5-2018

Great Bay Estuary Seaweed Monitoring Program: Quality Assurance Project Plan, 2018

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Great Bay Estuary Seaweed Monitoring Program 2018

Quality Assurance Project Plan

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Prepared by

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Project Manager: 5-23-2018
Signature / Date
Kalle Matso, PREP

Project QA Officer: **5-23-2018**
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Kalle Matso, PREP

Intertidal Lead Scientist/Field/Lab Operations Manager: **5-23-2018**
Signature / Date
David Burdick, UNH

Subtidal Lead Scientist and Field Operations Manager: **5-23-2018**
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Gregg Moore, UNH

Technical Specialist: Arthur P. Mathieson **5-23-2018**
Signature / Date
Art Mathieson, UNH

USEPA Project Officer: 5-23-2018
Signature / Date
Jean Brochi, US EPA

USEPA QA Officer: Nora J. Conlon 5/24/2018
Signature / Date
Nora Conlon, US EPA

A2 – Table of Contents

List of Appendices

List of Tables

List of Figures

A3 – Distribution List

Table 1 presents a list of people who will receive the approved QAPP, any QAPP revisions, and any amendments.

Table 1: QAPP Distribution List

QAPP Recipient Name	Project Role	Organization	Telephone Number and E-mail Address
Kalle Matso	Project Manager/ & Project QA Officer	PREP	603-781-6591 kalle.matso@unh.edu
Arthur Mathieson	Technical Specialist	UNH	603-862-5133 arthur.mathieson@unh.edu
David Burdick	Intertidal Lead Scientist/Field and Lab Manager	UNH	603-862-5129 david.burdick@unh.edu
Gregg Moore	Subtidal Lead Scientist/Field Manager	UNH	603-862-5138 gregg.moore@unh.edu
Ted Diers	Data User	NH DES	603-271-3289; ted.diers@des.nh.gov
Jean Brochi	EPA Project Officer	USEPA	617-918-1536 Brochi.Jean@epa.gov
Nora Conlon	EPA QA Officer	USEPA	617-918-8335; conlon.nora@epa.gov

A4 – Project/Task Organization

The Piscataqua Region Estuaries Partnership (PREP) is part of the U.S. Environmental Protection Agency's (EPA) National Estuary Program, which is a joint local/state/federal program established under the Clean Water Act with the goal of protecting and enhancing nationally significant estuarine resources. The PREP receives its funding from the EPA and is administered by the University of New Hampshire.

The project will be conducted and managed by PREP. The Project Manager (Kalle Matso) will be responsible for coordinating all program activities.

For the intertidal component of the work, David Burdick will serve as Lead Scientist and Field Operations/Lab manager. He will manage all field staff, be responsible for "stop/go" decisions for monitoring activities during extreme events and will communicate with the Laboratory Manager in reference to seaweed samples. Gregg Moore will serve the same role for the subtidal component of the activities. The two lead scientists will be responsible for resolving any logistical problems and communicating the results to other field staff.

Sample analysis will be supervised by David Burdick (Laboratory Manager) at the University of New Hampshire (UNH) Jackson Estuarine Laboratory (JEL). Laboratory operations will be managed by the Laboratory Manager, who will be responsible for conducting analyses according to the procedures in this QA Project Plan, identifying any non-conformities or analytical problems, and reporting any problems to the Project QA Officer/Project Manager.

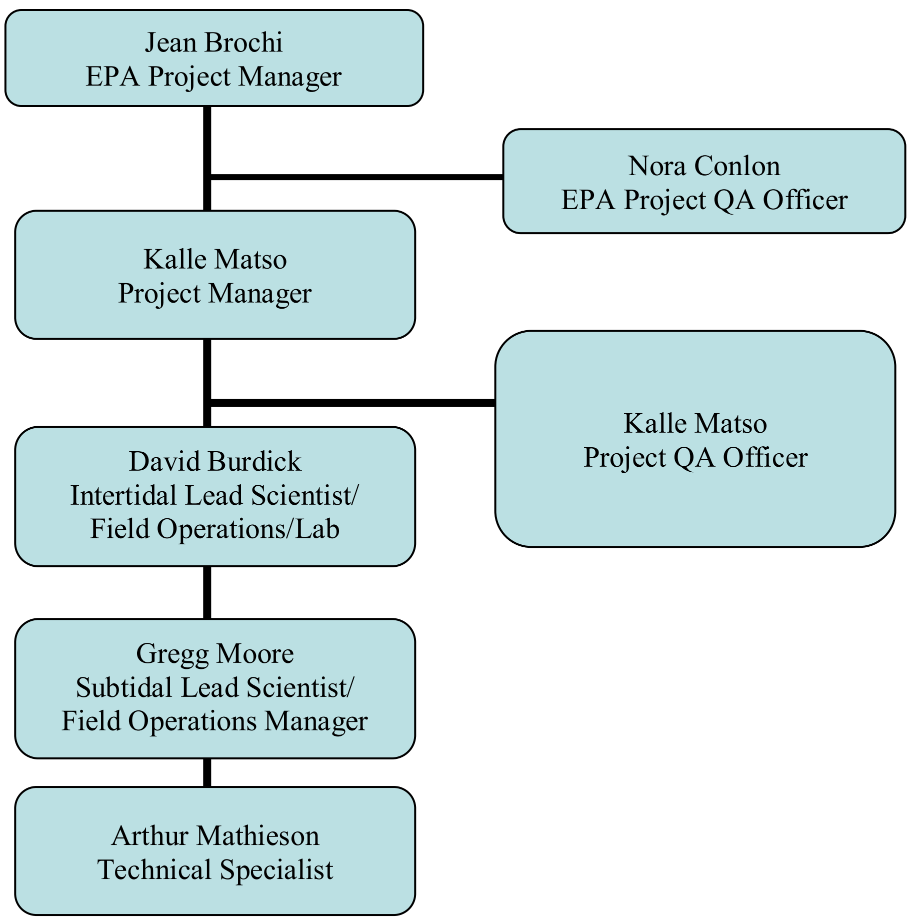
At the end of the project, the Project QA Officer (Kalle Matso) will review the results of QA/QC checks and verify that the procedures of this QA Project Plan were completed. The Project QA Officer will be responsible for a memorandum summarizing any deviations from the procedures in the QA Project Plan, the results of the QA/QC tests, and whether the reported data meets the data quality objectives of the project.

Funding for PREP is provided by the EPA. Therefore, the Project Manager will be accountable to the EPA Project Manager (Jean Brochi) and the EPA Project QA Officer (Nora Conlon). The EPA Project Manager and EPA Project QA Officer will be responsible for approving the Quality Assurance Project Plan.

