Surveys of Seagrass Habitat in the Barnegat Bay

QUALITY ASSURANCE PROJECT PLAN

July 2017

Approved by: _____ 7/13/17
Marc Ferko, Quality Assurance Officer — date
NJDEP Office of Quality Assurance

Approved by: _____ 7/13/17
Lynette Lurig, Project Officer — date
NJDEP

Approved by: _____ 18 July 2017
Jim Vasslides, Quality Assurance Officer — date
Barnegat Bay Partnership

Approved by: Elizabeth Lacey
Digitally signed by Elizabeth Lacey
DN: cn=Elizabeth Lacey, o=Stockton University, ou, email=elizabeth.lacey@stockton.edu, c=US
Date: 2017.07.20 08:19:30 -04'00'
_____
Elizabeth Lacey, Project Manager — date
Stockton University

2.0 Table Of Contents

3.0 QAPP Distribution List

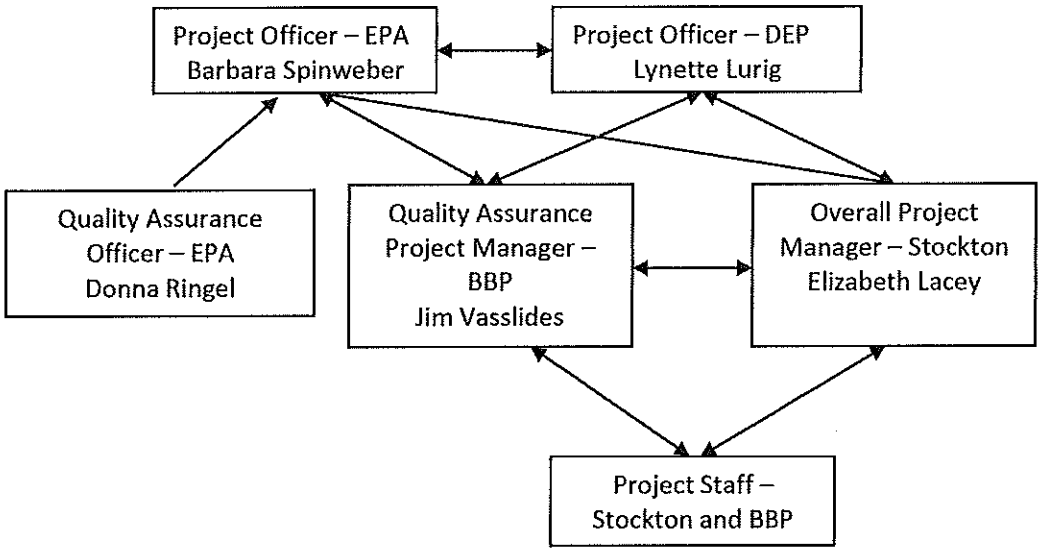
Signed copies of this Quality Assurance Project Plan (QAPP) and all subsequent revisions will be sent to the following individuals by electronic mail:

Barbara Spinweber, Project Officer, U.S. EPA, spinweber.barbara@epamail.epa.gov
Marc Ferko, Quality Assurance Officer, NJDEP, marc.ferko@dep.state.nj.us
Lynette Lurig, Project Officer, NJDEP, lynette.lurig@dep.state.nj.us
James Vasslides, Barnegat Bay Partnership, jvasslides@ocean.edu
Elizabeth Lacey, Stockton University, elizabeth.lacey@stockton.edu

4.0 Project Organization:

Overall project management will be the responsibility of Dr. Elizabeth Lacey. Dr. Lacey will oversee the collection of samples by technical staff and will be responsible for data analysis and maintenance of the approved QA Project Plan. Dr. Jim Vasslides will provide quality assurance management, reviewing data acquisition and data analysis protocols, and ensuring compliance with all elements of the QA Project Plan.

Organizational Chart-Lines of Communication



5.0 Special Training Needs/Certifications

There are no special training needs/certifications associated with this project. Dr. Lacey will provide training to all field staff in the correct procedures for enumerating and sampling of submerged aquatic vegetation and the collection of soil and water samples. During the initial training, all field staff will first observe the process from Dr. Lacey, then complete the sampling

independently. Dr. Lacey will assess each sample for validity and spot check technique throughout the survey period. All staff have experience in field sampling.

6.0 Problem Definition/Background

6.1 Problem Definition

This project seeks to document changes in the presence/absence, areal cover, biomass, and shoot density of seagrass habitat within the Barnegat Bay via transect surveys through historic seagrass beds. We will compare the findings of this survey to those conducted in 2004-2013 to assess the status and trends of seagrass within the estuary. This assessment will be include in the 2016 State of The Bay report prepared by the Barnegat Bay Partnership (BBP).

6.2 Background

The Barnegat Bay is a shallow, lagoonal back-barrier system located along the central New Jersey coastline between 39°31' N and 40°06' N latitude and 74°02' W and 74°20' W longitude (Figure 1). Since 2004, seagrass condition in the estuary has declined (Kennish et al. 2008, 2009, 2010), with aboveground and belowground biomass decreasing by 50-88% over the 2004-2006 period (Kennish et al. 2007b, 2008, 2010). Results of seagrass sampling subsequent to 2006 indicated continued decline, with 2009 having the lowest seagrass biomass values recorded in the estuary since comprehensive *in situ* sampling of seagrass beds commenced in 2004. While seagrass declines have been primarily associated with the effects of nutrient over-enrichment, the impact of Hurricane Sandy on the seagrass beds in the estuary are not yet well understood. A survey of selected seagrass beds was conducted in 2012 immediately before the storm and again in 2013 a year after the storm (M. Kennish, personal communication) but the longer-term response is not yet known. Sampling conducted by Stockton/BBP in 2015 appeared to show a small increase in seagrass biomass compared to previous years, though it is unclear if this was a short term increase, or the beginning of a period of seagrass recovery.

7.0 Project/Task Description

We propose to sample seagrass beds using the protocols of the SeagrassNet approach (Short et al. 2002) adopted by Kennish et al. (2007a, b, 2008, 2009) for previous seagrass studies in the estuary. This includes the collection of seagrass above and belowground biomass via cores, macroalgae biomass via quadrat, sediment carbon via sediment cores and measurement of abiotic factors (light via secchi, temperature, salinity, pH, dissolved oxygen) along a series of 9 transects within the Barnegat Bay (Figure 1). These transects are a subset of the 15 studied by Kennish et al. from 2004-2011 (Kennish et al. 2013), selected to represent the major seagrass species (*Ruppia maritima* and *Zostera marina*) found in the northern and central/southern sections of the estuary, respectively. Samples will be collected at the beginning (June/July) and end (October/November) of the growing season to document both annual and inter-annual changes in seagrass demographics.

This project will be conducted from June 1, 2017 to August 31, 2018, with 2 discrete field sampling events (June/July and October/November). Laboratory analysis of samples will begin with the first field collection and extend through November, with data analysis to follow. A draft report will be completed by June 1, 2018, and a final report available by August 31, 2018.

	2017							2018							
	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Field Sampling	X	X			X	X									
Lab analysis	X	X	X	X	X	X									
Data analysis								X	X	X					
Draft report													X		
Final report															X

8.0 Quality Objectives and Criteria for Measurement Data

8.1 Accuracy and Precision

The accuracy and precision of the abiotic and biotic data will vary with methodology (Table 1). In general, for all sites, replicate samples will be analyzed in triplicate and precision determined within stated parameters. Accuracy will be expressed as concordance of the measurement of a check standard or certified reference material (where available) for each run (within stated parameters). Acceptance criteria are found in Tables 1 and 4. Corrections for data found outside of the acceptance criteria is found in Tables 2 and 4.

8.1.1 Water Quality Parameters

The water quality meters will be calibrated for dissolved oxygen (winkler titration) weekly and for pH (standard buffers) and conductivity daily . Temperature is checked against a NIST standard thermometer yearly.

8.1.2 Sediment Parameters

Field quality control will be maintained by utilizing trained personnel following the SOPs.The sediment mass before and after ignition will be determined using the same analytical scale to make repeated measurements (dry and ash weight) on the same sample.

8.1.3 Biotic Parameters

Field quality control will be maintained by utilizing trained personnel following the SOPs. Visual assessments of percent cover and the presence of mesograzers and shellfish will be made by the same diver on each team. The precision of SAV, macroalgae, and epiphyte biomass measurements will be determined by using the same analytical scale to make repeated measurements (dry weight) on the same sample.

8.2 Bias

The determination of any bias in the abiotic and biotic data will vary with methodology. Acceptable bias and corrections for data found outside the acceptance criteria is found in Tables 2 and 4.

8.2.1 Water Quality Parameters

Bias in water quality measurements by all meters will be quantified through pre deployment calibrations according to YSI specifications. The QC checks should not require more than slight adjustments to bring the instrument into agreement. Failed calibration checks will initiate a thorough inspection of the unit for obvious sign of malfunction (e.g., loose connections, damaged probes, power source, fouling on DO membrane, etc.). After any maintenance to correct problems, the unit will be re-calibrated with documentation on the appropriate field data form. If the unit will calibrate within the guidelines, water column measurements can be continued. If one or more parameters remain suspect, the nature of the problem will be fully documented on the field form, and the situation will be reported to the Project QA Manager for resolution. If this situation occurs a backup instrument will be made available. Erroneous measurements and/or poor diagnostic values will warrant further scrutiny of the data collected and data outside of the accepted range for each probe will be flagged and removed prior to data analysis.

