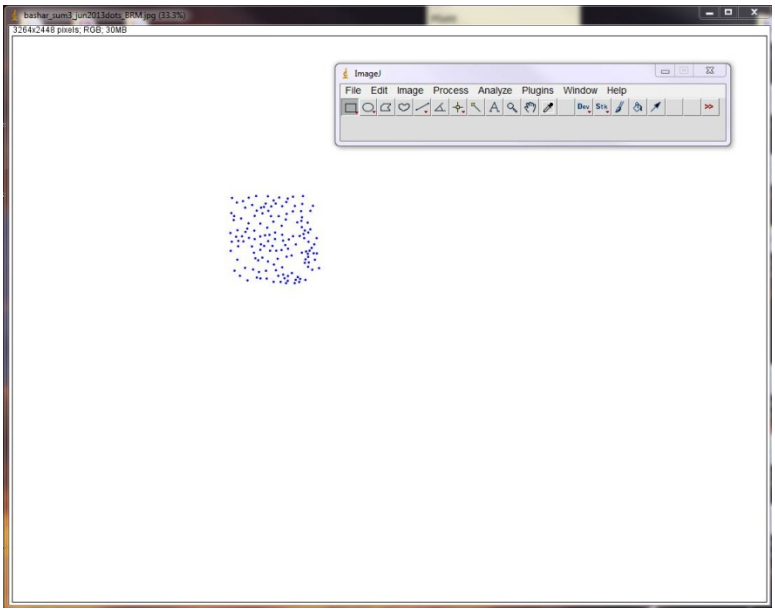
    GREISL_SET_4A_20090621.psd

    Save the dot layer as a jpeg with the following naming scheme (replace "XXX" with the observer's initials):

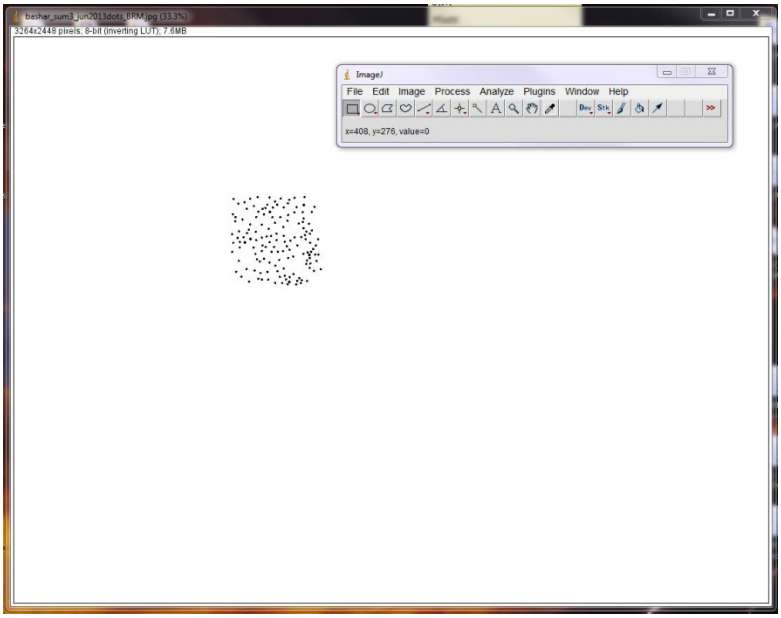
    GREISL_SET_4D_20090621_XXX.jpg

    Hide all layers except the dot layer. Use File>Save As…, select JPEG as the format, verify the correct file name, and click "Save". In the JPEG Options dialog, keep it at the maximum image size.

