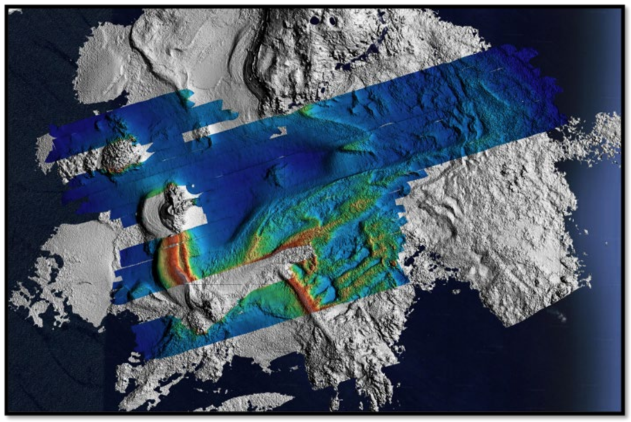
QUALITY ASSURANCE PROJECT PLAN

Bathymetric Mapping to Support Mattapoisett Harbor TMDL Development (2025)



Prepared for:
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Division of Watershed Management, Bureau of Water Resources
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CN 613.0

Quality Assurance Project Plan for Bathymetric Mapping to Support Mattapoisett Harbor TMDL Development
Version 0

Effective April 2025 to April 2030

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Cover Photo
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PROJECT MANAGEMENT

A1. TITLE AND APPROVALS

June 3, 2025

Matthew Reardon — Date
Senior Manager, Watershed Planning Program
Massachusetts Department of Environmental Protection

June 2, 2025

Holly Brown — Date
Project Manager, Watershed Planning Program
Massachusetts Department of Environmental Protection

June 3, 2025

Timothy Fox — Date
TMDL Analyst, Watershed Planning Program
Massachusetts Department of Environmental Protection

June 3, 2025

Jasper Sha — Date
Quality Assurance Manager, Watershed Planning Program
Massachusetts Department of Environmental Protection

May 27, 2025

Jon C. Ludwig — Date
Contractor Senior Manager
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May 22, 2025

Vamsi Krishna Sridharan — Date
Contractor Project Manager
Tetra Tech

June 2, 2025

Susan Lanberg — Date
Quality Assurance Manager
Tetra Tech

June 2, 2025

Mark Borrelli — Date
Chief Scientist
Center for Coastal Studies

This QAPP is approved for use for 5 years from the final approval signature or the length of the project.

A2. TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

A3. DISTRIBUTION LIST

Copies of this QAPP, and any subsequent revisions, will be distributed by the Watershed Planning Program (WPP), Massachusetts Department of Environmental Protection (MassDEP), after approvals have been obtained. The following groups will be made aware of this QAPP:

- MassDEP, WPP staff, and Southeast Regional Office (SERO) staff
- MassDEP QA Managers
- Massachusetts Office of Coastal Zone Management (MassCZM; Todd Callaghan)
- Executive Office of Energy and Environment (EEA; Joe Costa)
- U.S. Environmental Protection Agency (USEPA) Region 1 (relevant staff)
- Buzzards Bay Coalition (BBC; Rachel Jakuba)
- Center for Coastal Studies (CCS; Mark Borrelli; Agnes Mittermayr)

This QAPP is to be considered a "working document" and will be periodically updated and revised as technology and protocols change. An updated QAPP will be formally re-submitted for approval every five years as appropriate. The MassDEP Project Manager will ensure electronic copies of this QAPP are available on the MassDEP network drive.

A3.1 Modifications to the QAPP

This section addresses procedures to be followed when modifications are needed to this QAPP, including the associated SOP (Appendix A), that require real-time modifications to achieve project goals. Examples of such modifications include changes in procedures, assessment, and reporting. The formal WPP Control Number (CN) for this document (CN 613.0, Version 0) shall be modified if substantial revisions are made.

Discussions involving changes to this QAPP may be initiated at any level. Contact should be made with the TMDL Program Section Chief to discern whether modification is warranted. The scope of effect of the proposed change will determine the formality of the approval process. A formal QAPP modification will include reference to the section(s) of text being modified or added to, the reason why the modification is necessary and the actual replacement or additional language. It will be the responsibility of the TMDL Program Section Chief to seek review and approval from others within WPP. Signatories of this original QAPP will receive such updates for approval. If SAPs and/or SOPs are included in a future iteration of this QAPP, modifications, additions and retirements to these SAPs and/or SOPs must follow the same procedure as modifications to the QAPP. Additionally, SAPs and/or SOPs must be organized and formatted according to MassDEP WPP procedures. SAPs and/or SOPs under development should be included as part of the QAPP as soon as practicable.

A3.2 List of Acronyms

Acronym	Expansion
2D	two dimensional
3D	three dimensional
ASV	Autonomous Surface Vehicle
BBC	Buzzards Bay Coalition
CCS	Center for Coastal Studies
cm	centimeter

Acronym	Expansion
CN	Control Number
CTD	conductivity, temperature, and depth
CW	continuous wave
DMS	dynamic motion sensor
DQO	data quality objectives
DWM	Division of Watershed Management
EE	extraordinary event
EEA	Executive Office of Energy and Environment
EG	ecogroup
ft	feet
ft/s	feet per second
GHz	gigahertz
GAMS	GNSS azimuth measurement system
GNSS	Global Navigation Satellite System
GPS	global positioning system
GRTS	generalized random tessellation stratified
ha	hectare
HP	horsepower
Hz	hertz
HDPE	high-density polyethylene
IMU	inertial measurement unit
In	inch
INU	inertial navigation unit
INS	inertial navigation system
Kgs	kilograms
KHz	kilohertz
lbs	pounds
LOA	length overall
m	meter
ms	millisecond
m/s	meters per second
MassCZM	Massachusetts Office of Coastal Zone Management
MassDEP	Massachusetts Department of Environmental Protection
MassGIS	Massachusetts Geographical Information System
mm	millimeter
MRU	motion reference unit
NC	non conformity
NLM	nitrogen loading model
NOAA	National Oceanic and Atmospheric Administration
PC	personal computer
PMSS	phase measuring sidescan sonar
ppm	parts per million
QA	quality assurance
QAPP	Quality Assurance Project Plan

Acronym	Expansion
QC	quality control
RC	remote control
RMS	root mean square
RTK	Real Time Kinetic
R/V	Research Vessel
SAP	Sampling and Analysis Plan
SERO	Southeast Regional Office
SOP	Standard Operating Procedures
TMDL	Total Maximum Daily Load
TN	total nitrogen
TPU	total propagated uncertainty
TSA	Technical Surveillance Audit
USEPA	United States Environmental Protection Agency
UTC	Coordinated Universal Time
USGS	United States Geological Survey
WHOI	Woods Hole Oceanographic Institute
WGS	world geodetic system
WPP	Watershed Planning Program
YSI	Yellow Springs Instruments
µs	microsecond

A4. PROJECT AND TASK ORGANIZATION

A4.1 Scope and Application

Massachusetts Department of Environmental Protection (MassDEP) is developing a watershed nitrogen loading model (NLM) for Mattapoisett Harbor that will be used to inform a conceptual model of nitrogen loading into the embayment, which in turn will be used to develop a total nitrogen (TN) Total Maximum Daily Load (TMDL) for water quality improvement and benthic habitat recovery in this embayment of southeast coastal Massachusetts. TMDL development involves two components: (1) understanding from where and how nitrogen loads enter the embayment, and (2) how embayment water quality and benthic conditions respond to nitrogen loading. The former component involves a delineation of the contributing watershed and careful accounting of nitrogen sources and watershed transport and fate pathways in an NLM. The latter involves collecting the data needed to develop a hydrodynamic model and to establish TN thresholds at suitable locations (sentinel sites) where the effect of increased TN can be monitored and linked to load reduction actions. A conceptual model linking the NLM with the hydrodynamic model will indicate how nitrogen entering the embayment can be simulated. Bathymetric and benthic substrate mapping will be performed in Mattapoisett Harbor to (1) characterize the benthic environment, and (2) develop the datasets required for hydrodynamic model development.

This Quality Assurance Project Plan (QAPP) presents the organization, objectives, functional activities, and specific quality assurance (QA) and quality control (QC) activities associated with the collection of bathymetric data, benthic substrate characteristics, and flow data for MassDEP's development of TMDLs for TN in Mattapoisett Harbor. This document also describes the specific protocols that will be followed for sampling, data review and validation, document management, data management, and data usability assessment. All applicable federal, state, and local laws and regulations are to be followed when conducting activities described in this QAPP. A companion modeling QAPP (*Technical and Planning Support for the Development of Total Nitrogen TMDLs for Estuaries in Southeast Coastal Massachusetts QAPP*) [MassDEP 2023a] provides the general descriptions of the modeling needed to support TMDL development.

This QAPP was prepared in accordance with United States Environmental Protection Agency (USEPA) Region 1 guidance (USEPA 2024). The standard operating procedure (SOP) for Phase-Measuring Sidescan Sonar (Appendix A) provides the additional operational details required to conduct bathymetric data collection and describes staff responsibilities and specific equipment.

Additional documents will be prepared for other monitoring tasks related to TMDL development. Updates to the *Embayment-specific study plan* (MassDEP 2023b) sampling and analysis plan (SAP) will be made for collection of associated flow and water quality data. Benthic macroinvertebrate data will be collected and analyzed from various sampling locations indicated from the findings of the benthic substrate characterization in accordance with the Estuarine and Marine Water Quality Monitoring QAPP (MassDEP 2023c). An embayment-specific SAP for benthic macroinvertebrate and sediment sampling will be developed subsequently.

A4.2 Project Organization

The principal users of this bathymetric monitoring QAPP will be MassDEP and its contractors, who will use this QAPP to guide sampling for TMDL nutrient load reduction analysis in Mattapoisett Harbor. Project organization for this generic Quality Assurance Project Plan (QAPP) is summarized in Table 1.

Specific project roles for project participants are summarized in Table 1 and Figure 1.

Table 1. Program roles and responsibilities related to benthic mapping and data use.

Organization	Personnel, Title, and/or Primary Role	Responsibilities
MassDEP	Matthew Reardon, TMDL Section Chief, WPP Senior Manager	Oversee development and implementation of nutrient Total Maximum Daily Loads (TMDLs) for state waters. Primary MassDEP staff member responsible for overseeing monitoring work described in this QAPP. Also oversees model development and application.
MassDEP	Holly Brown or Timothy Fox, TMDL Analyst(s), WPP Project Manager(s)	Oversee and manage consultant and ensure high quality deliverables.
MassDEP	Jasper Sha, Quality Assurance Analyst, WPP QA Manager	Overall technical oversight of project data quality assurance and quality control (QA/QC) and management. Has independence from all units generating data and modeling. Oversees QA training for the Department.
Tetra Tech	Jon Ludwig, Contractor Senior Manager	Overall management of administrative and technical work conducted by Contractor staff.
Tetra Tech	Vamsi Sridharan, Contractor Project Manager	Primary person or entity responsible for overseeing monitoring work described in this QAPP.

Organization	Personnel, Title, and/or Primary Role	Responsibilities
Tetra Tech	Susan Lanberg, Contractor QA Manager	Primary person responsible for project QA/QC procedures. This includes creation of electronic data deliverables and data validation.
Center for Coastal Studies	Mark Borelli, Chief Scientist	Primary person responsible for overseeing the quality of work and data collected in the field.
Center for Coastal Studies	Survey Crew	Under the direction of the Chief Scientist, the survey crew follows the Field SOP to collect water quality samples and data.

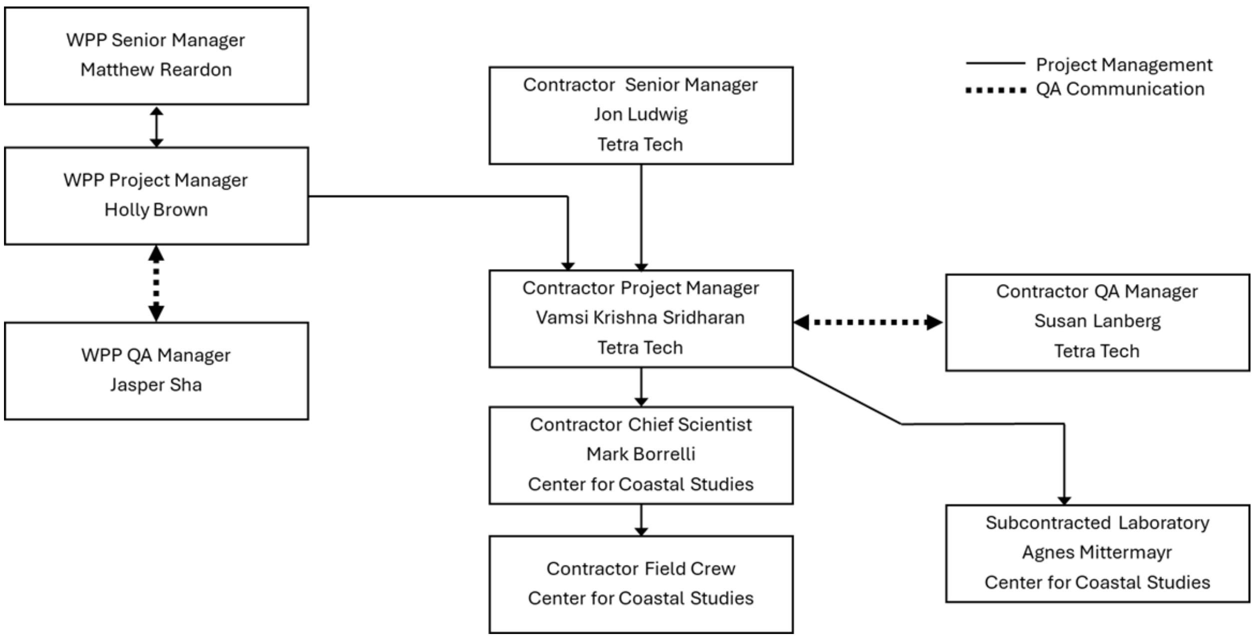

Figure 1. Organization chart.

A5. PROBLEM DEFINITION/BACKGROUND

Mattapoisett Harbor is a wide, relatively shallow embayment that is impacted by nutrient related causes. The Harbor has a surface area of approximately 775 hectares (Ha), in which open water areas at the mouth near Buzzards Bay are about 20-25 feet (ft) (6.1-7.6 meters [m]) deep, and shallow water inland areas that are less than 3 ft (0.9 m) deep. Semidiurnal tides with a range of approximately 6 ft (1.8 m) and local winds drive a predominantly counterclockwise current in the embayment. There are two smaller and very shallow (less than 3 ft [0.9 m] deep) embayments (Eel Pond and Pine Island Pond) along the northern and eastern shores of the Harbor. Mattapoisett Harbor had lost 74% of its eelgrass habitat between 1995 and 2017 (MassGIS 2024).

It is important to characterize the bathymetry and spatial distribution of benthic habitats in the embayment to achieve the following objectives:

(1) develop bathymetry for future hydrodynamic and water quality modeling, and
(2) characterize the benthic habitat structure and benthic habitat health.

The hydrodynamic model development relies on characterizing water quality and habitat conditions. Based on the interpolated TN concentrations, the remaining eelgrass appears to be limited to areas where the TN concentration is below 0.31 mg/L. In previous studies, healthy benthic infauna have typically been found to exist in areas with a TN concentration under 0.5 mg/L (Howes et al. 2003).

Embayment mixing, fate, and transport processes are influenced by the bathymetry and benthic substrate habitats. To parameterize a suitable hydrodynamic model, a phase-measuring sidescan sonar (PMSS) system comprising of a multibeam echosounder to collect bathymetric readings and a sidescan sonar to collect benthic substrate characteristics will be used. The benthic habitats identified from this mapping will also be used to identify representative locations for benthic invertebrate and sediment core sampling under a future task of this project. The sediment cores and benthic macroinvertebrate sample locations will be identified using a generalized random tessellation stratified (GRTS) approach based on the sidescan mapping of the embayment seafloor.

A6. PROJECT/TASK DESCRIPTION AND SCHEDULE

A6.1 Overview of Monitoring Tasks

Mattapoisett Harbor (Figure 2) TMDL development will include mapping using a PMSS system to collect bathymetric data and benthic substrate characteristics. Bathymetric mapping using sidescan sonar will determine the embayment bathymetry and characterize the benthic substrate. Benthic habitat assessment is necessary to convert sidescan mosaics into meaningful characterization of the substrate and benthic ecosystems. Updates to the *Embayment-specific study plan* (MassDEP 2023b) will be made, including updates to Section 2: Survey Plan for Mattapoisett Harbor Benthic Monitoring, to reflect the results of the bathymetric mapping task. The location and number of stations (15) to be sampled will be determined using a sampling survey design using a GRTS algorithm based on a characterization of the benthic substrate habitats identified in in the bathymetric mapping task as well as targeted sampling in each assessment unit within the embayment. The appropriate approach, data acquisition, and data quality control steps associated with bathymetric and benthic surveying are described in Appendix A.

During field collections, Chief Scientists will act as quality control supervisors who will monitor performance and results of quality control procedures; monitor instrument maintenance, calibration, and reliability; monitor sample control procedures and documentation; and monitor training of technicians.

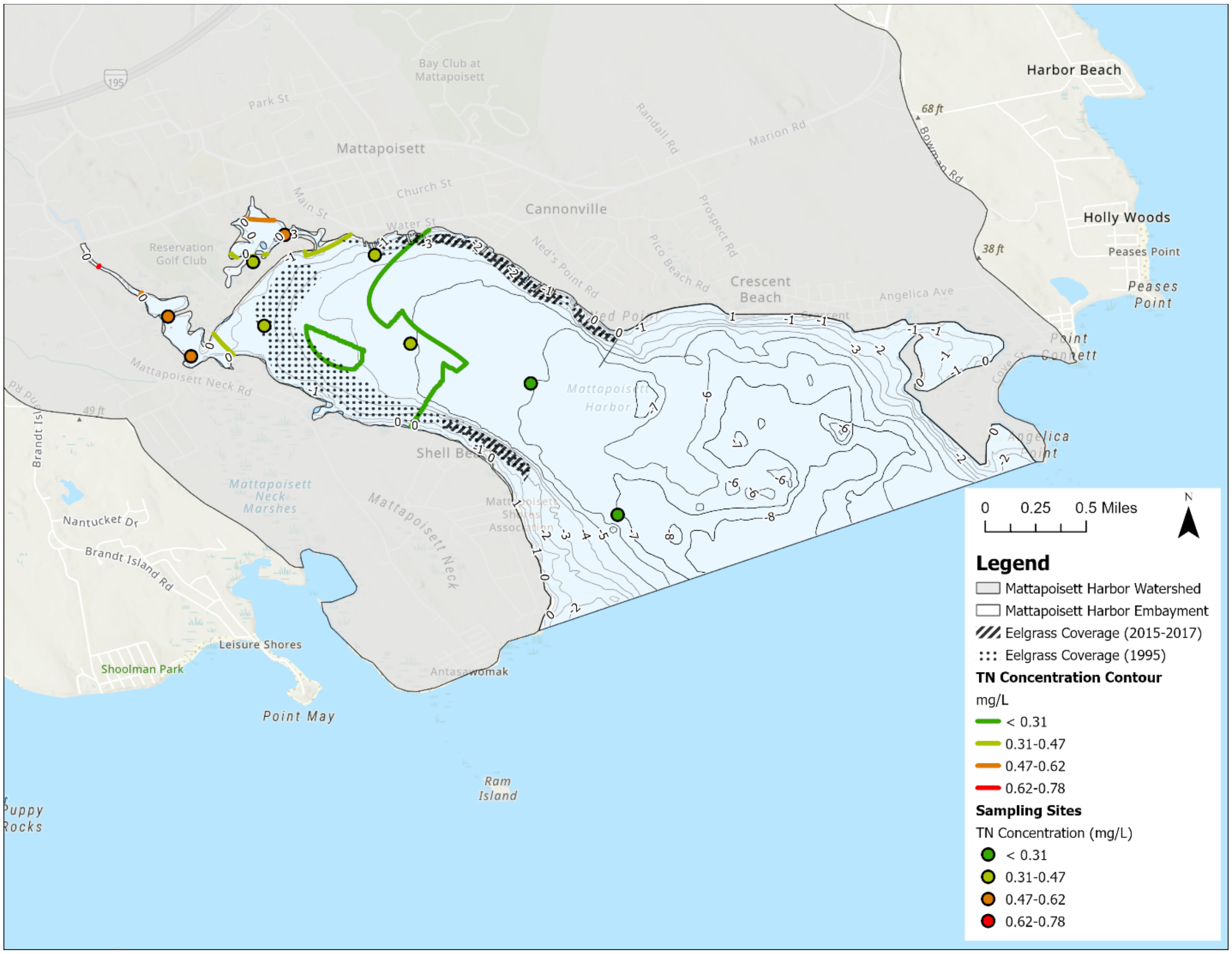

Figure 2. Mattapoisett Harbor bathymetry, historic and current eelgrass cover, and growing season average surface water total nitrogen concentration distribution. (Data adapted from the National Oceanic and Atmospheric Administration's Digital Coast program, the Buzzards Bay Coalition, and the Massachusetts Geographic Information System.)

A6.2 Bathymetric Mapping Task

High-resolution bathymetry and benthic habitat delineation are essential to map benthic habitats and provide data for calibrating the hydrodynamic model. Survey data will be collected by running a series of parallel survey transects (main lines) and perpendicular cross lines. Horizontal spacing of the main survey lines is determined to ensure sufficient overlap of survey instrumentation to provide complete sidescan coverage and eliminate data gaps. A PMSS system will be used to collect bathymetric and sidescan transects prioritized for sidescan returns over a three (3) to six (6) day period.

An EdgeTech 6205, or equivalent dual-frequency PMSS system will be used for high-resolution bathymetry and benthic habitat delineation. Additional instrumentation, such as a Teledyne TSS dynamic motion sensor (DMS)-05 motion reference unit (MRU), a Hemisphere global positioning system (GPS) V110 vector sensor, and a Trimble® R10 Global Navigation Satellite System (GNSS) receiver, a Real Time Kinematic (RTK)-GPS, and a Yellow Springs Instruments

(YSI) conductivity, temperature, and depth (CTD) sensor will be used to correct and minimize systematic biases. Either a nearshore deep draft vessel or an ultra-shallow draft vessel or autonomous surface vehicle will be used to collect acoustic data. If no surface vessels can be safely deployed (for example, due to the presence of a significant number of rock outcroppings, or large dry land areas in very shallow embayments), a drone will be flown to map the benthic environment, and bathymetry data will be obtained from reliable USGS maps or other resources.

According to the approach presented in the SOP (Appendix A) various data processing steps will be used to convert raw backscatter and echo soundings to usable bathymetry and benthic habitat raster mosaics. These steps will be undertaken using several instruments and a suite of instrument-proprietary software. Finally, a combination of automated and manual data processing including bottom-tracking, slant range correction, offset entry and gain setting adjustments will be performed. Calibration tests will be performed in the field to determine motion and timing offsets (roll, pitch, yaw, and latency). The study site will be mapped by ensonifying the seafloor with a minimum of 200% coverage of sidescan imagery. This technique serves two purposes: (1) redundancy of coverage maximizes the likelihood of mapping 100% of the seafloor in the presence of boat wake and noise, and (2) directionality to achieve 200% coverage while capturing the same stretch of seafloor from different angles to maximize interpretability. This data will be used to develop two dimensional (2D) sidescan mosaics and three dimensional (3D) bathymetric surfaces as stand-alone products.

The optimal window for the PMSS survey is between April and May, as after May, boat traffic in Buzzards Bay's embayments increase so substantially that passes with continuous swaths of data collection will become virtually impossible.

Additional guidance during campaign design will be provided by the Chief Scientist and an independent review of the bathymetric and benthic habitat data. The entire mapping task is anticipated to be completed within three (3) to six (6) days, with surveying occurring during the high tide periods.

A6.3 Schedule of Deliverables and Activities

Deliverables covered under this QAPP include the bathymetry data, including sidescan sonar data, and characterization of benthic habitat. The schedule for these deliverables and activities is outlined in Table 2 below.

Table 2. Schedule of Mattapoisett Harbor bathymetric mapping deliverables.

Task	Deliverable	Due Dates
Mattapoisett Harbor Bathymetric Mapping	Updated Monitoring QAPP	April 2025
	Bathymetry Data, Including Sidescan Sonar Data	May/June 2025
	Characterization of Benthic Habitat	June 2025

A7. QUALITY OBJECTIVES AND CRITERIA

As described above, MassDEP is developing TMDLs for TN to improve and/or maintain water quality and benthic habitat including eelgrass beds in the estuaries of southeast coastal MA.

Collection of bathymetric data, benthic substrate characteristics, and flow data is needed for MassDEP's development of TMDLs for TN in Mattapoisett Harbor.

The bathymetry and benthic habitat mapping will be conducted simultaneously using a PMSS approach. PMSS allows for both high-resolution bathymetric and substrate characteristics information to be collected with a minimal number of boat track passes across a wide swath (perpendicular to the boat path), thereby reducing operational cost and improving coverage. The PMSS survey will be conducted during the high tide within a window of two (2) hours of either side of the highest tide, and periods with minimal boat traffic to maximize the effectiveness of the wide beam angle coverage and minimize erroneous backscatter readings from obstructions in the water column. The tide phase will be determined using the nearest National Oceanic and Atmospheric Administration (NOAA) tide gage (ID 8447531) at Mattapoisett.

Sidescan imagery is a two-dimensional data set that documents bottom conditions by capturing the intensity of the returning acoustic pulse. Each pixel is geo-referenced to a horizontal datum and orthomosaics will be constructed of the study site. Bathymetric data comprises the vertical and horizontal positions of each sounding: x and y being the horizontal coordinates (latitude and longitude) and z representing the raw depth from the sonar to the seafloor. The raw depth is then corrected to a vertical datum, typically North American Vertical Datum of 1988 (NAVD88), and tide corrected using a differential GPS device, such as an RTK-GPS. To collect GPS data, a proprietary Virtual Reference Station network (KeyNetGPS) is used that provides virtual base stations via cellular phone. This negates the need to set up a terrestrial base station or post-process the GPS data, thus reducing costs, streamlining the field effort, and maximizing vessel-based survey time.

Proprietary instrument-specific software, such as Edgetech's Discover Bathymetric® software is used to monitor all incoming data streams and control settings for onboard acoustic instruments to optimize data quality for at-sea conditions. Survey planning is performed using software such as Hypack Survey® for line planning, coverage mapping and helmsman navigation.

The data quality objectives (DQOs) for bathymetry and benthic habitat mapping are:

(1) data are collected during the high tide within two (2) hours on either side of the high tide during a period when interference from boat wakes and other human disturbances are minimal,

(2) 200% sidescan sonar coverage is prioritized during the campaigns,

(3) the benthic habitat is characterized to an extent that the spatial distribution of sampling locations based on this characterization using a GRTS approach is sufficient to resolve the various habitat types,

(4) the benthic habitat characterization is sufficient to evaluate the sediment grain size distribution in a manner that can provide a spatial distribution of approximate bottom roughness values to parametrize a hydrodynamic model.

(5) the bathymetry can be used to reliably simulate embayment hydrodynamics using a hydrodynamic model with at least 330 ft (100 m) spatial resolution.

Requirements for ensuring that the data are usable for their intended purpose (that is, are of suitable quality) include precision, accuracy, representativeness, comparability, and completeness. When these requirements are met, the final data product is technically defensible. These data quality indicators are discussed below.

- **Precision:** This is a measure of the degree of agreement among repeated measurements (or values) of the same property of a survey value, measured under similar conditions. To ensure the consistency of depth measurements, periodic performance tests a few times during each survey day (e.g., patch tests, rub tests) will take place as per the procedure outlined in the SOP for Phase-Measuring Sidescan Sonar in Appendix A. As mentioned in the Accuracy section below and in Section 7 (Data Processing) of the SOP in Appendix A, performance test corrections and additional corrections will be applied to the data during processing.
- **Accuracy:** This is the extent of agreement between a measured or reported result and the true value and the degree to which bias is avoided or minimized. The surveyor will use an EdgeTech 6205 or similar sonar system for bathymetry and benthic habitat mapping. This system has a range resolution between 0.24 and 0.4 inches (in) (6 and 10 millimeters [mm]), which will meet the spatial resolution requirements for this project. Additional instrumentation, such as a Teledyne TSS DMS-05 MRU, a Hemisphere GPS V110 vector sensor, and a Trimble® R10 GNSS receiver, an RTK-GPS, and a YSI CTD sensor will be used to correct and minimize systematic biases. CTD and sonar system calibration is typically conducted once per year. Either a nearshore deep draft vessel or an ultra-shallow draft vessel or autonomous surface vehicle will be used to collect acoustic data. To ensure the accuracy of depth measurements, periodic performance tests a few times during each survey day (e.g., patch tests, rub tests) will take place as per the procedure outlined in the SOP for Phase-Measuring Sidescan Sonar in Appendix A. Calibration tests (patch tests) will also be performed in the field prior to survey operations in order to determine motion and timing offsets (roll, pitch, yaw, and latency). Those offsets will be recorded in the vessel file and applied when the survey lines are merged. Total propagated uncertainty (TPU) will be computed using device manufacturer specifications recorded in the vessel configuration file.

  As described in Section 7 (Data Processing) of the SOP in Appendix A, a performance test will be performed during data processing to compare the raw surface with the processed surface, as well as assessing individual “check lines” to identify potential biases and ensure that results meet accuracy standards and project specifications. The “Check Lines” assessment will be performed to evaluate consistency over the same area (ideally during different tidal phases), to detect potential biases in the original dataset or tidal modeling errors. Also, during processing, filters will be applied to remove depth outliers and “noise” typically found in the outer regions of the swath. Where necessary, area editors will be used to remove spurious soundings. More information about vessel-based surveys with a phase-measuring sidescan sonar including data collection, processing and analysis can be found in Borrelli et al. (2021).
- **Representativeness:** This is the extent to which measurements characterize the true environmental condition. Representativeness is affected by problems in any or all the other data quality indicators. As mentioned previously, the study site will be mapped by ensonifying the seafloor with a minimum of 200% coverage of sidescan imagery.
- **Comparability:** The extent to which data from a study can be compared directly to data from past studies or from other areas. For geophysical survey data collection activities, comparability is dependent on the proper design of the survey program and on adherence to

accepted surveying techniques in this QAPP and the SOP (Appendix A). Procedures for surveying the benthic habitat and bathymetry in the SOP for Phase-Measuring Sidescan Sonar (Appendix A) are consistent with SOPs used on a number of seafloor mapping projects in the New England area.

- **Completeness:** The amount of valid data collected using a measurement system. It is expressed as a percentage of the number of valid measurements that should have been collected. For geophysical survey data collection activities, the completeness criterion is meeting the planned minimum of 200% coverage of sidescan imagery to provide data sufficient for TMDL development. Complete bathymetric maps and georeferenced sidescan backscatter intensity images will be provided to MassDEP.

A8. SPECIAL TRAINING/CERTIFICATIONS

Field personnel will be experienced or trained in the sampling techniques documented in this QAPP. Prior to starting work, any new personnel will be given instructions specific to the project, covering the following areas:

- Organization and lines of communication and authority
- Overview of the QAPP
- QA/QC requirements
- Documentation requirements
- Health and safety requirements

Instructions will be provided and documented by the Contractor Project Manager and Chief Scientist. Digital records of required training and certifications will be maintained by MassDEP and its contractors for the effective duration of this QAPP. Hardcopy records will be archived for storage within a secure building according to MassDEP's record keeping requirements. The MassDEP Project Manager will maintain all personnel training/certification records associated with a project on MassDEP internal file servers.

A9. DOCUMENTS AND RECORDS

The approved QAPP and any subsequent revisions will be distributed to all individuals identified on the distribution list. A final copy will be kept on the MassDEP network drive. Documents and the data submission that will be generated for bathymetric mapping to support Mattapoisett Harbor are listed in Section A9.6. The due dates for these reports and data submissions are tabulated in Section A6.3.

A9.1 Survey Summary Notification

Survey summary notifications are prepared after each survey to briefly describe the sampling activities. Each notification is expected to include text containing the following information:

- An overview of the survey, including the vessel and a list of survey personnel
- Data and sample collection methods used during the survey
- Survey results presented as a narrative and including:
  - Actual vs. planned measurements and samples collected
  - Any unusual observations of environmental conditions

- Problems experienced, actions taken, and recommendations, including deviations from this QAPP and the SOP in Appendix A that were not known at the time of QAPP preparation.

The Chief Scientist will submit the survey summary to the Contractor Project Manager by email no later than one week after the completion of each survey. The Contractor Project Manager will share the survey summary with the MassDEP Project Manager.

A9.2 Survey Data Deliverable Submissions

Proprietary instrument-specific software such as Discover Bathymetric® (EdgeTech 20222c) and Hypack's Hysweep® will be used to collect data with the final raw output in JSF and HSX file formats, respectively. The JSF files will be imported into a software such as SonarWiz® where a combination of automated and manual data processing is undertaken, including bottom-tracking, slant range correction, offset entry and gain setting adjustments. After appropriate processing of each data file, mosaics will be generated, which will be then exported in a raster format (GeoTiffs).

Post-processing of bathymetric data is performed using software such as CARIS HIPS®. Raw data (HSX) files will be converted to CARIS proprietary format using vessel configuration files developed from vessel offsets, and device information. RTK-GPS tide corrections will be applied in the conversion process. Sound velocity corrections will be applied using measurements collected in-situ by an internal sound velocimeter located in the sonar housing and water column profiles obtained from casts performed for each survey using a YSI Castaway® CTD profiler.

This suite of data will be used to develop 2D sidescan mosaics and 3D bathymetric surfaces as stand-alone products. These data sets will also be used to aid the characterization of the benthic habitats in the study area.

A separate report will contain a discussion on QA/QC and detail if DQOs were met for informing the hydrodynamic model calibration and other project tasks.

A9.3 Data Submissions to the Contractor Project Manager

The Contractor Project Manager will receive and maintain all tracking records for bathymetric surveying including all records of sampling events.

A9.4 Data Submissions by the Contractor Project Manager

All quality-controlled bathymetric mapping data will be processed into the appropriate application format as described in Section A9.3. The Contractor Project Manager will submit the results to the MassDEP Project Manager.

A9.5 Project Files

The project files will be the central repository for all documents relevant to sampling and analysis activities as described in this QAPP. The Contractor Project Manager is the custodian of the project files and will maintain the contents of the project files, including all relevant records, reports, datasheets, pictures, subcontractor reports, and data reviews in a secured, limited access area and under custody of the Contractor Project Manager for the time set forth in the contract. All data deliverables and final data are owned by the entity (MassDEP) funding the monitoring conducted under this QAPP as detailed in the contract, teaming agreement, and/or other legal documentation authorizing the monitoring.

The project files will contain at a minimum:

- Approved QAPP
- Survey Summary Notifications
- Field notes
- Raw and processed data files

Electronic versions of reports and statistical analyses will be stored in a project-specific folder on a server or network. All the project records will be maintained for at least three years. The originator will share all project files related to the field data collected with MassDEP who will retain records based on the relevant records retention policy.

B. DATA GENERATION AND ACQUISITION

B1. SAMPLING PROCESS DESIGN (EXPERIMENTAL DESIGN)

The rationale for the design for using a PMSS system to collect bathymetric readings and sidescan sonar to collect benthic substrate characteristics to support Mattapoisett Harbor TMDL development, as well as data deliverables and project schedule, are given in Section A6. The SOP for Phase-Measuring Sidescan Sonar (Appendix A) includes the survey plan and data processing description, equipment description, geophysical survey instrument specifications, and QA/QC testing procedures.

B2. SAMPLING METHODS

As described above, mapping results will be used in modeling that will be performed to support development of TN TMDLs for Mattapoisett Harbor. The report and notification of data submission to MassDEP will begin and/or continue the modeling system process.

A PMSS system, using the EdgeTech 6205 or comparable system and their auxiliary equipment (Appendix A) will be deployed to map the embayment bathymetry and benthic habitat. Depending on the water depth, either a nearshore deep draft vessel or an ultra-shallow draft vessel or autonomous surface vehicle will be deployed. The survey will be designed to ensure maximum sidescan and bathymetric surveys in the main embayment and shallow fringing embayments, with a minimal number of boat passes within three (3) to six (6) days. If it is not possible to deploy a surface vessel, a drone will be flown with a predetermined flight plan to map the benthic environment visually.

A PMSS approach will be used to collect vessel-based acoustic data. The PMSS instruments effectively combine sidescan and multibeam sonars by simultaneously collecting 2D and 3D data, sidescan imagery and bathymetry, respectively. The primary instrument to be used in the field work will be an EdgeTech 6205 (or alternately, a 6205 S2) or comparable instrument, a dual-frequency, phase-measuring sidescan sonar. For the EdgeTech 6205, the operating frequencies are 550 kilohertz (KHz) and 1,600 KHz for sidescan imagery and 550 KHz for bathymetry. The sidescan range resolution is 0.4 in (10 mm), at 550 KHz, and 0.23 in (6 mm) at 1,600 KHz. The bathymetric range and vertical resolution are both 0.4 in (1 centimeter [cm]). The effective bathymetric swath width is six (6) to eight (8) times the height of the sonar over the bottom. The nominal effective sidescan backscatter swath width is often much greater, sometimes 25 to 50 times the height of the sonar over the bottom. Additional instrumentation, such as a Teledyne TSS DMS-05 MRU mounted on the sonar will collect data on heave, pitch, and roll, measuring heave to 2 in (5 cm) and roll and pitch to 0.05°. A Hemisphere GPS V110 vector sensor is used to measure heading. Two differential GPS receivers spaced 6.6 ft (2 m) apart will yield heading accuracies better than 0.10° root mean square (RMS). A Trimble® R10 GNSS receiver utilizing an RTK-GPS will be used for positioning and tide correction for vessel-based surveys. The research vessel used to collect acoustic data will be either a nearshore deep draft vessel or an ultra-shallow draft vessel or autonomous surface vehicle. A 2-kW Honda™ or similar gas-powered generator will be used to power all electronics for the hydrographic surveys onboard the vessel.

B3. SAMPLE HANDLING AND CUSTODY

The Chief Scientist maintains a digital directory of all collected geophysical survey data and will provide raw survey results, as well as final processed geophysical survey data products including maps and reports, to the Contractor Project Manager for review.

B4. ANALYTICAL METHODS

The PMSS survey campaign will be developed to ensure that the entire embayment and smaller, shallower embayments in fringing areas are surveyed within three to six days during a single spring or neap tidal period under high tide conditions. The study site will be mapped by ensonifying the seafloor with a minimum of 200% coverage of sidescan imagery.

B5. QUALITY CONTROL

Data quality will be addressed in the field through calibration tests conducted by the Contractor Chief Scientist prior to conducting surveying. Of primary importance for geophysical survey operations is to ensure the geographic completeness of the data record. It is important to complete the step while still in the field so that any incomplete portions or data gaps can be identified and corrected. A summary of the measurement quality objectives for this surveying project are provided in Table #.

- PMSS, sensor offsets (position and orientation) will be physically measured and verified to a tolerance of ≤ 0.066 ft (0.02 m) using a tape or laser rangefinder
- The two measurements at the crossings of survey tracks are compared to check the precision of the data collection. If the difference between the two measurements is greater than 15 cm, then the region must be resurveyed
- As mentioned previously, the study site will be mapped by ensonifying the seafloor with a minimum of 200% coverage of sidescan imagery.

<u>Precision, Accuracy, and Representativeness</u>

These qualities will be assured by the SOP (Appendix A), and ensuring that sidescan beam widths and PMSS frequencies are suitably set to produce a vertical and range resolution of 1 cm.

Sonar systems do not provide standalone precision or accuracy values. The reason is that the final position and depth of each sounding are the result of multiple components, including:

- GNSS positioning
- Vessel motion (pitch, roll, heave, yaw)
- Sound velocity corrections
- Timing synchronization

- Sensor offsets and alignments
- Beam angle geometry and bottom detection algorithms (e.g., amplitude vs. phase)

Therefore, accuracy and precision are assessed at the dataset level using the concept of TPU. TPU incorporates all known sources of error and expresses them statistically for each sounding.

The International Hydrographic Organization (IHO) does not assign accuracy or precision requirements to individual sonars. Instead, it defines acceptable uncertainty limits for entire surveys based on the intended use (e.g., Special Order, Order 1a, 1b, etc.). Compliance with these standards is demonstrated by modeling TPU and verifying results against internal consistency checks such as crosslines, repeat lines, and surface differencing.

Table 3 lists the main positioning, motion, heading, and sound velocity instruments used with the EdgeTech 6205 and 6205 S2, along with their integration status and accuracy specifications relevant to TPU modeling.

Table 3. Navigation, motion, heading, and sound velocity equipment used with EdgeTech 6205 and 6205 S2, and their accuracy.

Device	Integrated	Function	Parameter	Accuracy / Specs
Trimble R10	No	Positioning [Global Navigation Satellite System (GNSS)]	RTK Horizontal Accuracy (Network)	8 mm + 0.5 parts per million (ppm) of the total distance [root mean square (RMS) value]
			RTK Vertical Accuracy (Network)	15 mm + 0.5 ppm (RMS)
			Post-processing	Raw data logging supported
Teledyne DMS-05	No	Attitude [inertial measurement unit (IMU)]	Heave	±5 cm or 5% (whichever is greater)
			Roll & Pitch	±0.05°
			Maximum Range	±10 m (heave), ±60° (roll/pitch)
Hemisphere VS110	No	Heading	Heading Accuracy (2 m antenna separation)	< 0.10° RMS
Applanix AP+18 MV	Yes (6205 S2)	GNSS + Motion [inertial navigation system (INS)]	Horizontal Accuracy*	±(8 mm + 1 ppm × baseline length)
			Vertical Accuracy*	±(15 mm + 1 ppm × baseline length)
			Heading Accuracy (2 m baseline)	0.08°
			Roll & Pitch	0.03°
			Heave	5 cm or 5%
			TrueHeave	2 cm or 2%
			Accuracy During GNSS Outage (60s)	~3 m
CastAway SonTek	No	Sound Velocity Profile	Sound Speed Range	1,400–1,730 m/s (4,592–5,674 ft/s)
			Accuracy	±0.15 m/s (±0.49 ft/s)
			Max Depth	100 m (328 ft)
AML SVT	Yes (both sonars)	Sound Velocity at Sensor	Response Time	47 µs
			Resolution	0.001 m/s (0.003 ft/s)
			Accuracy	±0.025 m/s (±0.82 ft/s)

Comparability

Procedures for surveying the benthic habitat and bathymetry will be consistent with standard operating procedures used on a number of seafloor mapping projects in the New England area (Appendix A).

Completeness

The survey will be developed to provide at least 200% sidescan coverage so that each area of the seafloor is ensonified at least twice from different directions. This will ensure that the benthic habitat is well characterized to determine sediment substrate classes, and benthic habitat items such as eelgrasses. The bathymetric coverage will also be sufficient to represent the embayment with at least a 100 m resolution in a hydrodynamic model.

B6. INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Maintenance of and repairs to instruments will be conducted under the supervision of the Chief Scientist in accordance with manufacturers' manuals. Maintenance will be conducted after each deployment as described in Section A,8 of the SOP (Appendix A). All surveying gear and instrumentation will be kept in good repair as per manufacturer's recommendations to ensure proper function. All the maintenance and repairs will be carried out prior to the survey and are the responsibility of the entity conducting the survey. Equipment to be used during surveying is listed in Appendix A.

B7. INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

The surveyor an EdgeTech 6205 or comparable sonar system for bathymetry and benthic habitat mapping. To ensure the accuracy of depth measurements, periodic performance tests a few times a day (e.g., patch tests, rub tests) will take place as per the procedure outlined in the SOP for Phase-Measuring Sidescan Sonar in Appendix A. Instrument calibration will be conducted once per year by the Chief Scientist. Prior to survey operations, calibration tests (patch tests) will be performed in the field in order to determine motion and timing offsets (roll, pitch, yaw, and latency) and for the PMSS, sensor offsets (position and orientation) will be physically measured and verified to a tolerance of ≤ 0.066 ft (0.02 m) using a tape or laser rangefinder. These procedures will be repeated if any components are moved or reinstalled. Those offsets will be recorded in the vessel file and applied when the survey lines are merged. The TPU will be computed using device manufacturer specifications recorded in the vessel configuration file.

B8. INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

The purpose of this element of the QAPP is to establish and document a system for inspecting measurement equipment that may directly or indirectly affect the quality of the data provided. The Contractor Chief Scientist will be responsible for inspecting measurement equipment for the bathymetric field survey. As described above, prior to survey operations, patch tests and sensor offset checks will be performed. If issues are found, the Contractor Chief Scientist will initiate corrective action by initiating a calibration process to ensure that correct offsets are applied. All actions will be documented in the project files.

B9. NON-DIRECT MEASUREMENTS

No non-direct measurements are anticipated as part of this field geophysical survey collection program; however, it is expected that available data from NOAAs tide gage (ID 8447531) at Mattapoisett will be accessed during geophysical surveying.

B10. DATA MANAGEMENT

Bathymetric and sidescan sonar data streams during the survey will be monitored using software onboard the acoustic instruments. Post-processing raw data will be performed using standard software tools according to Appendix A. Final GeoTiffs of bathymetric and sidescan rasters will be provided to the Contractor Project Manager and independent technical reviewers to ensure that standard processing approaches have bene followed, and that the final data is error-free.

The Contractor Project Manager will provide final data deliverables to MassDEP. All relevant documentation, including QA/QC documentation, will be provided to MassDEP. The MassDEP TMDL Project Manager will retain records based on the relevant records retention policy.

C ASSESSMENT AND OVERSIGHT

C1 ASSESSMENT AND RESPONSE ACTIONS

This section identifies the number, frequency, and type of planned surveying activities that will be performed to assure bathymetric mapping to support Mattapoisett Harbor TMDL development. These activities will be overseen by the Contractor Project Manager and Contractor QA Manager.

C1.1 Assessments

C1.1.1 Field Sampling Readiness Reviews

The SOP for Phase-Measuring Sidescan Sonar (Appendix A) includes a section containing a field survey plan for bathymetric mapping. This section describes the specific field activities to be conducted. The SOP in Appendix A includes a description of required equipment.

C1.1.2 Field Sampling Technical System Audit

The Contractor QA Manager will be responsible for periodic Technical Surveillance Audits (TSAs) to verify that surveying procedures are properly followed. The internal field audit checklist (Table 4) will include examination of the following:

- Field sampling records
- Surveying procedures
- Adherence to the SOP (Appendix A) and this QAPP
- QA procedures

Results of internal field TSAs will be documented in the QA reports to the Contractor Project Manager. (Section C2). MassDEP personnel may conduct periodic field audits to ensure QAPP and SOP requirements are being met.

Table 4. Example of Internal Field Technical Surveillance Audit Checklist.

Project: **Site Location:** **Auditor:**
1. Was project-specific training held?

2. Are copies of the Bathymetric Mapping to Support Mattapoisett Harbor TMDL Development QAPP and SOP available to personnel?	
3. Is surveying being conducted in accordance with the SOP?	
4. Does the surveying area conform to the QAPP?	
5. Is field instrumentation being operated and calibrated in accordance with the QAPP and SOP?	
6. Are field records complete, accurate, up-to-date, and in conformance to good recordkeeping procedures?	
7. Are modifications to the QAPP and SOP being communicated, approved, and documented appropriately?	
Additional Comments:	
Auditor:	**Date:**

C1.1.3 Data Technical System Audits

Data will be audited under the direction of the Contractor QA Manager as part of the data validation process (Section D1). Raw data will be reviewed for completeness and proper documentation. Errors noted in data audits will be communicated to relevant staff, the Contractor Project Manager and corrected data will be verified. Data must be submitted in QAPP-prescribed formats; no other formats will be acceptable. All data must be reviewed by the Contractor QA Manager or designee prior to submission to the Contractor Project Manager.

C1.2 Assessment Findings and Corrective Action Responses

All technical personnel share responsibility for identifying and resolving problems encountered in the routine performance of their duties. Issues that affect the schedule, cost, or performance of project tasks will be reported to the Contractor Project Manager. The Contractor Project Manager will be accountable for overall conduct of bathymetric mapping to support Mattapoisett Harbor TMDL development, including the schedule, costs, and technical performance. The Contractor Project Manager will be responsible for identifying and resolving problems that (1) have not been addressed in a timely manner or successfully at a lower level, (2) influence multiple components of the project, or (3) require consultation with MassDEP. He/she will be responsible for evaluating the overall impact of the problem on the project and for discussing corrective actions with the MassDEP Project Manager. The Contractor Project Manager will also identify and resolve problems that necessitate changes to this QAPP. Problems identified by the Contractor QA Manger will be reported to the Project Manager and corrected as described in Section C2.

Corrective action is the process of identifying, recommending, approving, and implementing measures to counter unacceptable procedures or out-of-limit QC performance that can affect data quality. Corrective action can occur during field activities, data validation, and data assessment. Corrective actions may result from planned audits or from unanticipated events that occur during the course of the project. Significant events that result in deviations from this QAPP will be recorded through the "Extraordinary Event/Nonconformity" (EE/NC) reporting process. The appropriate corrective actions to address any such events will be assessed by the Contractor QA Manager in consultation with the Contractor Project Manager and with MassDEP. The Contractor QA Manager will generate and/or review all corrective actions required during the project and monitor their effectiveness in meeting project quality objectives. The Contractor

Project Manager will review these issues on a regular basis, but the Contractor QA Manager will bring serious issues to the Contractor Project Manager's attention immediately. All corrective action proposed and implemented should be documented in the QA reports to project management (Section C2). Corrective action should only be implemented after approval by the MassDEP Senior Manager or a designee. The Contractor Project Manager will report any corrective actions to MassDEP in a project QA/QC Corrective Action Log. A copy of the QA/QC Corrective Action Log will be provided to MassDEP with the deliverables.

Corrective actions will be implemented and documented as follows:

- A description of the circumstances that initiated the corrective action
- The action taken in response
- The final resolution
- Any necessary approvals
- Effectiveness of corrective action

No staff member will initiate corrective action without prior communication of findings through the proper channels. If at any time a corrective action issue which directly impacts the project DQOs is identified, the Contractor Project Manager will be notified.

C.2 REPORTS TO MANAGEMENT

The Contractor will provide updates to MassDEP related to project progress and results observed. QA reports will be prepared by the Contractor QA Manager and submitted on an as-needed basis to the Contractor Project Manager. QA reports will document any problems identified during surveying and the corrective measures taken in response. The QA reports will include:

- All results of survey result reviews
- Problems noted and actions taken during data validation and assessment
- Significant QA/QC problems, recommended corrective actions, and the outcome of corrective actions

A summary of QA issues, audit findings, and significant nonconformities will be included in the project QA/QC Corrective Action Log submitted to MassDEP.

D. DATA VALIDATION AND USABILITY

This section details the QA activities that will be performed to ensure that the collected data are scientifically defensible, properly documented, of known quality, and meet project objectives. Two steps are completed to ensure that project data quality needs are met:

- Data verification/validation
- Data usability assessment

D1. DATA REVIEW, VERIFICATION, AND VALIDATION

D1.1 Field Data

The field data verification includes verification of survey procedures. Field data will be reviewed daily by the Chief Scientist to ensure that the records are complete, accurate, and legible and to verify that the surveying procedures are performed in accordance with the protocols specified in the QAPP (refer to Section D2.1 for the specific elements reviewed).

D1.2 Data Management

The review process will include verification of collected data and QC checks performed prior to submitting the data to MassDEP. Detailed descriptions of these processes are included in Sections B9 and D2.

D2. VALIDATION AND VERIFICATION METHODS

Checks made of the data in the process of review and verification are summarized in Sections B5 and C.1. The Contractor QA Manager is ultimately responsible for ensuring the validity of the data, although performance of the specific checks may be delegated to other staff members. Survey QC data for calibrations and periodic performance tests will be reviewed by the Contractor Project Manager and/or Contractor QA Manager using relevant DQO detailed above in Section A7 prior to submittal to MassDEP.

D2.1 Field Data

Field survey records will be reviewed by the Chief Scientist to ensure that:

- Logged data are complete and that the information recorded accurately reflects the activities that were performed.
- Records are complete and legible and in accordance with good recordkeeping practices, *i.e.*, changes are documented initialed, dated, and explained.
- Equipment calibration, sample collection, handling, preservation, storage, and shipping procedures were conducted in accordance with the protocols described in the QAPP and SOP (Appendix A), and that any deviations were documented and approved by the appropriate personnel.

D2.2 Data Management

Survey data will be reviewed by the Contractor Project Manager prior to the electronic submission to MassDEP. Data review may include methods such as plots, logical checks, and range checks to identify suspect values. Routine system back-ups are performed daily. Hard copy/hand-entered data are not anticipated for this bathymetric surveying. Detailed description of data management and review is provided in Section B9 of this QAPP.

D2.3 Project Deliverables

Upon completion of the verification/validation process, a dataset packet will be prepared for submittal to MassDEP. This documentation will include the elements required as listed in Section A9.4.

- Survey Summary Notification, which includes a word file that documents data included in data deliverable along with associated metadata (general overview, file structure, contents, etc.),
- A separate report will contain a discussion on QA/QC and detail if DQOs were met, and
- All quality-controlled bathymetric mapping data will be processed into the appropriate application format as described in Section A9.3.

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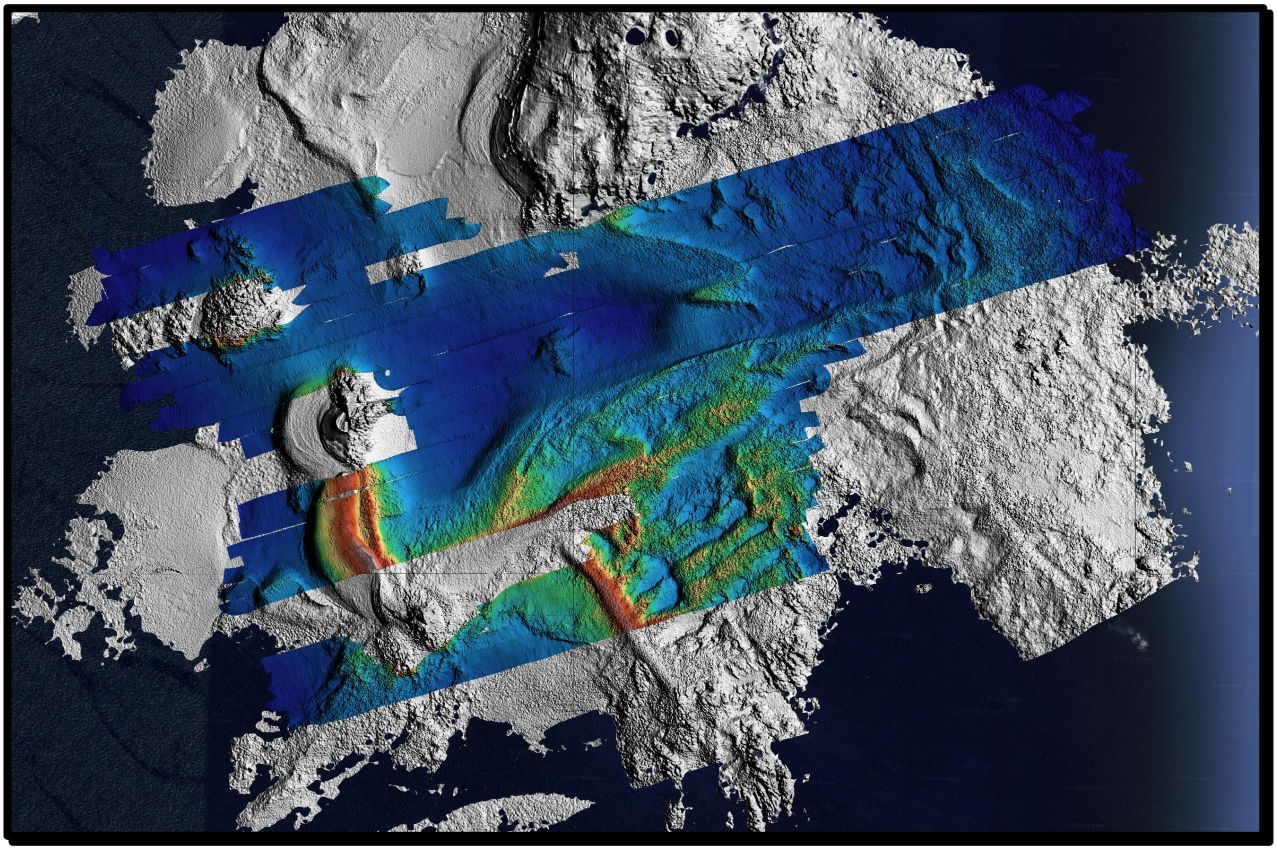
Appendix A: Standard Operating Procedure (SOP) for Phase-Measuring Sidescan Sonar

Standard Operating Procedure (SOP) for Phase-Measuring Sidescan Sonar



April 2025

SOP prepared by the Shoreline and Seafloor Mapping Program

at the Center for Coastal Studies

TABLE OF CONTENTS

A.1 INTRODUCTION

This Standard Operating Procedure (SOP) outlines the detailed procedures for operating a Phase-Measuring Side Scan Sonar (PMSS), specifically the EdgeTech 6205 and 6205 S2 models, along with integrated or auxiliary equipment. PMSS are well-suited for shallow-water environments due to their ability to collect co-registered sidescan, swath bathymetry and bathymetry backscatter data, providing significantly wider swath coverage compared to traditional multibeam echosounders.

While PMSS are not currently accepted for nautical chart updates under the IHO (2008) S-44 Standards (although the 4th generation 6205 S2 is compliant with IHO S-44 standards), their ability to support scientific research, environmental monitoring, and resource management is noteworthy. Ongoing research is focused on optimizing processing algorithms to further enhance the accuracy and reliability of their bathymetric data, potentially expanding their applicability in the future.

The primary goal of this SOP is to ensure accurate, reliable, and consistent data collection while maximizing the potential of PMSS. By following these procedures, users can minimize errors, maintain equipment integrity, and produce high-quality datasets suitable for scientific analysis, environmental monitoring, and decision-making. This document also serves as a training resource for new personnel and a reference for experienced operators.

This SOP should be followed in conjunction with the current version of the U.S. Army Corps of Engineers (USACE) Hydrographic Surveying Manual (EM 1110-2-1003) and/or the most recent version of the International Hydrographic Organization (IHO) Manual on Hydrography (Publication C-13). Additionally, the procedures outlined in the EdgeTech 6205 and 6205 S2 hardware manual (EdgeTech 2019, 2022a, 2022b) must be followed for proper system setup and data acquisition.

A.2 SCOPE

This SOP applies to all personnel involved in the operation, maintenance, and data collection using the EdgeTech 6205 or 6205 S2 systems and auxiliary equipment. The procedures outlined here are designed for use in coastal and shallow-water environments (depths <50 meters).

The scope of this SOP covers equipment setup, including the proper installation and configuration of the EdgeTech 6205/6205 S2 sonar and auxiliary equipment. It also includes data collection procedures, such as pre-deployment checks, real-time monitoring during surveys, and post-deployment data handling.

Additionally, the SOP provides guidelines for data processing, including the application of corrections, and the generation of final data products. Maintenance and calibration best practices are outlined to ensure the long-term reliability and accuracy of the equipment, along with protocols for safety and compliance to adhere to environmental regulations and ensure safe operations.

This SOP is intended for use by field teams responsible for operating equipment and collecting data in the field, data processors tasked with processing and analyzing collected data, and equipment technicians responsible for maintaining and calibrating the equipment.

A.3 RESPONSIBILITIES

The Field Team is responsible for operating the EdgeTech 6205/6205 S2 system and auxiliary equipment during surveys. This includes conducting pre- and post-deployment checks, monitoring real-time data quality, collecting sound velocity profiles (SVPs), and ensuring safety protocols are followed during operations.

The Equipment Technician(s) handle(s) the maintenance and troubleshooting of the sonar and auxiliary equipment. This involves routine cleaning and inspection, performing regular calibrations (SVP sensors), diagnosing and resolving malfunctions, and documenting all maintenance activities.

The Field Survey Lead is responsible for overseeing day-to-day survey operations in the field. This includes setting up equipment, ensuring data collection follows the survey plan, conducting in-field QA/QC checks, and coordinating with both the Equipment Technician(s) and the Contractor Chief Scientist to address any issues that arise. The Field Survey Lead ensures field activities are executed safely, efficiently, and in compliance with the SOP.

The Contractor Chief Scientist oversees survey operations, ensuring compliance with this SOP. They develop survey plans, allocate resources, monitor data collection, review QC reports, and ensure all activities adhere to environmental regulations and safety standards.

A.4 PLATFORM DESCRIPTIONS

A.4.1 Research Vessel (R/V) Marindin

The R/V Marindin is a 1995 Eastern® fiberglass hull vessel, converted from an inboard/outboard (I/O) to an outboard motor configuration with a Yamaha® 250 horsepower (HP) engine (Figure A.1). It has the following specifications:

- Length overall (LOA) of 26.9 ft (8.2 m),
- Beam of 8.33 ft (2.54 m), and
- A draft of 2 ft (0.61 m).

The vessel is equipped with the EdgeTech 6205 or the EdgeTech 6205 S2 sonar systems for bathymetric and sidescan surveys. The shallow-draft design makes it suitable for operation in both shallow and deeper nearshore environments, offering versatility in data collection. It has a retractable bow mount with power hoist to raise and lower the sonar for safe operation. The bow mount eliminates most of the noise from the vessel and engine, thus improving the quality of the acoustic data. The Real-Time Kinematic GPS (RTK-GPS), the Motion Reference Unit (MRU) and the vector sensor were all mounted onto the same survey pole as the sonar.

Figure A.1. R/V Marindin survey vessel equipped for shallow and nearshore bathymetric operations, showing retractable bow-mounted Edgetech 6205 system.

A.4.2 R/V Portnoy

The R/V *Portnoy* is a custom-built, ultra-shallow draft pontoon survey vessel designed specifically for high-resolution data collection in low-energy embayments and wetland areas (Figure A.2). It has the following specifications:

- Length overall (LOA) of 13.8 ft (4.2 m),
- Beam of 6.9 ft (2.10 m), and
- Draft of just 0.66 ft (0.20 m).

Optimized for operations in water depths as shallow as 1 meter, the R/V *Portnoy* is equipped with either the EdgeTech 6205 or the 6205 S2 sonar systems. The vessel utilizes a bow-mounted sonar pole that also supports all auxiliary sensors, including RTK-GPS, MRU, and vector sensor, providing an integrated and low-noise platform for surveying sensitive ecosystems.

Figure A.2. R/V Portnoy is an ultra-shallow draft pontoon survey vessel, custom-built for high-resolution data collection in low-energy embayments and wetlands. It is shown here equipped with an EdgeTech 6205 sonar system mounted on a bow pole.

A.4.3 Autonomous Surface Vehicle (ASV) Jetyak

The Jetyak (Integrated Coastal Solutions 2023), developed by scientists at the Woods Hole Oceanographic Institution (WHOI) and owned by the University of Massachusetts Boston (UMass Boston), is an unmanned hybrid surface vessel capable of both remote control (RC) and ASV operations. It has the following specifications:

- Length Overall (LOA) of 11.97 ft (3.65 m),
- Beam of 2.95 ft (0.90 m), and
- Draft of approximately 0.82 ft (0.25 m).

The vessel utilizes Ardupilot-based waypoint navigation and is equipped with a hull mounted phase-measuring EdgeTech 6205 S2 sonar system. A fanless onboard personal computer (PC) handles data logging, while remote control and long-range Wi-Fi allow for real-time monitoring and parameter adjustments. Powered by a 4-stroke, 9.5 HP gasoline engine and driven by a 4 in jet drive system, the Jetyak offers up to 9 hours of continuous operation under optimal conditions. Top speed varies between 10 to 14 knots, depending on environmental conditions, payload weight, and hydrodynamic drag from sensors. The hull is made of UV-stabilized, rotomolded high-density polyethylene (HDPE), and the platform supports a maximum payload capacity of 88 kilograms (Kgs) [195 pounds (lbs)], with performance optimized within this range.

Figure A.3. ASV Jetyak, a hybrid unmanned vessel supporting remote and autonomous operations with real-time monitoring and sensor integration.

A.5 EQUIPMENT LIST

A.5.1 Primary Equipment (Sonar)

This SOP is appropriate for use for marine surveys that utilize EdgeTech 6205 and EdgeTech 6205 S2 PMSS. The EdgeTech 6205 is typically used on larger platforms, while the EdgeTech 6205 S2 is generally installed on the Autonomous Surface Vehicle (ASV). When the ASV is not in use, the EdgeTech 6205 S2 may also be used on the larger vessel.

The EdgeTech 6205 relies on auxiliary equipment from a different manufacturer for positioning and attitude data, whereas the EdgeTech 6205 S2 features an integrated Applanix AP+18 MV system. This system combines GNSS and an inertial navigation system (INS) [built-in inertial measurement unit (IMU)] to provide a fully integrated positioning and attitude solution.

The following tables (Tables A.1 through A.3) provide an overview of the sonar systems, auxiliary equipment, and general performance metrics.

Table A.1. Primary sonar systems.

Model	Feature	Frequency	Horizontal Beamwidth (two-way)	Range Resolution	Maximum Range
EdgeTech 6205	Bathymetry	520 KHz	0.5°*	**	100 m (200 m swath)
	Sidescan	520 KHz	0.36°	10 mm	150 m
		1,600 KHz	0.2°	6 mm	35 m
EdgeTech 6205 S2	Bathymetry	520 KHz	0.5°*	**	100 m (200 m swath)
	Sidescan	520 KHz	0.36°	10 mm	150 m
		850 KHz	0.29°	9 mm	75 m

* Across track resolution expressed as a beamwidth at nadir

** Depend on range/ping rate and binning parameters

A.5.2 Auxiliary Equipment

The EdgeTech 6205 sonar requires integration with separate auxiliary equipment for positioning, motion compensation, and heading. These components are typically installed on-site as part of the survey system setup. The primary instruments used include:

Table A.2. Auxiliary equipment used with EdgeTech 6205.

Equipment	Function	Parameter	Accuracy
Trimble R10	Positioning	RTK Horizontal Accuracy (Network)	8 mm + 0.5 ppm RMS
		RTK Vertical Accuracy (Network)	15 mm + 0.5 ppm RMS
Teledyne DMS-05	Attitude	Heave	±5 cm or 5% (whichever is greater)
		Roll & Pitch	±0.05°
		Maximum Range	±10 m (heave) / ±60° (roll/pitch)
Hemisphere VS110	Heading	Heading Accuracy (2.0 m antenna separation)	< 0.10° RMS

In addition to the RTK solution, the Trimble R10 can record raw data continuously, which can be post-processed to ensure there are no gaps in the position data (Trimble 2023).

The EdgeTech 6205 S2 includes an integrated Applanix AP+18 MV INS, which combines positioning and motion sensing into a single factory-integrated unit. As a result, no additional on-site integration of positioning and attitude sensors is required for the 6205 S2.

Table A.3. Built-in Applanix AP+18 MV system used with EdgeTech 6205 S2.

Equipment	Function	Parameter	Accuracy
Applanix AP+18 MV	Positioning	Horizontal Accuracy*	+/- (8 mm + 1 ppm x baseline length)
		Vertical Accuracy*	+/- (15 mm + 1 ppm x baseline length)
	Orientation	Heading Accuracy (with 2 m baseline)	0.08°
		Roll & Pitch	0.03°
		Heave	5 cm or 5%
		TrueHeave	2 cm or 2%
		Accuracy for IAPPK Outage (60s total)	~3 m

*POSPac™ MMS IAPPK

The CastAway SonTek is used for sound velocity profiling (SVP) and is designed to measure the sound speed through the entire water column. It has a sound speed range of 4,592-5,674 feet per second (ft/s) [1,400-1,730 m/s] and an accuracy of ±0.49 ft/s (0.15 m/s), providing precise measurements to a maximum depth of 328 ft (100 m).

Additionally, both the EdgeTech 6205 and EdgeTech 6205 S2 sonar heads are equipped with an AML Sound Velocity Sensor (SVT) integrated into its flooded housing. The AML SVT measures sound velocity directly at the sonar head, offering a response time of 47 microseconds (µs), a resolution of 0.003 ft/s (0.001 m/s), and a theoretical accuracy of ±0.82 ft/s (0.025 m/s), enabling real-time compensation for sound speed variations during bathymetric and sidescan data collection.

The operating parameters of the various instruments are shown in Tables A.4 through A.6.

Table A.4. Parameters for dual frequency phase-measuring sidescan sonar (520kHz) for specific range settings (range = ½ swath). Ranges are set by the hydrographer at the time of survey.

Range	3 – 15 m	16 – 24 m	25 – 40 m	41 – 73 m	74 – 92 m	> 93 m
Pulse Type	Continuous wave (CW)	CW	Chirp	Chirp	Chirp	Chirp
Pulse Length	15 microseconds (µs)	25 µs	0.5 milliseconds (ms)	1.0 ms	2.1 ms	3.7 ms
Bandwidth	67 kHz	40 kHz	50 kHz	50 kHz	50 kHz	45 kHz
Max Ping Rate	250 Hz	46 Hz	30 Hz	18 Hz	10 Hz	7.8 Hz

Table A.5. Parameters for dual frequency phase-measuring sidescan sonar (850kHz) for specific range settings (range = ½ swath). Ranges are set by the hydrographer at the time of survey.

Range	5 - 29 m	30 - 48 m	49 - 57 m	58 - 67 m	68 m +
Pulse Type	Chirp	Chirp	Chirp	Chirp	Chirp
Pulse Length	0.2 ms	0.4 ms	0.8 ms	1.6 ms	2.0 ms
Bandwidth	110 kHz	110 kHz	105 kHz	100 kHz	85 kHz
Max Ping Rate	150 Hz	25.2 Hz	15.2 Hz	12.7 Hz	10.8 Hz

Table A.6. Sonar specifications for bathymetry and sidescan imagery data for the EdgeTech 6205 S2.

BATHYMETRY		
Sonar Frequency	520 kHz	850 kHz
Beamwidths	1° x 0.5°	1° x 0.4°
Max Swath Width	200 m	75 m
Max Swath Sector	200°	
Max Soundings Per Ping	800	
Sounding Patterns	Equidistant and Equiangular	
SIDESCAN SONAR IMAGERY		
Frequency	520 kHz	850 kHz
Horizontal Beamwidth (2-way)	0.36°	0.29°
Range Resolution	10 mm	9 mm
Max Range	150 m	75 m

A.6 FIELD PROCEDURES

Each platform (e.g., R/V Marindin, R/V Portnoy, Jetyak, etc.) has undergone static offset measurements (Lever Arm measurements), using the IMU/MRU as the origin point. These offsets are applied in the system configuration to ensure proper alignment during acquisition. These offsets are specific to each platform and will be rechecked at the start of the field survey. If the system is physically reconfigured, new offsets will be measured before the survey begins and used for both acquisition and processing. Additionally, a patch/alignment test will be performed at the start of the field survey to confirm that the offsets are still correct.

A.6.1 Survey Plan

Before the field work, a detailed survey plan must be established. As part of this effort, locate projects and publicly available lidar, nautical charts, satellite imagery, or a combination of these types of data, to delineate the boundaries of the area of interest. Within the survey planning software (e.g., Hypack, Qinsy, or similar), import the base chart data and set up the coordinate system to match the appropriate project specified geodetic reference [e.g., world geodetic system (WGS) 84]. Establish the desired survey line spacing and orientation, including a patch test (an installation calibration to determine pitch, roll, and yaw alignment between the sonar head and the motion sensor) and verification lines. Consider water depth, expected seabed features, and environmental conditions when setting these parameters.

Review the survey plan to ensure no potential gaps in coverage will be created during acquisition and validate the plan against referenced requirements. Save the completed plan and transfer it to the acquisition computer. Verify that the CTD calibration is valid on the calibration certificate.

A.6.2 Quality Assurance and Quality Control (QA/QC) Procedures

Comprehensive QA/QC procedures will ensure the integrity and accuracy of data acquired using the PMSS and the auxiliary sensors. These procedures will be executed pre-survey, during acquisition, and in post-processing.

Prior to survey operations, a system calibration will be conducted. For the PMSS, sensor offsets (position and orientation) will be physically measured and verified to a tolerance of ≤0.066 ft (0.02 m) using a tape or laser rangefinder. An installation calibration (patch test) will be conducted to determine pitch, roll, and yaw alignment between the sonar head and the motion sensor. This procedure will be repeated if any components are moved or reinstalled.

Daily geodetic control verification will be performed by positioning an RTK GNSS rover over established survey control monuments and comparing measured positions to published coordinates or RTK measurements taken before or after field work.

For the Trimble R10 GNSS, RTK corrections will be confirmed, and real-time positioning accuracy will be verified to be within 2 cm. The R10 will be connected via Wi-Fi, the web interface will be accessed, and raw data logging will be enabled.

The Applanix AP+18 MV system will be configured through its integrated web interface. Real-time logging will be enabled, and output group settings will conform to QINSy/Qimera import requirements. POS mode, INS status, GNSS azimuth measurement system (GAMS) status, and

NAV status (expected: FIXED RTK) will be verified. If any physical changes are made to the configuration between the sonar and GNSS antennas, a GAMS calibration[1] will be performed. Raw data logging will begin 20 minutes before the start of the survey and will continue for 20 minutes after the survey is complete

A minimum of two sound velocity profiles (SVPs) will be collected per full survey day—including prior to acquisition and post-acquisition. Additional casts will be collected by tidal stage changes, weather shifts, or if sonar head sound velocity differs by 6.6 ft/s (2 m/s) from the latest cast. Sound velocity at the sonar head will be monitored in real-time during operations.

Bathymetric accuracy checks will include:

- Cross-verification of sonar-derived depths over known submerged structures using RTK topo data collected at low tide. If systematic errors are detected, further review will be conducted using project configuration files, field sheets, vessel files, tide files, etc. and other relevant documentation to identify and correct the source of the error.

- Crossline survey tracks perpendicular to the primary survey direction to evaluate consistency and detect any systematic errors in depth soundings. A general rule of thumb is that 4% of the survey navigation is to be dedicated to crosslines, although specific crosslines will vary depending on the survey line lengths and their spacing.

- A manual wading-and-staff survey will not be conducted in shallow areas, because data produced by reading staff measurements in soft, clayey substrate is often not very reliable. In very shallow intertidal areas [< 3.3 ft (1 m) water depth], aerial drone surveys during the low tide and boat-based survey during the high tide will be compared.

All system clocks will be synchronized to coordinated universal time (UTC) using the Trimble R10 or the Applanix AP+18 MV as the time reference. Acquisition will be managed through QINSy or Hypack. Sensor settings, geodesy configurations, and test results will be documented on field log sheets.

Post-processing QC will be documented in the final completion report, including calibration values, sensor configuration, QC test results, and any deviations from procedures.

A.6.3 Larger platforms pre-survey procedures for R/V Marindin and R/V Portnoy

The pre-acquisition setup for the EdgeTech 6205 sonar system will begin with verifying that all bolts securing the sonar, MRU, and GNSS antennas are properly fastened. The equipment will be inspected for any physical damage or debris. Once the sonar is confirmed to be clean and undamaged, all connections will be checked to ensure they are properly made before connecting to the power supply. After powering on the system, the Discover® software will be launched on the acquisition computer to confirm stable communication with the sonar. The Advanced Sonar

[1] For detailed instructions on performing the calibration and conducting the Quality Assessment, refer to the Trimble *Technical Note: AP+ Setup and Operation for Marine Applications Rev 2.3 (2023).*

Controls will be accessed, the Transmit Level will be set to "OFF," the sonar will be turned on, and the "rub test" will be performed. After the test, the sonar will be turned off and the Transmit Level will be set to "FULL." The sonar will never be powered on with the Transmit Level set to "FULL" while it is out of the water.

A.6.4 ASV pre-survey procedures

On the day before deployment, it will be ensured that all batteries are fully charged. This will include the main battery, engine battery, RC controller battery, laptop battery, power station battery, and the CastAway CTD. The fuel tank will be verified as full by checking the fuel gauge, and the fuel can will also be checked to ensure it is full. The hull will be inspected for any signs of damage or wear, and the propulsion system, including motors and thrusters, will be examined. The steering linkage will be checked to ensure it is free from any bent or damaged components.

Next, all necessary connections will be verified, such as the navigation module to the engine, the bilge pump (yellow line), fuel line, engine battery, and main battery. The fuel cap will be double-checked to ensure it is securely fastened and locked. The four bolts on the second section of the hull will be tightened, and the Applanix antenna will be confirmed as connected and securely fastened. It will be ensured that there is sufficient data storage capacity for the mission, and all data logging systems will be verified as functioning as expected.

A.6.4.1 Pre-Deployment - Survey Day

A site survey will be conducted to assess hazards and environmental conditions. The deployment and recovery site will be verified as accessible, and the Base Station will be set up to ensure communication is ready for operation. Before heading to the deployment site, all emergency contacts will be confirmed as up to date, and emergency protocols will be reviewed with the team. Roles and responsibilities for the mission will be clarified and understood by all involved.

A.6.4.2 Deployment Procedure

Once the ASV is in the water, it will be ensured that the control is set to Manual and Armed mode. A home point will be set on the water, and the wind direction will be checked. Sufficient clearance for the sonar will be confirmed. Once the ASV is positioned, it will be navigated to a safe location, and the loiter function will be used. The remote desktop will be opened to access the sonar, and data input and error messages will be checked. If needed, the Applanix calibration (GAMS) will be performed, and raw data recording will begin. The range and bathymetry parameters on Discover will be adjusted, and recording will commence.

A.6.5 Data Acquisition

A bathymetric survey of the embayment will be performed along pre-established transects to ensure 200% ensonification of the seafloor to generate a sufficiently detailed picture of the embayment bottom. Additionally, high-resolution surveying is performed along longitudinal transects mirroring the primary channel(s) in the embayment as well as the embayment mouth or in any areas where rapid changes in bathymetry occur. Location is checked by periodic measurement of known geo-referenced points during a survey.

Discover and the third-party acquisition software will be launched in survey mode, and it will be verified that all sensors are active with no error messages. In Discover, it will be ensured that the stave data is being logged, and advanced bathymetry parameters will be adjusted using the Advanced Bathymetric Controls tab to match the specific survey requirements. For mostly flat seafloors, the Distance Binning method will be used, while for vertical structures or steep slopes, Angle Binning will be preferred. Recording stave data will allow for later reprocessing, ensuring data integrity if needed.

If using the ASV, Autopilot mode may be engaged. It will be ensured to switch back to Manual mode as needed. Throughout the mission, battery voltage and fuel levels will be monitored on the Heads-Up Display (HUD).

Real-time data quality will be continuously monitored, with particular attention to bathymetric coverage and positioning accuracy. A Sound Velocity Profile (SVP) will be acquired in the deepest part of the survey area to ensure accurate data collection in critical depths. SVPs will be acquired at regular intervals—typically every two hours or after notable environmental changes, such as approaching freshwater inputs or encountering abrupt seafloor gradients. If a thermocline is present, spatial and temporal variability in the sound velocity structure will be documented.

Alarms will be set in the survey software to notify the operator if the real-time sound velocity sensor (SVS) reading at the sonar head begins to drift more than 1–2 m/s from the most recent SVP. This will help to identify any significant discrepancies in sound velocity measurements during data acquisition, ensuring reliable results. Anomalies in sonar data, including excessive noise, beam dropout, or unexpected shoals, will be checked. GNSS positioning and MRU/INS stability will be confirmed throughout acquisition. Acquired lines will be regularly loaded on the main survey computer to verify data integrity and confirm that coverage aligns with the planned survey layout.

A.6.6 Post-Acquisition Procedures

Once the mission is complete, the last CTD cast will be collected, and the coverage will be checked for any gaps in the survey area. Data will be reviewed to ensure that all files are properly stored in their respective folders, such as *_Binned.jsf, *_Stave.jsf, and any third-party extension files. Backups will be created on external drives and/or offsite cloud storage.

If using the ASV, Manual mode will be re-engaged, and it will be navigated to a safe location, using loiter if necessary. The sonar will be turned off, and the Applanix recording will be disabled 20 minutes after the survey is complete. Once the ASV is secure, the engine will be killed, and the internal PC will be powered down, keeping the main power source and bilge pump active until removal from the water.

Upon returning to the office, all collected files will be uploaded to the server to ensure proper storage and availability for processing.

A.7 DATA PROCESSING

Data will be processed using a variety of software, with procedures for processing bathymetry outlined for CARIS HIPS and SIPS v11 and sidescan processing using SonarWiz v7.

A.7.1 Bathymetric Data Processing Workflow with CARIS

1. Import Sensor Data: Import raw data along with the appropriate vessel file, ensuring the correct coordinate system and vertical reference (e.g., NAD83-2011 and vertical tide). If available, import SBET (Smoothed Best Estimated Trajectory) files to provide more accurate positioning and attitude data.

2. Navigation Editor: Clean navigation data, focusing on speed anomalies and positional inconsistencies.

3. Georeference Bathymetry: Merge raw data with Sound Velocity Profiles (SVP) and tide data for vertical reference. Calculate the Total Propagated Uncertainty (TPU).

4. Export surface: Generate a raw surface named using the format YYYY_MM_DD_PROJ_JSF_NAD83-2011_vert_tide_RAW for visualization.

5. Filter Observed Depths Swath: Adjust swath data by refining across-track distance and applying the Nadir Depth Multiplier.

6. Subset Editor: Manually clean specific data areas by removing outliers or noise.

7. Export surface: Generate a low-resolution reference surface (4x the desired resolution).

8. Processed Depth Filter: Using the reference surface, filter the processed depth data by applying a standard deviation threshold or a static value as a filter.

9. Final Surface Creation: Create the final cleaned bathymetric surface.
10. Quality Assurance Performance Test: This test involves comparing the raw surface with the final processed surface, as well as assessing individual "Check Lines." If discrepancies or gaps remain, repeat the subset editing and depth filtering steps (Steps 7 and 8) as necessary to further refine the data before finalization. If issues persist, initiate a calibration process to ensure the correct offsets are applied.

The primary objective of the Quality Assurance Performance Test is to assess data repeatability and identify potential biases, ensuring the results meet accuracy standards and project specifications. The process typically involves creating a Reference Surface by surveying a flat and stable seabed area. Ideally, the area would coincide with an area where more data is available (e.g., lidar) and the seafloor is relatively flat and at mid-shallow depth. The area should have 100% coverage in each orthogonal direction (i.e., 200% total coverage) and a total of 10 survey lines, covering an area of approximately 500 ft x 500 ft (150 m x 150 m). If no changes are made to the instrumentation and survey operations are conducted on consecutive days, one reference surface per survey platform should suffice.

To evaluate consistency, Check Lines processed over the same area, ideally during different tidal phases, to detect potential biases in the original dataset or tidal modeling errors. The comparison analyzes parameters such as mean difference (bias), standard deviation, and the presence of outliers. Significant biases or inconsistencies may indicate the need for recalibration or corrective action.

A.7.2 Sidescan Data Processing Workflow with SonarWiz v7 (Low and High Frequency)

1. Import Sensor Data: Import the raw JSF files into SonarWiz, ensuring both low and high-frequency channels are loaded. Verify that the correct coordinate system (e.g., NAD83-2011) and geodetic reference are applied.

2. Frequency Management: In Layer panel, separate the low-frequency and high-frequency channels into individual groups for independent processing (e.g., LF for low frequency, HF for high frequency).

3. Bottom Tracking: Run Auto Bottom Tracking on both frequency channels to detect the seafloor and separate the water column. Manually adjust bottom tracking in areas where the auto-tracking fails to accurately detect the seafloor. Ensure that both frequency channels have consistent bottom tracking alignment.

4. Gain Correction: Use the EGN filter to normalize the amplitude data for each sidescan channel (low and high frequencies).

5. Clip or remove turns and undesirable coverage.

6. Adjust the order or the lines to generate a consistent mosaic.

7. Final Georeferenced Image Export: Export the low-frequency and high-frequency channels separately as georeferenced images (GeoTIFF), ensuring they include the appropriate resolution and projection. Use the naming scheme:
   YYYY_MM_DD_PROJ_JSF_NAD83-2011_SideScan_LF_FINAL
   YYYY_MM_DD_PROJ_JSF_NAD83-2011_SideScan_HF_FINAL

After processing the bathymetric and sidescan sonar data, integrate the results into a GIS project. Upload the final processed surfaces and georeferenced images to the server for storage and further analysis.

A.8 MAINTENANCE

A.8.1 EdgeTech 6205 and 6205s2 System

Both the 6205 and 6205s2 Sonar Heads are not designed for long-term deployments. They should not remain in water for more than two weeks at a time, particularly in warm, salty waters.

After each mission, thoroughly rinse the sonar head and system with freshwater to remove saltwater and debris. Pay special attention to the Sound Velocity Sensor (SVS), which is mounted on the connector nose cap, as well as the connectors at the back.

Inspect the array faces regularly for any fouling or corrosion, which could impact the sonar system's measurements and the sound velocity sensor at the bottom of the Sonar Head. If fouling is observed, clean the sonar head with a washcloth using mild soap and freshwater.

The SVS should be inspected and cleaned regularly and recalibrated according to the manufacturer’s guidelines to maintain measurement accuracy.

Never power on the 6205 or 6205s2 Sonar Head when it is not submerged in water, as this can lead to overheating and permanent damage. If testing is required before deployment, the system can be briefly powered on with the Tx Power OFF, but this should never exceed a few minutes.

A.8.2 ASV Maintenance

Regularly clean the engine, check the oil level, and ensure bolts and nuts are secure. Change the engine oil with 10W-30 (1.16 US quarts) as specified. Clean the air cleaner and replace the air cleaner element as needed. Replace the spark plug and check the valve clearance, adjusting as necessary.

The hull is made of high-impact polyethylene plastic, which requires repairs with a plastic welder or soldering iron, as standard adhesives and paints will not adhere. The bow handle should not bear any load, while the cockpit handle is suitable for carrying or securing the vessel to a vehicle or trailer.

For cleaning, check the drain plugs located on the starboard side of the cockpit section and engine bay. For short-term storage, cover the boat, and for long-term storage outdoors, remove the engine, jet drive, battery, and seats, then cover the vessel.

When transporting, ensure the engine remains upright. If tipped more than 30 degrees for an extended period, the engine may not start. In such cases, remove the spark plug, pull the starter cord to cycle the engine, clean the spark plug, and wipe away any excess oil from the air filter and airbox.

After exposure to saltwater, rinse the engine thoroughly, apply a corrosion-blocking spray, and remove and rinse the jet drive.

A.9 TROUBLESHOOTING

Tables A.7 and A.8 provide troubleshooting guidance for instrumentation and equipment operations.

A.9.1 EdgeTech 6205 and EdgeTech 6205 S2

Table A.7. Troubleshooting actions for sidescan sonar systems.

Problem	Solution	Specific Action
SV sensor not reporting data.	Ensure the SV sensor is submerged at least 1 meter below the water surface for proper functioning.	1. Submerge the Sonar Head in water deep enough to fully submerge the SV probe. 2. Confirm that the sensor is properly connected and that the water depth is sufficient.
No data reported by the SV sensor on Port 4.	Re-initialize the sonar head after a power cycle to restore the connection and check for SV data.	1. Open Remote Desktop to Sonar and check the "Serial Port Information" for Port 4. 2. If no data is displayed, power cycle the sonar head (turn it off and on) and check again.
Port settings incorrect or not recognized.	Adjust serial port settings to match the required communication parameters for the SV sensor.	1. Launch TeraTerm or a similar terminal emulator and connect to COM4. 2. Set the serial port configuration to 9600 baud rate, 8 data bits, no parity, and 1 stop bit. 3. Press enter and verify the configuration.
SV sensor does not respond after command input.	Power cycle the sonar head to reset the sensor communication and check the status again.	1. Open a terminal emulator (e.g., TeraTerm) and send the "SV-STATUS" command to the sensor. 2. If there is no response, turn off the sonar head for 10 seconds and then power it back on.
No scrolling data or missing SV data.	Disable any unnecessary header data in the sonar software to ensure the SV data is transmitted correctly.	1. In Remote Desktop, check for any errors in the "Serial Port Information" or under the "Sonar.exe" configuration. 2. If the data still isn't scrolling, disable the "Header Data" setting in Sonar.exe and try again.
Redundant or conflicting sensor data (e.g., two sensors reporting the same message).	Modify the sonar software to accept data from only one sensor to avoid redundancy.	1. In Sonar software, check the sensor output configuration. 2. If both sensors are configured to transmit the same message, change the sensor output settings so only

Problem	Solution	Specific Action
		one sensor transmits the relevant data.
Misalignment of sensor data due to conflicting input.	Disable unnecessary or conflicting fields (e.g., heading) in the configuration file to avoid data overlap.	1. Open SonarSerial.ini configuration file. 2. Locate the field for "Heading" and disable it for the redundant sensor. 3. Verify the sensor configuration to ensure proper alignment.
Error in sensor data transmission.	Ensure the baud rate is consistent across all systems and the usage of the COM port does not exceed the recommended capacity.	1. Verify that the sensor's baud rate matches the configured settings. 2. Check the COM port configuration and ensure that the sensor usage percentage is below 80%.
Incorrect configuration or missing sensor data.	Follow the correct setup for the number of sensors and ensure all configurations are properly aligned for data acquisition.	1. Verify the number of sensors in use and adjust the configuration. 2. In Sonar software, configure for one, two, or three sensors as necessary.

A.9.2 ASV

Table A.8. Troubleshooting actions for autonomous surface vehicle operation.

Problem	Possible Cause	Specific Action
Engine will not start	Choke Off	Put choke to the ON position
	Safety Lanyard not attached	Attach safety lanyard
	Out of fuel	Refuel
	Engine key in the OFF position	Turn engine key to the ON position
	Dead battery	Pull cord located on engine
Abnormal Pump Performance	Weeds or debris clogging intake grate	Turn off engine, remove debris, restart
	Weeds tangled around drive shaft	Remove jet drive (on land), remove tangled debris, reinstall pump & restart
	Damage to drive shaft or coupler	Inspect damage, call MOKAI manufacturing
	Pump inefficiency	Inspect wear ring (green, located at the stem where the jet drive attaches). Replace.

Problem	Possible Cause	Specific Action
No Fuel to Engine	Fuel lines not connected	Connect fuel lines
	Fuel Shut off closed	Open fuel valve
Poor Performance	Dirty or clogged air filter (air filter should not be oiled when used in MOKAI application)	Clean or replace air filter (to quickly diagnose, remove air filter, start engine. If performance improves, clean or replace filter)
No Manual Control	--------------------	Check batteries on Taranis X9D RC handheld
		Ensure RC handheld is in manual mode
		Check operation of Pixhawk onboard Jetyak
		Check comm functionality from RC controller to Jetyak
No Auto Control	--------------------	Ensure RC handheld is in Auto mode
		Verify steering and throttle operation using handheld. If problems occur with either servo, autonomous modes will not function
No Comms to Science PC	--------------------	Check 2.4 gigahertz (GHz) communication functionality from ship to shore ubiquity
		Verify IP addresses for on-board Science PC and Basestation PC
		Ensure remote utilities are correctly installed and configured on both PCs (Viewer (Admin) → Basestation PC, Remote (Host) → Science PC)

A.10 REFERENCES

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