No field calibration procedures are required for the Secchi disk. The disk must be clean, free of algae or other debris, and all surfaces white in color. All surfaces on the disk must be in good condition such that they are clearly visible.

8.2.3 Biotic Parameters

Bias of SAV, macroalgae, and epiphyte biomass measurements will be determined by having a member of the laboratory crew, who did not process the original sample, visually determine if the samples were processed according to acceptable methods before the samples are placed in the drying oven. To reduce bias SAV and macroalgae biomass samples will be rinsed thoroughly with deionized water to remove any sediment or epiphytic algae prior to measurement. Epiphyte samples will be rinsed briefly to remove all sediments before processing.

8.3 Representativeness

The seagrass community in Barnegat Bay is typically dominated by eel grass (*Zostera marina*) in the southern and central portions of the bay and widgeon grass (*Ruppia maritima*) in the northern segment of the bay. In order to capture this distribution we selected survey transects that are located in historic beds of both types, as documented by earlier survey work (Kennish et al 2013). The transects selected also span the salinity, temperature, and nutrient gradients known to exist in Barnegat Bay.

8.4 Comparability

All abiotic and biotic sample collection and handling methods, sample preparation, and analytical procedures will follow methodologies in which the quantitative output can be directly compared to published literature values and existing NJDEP and EPA data. Seagrass, macroalgae, and epiphyte sampling techniques follow those outlined in Coles et al. (2001) which

is the standard for global seagrass methodology (Table 3). In addition, biotic data will be reported in a format that can also be directly compared to Kennish et al. (2008, 2013) and prior Stockton/BBP efforts.

8.5 Completeness

As this data is to be used in a status and trends assessment the completeness goal for all samples collected is 100%. Minimum requirements for abiotic and biotic sample collection compliance are 80% of samples per parameter per sampling date. If more than 20% of samples are not collected or lost during processing then a second sampling trip for that time period will occur to collect the missing data if feasible.

8.6 Sensitivity

8.6.1 Abiotic and Biotic Parameters:

Sensitivity of all abiotic and biotic measurements are defined in Table 5. The minimum level of detection varies with each parameter and method used (Table 5). Measurements for all parameters are within the expected range of concentrations for coastal estuarine systems as they apply to SAV ecosystems.

9.0 Non-Direct Measurement (Secondary Data)

There will be no use of secondary data with this project.

10. Field Monitoring Requirements

10.1 Monitoring Process Design

The field teams will collect abiotic and biotic data at the 9 sampling sites established during the 2015 monitoring effort (Figure 1, Table 6). If a seagrass bed is no longer present at that location, we will circle that point at increasing 5m distances until SAV is found, and that will serve as the edge of the sampling area. Sites will be sampled in late June/early July and again in late October/early November of 2017 for both abiotic and biotic measurements. The crew will locate the sampling stations by use of on-board Global Positioning Satellite System (GPS), which is accurate within 3.5 meters depending on atmospheric effects and sky blockage. At the sites all sampling crews will uniformly collect samples following established sampling protocols and methods as outlined in this document. Field data samples include (these will be discussed in greater detail in following sections):

- Water quality parameters (temperature, salinity, pH, DO, and light attenuation)
- Sediment Parameters (Percent organic content)
- Seagrass (above and belowground biomass)
- Epiphytes (biomass)
- Macroalgae (biomass)

Samples collected from the field will be taken to Stockton University for storage and analysis.

10.2 Monitoring Methods

10.2.1 Water Quality Sampling Methods

At each site a YSI hand-held water quality meter will be used to record temperature, salinity, pH, and dissolved oxygen. Secchi depth will be determined by using a 20-cm diameter white Secchi disc. The disc will be lowered to the depth, at which it can no longer be discerned, and then it will be slowly retrieved. Secchi depth will be reported in cm.

10.2.2 Sediment Sampling Methods

At all sites sediment cores will be collected to quantify organic content. Nine clear acrylic cores (10.4 cm diameter by 10 cm depth) will be randomly collected within a 50m radius at each site, divided into three 2 cm horizontal sections (0-2 cm, 2-4 cm, and 4-6 cm), and placed in a plastic bag in a cooler on ice until taken back to the lab for processing (Section 11.1.1).

10.2.3 Biotic Sampling Methods

A quadrat measuring 1 m on each side with an area of 1 m^2 will be randomly placed 10 times within an 50m radius at each sampling site to measure seagrass and macroalgae areal coverage. The percent cover of seagrass, macroalgae, sponge, or mud will then be estimated in situ by a diver using a scale of 0 to 100 in increments of 5. Subsequently, the diver will measure the length of 5 randomly chosen seagrass blades to the nearest millimeter. The diver will then visually inspect the seagrass bed within the quadrat for presence/absence of shellfish and mesograzers.

A total of 5 cores (22 cm diameter, 10 cm depth) will be taken haphazardly within the 50m region at each site to collect aboveground and belowground (roots and rhizomes) seagrass tissue for biomass estimates. Samples will be sieved (1.0 cm mesh box sieve) and washed clean of sediment in the field and all plant material will be placed in a plastic bag in a cooler on ice until taken back to the lab for processing(Short et al., 2002; Sidik et al., 2001; Section 11.1.2).

Ten macroalgal biomass sample (0.25 m^2 quadrat) will also be collected from each site. These samples will be placed in a plastic bag in a cooler on ice until taken back to the lab for processing (Section 11.1.3).

Lastly, 15 individual *Z. marina* shoots will be randomly selected from each site and transported back to the lab in plastic bags to determine epiphyte biomass (Section 11.1.4; Kendrick and Lavery, 2001).

10.3 Field Quality Control (QC)

There is a diverse array of sampling and analytical requirements necessary in this investigation; therefore, sampling and QA procedures vary among the methods (Tables 2 and 4). If problems occur, such as lost, contaminated, mislabeled or improperly handled samples, these problems will be documented in the appropriate project record-keeping location (field or laboratory logs). If practical, replacement samples will be obtained. If differences between temporal or spatial characteristics of the replacement samples and the original samples have a bearing on project activities or objectives, such differences will be noted in all subsequent documentation and products in which the replacement samples were used.

NJDEP approvals/certifications held by the project team for *in* situ water quality analysis.

Entity	Parameter	Approval/Certification
Barnegat Bay Partnership	pH	Barnegat Bay Program
	temperature	Barnegat Bay Program
	dissolved oxygen	Barnegat Bay Program
	conductivity	Barnegat Bay Program
	total organic carbon	-
Stockton University	pH	Barnegat Bay Program
	temperature	Barnegat Bay Program
	dissolved oxygen	-
	conductivity	Barnegat Bay Program
	total organic carbon	-

11.0 ANALYTICAL REQUIREMENTS

Biotic samples will be analyzed at Stockton University's Marine Science and Environmental Field Station (MSEFS). Biotic measurements will include:

- seagrass aboveground and belowground biomass
- epiphyte biomass
- macroalgal biomass

Sediment data used in this project will be collected and analyzed at MSEFS. Sediment measurements will include:

- Percent organic matter (% LOI, MSEFS)

11.1 Analytical Methods

11.1.1 Sediment Total Organic Content Methods

At each site nine sediment cores (10.4 cm diameter by 10 cm depth) will be collected to quantify sediment total organic content and sectioned into 2 cm sections (0-2 cm, 2-4 cm, 4-6 cm). In the lab each sub-section will be cut in half and percent organic matter will be determined by drying the sediment sub-section at 50 °C until a constant dry weight is reached. Samples will then be weighed, combusted at 400 °C for eight hours, and weighed again. Percent organic matter will be calculated as the difference in weights (Schumacher revised 2002; Table 3, Appendix 1.1).

11.1.2 Seagrass Biomass Methods:

Seagrass will be removed from bag and placed in large plastic tray. The plants will be separated by species and into vegetative or flowering shoots. Shoots covered in epiphytes will be scraped with single edge razor blade held 90° to the leaf surface. The sample will then be rinsed with deionized water. The total number of shoots (vegetative and flowering) in the sample will be counted. The leaves will then be separated from the rhizome directly below the leaf sheath into aboveground and belowground biomass. The data sheet will be filled out with date, site, replicate, and species. The sample will be placed into the appropriate aluminum foil envelope and the weight recorded (different envelopes will be used for above and belowground biomass). All samples will be placed in an air circulating oven at 50°C for a minimum of 24

hours. Each sample will be weighed a minimum of 3 times using the same scale or until the sample reaches a constant dry weight (weight loss < 0.5 mg) and all weights will be recorded on the appropriate data sheet. Biomass will be reported as g dry weight (DW) m^{-2}; (Duarte and Kirkman, 2001; Table 3, Appendix 1.2).