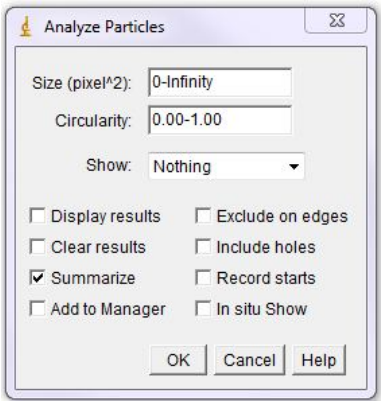
12. Open the dot image in ImageJ (a free program available at http://rsbweb.nih.gov/ij/, and on the NETN server at Z:\LIBRARY\SOFTWARE\Applications\ImageJ). The following image is from an image where dot placement was only partially complete:

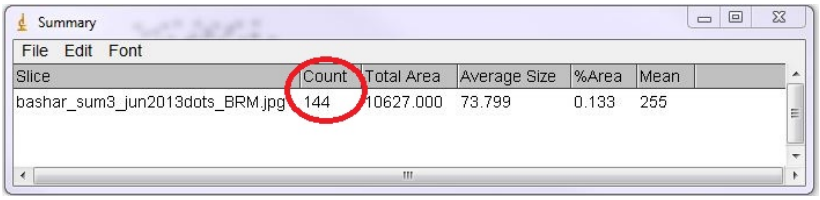


13. Convert the image in ImageJ to binary, black and white (select Process>Binary>Make Binary).



14. Count the dots using ImageJ. Select Analyze>Analyze Particles. Select “Summarize” in the options before clicking “OK”. The “Count” column in the summary window is the number of dots.





15. Record dot density as the number of barnacles per 100 cm^2 (10 x 10 cm area) directly into the database (Switchboard → Enter/Edit/View Data → Navigate to the proper survey event → Barnacle Recruitment tab).

SOP 22 – Season Wrap-up

Version 2.00 (December 4, 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
1.00	9/3/2010	B. Mitchell	Added specific reference to maintaining Ikelite equipment.	Minor revision	1.01
1.01	12/4/2010	A. Kozlowski	Added procedures for tidal and temperature data download and import	Finalized database procedures	2.00

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. The Ikelite camera housing and strobe should be maintained according to the manufacturer's instructions, including lubricating the O-rings with an approved silicone lubricant.

Data Sheet Management

1. Arrange data sheets in the following order: Field Log (Form 1), Motile Invertebrates (Form 3), Point Intercept (Form 4), and Band Transect (Form 5). Additionally, 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.

2. Verify that original datasheets were copied onto acid-free paper. Once the computerized data are verified as accurately reflecting the original field data and validation is complete, all paper field forms (copies and originals) shall be delivered to the Northeast Temperate Network data manager. The electronic version of the data is used for all subsequent data activities.

Temperature Data Management

Surface water temperature should be downloaded from the Gulf of Maine Ocean Observing System (GoMOOS) website, preprocessed, and uploaded to the Rocky Intertidal Monitoring database annually. Offshore 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 S22.1. 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. The specific process steps to obtain and then import offshore surface water temperature data into the NETN Rocky Intertidal database are documented here:

Obtaining Surface Water Temperature Data from GoMOOS

Surface water temperature data will need to be obtained separately from three offshore buoys (Table S22.1). These buoys are the nearest and most reliable oceanographic buoys to each rocky intertidal monitoring site at the time this procedure was written.

Table S22.1. Nearest oceanographic data buoy to each Rocky Intertidal Monitoring site.

Buoy Location	Buoy Code	Monitoring Site
Boston Harbor	NOAA44013	All BOHA sites
Eastern Maine Shelf	GoMOOS I01	All ACAD sites & MCI_PETMAN
Central Maine Shelf	GoMOOS E01	MCI-METISL

Process steps for downloading surface water temperature data 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. Make note of the date of the last row of data in the table (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:

    a. Data Type = Water Temperatures

    b. Specify = Hourly

    c. Unit = Degrees Centigrade

5. 'Add Data Type' button → 'Continue' button

6. Output time zone = Eastern Time EST / EDT

7. Enter a custom time interval based on the date of last download (determined in step 1). When in doubt, download a longer time interval than you need. The database will trim off duplicate records upon upload.

