8-29-2013

Great Bay Estuary Eelgrass Monitoring Program for 2013 Quality Assurance Project Plan conducted by Kappa Mapping, Inc.

Philip Trowbridge
Piscataqua Region Estuaries Partnership

Great Bay Estuary Eelgrass Monitoring Program for 2013
Quality Assurance Project Plan

August 29, 2013
Version 3

Prepared by:
Philip Trowbridge, P.E.
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Name	Project Role	Organization	Signature & Date
Rachel Rouillard	Project Director	Piscataqua Region Estuaries Partnership	10.1.13
Chris Williams	Project Advisor	NH Dept. of Environmental Services	10/1/13
Dean Peschel	Project Advisor	Great Bay Municipal Coalition	10/1/13
Jean Brochi	ERA Project Officer and Dive Team Leader	US Environmental Protection Agency	
Phil Trowbridge	Project Manager	Piscataqua Region Estuaries Partnership	9/26/13
Matt Wood	Project QA Officer	NH Dept. of Environmental Services	9/30/13
Claire Kiedrowski	Aerial Survey Contractor	Kappa Mapping, Inc.	9/30/13
Derek Sowers	Ground Truth Survey Leader	Piscataqua Region Estuaries Partnership	10/2/13
Ray Grizzle	Ground Truth Survey Contractor	UNH Jackson Estuarine Laboratory	10/1/13
Adele Fiorillo	Ground Truth Survey Contractor	Normandeau Associates	9/30/13
Seth Barker	Photointerpretation Contractor	Independent contractor	9/30/13
Vincent Perelli	NHDES Quality Assurance Manager	NH Dept. of Environmental Services	8/12/13
Steve DiMattei	USEPA Quality Assurance Officer	US Environmental Protection Agency	09-26-13

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Derek Sowers	Ground Truth Survey Leader	Piscataqua Region Estuaries Partnership	
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Adele Fiorillo	Ground Truth Survey Contractor	Normandeau Associates	
Seth Barker	Photointerpretation Contractor	Independent contractor	
Vincent Perelli	NHDES Quality Assurance Manager	NH Dept. of Environmental Services	Vincent R. Perelli 8/12/13
Steve DiMattei	USEPA Quality Assurance Officer	US Environmental Protection Agency	

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A3 – Distribution List

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

Table 1: QAPP Distribution List

Name	Project Role	Organization	Telephone number and Email address
Rachel Rouillard	Project Director	Piscataqua Region Estuaries Partnership	603-862-3948 rachel.rouillard@unh.edu
Chris Williams	Project Advisor	NH Dept. of Environmental Services	603-559-0025 Christian.Williams@des.nh.gov
Dean Peschel	Project Advisor	Great Bay Municipal Coalition	603-781-5931 dean_peschel@yahoo.com
Jean Brochi	EPA Project Officer and Dive Team Leader	US Environmental Protection Agency	617-918-1536 brochi.jean@epa.gov
Phil Trowbridge	Project Manager	Piscataqua Region Estuaries Partnership	603-271-8872 Philip.Trowbridge@des.nh.gov
Matt Wood	Project QA Officer	NH Dept. of Environmental Services	603-271-8868 Matthew.Wood@des.nh.gov
Claire Kiedrowski	Aerial Survey Contractor	Kappa Mapping, Inc.	207-942-5200 Claire@kappamap.com
John Dwyer	Aerial Survey Pilot	Richard Crouse and Associates	(207) 827-5979 jdwyer@richardcrouse.com
Derek Sowers	Ground Truth Survey Leader	Piscataqua Region Estuaries Partnership	603-862-2641 Derek.Sowers@unh.edu
Ray Grizzle	Ground Truth Survey Contractor	UNH Jackson Estuarine Laboratory	603-862-5130 ray.grizzle@unh.edu
Adele Fiorillo	Ground Truth Survey Contractor	Normandeau Associates	603-319-5303 afiorillo@normandeau.com
Seth Barker	Photointerpretation Contractor	Independent contractor	207-633-3735 seth.l.barker@gmail.com
Vincent Perelli	NHDES Quality Assurance Manager	NH Dept. of Environmental Services	603-271-8989 vincent.perelli@des.nh.gov
Steve DiMattei	USEPA Quality Assurance Officer	US Environmental Protection Agency	617-918-8369 DiMattei.Steve@epa.gov

Based on EPA-NE Worksheet #3

A4 – Project/Task Organization

The project will be completed by the Piscataqua Region Estuaries Partnership (PREP) with technical assistance from contractors and the Environmental Protection Agency (EPA).

Funding for the project will be provided by the NH Department of Environmental Services (NHDES), Great Bay Municipal Coalition (GBMC), and PREP using funds from EPA. Representatives from NHDES and GBMC will serve as project advisors to the PREP Project Manager and PREP Project Director due to their financial contribution.

The Project Manager will be Philip Trowbridge of PREP. The Project Manager will be responsible for coordinating all program activities. The Project Manager will manage all contractors and field staff, be responsible for "stop/go" decisions in the field, coordinate data analysis and will be responsible for all final products.

The Project QA Officer will be Matt Wood of NHDES. The QA Officer will be responsible for reports to the Project Manager summarizing any deviations from the procedures in the QA Project Plan, the results of the quality control (QC) tests, and whether the reported data meet the data quality objectives of the project.

The project has three components: (1) an aerial survey; (2) a ground truth survey; and (3) photointerpretation of the aerial imagery. PREP will hire contractors to assist with all three components of the project.

The Aerial Survey will be completed by Kappa Mapping, Inc. Claire Kiedrowski is President of Kappa Mapping, Inc. and will be responsible for all work tasks for the aerial survey.

The Ground Truth Survey will be completed by PREP with assistance from contractors. Derek Sowers will be Ground Truth Survey Leader for PREP. He will direct field staff, make field observations, and oversee contracts. One contractor will be Ray Grizzle of the University of New Hampshire. Ray Grizzle will assist PREP staff by operating the boat and drop camera for field surveys. Adele Fiorillo of Normandeau Associates will be another contractor. She and her colleagues will map eelgrass bed boundaries from a boat to provide data for the spatial accuracy assessment. Finally, Jeannie Brochi and the EPA Dive Team will assist with underwater observations of eelgrass for the ground truth effort. The EPA Dive Team efforts will be contributed in-kind.

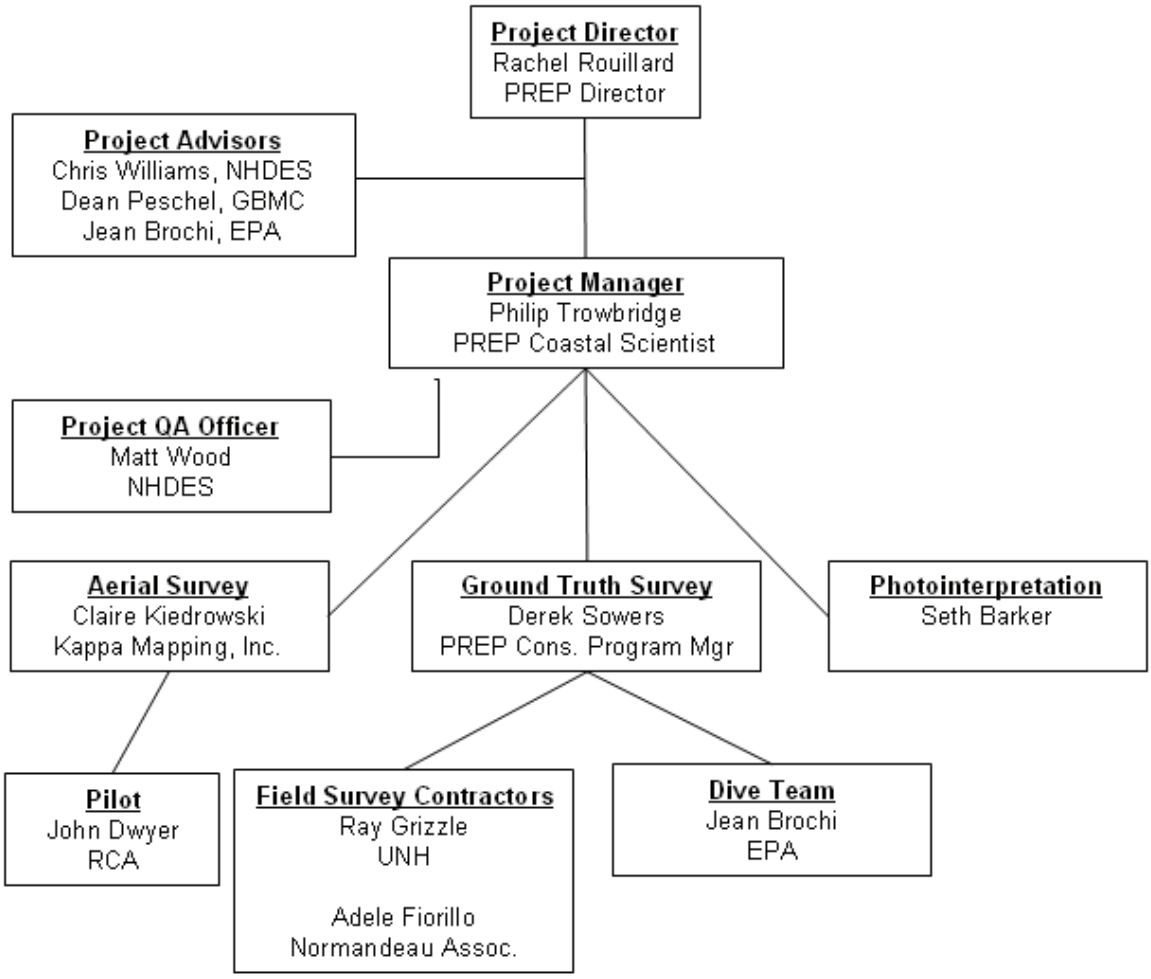
The Photointerpretation component of the project will be conducted by Seth Barker under a contract with PREP. The work will consist of field surveys to calibrate the interpreter to on-the-ground conditions and interpretation of the aerial imagery to map boundaries of eelgrass beds.

The principal users of the data from this project will be the PREP, NHDES, EPA, and GBMC. The Project Manager will submit a report to the partners at the end of the project with the final data and the QA Officer's reports.

This QA Project Plan is for the 2013 mapping effort, but the 2013 monitoring is part of a yearly monitoring program for trends.

Figure 1 shows an organizational chart for this project.

Figure 1: Project Organizational Chart

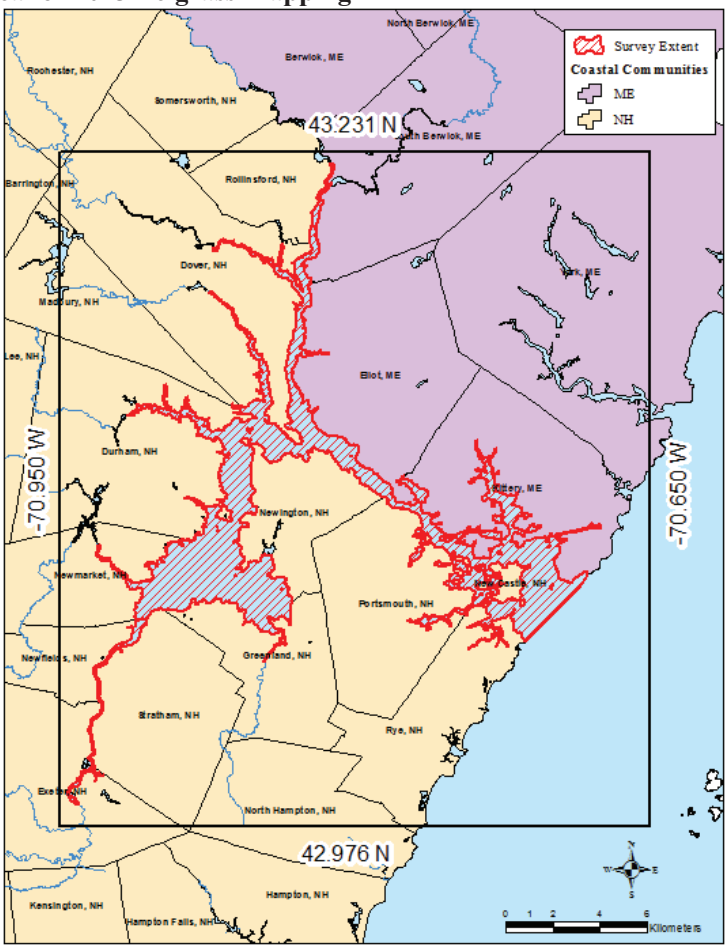


A5 – Problem Definition/Background

Eelgrass (*Zostera marina*) is essential to estuarine ecology because it filters nutrients and suspended particles from water, stabilizes sediments, provides food for wintering waterfowl, and provides habitat for juvenile fish and shellfish, as well as being the basis of an important estuarine food web. Healthy eelgrass both depends on and contributes to good water quality. Therefore, PREP tracks the cover and density of eelgrass in the Great Bay Estuary as an indicator of estuarine health.

The objective of this project is to map eelgrass habitat in the Great Bay Estuary during the summer growing period of 2013. The Great Bay Estuary is 21 square miles of tidal waters located in southeastern New Hampshire. The area for eelgrass mapping extends from the head-of-tide of all tidal rivers and creeks to the mouth of Portsmouth Harbor. The mouth of Portsmouth Harbor is defined by lines extending from Odiorne Point in Rye, NH to White Island to Horn Island to Sewards Point on Gerrish Island in Kittery, ME. The total area to be mapped is approximately 22 square miles. The study area in which eelgrass will be mapped for this project is shown in Figure 2.

Figure 2: Study Area for 2013 Eelgrass Mapping



PREP has funded eelgrass mapping in the Great Bay Estuary every year from 2002 to 2012. In each of these years, eelgrass beds have been classified into one of four "cover classes", which approximate the percent cover of eelgrass in the area. The purpose of the monitoring is to assess long-term trends in eelgrass habitat for State of Our Estuaries reports (see PREP, 2013). Orthorectified imagery provides the best spatial accuracy for the mapping habitats. Orthorectified imagery for habitat mapping was last obtained in 2007 and needs to be updated. Therefore, in 2013, PREP intends to collect orthorectified imagery and conduct a robust ground truth survey. Information on nuisance macroalgae presence/absence will also be collected during the Ground Truth Survey for supporting information because these species can affect eelgrass populations. The prevalence of macroalgae has been increasing in Great Bay (PREP, 2013). Information on the two most common macroalgae species will be collected.

Maps of eelgrass in the estuary will be used by PREP, NHDES, EPA, GBMC, UNH, and other coastal resource managers to evaluate trends in eelgrass populations over time and other resource decisions.

A6 – Project/Task Description

The main tasks for the project are:

1. Hire Contractors

The Project Manager will set up contracts for the Aerial Survey, Ground Truth, and Photointerpretation work tasks.

2. Prepare QA Project Plan

A QA Project Plan for eelgrass mapping will be produced by PREP. Therefore, this plan must have EPA approval. In addition, this plan will be at least provisionally approved by all partners (PREP, EPA, NHDES, and GBMC) before field work on this project begins. This QA Project Plan is for the 2013 mapping effort, but the 2013 monitoring is part of a yearly monitoring program for trends.

3. Conduct Ground Truth Surveys

The Ground Truth Survey Leader will organize field crews and dive teams to ground truth the aerial imagery. Data from the Ground Truth Survey will be incorporated into the QA Officers Report which will be appended to the final report.

4. Acquire Aerial Imagery of the Estuary

The Aerial Survey Contractor will plan and execute an aerial over-flight in late August or early September to collect aerial imagery during periods of suitable conditions (see Section A7). A rough draft of the imagery will be provided to the Project Manager within 21 days of the survey. A draft report will be provided by 11/30/13. The final imagery dataset will be available by 1/31/14.

5. Photointerpret Aerial Imagery

The Photointerpretation Contractor will review the aerial imagery and, based on their field visits to the estuary and published guidance, will map eelgrass beds in the estuary. The four "cover classes" that have been used to classify eelgrass beds in past surveys will be used for this study. A draft report will be provided to the Project Manager by 4/30/14. The final report will be prepared by 6/30/14.

6. Prepare Quality Assurance Reports

The Project QA Officer will prepare QA Reports for each of the final reports from contractors: the Final Report for the Aerial Survey and the Final Report for the Photointerpretation. The QA Reports will evaluate whether or not the data quality objectives for the project have been met (see Section A7 and B5).

7. Issue Final Reports, Data Management, and Archiving

After completing the quality control tests and verification/validation process (see Sections D1-D3), the Project Manager will make the final reports available to the public on the PREP website. See Section C2 for lists of information that will be included in the final reports. GIS datasets for aerial imagery and final eelgrass maps will be made available for download from the NH GRANIT Clearinghouse. All data associated with the project will be archived with PREP as electronic files.

Table 2 shows an approximate timeline for all of the tasks for this project.

Table 2. Project Schedule Timeline

Activity	Dates (MM/DD/YYYY)		Product	Due Date
	Anticipated Date(s) of Initiation	Anticipated Date(s) of Completion		
Hire contractors	7/1/13	8/13/13	Executed contracts	8/13/13
QAPP preparation	8/3/13	8/29/13	Approved QAPP document	8/16/13
Ground truth surveys	8/22/13	9/30/13	Field observations	10/7/13
Acquire aerial imagery	8/23/13	8/23/13	Raw aerial imagery	9/13/13
Draft Aerial Survey Report	10/1/13	11/30/13	Draft report	11/30/13
QA Report for Aerial Survey	12/1/13	12/31/13	QA report	12/31/13
Final Aerial Survey Report	1/1/14	1/31/14	Final report and files	1/31/14
Photointerpretation work	2/1/14	3/31/14	Eelgrass bed boundaries	3/31/14
Draft Photointerpretation Report	4/1/14	4/30/14	Draft report	4/30/14
QA Report for Photointerpretation	5/1/14	5/31/14	QA report	5/31/14
Final Photointerpretation Report	6/1/14	6/30/14	Final report and files	9/30/14

Based on EPA-NE Worksheet #10.

A7 – Quality Objectives and Criteria

Data quality objectives for the aerial imagery, ground truth field surveys, and the photointerpretation are summarized in Table 3, Table 4, and Table 5, respectively.

Table 3: Data Quality Objectives, Criteria, and Quality Control Protocols for the Aerial Survey

Data Quality Objective	Criteria	Protocol
Imagery Completeness	4-band source imagery obtained for 100% of study area	Extent of imagery will be compared to study area.
Ground Pixel Resolution	Less than or equal to 0.30 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 orthorectified imagery will be checked against the known coordinates.
Environmental & Timing Conditions	Environmental & timing conditions met during flight - 7/1/13 to 9/30/13 - 7 AM to 10 AM - 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.

*Root Mean Square Error (RMSE). A measure of the difference between locations that are known and locations that have been interpolated or digitized. RMSE is derived by squaring the differences between known and unknown points, adding those together, dividing that by the number of test points, and then taking the square root of that result. Following guidance from the National Standard for Spatial Data Accuracy (NSSDA), the spatial accuracy will be calculated as the 95% confidence level using the circular map accuracy standard (Accuracy = 1.7308 * RMSE). See http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part3/chapter3 for methods.

Table 4: Data Quality Objectives, Criteria, and Quality Control Protocols for the Ground Truth Field Surveys

Data Quality Objective	Criteria	Protocol
Spatial Accuracy	Field GPS units should have a reported accuracy less than or equal to 3 meters using WGS84 datum	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.
Completeness	Field observations should be made at planned locations and should ideally represent conditions in eelgrass beds in all four cover classes and in areas where eelgrass does not exist currently but existed in the past. At least 80% of the ground truth stations should be visited.	Check ground truth observation locations against planned locations listed in Section B1. Check eelgrass cover classes at ground truth stations. Check that 80% of ground truth stations were visited.

Table 5: Data Quality Objectives, Criteria, and Quality Control Protocols for Photointerpretation

Data Quality Objective	Criteria	Protocol
Mapping completeness	Eelgrass cover classes (dense, some bottom, half, and patchy) mapped for 100% of study area	Extent of mapped eelgrass will be compared to study area.
Minimum Mapping Unit	Less than or equal to 200 square meters	The area of the smallest delineated eelgrass beds will be compared to the criteria.
Spatial Accuracy	Less than or equal to 5 meters	The bed edge measured at 10 ground truth locations will be compared to mapped edge. See Section B5 for methods.
Classification Accuracy	Greater than or equal to 85% overall accuracy from an error matrix	Eelgrass cover class assessed by ground truth teams at 60 locations will be compared to mapped cover class. Locations will include areas without eelgrass. See Section B5 for methods.

A8 – Special Training/Certification

The Ground Truth Survey Leader will organize and implement training for all field staff and contractors. The training will be based on the QA Project Plan document. The Ground Truth Survey Leader will notify the Project Manager after each training session is complete. The training will be completed before sampling begins.

EPA Dive team will follow their safety protocol and efforts will be coordinated by the Dive Team Leader.

A9 – Documents and Records

QA Project Plan

The Project Manager will be responsible for maintaining the approved QA Project Plan and for distributing the latest version to all parties on the distribution list in section A3. A copy of the approved plan will be made available on the PREP website (www.prep.unh.edu) at least until the project is complete.

Reports to Management and the Public

The Project Manager will provide final reports from the Aerial Survey and the Photointerpretation to the partners and will be posted on the PREP website for the public. See Section C2 for details about the final reports. In addition, PREP will use data from this project in future State of Our Estuary reports and conferences. All final GIS shapefiles and orthophotographs will be made available for public download on the NH GRANIT GIS clearinghouse (www.granit.unh.edu).

Archiving

The QA Project Plan and final reports will be kept on file with PREP (in electronic formats) for a minimum of 10 years and/or the duration of the EPA grant.

B1 – Sampling Process Design

The project has three components: (1) an aerial survey; (2) a ground truth survey; and (3) photointerpretation of the aerial imagery.

Aerial Survey

The Aerial Survey will be completed by Kappa Mapping, Inc. with a sub-contract to Richard Crouse and Associates. This component of the project will collect four-band aerial orthorectified imagery for the study area. A total of 468 images with a ground resolution of 0.3 meters (1 foot) will be collected from 10 flightlines at approximately 9,000 feet altitude (see Figure 3). The imagery will be overlapping with 60% forward lap and 30% sidelap. The imagery will be collected on 8/23/13 when sun angle, tide, and environmental conditions meet the criteria listed in Section A7 (Table 3). A draft of the imagery will be provided to the Project Manager within 21 days of the flight (9/13/13). The final imagery will be delivered to PREP by 1/31/2014.

Ground Truth Survey

The Ground Truth Survey will be completed by PREP with assistance from contractors. Ground truth data will be collected by divers and by drop camera. A total of 60 stations will be surveyed. All of the stations will be assessed using a drop camera. Twenty of the stations will be assessed by divers for quantitative measurements of eelgrass cover on 8/22/13, 8/29/13, and 9/4/13 (dates are subject to change based on tide/weather etc). At 10 of the stations, the edge of the eelgrass bed will be recorded using field GPS units. The field visits to the ground truth stations will be completed within 30 days of the aerial survey.

Table 7 lists the coordinates for each station and what type of assessment will be done at each station (e.g., divers, edge mapping, etc.). Maps showing the locations of the stations in Great Bay, Little Bay, and Portsmouth Harbor are shown in Appendix E. The stations for the Ground Truth Survey have been chosen by the PREP Project Manager based on eelgrass maps from 2009-2011 (most recent 3-years of data) and historic data from 1948-1981. The stations were chosen such that all of the four cover classes of eelgrass and areas where eelgrass is not currently present (but was present in the past) are expected to be assessed in the field.

Photointerpretation

The Photointerpretation component of the project will be conducted by Seth Barker. The aerial imagery will be made available first as a draft (within 21 days of the flight) and in final form by 1/31/2014. To assist with the photointerpretation, Seth Barker will visit 10 sites where the draft 2013 imagery shows obvious eelgrass habitat and 10 sites where there is the potential for confusion. Five additional sites will be selected where eelgrass was previously mapped but is not longer visible in the aerial photography. Field observations will be made using a drop camera and high accuracy GPS within 45 days of the aerial survey (10/7/13). The locations (stations and transects) to be visited will be determined by the Photointerpretation Contractor by reviewing previous eelgrass maps and from the draft 2013 imagery. As an alternative and in areas where eelgrass is known to persist, eelgrass maps from previous years will be used to select stations and transects.

Figure 3: Flightlines for Aerial Survey (Reproduced from Appendix A, Figure 1). The green line is the project boundary, red lines are flight lines, and shaded areas indicate stereo coverage. Ground sample resolution for the raw imagery is 0.29 meters.

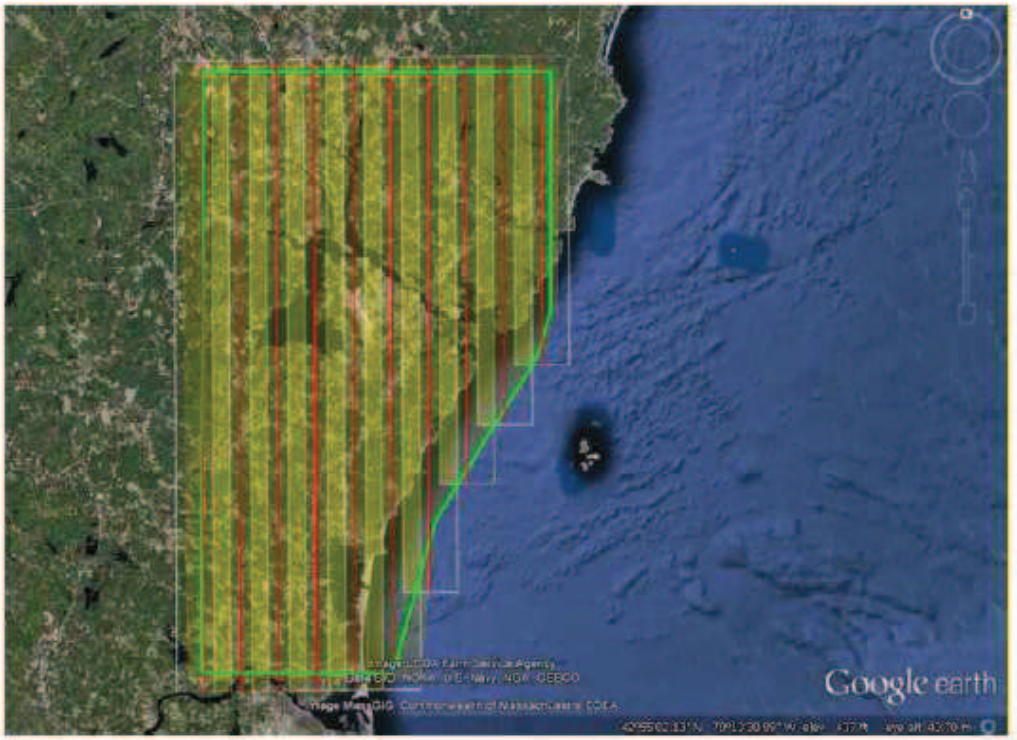


Table 6: Optimal Dates for Aerial Survey in August and September 2013

Date	Low Tide Height (ft)	Time of Low Tide at Adams Pt	Time of 25 deg Sun Angle	Time of 50 deg Sun Angle
8/23/2013	-1.1	9:17	8:30	11:00
8/24/2013	-0.7	10:05	8:30	11:00
8/25/2013	-0.2	10:52	8:30	11:00
9/9/2013	0	10:06	8:40	11:50
9/10/2013	0.2	10:51	8:50	11:50
9/11/2013	0.4	11:40	8:50	12:00
9/23/2013	0.3	10:20	9:00	12:30

Table 7: Ground Truth Survey Stations

Station ID	Method	2011 Density	Latitude	Longitude	Latitude	Longitude
GB01	DIVE TEAM	SB	43.083942	-70.874136	43° 05' 02.19" N	-070° 52' 26.88" W
GB02	DIVE TEAM	SB	43.064324	-70.892611	43° 03' 51.56" N	-070° 53' 33.39" W
GB03	DIVE TEAM	H	43.066310	-70.856009	43° 03' 58.71" N	-070° 51' 21.63" W
GB04	DIVE TEAM	P	43.062384	-70.865911	43° 03' 44.58" N	-070° 51' 57.27" W
GB05	DIVE TEAM	SB	43.077591	-70.875367	43° 04' 39.32" N	-070° 52' 31.32" W
GB06	DIVE TEAM	P	43.071097	-70.897778	43° 04' 15.94" N	-070° 53' 52.00" W
GB07	DIVE TEAM	SB	43.068127	-70.873157	43° 04' 05.25" N	-070° 52' 23.36" W
GB08	DIVE TEAM	SB	43.059668	-70.855311	43° 03' 34.80" N	-070° 51' 19.11" W
GB09	DIVE TEAM	SB	43.084482	-70.861926	43° 05' 04.13" N	-070° 51' 42.93" W
GB10	DIVE TEAM	H	43.063415	-70.897203	43° 03' 48.29" N	-070° 53' 49.93" W
GB11	DIVE TEAM	P	43.087699	-70.874867	43° 05' 15.71" N	-070° 52' 29.52" W
GI01	DIVE TEAM	H	43.060905	-70.690189	43° 03' 39.25" N	-070° 41' 24.68" W
GI02	DIVE TEAM	SB	43.067169	-70.683054	43° 04' 01.80" N	-070° 40' 58.99" W
LH02	DIVE TEAM	P	43.053688	-70.722457	43° 03' 13.27" N	-070° 43' 20.84" W
LLB01	DIVE TEAM	SB	43.094531	-70.855800	43° 05' 40.31" N	-070° 51' 20.88" W
LLB02	DIVE TEAM	SB	43.106130	-70.855184	43° 06' 22.06" N	-070° 51' 18.66" W
LLB03	DIVE TEAM	H	43.101875	-70.854891	43° 06' 06.74" N	-070° 51' 17.60" W
LLB04	DIVE TEAM	P	43.112477	-70.854527	43° 06' 44.91" N	-070° 51' 16.29" W
PH01	DIVE TEAM	H	43.065121	-70.695651	43° 03' 54.43" N	-070° 41' 44.34" W
PH02	DIVE TEAM	SB	43.071882	-70.713047	43° 04' 18.77" N	-070° 42' 46.96" W
BLM01	DROP CAMERA	NP	43.132497	-70.855699	43° 07' 56.98" N	-070° 51' 20.51" W
GB17	DROP CAMERA	NP	43.093565	-70.873762	43° 05' 36.83" N	-070° 52' 25.54" W
GB18	DROP CAMERA	P	43.059906	-70.897420	43° 03' 35.66" N	-070° 53' 50.71" W
GB19	DROP CAMERA	P	43.075084	-70.893442	43° 04' 30.30" N	-070° 53' 36.39" W
GB20	DROP CAMERA	H	43.068645	-70.852319	43° 04' 07.12" N	-070° 51' 08.34" W
GB21	DROP CAMERA	H	43.057725	-70.891763	43° 03' 27.80" N	-070° 53' 30.34" W
GB22	DROP CAMERA	H	43.077175	-70.862927	43° 04' 37.82" N	-070° 51' 46.53" W
GB23	DROP CAMERA	SB	43.071482	-70.883468	43° 04' 17.33" N	-070° 53' 00.48" W
GB24	DROP CAMERA	SB	43.065045	-70.882576	43° 03' 54.16" N	-070° 52' 57.27" W

Station ID	Method	2011 Density	Latitude	Longitude	Latitude	Longitude
GB25	DROP CAMERA	SB	43.062094	-70.869133	43° 03' 43.53" N	-070° 52' 08.87" W
GB26	DROP CAMERA	SB	43.086055	-70.872722	43° 05' 09.79" N	-070° 52' 21.79" W
GB27	DROP CAMERA	SB	43.075889	-70.883574	43° 04' 33.20" N	-070° 53' 00.86" W
GB28	DROP CAMERA	SB	43.058741	-70.852969	43° 03' 31.46" N	-070° 51' 10.68" W
GI03	DROP CAMERA	H	43.063424	-70.687541	43° 03' 48.32" N	-070° 41' 15.14" W
LH01	DROP CAMERA	SB	43.056684	-70.717429	43° 03' 24.06" N	-070° 43' 02.74" W
LH04	DROP CAMERA	P	43.055413	-70.722449	43° 03' 19.48" N	-070° 43' 20.81" W
LLB06	DROP CAMERA	NP	43.105893	-70.865639	43° 06' 21.21" N	-070° 51' 56.30" W
LLB07	DROP CAMERA	P	43.096591	-70.855070	43° 05' 47.72" N	-070° 51' 18.25" W
LLB08	DROP CAMERA	SB	43.107186	-70.855431	43° 06' 25.86" N	-070° 51' 19.55" W
LMP01	DROP CAMERA	NP	43.065133	-70.913433	43° 03' 54.47" N	-070° 54' 48.35" W
OYS01	DROP CAMERA	NP	43.122861	-70.874034	43° 07' 22.29" N	-070° 52' 26.52" W
PH06	DROP CAMERA	P	43.066783	-70.696777	43° 04' 00.41" N	-070° 41' 48.39" W
PH07	DROP CAMERA	H	43.068915	-70.711571	43° 04' 08.09" N	-070° 42' 41.65" W
PH08	DROP CAMERA	SB	43.072191	-70.713904	43° 04' 19.88" N	-070° 42' 50.05" W
PH09	DROP CAMERA	SB	43.060035	-70.695773	43° 03' 36.12" N	-070° 41' 44.78" W
SQM01	DROP CAMERA	NP	43.054714	-70.913049	43° 03' 16.97" N	-070° 54' 46.97" W
ULB01	DROP CAMERA	NP	43.115612	-70.842431	43° 06' 56.20" N	-070° 50' 32.75" W
ULB02	DROP CAMERA	NP	43.123578	-70.840698	43° 07' 24.88" N	-070° 50' 26.51" W
UPR01	DROP CAMERA	NP	43.133283	-70.832438	43° 07' 59.81" N	-070° 49' 56.77" W
UPR02	DROP CAMERA	NP	43.126366	-70.831068	43° 07' 34.91" N	-070° 49' 51.84" W
GB12	EDGE MAPPING	SB	43.076464	-70.881670	43° 04' 35.27" N	-070° 52' 54.01" W
GB13	EDGE MAPPING	SB	43.065574	-70.886025	43° 03' 56.06" N	-070° 53' 09.69" W
GB14	EDGE MAPPING	SB	43.070517	-70.880478	43° 04' 13.86" N	-070° 52' 49.72" W
GB15	EDGE MAPPING	H	43.064184	-70.859009	43° 03' 51.06" N	-070° 51' 32.43" W
GB16	EDGE MAPPING	SB	43.089712	-70.867849	43° 05' 22.96" N	-070° 52' 04.25" W
LH03	EDGE MAPPING	SB	43.054737	-70.717640	43° 03' 17.05" N	-070° 43' 03.50" W
LLB05	EDGE MAPPING	SB	43.108545	-70.855748	43° 06' 30.76" N	-070° 51' 20.69" W
PH03	EDGE MAPPING	SB	43.079352	-70.716121	43° 04' 45.66" N	-070° 42' 58.03" W
PH04	EDGE MAPPING	H	43.068007	-70.738827	43° 04' 04.82" N	-070° 44' 19.77" W
PH05	EDGE MAPPING	H	43.062477	-70.695966	43° 03' 44.91" N	-070° 41' 45.47" W

* For an explanation of density codes, see Section B4.

** Drop camera assessments will be performed at all 60 stations, not just the 30 listed as “drop camera”.

B2 – Sampling Methods

The project has three components: (1) an aerial survey; (2) a ground truth survey; and (3) photointerpretation of the aerial imagery.

Aerial Survey

Aerial imagery will be collected using an Intergraph Digital Mapping Camera. The Intergraph Digital Mapping Camera captures panchromatic, color, and color infrared imagery in a single pass. During the flight mission, a GPS supported navigation system interfaces with the camera control software, differential GPS, and inertial mapping unit (IMU) sensors to capture positional data.

The imagery will be georeferenced using direct georeferencing from the airborne GPS and IMU measurements. If this process does not provide the positional accuracy required for the project (see Section A7), a traditional aerotriangulation process will be used.

Digital orthophotographs will be created from aerial imagery from the digital camera, exterior orientations from either direct georeferencing or aerotriangulation, and digital elevation models from LiDAR or USGS datasets for the study area. Individual images will be orthorectified using specialized orthorectification software. The orthorectification process will use a bi-cubic convolution algorithm. Images will be radiometrically balanced to ensure consistency across flight lines. The projection for the orthophotographs will be New Hampshire State Plane-Feet with a horizontal datum of NAD83.

Ground Truth Survey

The following protocol will be used for ground truth observations.

1. Navigate to station by boat.
2. Drop a small weighted float to indicate the approximate location of the ground truth station indicated by the GPS.
3. Activate a drop camera linked to a high accuracy GPS (≤ 3 meters accuracy).
4. Record weather and sea conditions on data sheet for station.
5. Record coordinates from GPS in DD.DDDDDD format.
6. Record water depth in meters to the closest tenth of a meter using either a weighted line or a depth meter.
7. Deploy drop camera.
8. Slowly move within an 8-meter radius of the site, making multiple observations of the percent cover of eelgrass, percent cover of macroalgae (*Ulva* and *Gracilaria*), and other features via the camera. Use the visual guides in Appendix B and Appendix C to assist with percent cover estimates and macroalgae species identification.
9. Record observations on the standardized field sheet.
    - Classify the eelgrass cover into one of the five types (dense, some bottom, half, patchy, or not present), if possible.

- Classify the macroalgae cover into one of two types (less than 10%, greater than 10%, or not present), if possible.

10. Save photographs and video collected at the station and record filenames on field datasheet.
11. Record any other observations from the site on the field sheet.

If diver observations will be used at the site, continue with Steps 12-18.

12. Deploy divers.
13. Divers will use a 0.5 m x 0.5 m quadrat (encompassing an area of 0.25 square meters) to make quantitative observations at the station location (identified above). The divers will make observations within an 8-meter area at the location. The quadrat will be placed 4 meters north, south, east, and west of the location. Beginning at the weight, a compass bearing will be used to guide the diver to these principal directions and the distance from the weight will be measured with a 4 meter line attached to the weight. At each of these four sampling locations the 0.25 square meter quadrat will be flipped over in a clockwise pattern such that percent cover observations are recorded for four different quadrats encompassing an overall area of 1 square meter. Thus, a total of sixteen 0.25 square meter observations will be made at each groundtruth location visited by the dive team. The percent cover measured from the quadrats will later be used to generate an average value for the location. If diver inspection of the site reveals that eelgrass is not present within an 8 meter radius of the weight location, percent cover will be noted as zero on the field form and no further quadrat, video, or camera data gathering will be necessary at that location.
14. For each quadrat, the divers will record the percent cover of eelgrass, *Ulva*, and *Gracilaria* using the visual guides in Appendix B and C. Percent cover will be estimated to the nearest 10^{th} percentile (e.g., 10%, 20%, 30% …) where water depths and clarity permit.
15. Underwater photographs and/or video footage will be obtained for each of the quadrats as supporting documentation of field observations. The site number and quadrat number shall be indicated on a visible dive slate for each quadrat (e.g., "GB01-N1" for the north quadrat at station GB01, quadrat #1 of 4 at that location). Quadrats completely devoid of eelgrass cover shall be noted as zero on the dive slate and datasheet – photo and video documentation is not required in this case as time is of the essence in dive operations.
16. If there is an unrooted macrophyte in the quadrat and the divers are not certain that it is *Ulva* or *Gracilaria*, they will bring a specimen to the boat to be photographed in better light. The photograph will be sent to the Project Manager who will share it with macroalgae experts for identification.
17. Save photographs and video collected at the quadrat and record filenames on field datasheet.
18. Record observations on field data sheet.

If edge mapping will be performed at the site, continue with Steps 19-24.

19. Use underwater video camera, underwater viewtube, and visual inspection (where water depths and clarity permit) to locate the boundary of the eelgrass bed. In areas where the eelgrass boundary is gradual, the point at which eelgrass is visually estimated to have less than 10% cover will be defined as the boundary.

20. A small weighted float will be dropped to indicate the start of the map segment.
21. Repeat process to mark the boundary every 5-10 meters along a 50 meter boundary.
22. Return to each float and use GPS to accurately record its location. Record coordinates from GPS in DD.DDDDDD format.
23. Retrieve all weighted floats.
24. Record observations and coordinates for floats on field data sheet.

Photointerpretation

The Photointerpretation Contractor will perform independent field work to guide the photointerpretation. Field observations will be made by the Photointerpretation Contractor along transects using a drop camera and high accuracy GPS within 45 days of the Aerial Survey. Transects will be recorded in a GPS as routes and observations will be taken using a drop camera along the route at a minimum interval of 30 meters. Multiple observations of presence/absence, relative density using cover categories described in Section B4, presence of macroalgae, and other features will be made. These observations will be georeferenced and used in a GIS to clarify and correct interpretations of eelgrass distribution.

The methods that will be used for the actual photointerpretation are described in Section B4.

B3 – Sample Handling and Custody

Not applicable. No samples will be collected.

B4 – Analytical Methods

Digital orthophotographs will be photointerpreted using methods from Short and Burdick (1996), NOAA (1995), and NOAA (2001) to delineate the boundaries of eelgrass beds. The boundaries of eelgrass beds will be interpreted from orthophotos and polygons will be created using a GIS. Observations made during site visits by the Photointerpretation Contractor (see Section B2) will be used to assist in the location of polygon boundaries and the assignment of cover classes.

Each polygon is assigned a percent cover value from the following list. For assigning eelgrass cover classes, a visual guide and the following narrative description will be consulted:

- d = "Dense" cover is when only eelgrass is seen in the photo (no bottom: sediment, rocks, or algae), 90 to 100 % cover.
- sb = "Some-bottom" is when some bottom (sediment, rocks, or algae) can be seen, but the cover is mostly eelgrass, 60 to 90 % cover.
- h = "Half" is when the photo is half eelgrass and half bottom (sediment, rocks, or algae), 30 to 60 % cover.
- p = "Patchy" or sparse is when eelgrass can be seen in photos as patches but show mostly bottom (sediment, rocks, or algae), 10 to 30 % cover.
- np = “Not present”. This code will only be used for the Ground Truth Field Surveys.

The visual guide that will be used for determining the cover classes from the aerial imagery is provided in Appendix F. This guide has been widely used as an aid for interpretation and mapping in Chesapeake Bay. The original graphic produced by the Virginia Institute of Marine Science can be found at http://web.vims.edu/bio/sav/sav11/crown_density.html.

Topology rules will be created in a GIS to identify and correct gaps and overlaps between polygons.

The projection for the eelgrass bed shapefile will be New Hampshire State Plane-Feet with a horizontal datum of NAD83.

B5 – Quality Control

Aerial Survey

The Project QA Officer will check that the data quality objectives were met using the criteria and methods from Table 3 in Section A7. Details of the quality control procedures for the aerial survey are provided in the Quality Control Plan for Acquisition for Aerial Imagery for Habitat Mapping (Appendix A).

Ground Truth Survey

The Project QA Officer will check that the data quality objectives were met using the criteria and methods from Table 4 in Section A7.

Photointerpretation

The Project QA Officer will check that the data quality objectives were met using the criteria and methods from Table 5 in Section A7.

For the spatial accuracy assessment, the 10 bed boundaries mapped using a hand-held GPS (see section B2) will be mapped on top of the eelgrass polygons using GIS software. For each of the 10 bed boundaries, the shortest distance between each GPS point and the photo interpreted boundary will be calculated. The average distance for all the GPS points in each boundary will then be compared to the data quality objective of +/- 5 m.

For the classification accuracy assessment, an error matrix will be used to classify the overall accuracy of the eelgrass cover class assignments. The steps to be used to perform this calculation are:

1. Each of the 60 ground truth stations will be assigned an eelgrass cover class based on the results of the field surveys. The cover classes will be: “d” (90-100% cover), “sb” (60-90%), “h” (30-60%), “p” (10-30%), or “np” (0%). (Code for percent coverage: d = dense; sb = some bottom; h = half; p = patchy (or sparse); np = not present.) The cover class will be assigned based on the average cover measured in the four quadrats at the station and/or observations from the drop camera. The cover class that is most representative of the eelgrass resource in the vicinity of the station (within a 8-meter radius) will be selected in order to make the ground truth results comparable to the scale of the photointerpretation.
2. Each ground truth station will be buffered with a 8-meter radius in a GIS to create a circular polygon covering 200 m^2 (hereafter, the “ground truth station polygon”). Note that 200 m^2 is the minimum mapping unit for the photointerpretation.
3. Using a GIS, the ground truth station polygons will be intersected with the eelgrass bed boundaries mapped by the Photointerpretation Contractor.

4. If the eelgrass cover class for the ground truth station polygon overlaps with a mapped eelgrass bed of the same cover class, then the ground truth and photointerpretation will be considered to match at that station.
5. If the eelgrass cover class for the ground truth station polygon does not overlap with a mapped eelgrass bed of the same cover class, then the ground truth and photointerpretation will not be considered to match at that station. It should then be noted which of the mapped eelgrass cover classes overlaps with the majority of the ground truth station polygon. This cover class will be considered the mapped cover class for the ground truth station.
6. The results for all 60 stations will be combined into an error matrix. Overall accuracy, producer's accuracy, and user's accuracy should be calculated as shown in Figure 4. The overall accuracy will be compared to the data quality objective of >85%.

Figure 4: Example of Error Matrix and Calculations

Reference Data

Classified Data: Land Cover	A	B	C	D	Row Total
A	**60**	7	2	15	84
B	4	**75**	11	9	99
C	1	21	**80**	14	116
D	5	13	0	**83**	101
Column Total	70	116	93	121	**400**

Overall Accuracy

(60+75+80+83)/400 = 74.5%

Land Cover	Producer's Accuracy	
A	60/70 =	85.7%
B	75/116 =	64.7%
C	80/93 =	86.0%
D	83/121 =	68.6%

Land Cover	User's Accuracy	
A	60/84 =	71.4%
B	75/99 =	75.8%
C	80/116 =	69.0%
D	83/101 =	82.2%

Source: A Guide to Mapping Intertidal Eelgrass and Nonvegetated Habitats in Estuaries of the Pacific Northwest, USA. U.S. Environmental Protection Agency, Office of Research and Development. EPA/600/R-07/062. August 2007.

B6 – Instrument/Equipment Testing, Inspection, Maintenance

All equipment used for the Aerial Survey shall be inspected prior to the flight to ensure proper operation. Drop cameras and GPS units for the Ground Truth Field Survey shall be inspected, charged, and cleaned before each field day.

B7 – Instrument/Equipment Calibration and Frequency

The Aerial Sensors/Camera(s) used to acquire project imagery shall have current USGS certification, or in the case of digital sensors a current Product Characterization Report.

B8 – Inspection/Acceptance Requirements for Supplies and Consumables

Not applicable.

B9 – Non-direct Measurements

Information on tides, sun angles, weather, water clarity, and precipitation will be used to decide on the date for the aerial survey. The data sources that will provide this information are:

- Tides: NOAA Tide Predictions at Fort Point, Dover Point, and the Squamscott River span the study area.
    - Fort Point (Portsmouth Harbor) http://tidesandcurrents.noaa.gov/noaatidepredictions/NOAATidesFacade.jsp?Stationid=8423898
    - Dover Point http://tidesandcurrents.noaa.gov/noaatidepredictions/NOAATidesFacade.jsp?Stationid=8421897
    - Squamscott River http://tidesandcurrents.noaa.gov/noaatidepredictions/NOAATidesFacade.jsp?Stationid=8422687
- Sun Angles: Sun angles for Portsmouth, NH are available from http://aa.usno.navy.mil/data/docs/AltAz.php.
- Weather: Weather predictions for Portsmouth, NH are available from http://forecast.weather.gov/MapClick.php?CityName=Portsmouth&state=NH&site=GYX&textField1=43.0568&textField2=-70.782&e=1
- Water Clarity: The Project Manager will contact Tom Gregory at the UNH Jackson Estuarine Laboratory for the latest information on water clarity in the estuary. Tom Gregory is responsible for collecting water samples and deploying buoys in the estuary for many programs. He is frequently on the water. He will be consulted about his observations of water clarity. If possible, he will measure a profile of Photosynthetically Active Radiation with depth in the water column off the dock at the Jackson Estuarine Laboratory. The contact

information for Tom Gregory is: (603) 862-5136, (808) 294-0265, or tomgregory.unh@gmail.com.

- Precipitation: Precipitation data and forecasts are available from the sources listed below.
    - Northeast River Forecast Center – 48-hour forecasts of precipitation http://www.erh.noaa.gov/nerfc/fcstprecip.shtml .
    - National Weather Service - Daily weather observations, including daily precipitation, in Rochester NH http://www.erh.noaa.gov/box/dailystns.shtml.
    - U.S. Geological Survey - Streamflow in the Lamprey River http://waterdata.usgs.gov/nh/nwis/uv/?site_no=01073500&PARAmeter_cd=00065,00060,72020

B10 – Data Management

Aerial photographs and orthophotographs from the Aerial Survey will be stored on hard drives by the Aerial Survey Contractor. The files will be transferred to the Project Manager on external hard drives. The Project Manager will deliver the external drives to the Photointerpretation Contractor and to the NH GRANIT clearinghouse. The orthophotographs will be uploaded to the NH GRANIT GIS clearinghouse for public distribution. 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 using ¼ quadrangle tiles (1:24,000 scale) and a composite true-color compressed file in SID format.
- The imagery will be projected in New Hampshire State Plane-Feet NAD83 and shall have metadata meeting FGDC standards.

Field data from the Ground Truth Survey will be stored on standardized field data sheets (Appendix D). The Ground Truth Survey teams will provide the Project Manager a summary report for each field day, completed field data sheets, as well as a DVD or other media with directories that contain all photographs and videos for each station visit. Photographs shall be in JPEG format. Videos shall be in AVI format. The files will be delivered to the Project Manager within 30 days of the completion of the field work. All hard-copy documents will be scanned and saved in a dedicated project directory on the PREP computers along with electronic files.

Eelgrass bed boundaries from the Photointerpretation Contractor will be delivered to the Project Manager in shapefile format compatible with ArcGIS 10.1 in New Hampshire State Plane-Feet NAD83 projection. The shapefiles will be stored in a dedicated project directory on the PREP computers. The shapefiles will also be uploaded to the NH GRANIT GIS clearinghouse for public distribution.

C1 – Assessments and Response Actions

The Project Manager will be in frequent communication with contractors and the Ground Truth Survey Leader 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 Plan for Aerial Survey contract (by 8/16/13)
- Review Field Sampling Plan for Photointerpretation contract (by 8/27/13)
- Review QC Plan for Photointerpretation contract (by 9/10/13)
- Conference with Aerial Survey Contractor before flight windows
- Conference with Ground Truth Survey Leader after first day of field work (by 9/15/13)
- Conference with Photointerpretation Contractor after first day of field work (by 9/15/13)
- Review of draft imagery provided by Aerial Survey Contractor (by 9/13/13)
- Review draft report from Aerial Survey Contractor (by 11/30/13)
- Review draft report from Photointerpretation Contractor (by 4/30/14)
- Review and approve any other reports provided by contractors

The Project Manager will initiate appropriate response actions after each check, if needed.

C2 – Reports to Management

Two final reports will be produced for this project: (1) Final Report for the Acquisition of Aerial Imagery for Habitat Mapping; and (2) Final Report for the Photointerpretation of Aerial Imagery for Eelgrass Habitat Mapping.

The Final Report for the Acquisition of Aerial Imagery for Habitat Mapping will contain the following:

- A Quality Control Report that demonstrates that the imagery meets or exceeds the specifications from Task 1 according the procedures specified in the Quality Control Plan (Appendix A).
- Final quality-assured imagery in the format specified in Section B10.
- ArcGIS shapefile(s) showing photo centers and times of all photographs and tile layout, if applicable.

The Aerial Survey Contractor will provide a draft of this report to the Project Manager by 11/30/13. The Project Manager will review the draft report using the process from Sections D1-D3 and provide comments to the Aerial Survey Contractor. The Aerial Survey Contractor will provide a final version of the report by 1/31/14.

The Final Report for the Photointerpretation of Aerial Imagery for Eelgrass Habitat Mapping will contain the following:

- Introduction
- Methods
  - Methods for field surveys
  - Methods for photointerpretation and mapping of eelgrass beds
  - Methods for quality control checks
- Results

    - Summary of the area of eelgrass cover (in acres) in the Great Bay Estuary
    - Maps showing the location of eelgrass beds in the Great Bay Estuary at a scale of 1:24,000.
- References
- Appendices/Attachments
    - Raw field survey data
    - Quality-assured eelgrass bed boundaries as an ArcGIS shapefile (compatible with ArcGIS10) in New Hampshire State Plane-Feet NAD83 projection with project metadata meeting FGDC standards.

The Photointerpretation Contractor will provide a draft of this report to the Project Manager by 4/30/14. The Project Manager will review the draft report using the process from Sections D1 through D3 and provide comments to the Photointerpretation Contractor. The Photointerpretation Contractor will provide a final version of the report by 6/30/14.

D1 – Data Review, Verification and Validation

The final reports from the Aerial Survey Contractor and the Photointerpretation Contractor will be provided to the Project Manager as drafts by 11/30/13 and 4/30/14, respectively.

The Project Manager will review the reports and will provide copies of the reports to the Project QA Officer.

The Project QA Officer will be responsible for independently assessing that the data quality objectives from Section A7 have been met for each report using the criteria and methods from Sections A7 and B5. For each of the final reports, the Project QA Officer will prepare a QA Report that documents the results of quality control tests. The QA Report for the Photointerpretation contract will include all Ground Truth Field Survey data used to assess the data quality objectives. These ground truth observations will not be shared with the Photointerpretation Contractor until the report is complete to ensure an independent check of the data.

D2 – Verification and Validation Procedures

For each of the final reports, the Project Manager will review the QA Report from the Project QA Officer to see if there have been deviations from the QA Project Plan and if the data quality objectives have been met. 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.

D3 – Reconciliation with User Requirements

The Project Manager will be responsible for reconciling the results from the final reports from the Aerial Survey Contractor and the Photointerpretation 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 the QA Report from the Project QA Officer.
3. If the data quality objectives from Section A7 are met, then the user requirements have been met and the eelgrass maps can be used without qualification.
4. If the data quality objectives from Section A7 have not been met, the Project Manager will consult with project personnel and partners and make a recommendation about whether the 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 providing comments on the draft report from the contractor 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. The QA Report will be attached to the final report from the contractor to document any QA concerns and qualify the data, if needed.

References

National Oceanic and Atmospheric Administration (NOAA). 1995. NOAA Coastal Change Analysis Program (C-CAP): Guidance for regional implementation by J.E. Dobson, E.A. Bright, R.L. Ferguson, D.W. Field, L.L. Wood, K.D. Haddad, H. Iredale, J.R. Jensen, V.V. Klemas, R.J. Orth, and J.P. Thomas. NOAA Technical Report NMFS 123. http://www.csc.noaa.gov/crs/lca/pdf/protocol.pdf

National Oceanic and Atmospheric Administration (NOAA). 2001. Guidance for Benthic Habitat Mapping: An Aerial Photographic Approach by Mark Finkbeiner [and by] Bill Stevenson and Renee Seaman, Technology Planning and Management Corporation, Charleston, SC. NOAA/CSC/20117-PUB. http://www.csc.noaa.gov/digitalcoast/_/pdf/bhmguide.pdf

PREP. 2013. State of Our Estuaries Report. Piscataqua Region Estuaries Partnership, University of New Hampshire, Durham, NH. Available at www.stateofourestuaries.org.

Short FT and Burdick DM (1996) Quantifying eelgrass habitat loss in relation to housing development and nitrogen loading in Waquoit Bay, Massachusetts. *Estuaries*, **19**:730-739.

Great Bay Estuary Eelgrass Monitoring Program for 2013
Quality Assurance Project Plan

Appendix A

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Quality Control Plan
For
Acquisition of Aerial Imagery
For Habitat Mapping

KAPPA Mapping, Inc. Project # 5065-001

July 22, 2013

I. Introduction

Our overall quality assurance plan starts at the project planning stage and ends with a customer satisfaction de-brief upon completion of the project. The general principle of "*Do it right the first time*" is followed throughout the project.

The key elements of a project are defined up front, when the contract is first negotiated. This ensures that the project is completed on time, within budget, and that the deliverables meet with the client's expectations.

A. Customer Satisfaction

The initial step of the project involves the contractual negotiations whereby the Project Team becomes more familiar with the client's project: specifications, final end use of any mapping products, time schedules, coordination with other projects or uses of products, contract terms, fee for services, change order procedures, specific technologies that will be used, QA/QC procedures that will be followed, etc. Having a thorough understanding of each of these components, and how they all relate to one another, results in no surprises during the project life cycle.

It is during this initial stage (Project Kickoff Meeting) that a complete project schedule and an allocation of labor hour requirements are finalized, to ensure that adequate resources are available to meet client needs and expectations.

B. Built-in Product Quality

On the technical side, a series of specific questions have been developed for each phase of a project. This ensures that the necessary elements of a project have been addressed not only by the customer, but also by the project team. This information, along with the specifications, is then passed directly to the technical/production people so that all project specific information has been transmitted to the appropriate individuals and that all production people are aware of upcoming projects and schedules. These instructions are provided to the team in writing and subsequently discussed in team and one on one meeting with the project leads.

Each technical task that the project team performs is structured with specific procedures to guarantee generation of a quality product. The QC process for mapping projects is linear in nature because the processes are linear in nature. Therefore, before each phase can be started, the previous phase has to pass certain QC criteria. This protocol is followed for each phase of the project.

At the start of each project, production procedures (checklists, progress charts, QC testing and reporting mechanisms) are developed. A portion of the project is then created and all production processes exercised, including QC procedures. This sample project data is then submitted to the customer for final approval. Any changes are noted and improvements to the production process implemented. At this point, production begins.

The next step in the production process is to complete the feedback loop by informing the production personnel of the QC analysis and results. Production personnel are given complete access to QC data so that they can improve their individual processes to conform to project standards.

After approximately 10-15% of the project has been completed, supervisory personnel meet with production staff members to identify bottlenecks or other challenges in the production process. This results in better, more highly automated routines to speed the process and improve the quality of the work product. Notable by-products of these meetings are the continued education and training of production staff, which leads to fewer human errors as production progresses.

II. Quality Assurance and Quality Control Procedures

Quality Assurance (QA) and Quality Control (QC) are two separate, but closely linked processes that ensure that the project deliverables meet the project specifications. Quality Assurance is a written plan of the procedures and processes that are to be followed for each task. These processes and procedures have been designed and proven to be effective in producing a quality product in a repeatable and sustainable fashion.

Quality Control is a process of evaluating, or testing, the final product to identify any defects. This process involves different people using different software/processes (than what was used to produce the product) to evaluate the product for conformance to specifications. QC involves using a structured and rigorous approach to the evaluation. Generally, if any part of the project specifications can be quantified, or measured, then it should be evaluated. Acceptance criteria are developed to provide a pass/fail analysis of each item. Both automated and manual review techniques are employed: automated routines for 100% review, and manual reviews for a random sample of products.

The linkage between QA and QC occurs after the results of the QC are known. If any defects are discovered, we determine why the QA plan did not prevent the defects and the plan is appropriately modified and implemented. This process is initiated after each QC cycle if defects are found. This method of constant and continual improvement results in highly consistent products with high quality. Both production and QC team members participate in the analysis and improvement of the process to make sure that

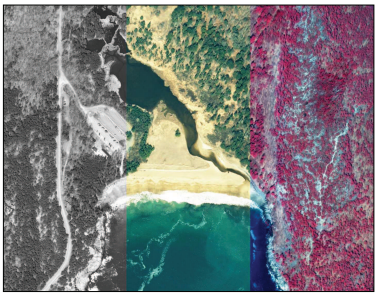
all team members are up-to-date on the latest techniques and procedures for the entire project.

III. Tasks

A. TASK 1: Collect Aerial Imagery for the Piscataqua Region Estuaries

Task 1 involves the collection of digital 4-band imagery with a nominal 1 foot resolution. Also included is a preliminary set of orthophotographs produced using the ABGPS/IMU data and assuming an average elevation.

The mission will be flown using the Intergraph Digital Mapping Camera (DMC). The KAPPA Project Team selected the DMC due to its superior accuracy, image clarity, and versatility. Flight lines and exposure stations for this project will have been pre-planned by KAPPA according to the specifications listed in the RFP.



Multiple flights over the same area are not required because the DMC simultaneously captures panchromatic, color, and color infrared imagery in a single pass. The DMC system is a complete end-to-end digital imaging system. It has an integrated workflow, from mission planning and preparation to the creation of deliverable products. During a flight mission, a Global Positioning System supported navigation system interfaces with the camera control software, differential-GPS, and inertial measurement unit (IMU) sensors to capture positional data to the 0.62 meters (2 foot) accuracy required for the project.

The DMC captures imagery suitable for engineering-level planimetric and topographic mapping as well as superior ortho image products and it has been documented that the DMC's accuracy and image quality exceeds other digital imaging systems.

KAPPA will work closely with both PREP Project Manager and the aerial survey firm, RCA, to schedule potential acquisition dates and times. KAPPA will continue to actively monitor the conditions along the coast so that everyone is kept up-to-date with the status of image acquisition and its specific parameters. The KAPPA Project Team is very familiar with tracking tides and solar sun angles based on client criteria.

RCA's Maine and New Hampshire flight operations are based out of Old Town Maine. ***This proximity to New Hampshire and southern Maine ensures that a decision to fly can be made quickly and early while acquisition conditions are optimal.***

The flightplan is shown below in Figure 1 and consists of 10 flight lines with 468 images at a pixel resolution of 0.29 meters. The flightplan is based on mapping limits provided by PREP and includes the optional areas.

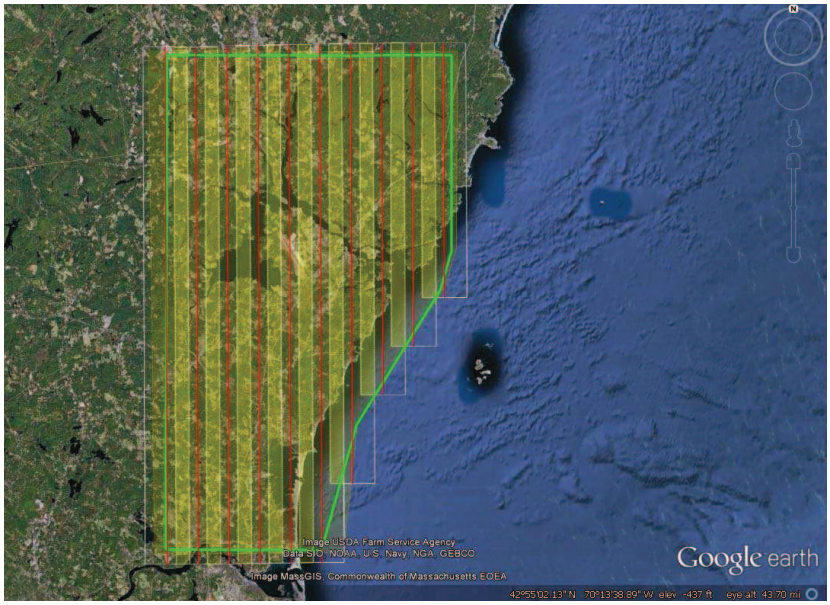


Figure 1. Flightplan layout consisting of 10 flightlines and 468 images. The green line is the project boundary, red lines are flight lines, and shaded areas indicate stereo coverage. Ground sample resolution for the raw imagery is 0.29 meters.

Quality Assurance

Project specifications for not only the flight, but also the derivative project deliverables, will be conducted with the flight crew and staff so that they have a complete understanding of this important project.

RCA, working closely with KAPPA and PREP, will collect aerial imagery that meets or exceeds the following specifications.

- Mapping location: The Great Bay Estuary, Hampton-Seabrook Estuary, and the New Hampshire Coastline. See attached description and map.
- 4-band source imagery (red, green, blue, and near infrared) and will be of sufficient resolution to support production of digital orthorectified images to a ground pixel resolution of 0.30 meters (nominal 1 foot).
- Orientation: Vertical.
- Ground Pixel Resolution: 0.30 meters (1 foot)
- Spatial accuracy: Digital orthorectified imagery shall have a horizontal positional accuracy not to exceed 0.62 meters (2 feet) Root Mean Squared Error. A digital elevation model of sufficient accuracy and resolution shall be used in the

orthorectification process to ensure compliance with the accuracy specification for the final imagery product.

- Overlap: The extent of image coverage over the project area shall be sufficient to ensure void areas do not exist within the defined project area.
- Camera Station Control: Camera position shall be recorded at the instant of exposure for each image using airborne, differential GPS. Camera attitude shall be recorded at the instant of exposure for each image.
- Sensor Calibration: A current Product Characterization Report will be provided
- Environmental Conditions:
  - July 1 to September 30, 2013 (August 1 to August 31 is ideal)
  - Early morning (7:00 am – 10:00 am)
  - Low spring tide (+/-2 hours of low tide at Adams Point in Great Bay)
  - Low sun angle (>30 degrees ideal, >50 degrees unacceptable. Flight window was extended to >25 degrees, to accommodate ideal tide conditions. Flight lines shall be planned, and imagery acquired, in such a way so as to minimize sun glint over areas of interest.)
  - Low cloud cover (>10% cover is unacceptable)
  - Calm winds (<10 mph)
  - No preceding rain events (TBD by PREP Project Manager)
  - Low turbidity / good water clarity (TBD by PREP Project Manager)

Flight maps will be prepared using a well established and trusted flight planning software. Project limits furnished by the client will be used to determine the area coverage. Digital output from the flight planning software is transferred electronically into the flight navigation and the DMC image capture system.

The Flight Contractor, Richard Crouse & Associates (RCA), will obtain prior authorization from the PREP Project Manager for the date of the aerial survey. The Flight Contractor will also coordinate with the Pease International Tradeport regarding flight restrictions near the Portsmouth International Airport.

A contacts list was generated to discuss status of water, ground, tide, sun angle, and weather conditions prior to flight:

Contact List:

Name	Organization	Work Phone	Mobile Phone	Email	Role
Phil Trowbridge	PREP / NH Dept. of Environmental Services	(603) 271-8872	(603) 340-5220	Philip.Trowbridge@des.nh.gov	Project Manager
Claire Kiedrowski	KAPPA Mapping, Inc.	(207)-942-5200	(207)-266-7087	claire@kappamap.com	Project Manager
Bruce Berry	KAPPA Mapping, Inc.	(207)-942-5200	(207)-570-3447	bruceb@kappamap.com	Production Supervisor
John Dwyer	Richard Crouse & Associates (RCA)	(207)-827-5979	(207)-478-1440	jdwyer@richardcrouse.com	Pilot

QC for Aerial Imagery and AGPS/IMU capture

- Pre-flight
    - The digital flight maps will be checked for proper coverage, sidelap, overlap, and flight height by KAPPA personnel.
    - Teleconference meetings to discuss appropriate flight conditions will be documented by KAPPA and distributed to each party.
    - Images will be automatically inspected to verify that it is in the 4-band format, with a nominal ground resolution exceeding 1 foot ground resolution. Performed by RCA.
- Post-flight
    - Flight logs will be inspected to verify that all environmental conditions have been met along with proper time considerations. Performed by RCA.
    - When the flying mission has been successfully completed and the images have been processed suitable to work with them as individual images, they will be imported into ArcMap and inspected for cloud shadow, density, clarity and image consistency. Images will also be checked for acceptable overlap, and sidelap. Tilt, and crab angle will be reviewed by inspecting the IMU rotational angles. Performed by KAPPA.
    - The AGPS/IMU data will be verified post-flight by importing photo center positions into ArcMap and checked for proper coverage, overlap and sidelap. Performed by KAPPA.
    - Again, the images will be visually inspected to verify that it is in the 4-band format, with a nominal ground resolution exceeding 1 foot ground resolution. Performed by KAPPA.

There are two sets of deliverables with Task 1: the first is a preliminary set of ortho rectified images and the second is the final unrectifed images along with photo center information and supporting documents.

Preliminary Deliverables:

Within 21 days of collecting the imagery, the Contractor shall provide PREP with preliminary images for the study area to be used in the ground truth survey. The images shall be in SID format and be geo-referenced using direct geo-referencing and assuming an average elevation.

We will use AGPS/IMU for geo-positioning and an average elevation (the same across all images) will be used to generate 4-band orthophotographs with a 1 foot resolution.

Quality Control Checks and Procedures for Preliminary Digital Orthophotographs

- Check that all images were orthorectified and are readable with at least two software packages.
- Check coordinate system and units.
- Preliminary check on quality of imagery.
- Check that imagery covers project area.
- Check for proper image format.

Delivery Materials

- Prelim orthophotographs in SID format using Direct geo-referencing

Final Deliverable Materials

The final deliverables will be will be verified for completeness prior to shipping.

- Digital Camera Product Characterization Report
- ArcGIS shapefile(s) showing photo centers and times of all photographs
- Raw imagery data with camera station control data in the New Hampshire State Plane Coordinate System referenced to NAD83. Elevations will be referenced to NAVD88 via NAD83 ellipsoid heights, and geoid modeling. Units will be US Survey Feet.
- Raw images on external disk drive
- QC summary report

B. TASK 3: Prepare and Deliver Digital Files to PREP

Task 3 involves the preparation of orthorectified multi-band imagery and RGB composite true color imagery mosaicked in uncompressed GeoTiff format.

1. Direct geo-referencing or AT

Quality Assurance

KAPPA proposes to use direct geo-referencing for the positioning of the imagery. In this scenario, ground control points are not used because the aircraft is equipped with integrated Airborne GPS (AGPS) and IMU systems. The AGPS calculates the exposure centers for each photo. The IMU unit provides the roll, tip, and yaw of the aircraft at the instance of exposure. In essence, each photo center is a control point with this approach.

To verify the geo-positioning, KAPPA proposes to obtain scaled ground control check points surrounding the project area. We will scale a minimum of 20 coordinates from photo-identifiable points from New Hampshire's GRANIT Statewide GIS Clearinghouse and the Maine GIS Geolibrary such as the recent 2012 orthophotographs in York County. We will compare scaled coordinates with the directly geo-referenced coordinates to ensure that we meet the 0.62 RMSE as specified for the horizontal accuracy. Points will be well distributed over the entire project area: points will enclose the project area as well as a number of them will be sprinkled throughout the middle. Points will be selected after KAPPA receives the imagery.

If we do not meet the positional accuracy requirements, then we are prepared to follow a traditional workflow of running the aerotriangulation (AT) process. Typically, the aerotriangulation (also called bridging) process is used to densify the ground control network and the AGPS, and to extend the limited control into every frame of photography. The process involves measuring points on each stereo model, tying the stereo models into strips, and then tying the strips into a block. The block is then transformed to fit the existing scaled ground control. A sophisticated least squares algorithm is then used to adjust all of the measurement values simultaneously to achieve a best fit solution.

The above bridging process would be used to the extent possible on this project. However, water photos cannot be bridged in the above manner unless sufficient land features are present. Where typical bridging is not possible, we will rely on the AGPS exposure center coordinates, and the photo rotations derived from the inertial measurement unit (IMU). On land features that are present, we will scale coordinates of photo-identifiable points from New Hampshire's GRANIT Clearinghouse, and will add such points to the aerotriangulation solution for that area. This process is discussed in the "*Guidance for Benthic Habitat Mapping*" in the section Alternative Sources of Control.

Quality Control Checks

- If Direct georeferencing
    - Check points from scaled imagery
- If Aerotriangulating (AT)
    - Check model ties
    - Check flight ties for blunders.
    - Check ground control residuals.
    - Check RMSE of final block adjustment

Delivery Materials

The final deliverables will be will be verified for completeness prior to shipping.

- If Direct geo-referencing
    - Exterior orientation parameters (X, Y, Z, Omega, Phi, Kappa).

    - Listing of check points and their coordinates
- If Aerotriangulation (AT)
    - Report and listing of the refined plate coordinates; pass point and flight tie residuals, final coordinates of all pass points, flight ties, and ground control, and exterior orientation parameters (X, Y, Z, Omega, Phi, Kappa).
- ArcGIS shapefile(s) showing photo centers and times of all photographs

2. Digital Elevation Model

Quality Assurance

Digital Elevation Models (DEM) are a necessary element to create digital orthophotographs. KAPPA will obtain the best, freely available LiDAR data or USGS DEMs that cover the project area and use these in the orthorectification process. We propose to use the LiDAR for the Northeast data which was acquired in 2010. We have been using this data in southern and coastal Maine, and have a high confidence that it meets this project's criteria.

The DEM will be imported into our softcopy system and edge matching will be verified in stereo using photogrammetric software and hardware. In areas of gaps or overlaps, KAPPA will correct the area in stereo using our softcopy system. The Digital Elevation Model will be of sufficient accuracy and resolution for the orthorectification process to ensure compliance to the spatial accuracy of the RFP.

QC of Digital Terrain Model

- Stereo visual inspection and correction, if necessary.

Delivery Materials

- None

3. Orthophotography & Mosaicking

Quality Assurance

Ortho-rectified multi-band (red, green, blue, and near infrared) imagery will be created from the following raw data sources: aerial imagery from the digital camera, exterior orientations from either direct geo-referencing or aerotriangulation, and the Digital Elevation Model (DEM).

The individual images will be orthorectified using specialized orthorectification software. The orthorectification process will use a bi-cubic convolution algorithm,

which produces a quality orthophotograph. Output pixel resolution for each image will be 1 foot (0.30 meters) and the projection will be the New Hampshire State Plane Coordinate System with horizontal datum of NAD83.

Images will be mosaicked into a seamless database using OrthoVista software. This software package also provides tools for radiometrically balancing of the images, to ensure image consistency and enhancement across flight lines. We will review the radiometric balance options with PREP to ensure optimal viewing of the eelgrass and salt marshes. Changes in color balance across the project will be gradual (if at all). It is understood that abrupt tonal variations are not acceptable.

Once the images are color corrected and mosaicked, they will be tiled to a layout suitable for PREP. The geo-referenced mosaic images will be in uncompressed GeoTIFF format. As the images are loaded into your GIS package, they will automatically be placed in the correct geographic position.

Deliverables will also include a 3-band (red, green, blue) true-color composite.

QC for Orthophotography

- DEM will be verified before the orthorectification process
- Imagery locations will be checked against checkpoints and existing vector data. A minimum of 20 check points that are distributed throughout the project area will be evaluated to determine the accuracy of the final product. Existing data sets (vector maps, high resolution/quality digital orthophotographs, etc) as well as the initial points used to verify the quality of the direct georeferencing or AT will be used to extract suitable points. RMSE's for both the x and y component of the check points will be computed assuming that the RMSE of the x and y components are roughly equal. The 95% confidence level using the circular map accuracy standard (Accuracy = 1.7308 * $RMSE_r$) will be applied. The results will be reported in the standard NSSDA report format showing all computations. This step is in addition to the step checking the horizontal accuracy in Task 3, Subtask 1 (Direct Georeferencing or AT).
- Individual inspection of the imagery for pleasing and consistent color balancing suitable for eelgrass habitat monitoring

The final deliverables will be will be verified for completeness prior to shipping.

Delivery Materials

- Digital media on hard drive
- Ortho images in uncompressed GeoTIF/TFW format
- Index of tile layout in ArcGIS format
- Composite image

- Orthophoto metadata meeting FGDC standards.

C. TASK 4: Quality Control Report

Task 3 involves the preparation of the Quality Control Report that demonstrates that the imagery meets or exceeds the specifications from Task 1 according to the procedures specified in the Quality Control Plan from Task 2.

Quality Assurance

The QC reports and check lists from the previous tasks will be assembled.

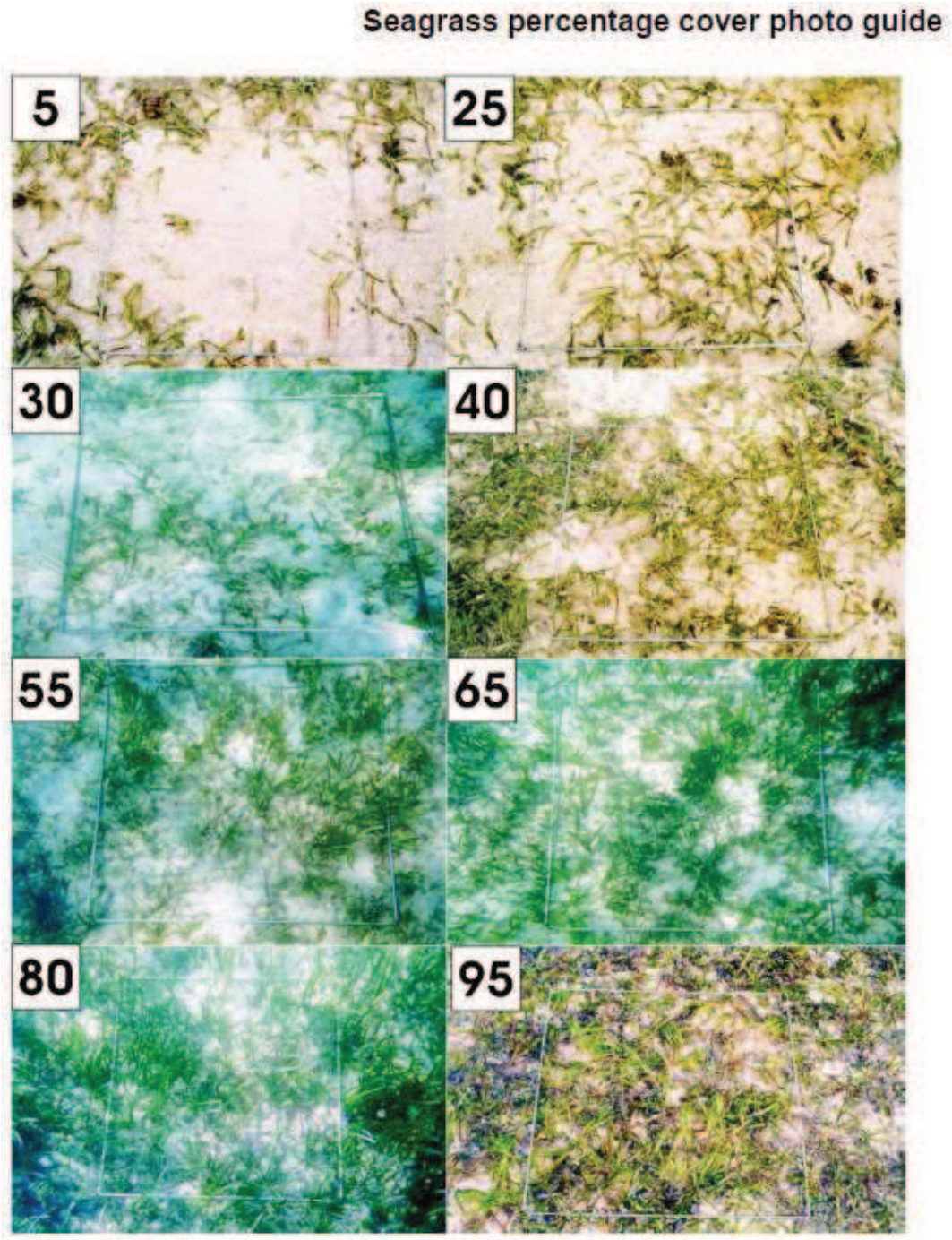
Quality Control

The assembled reports will be reviewed to make sure all required items are a “pass”.

Great Bay Estuary Eelgrass Monitoring Program for 2013
Quality Assurance Project Plan

Appendix B

Appendix B: Visual Guides for Seagrass Percent Cover in Quadrats



Source: SeagrassNet Short, F.T., McKenzie, L.J., Coles, R.G., Vidler, K.P., Gaeckle, J.L. 2006. SeagrassNet Manual for Scientific Monitoring of Seagrass Habitat, Worldwide edition. University of New Hampshire Publication. 75 pp.

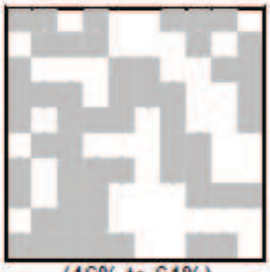
Plant Survey

Standard Cover Classes and Midpoints for Estimating Abundance

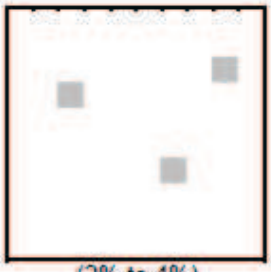
One method for obtaining abundance values for vegetation surveys is to estimate the percent of a plot occupied by the target plant. To assess percent cover, one estimates the area of the plot frame ($1m^2$) that is covered by all of the leaves, branches, and stems of the target species. Visual estimates may vary from one person to another. This variability can be significantly reduced by using standard cover classes and midpoint abundance values. The following figures illustrate 9 standard cover classes to use. For each plot, first identify and list the species present, then for each species determine which figure best describes its cover. Record the midpoint value on the data sheet.

(Trace to 1%)
Use 1%

(11% to 19%)
Use midpoint 15%



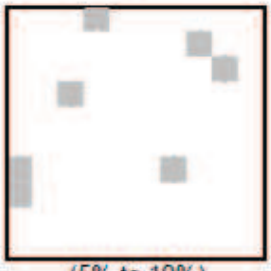
(46% to 64%)
Use midpoint 55%



(2% to 4%)
Use midpoint 3%

(20% to 30%)
Use midpoint 25%

(65% to 87%)
Use midpoint 76%



(5% to 10%)
Use midpoint 7%

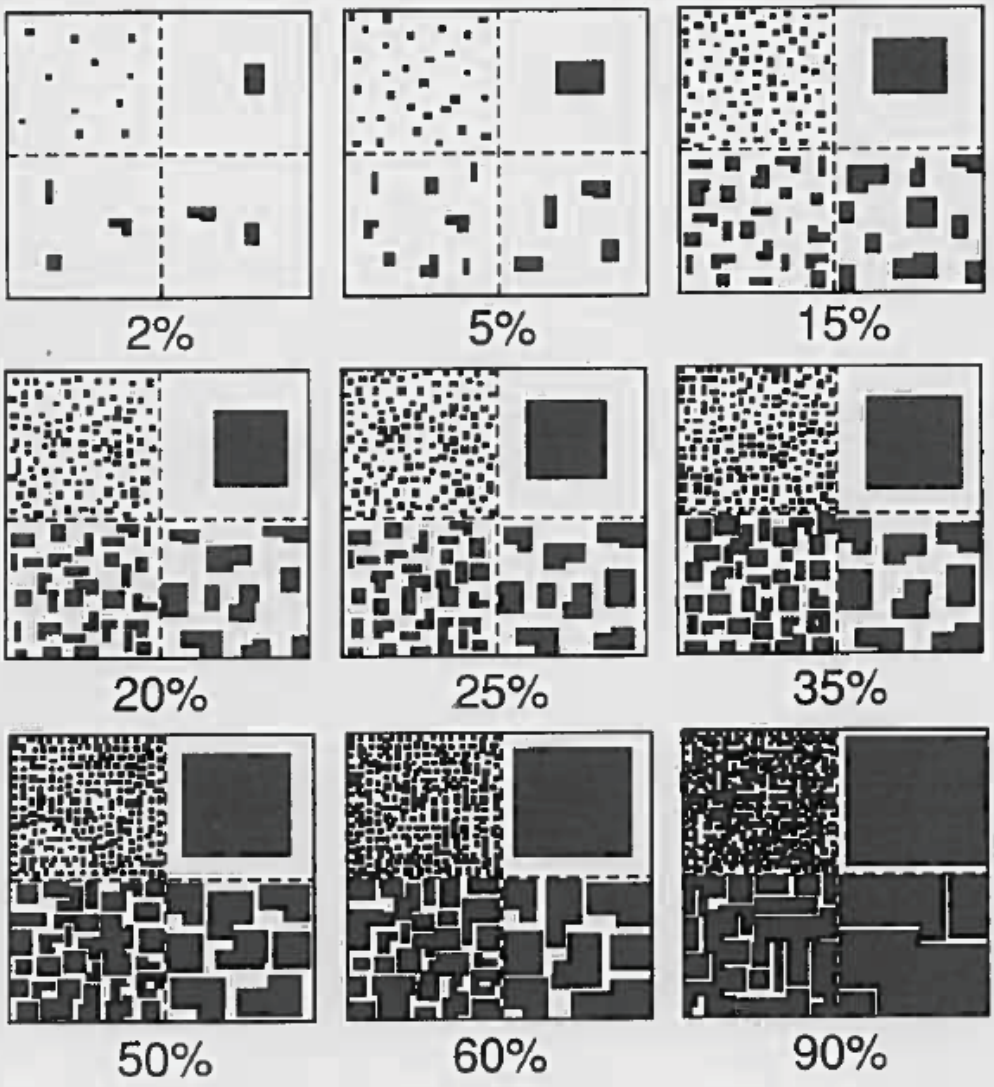
(31% to 45%)
Use midpoint 38%

(88% to 100%)
Use midpoint 94%

Carlisle, B.K., J.D. Baker, A.L. Hicks, J.P. Smith, and A.L. Wilbur. 2004. Cape Cod Salt Marsh Assessment Project; Final Grant Report, Volume 1: Relationship of salt marsh Indices of Biotic Integrity to surrounding land use, 1999 Boston, MA. Massachusetts Office of Coastal Zone Management.

EXAMPLES OF PERCENT OF AREA COVERED

The following graphic can be used for various data elements to convey "Amount" or "Quantity." ***NOTE***: Within any given box, each quadrant contains the same total area covered, just different sized objects.

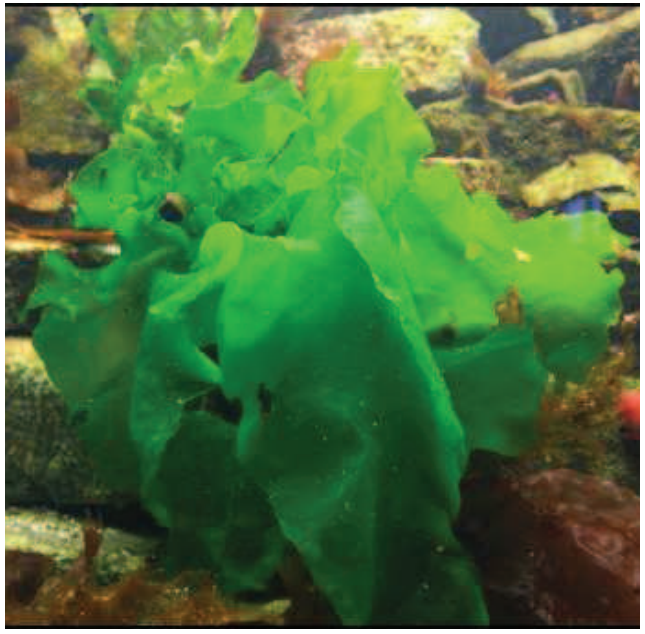


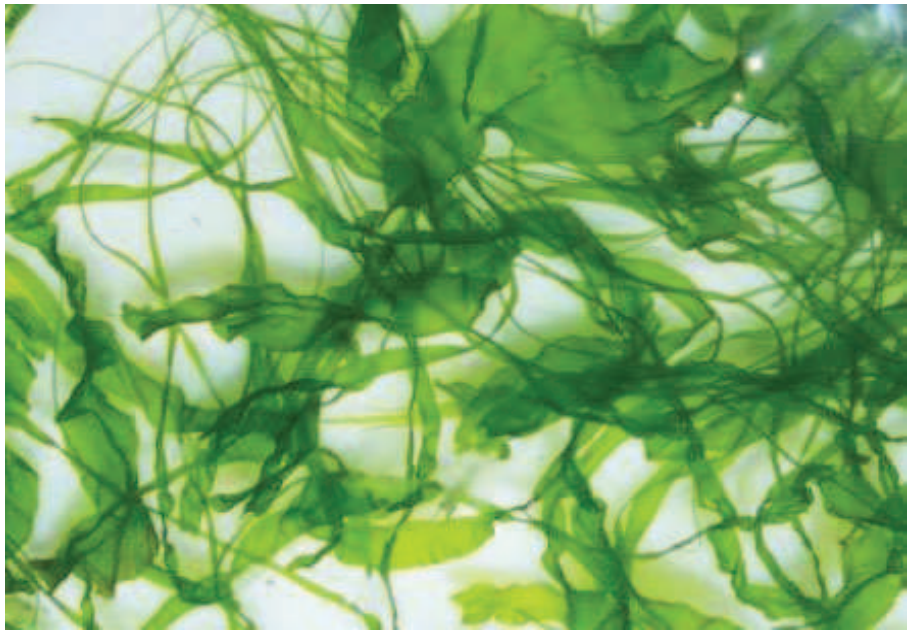
Source: USDA/NRCS. Field Book for Describing and Sampling Soils. September 2002.

Great Bay Estuary Eelgrass Monitoring Program for 2013
Quality Assurance Project Plan

Appendix C

Appendix C: Visual Guide for Macroalgae Species Identification





From upper left to upper right:
Ulva (blade)
Ulva (tube)

Bottom left:
Gracilaria (non-native *vermiculophylla* shown; may also be red or black)

Great Bay Estuary Eelgrass Monitoring Program for 2013
Quality Assurance Project Plan

Appendix D

Appendix D

Field Data Sheet - Eelgrass Ground Truth Monitoring

Station Number		**Date MMDDYY**						
Crew Chief		**Crew Member 1**						
Crew Member 2		**Crew Member 3**						
Purpose for Visit	☐ Drop Camera Observations ☐ Diver Observations ☐ Edge Mapping							

Weather Condition	☐ Sunny ☐ Partly Cloudy ☐ Overcast ☐ Rainy ☐ Windy ☐ Foggy
Sea Condition	☐ Calm ☐ Choppy ☐ Rough
Time On Station	: (HH : MM EDT)
Water Depth	. (meters, one decimal place)

Latitude		.							**DD . DDDDDD format**
Longitude		.							**DD . DDDDDD format**

Drop Camera Observations

Eelgrass Cover	☐ Dense ☐ Some Bottom ☐ Half ☐ Patchy ☐ Not Present
Ulva Cover	☐ Less than 10% ☐ More than 10% ☐ Not Present
Graciliaria Cover	☐ Less than 10% ☐ More than 10% ☐ Not Present
Filenames for Photos or Video	
Notes	

Field Data Sheet - Eelgrass Ground Truth Monitoring

Station Number		Date MMDDYY						

Diver Observations

Quadrat	Percent Cover (to closest 10%)						Filenames for Photo or Video
	Eelgrass		Ulva		Gracilaria		
North Direction (quadrats N1, N2, N3, N4)	N1	N2	N1	N2	N1	N2	
	N4	N3	N4	N3	N4	N3	
East Direction (quadrats E1, E2, E3, E4)	E1	E2	E1	E2	E1	E2	
	E4	E3	E4	E3	E4	E3	
South Direction (quadrats S1, S2, S3, S4)	S1	S2	S1	S2	S1	S2	
	S4	S3	S4	S3	S4	S3	
West Direction (quadrats W1, W2, W3, W4)	W1	W2	W1	W2	W1	W2	
	W4	W3	W4	W3	W4	W3	
Notes							

Field Data Sheet - Eelgrass Ground Truth Monitoring

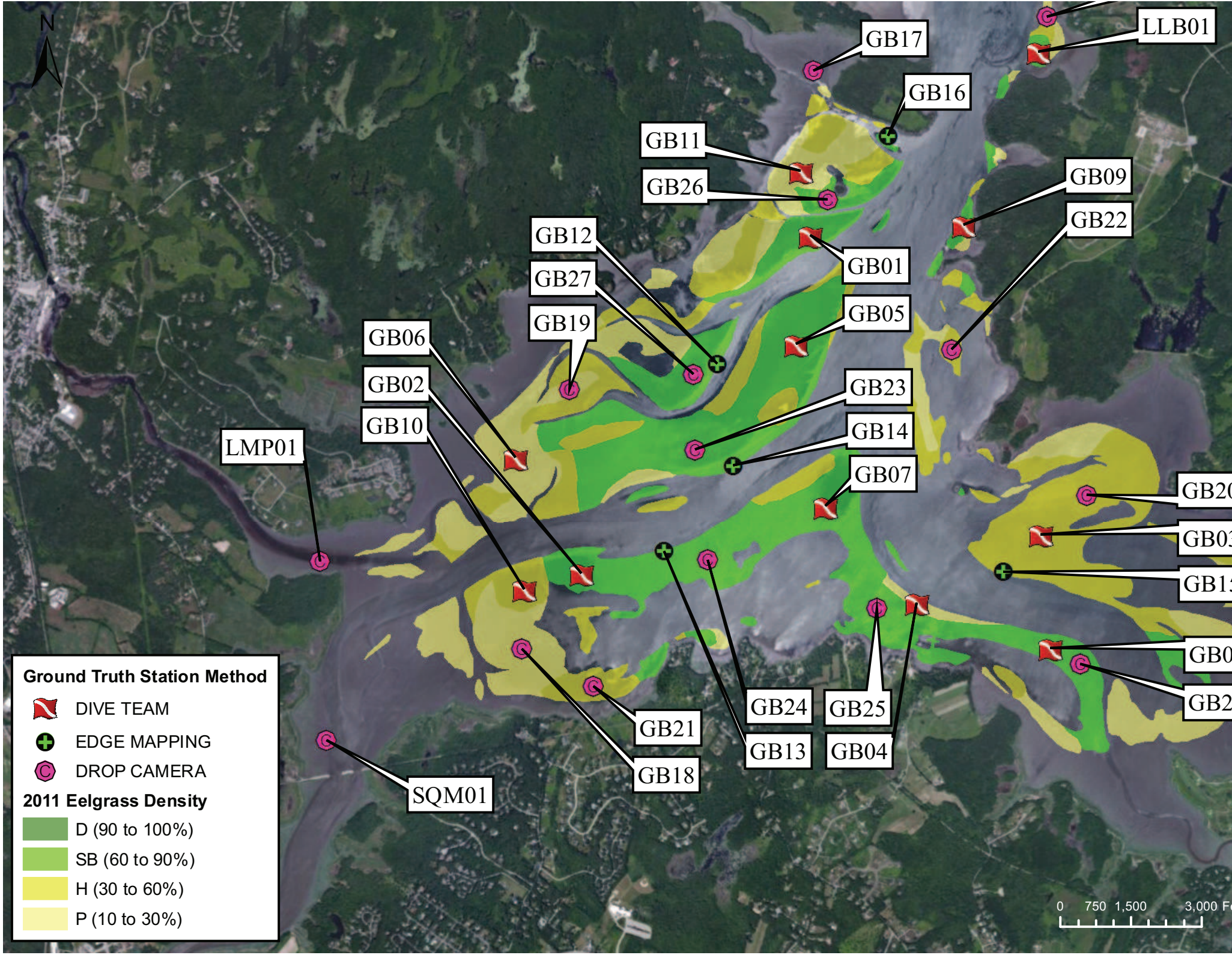
Station Number		Date MMDDYY						

Edge Mapping

Marker	Latitude (DD . DDDDDD)								Longitude (DD . DDDDDD)							
1		.								.						
2		.								.						
3		.								.						
4		.								.						
5		.								.						
6		.								.						
7		.								.						
8		.								.						
9		.								.						
10		.								.						
Notes																

Great Bay Estuary Eelgrass Monitoring Program for 2013
Quality Assurance Project Plan

Appendix E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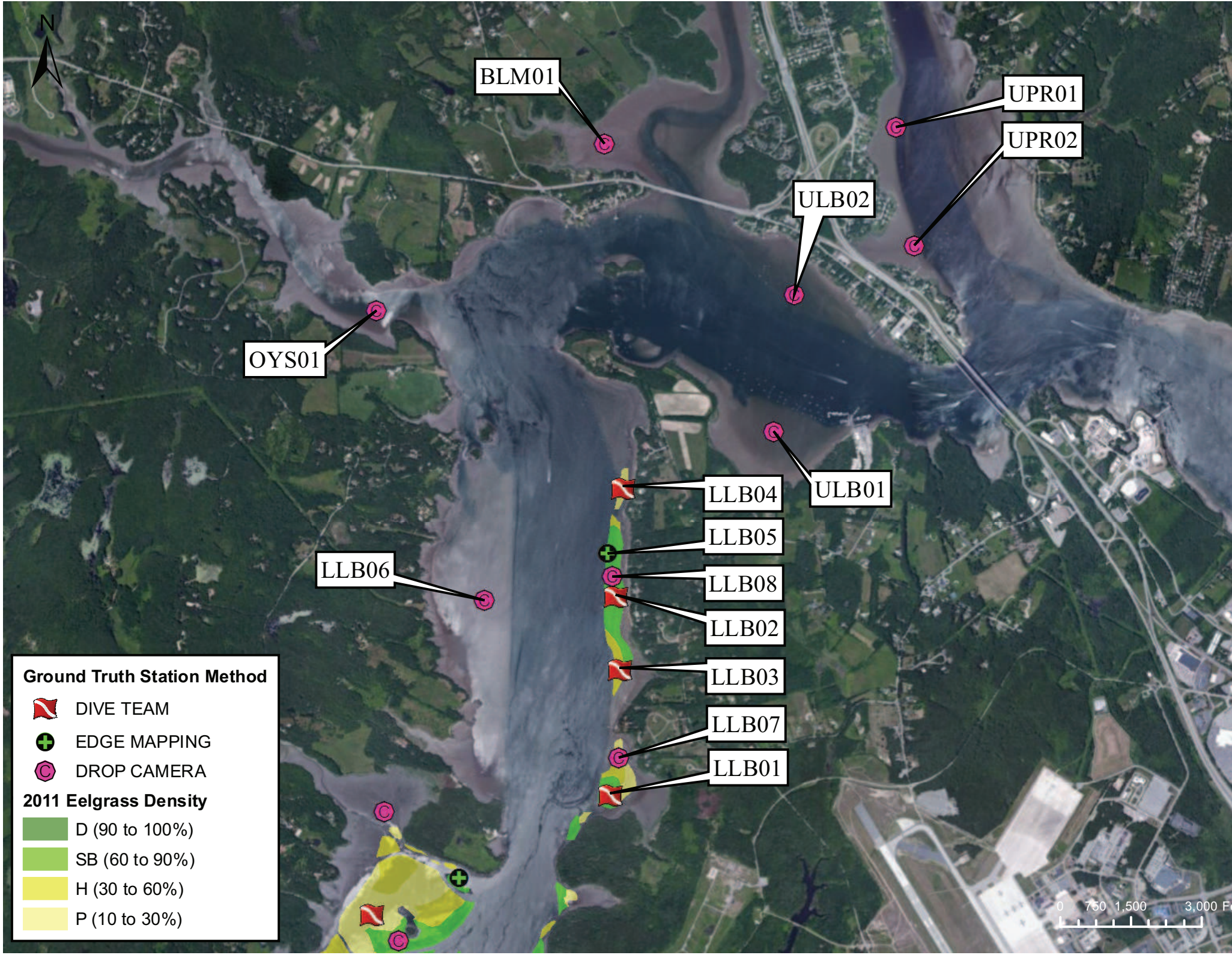
GB17
LLB01
GB16
GB11
GB26
GB09
GB22
GB12
GB01
GB27
GB05
GB19
GB06
GB02
GB23
GB10
GB14
LMP01
GB07
GB20
GB03
GB15
GB24
GB25
GB21
GB13
GB04
GB18
SQM01
Ground Truth Station Method
DIVE TEAM
EDGE MAPPING
DROP CAMERA
2011 Eelgrass Density
D (90 to 100%)
SB (60 to 90%)
H (30 to 60%)
P (10 to 30%)
0 750 1,500 3,000


N
BLM01
UPR01
UPR02
ULB02
OYS01
ULB01
LLB04
LLB05
LLB06
LLB08
LLB02
LLB03
LLB07
LLB01
Ground Truth Station Method
DIVE TEAM
EDGE MAPPING
DROP CAMERA
2011 Eelgrass Density
D (90 to 100%)
SB (60 to 90%)
H (30 to 60%)
P (10 to 30%)
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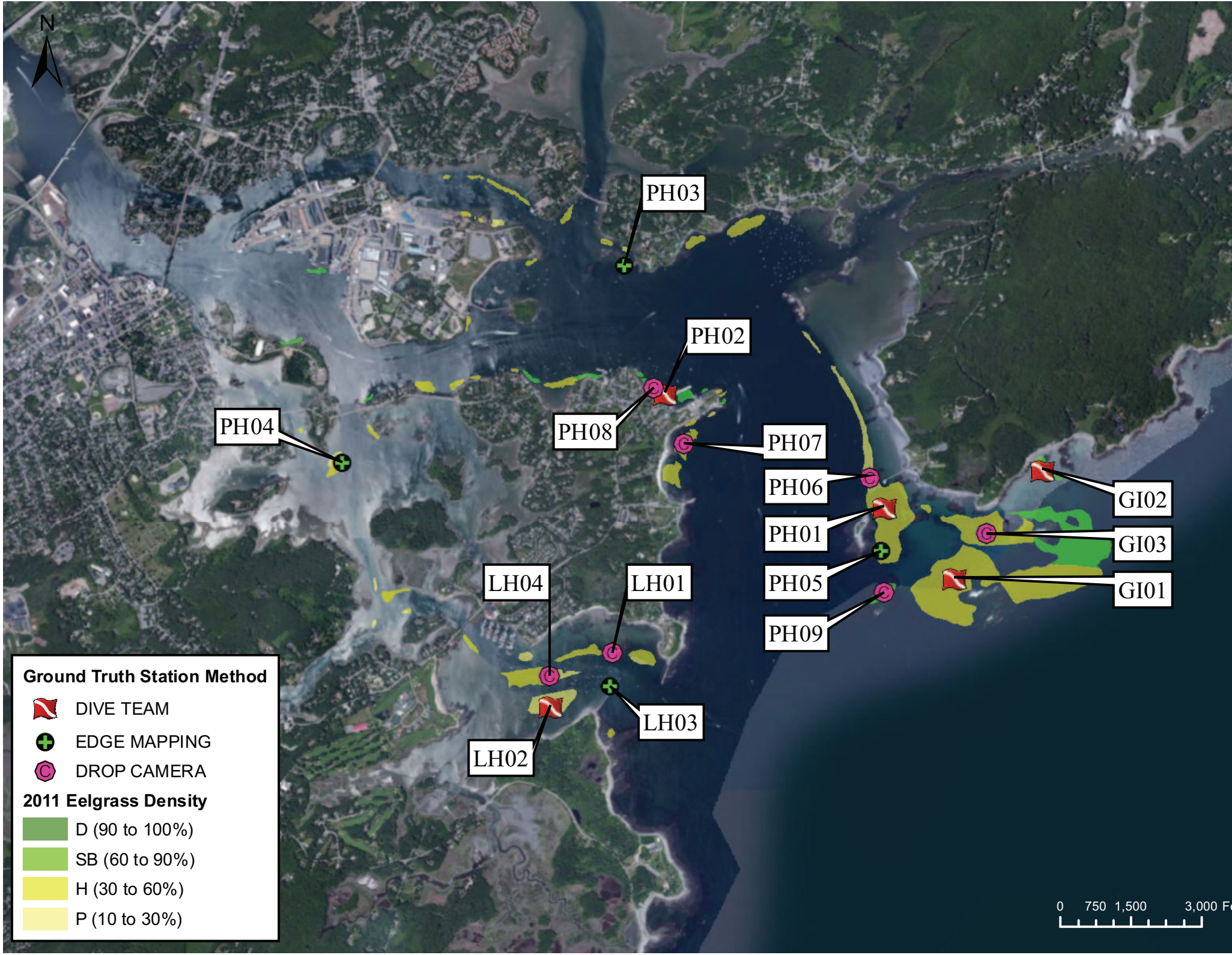
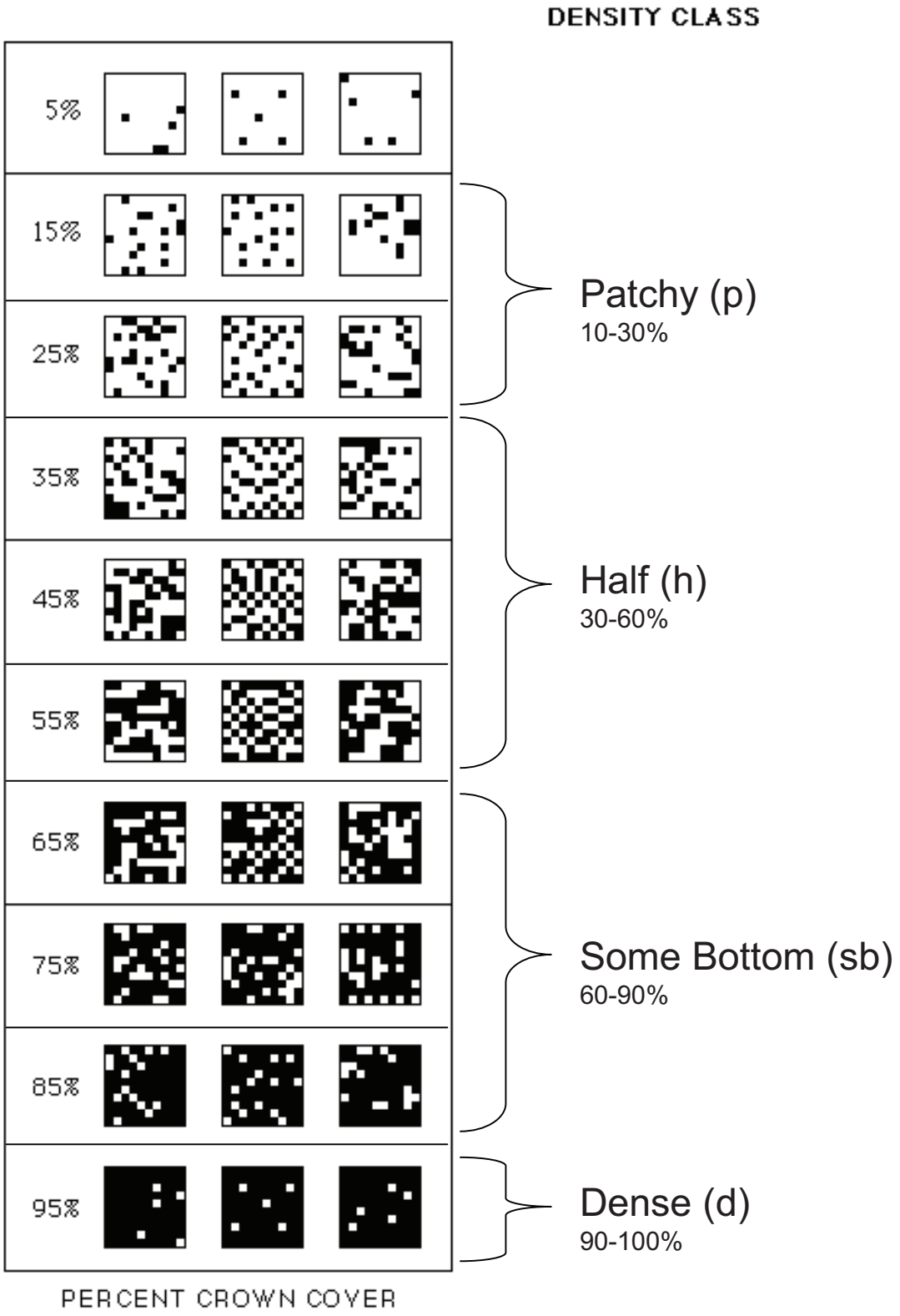

N
PH03
PH02
PH04
PH08
PH07
PH06
PH01
PH05
PH09
GI02
GI03
GI01
LH04
LH01
LH03
LH02
Ground Truth Station Method
DIVE TEAM
EDGE MAPPING
DROP CAMERA
2011 Eelgrass Density
D (90 to 100%)
SB (60 to 90%)
H (30 to 60%)
P (10 to 30%)
0 750 1,500 3,000 F

Great Bay Estuary Eelgrass Monitoring Program for 2013
Quality Assurance Project Plan

Appendix F

Appendix F

Visual Guide for Eelgrass Percent Cover for Photointerpretation



Source: http://web.vims.edu/bio/sav/sav11/crown_density.html