11.1.3 Macroalgal Biomass Methods:

All algae will be removed from sample bags placed in large plastic tray. The sample will then be separated by species and rinsed with distilled or deionized water. Species will be identified using guides and magnifying equipment. All data will be recorded on appropriate data sheets. Once the sample has been completely identified algae biomass will be placed into the appropriate aluminum foil envelope (by species) and the weight recorded. All samples will be placed in an air circulating oven at 50°C for a minimum of 24 hours. Each sample will be weighed a minimum of 3 times using the same scale or until the sample reaches a constant dry weight (weight loss < 0.5 mg). Record all weights on the appropriate data sheet. Biomass will be recorded as g Dry Weight (g DW) m^{-2} (Sidik et al., 2001; Table 3, Appendix 1.3).

11.1.4 Epiphyte Biomass Methods:

The individual seagrass shoots will be removed from the sampling bag and placed in large plastic tray. The shoot will then be separated into individual leaves and rinsed with distilled or deionized water. Larger epiphytes will be removed from the leaves by hand or with forceps. Each individual leaf will be scraped with a single edge razor blade held 90° to the leaf surface. The entire length of each leaf will be scraped on both sides. All material scraped off of the leaves will be rinsed into pre-weighed aluminum pans. The total number of leaves will be counted and the leaf length and width will be measured for each leaf. All leaf data will be recorded on the data sheet along with date, site, replicate and sample wet weight. All samples will be placed in an air circulating oven at 50°C for a minimum of 24 hours. Each sample will be weighed a minimum of 3 times using the same scale or until the sample reaches a constant dry weight (weight loss < 0.5 mg). All weights will be recorded on the appropriate data sheet. Biomass will be recorded as g Dry Weight (g DW) m^{-2} (Kendrick and Lavery. 2001; Table 3, Appendix 1.4).

11.2 Analytical Quality Control

There is a diverse array of analytical requirements necessary in this investigation; therefore, sampling and QA procedures vary among the methods (Table 4). If problems occur, such as lost, contaminated, mislabeled or improperly handled samples, these problems will be documented in the appropriate project record-keeping location (field or laboratory logs). If practical, replacement samples will be obtained. If differences between temporal or spatial characteristics of the replacement samples and the original samples have a bearing on project activities or objectives such differences will be noted in all subsequent documentation and products in which the replacement samples were used.

12.0 Sample Handling and Custody Requirements

Prior to all sampling dates all materials will be cleaned and an inventory of materials necessary for the field and in the laboratory will be completed and signed off by the project

manager (Appendix 2). All acrylic cores, acrylic spacers and core caps will be acid washed using 10% HCl, and rinsed 3 times with DI water to remove any remaining acid residue, and dried before each sampling date. All glassware, plastic trays, metal spatulas, metal slicers, and forceps used for biomass or sediment TOC analysis will be rinsed with DI water 3 times before each sampling date.

12.1 Field Data:

12.1.1 Field Data Forms

The project field crews will record most of their raw field data on hard copy data sheets. The template for field data sheets will be the one designed for previous bioassessment field data acquisitions in similar estuaries and all field data sheets will be printed on Rite in the Rain© paper (Appendix 3). The field sheet will record site information (date, time, site, weather) as well as water quality data measured on site with YSI water quality meter. All sample bags and cores collected on site will also be recorded. Data on overall site % cover for seagrass (*Z. marina and Ruppia maritima*) as well as macroalgae and bare sediment will also be recorded. All samples will be handled according to the appropriate SOP standards (Table 2; Appendix 1). Upon return to the field station all field data will be scanned into a digital format and then entered into an electronic spreadsheet format and saved on Stockton University's Marine Science and Environmental Field Station (MSEFS) servers.

12.1.2 Site/Sample Identification

Sample ID numbers, month of data collection, and data parameters will be marked with permanent ink on the outside of the bag. Samples for seagrass biomass will be labeled "Site # - Seagrass Biomass – Replicate # - June 2017". Samples for epiphytic coverage will be labeled "Site # - Epiphytes – Replicate # - June 2017". Samples for macroalgae biomass will be labeled "Site # - Macroalgae Biomass – Replicate # - June 2017". Samples for sediment will be labeled "Site # - Core # - depth profile (e.g. 0-2cm) - June 2017". Sampling packets for each site will be prepared prior to the sampling date by placing a complete set of field data forms and pre-labeled sample bags and cores into the appropriate dry box or cooler. Bag IDs for all field samples will be recorded for each site in situ using write-in-the-rain paper and pencils. Samples within all bags will be individually processed in the laboratory according to the appropriate SOP standards (Appendix 1). Results are then entered into database management software by the laboratory researcher.

12.2 Laboratory Data

Prior to field sampling all aluminum foil envelopes and aluminum pans will be pre-labeled with pencil, weighed, and their weights will be recorded on the appropriate data sheets. All samples will be processed within the time frame determined by each SOP (Table 3, Appendix 1).

12.3 Data Transfer

Field information recorded on hardcopy must be transferred to an electronic format. The hardcopy field data will be transcribed within a week of collection to the electronic format. The electronic format will be a template similar to the hardcopy form; the same data will be entered

to the electronic file that was recorded in the field. The Project Quality Assurance Manager will conduct QA/QC checks on the transfer of hardcopy data to the electronic format.

All electronic files created during field activities must be periodically backed up on disks. All QAPP related data and all associated raw data records (including chain of custody records, records of calibrations and calibration checks) shall reside for seven years at MSEFS. If the facility cannot provide the required storage, the data shall be transferred for archival storage to the Stockton University School of Natural Science and Mathematics.

12.4 Sample Transfer

When the field crew returns to the dock or staging area, they will turn both the field samples and respective data forms over to their land-based support team (or designated recipient) who will again verify that all samples are accounted for by comparing actual sample containers against the field data forms (Appendix 2). Upon inventorying samples, the crew will then temporarily store the samples under designated conditions until processing. In the event that a sample is missing, the person checking in samples will record the sample as missing on the inventory sheet. The boat crew responsible for the collection of that sample will be informed so that they may check the sample storage areas on the vessel. It may be that conditions in the field prevented the collection of a particular sample; in that situation, the reasons should have been recorded as a comment on the field data form. If the sample is not recovered, the crew chief will make the decision for corrective action, whether simply to re-sample while still in the area or to schedule a make-up sampling on a later date.

Once a complete set of field collected samples are received by the processing laboratory, a master list will be compiled of all sets of samples and where they reside (e.g., freezer A, refrigerator B, or storage shed Z). The master list should be filed in the general area where the samples are held. When samples are released to an analyst, the transfer will be documented on the master list by initial and date; the quantity of sample released should be recorded. If the sample or portions of it are returned to the central storage area, this should also be logged on the master list. When the laboratory uses internal tracking codes, they must be indexed to the original sample ID code (both site and sample identifiers), and all analytical results will be reported using this code.

13.0 TESTING, INSPECTION, MAINTENANCE, AND CALIBRATION REQUIREMENTS

Appendix 2 shows a list of field equipment and instruments used in this project. Both field and laboratory equipment and instruments require routine calibration checks to verify that their performance is within acceptable quality standards. The following sections will discuss the procedures and frequency for the various instrument calibrations that are key components in the collection of accurate environmental data.

13.1 Instrument/Equipment Testing, Inspection and Maintenance

All sampling gear and laboratory instrumentation will be maintained in good repair as per manufacturer's recommendations or common sense to ensure proper function. The YSI handheld water quality meters undergo bi-weekly inspection and have yearly testing and maintenance through the manufacturer.

13.2 Instrument/Equipment Calibration and Frequency

13.2.1 YSI water quality meter calibrations:

The YSI water quality meters will be calibrated for pH and conductivity daily against standard buffers and for DO weekly via winkler titration. Spare probes will be maintained and stored according to factory directions at MSEFS and BBP.

13.2.3 Laboratory Calibrations:

Several pieces of equipment that may be utilized to collect or analyze environmental data will have periodic calibration verification performed laboratory analysis. These procedures will be documented by date and the signature of the person performing the inspection:

- Analytical balances – multipoint calibration bracketing expected measurements on level surface prior to each use; analyst will check that scale is at 0 prior to weighing all samples; scale will be zeroed as necessary
- All other sampling gear and laboratory instrumentation will be calibrated (if possible) as per manufacturer's recommendations or common sense to ensure proper function.

Each piece of routine tools common to most laboratories (e.g., drying ovens, freezers, etc.) will have an assigned logbook in which the calibration or performance records are maintained. Other equipment such as sample drying ovens should be monitored on a routine basis during periods of use to ensure their performance.

13.3 Inspection/Acceptance of Supplies and Consumables

All replacement probes for YSI meters must be received directly from the appropriate company. Probes will only be accepted if they are shipped with a certificate of calibration, are not noted as damages after a visual inspection, and pass initial calibration tests (YSI). Materials that do not meet this criteria will be returned to the manufacturer and replaced.

14.0 DATA MANAGEMENT

The project will require that each data generating activity, both field measurements and laboratory analyses, be thoroughly documented. Data will be recorded in a variety of paper and digital formats. Specific formats for both written and electronically recorded data will be prescribed to document the field monitoring and pertinent steps of laboratory analyses (Appendix 3). Once the field crews have returned to the lab all data sheets will be scanned electronically and the data will be entered manually into Microsoft Excel. All data sheets used in the laboratory will also be scanned and the data will be recorded in Excel. All data will be backed up on a hard drive and on the MSEFS servers.