8. 'Add Selection' button → 'Continue' button

9. Locations Tab: Select one buoy from Table S20.1. For the GMOOS buoys, only check the 1m depth box and click the 'Update Selection' button.

10. Click ‘Create report now’ button
11. Select the format for your report: Text File – CSV
12. Click ‘View report now’ button and choose a file name and location to save this intermediate file to your desktop (e.g. RockyIntertidal_WaterTemp_EMaine_2010.txt)
13. Repeat steps 4 through 12 until data is downloaded for all three offshore buoys

Preparing GoMOOS Water Temperature files for Import into the NETN Rocky Intertidal Database

1. Open a new, temporary Access database
2. External Data → Import → Text File
3. Browse to the .csv file you are importing
4. Maintain standard import settings → OK
5. Choose ‘Delimited’ format → Next
6. Choose ‘Comma’ delimited; Choose ‘First Row Contains Field Names’ → Next
7. Rename fields as Time, Temp_C → Next.
8. Select ‘No primary key’ → Next
9. Name the table (something logical) → Finish
10. Open the table to verify a clean import. There should be no header information.
11. Repeat steps 2 through 10 until all files you wish to import are in the temporary database.

Importing processed GoMOOS data into the NETN Rocky Intertidal Database

1. Open the NETN Rocky Intertidal Database
2. From the Main Menu select ‘Import Data Files’
3. Follow the instructions given on the Import Data Files form
4. Check to make sure all files uploaded correctly (e.g. check record count)
5. Delete all temporary text and database files generated during this process

Tidal Data Management

Tidal data should be downloaded from NOAA, preprocessed, and uploaded to the Rocky Intertidal Monitoring database annually. Tidal height data are used to identify long term changes to the magnitude or periodicity of water levels, document extreme tidal events, and provide a covariate against which to measure changes to the biotic community at each site. Site-specific tidal heights are

also used to filter the temperature data from the fixed data loggers (tidbits) to only include temperature measurements that were taken when the data loggers were completely submerged.

Note that predicted (modeled) and actual (verified) tidal data are both available on NOAA's website. Although modeled tidal heights are useful for planning purposes (See SOP 3 – Pre-season Preparations), only verified tidal data are imported into the database. The specific process steps to download verified tidal height data are documented here:

Obtaining verified tidal data from NOAA

Verified tidal data will need to be retrieved separately from two tidal stations: Boston (ID 8443970) for BOHA sites and Bar Harbor (ID 8413320) for ACAD and MCI sites. Boston and Bar Harbor are the most reliable tidal stations closest to established rocky intertidal monitoring sites at the time this procedure was written.

Process steps for downloading tidal station data from surface temperatures from NOAA's website:

1. Before downloading any tidal data 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. Make note of the date of the last row of data in the table (tbl_Tides).

2. Navigate to the Tides and Currents page of NOAA's website (http://tidesandcurrents.noaa.gov/gmap3/index.shtml?type=PreliminaryData&region)

3. Type the station ID into the 'Search for Station' dialog box (top of page).

    a. Boston, MA Station ID: 8443970

    b. Bar Harbor, ME Station ID: 8413320

4. In the pop-up window for the station select 'Verified Data'

5. Populate the web form with the following values:

    a. Date Range:

        i. Begin Date: Record the date of last data included in database table tbl_Tides; individual records overlapping last data download will be rejected.

        ii. End Date: Use the Data Inventory link (upper right) to view the most current date verified water level data is available. Record this as the End Date.

        iii. Date Range: Data can only be retrieved one month (31 days) at a time when the water level interval is set to six minutes. This is a limit set by the website. Therefore monthly queries will need to be run to string together the data for the previous year. Repeat steps 6 through 8 for each month until data has been retrieved for the date range required.

