Quality Assurance Project Plan For Mapping Eelgrass Beds in Casco Bay, Maine

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Document date:

Initial: October 12, 2018
Final: December 20, 2018

Project period:
2018

QAPP Approval Date:

Title

Quality Assurance Project Plan for Mapping Eelgrass Beds in Casco Bay

Contacts and approvals:

Name	Project Role	Organization	Signature & Date
Angela Brewer	Project Manager	Maine Dept. of Environmental Protection	[signature] 1/2/19
Matthew Liebman	Project Officer	U.S. Environmental Protection Agency	[signature] 1/28/19
Curtis Bohlen	Project Advisor	Casco Bay Estuary Partnership	[signature] 12/26/18
Matthew Craig	QAPP Preparation	Casco Bay Estuary Partnership	[signature] 12/20/18

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1.3 Distribution List

Table 1. QAPP distribution list.

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John Noll	Maine Dept. of Agriculture, Conservation & Forestry	Funder	john.noll@maine.gov, 207-287-4919
John Dwyer	Geomni	Aerial Imagery Contractor	JLDwyer@verisk.com; 207-827-5979
Matthew Liebman	U.S. Environmental Protection Agency	Project Officer	liebman.matt@epa.gov; 617-918-1806
Claire Kiedrowski	Cornerstone Energy Services, Inc.	Aerial Imagery Contractor	ckiedrowski@cornerstoneengeryinc.com; 207-942-5200
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Table 2. List of Acronyms & Abbreviations

Abbreviation	**Meaning**
APP	Appendix
CBEP	Casco Bay Estuary Partnership
CCAP	Coastal Change Analysis Program (NOAA)
CCMP	Comprehensive Conservation and Management Plan
DMC	Digital Mapping Camera
EPA	U.S. Environmental Protection Agency
GeoTIFF	Georeferenced Tagged Image File Format
GIS	Geographic Information System
GPS	Global Positioning System
GRTS	Generalized Random Tessellation Stratified Sample
GSD	Ground Sample Distance
IMU	Inertial Measurement Unit
MDACF	Maine Department of Agriculture, Conservation & Forestry
MDEP	Maine Department of Environmental Protection
MDMR	Maine Department of Marine Resources
MIFW	Maine Department of Inland Fisheries and Wildlife
MEGIS	Maine Office of GIS
MLLW	Mean Lower Low Water
MMU	Minimum Mapping Unit
NEP	National Estuary Program
NIR	Near InfraRed
NOAA	National Oceanic and Atmospheric Administration
NSSDA	National Standard for Spatial Data Accuracy
PDOP	Position Dilution Of Precision
QA/QC	Quality Assurance and Quality Control
QAPP	Quality Assurance Project Plan
RTK GPS	Real Time Kinematic Global Positioning System
RGB	Red Green Blue
RMSC	Root Mean Square Error
SAP	Site Analysis Plan
TNC	The Nature Conservancy in Maine
USM	University of Southern Maine

1.4 Project Organization

The project will be directed by Maine DEP with technical assistance from contractors and CBEP. Funding for the project will be provided by Maine DEP, CBEP, MDACF, TNC, and MIFW. CBEP entered into a Memorandum of Understanding with Maine DEP to complete this effort. The project has three components: (1) an aerial survey; (2) photointerpretation of the aerial imagery; and (3) a ground truth survey. DEP will hire contractors to complete all three components of the project.

The Project Manager will be Angela Brewer of MDEP. The Project Manager will be responsible for managing administrative documents, including the Casco Bay Aerial Imagery Survey RFP, the Aerial Imagery Contractor and the Aerial Survey Coordinator contracts, and signing off on deliverables. MDEP is providing funding toward the project, as well as a vessel, a vessel captain, and other assistance with carrying out the field verification.

The Aerial Imagery Contractor will be Cornerstone Energy Services. Claire Kiedrowski will be responsible for all work tasks for the aerial survey. Cornerstone will subcontract with Geomni, led by John Dwyer. Geomni is a subcontractor to Cornerstone on the project. The Aerial Imagery Contractor will be responsible for acquisition of aerial imagery, orthorectification and QA/QC of imagery, and production of draft and final imagery.

The Aerial Survey Coordinator will be Seth Barker, Independent Contractor. The Aerial Survey Coordinator will be responsible for (A) aerial imagery coordination, including: (1) planning the acquisition of aerial imagery, (2) identification of periods when conditions are optimal for photography, (3) review of aerial imagery deliverables provided by Aerial Imagery Contractor, (4) distribution of imagery to Project Manager; (B) Photointerpretation and GIS, including (1) Mapping of eelgrass distribution, (2) field verification of mapped eelgrass distribution, (3) QA/QC and distribution of GIS files containing eelgrass polygons and percent cover to Project Manager, and (4) composition of a summary project report.