A study file containing planning documents (QAPP), SOPS, field data sheets, laboratory notebooks or work sheets, study-related correspondence, records of peer reviews or QA assessments (reviews), and reports and publications will be maintained. These records will be permanently archived by Stockton University.

14.1 Field Activities

Field crews will rely primarily upon hardcopy field data forms to record most field collected data. Standardized hardcopy forms will be used (Appendix 3). All core data recorded on field data sheets will be transcribed into the computer system within a reasonable time following collection (target period, within a week). To ensure consistency, one person will be

responsible for the data entry. Data entry will be straightforward and user friendly; the fields in the electronic format will closely resemble the hardcopy raw data forms. The hardcopy data forms filled out for a given station will be compiled into a "station data package" and scanned to provide in-house working copies. The original field sheets will be archived, as well as backup disks for all electronic files. These raw data will be kept on file indefinitely at Stockton University.

A systematic approach of sample tracking will be used to ensure accountability for the handling, storage, and transfer or shipment of the field collected samples. Chain-of-custody documentation (as per GLPs) will include the following basic components:

Sample Collection:

- A master inventory of all field samples that are expected to be collected (separate list(s) for each sample type and corresponding station IDs), with check off fields providing documentation of all samples that are collected (when, and by whom)
- Sample transfer information/invoice (where, what, to whom, and when, and by whom samples are transferred or shipped)

Sample Receipt (log-in):

- Documentation (sample log-in form) of the person receiving; when and what they receive; and general condition of shipment (e.g., breakage, thawed, etc)
- Reconciliation that what was reported shipped was in fact received
- Deposition/distribution of samples (e.g., where stored and holding conditions)
- Sample release to analysts

As in the case of the field data sheets, a sample tracking system will be followed verbatim. If a sample is missing, the laboratory should then go through appropriate channels to contact the field team as soon as possible so that they may attempt to locate the sample at their end or possibly re-sample. A complete set of field data sheets, laboratory data sheets, and tracking documents will be submitted to the Project manager to be archived for at least a period of 7 years

14.2 Laboratory Analyses

As with field collected data, the overall flow of data generated from laboratory analyses will follow the route established below:

Data Generator (raw data from laboratory)
↓
Project Manager (initial validation and formatting)
↓
Quality Assurance Officer (additional validation/verification, and formatting)
↓
Stockton University
↓
Public Website

The specific reporting requirements for each of the major laboratory activities are described in the following sections.

All analytical and processing laboratories used in this project will retain raw data files (e.g., primary standard certification, working standard preparations, instrument calibration records, results of QC check samples/measurements, instrument printouts, and final data calculations) for each indicator and will be stored indefinitely at Stockton University. Demonstration of laboratory approval is required. The contractor (Stockton University) will review all data to verify that quality goals are satisfied. Upon issuing appropriate advance notification (i.e., minimum of 2 weeks), Barnegat Bay Partnership (BBP) and US EPA maintains the authority to access the active files and/or request copies of specific information at any time. In addition, the full set of data will be part of the study file of which BBP and US EPA will receive a copy at the completion of the project.

Whenever changes or updates are made to the QA Project plan, copies of the most current copy will be electronically transmitted to all persons on the distribution list specified in the QAPP distribution list. This will be the responsibility of the Project Manager. Procedures that will be used for document and record keeping are described in sections 15 and 16.

15.0 ASSESSMENTS AND OVERSIGHT

The following sections outline the structured data reviews and assessments of data quality planned for the project. Note: Routine audits will be conducted by the Quality Assurance Officer during the course of the project, and will include review of any project environmental data collection activity. EPA may implement, at their discretion, various audits or reviews of this project to assess conformance and compliance to the quality assurance project plan.

15.1 Field Monitoring

15.1.1 Field Reviews

Field reviews will be carried out once a sampling period by the Project QA Manager or a member of the MSEFS staff. Any minor deficiencies observed during field surveillance (e.g., slight deviation from approved procedures, labeling irregularities, data reporting, etc.) should be immediately pointed out to the crew and corrective actions imposed on-the-spot. The evaluator will document with a brief note on the checklist and no further write-ups are required. If significant deficiencies (i.e., data quality is seriously compromised) are observed, the evaluator will make the appropriate on-the-spot correction, and, if the case warrants, call a halt to the field activities until the problems are resolved to the satisfaction of the Project QA Manager. All cases of this nature will be documented through a written report submitted to the Project QA Manager. A completed checklist along with a copy of the completed field data forms, and sample checklist from each sampling date provides the basic documentation for an evaluation of the crew's overall performance on this sampling date. All field review data will be maintained as part of the study file (Section 14.0).

15.2 Laboratory Activities

15.2.2 Laboratory Reviews

Laboratory reviews will be carried out once per sampling processing period by the Project QA Manager or a member of the MSEFS staff. Any minor deficiencies observed during sample processing (e.g., slight deviation from approved procedures, labeling irregularities, data

reporting, etc.) should be immediately pointed out to the analysts and corrective actions imposed on-the-spot. The evaluator will document with a brief note on the checklist and no further write-ups are required. If significant deficiencies (i.e., data quality is seriously compromised) are observed, the evaluator will make the appropriate on-the-spot correction, and, if the case warrants, call a halt to the field activities until the problems are resolved to the satisfaction of the Project QA Manager. All cases of this nature will be documented through a written report submitted to the Project QA Manager. A completed checklist along with a copy of the completed field data forms, and sample checklist from each sampling date provides the basic documentation for an evaluation of the crew's overall performance on this sampling date. All laboratory review data will be maintained as part of the study file (Section 14.0).

16.0 DATA REVIEW, VERIFICATION, VALIDATION AND USABILITY

The data generated during the project will be systematically reviewed with varying levels of scrutiny at several junctures along the path from time of collection to final reporting; from quick, on-the-spot screening to in-depth evaluation against established criteria or standards. For much of the field collected data, the first level of validation, a cursory screening, will occur as data are recorded; persons conducting and documenting real-time observations should be aware of the range that constitutes realistic values for a specific measure. Certainly a water temperature of 40 °C should jump out as an obvious outlier and trigger an immediate response to find the source of the error. With other types of data, the initial validation may not occur in such an immediate time frame. Nonetheless, most data are amenable to some form of quick screening soon after being generated and the responsibility for this first- cut validation falls on the personnel performing the measurement. In addition, most laboratory analyses of the project samples will be monitored by a series of in-stream QC checks that indicate the general level of data quality for a given batch of samples. In addition, documented verifications are required to determine if data quality remains at a level acceptable for the program. The following sections outline the format and procedures to be used for evaluating and documenting data quality for the project and discuss how issues will be resolved when they occur.

16.1 Data Review, Verification, and Validation

16.1.1 Review of Field Data:

A first review of field data occurs as the data are being collected by the field crews (e.g., are these data in the ballpark?). If the field personnel encounter situations where they question the validity of data they are collecting, they should immediately refer back to the appropriate SOP, attempt to isolate and resolve the problem; if they are unable to do so, then they must describe the situation in writing on the appropriate data sheet, and, as soon as possible, consult with their respective senior Field Manager or Project Manager for corrective actions.

The next level of review takes place as the Project Manager double checks that samples were properly checked in to the lab and consolidates and formats the field data. Most of the field crew will use hardcopy data sheets to record the bulk of field data; therefore, the data must be transcribed into an Excel spreadsheet. As soon as possible, upon return from the field, all raw data forms should be scanned and a digital PDF file created. All hard copy originals will then be placed in a secure file; and the electronic copies will be backed up on the MSEFS server and then be used for entering the data.

During the data entry process, the field data will be screened for missing or errant information based on instrument sensitivity (Appendix 2). All field data will be subject to an evaluation of the relative frequency of transcription errors enacted going from hardcopy into the electronic format. To determine this, a randomly selected subset of at least 10% of the station packages (the entire set of field data sheets submitted for a given station) will be pulled and the data (primarily, measurements or numerical values) manually compared against the electronic version on a field - by-field basis. Any errors will be listed in the data logbook and a final tally derived for the station. The total number of transcription errors for a complete set of data sheets should not exceed 5. If more than 5 transcription errors are found, the entire set of field data sheets will be pulled and re-examined for review and check for errors. If corrective actions are initiated (e.g., correcting a spelling error on the copied data form), the correction must be legible and the person who made the correction must document the alteration with their initial and date; a description of the correction must be noted in the bound log.

16.1.2 Review of Laboratory Data:

All laboratory data generated for the project will be systematically reviewed and evaluated by both the Project Manager and the Project QA Officer. Upon receipt of a data set, a temporary file will be created and a series of error checks developed (checks will vary with SOP) will be performed to ensure the data: 1) are within specified ranges appropriate to each parameter measured, 2) contain all required fields, 3) have encoded valid values from constrained look-up lists where specified, and 4) are in the correct format (text in text fields and values in numeric fields, etc.).