(i.e. The first request should start with the date determined in step 5.a.i. The last request should end with the data determined in step 5.a.ii)

b. Interval: Six Minute Water Level (WL)

c. Datum: MLW (Mean Low Water). The datum defines the base elevation used as a reference from which to reckon heights or depths. NETN uses mean low water as its standard datum. More information on tidal datums can be found here: http://tidesandcurrents.noaa.gov/datum_options.html

d. Data Units: Meters

e. Time Zone: LST/LDT (Local Standard Time w/ Daylight Saving adjustment to match temperate logger settings)

6. Click 'View Data' button.
7. Select and copy (crtl+c) the 5 data columns returned by the query.
8. Open a blank text document (e.g. Notepad) and paste (ctrl+v) the data into it.
9. Repeat steps 5 thru 8 until data for the entire date range desired have been retrieved.
10. Save this intermediate text document to your desktop and name it something meaningful (e.g. RockyIntertidal_TideData_BarHarbor_2010.txt).
11. Repeat steps 3 thru 10 for the second tidal station.

Preparing the NOAA Tidal Data File for Import into the NETN Rocky Intertidal Database

1. Open a new, temporary Access database
2. External Data → Import →Text File
3. Browse to the text file you are importing (e.g. RockyIntertidal_TideData_BarHarbor_2010.txt)
4. Maintain standard import settings → OK
5. Choose 'Fixed Width' format → Next
6. Create a field break between Station and Date by clicking between the columns → Next
7. Do not import column 'Pred 6' (Field 4).
8. Rename remaining fields as Station, Date, Time, Tide → Next.
9. Select 'No primary key' → Next
10. Name the table (something logical) → Finish

11. Open the table. Select and delete rows 1 through 7 (the header).

12. Repeat steps 2 through 11 until all files you wish to import are in the temporary database in separate tables.

Importing Processed Tidal Data into the NETN Rocky Intertidal Database

1. Open the NETN Rocky Intertidal Database

2. From the Main Menu select ‘Import Data Files’

3. Follow the instructions given on the Import Data Files form

4. Check to make sure all files uploaded correctly (e.g. check record count)

5. Delete all temporary text and database files generated during this process

SOP 23 – Data Analysis and Reporting

Version 1.02 (December 15, 2010)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	5/3/2010	B. Mitchell and J. Long	Based on KLMN Rocky Intertidal Data Analysis and Report Writing SOP v1.00	Original	1.00
1.00	9/3/2010	B. Mitchell and J. Long	Revisions to data analysis section to be more specific about plans and document limitations of NETN data. Minor edits.	External review	1.01
1.01	12/15/2010	B. Mitchell	Emphasize that extrapolation beyond sites is not possible, but that tools like hierarchical models can provide a more complete understanding of site data. Trend reports will be every 5 years.	External review	1.02

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 5 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.

3. 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.

4. 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.

5. 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.

6. 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.

7. 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 5 years, 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.

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

Data collected using the NETN monitoring protocol have some important limitations. Because sites were not selected randomly or systematically, they cannot be assumed to be representative of a larger area. Inference from statistical analyses of the monitoring data is limited to the site level, and the data should not be used to make statements about the park or refuge as a whole. Nevertheless, any highly significant trend between all sites at a park or refuge would certainly be suggestive of a larger-scale trend. Additionally, these data may be suitable for correlative analyses to explore potential causes of long-term trends, but those analyses would need to be followed with manipulative experiments to affirm their validity.

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, groups of sites (e.g., park or refuge), and sample periods are calculated and graphically plotted. Linear modeling procedures (regression, ANOVA, ANCOVA, and multivariate approaches like PERMANOVA, as appropriate) 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 and all sites are modeled together. While this approach would still not allow extrapolation beyond sites sampled, it would potentially enable a more complete understanding of the site-level data. 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 would provide more power to evaluate local changes in the context of a broader system, and enable consideration of 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, photoplot target types are not pooled when analyzed. For example, the percent cover of mussels is considered only in mussel plots. Photoplots 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 ($p < 0.05$) 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.