The principal user of the data from this project will be PREP for State of Our Estuaries Reports. The lead scientists and the Project Manager will work together to prepare a report at the end of the project with all the data and the QA summary report.

Figure 1 shows an organizational chart for this project.

Figure 1: Project Organization



A5 – Problem Definition/Background

Seaweed blooms can be a sign of estuarine ecosystem impairment because they can occur in response to elevated nitrogen inputs as well as other environmental factors. In addition, seaweed can entangle and ultimately outcompete eelgrass in subtidal environments. Therefore, PREP aims to track the abundance of seaweed in the Great Bay Estuary as an indicator of estuarine health.

The objective of this project is to determine trends in seaweed abundance by means of repeated sampling over time using standardized methods. No particular seaweed species are targeted; rather all seaweeds encountered are identified to species level. Since 2014, eight sites have been monitored. Five sites will be monitored each year such that each site is monitored once every two years with two sites monitored every year. Until this year, seaweed studies have focused only on intertidal seaweeds; this year, a new component is added to pilot-test protocols for monitoring subtidal seaweeds (see Section B2 for details.) Because competition between seaweed and eelgrass (much of which is subtidal) is important to track, the subtidal habitat is critical to monitor.

Trends of seaweed abundance published in PREP State of Our Estuaries reports (PREP, 2017) are of interest to the EPA, the NH Department of Environmental Services (NHDES), and other partners. Charts showing changes in seaweed percent cover and/or biomass (PREP, 2017) are important for understanding the impacts of changes in water quality as well as water temperature. The historical seaweed data available at this time are based on a repeated transect sampling approach. Therefore, PREP and UNH JEL intend to continue to use a repeated transect sampling scheme while incorporating new sites into the long-term seaweed monitoring program. The data generated through the Great Bay Estuary long-term seaweed monitoring program will be used by PREP and its partners to evaluate trends in seaweed abundance over time and make other resource decisions. This QAPP will apply to the year 2018 and will be revised for 2019. (The only previous QAPP for this monitoring work was for the year 2016 (Matso, 2016).)

A6 – Project/Task Description

Table 2: Project Schedule Timeline

Activity	Dates		Product	Due Date
	Anticipated Date(s) of Initiation	Anticipated Date(s) of Completion		
QAPP Preparation	3/01/18	05/30/18	QAPP Document	05/30/18
Training	06/1/18	06/7/18	Field crews trained on SOPs	06/11/18
Intertidal Monitoring and Sample collection (June, August and October)	06/13/18	10/30/18	Intertidal photographs recorded, and samples collected for analysis.	10/30/18
Subtidal Monitoring and Sample collection (July and September)	06/13/18	9/30/18	Intertidal photographs recorded, and samples collected for analysis.	9/30/18
Sample analysis	06/30/18	11/30/18	Seaweed species identification and biomass measurements.	12/30/18
Data Quality Audit	08/01/18	01/30/19	Memo (see Section C2) summarizing any QAPP nonconformance	01/30/19
Annual Report	01/01/19	03/31/19	Final project report	04/01/19

A7 – Quality Objectives and Criteria

Data quality objectives for the seaweed monitoring program are summarized in Table 3.

Table 3: Data quality objectives, criteria, and quality control protocols for the seaweed monitoring program.

Data Quality Objective	Criteria	Protocol
Precision	Biomass measurements should be maintained to 1/100 of a gram.	Field assessment team will measure biomass with a Sartorius Balance (Type = E2000D).
Bias	Percent cover estimates should be comparable across members of the field assessment team within ±10%	Field assessment team members will "calibrate" their visual interpretations of percent cover prior to field work by reviewing published examples of visual representations different percent covers (REF). Field estimates will then be made by consensus of the field team. The field assessment team will also review photographs and associated percent cover estimates from previous years before the field season begins.
Spatial accuracy	GPS units should have a reported accuracy less than or equal to 2 meters.	Plots will be established using a highly accurate real-time kinematic (RTK) GPS. Plot locations will then be staked in the field using lengths of 0.5inch PVC pipe. The minimum accuracy tolerance of the unit will be set to reject saving of waypoints with spatial accuracy less than 0.03m, thereby assuring spatial accuracy requirements met or exceeded.
Comparability	Field and laboratory data should be collected using standardized methods.	Check that protocols from the QAPP were used for field observations. The QA Manager should use filtering functions to check the field assessment team's spreadsheets for data entry errors. All percent cover values should fall into one of the categories specified in the sampling methods. All biomass values should be between 0 and 500 grams. A minimum of 10% of field observations should be checked against electronic spreadsheets.
Completeness	Field observations should be made for seaweed cover at all pre-determined elevations at each site (for example: 0.0 to 2.5m, with 0.5m intervals).	Check field observations for completeness by elevation. Document reasons for any deviations from sampling protocol.

A8 – Special Training/Certification

The Intertidal and Subtidal Leads will organize and implement a training session for field staff. The training session will cover SOPs for percent cover determination, quadrat usage, photography and collection of seaweed specimens. The training will be based on the QAPP document. Field staff will sign an attendance sheet for the training, which will be retained by the Field Operations Manager. The training will be completed before sampling begins.

Table 4: Special Personnel Training Requirements

Project Function	Description of Training	Training Provided by	Training Provided to	Location of Training Records
Intertidal Seaweed Component:	Percent cover determination; photography of quadrats; sample collection for identification and biomass assessment (see Section B2 for more on Sampling Methods)	Intertidal Lead and Field Operations Manager	All field team staff	With Intertidal Lead/Field Operations Manager
Subtidal Seaweed Component:	Percent cover determination; fixed array placement; GPS usage; sample collection for identification and biomass assessment (see Section B2 for more on Sampling Methods)	Subtidal Lead and Field Operations Manager	All field team staff	With Subtidal Lead/Field Operations Manager

A9 – Documents and Records

QA Project Plan

The Project Manager will be responsible for maintaining the approved QA Project Plan and for distributing the latest version to all parties on the distribution list in section A3. A copy of the approved plan will be posted to the PREP website (scholars.unh.edu/prep).

Field Data Sheets

The field data sheets for this project are attached as Appendix (TBD). Field crews fill in these forms during the day and return them to the appropriate Field Operations Manager (intertidal versus subtidal) upon completion. The original forms, or scanned copies of the original forms will be retained on file by the respective Field Operations Managers.

Laboratory Data Sheets

Laboratory results from the Laboratory Manager will be transferred to the appropriate Field Operations Manager in the form of electronic laboratory data sheets. The Project QA Officer will confirm the results of the required QC tests performed.

Reports to Management

The Project QA Officer will collaborate with the Intertidal and Subtidal leads to produce an annual report for PREP. The final work product will describe any deviations from the protocols established in the QA Project Plan as well as summarize the results. The annual report will be posted to the PREP website (scholars.unh.edu/prep).

Archiving

The QA Project Plan and final report will be kept on file at PREP for a minimum of 10 years after the publication date of the final report. The original field data sheets, or scanned copies of the original field data sheets will be retained by the Field Operations Managers and laboratory data sheets will be retained by the Laboratory Manager for a minimum of 5 years.

B1 – Sampling Process Design

The sampling process for this project will follow a repeated sampling design. A total of eight sites will be sampled in a full 2-year monitoring rotation, with five sites sampled each year. Two of the sites will be sampled every year. Table 5 shows the number of samples that will be collected for each parameter. The stations that will be sampled as part of this study are provided in Table 6. A map of the stations is provided in

Figure 2. The sampling dates for 2018 and station for the field duplicate sample are shown in Table 7.

Table 5: Sample Summary

Parameter	No. of Stations	Samples per Event per Site	Number of Sampling Events	Total Number to Lab
Intertidal Species ID, % Cover & Biomass	5/year	9-18	1	54
Intertidal Species ID, % Cover & Biomass	4/year	9	2	72

Table 6: Sample Locations

Station ID	Town, State	Latitude	Longitude	Elevations (m above MLW)	Years Sampled
Four Tree Island (FTI)	Portsmouth, NH	43.07536	070.74701	0.0, 0.5, 1.0, 1.5, 2.0, 2.5	2014, 2016 (even years)
Hilton Park (HP)	Dover, NH	43.12292	070.82786	0.0, 0.5, 1.0, 1.5, 2.0	2014, 2016 (even years)
Cedar Point (CP)	Durham, NH	43.12934	070.85238	0.0, 0.5, 1.0, 1.5	2013, 2015 (odd years)
Wagon Hill Farm (WHF)	Durham, NH	43.12457	070. 87260	0.0, 0.5, 1.0, 1.5	2013, 2015 (odd years)
Adams Point (AP)	Durham, NH	43.09019	070. 86735	0.0, 0.5, 1.0, 1.5	2014-2016 (all years)
Lubberland Creek (LC)	Newmarket, NH	43.07427	070. 90339	0.5, 1.0, 1.5	2013, 2015 (odd years)
Depot Road (DR)	Greenland, NH	43.05611	070. 89682	0.5, 1.0, 1.5	2013-2016 (all years)
Sunset Hill Farm (SHF)	Newington, NH	43.05751	070. 83443	0.75, 1.0, 1.5	2014, 2016 (even years)

Table 7: Sampling Schedule for 2018

Month	Intertidal vs. Subtidal	Week	# Days Required	Site
June	Intertidal	Week 3	3	CP, WHF, AP, DR, LC
July	Subtidal	Week 4	4	AP, DR, LC, SHF
August	Intertidal	Week 2	4	CP, WHF, AP,

				DR, LC
September	Subtidal	Week 1	4	AP, DR, LC, SHF
October	Intertidal	Week 2	3	CP, WHF, AP, DR, LC

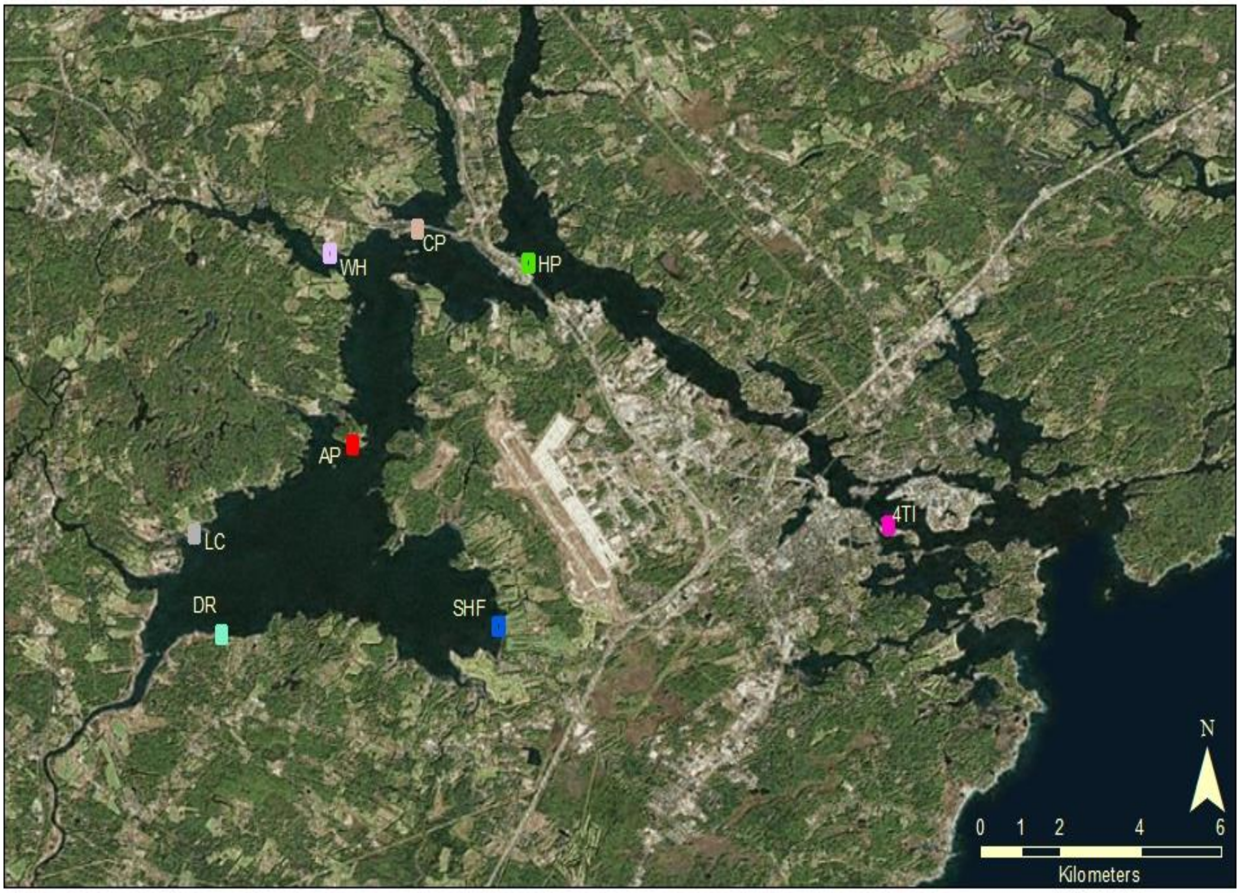


Figure 2: Location of the eight sampling sites for monitoring seaweeds in the Great Bay Estuary. Four sites are located within Great Bay (Adams Point, Lubberland Creek, Depot Road and Sunset Hill Farm), three are located mid estuary (Hilton Point, Cedar Point and Wagon Hill Farm), and one is near the estuary mouth (Four Tree Island).

B2 – Sampling Methods

Intertidal

For each site visit, the field assessment team will measure percent cover and biomass of seaweed at each point on the three transects using the methods described below, which are consistent with previous studies. Note that the seaweed is not distributed uniformly on the flats. Also, there have been no studies characterizing the distribution of nuisance seaweeds in estuaries. Our sample scheme of three transects that are randomly selected at 10 to 50 meters apart and sampled every 0.5 m in elevation was chosen to address this variability.

Percent cover

Field staff will lay out a 0.5 meter x 0.5 meter PVC quadrat and obtain a photographed prior to assessment. Then, staff will visually estimate the percent of the ground covered by each species of seaweed. Values will be classified as either <1%, 5%, 10% or any multiple of 10% thereafter. Staff will estimate one cover value for all "blade-forming" species of *Ulva*, one cover value for all "tube-forming" species of Ulva, and one cover value for all species of *Gracilaria*.

Biomass

Sample labels are prepared prior to field, containing the following information on Rite in the Rain paper: site name, transect letter, elevation, date. Each label is placed in a 1-gallon plastic bag. At each sampling point, staff will lay out a 0.25 meter x 0.25 meter PVC quadrat 2 meters (8 paces) west of percent cover plot. Percent cover is recorded by species using cover classes described for percent cover assessment of 0.25 m^2 plots before collecting material from within the quadrat. Material with holdfasts outside of the plot will be cut and collected. While hand-collecting will be sufficient for most samples, the field assessment team will carry a set of shears and/or a knife that can be used to cut aboveground biomass within the plot boundaries if needed. Samples are transported back to the lab in a cooler as soon as sampling has been completed for the day. Follow Biomass Analysis SOP as articulated in Appendix E.

Subtidal

The sample sites will be extensions of the existing intertidal transects, continuing into deeper water and accessed by small, shallow draft vessel. There are relatively few published studies of seaweed monitoring methods, and methods vary greatly depending on the conditions of the estuary. The goal of the 2018 work is to pilot-test the methods described below and determine the optimal number of samples and plot arrangement to characterize sub-tidal seaweed composition and abundance.

Percent Cover

A fixed array of nine quadrat samples will be placed at each sampling location (Figure 3). Locations and sub-tidal elevations will be determined using real-time kinematic GPS survey. Plot placement will be based on bearing and distance from the location center point. Visual percentage cover by species and canopy height within the 0.25m^2 plots will be facilitated with use of an aquatic viewing scope or mask/snorkel, when conditions require.

Biomass

In most respects, biomass assessment will follow the protocols described above for intertidal biomass. One exception is that field staff will use the field sheets to differentiate between drift and attached seaweeds. Determining the abundance of drift versus attached seaweeds has important implications for management options. Total biomass of seaweed will be collected and identified to species level at JEL. Dry weight will be determined on an areal basis after drying samples. Subsampling will be employed if samples are large to determine dry weight. Where eelgrass exists, percent cover and canopy height of eelgrass will also be recorded and dry biomass determined at JEL.

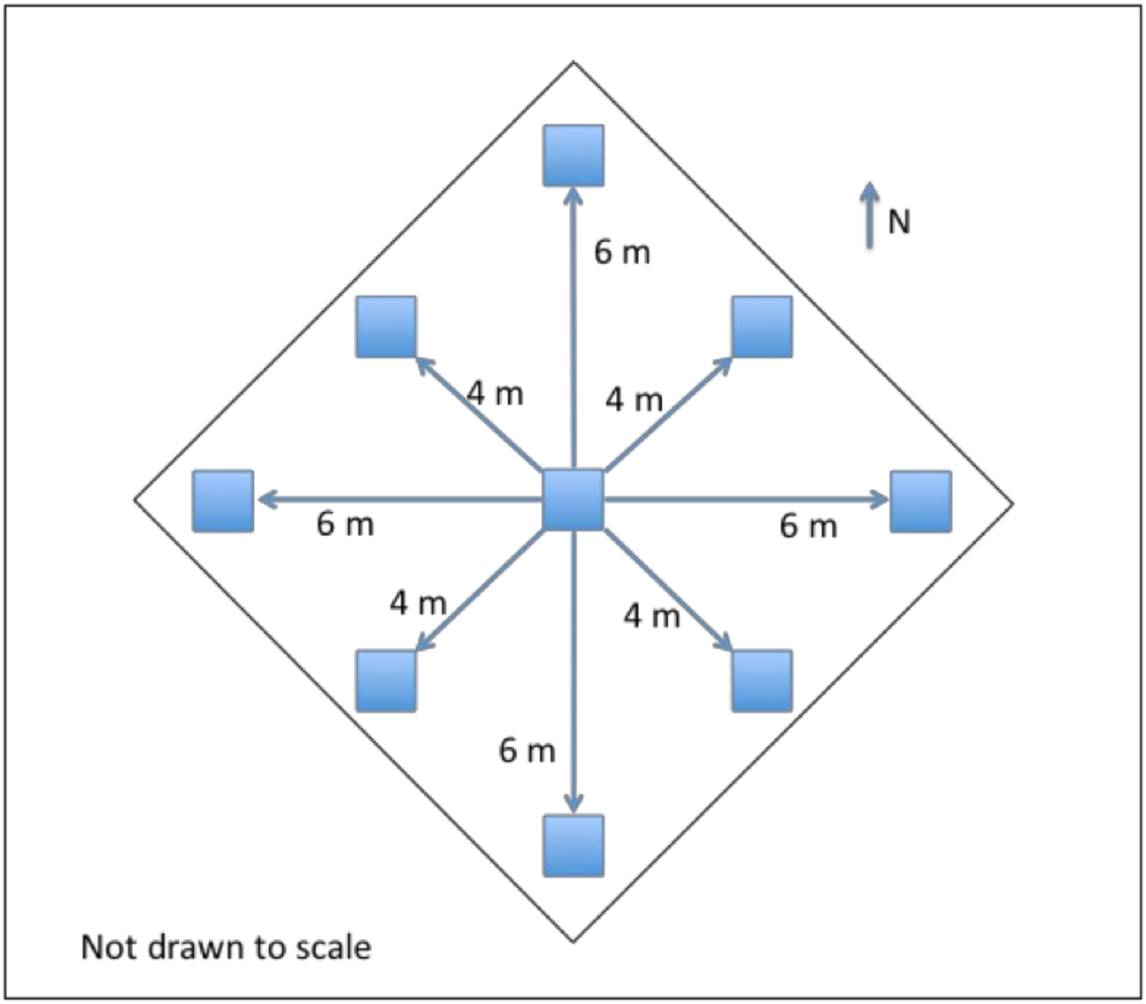


Figure 3. Proposed sub-tidal sample arrangement of nine plots (0.5 by 0.5 m in size) that represent an area of 100 m^2.

Table 8: Sample Requirements

Analytical Parameter	Collection Method	Sampling SOP	Container Size and Type	Preservation Requirements	Max. Holding Time (Preparation and Analysis)
Species ID/Biomass	Grab	Section B2	1 gallon plastic bag	placed in cooler	6 hours to lab; 7 days in lab cold storage (4°C)

B3 – Sample Handling and Custody

Biomass and any voucher specimens collected will be held in the custody of UNH JEL. Biomass samples will be held at UNH JEL at least until the Project Manager has received and reviewed the electronic data for the current year. After this time, samples that are brought to UNH JEL by the field assessment team may be given to the marine/estuarine collections of the UNH Hodgdon Herbarium or the herbarium of another institution at the discretion of UNH JEL.

B4 – Analytical Methods

At the end of each sampling season, the Science Leads will integrate the percent cover and biomass data collected in the current year into the existing regressions expressing the relationship between cover and biomass for each species. The Project QA Officer will screen the regression plots for outliers (see Section B5) and will remove outlying data points from the regression plots and annotate these data points where they appear in the electronic data tables.

B5 – Quality Control

The Project QA Officer will check that the data quality objectives are met using the criteria and methods from Table 3 in Section A7.

The Field Operations Manager will verify that the field crews are following the protocols correctly during the field sampling audit (see Section C1).

Databases of results will be checked for transcription errors and bad data using two methods. First, the entire data set will be printed and checked against the entries in each field or laboratory data sheet, spreadsheet entries will be summed to ensure no cover exceeds 100%, data will be graphed to identify outliers, and the Quartile Robust Fit method (JMP version 13) will be applied to each regression by the appropriate Science Lead. Second, the Project QA Officer will discuss outlier occurrences with project lead to determine if there are outliers in the data set. The Project QA Officer/Project Manager will examine the four approaches to identify outliers to determine whether these data should remain in the dataset.

B6/B7 – Instrument/Equipment Testing, Inspection, Maintenance, Calibration and Frequency

The field assessment team will be responsible for checking the batteries in the GPS and digital camera before traveling to sampling sites each day that this equipment is in use. The GPS, camera, and a spare set of batteries will be taken into the field in a re-sealable plastic sampling bag or other watertight container. The field assessment team will also transfer photographs from the camera to a computer at the end of each sampling day to ensure that the camera has sufficient memory available to store new pictures on the next sampling day.

B8 – Inspection/Acceptance Requirements for Supplies and Consumables

The field assessment team will prepare field equipment for daily use, insuring proper calibration completed, software updated, and/or power sources optimized for peak performance (i.e., charged/cycled).

B9 – Non-Direct Measurements

Information on tides will be used to determine the dates and times at which site establishment and sampling will occur. NOAA Tide Predictions at Fort Point, Dover Point, and the Squamscott River span the study area:

- Fort Point (Portsmouth Harbor)
  http://tidesandcurrents.noaa.gov/noaatidepredictions/NOAATidesFacade.jsp?Stationid=8423898
- Dover Point
  http://tidesandcurrents.noaa.gov/noaatidepredictions/NOAATidesFacade.jsp?Stationid=8421897
- Squamscott River
  http://tidesandcurrents.noaa.gov/noaatidepredictions/NOAATidesFacade.jsp?Stationid=8422687

B10 – Data Management

Field data will be recorded on standard field data sheets. Laboratory data will be transferred from laboratory data sheets to Excel spreadsheets. All laboratory data will be stored electronically in Excel spreadsheets which will be transferred to the Project QA Officer as part of the laboratory report.

The field assessment team will assign filenames to photographs using the sample labeling scheme: site name, transect letter, elevation, and date. The field assessment team will provide the Project QA Manager with copies of all electronic files via an electronic data transfer system, such as Dropbox, or on a flash drive within 10 business days of the completion of laboratory work for the current field season. Files will be stored in a dedicated project directory on the PREP computers. The Project QA Officer will be responsible for uploading the data to PREP publications website at scholars.unh.edu/prep/. Management of hardcopy data and documents is described in Section A9.

C1 – Assessments and Response Actions

In order to confirm that field sampling, field analysis and laboratory activities are occurring as planned, the Project QA Officer, Field Operations Manager, and Laboratory Manager shall confer, after the first sampling event each year, to discuss the methods being employed and to review the quality assurance samples. At this time all concerns regarding the sampling protocols and analysis techniques shall be addressed and any changes deemed necessary shall be made to ensure consistency and quality of subsequent sampling. The Project Manager will have the authority to resolve any problems encountered. Assessment frequencies and responsible personnel are shown in the following table.

Table 9: Project Assessment Table

Assessment Type	Frequency (Annual Basis)	Person Responsible for Performing Assessment	Person Responsible for Responding to Assessment Findings	Person Responsible for Monitoring Effectiveness of Corrective Actions
Field sampling audit	Once after first sampling day	Field Operations Manager	Field Operations Manager	Field Operations Manager
Field analytical audit (GPS, Camera)	Once after first sampling day	Field Operations Manager	Field Operations Manager	Field Operations Manager

Assessment Type	Frequency (Annual Basis)	Person Responsible for Performing Assessment	Person Responsible for Responding to Assessment Findings	Person Responsible for Monitoring Effectiveness of Corrective Actions
Data Quality Audit	Annually	Project QA Officer	Project QA Officer	Project QA Officer

C2 – Reports to Management

The Project QA Officer will produce a QA/QC memo addressed to NHDES that will be part of the annual report. The final work product will be a table containing quality assured laboratory results for each station on each date and a memo describing any deviations from the protocols established in the QA Project Plan. Data from the annual reports will be published in PREP's State of Our Estuaries Reports.

D1 – Data Review, Verification and Validation

The Project QA Officer will be responsible for a memorandum to PREP summarizing any deviations from the procedures in the QA Project Plan and the results of the QA/QC tests. The Project QA Officer will review all field data sheets and/or final computer data files for completeness and quality based on the criteria described in Section A7. The Project QA Officer will also *affirmatively* verify that the methods used for the study followed the procedures outlined in this QA Project Plan. If questionable entries or data are encountered during the review process (see methods in Section B5), the Project QA Officer will contact the appropriate personnel to determine their validity.

D2 – Verification and Validation Procedures

The Project Manager will compare the QA memorandum against the QA Project Plan. Any decisions made regarding the usability of the data will be left to the Project Manager; however, the Project Manager may consult with project personnel or with personnel from EPA, if necessary.

D3 – Reconciliation with User Requirements

The Project Manager will be responsible for reconciling the results from this study with the ultimate use of the data. Results that are qualified through the QA process may still be used if the limitations of the data are clearly reported to decision-makers. Data for this project are being collected as part of a long-term monitoring program. It is not possible to repeat sampling events without disrupting the time series. Therefore, the Project Manager will:

1. Review data with respect to sampling design.
2. Compare the QA memorandum with the QA Project Plan.
3. If the data quality objectives from Section A7 are met, the user requirements have been met. If the data quality objectives have not been met, corrective action as discussed in D2 will be established by the Project Manager.

References

PREP. 2017. State of Our Estuaries 2018. Piscataqua Region Estuaries Partnership, University of New Hampshire, Durham, NH. Published online: www.stateofourestuaries.org.

Raposa, K., B. Russell, and A. Bertrand. 2011. A protocol for rapidly monitoring macroalgae in the Narragansett Bay Research Reserve. Narragansett Bay National Estuarine Research Reserve Technical Reports Series 2011:4.

Cianciola, E and Burdick, D.M., 2014. Results of 2013 Macroalgal Monitoring and Recommendations for Future Monitoring in Great Bay Estuary, New Hampshire. PREP Publications. 284. http://scholars.unh.edu/prep/284

Wallace, R.B., and C.J. Gobler.2015. Factors controlling blooms of microalgae and macroalgae (Ulva rigida) in a eutrophic, urban estuary: Jamaica Bay, NY, USA. Estuaries and Coasts 38:519-533.

Appendix A. Visual Guide for Macroalgae Percent Cover in Quadrats

Figure A-1. <1% blade-forming *Ulva*.

Figure A-2. 5% blade-forming *Ulva*.

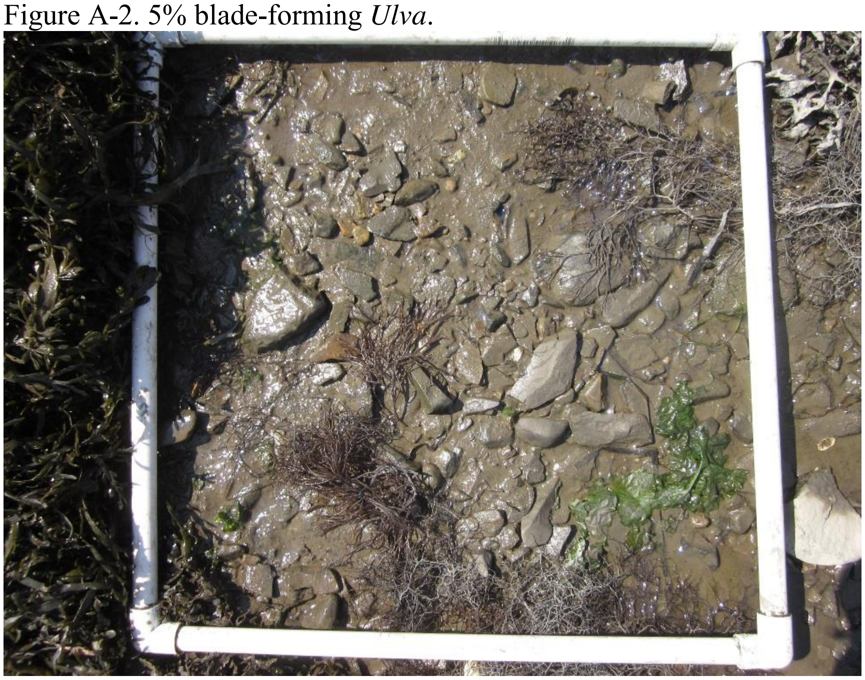


Figure A-3. 10% *Gracilaria* cover.

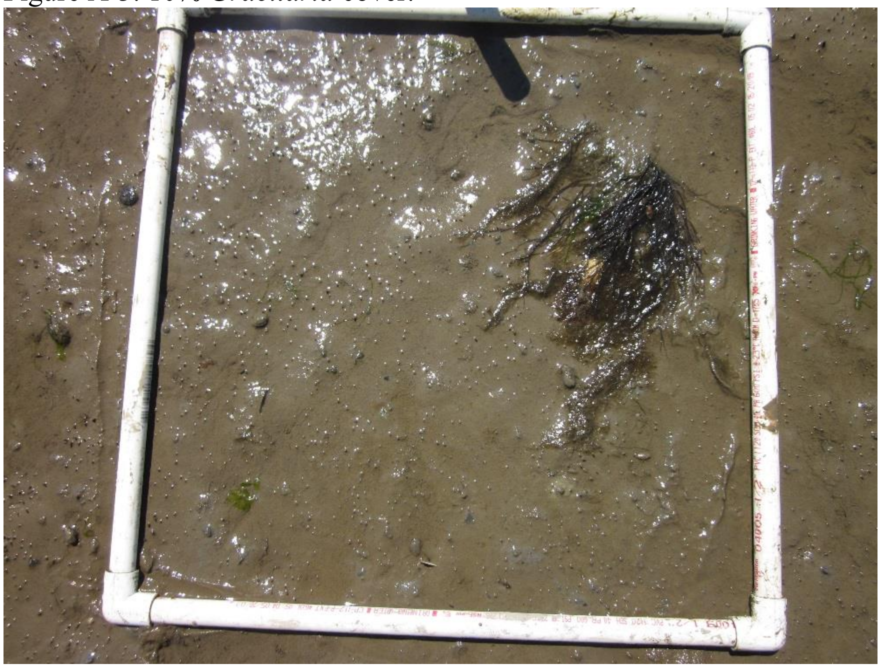


Figure A-4. 20% *Gracilaria* and 40% *Fucus vesiculosus*.

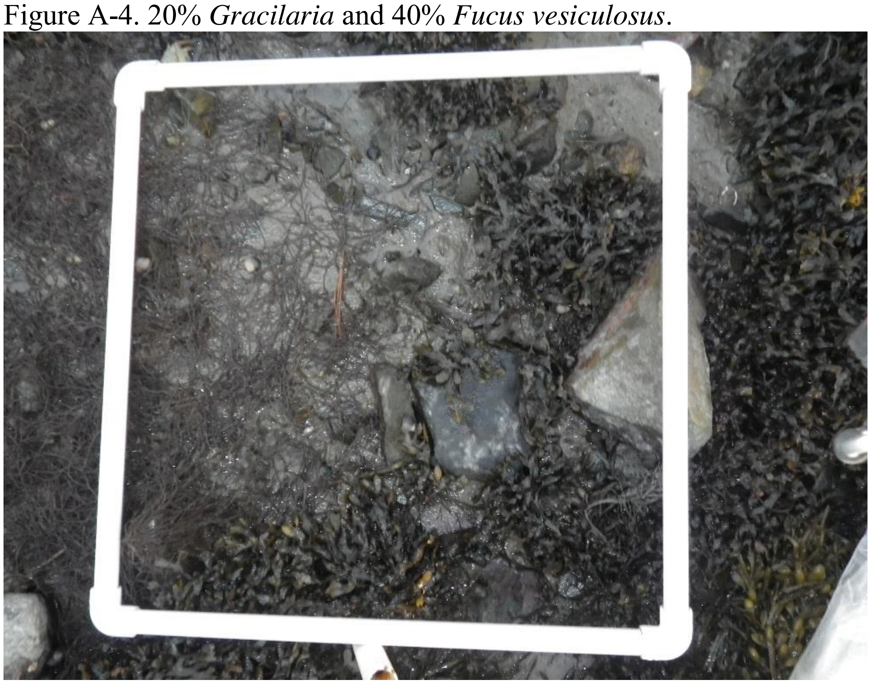


Figure A-5. 30% *Cladophora sericea*.

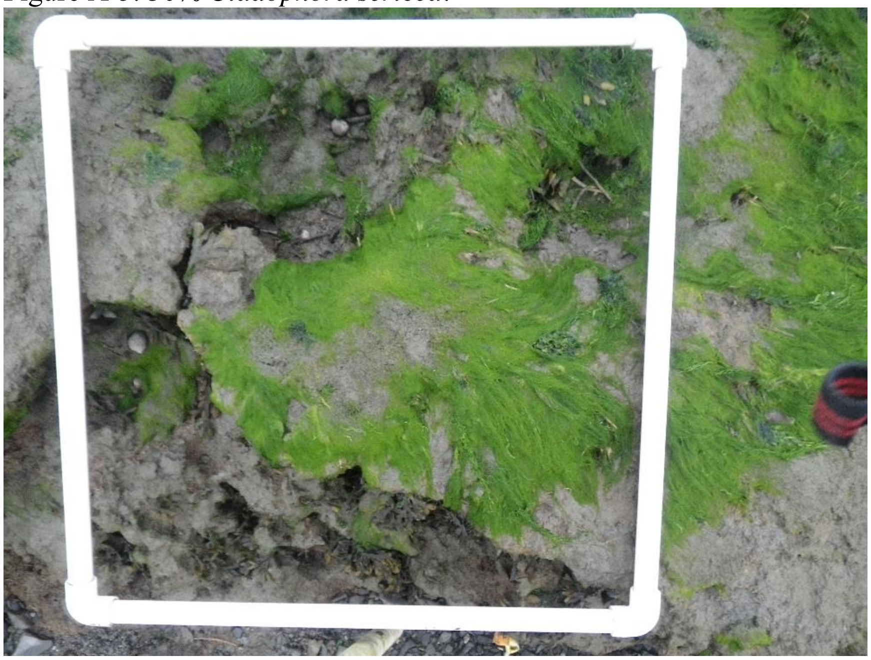


Figure A-6. 40% *Fucus vesiculosus* and 20% *Gracilaria*.

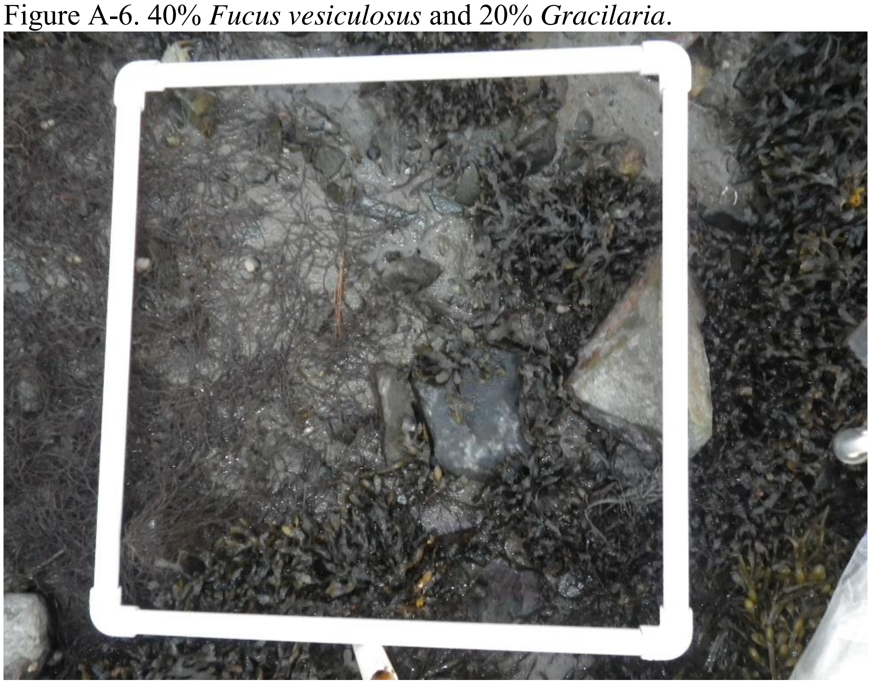


Figure A-7. 50% *Fucus vesiculosus*.

Figure A-8. 60% *Fucus vesiculosus*.

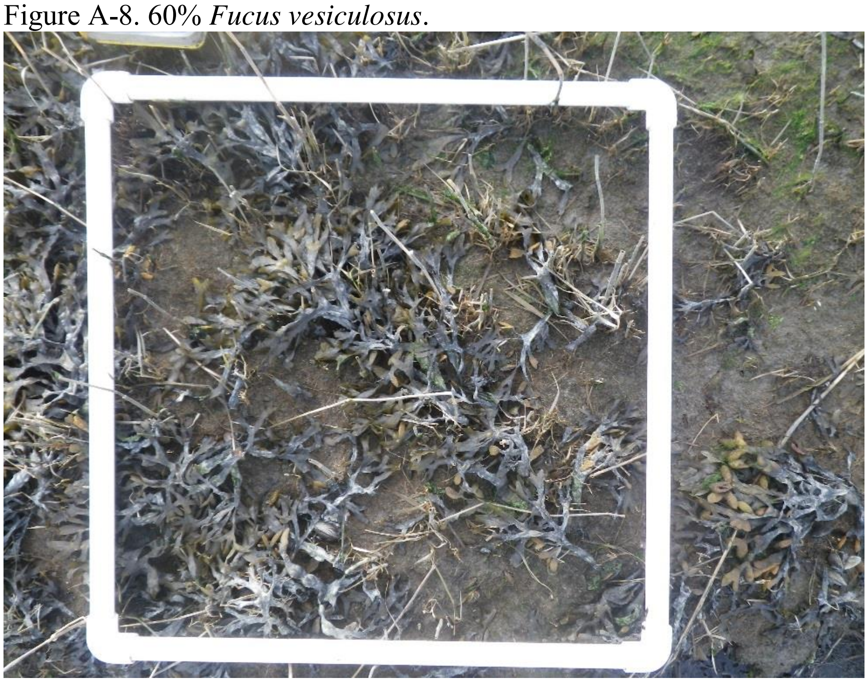


Figure A-9. 70% *Fucus vesiculosus*.

Figure A-10. 80% *Gracilaria*.

Figure A-11. 90% *Gracilaria*.

Appendix B. Visual Guide for Macroalgal Species Identification

Figure B-1. *Ascophyllum nodosum*.

Figure B-2. *Fucus vesiculosus*.

Figure B-3. Blade-forming *Ulva*.

Figure B-4. Tube-forming *Ulva*.

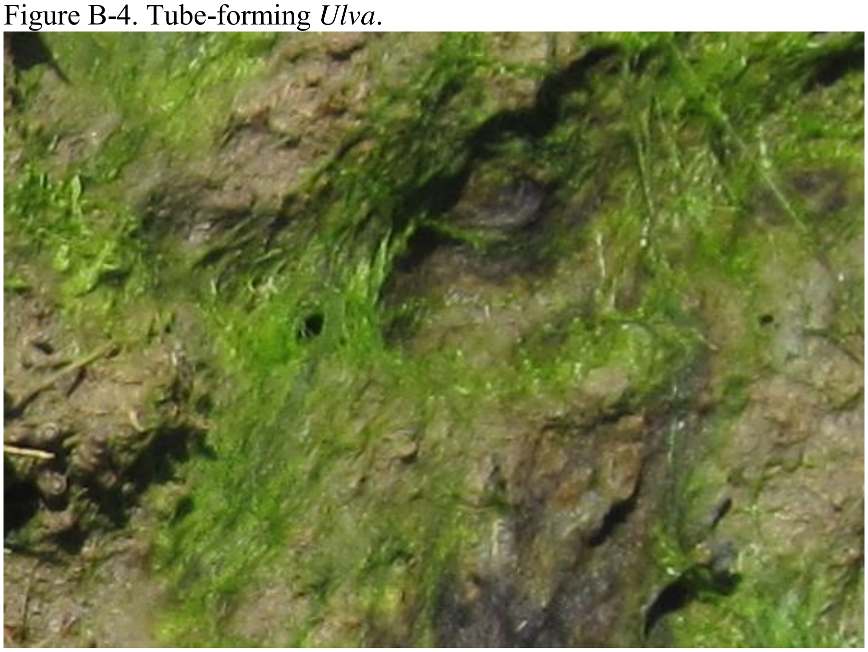


Figure B-5. *Ceramium rubrum*.

Figure B-6. *Gracilaria*.

Figure B-7. *Cladophora sericea*.

Figure B-8. *Pylaiella littoralis* (dark brown).

Figure B-9. *Vaucheria* (dark green).

Figure B-10. *Polysiphonia stricta*.

Appendix C

Macroalgae Intertidal Monitoring Field Data Sheet

		Jackson Estuarine Laboratory					
Date:		Field Site:		Monitors:			
					Cover/Biomass (circle one)		
	Camera:		GPS unit:				
Transect A	Photo#	Waypoint	Species/ cover	Species/ cover	Species/ cover	Species/ cover	
0.0							
0.5							
1.0							
1.5							
2.0							
2.5							
Transect B							
0.0							
0.5							
1.0							
1.5							
2.0							
2.5							
Transect C							
0.0							
0.5							
1.0							
1.5							
2.0							
2.5							
0.25 m2 (0.5 by 0.5 m) Quadrat for Cover; 0.016 m2 (0.25 by 0.25 m) for Biomass							

Appendix D

Standard Operating Procedure (SOP) for Laboratory Macroalgae Biomass Analysis

1.0 Storage, Rinsing, Sorting

- 1.1 Store biomass samples in a refrigerator until the field assessment team is ready to clean and sort them.
- 1.2 Rinse the samples under distilled water and sort them by species on sheets of aluminum foil.

2.0 Drying

- 2.1 Samples from different sampling points should be dried on separate foil sheets.
- 2.2 Transfer sample labels from sampling bags to foil sheets. (Sampling bags may be cleaned and reused.)

3.0 Weighing

- 3.1 Dry samples in an oven for 3-5 days at 65 degrees Celsius.
- 3.2 To test that samples are dry, remove a portion of the samples for a specific date, weigh, and then return to the oven for an additional 1-2 hours. Remove only 3-4 samples at a time to ensure weights do not increase from moisture from the air.
- 3.3 If weights are constant, the samples are considered dry. If samples are not dry, place back in the oven for an additional 1-2 hours. Then retest. (Do not use a desiccator.)
- 3.4 Weigh the material by species to the nearest hundredth of a gram.
- 3.5 Enter weights directly into an electronic spreadsheet.

Macroalgae Subtidal Monitoring Field Data Sheet

		Jackson Estuarine Laboratory				
Date:		Field Site:		Monitors:		
Time	Begin:		End:			
	Time of	Low Tide:		Water depth:		
GPS/Waypoint:			**(DD) Lat:**		**Long:**	
Transect A	Photo		Species/ cover	Species/ cover	Species/ cover	Species/ cover
Center						
N						
E						
S						
W						
NE						
SE						
SW						
NW						
0.25 m2 (0.5 by 0.5 m) Quadrat						