A first review of laboratory generated data occurs as the data are being processed by the laboratory analysts (e.g., are these data in the ballpark?). If the analysts encounter situations where they question the validity of data they are collecting, they should immediately refer back to the appropriate SOP, attempt to isolate and resolve the problem; if they are unable to do so, then they must describe the situation in writing on the appropriate data sheet, and, as soon as possible, consult with their respective senior MSEFS staff or Project Manager for corrective actions.

The next level of review takes place as the Project Manager double checks that samples were properly checked into the lab, stored, and checked out, that the proper number of QC samples was analyzed depending upon SOP (Appendix 1), as well as consolidates and double checks all calculations and formats all laboratory data. Most of the laboratory analysts will use hardcopy data sheets to record the bulk of the laboratory data; therefore, the data must be transcribed into an Excel spreadsheet. All hard copy originals will then be placed in a secure file; and the electronic copies will be backed up on the MSEFS server and then be used for entering the data.

During the data entry process, the field data will be screened for missing or errant information based on instrument sensitivity. All laboratory data will be subject to an evaluation of the relative frequency of transcription errors enacted going from hardcopy into the electronic format. To determine this, a randomly selected subset of at least 10% of the station packages (the entire set of laboratory data sheets submitted for a given sampling date) will be pulled and the data, manually compared against the electronic version on a parameter by parameter basis. Any errors will be listed in the data logbook and a final tally derived for the parameter. The total number of transcription errors for a complete set of data sheets should not exceed 5. If more than

5 transcription errors are found, the entire set of laboratory data sheets will be pulled and re-examined for review and check for errors. If corrective actions are initiated (e.g., correcting a spelling error on the copied data form), the correction must be legible and the person who made the correction must document the alteration with their initial and date; a description of the correction must be noted in the bound log.

16.2 Reconciliation With User Requirements

All data collected as part of this project must meet the QA/QC standards defined by this QAPP. Missing data will be tracked with the sample log in systems both in the field and in the lab (Appendix 2). If possible missing samples will be replaced with additional samples. When that is not possible the data will be noted as missing in all excel datasheets.

During analysis not all data quality goals may be met. For example, samples may be held longer in storage than defined by the SOP for that parameter. Due to the high frequency of sampling for this project samples will have to be processed quickly in order to free up equipment for additional sampling. However, if this did occur, the samples will be processed according to the appropriate SOP, the data will be flagged in the excel spreadsheet, and potential bias of the measurements will be quantified. If the bias is significant, then those samples will be removed from the analysis. Finally, due to the high amount of field data required as part of this project it is possible that field conditions require that sampling procedures be changed significantly. Sampling during high wind or rain events will avoided as much as possible. In the event that conditions deteriorate as the sampling day progresses, remaining samples will not be collected and the field crew will return to the same sampling site the following day. A note about the extended sampling period (2 days instead of 1) will be noted on the field data sheets.

Data that pass the verification process will be used to assess changes in the status and trends of seagrass habitat compared to historic data. To use the validated data generated as part of this project in the model it will first have to be analyzed. Data analysis will be undertaken in R, SAS, SigmaStat and SigmaPlot Software Packages. The software package used will be dependent on the specific spatial, temporal question and the input data type. All output will be saved in an electronic format on MSEFS servers.

17.0 REPORTING, DOCUMENTS AND RECORDS

All project documents and records will make use of a document notation system located in the footer region of all data sheets/reports. All documents will list the Project Name, Document Name and Revision number, Date, page number, and total number of pages in the document. All field and laboratory data will be maintained in hard copy in the data logbook, scanned copies of all sheets, and electronic versions of the data in Microsoft Excel will be maintained on Project Manager's computer at the MSEFS as well as on the MSEFS servers (e.g. copies will be backed up on 2 servers). All data (hard and electronic copies) will be maintained at the MSEFS for an indefinite period of time.

Sampling collection and handling records will be maintained by the Project Manager and checked by the QA officer after each sampling date. Analytical logbooks will be updated following the processing of each sample by the analyst and audited by the QA officer. All QC sample records and equipment calibration records will be maintained as part of the appropriate analytical logbook and will be observed with the logbooks. The project manager will prepare

progress reports and submit them to the Barnegat Bay Partnership, as required by the contract between BBP and Stockton University.

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Figure 1. Barnegat Bay-Little Egg Harbor Estuary showing all historic sampling transects in green dots (from Kennish et al 2013). Transects are numbered from south to north. We will sample at Transects 1, 3, 6, 8, 10, 12, 13, 14, and 15.

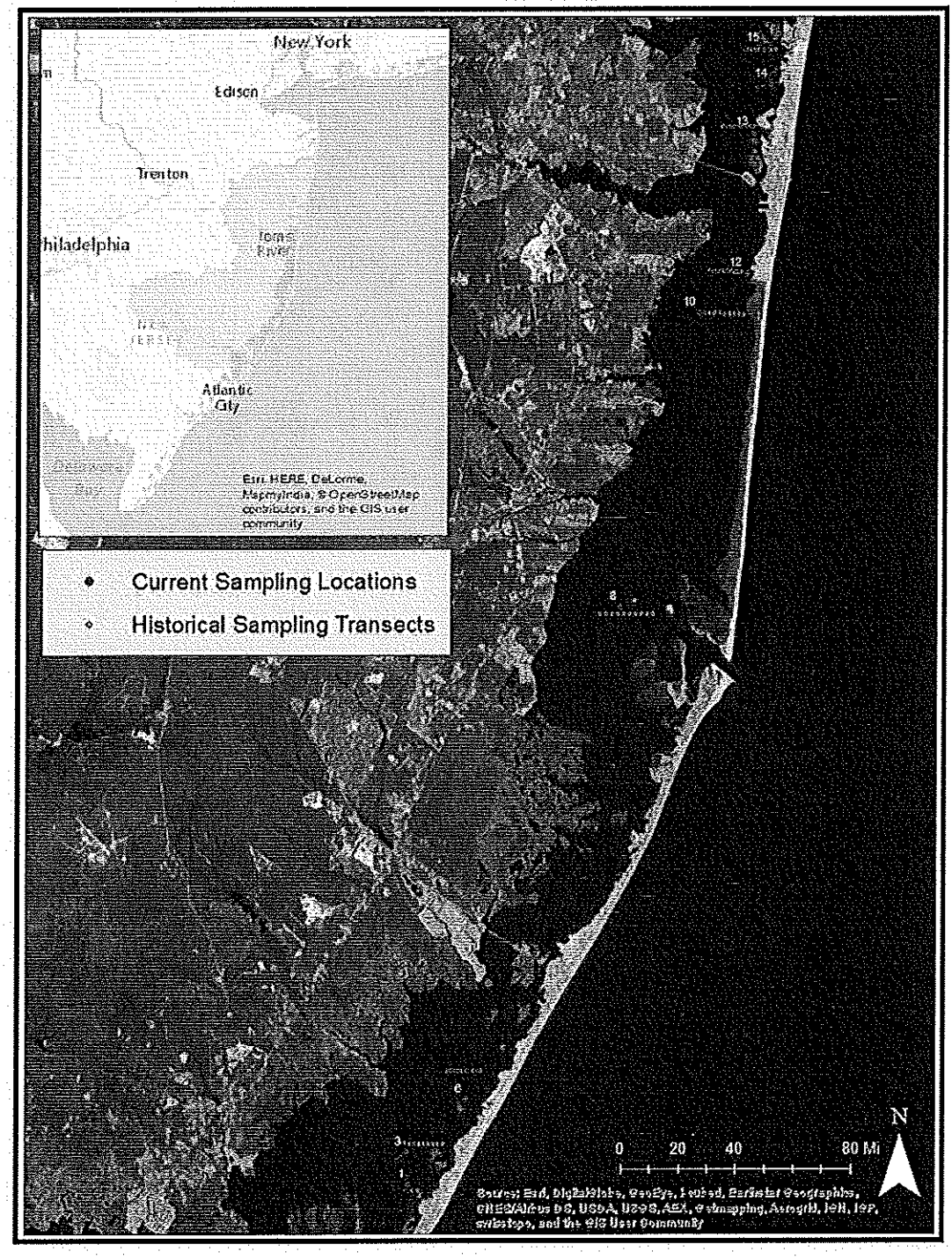

Table 1. Quality objectives and criteria for measurement data. Precision goals are expressed as relative percent difference (RPD) or relative standard deviation (RSD) between two or more replicate measurements. Bias goals are expressed either as absolute difference (± value) or percent deviation from the "true" value. Completeness goal is the percentage of expected results that are obtained successfully to maximize representativeness of the samples.

Indicator/Data Type	Maximum Allowable Precision Goal	Maximum Bias Goal	Completeness Goal
SAV			
Biomass	30%	10%	100%
Density	30%	10%	100%
Macroalgae			
Biomass	30%	10%	100%
Epiphytes			
Biomass	30%	10%	100%
Water Column Characteristics			
Temperature	10%	0.15 °C	100%
Salinity	10%	0.1 PSU	100%
pH	10%	0.2 units	100%
Dissolved oxygen	10%	0.3 mg/L	100%
Depth	10%	0.018 m	100%
Secchi depth	10%	NA	100%
Sediment Characteristics			
Percent organic content	10%	10%	100%

Table 2. Field quality control summary and actions taken to resolve or reconcile variability with project objectives. Data quality indicators (DQI) are defined as P = precision, B = Bias, R = representativeness, C_1 = comparability, C_2 = completeness; S = sensitivity.