NETN will also pursue the use of the first 5 years of data to produce a comparison against baseline "ecological integrity." We will initially use the 5-year mean and standard deviation to establish the baseline for each monitoring metric, and will assume a normal distribution and consider the "range of natural variation" to be data within 1.96 standard deviations of the mean (i.e., 5% of observations would be outside this range even if there is no change). The end points of the mean +/- 1.96 SD will become our "assessment points," and results outside of these endpoints will be considered indicative of a problem. This approach assumes that the ecosystem is in its "natural" state during the baseline period, which is not likely the case, so the approach should be considered a "first cut" at ecological integrity. NETN has not had a chance to review historic data that could be suitable for establishing the range of natural variation for our metrics, and the network will conduct this review and adjust assessment points as time permits.

Creating Summary Charts

Create annual summaries for the park and refuge sites for:

- Photoplots (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 25^{th} and 75^{th} 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 photoplot summary (Figure S23.1) and a summary of motile invert counts and size frequency (Figure S23.2). Example trend graphs of acorn barnacles from the MARINe program (Figure S23.3) and from Redwoods (Figure S23.4) are also included.

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

Figure S23.1. Photoplot summary of the mean percent cover by zone at Scorpion Rock, Santa Cruz Island, Spring 2004 (five plots/zone). Tables developed for NETN reports should include sample sizes and estimates of variability. (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 S23.2. Motile invertebrate (A) size frequency measurements (mm) and (B) counts for Scorpion Rock, Santa Cruz Island, Spring 2004. Tables developed for NETN reports should include sample sizes and estimates of variability. (Channel Islands National Park rocky intertidal monitoring data excerpt.)

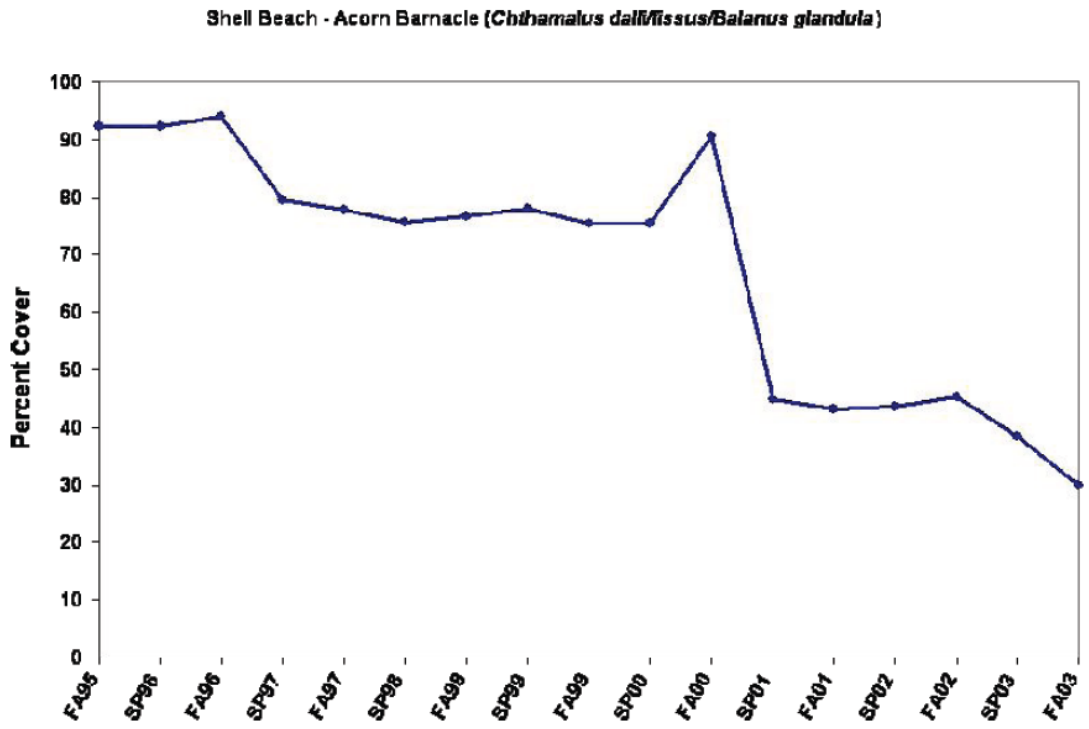


Figure S23.3. Example trend graphs from 9 years of MARINe data for Acorn Barnacles *Chthamalus dalli/fissus/Balanus glandula* at Shell Beach in San Louis Obisbo County (from http://www.marine.gov/). Figures for NETN reports should include error bars.