CBEP will prepare the project QAPP, receive and implement edits from reviewers, and circulate the EPA approved version for signatures. CBEP is providing funding toward the project.

Project collaborators MDACF, MIFW, and TNC are providing funding and technical assistance to support the project.

EPA will provide technical assistance through review of the QAPP.

The principal users of the data from this project will be DEP, CBEP, EPA, and the other project collaborators. Imagery and eelgrass cover maps will be publicly available through MEGIS.

This QA Project Plan is for the 2018 bay-wide eelgrass mapping effort in Casco Bay.

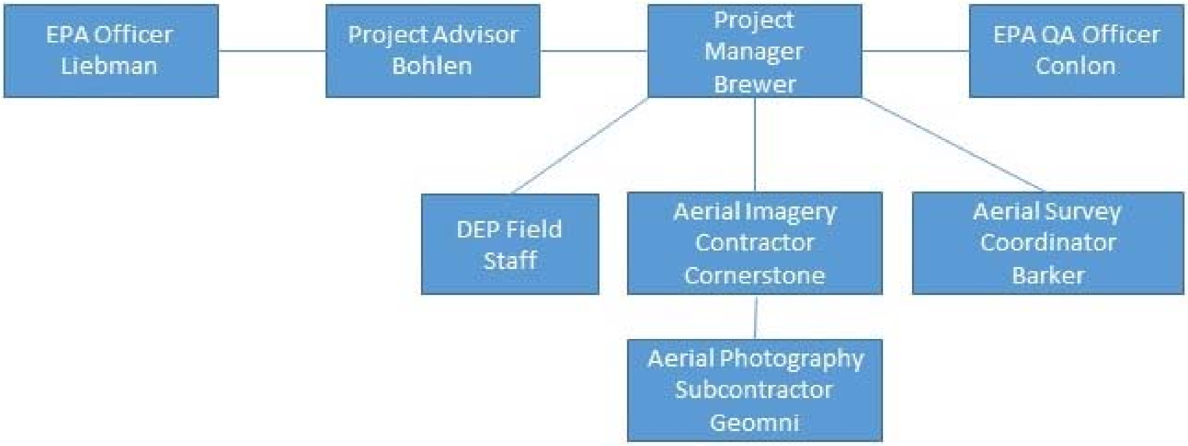

Figure 1. Organization Chart

1.4.1 Amendments or revisions to QAPP

For future eelgrass mapping efforts, amendments or revisions to the QAPP may be required. Revisions may be necessary (1) to reflect changes in project organization, tasks, schedules, objectives, and methods; (2) to add descriptions of additional monitoring methods; (3) to address deficiencies and nonconformance; (4) to improve operational efficiency; and/or (5) to accommodate unique or unanticipated circumstances. Requests for Amendments/Revisions will be made to EPA via email. Any changes that significantly affect the technical and quality objectives of the project will require a revision and re-approval of the QAPP, and a revised copy will be sent to all persons on the distribution list.

1.5 Problem Definition/Background

1.5.1 Problem Statement

This Quality Assurance Project Plan (QAPP) covers work by MDEP and project partners to document areal extent and percent cover of eelgrass beds in Casco Bay. For the purpose of this project, Casco Bay is defined as the marine waters to the northwest of Two Lights State Park in Cape Elizabeth to Small Point in Phippsburg (Figure 2).

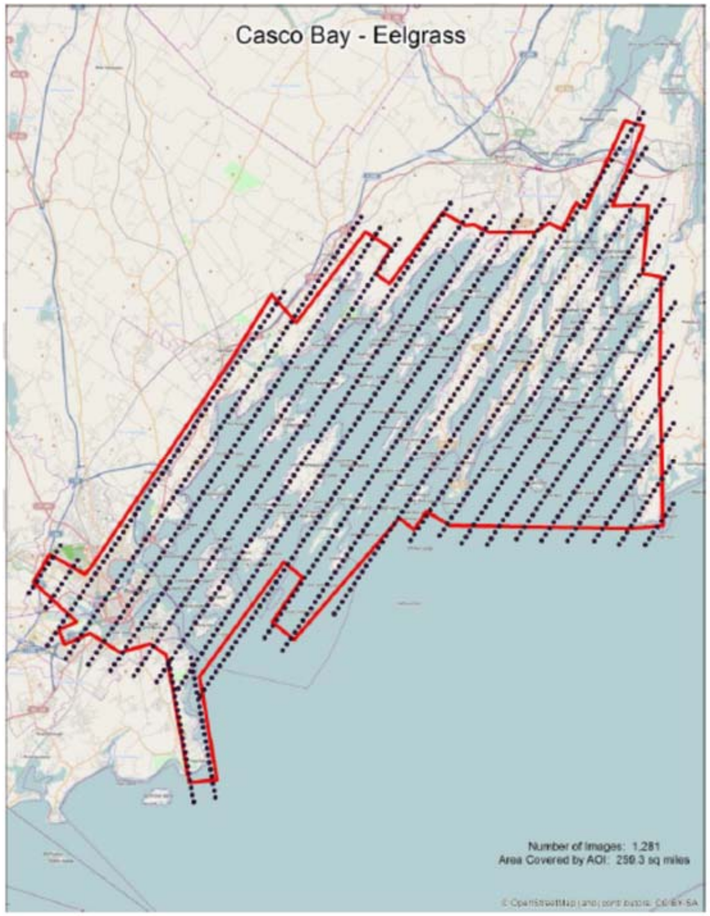

Figure 2. Study Area for 2018 eelgrass mapping (outlined in red) with preliminary flight lines.

Eelgrass (*Zostera marina*) forms extensive intertidal and nearshore subtidal meadows in Casco Bay (CBEP 2010, 2015). Eelgrass meadows, or beds, provide critical nursery habitat for larval and juvenile invertebrates and fish, as well as serving as feeding and nesting areas for migratory species of fish and birds. Eelgrass meadows provide water quality benefits through nutrient uptake, sediment stabilization, and buffering of pH in the adjacent water column while storing carbon and attenuating wave and current energy (Neckles 2015 [citing Hendriks *et al.* 2014, Mcleod *et al.* 2011, and Orth *et al.* 2006]). Eelgrass is widely recognized as critical habitat for species of commercial interest at various life stages. Through the State's wildlife action planning process, submerged aquatic vegetation was a habitat assigned to at least 20 of Maine's Species of Greatest Conservation Need.

Casco Bay is a federally-designated *Estuary of National Significance* under the Clean Water Act, and the Casco Bay Estuary Partnership (CBEP), part of the National Estuary Program, utilizes eelgrass coverage as a state-of-the-system indicator of ecosystem integrity (CBEP 2010, 2015). CBEP's recently updated Comprehensive Conservation and Management Plan (CCMP) focuses on eelgrass meadows as a vital habitat within the Bay's ecosystem, and calls for expanded efforts to monitor and restore eelgrass beds (CBEP 2016).

Legislative mandate directs MDEP to "…prevent, abate and control the pollution of the air, water and land and preserve, improve and prevent diminution of the natural environment of the State" (38 MRS §341-A). To achieve this mission, the MDEP's Marine Unit implements "…a comprehensive monitoring strategy of estuaries…" (No. 3) and provides "…technical information to committees of the CBEP" (No. 61)(2017 Priorities & Commitments List). Further and as part of the biennial Integrated Water Quality Monitoring and Assessment Report to EPA, the MDEP's Marine Unit must determine attainment status of marine waters of the State based on designated uses established for respective water classifications. Eelgrass is an important indicator of aquatic life use support when considering water quality. Eelgrass is ubiquitous along the Maine coast and knowledge of its presence/absence and vitality is essential to detection of change and possibly, impairment determination. Maine does not have a percent cover or areal extent (change) criterion for eelgrass. However, gains and losses of eelgrass in Casco Bay, where mapping history is somewhat more robust than the remainder of Maine, are informative and serve to focus DEP's attention on locations where water quality contributions to change may be a dominant factor. At a Bay-wide scale, a significant decline in the areal extent of eelgrass bed cover and/or density is indicative of a degraded resource condition. In New Hampshire and some other New England states, eelgrass declines factor into impairment designation for aquatic life use in marine waters, but this is not currently the case in Maine.

Aerial surveys of the Casco Bay shoreline were conducted near low tide by the Maine Department of Marine Resources (MDMR) in June through September of 1993-1994 and 2001-2002 at a scale of 1:12,000, based on the National Oceanic and Atmospheric Administration Coastal Change Analysis Program protocols (C-CAP) (NOAA 1995; 2001). A higher resolution, low tide aerial survey of Casco Bay was completed during August 2013, and produced 4-band digital orthoimagery at 0.15-meter pixel resolution. All three surveys produced georectified imagery in seamless mosaics, with a state employee or independent contractor completing eelgrass groundtruthing and production of GIS polygons and associated percent cover estimates on a four category scale as applied to eelgrass by Orth *et al.* (1991), where 1 = 0-10% cover (very sparse), 2 = 10-40% cover (sparse), 3 = 40-70% cover (moderate), and 4 = 70-100% cover (dense). Final cover classes are assigned to each individual eelgrass bed based on interpretation of the final imagery. The seamless mosaic is used for the interpretation of cover for each contiguous eelgrass bed.

A new round of eelgrass mapping is needed to assess current eelgrass distribution, bed size, and percent cover. Eelgrass distribution and percent cover are critical to State and Federal resource agencies for effective protection of eelgrass resources, particularly related to aquatic life use assessments and permitting. The updated eelgrass coverage files will also support higher resolution, smaller scale monitoring efforts aimed at assessing the impact of stressors such as invasive species, disease, and nutrient enrichment at a subset of local eelgrass beds, providing an 'early warning' of emerging threats to eelgrass health at a bay-wide scale.

CBEP will utilize the resulting data in numerous ways, including updating the status of eelgrass beds an indicator of 'ecosystem health' in the 2020 State of the Bay report. The results will also be particularly important in informing future strategies and actions of the *ad hoc* committee, the Casco Bay Eelgrass Consortium, with regard to eelgrass management, monitoring, and research needs. Maps of eelgrass will be used by MDEP and CBEP to evaluate trends in eelgrass population over time and to inform other resource management decisions, such as permitting.

Note: This QAPP expands and updates well established protocols that have been previously described by Barker (2015) and MDEP (2018) for mapping eelgrass in Casco Bay. Others have used similar methods, including the Piscataqua Region Estuaries Partnership for mapping eelgrass in the Great Bay region of New Hampshire in 2013 and 2018. The relative similarity of methodologies over multiple rounds of eelgrass mapping in both Casco Bay and Great Bay allows for direct use of previously developed content. Some sections of this QAPP directly utilize text from the PREP QAPP, *Great Bay Estuary Submerged Aquatic Vegetation (SAV) Monitoring Program for 2018: Quality Assurance Project Plan* (Matso *et. al.* 2018), as well as Barker 2015 and MDEP 2018.

1.5.2 Project/ Task Description

The core tasks for eelgrass mapping are as follows. A generalized timeline is provided below, with the understanding that contractors and contract language dictate scheduling details, and completion of Tasks 4 – 9 depends on date of imagery acquisition.

1. Hire contractors – the Project Manager will select an Aerial Survey Coordinator and an Aerial Imagery Contractor via State of Maine competitive bid process to complete the aerial survey, field verification, photointerpretation, and reporting tasks. December – February.
2. Prepare Quality Assurance Project Plan – CBEP will prepare a QAPP for mapping eelgrass in conjunction with MDEP and with approval from EPA. March – May.
3. Collect aerial imagery – Two days are typically needed to acquire imagery. The Aerial Survey Coordinator will work with the Aerial Imagery Contractor to plan and conduct flights for acquiring aerial imagery of Casco Bay between June and September 2018, preferably on sequential days in June, July, or August, within two hours of low spring tides (Table 3). In addition to negative low tides, ideal conditions include early-mid morning, low sun angle (25-50°), low wind velocity (<10 mph), and low cloud cover (<10%). The survey should not occur following a rain event or during a phytoplankton bloom in order to minimize water column turbidity. June – September.

4. Orthorectification, Mosaicking, and Tiling – The Aerial Imagery Contractor will refine aerial imagery to ensure presentation of draft imagery to the Aerial Survey Coordinator. Imagery will be orthorectified using specialized software. Imagery will then be mosaicked into a seamless database using OrthoVista software. Once imagery is color corrected and mosaicked, imagery will be tiled in a layout suitable for MDEP. Georeferenced mosaic images will be in GeoTIFF format. June – September, following Task 3.
5. Photointerpret aerial imagery – The Aerial Survey Coordinator will review the draft aerial imagery and, based on best professional judgement, prepare preliminary maps of eelgrass beds based on Barker 2015. Quality control measures described in this document are the responsibility of the Aerial Survey Coordinator. June – September, following Task 4.
6. Conduct field verification surveys – The Aerial Survey Coordinator will work with DEP to schedule and conduct boat-based site visits and employ underwater video to verify eelgrass presence/absence. June – September.
7. Map adjustments – The Aerial Survey Coordinator will refine preliminary maps of eelgrass distribution based upon field verification surveys and underwater video, resulting in a final layer consisting of polygons with percent cover assignments and associated metadata. Pixel size dictates accuracy of interpretation. The Aerial Survey Coordinator generates the GIS layer from delineation of polygons on an individual bed basis. October – December.
8. Reporting – The Aerial Survey Coordinator will prepare a report that summarizes findings and evaluates whether or not data quality objectives for the project have been met.
9. Data management and archiving – CBEP will make the project report available to the public on the CBEP web site. GIS datasets for aerial imagery and final eelgrass maps will be made available for download from MEGIS. All data associated with the project, including underwater video, will be archived with CBEP and MDEP as electronic files.

Table 3. Optimal survey windows based on Portland tide station tide predictions. Two sequential days are required to complete imagery acquisition for Casco Bay.

Date	Predicted Time of Low Tide	Predicted Height of Low Tide (Ft. MLLW)
June 16	07:41	-1.6
June 17	08:35	-1.4
June 18	09:32	-1.1
July 15	07:24	-1.7
July 16	08:18	-1.6
July 17	09:13	-1.2
August 14	07:56	-1.4
August 15	08:48	-1.0

1.6 Data Quality Objectives and Criteria

Each mapped eelgrass bed will be assigned a percent cover class to convey eelgrass density within the bed. The resolution of aerial imagery and eelgrass bed mapping should be sufficient to accurately distinguish between cover classes. Data quality indicators for the aerial imagery, ground-truth field surveys, and photointerpretation are summarized in Tables 4, 5 and 6.

Table 4. Data Quality Indicators, Criteria, and Quality Control Protocols for the Aerial Survey

Data Quality Indicator	Criteria	Protocol
Imagery Completeness	4-band (RGB and NIR) source imagery obtained for 100% of study area; Forward lap will be at least 60% and sidelap at least 30%	Extent of imagery will be compared to study area and project objectives.
Imagery Resolution	Ground Sample Distance (GSD; the distance between pixels in the image on the ground) less than or equal to .30 meters (1 foot)	Pixel size of imagery will be compared to criteria.
Spatial Accuracy	Horizontal positional accuracy less than or equal to 0.62 meters (2 feet) Root Mean Square Error following guidance from NSSDA	The positions of 20 known locations in the ortho-rectified imagery will be checked against the known coordinates.
Environmental & Timing Conditions	Environmental & timing conditions met during flight* -2018 flight windows: 6/16-18; 7/15-17; 8/14-15 - Low spring tide (+/- 2 hrs.) - Low sun angle (25-50^{O}) - Low cloud cover (<10%) - Calm winds (<10 mph) - No preceding rain events - Good water clarity	Environmental & timing conditions during flight will be compared to criteria; images will also be inspected for cloud shadow, density, clarity and image consistency.

* The following people will communicate by email and cell phone in order to determine that environmental conditions are met: Seth Barker, John Dwyer, Claire Kiedrowski, and Angela Brewer.

Table 5. Data Quality Indicators, Criteria, and Quality Control Protocols for Field Verification Surveys

Data Quality Indicator	Criteria	Protocol
Spatial accuracy	Field GPS units should have a reported accuracy less than or equal to 3 meters	Check reported accuracy of field GPS units
Comparability	Field observations should be collected using a standardized protocol	Check that protocols from the QAPP were used for field observations
Representativeness	Field observations should be made at planned locations and should represent various condition in eelgrass beds	Check field verification observation locations against planned locations

Table 6. Data Quality Indicators, Criteria, and Quality Control Protocols for Photointerpretation

Data Quality Indicator	Criteria	Protocol
Mapping completeness	SAV presence-absence mapped for 100% of study area	Extent of mapped eelgrass will be compared to study area
Minimum Mapping Unit (MMU)	100 square meters	The area of the smallest delineated eelgrass beds will be compared to the criteria. If eelgrass beds smaller than 100 sq. meters can be clearly discerned, they will be mapped but flagged as being below the MMU.
Spatial Accuracy	Less than or equal to 5 meters	The bed edge measured at field verification locations will be compared to mapped edge.

1.7 Documents and Records

CBEP will prepare the QAPP and distribute a draft to parties named on the cover page for review prior to forwarding the QAPP to EPA for approval. CBEP will circulate the EPA-approved QAPP to the parties listed in Table 1. The QAPP Preparer will be responsible for assuring that all parties and project personnel have the most recent version of the QAPP, any amendments to the QAPP, and any updates.

Documents collected under this QAPP will be retained by MDEP and other project partners as described in Table 7, and consistent with MDEP record retention schedules (MDEP 2017).

Table 7. Document and record retention information.

Document/Record	Location	Retention	Form
QAPP	MDEP, CBEP, EPA	Indefinitely	Electronic
Flight plan	MDEP	Indefinitely	Electronic
Flight logs	MDEP	Indefinitely	Electronic
Field verification field notebook	MDEP	Indefinitely	Paper/electronic
Photo print index	MDEP, CBEP	Indefinitely	Electronic
Individual ortho tiles	MDEP, CBEP	Indefinitely	Electronic
Georeferenced mosaic imagery	MDEP, CBEP	Indefinitely	Electronic
GIS files	MDEP, CBEP	Indefinitely	Electronic
Video files	MDEP, CBEP	Indefinitely	Electronic
Final report	MDEP, CBEP	Indefinitely	Electronic

2 Measurement and Data Acquisition

2.1 Methods

2.1.1 Aerial Survey

Aerial survey acquisition, post-processing of individual tiles, and creation of a seamless mosaic image will follow procedures described in NOAA (1995, 2001) and Orth *et. al.* (1991). The Aerial Survey Coordinator will work with the Aerial Imagery Contractor and subcontractor to plan and conduct flights for acquiring aerial imagery of Casco Bay between June and September 2018, preferably on sequential days in June, July, or August, within two hours of low spring tides. In addition to negative low tides, ideal conditions include early-mid morning, low sun angle (25-50°), low wind velocity (<10 mph), and low cloud cover (<10%). The survey will not occur following a rain event or during a phytoplankton bloom in order to minimize water column turbidity.

Approximately 13 flightlines will be flown, and approximately 358 digital images will be captured. Pixel resolution will be 12 inches or better, forward lap will be at least 60%, and sidelap at least 30%.

Aerial imagery will be collected by plane using an Intergraph Digital Mapping Camera (DMC). The DMC will capture four-band images (true color [RGB] and color infrared). A GPS supported navigation system will interface with the camera control software, differential-GPS, and inertial measurement unit sensors to capture horizontal positional data to a 2-foot accuracy.

Direct georeferencing will be used to position the imagery through integrated Airborne GPS and IMU systems (Rizaldy and Firdaus 2012). The Airborne GPS will calculate the exposure centers for each photo. The IMU will provide the roll, tip, and yaw of the aircraft at the instance of exposure. Each photo center will be a control point.

2.1.2 Field Verification

The Aerial Survey Coordinator will prepare preliminary eelgrass polygons from the draft aerial imagery.

Ground-truthing to field verify the presence/absence and location of eelgrass, especially at the deep edges of beds, will occur at systematically selected embayments and shoreline reaches under the direction of the Aerial Survey Coordinator, who will coordinate with MDEP to schedule and conduct boat-based site visits. Field verification will occur within two weeks of receipt of the draft aerial imagery, and require approximately two to three weeks to complete. Field visit locations will be determined in advance, using draft aerial imagery to inform the location, with priority placed on visiting beds without clear boundaries or signatures. Ground-truthing will consist of GPS navigation to and within mapped eelgrass beds, and viewing and recording of underwater footage of eelgrass along transects using a towed underwater video camera and on-board laptop, monitor, and DVR.

The Aerial Survey Coordinator will use an underwater drop camera towed over the bottom to allow continuous observations during field surveys, although when conditions permit (water clarity is good and tide is low), the camera may not be needed to locate the shallow bed edge if it can be viewed from over the side of the boat. The camera will be cabled to two monitors on board the boat, with one monitor for use by the camera tender, and the other by the boat operator. Video will be employed to verify species identification, identify deep edge, and differentiate signatures of eelgrass from other subtidal features such as mussel beds and macroalgae. Video will be recorded and stored for later use in the office.

The Aerial Survey Coordinator will use a GPS device (chart plotter or portable GPS unit) to store waypoints, record locations of observations, and plot points along the edges of beds. Preliminary eelgrass polygons, waypoints to visit, and other GIS data will be loaded onto the GPS in advance of the field visits and used as a reference while making observations. In the field, GPS will track the boat path and record time stamps. The Aerial Survey Coordinator will provide MDEP with a GIS shapefile with GPS track lines to enable referencing of the boat's location and time with associated video footage.

The Aerial Survey Coordinator will record information in a field notebook. The location and time of surveys will be noted, as well as an estimate of water depth from a boat-based depth finder. Observations of other subtidal features will be recorded, including qualitative notes of sediment and macrophyte compositions observed during video tows.

In the office, the Aerial Survey Coordinator will utilize field notes, GPS data, video, and aerial imagery to inform photointerpretation in refining eelgrass polygons. Comparison of time-stamped video and GPS data will assist correlation of video with location. The accuracy of GPS data will be evaluated by reviewing PDOP data.

2.1.3 Photointerpretation

The Aerial Survey Coordinator will photointerpret digital orthophotographs using methods from NOAA (1995 and 2001) to delineate the boundaries of eelgrass beds in GIS. Observations made during field verification, as well as video, field notes, and GPS data, will be used to modify bed boundaries. Percent cover classes are not assigned until the final imagery is available. Cover classifications will be assigned using methods provided by Orth *et al* 1996 using four categories: 0-10%, >10-40%, >40-70%, and >70-100% (Figure 3).

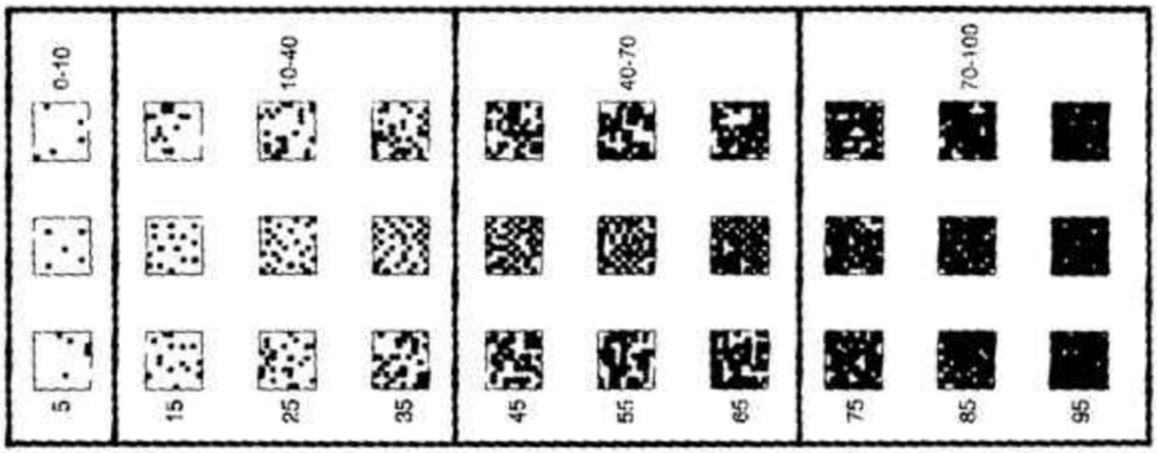

Figure 3. Percent cover scale used to categorize relative density of eelgrass beds. Source: Orth et al, 1996.

2.2 Sample Handling and Custody

This study will not result in the collection of field samples.

2.3 Quality Control

The Aerial Survey Coordinator will be responsible for overall quality assurance and quality control for the project, including consistency comparisons between aerial imagery and data quality indicators, criteria and protocols in Tables 4 - 6.

2.4 Instrument/Equipment Testing, Inspection, Maintenance

All equipment used for the aerial survey will be inspected prior to the flight to ensure proper operation. Drop cameras and GPS units for the Field Verification will be inspected, charged, and cleaned before each field day.

2.5 Instrument/Equipment Calibration and Frequency

The Aerial Imagery Contractor will provide a Geometric Calibration Verification Certificate detailing the instrumentation used, calibration dates, and accuracy and resolution achieved.

2.6 Non-Direct Measurements

Information on tides, sun angles, weather, water clarity, and precipitation will be used to decide whether to proceed with a flight within previously designated windows. After a flight, a log is created that includes exact time of photo acquisition for each flight line as well as wind speed, wind direction, and sun angle. Verified tide heights can be retrieved via NOAA's Portland Tide Station in the weeks following the survey dates. The data sources that will provide this information are:

2.6.1 Predicted Tides and Observed Water Levels

Portland, ME Tide Station (ID 8418150)
https://tidesandcurrents.noaa.gov/stationhome.html?id=8418150#available

2.6.2 Sun Angle

Sun angles for Portland, ME are available from:
http://aa.usno.navy.mil/data/docs/AltAz.php

2.6.3 Weather

Weather forecasts leading up to the planned date of aerial imagery acquisition will be obtained from the National Weather Service for Portland.
https://forecast.weather.gov/MapClick.php?CityName=Portland&state=ME&site=GYX&textField1=43.6621&textField2=-70.256&e=0

2.6.4 Water Clarity

Immediately prior to each potential flight window, MDEP Marine Unit staff and the Aerial Survey Coordinator will assess water quality conditions by monitoring water clarity, turbidity and/or chlorophyll sonde data at selected locations around Casco Bay. These data are compared with the same parameters collected prior to the 2013 Casco Bay eelgrass survey, and qualitatively used to determine suitability of conditions for acquisition of aerial imagery. Data collection will follow the MDEP Marine Environmental Monitoring Program QAPP. A Secchi disk will be used for assessing transparency / clarity, and a sonde will be used for assessing turbidity and chlorophyll.

2.6.5 Precipitation

Precipitation data are available for the Portland International Jetport at
http://w1.weather.gov/obhistory/KPWM.html

2.7 Data Management

The Aerial Survey Coordinator will store individual and mosaicked imagery, and the eelgrass shapefile with associated GIS file types, on external hard drives for transfer to the Project Manager. The Project Manager will deliver the external drives to CBEP. The orthophotographs and shapefiles will be uploaded to MEGIS for public use. The following file formats will be used for the imagery:

- Draft imagery as a composite true-color compressed file in SID format, geolocated using direct georeferencing and assuming an average elevation.

- Final imagery as orthorectified 4-band (red, green, blue, and near infrared), 8-bit imagery for the entire area in uncompressed GeoTiff format and a composite true-color compressed file in SID format.
- Eelgrass bed polygons will be delivered on thumb or hard drives to the Project Manager in shapefile format compatible with ArcGIS. The shapefiles will be stored in a dedicated project directory on MDEP and CBEP computers. Field verification information, including video and still imagery, will be provided to MDEP and CBEP.

3 Assessment/Oversight

3.1 Assessments and Response Actions

The Project Manager will be in frequent communication with contractors during the project. The Project Manager will ask about difficulties encountered and ensure that protocols from the QA Project Plan are being following. At a minimum, the Project Manager will complete the following checks while the project is proceeding:

- Review QC information for Aerial Imagery Contractor, including aerial image acquisition QA-QC report (flight logs) and QC checkpoints for horizontal accuracy
- Review QC information for Aerial Survey Coordinator contract
- Conference with Aerial Survey Coordinator before flight windows
- Conference with Aerial Survey Coordinator periodically during field verification site visits
- Aerial Survey Contractor is responsible for reviewing draft imagery from Aerial Imagery Contractor.
- Review final imagery and imagery metadata provided by Aerial Imagery Contractor
- Review eelgrass layer metadata and draft report from Aerial Survey Coordinator
- Review and approve any other reports provided by contractors
- The Project Manager will initiate appropriate response actions after each check, if needed.
- Reports regarding assessment status will be made available to management, CBEP, EPA, and project partners upon request.
- The Project Manager will assess DQIs as the survey steps occur and deliverables become available for review.

3.2 Reports to Management

The final project report will focus on the photointerpretation of aerial imagery for eelgrass bed mapping and cover classifications. Maps will show areal extent of eelgrass beds. Cover classes may be represented in tabular form, and will be compared to prior survey values. The units shown will be based on a bed level scale and not MMU. Results will be based on cumulative information gleaned from imagery and video (as described in sections above).

The report will contain the following:

- Introduction
- Methods (photointerpretation, field verification, and quality assurance)
- Results

    - Summary of the eelgrass areal extent (in acres) within the study area and shown on maps
    - Summary of eelgrass cover classifications
    - Analysis of change in eelgrass area from prior monitoring (1993, 2001/2002, 2013)
    - Maps showing the location of eelgrass beds in the study area, including analysis comparison with prior monitoring.
    - Qualitative observations from underwater video footage
- Appendices / Attachments
    - NSSDA Report for orthophotography (provided by the Aerial Imagery Contractor)
    - Raw data, including photographs, location data and notes from field verification survey (provided electronically)
    - Quality-assured eelgrass bed boundaries as a shapefile (provided electronically, and compatible with Arc GIS)
    - Metadata to accompany shapefiles (provided electronically with shapefiles)

The Aerial Survey Coordinator will provide the Project Manager with a draft of the report. The Project Manager will review the draft report and provide comments. The Aerial Survey Coordinator will provide a final version of the report.

4 Data Validation and Usability

4.1 Data Review, Verification and Validation

The Aerial Survey Coordinator will provide the Project Manager with a draft final report. The Project Manager will review and edit the report, and produce a final report. A copy of the final report will be provided to CBEP. CBEP will provide a copy of the report to the Project Officer.

The Aerial Survey Coordinator will be responsible for assessing that the data quality objectives have been met. The Aerial Survey Coordinator will discuss quality assurance and quality control in the metadata file and the final report.

4.2 Data Validation and Verification Methods

The Project Manager will review QC information, including metadata files, from the Aerial Survey Coordinator and the Aerial Imagery Contractor to see if there have been deviations from the QAPP and if the data quality objectives have been met. The Project Manager will evaluate the results compared with DQI criteria (goals). 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 and partners, if necessary.

4.3 Reconciliation with User Requirements

The Project Manager will be responsible for reconciling the results from the final report from the Aerial Survey Coordinator and the Aerial Imagery Contractor with the requirements of the study (the ultimate use of the data). Results that are qualified by the Project Manager may still be used if the limitations of the data are clearly reported to decision-makers. The decision-making process will be:

1. The Project Manager will review data with respect to sampling design.
2. The Project Manager will review QA/QC with the Aerial Survey Coordinator.
3. If the data quality objectives are met, then the user requirements have been met and the imagery and eelgrass maps can be used without qualification.
4. If the data quality objectives have not been met, the Project Manager will consult with project personnel and partners and make a recommendation about whether the imagery and/or eelgrass maps are still usable for their intended purpose or whether the data need to be qualified or rejected. The Project Manager may also initiate appropriate corrective actions to improve the quality of the data, if possible. Corrective actions may include reviewing data acquisition procedures, adjusting imagery brightness and contrast to enable better viewing of exposed intertidal areas, providing comments on the draft report and asking for revisions.
5. The Project Manager will document this decision-making process in a memorandum that will be appended to the QA Report.
6. QA/QC will be discussed in the final report. Any QA concerns and data qualifications will be noted, if needed.

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