Analyte	DQI	Field QC Check	Frequency of Collection	Acceptance Criteria	Action(s) Taken
Temperature (YSI meter)	$P/C_1/S$	Thermometer	Annually	± 1°C	Recalibration as specified
	P/B	Visual Fouling Check	Sampling effort	< 10% fouled	Cleaning and maintenance
	C_2/R	Handheld display	Sampling effort	± 1°C	Repair and replacement as needed
Conductivity/ Salinity (YSI meter)	$P/C_1/S$	Standard Seawater	Sampling effort	± 0.2 ppt	Recalibration as specified
	P/B	Visual Fouling Check		< 10% fouled	Cleaning and maintenance
	C_2/R	Handheld display		± 0.2 ppt	Repair and replacement as needed
Dissolved oxygen (YSI meter)	$P/C_1/S$	Water-saturated air	Sampling effort	± 5%	Recalibration as specified
	P/B	Visual Fouling Check		< 10% fouled	Cleaning and maintenance
	C_2/R	Handheld display		± 5%	Repair and replacement as needed
pH (YSI meter)	$P/C_1/S$	Standard buffers	Sampling effort	± 0.2 pH units	Recalibration as specified
	P/B	Visual Fouling Check		< 10% fouled	Cleaning and maintenance
	C_2/R	Handheld display		± 5%	Repair and replacement as needed
Secchi depth	$P/C_1/S$	Second instrument	Sampling effort	± 5%	Recalibration as specified
	P/B	Visual Fouling Check		< 10% fouled	Cleaning and maintenance
	C_2/R	Handheld display		± 5%	Repair and replacement as needed

Table 3. Analytical methods. References: 1 = Schumacher 2002; 2 = Small et al. 2013; 3 = Coles et al. 2001.

Analyte	Sample Matrix	Method	Analytical Method		Detection Limit	Reporting Limit
			Method	Reference		
Sediment TOC	Sediment	% Loss on Ignition	EMASC-001	1	0%	0%
Data Sonde: Salinity	Water	Conductivity probe: Yellow Springs Incorporated (Y.S.I.)	NA	2	0 ppt	0 ppt
Data Sonde: Temperature	Water	Yellow Springs Incorporated Thermistor	NA	2	-5 °C	-5 °C
Seagrass Biomass	Biomass	Dry weight by drying oven	NA	3	0 g DW m^{-2}	0 g DW m^{-2}
Macroalgal Biomass	Biomass	Dry weight by drying oven	NA	3	0 g DW m^{-2}	0 g DW m^{-2}
Epiphyte Biomass	Biomass	Dry weight by drying oven	NA	3	0 g DW m^{-2}	0 g DW m^{-2}

Table 4. Analytical quality control. Data quality indicators (DQI) are defined as P = precision, B = Bias, R = representativeness, C_1 = comparability, C_2 = completeness; S = sensitivity.

Method/SOP	DQI	Lab QC Check	Frequency	Accept. Criteria	Corrective Action
Water Quality Meter Calibration: Conductivity/ Specific Conductivity	P/B/S	Calibration to Standard	Daily	± 0. 01 mS cm^{-1}	Recalibrate machine
Water Quality Meter Calibration: DO	P/B/S	Calibration to Standard	Weekly	0.3 mg/L	Recalibrate machine
Water Quality Meter Calibration: pH	P/B/S	Calibration to Standard	Daily	0.2 units	
Water Quality Meter Calibration: Temperature	P/B/S	Calibration to Standard	Annual	± 1.0 °C	Recalibrate machine
Sediment Total Organic Content	P/S	Replicate samples	Monthly	± 5%	Replicate samples on same analytical balance (n = 9 per site)
	B/C_1	Triplicate measurements	Per processing	± 5%	Samples measured 3 times on same analytical balance
	R/C_2	Sample processing	Monthly	80%	Collect additional samples as needed
Seagrass Biomass	P/S	Replicate samples	Monthly	± 5%	Replicate samples on same analytical balance (n = 10 per site)
	B/C_1	Triplicate measurements	Per processing	± 5%	Samples measured 3 times on same analytical balance
	R/C_2	Sample processing	Monthly	80%	Collect additional samples as needed
Macroalgal Biomass	P/S	Replicate samples	Monthly	± 5%	Replicate samples on same analytical balance (n = 5 per site)
	B/C_1	Triplicate measurements	Per processing	± 5%	Samples measured 3 times on same analytical balance
	R/C_2	Sample processing	Monthly	80%	Collect additional samples as needed

Method/SOP	DQI	Lab QC Check	Frequency	Accept. Criteria	Corrective Action
Epiphyte Biomass	P/S	Replicate samples	Monthly	± 5%	Replicate samples on same analytical balance (n = 15 per site)
	B/C_1	Triplicate measurements	Per processing	± 5%	Samples measured 3 times on same analytical balance
	R/C_2	Sample processing	Monthly	80%	Collect additional samples as needed

Table 5. Lowest detection limit for samples.

Indicator/Data Type	Units	Minimum Reporting Level
SAV		
Biomass	g DW m^{-2}	0
Density	# shoots m^{-2}	0
Macroalgae		
Biomass	g DW m^{-2}	0
Epiphytes		
Biomass	g DW m^{-2}	0
Water Column Characteristics		
Temperature	°C	-5
Salinity	PSU	0
Secchi depth	cm	0
Sediment Characteristics		
Total organic content	percent	0.1

Table 6: Coordinates (Decimal degrees) of seagrass sampling stations. Site number refers to location in relationship to previously established research transects (#1-15). See Figure 1 for representation of all transects and current sampling sites.

Latitude	Longitude	Site #
39.57246	74.25129	1
39.58443	74.25255	3
39.6039	74.22392	6
39.78495	74.14985	8
39.89312	74.11174	10
39.90771	74.08906	12
39.95913	74.08618	13
39.9767	74.0773	14
39.98976	74.08128	15

APPENDICES

Appendix 1. Standard Operating Procedures for entire project

Appendix 1.1 Field Sampling

Before Leaving the Dock:

1) Make sure that the following items are prepared and are on the boat or are ready in the laboratory once the sampling is complete. Check off each item as it is addressed.

General

a. Field sheets
b. Pencils
c. Sharpies
d. Plastic clipboard
e. Dry box
f. 2 - 5 gallon buckets
g. Dive gear (mask, snorkel, wet suit)
h. Camera w/case
i. Extra memory card for camera
j. Cell phone in waterproof case
k. Cooler for lunch w/ice and water
l. State boaters safety card
m. Sunscreen
n. Bug spray
o. Dive Flag for boat
p. In water dive flag
q. Boat key
r. Boat Log Book
s. Anchor
t. Diver Ladder
u. Extra dock line

Water Quality

a. Hand held YSI in bucket
b. Extra batteries for YSI
c. Secchi disk and line

Biomass

a. biomass corer and plug
b. transect tape
c. field sieve
d. 10 gallon-sized pre-labeled Ziploc bags (5 per site) for *Z marina* and *R maritima*
e. 5 gallon-sized pre-labeled ziploc bags (10 per site) for macroalgae
f. 15 - 1 quart pre-labeled ziploc bags (15 per site) for epiphytes

Sediment Analysis

v. 1 large cooler with ice

w. 9 (3.25"x 6") cores for sediment analysis (9 per site)
x. 18 plugs
y. 1 core divider
z. Metal spatula
aa. metal tray
bb. DI water
cc. 27 labeled sample bags

Locating the Station:

1) "Tighten" the resolution on console GPS unit and motor over station (into wind/current, whichever is dominant)
2) Anchor nearby (as close as possible without interfering with diver in water), considering wind and current.
3) Record site location (transect and station), time (EST), and general weather conditions on field sheet.

Once at the Station: (for specific information about each protocol please see Appendix 2.2)

1) Deploy YSI units - allow to contact bottom briefly, pull up approx 10cm from bottom and lash to cleat, allow to equilibrate for 2-3 minutes, record physico-chemical parameters on field sheet (refer to field sheet).
2) Obtain depth from sonde, meter stick and Secchi values. The Secchi disk is to be lowered into the water from the shady side of the boat (if appropriate) and read without sunglasses.
3) Diver enters water to put dive flag in a clear area to warn passing boaters of divers in the water.
4) Diver obtains sediment cores from each site and transports them back to the boat. Technician on board sections core, places sample into the bags with appropriate label, and places in cooler.
5) Diver obtains macroalgal samples, places them in the appropriate bag and transports the samples back to the boat. Technician on board places sample in cooler.
6) Diver obtains epiphyte samples, places them in the appropriate bag and transports the samples back to the boat. Technician on board places sample in cooler.
7) Diver obtains seagrass core from a haphazardly selected location and places it on box sieve held by a second diver. The second diver sieves the sample removing excess sediment, places the in the appropriate bag and transports the samples back to the boat. Repeat process a total of 5 times. Technician on board places samples in cooler.
8) Diver obtains percent cover, *Zostera* blade height and presence/absence of shellfish and mesograzers.
9) Supervisor/delegated technician reviews field sheet and initials it if complete and approved.

10) Team retrieves dive float and moves on to next station.

Upon return:

Field Sheets

1) Field sheets are reviewed to verify that all stations and samples are accounted by the project manager.
2) Sheets are scanned and placed in designated physical and electronic folders/binders and placed in an approved location at MSEFS
3) Photocopied sheets are relocated to a secondary secure location (Stockton University Office) and placed in the binder there.

Biomass:

1) Biomass samples are cross-checked with field sheets to assure all samples are accounted for. The supervisor or senior technician should initial on a tracking sheet that all samples are accounted for. If any samples are missing, the site should be revisited at the next possible opportunity to obtain a replacement sample.
2) Biomass samples from the day are placed in a larger, single bag (small or medium wastepaper basket bag) and placed in the "cold water table" in building 504 at MSEFS.
3) All biomass samples should be kept in the "cold water table" and processed within 72 hrs. If unable to process within 72 hrs, samples should be frozen along with the biomass samples.

Sediment Total organic content

1) Sediment total organic content samples are cross-checked with field sheets to assure all samples are accounted for. The supervisor or senior technician should initial on a tracking sheet that all samples are accounted for. If any samples are missing, the site should be revisited at the next possible opportunity to obtain a replacement sample.
2) Sediment samples from the day are placed in a larger, single bag (small or medium wastepaper basket bag) and placed in the "cold water table" in building 504 at MSEFS.
3) All sediment samples should be kept in the "cold water table" and processed within 72 hrs.

Other:

1) The field sheets should be transcribed into a digital spreadsheet as soon as possible.

Appendix 1.2 Sediment Total Organic Content *(Loss on Ignition: EMASC-001)*

1. Materials and Equipment:
    a. clear acrylic cores (10.4 cm diameter by 10 cm depth)
    b. 10.4 cm diameter red lids
    c. cooler with ice
    d. Gloves
    e. rubber plunger (of slightly smaller diameter than acrylic core) on free-standing pole
    f. metal plate
    g. metal spatula
    h. 5 gallon bucket
    i. clear acrylic cores cut to 2cm as sediment sub-section depths
    j. De-ionized (DI) water for cleaning
    k. Large plastic tray
    l. pre-weighted/numbered aluminum pans (use pencil to number pan)
    m. analytical balance capable of 3 decimal places
    n. drying oven set at 50°C
    o. muffle furnace capable of maintaining 400°C
    p. Desiccator with desiccant
    q. Tongs
    r. Heat resistant gloves
2. Field Methods:
    a. Select sampling sites based on needs of study.
    b. At site randomly select area to core. Place core flush with the sediment surface and push down to a minimum depth of 10cm.
    c. Secure the red lid on top of the corer and carefully remove the core. Cap the bottom of the core with a second red lid and hold upright with a minimum of 2 cm of water above the sediment surface.
    d. Place plunger in 5 gallon bucket. With stopper on top of core, remove bottom stopper. Place core on top of plunger, remove top stopper, and push sediment up inside core with plunger until sediment surface is pushed to top of core.
    e. To sub-core, place 2 cm core section on top and push sediment to top of sub-core. Insert metal plate between cores to separate it. Place sediment sub-section into the appropriate plastic bag.
    f. Divide the core into two more sections following the same protocol.
    g. Repeat coring procedure until 9 cores are collected per site. Store all samples on ice in cooler until the samples are taken back to the lab.
    h. Rinse acrylic sub-cores, metal plates and metal spatulas with DI water between core sampling.

3. Laboratory Procedure and Data Recording:
    a. Place sample from plastic bag into clean large plastic tray. Divide the sample in half placing one half into pre-weighed, numbered aluminum pans using the metal spatula.
    b. Weigh and record weight, date sample was collected, and sediment core #, site from where it was collected, depth section on datasheet.
    c. Discard remaining sediment sections in 5 gallon bucket.
    d. Place aluminum pans with sediment in drying oven (50°C) for a minimum of 24 hrs. Weigh each sample a minimum of 3 times using the same scale or until the sample reaches a constant dry weight (weight loss < 0.5 mg). Record all weights on the appropriate data sheet.
    e. Once the sample as reached a constant dry weight place into muffle oven at 400 °C for a minimum of 8 hours.
    f. After combustion, remove samples from muffle oven with tongs and heat resistant gloves, and place samples into desiccator to cool. Once cool weigh samples and record weights.
    g. Total organic content is presents as a percent and is calculated using the following equation:

$$\%\,TOC = \frac{(pre-combustion\,weight - post\,combustion\,weight)}{pre-combustion\,weight} \times 100$$

Appendix 1.3 Seagrass Biomass *(Duarte and Kirkman, 2001):*

1. Materials and Equipment:
    a. Local area map and tide tables
    b. Small boat for visiting sites
    c. GPS (if available)
    d. Snorkel, mask, and wetsuit for intertidal sampling
    e. Cooler with ice for storing samples
    f. 5 pre-labeled plastic bags (with a zipper, and date, site identification code, and sample number written on bag in permanent ink) for storing samples
    g. Waterproof data sheets and a clipboard
    h. Sampling corer (22 cm diameter) of light and durable material (e.g. PVC) with hole and stopper on lid
    i. Box sieve (1.0 cm mesh)
    j. Large plastic tray
    k. Single edge razor blades
    l. Distilled/deoionized water
    m. Preweighed and numbered aluminum envelopes
    n. Digital scale capable of reading 3 decimal places
    o. Drying oven
2. Field Methods:
    a. Select sampling sites based on needs of study.
    b. At site randomly select area to core. Place core flush with the sediment surface and push down.
    c. Place the stopper in to the hole on top of the corer (make sure no leaves are floating out of the top of the corer) and carefully remove the core.
    d. Place the sediment and plants removed with the core into the mesh box sieve and rinse with site water.
    e. Place all plant material into pre-labeled plastic bag with site water to keep plants moist.
    f. Collect 5 cores per site. Store all samples on ice in cooler until the samples are taken back to the lab.
3. Laboratory Procedure and Data Recording:
    a. Remove seagrass from bag and place in large plastic tray. Make sure that the entire sample has been removed from the bag. Set bag aside for cleaning and reuse.
    b. Separate all plants by species and into vegetative or flowering shoots.
    c. Scrape leaf blades with Single edge razor blades held 90° to the leaf surface. Be careful to not remove any leaf epidermis.
    d. Rinse seagrass with distilled or deionized water.

e. Count the total number of shoots in the sample.
f. Separate leaves from the rhizome directly below the leaf sheath into aboveground and belowground biomass.
g. Fill out data sheet with date, site, replicate, and species and place sample into appropriate aluminum foil envelope and record the weight (different envelopes will be used for above and belowground biomass).
h. Place all samples in an air circulating oven at 50°C for a minimum of 24 hours.
i. Weigh each sample a minimum of 3 times using the same scale or until the sample reaches a constant dry weight (weight loss < 0.5 mg). Record all weights on the appropriate data sheet.
j. Biomass is measured as g Dry Weight (g DW). To determine the final sample dry weight subtract the weight of the aluminum foil envelope from the last dry weight of the sample.
k. Biomass is converted from g Dry Weight (DW) cm^{-2} to g DW m^{-2} by using the following equation: $\frac{x\ g\ DW}{380\ cm^2} \times \frac{10{,}000\ cm,^2}{1\ m^s} = x\ g\ DW\ m^{-2}$

Appendix 1.4 Macroalgae Biomass *(Sidik et al., 2001)*

1. Materials and Equipment:
    a. Local area map and tide tables
    b. Small boat for visiting sites
    c. GPS (if available)
    d. Snorkel, mask, and wetsuit for intertidal sampling
    e. Cooler with ice for storing samples
    f. 10 pre-labeled plastic bags (with a zipper, and date, site identification code, and sample number written on bag in permanent ink) for storing samples
    g. Waterproof data sheets and a clipboard
    h. Sampling quadrat (25 cm x 25 cm) of light and durable material (e.g. PVC)
    i. Dive knife
    j. Large plastic tray
    k. Distilled/deoionized water
    l. Identification guides for macroalgae
    m. Pre-weighed and numbered aluminum envelopes
    n. Hand lens or magnifying device
    o. Digital scale capable of reading 3 decimal places
    p. Drying oven
2. Field Methods:
    a. Select sampling sites based on needs of study.
    b. At site randomly select area to toss quadrat. Make sure that the quadrat is placed completely flush with the sediment surface.
    c. Carefully cut around the interior edges of the quadrat and scrape holdfasts away from substrate
    d. Carefully remove macroalgae from quadrat and place into pre-labeled plastic bag.
    e. Collect 10 samples per site. Store all samples on ice in cooler until the samples are taken back to the lab.
3. Laboratory Procedure and Data Recording:
    a. Remove algae from bag and place in large plastic tray. Make sure that the entire sample has been removed from the bag. Set bag aside for cleaning and reuse.
    b. Separate all algae by species
    c. Rinse algae with distilled or deionized water.
    d. Identify species using guides and magnifying equipment
    e. Fill out data sheet with date, site, replicate, and species.
    f. Place sample into appropriate aluminum foil envelope and record the weight.
    g. Place all samples in an air circulating oven at 50°C for a minimum of 24 hours.

h. Weigh each sample a minimum of 3 times using the same scale or until the sample reaches a constant dry weight (weight loss < 0.5 mg). Record all weights on the appropriate data sheet.

i. Biomass is measured as g Dry Weight (g DW). To determine the final sample dry weight subtract the weight of the aluminum foil envelope from the last dry weight of the sample.

j. Biomass is converted from g DW cm^{-2} to g DW m^{-2} by using the following equation: $\frac{x\ g\ DW}{25\ cm^2} \times \frac{10{,}000\ cm,^2}{1\ m^s} = x\ g\ DW\ m^{-2}$

Appendix 1.5 Seagrass Epiphyte Biomass *(Kendrick and Lavery, 2001)*

1. Materials and Equipment:
    a. Local area map and tide tables
    b. Small boat for visiting sites
    c. GPS (if available)
    d. Snorkel, mask, and wetsuit for intertidal sampling
    e. Cooler with ice for storing samples
    f. 15 pre-labeled plastic bags (with a zipper, and date, site identification code, and sample number written on bag in permanent ink) for storing samples
    g. Waterproof data sheets and a clipboard
    h. Fine forceps
    i. Large plastic tray
    j. Single edge razor blades
    k. Distilled/deoionized water
    l. Pre-weighed and numbered aluminum pans (label pans with pencil)
    m. Digital scale capable of reading 4 decimal places
    n. Drying oven
2. Field Methods:
    a. Select sampling sites based on needs of study.
    b. At site randomly select 1 single shoot to sample. Remove shoot from rest of pant at the first rhizome increment.
    c. Place all plant material into pre-labeled plastic bag with site water to keep plants moist.
    d. Repeat random shoot collection 15 times per site. Store all samples on ice in cooler until the samples are taken back to the lab.
3. Laboratory Procedure and Data Recording:
    a. Remove seagrass from bag and place in large plastic tray. Make sure that the entire sample has been removed from the bag. Set bag aside for cleaning and reuse.
    b. Separate shoots into individual leaves.
    c. Remove larger epiphytes from the leaves by hand or with forceps.
    d. Scrape leaf blades with a Single edge razor blades held 90° to the leaf surface. Scrape the entire length of the leaf on both sides. Be careful to not remove any leaf epidermis.
    e. Rinse all material scraped off of the leaves into pre-weighed aluminum pans.
    f. Count the total number of leaves and measure the length and width for each leaf.
    g. Record all leaf data on data sheet along with date, site, replicate and sample wet weight.
    h. Place all samples in an air circulating oven at 60°C for a minimum of 24 hours.

i. Weigh each sample a minimum of 3 times using the same scale or until the sample reaches a constant dry weight (weight loss < 0.5 mg). Record all weights on the appropriate data sheet.
j. Calculate the leaf area for all leaves in each sample and then sum the areas. This will equal the total area of epiphytes sampled *l*.
k. Biomass is measured as g Dry Weight (g DW). To determine the final sample dry weight subtract the weight of the aluminum pan from the last dry weight of the sample.
l. Biomass is converted from g DW cm^{-2} to g DW m^{-2} by using the following equation: $\frac{x\ g\ DW}{l\ cm^2} \times \frac{10{,}000\ cm,^2}{1\ m^s} = x\ g\ DW\ m^{-2}$

Appendix 2. Project check lists

Appendix 2.1 Checklist for field sampling

General

1. field sheets
2. dive slates
3. pencils
4. sharpies
5. plastic clipboard
6. dry cooler
7. 5 gallon bucket
8. dive gear
9. Camera w/case
10. Extra memory card
11. Cell phone in waterproof case
12. Cooler for lunch w/ice and water
13. State boaters safety card
14. Sunscreen
15. Bug spray
16. Dive Flag
17. In water dive flag
18. Weight belt
19. Truck key
20. Trailer Box
21. Boat key
22. Boat Log Book
23. Anchor
24. Diver Ladder
25. Extra dock line

Water Quality

26. YSI 650 in bucket with read out
27. Extra batteries for YSI
28. Secchi disc and line

Sediment

29. 9 clear acrylic cores (10.4 cm diameter by 10 cm depth)
30. 18 10.4 cm diameter red lids
31. cooler with ice
32. Gloves
33. rubber plunger (of slightly smaller diameter than acrylic core) on free-standing pole
34. metal plate
35. metal spatula
36. 5 gallon bucket
37. clear acrylic cores cut to 2cm as sediment sub-section depths
38. De-ionized (DI) water for cleaning
39. 27 pre-labeled Whirl-Pak 6 oz bags

Biomass

40. biomass corer and plug
41. field sieve
42. 5 1 gallon pre-labeled Ziploc bags (5 per site) for *Z marina* and *R. maritima*
43. 10 1 gallon pre-labeled ziploc bags (5 per site) for macroalgae
44. 15 1 quart pre-labeled ziploc bags (15 per site) for epiphytes

Appendix 2.2 Checklist for laboratory analysis

Sediment TOC:

1. Large plastic tray
2. pre-weighted/numbered aluminum pans (use pencil to number pan)
3. analytical balance capable of 3 decimal places
4. aluminum baking pans
5. drying oven set at 50°C
6. muffle furnace capable of maintaining 400°C
7. Desiccator with desiccant
8. Tongs
9. Heat resistant gloves

Seagrass Biomass:

1. Large plastic tray
2. Single edge razor blades
3. Distilled/deoionized water
4. Preweighed and numbered aluminum envelopes
5. Digital scale capable of reading 3 decimal places
6. Drying oven

Macroalgal Biomass:

1. Large plastic tray
2. Distilled/deoionized water
3. Identification guides for macroalgae
4. Pre-weighed and numbered aluminum envelopes
5. Hand lens or magnifying device
6. Digital scale capable of reading 3 decimal places
7. Drying oven

Epiphyte Biomass:

1. Fine forceps
2. Large plastic tray
3. Single edge razor blades
4. Distilled/deoionized water
5. Pre-weighed and numbered aluminum pans (label pans with pencil)
6. Digital scale capable of reading 4 decimal places
7. Drying oven

Appendix 3: Projects Datasheets

Appendix 3.1 Field data sheet

Field Data Sheet

Date: _____ Time: _____ Site: _____

Temp C	_____	DO (%)	_____
Sp Cond	_____	DO (conc)	_____
Salinity	_____	Turb (NTU)	_____
pH	_____	Depth (sonde)	_____
Depth (stick)	_____	Secchi	_____

% Cover *Zostera*	_____	_____	_____
	_____	_____	
% Cover *Ruppia*	_____	_____	_____
	_____	_____	
% Cover macroalgae	_____	_____	_____
	_____	_____	
% Cover *other*	_____	_____	_____
	_____	_____	
5 blade lengths (mm) *(Zostera* only)	_____	_____	_____
	_____	_____	
Mesograzer/Shellfish (Presence/Absence)	_____	_____	_____
	_____	_____	

Supervisor Initials _____

Date Scanned: _____

Data Entered: _____

Appendix 3.2 Sediment TOC data sheet

Site: ____________
Date: ______________

Sediment Organic Matter Data Sheet

Core	Depth cm	Pan #	Pan Wt g	DW g Pan+Sed	DW g Pan+Sed	DW g Pan+Sed	Ash Wt g Pan + Sed	Ash Wt g Pan + Sed	Ash Wt g Pan + Sed
	0,2								
	2,4								
	4,6								
	0,2								
	2,4								
	4,6								
	0,2								
	2,4								
	4,6								
	0,2								
	2,4								
	4,6								
	0,2								
	2,4								
	4,6								
	0,2								
	2,4								
	4,6								
	0,2								
	2,4								
	4,6								
	0,2								
	2,4								
	4,6								
	0,2								
	2,4								
	4,6								

Date Scanned: __________
Date Entered: __________

Appendix 3.3 Seagrass biomass data sheet. **Spp/VF = species (Z. marina or R. maritima); AG/BG = above ground/below ground, WW = wet weight, DW = Dry weight.**

Site ____________________
Date ____________________

Seagrass Biomass Data Sheet

Rep	Spp/VF	AG/BG	Foil wt	DW g 1	DW g 2	DW g 3	# of shoots

Date Scanned: __________
Date Entered: __________

Appendix 3.4 Macroalgae biomass data sheet

Site _____

Date _____

Macroalgae Biomass Data Sheet

Rep	Species	Env. Wt g	DW g 1	DW g 2	DW g 3

Date Scanned: _____

Date Entered: _____

Appendix 3.5 Epiphyte area and biomass data sheet

Site _____
Date _____

Epiphyte Area and Biomass Data Sheet

Pan #	Pan Wt Initial	Pan Wt Final	Pan Wt Final	Pan Wt Final	# shoots	L/W	L/W	L/W	L/W	L/W	L/W	L/W

Date Scanned: _____
Date Entered: _____