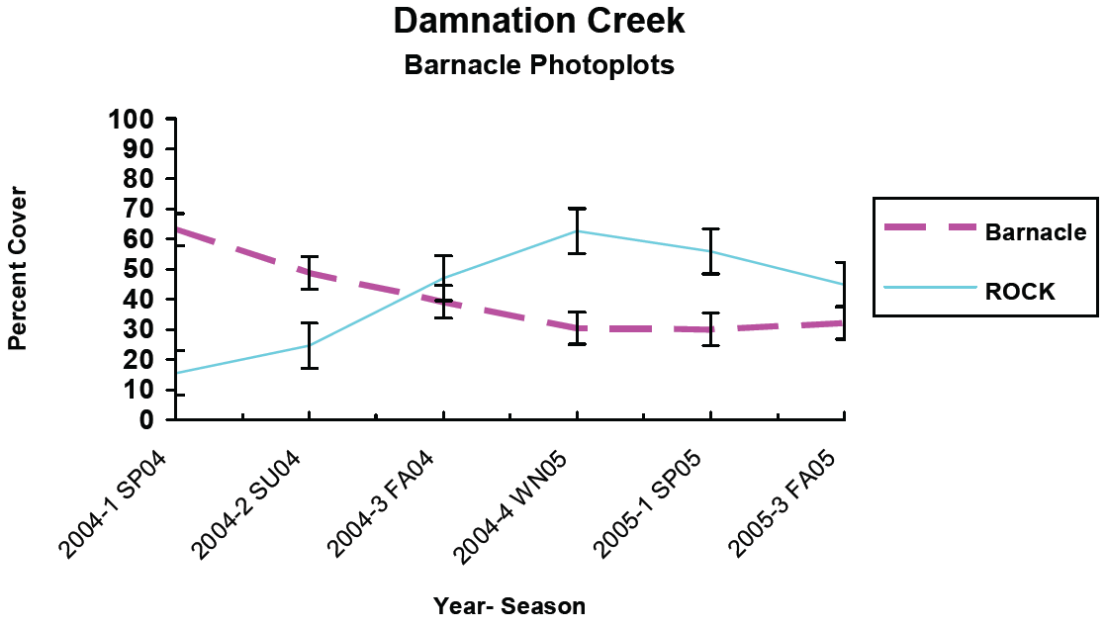


Figure S23.4. Example graph from 2 years of percent cover data for Acorn Barnacles *Chthamalus dalli/fissus/Balanus glandula* at Damnation Creek, RNSP. Figures for NETN reports should specify the type of error being portrayed by error bars (e.g., 95% CI).

Literature Cited

Becker, B. J. 2006. Status and trends of ecological health and human use of the Cabrillo National Monument rocky intertidal zone (19902005). Natural Resource Technical Report NPS/PWR/CABR/NRTR—2006/03. National Park Service, Seattle, WA.

Burnham, K. P., and D. R. Anderson. 2002. Model Selection and Multimodel Inference. Springer, New York, New York.

Miller, A. W., and R. F. Ambrose. 2000. Sampling patchy distributions: Comparison of sampling designs in rocky intertidal habitats. Marine Ecology-Progress Series 196:114.

Miner, M., P. T. Raimondi, R. F. Ambrose, J. M. Engle, and S. N. Murray. 2005. Monitoring of rocky intertidal resources along the central and southern California Mainland: Comprehensive 100 report (19922003) for San Luis Obispo, Santa Barbara, and Orange Countries. OCS Study, U.S. Minerals Management Service MMS 05071.

Murray, S. N., R. F. Ambrose, and M. N. Dethier. 2006. Monitoring rocky shores. University of California Press. Berkeley, CA.

Sondregger, D. L., H. Wang, W. H. Clements, and B. R. Noon. 2009. Using SiZer to detect thresholds in ecological data. Frontiers in Ecology and the Environment 7(4):190-195.

Underwood, A.J. 2002. Research techniques in animal ecology: controversies and consequences, edited by L. Boitani and T.K. Fuller. Journal of Experimental Marine Biology and Ecology, 268: 115-11

SOP 24 – Deviations and Summary of Major Changes

Version 1.00 (January 9, 2015)

Revision History Log

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
---	1/9/2015	B. Mitchell	---	Original	1.00

Overview

This SOP documents:

- Known deviations from established methods. Deviations are situations where data were collected in a manner that is substantially different from the methods documented within the SOPs used during a particular field season.

- Major changes in the protocol. Major changes are fundamental shifts in the way data are collected that cannot easily be rectified with earlier data. Major changes are not deviations, provided that the changes are documented in the SOPs. Ideally, any time there is a major change in methods the networks will use both methods long enough to determine whether the results from the different methods are sufficiently correlated to allow old data to be corrected. In some cases (especially early in the use of the protocol), the small amount of data lost by the protocol change will not be worth the cost of overlapping methods.

Known Deviations and Major Changes

Site Visits

CALISL 2013: B2 not sampled, U plots not scraped until late summer. 2014: Most photos not usable; site revisited in mid-August for photography.

METISL 2013: not visited. 2014: not visited.

OTTPOI 2013: missing photos of U3-U5 in 2013. 2014: T2 and T3 were partially sampled.

PETMAN 2013: A1, A2, F1, F3-F5, R5, S1-5, X1-3 not sampled. Temp3 not located. 2014: A1, A2, F4, R1, R2, R5, X3 not sampled. Temp 3 not located.

SOP 14 – Photoplots and Overview Photos

Major Change: Beginning in 2014, photographs are taken at the maximum camera resolution. In 2013, photos were lower resolution (5-6 M for photoplots, 8-10 M for recruitment plots).

Deviation: At CALISL in 2014, original photos of barnacle recruitment, *Ascophyllum*, barnacle, and *Fucus* were not usable due to water on the lens; site revisited in mid-August for photography, and protocol revised to require checking of lens before photographing each plot.

Deviation: At ACAD and BOHA sites in 2014, stretch cords were left on plots during photography, resulting in a few points per photo that could not be used during analysis.

Deviation: At PETMAN in 2014, photoplots were low resolution (~6 M rather than maximum resolution).

Deviation: At PETMAN in 2014, recruitment photos were not usable; taken on unscraped plots and using large photoquadrupod.

SOP 15 – Motile Invertebrates

Major change: In 2013 and 2014, some plots were subsampled with a 20cm square frame at three locations. This method was eliminated starting in 2015 because it did not save much time and introduces problems for data analysis (since invertebrates are not randomly distributed on a plot, the subsampling approach could not be scaled up to an equivalent full sample estimate).

SOP 17 – Point-intercept Transects

Major Change: *Enteromorpha* and *Ulva* were grouped together in 2013 surveys, and separated in 2014 and later.

Deviation: In 2013 and 2014, PETMAN and METISL vertical transects not upgraded to protocol standard (with intermediate bolts and elevation survey).

Deviation: In 2014 at PETMAN, *Ulva* and *Enteromorpha* were grouped together.

Deviation: Crustose Non-coralline category not handled consistently in 2013 and 2014; definition clarified for 2015.

SOP 19 – Field Log

Deviation: Inconsistent use of “L” and “0” in site conditions, 2013-2014. Definitions clarified beginning in 2015.

Deviation: Inconsistent definition of area for bird/mammal observations, 2013-2014. Observers varied in whether they included upland and off-shore area. Definition clarified in 2015 to exclude upland but include waters within 50 m of shore.

SOP 25 – Procedures for Future Consideration

Version 1.04 (January 12, 2012)

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
1.01	9/3/2010	B. Mitchell	Revised to incorporate external review suggestions, including: additional enhancements to point-intercept transects, study of timing of barnacle recruitment plot scraping, *Nucella* egg capsule monitoring, and *Nucella* damage.	External review	1.02
1.02	12/15/2010	B. Mitchell	Revised Procedures for future implementation to describe high/med/low priorities, and prioritized all procedures.	External review	1.03
1.03	1/12/2012	B. Mitchell	Document 2011 work on high priority items (enhanced point-intercept transects, RTK surveying, and summer scraping barnacle settlement plots).	Document 2011 field activities.	1.04

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

Each of the following procedures is designated as high, medium, or low priority. High priority procedures have the potential to significantly improve the quality of data or extend monitoring in useful new directions with minimal additional time and cost. They may also have the potential for producing long-term cost savings. Low priority procedures are expected to have a lower improvement on data quality or the diversity of metrics monitored, with a significant cost for implementation. Medium priority procedures are expected to have intermediate data benefits and costs.

Enhanced Point-Intercept Transect (High Priority)

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.

An additional enhancement to the transect method would be recording all species or substrates detected, down to the rock, beneath each point. This would provide the data to assess true species cover or abundance rather than just canopy species cover. The drawback of this approach is additional field time for sampling.

Because *Chondrus* and *Mastocarpus* can be easily distinguished in the field, another potential enhancement would be to record these species separately. However, they would need to be lumped together for any comparisons against photoplot data, since the species are difficult to distinguish in photographs.

In 2011, most transects at ACAD and BOHA were enhanced by adding additional bolts every 2-3 m and at high and low points along the transect. All bolts were surveyed with RTK-GPS. OUTBRE at BOHA needs additional work, as do some lower portions of transects at other sites.

RTK-GPS Surveying (High Priority)

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).

Most bolts at ACAD and BOHA were surveyed in 2011. Some additional work needs to be done, particularly in the lower intertidal where weather and tides prevented the crew from completing the survey work.

Barnacle Recruitment Plots (High Priority)

Scraping barnacle recruitment plots in the winter or early spring requires a significant effort at a time of year when weather makes intertidal work difficult. Scraping these plots immediately after sampling in the summer, rather than in the winter or spring, would save effort but may allow other species to settle on the plots before barnacle settlement, thereby preventing an accurate measurement of recruitment. However, the extent of settlement of other species between June and February or March is unknown. Consider adding five additional (temporary) recruitment plots at two sites (one ACAD, one BOHA) that are scraped in the summer rather than the winter. Analyze 3 years of data to determine if the data are comparable to the current method.

In 2011, summer scraping barnacle recruitment plots were added at five sites (25 total plots) in ACAD (three sites) and BOHA (two sites).

Timed Search – Invasives and Other Species (Medium Priority)

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. The timed search could potentially be conducted during site reconnaissance (SOP 19 – Field Log).

Nucella Damage (Medium Priority)

SOP 15 – Motile Invertebrates asks that the survey team inspect snails for shell damage. Damage is defined as snails "showing signs of repair after damage by a crab." Not too infrequently, *Nucella* will drill into another *Nucella*, with the telltale sign of a straight (not countersunk) hole in the shell. This type of damage could be recorded as well to give a frequency (albeit probably low) of snail predation on other snails.

Nucella Egg Capsule Monitoring (Low Priority)

The protocol currently does not assess dog whelk (*Nucella*) reproduction, and one protocol reviewer (Brian Beal) has suggested that changes in the number of capsules per unit area, their location, and even size (a relative measure of fecundity) could be used to determine long-term changes in this species, much the same as changes in barnacle recruitment through time is currently used. *Nucella* lays its eggs May-July in the northeast.

Crab Monitoring (Low Priority)

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 (Low Priority)

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 photoplot 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 mollusks 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 variables 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.

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 962/127984, February 2015

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov