Quality Assurance Project Plan
Lake Classification and Inventory (LCI) Monitoring Program

New York State
Department of Environmental Conservation
Division of Water
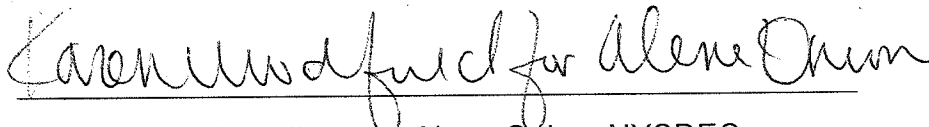**Bureau of Water Assessment and Monitoring**

Prepared by NYSDEC Division of Water

_____ $\dfrac{7/18/19}{\text{Date}}$

LCI Program Manager – Alexander Smith, NYSDEC

_____ $\dfrac{7/18/2019}{\text{Date}}$

LCI Program Coordinator – Alene Onion, NYSDEC

_____ $\dfrac{07/18/2019}{\text{Date}}$

DOW Quality Assurance Officer, RoseAnn Garry, NYSDEC

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LCI QAPP Update Log

Prepared/Revised By:	Date:	Revision	Summary of Changes:
David Newman	05/201	1.0	Removed Targeted Network, Modified data storage procedures updated personnel, and basin information.
Karen Woodfield Alene Onion	03/201	2.0	Updates to QA/QC procedures Updates to Primary and Secondary Program Coordinators responsibilities Updates to site selection procedures Updates to include electronic forms and iPads Update to include Bathymetry

No substantive changes include updating references, correcting typographical errors, and clarifying certain language to make the document more useful and effective.

DISTRIBUTION LIST

Name	Title	Organization	Document Type
Alexander Smith	LCI Program Manager	NYSDEC	Electronic
Alene Onion	LCI Primary Program Coordinator	NYSDEC	Electronic
Karen Woodfield	LCI Secondary Program Coordinator	NYSDEC	Electronic
Matt Kraft	LCI QA Officer		
Rose Ann Garry	DOW QA Officer	NYSDEC	Electronic
Jason Fagel	Lab Coordinator	NYSDEC	Electronic
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Janice Jaeger	Laboratory Manager	ALS Environmental	Electronic
Sampling personnel	Central and Regional Offices	NYSDEC	Electronic

INTRODUCTION

This document has been prepared to meet the Quality Assurance/Quality Control (QA/QC) requirements for the Lake Classification and Inventory (LCI) monitoring program, which is a component of the Statewide Waters Monitoring Program (SWMP) of the New York State Department of Environmental Conservation (NYSDEC) Division of Water. All component projects of this program are covered under the SWMP Quality Assurance Management Plan (NYSDEC, 2014). While the Management Plan covers goals, objectives, and procedures common to all component projects, this QAPP documents project goals and objectives, standard operating procedures, data review and evaluation procedures, and quality control methods specifically for implementation of the LCI monitoring program.

The LCI Monitoring Program uses a rotating strategy in which waterbodies in all major drainage basins in the state are monitored over a five-year cycle. The Year One Screening Network's focus is on screening of-interest lake segments. Each lake is sampled once during the most productive summer months (August-Sept). Year One Screening as well as the historic data set (<20 year) will be used to identify lakes where more intensive monitoring is appropriate. Intensively monitored lakes are sampled four times, monthly, throughout the summer. In 2019, the Screening basins to be sampled are the Delaware River, Saint Lawrence River, and Genesee River basins (Year 1, Screening Sampling), and the Lake Champlain, Susquehanna River, and Atlantic Ocean/Long Island Sound drainage basins (Year 2, Intensive Sampling).

I. Project Management

1. Organization/Responsibilities

The following outline describes the staff involved with the LCI Monitoring Program and their respective roles.

LCI Program Management

New York State Department of Environmental Conservation
Division of Water, Bureau of Water Assessment & Monitoring
Lake Monitoring and Assessment Section
Alexander J. Smith, PhD, Section Chief, 518-402-8287

Responsibilities
- Management of the LCI Program
  - Determine sampling strategy and overall monitoring network design, including site selection strategies, parameter selection, sampling frequency, etc.

LCI Program Coordination

New York State Department of Environmental Conservation
Division of Water, Bureau of Water Assessment & Monitoring
Lake Monitoring and Assessment Section
Alene Onion and Karen Woodfield, LCI Primary and Secondary Program Coordinators, respectively, (518)-402-8166 – Alene and (518)-402-8196 - Karen

Responsibilities
- Coordination of Sampling Design – Alene Onion
  - Selects site locations, parameters for sampling according to the LCI sample design.
  - Produce periodic assessments of monitoring results.
  - Conduct occasional and appropriate program reviews and implement modifications to enhance monitoring effort as necessary.
  - Respond to all inquiries concerning the LCI Monitoring Program.
  - Participate in training sessions offered by EPA or Agency staff related to monitoring, processing, assessment, boating, health and safety, data management or other program elements as needed in support of the broad objectives of the LCI Program.

- Coordination of Sampling Operations- Karen Woodfield
  - Develop sampling protocols and any necessary modifications to SOPs for Lakes Projects.
  - Provide sample collection technical support and training to sampling staff, as needed.

- o Coordinate the purchase of equipment, supplies and/or training.
  - o Draft, maintain and modify (when necessary) the official signed copy of the QAPP

  - o
- Management of Analytic Data Results – Alene Onion
  - o Coordinate sampling logistics (including paperwork) between sampling staff and the analytic laboratories.
  - o Coordinate receipt of data from laboratory with laboratory staff and Division Quality Assurance officers
  - o Enter all data from sample collection electronic data field forms into the lakes monitoring databases.
  - o Review, edit (if necessary), and store the data generated by the LCI Monitoring Program within Lake Monitoring and Assessment Section's database and/or other Division, Agency, State or Federal database.
  - o Provide water quality assessment and expertise in data evaluation.

LCI Quality Assurance Officer
New York State Department of Environmental Conservation
Division of Water, Bureau of Water Assessment & Monitoring
Lake Monitoring and Assessment Section
Matt Kraft, LCI Quality Assurance Officer, (518)-402-8166 and (518)-402-8196

Responsibilities
- Develop quality assurance/quality control plans for the LCI Monitoring Program.
- Coordinate with QA Officer annual field audits of sampling staff to ensure proper sample collection methods are used and discuss problems and/or needs.
- Review water quality and quality control data results for adherence to appropriate specifications.

Central Office Primary Samplers

Alene Onion, 518-402-8166 (alene.onion@dec.ny.gov)
Jesse Keltz, 518-402-8201 (jesse.keltz@dec.ny.gov)
Stephanie June, 518-402-9255 (Stephanie.june@dec.ny.gov)
Matthew Kraft, 518-402-8260 (Matthew.Kraft@dec.ny.gov)
Rebecca Gorney, 518-402-8258 (Rebecca.gorney@dec.ny.gov)
Karen Woodfield, 518-402-8196 (Karen.Woodfield@dec.ny.gov)

Responsibilities
- Sample Collection
  - o Collect lake samples in assigned geographic areas as scheduled following prescribed sampling procedures and quality assurance methods.
  - o Collect biological (harmful algal bloom, plant, etc.) samples following prescribed procedures and quality assurance methods.
  - o Process samples as scheduled following prescribed sampling procedures and quality assurance methods.

- o Transport or secure proper shipping of samples to the appropriate laboratory following prescribed procedures and quality assurance methods.
- o Maintain LCI Monitoring Program field equipment.

- Assist in Management of Analytic Data Results
  - o Assist LCI Primary Program Coordinator in entering data from the electronic sample collection forms into the lakes monitoring databases.
  - o Assist LCI Quality Assurance Officer in reviewing and editing (if necessary) data generated by the LCI Monitoring Program within the Lake Monitoring and Assessment Section's database and/or other Division, Agency, State or Federal database.
  - o Assist LCI Primary Program Coordinator in storage and maintenance of the data generated by the LCI Monitoring Program within Lake Monitoring and Assessment Section's database and/or other Division, Agency, State or Federal database.
  - o Assist LCI Primary Program Coordinator in providing water quality assessment and expertise in data evaluation.

Central Office Secondary Samplers (must be accompanied by primary sampler)

Erik Posner, 518-402-8259 (erik.posner@dec.ny.gov)
Sarah Rickard, 518-402-8155 (sarah.rickard@dec.ny.gov
Brain Duffy, 518-285-5682 (Brian.duffy@dec.ny.gov)
Gavin Lemley, 518-402-8202 (Gavin.Lemley@dec.ny.gov)
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Callan Green – 518-402-8207 (callan.green@dec.ny.gov)
Alexa Blunk – 518-402-8207 (Alexa.Blunk@dec.ny.gov)

Responsibilities
- Sample Collection
  - o Assist primary sampling staff in the collection of lake samples following prescribed sampling procedures and quality assurance methods.

DEC Regional Office Secondary Samplers (must be accompanied by primary sampler)

Region 4 Division of Water- Schenectady
        Carrie Buetow, 518-357-2268 (carrie.buetow@dec.ny.gov)
Region 5 Division of Water- Warrensburg, Raybrook

Andy Luce –Warrensburg 518-623-1229 (andrew.luce@dec.ny.gov)
Region 6 Division of Water- Watertown
Brian Boyer 315-758-2518 (brian.boyer@dec.ny.gov)
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Brian Lee, 585-226-5451 (brian.lee@dec.ny.gov)
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Sevon Thompson, (sevon.thompson@dec.ny.gov)
Region 9 Division of Water- Buffalo
Molly Detine, 716-851-7070 (molly.detine@dec.ny.gov)
Rick Rink, 716-851-7070 (richard.rink@dec.ny.gov)
Melanie Stein, 716-851-7070 (melanie.stein@dec.ny.gov)
Great Lakes Restoration Initiative- Buffalo, Watertown
David Clarke, (david.clarke1@dec.ny.gov)
Chris Fidler, 315-785-2262 (christopher.fidler@dec.ny.gov)
James Lehnen, 716-851-7130 (james.lehnen@dec.ny.gov)
Jennifer Reeher, 315-785-2261 (jennifer.reeher@dec.ny.gov)
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Finger Lakes Watershed Hub- Syracuse
Aimee Clinkhammer, 315-426-7507 (aimee.clinkhammer@dec.ny.gov)
Scott Cook, 315-426-7502 (scott.cook@dec.ny.gov)
Lewis McCaffrey, 315-426-7507 (lewis.mccaffrey@dec.ny.gov)
Tony Prestigiacomo, 315-426-7507 (tony.prestigiacomo@dec.ny.gov)
Western Flood Protection and Dam Safety Hub- Avon
Mary Binder, 585-226-5447 (mary.binder@dec.ny.gov)
Beth Coddington, 585-226-5452 (beth.coddington@dec.ny.gov)
Catherine Hardison, 585-226-5401 (catherine.hardison@dec.ny.gov)
Kerrie O'Keeffe, 585-226-5465 (Kerrie.OKeeffe@dec.ny.gov)

Responsibilities

- Sample Collection
  - o Assist primary sampling staff in the collection of lake samples following prescribed sampling procedures and quality assurance methods.
- Provide Site Selection Guidance to Central Office as requested.

DOW Quality Assurance Officer

Rose Ann Garry, Division of Water Quality Assurance Officer, 518-402-8159
(roseann.garry@dec.ny.gov)
NYSDEC Standards & Analytical Support Section

Responsiblities

- Review the QA project plan to verify that those elements outlined in the EPA Requirements for QA Project Plans (QA/R-5) were successfully discussed.

LCI Program Quality Assurance Officer – Matthew Kraft

Responsibilities
- Conduct as-needed technical field audits.
- Provide expertise regarding analytical and QA/QC issues.
- Review the QA project plan to verify that those elements outlined in the EPA Requirements for QA Project Plans (QA/R-5) were successfully discussed.

Jason Fagel, Laboratory coordinator, 518-402-8156 (jason.fagel@dec.ny.gov)

Responsibilities
- Manage analytical laboratory contracts
- Conduct as-needed technical laboratory audits

Analytical Laboratories

The complete list of laboratories that will be used in this monitoring program appears in Table 8 of Section II, Data Generation and Acquisition.

Responsibilities
- Provide sample containers and paper work per requested list of parameter analysis.
- Maintain NYSDEC DOH ELAP accreditation for LCI selected parameters that NYSDOH ELAP issues certificates for.
- Provide expertise in sample collection protocols.
- Provide expertise in analytic methods.
- Analyze water quality samples and report results.
    - Provide analysis of specified parameters for water column.
    - Transmit analytic data to NYS-DEC via agreed upon media/format.
- Implement internal quality assurance/quality control procedures.

Figure 1: Organization Chart

Alexander Smith
Manager Lake Monitoring and Assessment Section

Rose Ann Garry
QA Officer

Alene Onion, Karen Woodfield
Program Coordinators Lake
Classification and Inventory

Lake Classification and Inventory Primary Samplers
(Central Office)

Central Office Secondary Samplers
(See list of samplers above)

Regional Staff
Lake Classification and Inventory Samplers

Janice Jaeger
Lab Manager
ALS Columbia Analytical Services

Gina Kehoe
Lab Director
Upstate Freshwater Institute

2. Background– Description of Problem

New York State is mandated by the Clean Water Act to monitor the ambient water quality conditions within the state. This mandate originated in the mid-1960s and activities to fulfill this mandate have evolved over time. By the early 1980s an ambient lake monitoring program was developed to evaluate baseline water quality conditions in lakes throughout the state, utilizing a rotating monitoring cycle loosely patterned after the stream monitoring programs conducted by the Department. However, due to staff shortages, this ambient lake monitoring program (the LCI) was suspended in 1990. This left the NY Citizens Statewide Lake Assessment Program (CSLAP), a volunteer lake monitoring program overseen by NYSDEC, as the only statewide ambient lake monitoring program conducted by the NYSDEC.

In 1987 the Rotating Integrated Basin Studies (RIBS) Sampling Program was established within the NYSDEC's Division of Water, to bring together a variety of monitoring strategies into one program. In the years since, the program has undergone steady changes and growth, aimed at providing better monitoring and assessment of New York State's water quality. One component of this evolution was the coordination of efforts between the RIBS stream program and the re-establishment of the LCI Monitoring Program in the mid-1990s. By 1998, the rotating schedule developed through the RIBS stream program was adopted by the LCI Monitoring Program, with a further convergence between some site selection and logistics activities associated with each program. The LCI Monitoring Program outlined in this document is an integral component of the NYSDEC Division of Water Statewide Waters Monitoring Strategy 2019 – 2021 QA Management Plan.

The New York Strategy represents the foundation of the Division of Water's statewide water monitoring program. The primary goals of the LCI Monitoring Program component of the New York strategy include:
- water quality screening of as many waters as possible to document "good" waters that support designated uses, and identify waters with possible/potential impairment to uses;
- intensive sampling of selected waters to evaluate impairments, causes and sources and to characterize general water quality conditions

The water quality data and assessments generated by the LCI Monitoring Program are used to support various water quality management functions within the NYSDEC Division of Water. Specifically, lake monitoring information is used to: update the Division's Waterbody Inventory/Priority Waterbody List, a database of water quality conditions and impairments across the state;

- help identify water bodies not meeting their designated uses for inclusion on the New York State Section 303(d) List of Impaired Waters
- prepare the New York State 305(b) Water Quality Report, a biennial report to Congress on the quality of water resources in the state;

- select locations for more intensive water quality surveys and investigation as well as other special water quality monitoring projects;
- support the development of Total Maximum Daily Load (TMDL) plans and water quality based SPDES permit limits;
- support development of nutrient criteria within the state and within selected NYS ecoregions;
- complete USEPA's Index of Watershed Indicators (IWI), the Unified Watershed Assessment (UWA) and other federal water quality initiatives.

3. Program / Task Description

The LCI Monitoring Program uses a rotating strategy in which waterbodies in all major drainage basins in the state are monitored over a five-year cycle. The Year One Screening Network's focus is on screening of-interest lake segments. Each lake is sampled once during the most productive summer months (August-Sept). Results of the Year One Screening as well as the historic data set (<20 year) will be used to identify lakes where more intensive monitoring is appropriate. Intensively monitored lakes are sampled four times, monthly, throughout the summer.

A. Collection of single samples at screening sites through the LCI Monitoring Program surveys in the **Delaware, Saint Lawrence, and Genesee River basins.** Sampling sessions will include water sample collections for parameters specified in
B. Table 5, assessments of use impairments, visual observations and identification of submergent macrophytes (to genus level for indigenous species, and to species level for exotic species; voucher specimens of exotic species will be collected and bagged for laboratory identification), and observations about weather and sky conditions from a single site at the lake, corresponding to the deepest portion of the lake.

C. Collection of monthly samples and field observations during the summer months at intensive network sites, through the LCI Monitoring Program surveys in the **Lake Champlain, Susquehanna River, and Atlantic Ocean/Long Island Sound** drainage basins. Sampling sessions will include water sample collections for parameters specified in
D. Table 5 assessments of use impairments, visual observations and identification of submergent macrophytes (to genus level for indigenous species, and to species level for exotic species; voucher specimens of exotic species will be collected and bagged for laboratory identification), and observations about weather and sky conditions from a single site at the lake, corresponding to the deepest portion of the lake.

The following parameters are collection at a subset of the sites in addition to screening and intensive lake sampling described above.
A. Collection of harmful algal bloom samples whenever bloom conditions are observed on a lake. These could be collected in lakes in the screening or intensive network. Sampling will consist of a surface grab sample according to SOP 212-19.

B. Collection of bathymetric data from a subset of priority waterbodies in the intensive network sites. Each lake takes at least one day to collect sufficient bathymetric data. Due to limited staff time bathymetric data will only be collected from one lake each week of intensive sampling. Priority will be given to larger lakes with motorboat access due to the required time and equipment. Priority is also given to those waterbodies with higher historic nutrient values since these waterbodies are more likely to have internal loading.

The LCI Monitoring Program schedule is given below.

Table 1: Sampling schedule for all networks and sampling media for the 2019 water quality sampling year. These are target sampling dates and are subject to change based on current weather conditions, stream flow conditions, and staff/resource availability.

Network	Week of					
	April	June	July	August	September	October
Intensive Sampling						
Long Island Basin		06/10/19	07/08/19	08/05/19	09/09/19	
Susquehanna Basin		06/17/19	07/15/19	08/12/19	09/02/19	
Lake Champlain Basin		06/24/19	07/22/19	08/26/19	09/23/19	
Screening Surveys						
Genesee River Basin					09/16/19	
Delaware River Basin				08/19/19		
St. Lawrence River Basin			07/29/19			

* These are target sampling dates and are subject to change based on current weather conditions, and staff/resource availability. However, every effort should be made to remain within a one-two week window of the targeted weeks.

4. Quality Objective and Criteria

Data quality requirements including criteria for accuracy and precision for discrete and in situ water chemistry parameters are listed in
Completeness is a measure of the number of samples intended to be collected and analyzed compared to the number of samples actually collected and analyzed, expressed as a percentage. Due to the nature of the intensive LCI Monitoring Program as an ambient monitoring program--where water quality sampling is repeated at the same locations--incomplete data would result in a lower level of confidence in, but not necessarily invalidate, conclusions drawn from the data. Generally, eighty-five percent (85%) of intensive LCI samples at a site is the minimum acceptable level of completeness. For the screening lakes, only one sample is collected per lake. Therefore, eighty-five percent (85%) of screening lake samples, over all, is considered the minimum acceptable level of completeness.

Table 2. The application of the requirements in Table 2 are described below as well as additional data quality considerations. These data quality requirements are consistent with those used in the NYSDEC Rotating Integrated Basin Studies Project (RIBS QAPP 2019) and are consistent with requirements provided by USEPA. These also satisfy the data requirements associated with the state water quality standards, 6 NYCRR Part 703.

Precision will be measured by evaluating lab duplicate samples. Lab duplicates will be collected immediately after collection of the environmental sample, using the same sampling equipment and procedures followed for the collection of the environmental sample. Lab duplicates will be assigned unique sample identification numbers by field staff. Lab duplicate samples will be collected at a frequency of one per 15-20 environmental samples, roughly corresponding to one lab duplicate sample collected during each week of sampling. Given the sampling schedule outlined in

Table 1, this will correspond to approximately 1 lab duplicate per sample delivery group (SDG). The precision of field measurements will be measured by duplicating one complete vertical profile per every 15 sampling events – sampling event is a unique date/lake combination. A duplicate Secchi Disk reading will also be collected once per 15 lakes.

Accuracy will be measured by spiking at least 5% of the samples with a known aliquot of the parameter at the laboratory and carried through the analysis process as a matrix spike. The laboratory will also run the spiked reagent water blank (or LCS, frequency = minimum 1 per SDG) to assess any bias in the analytical system. Multiprobes will be calibrated to the manufacturer's specification at the intervals listed in Completeness is a measure of the number of samples intended to be collected and analyzed compared to the number of samples actually collected and analyzed, expressed as a percentage. Due to the nature of the intensive LCI Monitoring Program as an ambient monitoring program--where water quality sampling is repeated at the same locations--incomplete data would result in a lower level of confidence in, but not necessarily invalidate, conclusions drawn from the data. Generally, eighty-five percent (85%) of intensive LCI samples at a site is the minimum acceptable level of completeness. For the screening lakes, only one sample is collected per lake. Therefore, eighty-five percent (85%) of screening lake samples, over all, is considered the minimum acceptable level of completeness.
Table 2.

Representativeness of samples in defining the sampled waterbodies is addressed by using standard limnological sampling protocols regarding sample location within the waterbody and water column (for spatial representativeness) and frequency of sampling (for temporal representativeness). These are addressed by complying with the existing NYSDEC SOP 203-19: Collection of Lake Water Quality Samples. These are also discussed in Section II.

Comparability is a measure of how data results can be compared between different sampling events at the same location, how data can be compared between different sampling locations, and how data can be compared to water quality standards. For the LCI, comparability will be achieved by following consistent field sampling protocols (from site to site and year to year), sampling at the same locations, and obtaining analytical data following standardized methods for chemical analyses of water.

Completeness is a measure of the number of samples intended to be collected and analyzed compared to the number of samples actually collected and analyzed, expressed as a percentage. Due to the nature of the intensive LCI Monitoring Program as an ambient monitoring program--where water quality sampling is repeated at the same locations--incomplete data would result in a lower level of confidence in, but not necessarily invalidate, conclusions drawn from the data. Generally, eighty-five percent (85%) of intensive LCI samples at a site is the minimum acceptable level of completeness. For the screening lakes, only one sample is collected per lake. Therefore, eighty-five percent (85%) of screening lake samples, over all, is considered the minimum acceptable level of completeness.

Table 2: Analytic Specifications and QA/QC Requirements - in Water Column

Parameter	Analytic Lab	Standard Method	Precision	Accuracy	Calibration	Blanks	Quantitation Limit
Field							
Temperature		2550 B	± 1°C	± 1.5°C	N/A		
Dissolved Oxygen, field		4500-0 G	± 1%	± 6%	Daily	~	
pH, field		4500-H + B	± 0.05 SU	± 0.2	Weekly	~	
Conductivity, field	In Situ	2510 B	± 0.001mS/cm	± 1%	Weekly	~	
ORP, field		2580 B	± 1mV	± 20mV	Monthly	~	
Clarity, field		SOP 203-19	± 0.1 m	± 0.1 m	N/A	~	
Nutrients							
Ammonia		ASTM D6919-09					0.01 mg/L
TKN		EPA 351.2					0.1 mg/L
Nitrate/Nitrite (NOx)	ALS Environmental-Rochester	EPA 353.2	^	± 25%	~	Every 10 Samples	0.05 mg/L
Phosphorus, Total		EPA 365.1					0.005 mg/L
Phosphorus, Total Dissolved (field filtered filtrate)		EPA 365.1					0.005 mg/L
Minerals and Metals							
Arsenic		EPA 200.8					1.0 ug/L
Calcium		EPA 200.7					1000 ug/L
Chloride		EPA 300.0					2.0 mg/L
Copper	ALS Environmental-Rochester	EPA 200.8	^	± 25%	~	Every 10 Samples	20 ug/L
Iron		EPA 200.7					100 ug/L
Magnesium		EPA 200.7					1000 ug/L
Manganese		EPA 200.7					10 ug/L

Parameter	Analytic Lab	Standard Method	Precision	Accuracy	Calibration	Blanks	Quantitation Limit
Potassium		EPA 200.7					2000 ug/L
Sodium		EPA 200.7					1000 ug/L
Sulfate		EPA 300.0					2.0 mg/L
Other							
Chlorophyll *a* (field filtered filter)	ALS Environmental-Rochester	SM 10200H (Fluorometric)	^	± 25%	~	Every 10 Samples	0.4 ug/L
UV-254		SM 5910B					0.0063 cm^{-1}
True Color		SM 2120B					1 CU
Total Alkalinity		SM 2320B					2.0 mg/L
Total Organic Carbon		SM20 5310C					1.0 mg/L
Dissolved Organic Carbon (field filtered filtrate)		SM20 5310C					1.0 mg/L
Microcystin*	UFI	EPA 546	N/A	N/A	~	Every 10 Samples	0.03 µg/l
Chlorophyll a, unextracted*	UFI	Bbe Moldaenke, 2014	± 0.01 µg/L	± 20%L	~	Every 10	0.02 µg/l

^ Precision is calculated using the following equation: %RPD > (0.9465x^-0.344)100 +5, where: x = sample / detection limit %RPD = [diff(duplicate pair)/av(duplicate pair)]*100. See SOP SOP 108-19: Data Validation for more details.
*HABs parameters are only run on HABs samples.

5. Special Training/Certifications

All Primary Samplers will meet the minimum job qualifications for the New York State Civil Service titles of "Environmental Engineering Technician 1", "Research Scientist 1" and/or "Environmental Program Specialist Trainee 1" before they will be able to be a Primary Sampler (minimum qualifications are available at http://www.dec.ny.gov/about/571.html). Primary and Secondary Samplers are required to attend Department of Environmental Conservation training on sample collection and processing. Primary Samplers must also attend Lake Monitoring and Assessment Section trainings specific to the Lake Classification and Inventory Program, referred to as our "Calibration Day".   Secondary samplers must always be accompanied by a Primary sampler for all sample collection activities.

Program specific training is the responsibility of the Secondary Program Coordinator and is required for all field staff involved in the current sampling program to ensure the proper collection of water samples and field data.

In addition, all DOW staff conducting sampling through the LCI Monitoring Program, will be familiar with, and will follow the procedures outlined in the Health and Safety SOP and shall participate in health and safety training when these courses are offered by the Department. These courses include:
- US Coast Guard boating safety course offered through the DEC training program
- ECO Training Academy hands-on boating safety class
- Other recommended training provided through the DOW Health and Safety Program

6. Document and Records

Electronic Field Data Collection Forms and Physical Field Data Sheets
Hard copies of the field data sheets (see Figure 2) are to be submitted to the LCI Primary Program Coordinator and/or entered by one of the Primary Samplers into the MS Excel workbook for the appropriate sampling year. Field data will be stored electronically at L:\DOW\Statewide Monitoring\Lakes WQ Data.

Starting in 2019, the LCI Program will be transitioning to collecting field data using field data collection forms through ArcGIS Survey 123. These forms contain the fields to enter observational data and will also be recorded on paper field sheets. The submitted forms are sent to NYSDEC's ArcGIS Online account and are saved in an LCI group accessible by the program coordinator, section chief, and creator of the survey. The actual survey form is accessible to anyone in the NYSDEC ArcGIS Online account, however the returned surveys with data are only available to the group members. Specifics regarding the ArcGIS Survey 123 data input procedures are outlined in SOP 102-19 Data Handling and Archival. As part of the transition, information from each ArcGIS Survey will be entered on both paper field sheets and the electronic data collection form. The accuracy and reliability of the ArcGIS Survey 123 electronic data collection forms will be assessed before discontinuing paper field sheets during the 2019 field season.

The information collected in the electronic forms is stored locally on the ipad or smartphone device being used and is uploaded to the Department on Environmental Conservation ArcGIS Online account, a cloud-based service. Once the survey is completed on the electronic device, the collector is given the option to store the survey as a draft or to submit ("send") the survey for upload to the ArcGIS Online server. If the survey is saved as a draft, it remains stored locally on the device and can be reopened and edited before being uploaded to the server. If cellular internet service is unavailable when the survey is submitted to be uploaded, the survey data is stored locally on the device until it is connected to a cellular or Wi-Fi internet connection. Once the device is reconnected to the internet, all surveys queued to be sent to the server are automatically uploaded.

Analytical Laboratory Results
Complete data packages are required for the LCI Monitoring Program, in order to provide data validation capability. Data packages will be delivered to the Laboratory Coordinator, in accordance with the requirements of the NYSDEC Prescribed Analytical Protocols (PAP) -Volume 5 (2016), and to the LCI Primary Program Coordinator. The LCI Quality Assurance Officer will review the results and discuss any irregularities with QA staff.

Linking Field Data to Analytical Laboratory Data
A sample identification number is used to associate laboratory water chemistry data with data that was collected in the field. These sample identification numbers are created by the LCI Secondary Program Coordinator before sampling takes place. The sample identification number will take the form of the following:

YYACBxxx

- YY: corresponds to the two-digit year of sampling (19 will be used for all 2019 samples)
- ACB: corresponds to the basin the sample was collected from.
    - Allegheny River (ALG), **Atlantic Ocean/Long Island Sound (LIS)**, Black River (BLK), Chemung River (CHM), **Delaware River (DRB)**, **Genesee River (GRB)**, **Lake Champlain (LCB)**, Lake Ontario (ONT), Lower Hudson River (LHB), Mohawk River (MRB), Niagara River/Lake Erie (NRB), Seneca-Oneida-Oswego Rivers (SOO), **Susquehanna River (SRB)**, **St. Lawrence River (STL)**, Upper Hudson River (UHB), Ramapo and Housatonic River Basins will be included with the Lower Hudson River for the purposes of assigning sample identification numbers
- xxx: is a pre-assigned (by the Secondary Program Coordinator) 3-digit number that is unique for each sample taken in a given basin during a given year. This unique number is assigned before sampling begins based on epilimnion or hypolimnion samples and how many times the lake is to be sampled in the

intensive sampling season. First an ordered list of lakes is created. Then each lake is assigned a unique number starting with 001. Epilimnion samples are assigned an odd number and hypolimnion samples are assigned an even number. For example: A lake assigned an odd number of 001 would represent the epilimnion sample for that lake and 002 would then represent the hypolimnion sample. For the second visit to that same lake the first of the three-digit numbers would be changed to a 1. Therefore, the three-digit numbers would be 101 epi and 102 hypo, for the third visit 201 epi and 202 hypo and so on consecutively for each visit. The next lake on the list would be assigned three-digit codes of 003 and 004. If a given lake only requires an epilimnion sample, then that lake would have only a three-digit odd numbered sample and no even number sample. The next lake on the list would be the next odd number. Therefore, in the case of only an epilimnion sample in Lake 001, the next lake visited would be numbered 003 and there would be no 002 sample-number.

- HAB shorebloom samples are assigned the same unique sample identification numbers as above, and then appended with "-B#" to distinguish from water chemistry samples, where # is a sequential number for samples within a single sampling event– sampling event is a unique date/lake combination. For example, if a HABS sample is collected during the first sampling event, the sample would be numbered 19ACBxxx-B1, a second sample collected at that site during that same sampling event would be numbered 19ACBxxx-B2

Aquatic Macrophyte Identifications
The scientific name of any aquatic macrophytes that is submitted to Central Office for identification or identified in the field will be added to the corresponding electronic record that contains the field data collected in conjunction with the macrophyte.

Calibration Log Books
A calibration/maintenance log book is kept with each multiprobe unit in accordance with SOP 211-19: Use, Calibration, Maintenance and Storage of Multi-probe meters used to Measure Water Quality Parameters.

Records Retention
Legally, all records from the LCI Monitoring Program fall under Division's Records Disposition Authorization Number #19586 and are to be retained for at least 10 years after the study and a final report are completed.

All results will be summarized in a final report to be prepared by the Primary Project Manager. The final report will include all field and laboratory QA/QC results including any blanks, lab duplicate analyses, matrix spike and matrix duplicates analyzed during this study. An evaluation of the precision, accuracy, and completeness based upon replicate and spike analysis will be accomplished. A summary section on how QA/QC objectives were or were not met will be included in the final report. The final report will include a summary and discussion of analytical results for those parameters included in Table 2.

II. DATA GENERATION AND ACQUISITION

1. Rationale of Monitoring Design

Sample Distribution

Based on the objectives of the New York SWMP and contained in the program's Quality Assurance Management Plan (NYSDEC, 2014), the LCI Monitoring Program uses a rotating strategy in which waterbodies in all major drainage basins in the state are monitored over a five-year cycle. In 2019, waterbodies of six of the seventeen major drainage basins in New York State will be sampled. These basins are the Delaware, Saint Lawrence, and Genesee River basins (Year 1: Screening Sampling) and the Lake Champlain, Susquehanna River, and Atlantic Ocean/Long Island Sound drainage basins (Year 2: Intensive Sampling).

Sampling locations are selected according to criteria that ensure samples collected will meet the monitoring program's objectives (see below for criteria used).

Year One: Planning and Screening

The Year One Screening Network's focus is on screening of-interest lake segments. Lake segments are first stratified for selection based on the following categories:

Stratification Category	Percent of Total
Regional Reference	10%
Long Term Trend	20%
Unassessed Waters	20%
Department Interest	50%

Regional Reference lake segments are selected to be representative of the highest water quality or best attainable condition in a basin. They are sampled each time a basin is monitored. If these lake segments happen to be included in the current year's CSLAP sampling, they are excluded from LCI monitoring. These lake segments are selected using landscape characteristics and historical datasets. For watersheds with minimal disturbance such as those within the Catskills and Adirondacks, Regional reference sites typically exceed 95% natural cover (forest, wetland, open water etc.). In regions with more extensive anthropogenic disturbance, a minimum of 75% natural and less than 2% impervious surface may be used to represent the best attainable Regional referencesite.

Long Term Trend lake segments represent the historical knowledge based on water quality trends in a given watershed. Trend lake segments are selected to be well represented in the historical database, including CSLAP and LCI samples. These lake segments typically have between 4 and 8 years of previous sampling records, with a minimum of 3 years. Geographic distribution among the ecoregions should also be considered when selecting trend lake segments, trying not to over emphasize the water quality information of a single ecoregion. Long term trend lake segments are sampled each time a basin is monitored by LCI. If these lake segments happen to be included in

the current year's CSLAP sampling, they are excluded from LCI monitoring. However, as programmatic desires change, new trend lake segments may replace older ones. Emphasis should be placed on retaining trend lake segments with the longest historic record.

Unassessed lake segments are those that have never been sampled or haven't been sampled in the past 10 years. These waters are selected from the National Hydrography Dataset layer and compared to the historic data set, including both CSLAP and LCI samples. Sites that are listed as impaired on the NYSDEC Waterbody Inventory and Priority Water Bodies List (WI/PWL) are omitted even if the data records are older than 10 years. Since there are far more unassessed waters than can be sampled in a given cycle, lakes are prioritized if they are public drinking supplies, have had harmful algal blooms in the past, and/or have high potential for excessive nutrient loading.

Department Interest lake segments are identified through meetings with Division of Water staff including Water Assessment and Management Section, Streams Section, Watershed Basin Programs, Bureau of Water Resource Management, Permits Bureau, Compliance Bureau, and Regional Offices. In addition, through the DOW Monitoring Program Kick Off meetings in the spring of each year, LCI Monitoring Program staff will meet with local parties to discuss water quality issues/problems in the basin, and where specific monitoring efforts may be directed.

It's important to note that NYSDEC cannot request specific lakes be included in the CSLAP program so this overlap cannot be guaranteed each time LCI cycles into a basin.

Year Two: Intensive
Results of the Year One Screening as well as the historic data set (<20 year) will be used to identify lakes where more intensive monitoring is appropriate. This includes candidates identified during the DOW Monitoring Program Kick Off meetings and meeting with Division of Water staff. The sampling of these Intensive lake segments is the primary LCI Monitoring Program activity during Year Two of the study. The primary focus of the intensive monitoring cycle is to conduct enough sampling to characterize these waterbodies using criteria established in the NYSDEC DOW Consolidated Assessment and Listing Methodology (CALM) document (NYSDEC 2018). The CALM criteria are developed to determine if the designated uses for each waterbody are attained.

Selection of Lakes to be Sampled
One of the most important components of planning a monitoring network is site selection. The specific rationale for the selection of the lakes to be sampled varies for each of several component networks due to the different objectives of each.

Screening Network lakes are identified using the criteria described below

- Regional Reference, Long Term Trend, and Department Interest lake segments are selected based on the process described above.
- Unassessed lake segments are those for which the Division of Water does not have previous water quality data, or the data were collected (far) more than 10 years ago. The temporally limited data collected in the Screening Network may be sufficient to characterize extreme conditions in these lakes (particularly at the extremes in the trophic spectrum) or may be utilized to move a sampled waterbody into Intensive Network Sampling.
  o Unassessed lake segments are also prioritized by delineating their watershed and estimating phosphorus load using the LENS (Loading Estimator of Nutrient Sources) tool. The estimated nutrient load of each lake is normalized by its surface for comparison purposes.
  o Lakes that are public water supplies are prioritized above all others in the screening network.
  o Lakes that have had more than one harmful algal bloom recorded are prioritized for sampling in the screening network.

Intensive Network lakes are identified using the criteria described below:

- The data used to produce the ranked list for intensive sampling include 2018 screening data as well as any data collected in the past 20 yrs from lakes listed in the waterbody inventory as needs verification, unassessed, or having minor impacts.
- The above data are analyzed for possible impacts to drinking water, recreation, and aquatic life using thresholds defined by the Consolidated Assessment and Listing Methodology.
- The list of lakes is ranked in order based on the following cascading criteria: presence of a public water supply > Possible impacts to drinking water > Possible impacts to recreation > Possible impacts to aquatic life > Harmful algal bloom detected at least once since 2012 > Indicators of eutrophic conditions.
- The lakes are selected sequentially from this list based on department needs and budgetary constraints.

Targeted Network lakes represent those waterbodies that fall outside of the RIBS rotational schedule but are sampled to meet some other NYSDEC objective, including TMDL or Nine Element (9E) Plan development, post-TMDL or -9E monitoring, source water protection, biomonitoring in support of HABs mitigation pilots or Division of Fish and Wildlife permitting, or other NYSDEC priorities.

Identification of Sampling Sites
Sampling sites are located at the "deep hole" of each lake and are chosen through bathymetry or an initial sounding survey using an electronic sounding device. Once the

sampling site is chosen GPS coordinates are recorded, these coordinates entered into GPS devices (or physical triangulation using shoreline landmarks in the absence of available GPS devices) are used to locate the sampling site in any subsequent sampling sessions at the target waterbody.

Accessibility of Sampling Locations

Sampling sites are accessed through public or private boat launches or from gaining permission from local residents (including municipalities) with shoreline access to the lake, particularly if public boat launches are far from the primary sampling location. The LCI Secondary Program Coordinator with assistance from other Primary Samplers and/ or regional DEC staff will attempt to determine the most suitable access point for all lakes two to six weeks before sampling is begun. Once suitable access sites are determined the LCI Secondary Program Coordinator will contact local residents or lake associations found through tax map information and internet searches, to request permission (written or verbal) to sample those lakes from these alternative locations. Sampling locations not accessible, due to the inability to secure permission, are deferred until access can be secured.

Selection of Monitoring Parameters

User Perception Surveys

Samplers complete a field perception survey during each sampling session. These surveys are used to evaluate recreational and water quality perceptions and, when linked with water quality data collected at the same time, can tie water quality data to management objectives. The LCI user perception questions are identical to those used in the New York Citizens Statewide Lake Assessment Program (CSLAP) since 1992. These surveys also provide a permanent record of field 'impressions' that are particularly important for characterizing lake conditions not captured with routine water quality monitoring indicators. This portion of the electronic field data collection forms (and/or paper field sheet) is completed before all other measurements are taken. This eliminates bias based on water quality measurements.

Chemical Monitoring Parameters are selected based on several factors. Limited analytic budgets dictate that economy and efficiency are considered in parameter selection and sampling frequency. Beyond that, the LCI Monitoring Program chemical sampling is designed to evaluate trophic status and characterize ambient water quality conditions in lakes using trophic or trophic-surrogate indicators (Table 3).

Bathymetric Mapping is only possible on one lake each sampling week. Priority will be given to larger lakes with motorboat access due to the required time and equipment. Priority is also given to those waterbodies with higher historic nutrient values since these waterbodies are more likely to have internal loading.

Harmful Algal Bloom Parameters are collected whenever HABs are observed in a waterbody. This could be during screening or intensive sampling. These

procedures are established in SOP 212-19: Collection of Harmful Algal Bloom Samples and the sampling event should be reported to the HABs Program immediately using the NYHABs online notification and reporting system, available on the NYSDEC website or email HABSInfo@dec.ny.gov . HAB sample names are provided on the field sheet, corresponding to the labels affixed to the HAB sample bottles

Biological Monitoring Indicators- a limited number of biological monitoring parameters have also been incorporated into the LCI Monitoring Program (Table 4). Specific biological monitoring activities include collecting integrated samples for chlorophyll *a* analyses, collecting macrophytes for identification and integrated and/or grab samples for investigating harmful algal blooms.

- **Biological Sampling**- To address potential swings in the biologic community structure, and to complete the trophic characterization of the lake, chlorophyll *a* samples are collected in conjunction with all surface (versus hypolimnion) water samples. Macrophyte specimens are collected during the first visit to each program lake and during each subsequent sampling event only if additional species are observed.

Specific Parameters

The specific parameters collected at each lake are selected based on the waterbody classification and where in the water column the sample is collected from.

Table 5 outlines the parameters that will be collected.

Table 3: Water Column Parameters

Indicator	Description	Sampling Network
Field Parameters (Air and Water Temperature, pH, DO, Conductivity, ORP, chlorophyll a, Clarity)	to provide general characterization of lake	Intensive, Targeted and Screening Networks
Conventional Parameters (Nutrients & Color)	to indicate cultural eutrophication; determine sediment and nutrient load as impacting phytoplankton or macrophyte growth	Intensive, Targeted and Screening Networks and OPRHP sampling
Common Minerals, Metals	to determine geologic contribution and evaluate potential human health impacts	Intensive, Targeted and Screening Networks
Heavy Metals or toxins	frequently detected priority toxics (naturally occurring/industrial use, including cyanotoxins)	Intensive, Targeted and Screening Networks

Table 4: Biological Indicators of Water Quality

Indicator	Description	Sampling Network
Phytoplankton standing crop (extracted chlorophyll *a*)	Used to estimate density of algal communities.	Intensive, and Screening Network
Macrophyte identification	Focuses on collection and identification of nuisance macrophyte species and/or endangered aquatic plant species; the former consists primarily of exotic submergent macrophytes.	Intensive, and Screening Networks
HABs	Focuses on identification of a cyanobacteria HAB. Shore bloom samples are analyzed for qualitative phytoplankton microscopy, fractional unextracted chlorophyll a and cyanotoxins.	Intensive, Screening and Targeted Networks

Table 5: Water Chemistry Parameters by Class and Depth

* On a site-specific basis additional parameter may be added to address specific questions such as harmful algal blooms.

** Only surface water samples are collected from unstratified waterbodies. A waterbody is considered stratified if a metalimnion is observed – a region in the vertical profile where temperature drops at least one degree with each 1m increase in depth.

	CLASS A, SURFACE WATER	CLASS A, BOTTOM WATER	CLASS B, SURFACE WATER	CLASS B, BOTTOM WATER
ALKALINITY, TOTAL (AS CACO3)	1	1	1	1
COLOR	1	1	1	1
NITROGEN, AMMONIA (AS N)	1	1	1	1
NITROGEN, KJELDAHL, TOTAL	1	1	1	1
NITROGEN, NITRATE-NITRITE	1	1	1	1
SOLUBLE PHOSPHORUS	1	1	1	1
TOTAL ORGANIC CARBON	1	1	1	1
PHOSPHORUS	1	1	1	1
Calcium	1	1	1	1
CHLORIDE (AS CL)	1	1	1	1
CHLOROPHYLL A	1		1	
DOC	1	1		
SULFATE (AS SO4)	1	1		
UV254	1	1		
ARSENIC		1		
IRON	1	1		
MANGANESE	1	1		

2. Sampling Methods

Sampling methods utilized in this Monitoring Program have been previously outlined in NYSDEC Division of Water Lake Sampling, SOP 203-19: Collection of Lake Water Quality Samples, and in SOP 212-19: Collection of Harmful Algal Bloom Samples. No variances from these standard operating procedures regarding sampling methodology, sampling equipment, and sample processing are expected for this monitoring program.

The following equipment will be utilized for *in-situ* data collection as part of this sampling program- the use of this equipment is outlined in SOP 203-19: Collection of Lake Water Quality Samples.

Lake Water Sampling-
▪ Water Sample Collection:

- o Amber Wide-Mouth Sampling Bottle (surface monitoring for lakes less than 1.5 meters in depth)
- o Integrated sampling tube (surface monitoring for lakes 1.5 meters or greater in depth)
- o Van Dorn bottle (grab depth samples, primarily for hypolimnetic samples)
- o Field filtration (electric vacuum pump with disposable bottle insert for water chemistry indicator, hand pump for chlorophyll a filtrations)

- ▪ Field Measurements
    - o Secchi disk
    - o electronic multiprobe
- ▪ Macrophyte Sampling-
    - o Two-sided rake with tether line
- ▪ Bathymetric Mapping
    - o Chart-plotter
    - o Transducer

The Screening and Intensive sites are monitored by NYSDEC staff using a NYSDEC sampling vessel. Hand-operated sampling boats- canoes and small john boats with oars and or an electric trolling motor- are generally used for the sites that are less than 200 hectares (500 acres) in surface area or for sampling sites that are less than 1 mile from the boat launching area. A larger Tracker boat with a gasoline powered motor is typically used for larger lakes, and for smaller lakes with boat ramp launches.

Split sampling will be conducted for QA purposes. Filtering, compositing, and splitting of samples are discussed in detail in SOP 203-19: Collection of Lake Water Quality Samples. Samples are well mixed when the subsamples are drawn. The sample splitting churn or mixing carboy are designed to accomplish this. Sample splitting procedures are performed as described in the NYSDEC Sample Handling, Transport, and Chain of Custody SOP; SOP 101-19: Sample Handling, Transport, and Chain of Custody. As per the SOP subsamples are filled in the order that will minimize possible contamination of the subsequent sample containers. Samples that require no preservative are filled first. Samples for nitrogen series parameters are filled before bottles that are preserved with nitric acid. Samples with sulfur as a target analyte are filled prior to bottles with sulfuric acid preservation. Filtered samples are drawn last unless their preservation method contravenes the above fill order guidance.

- • Class A bottle set fill order
    - o Color, Sulfate, Alkalinity*, UV-254
    - o Total Nutrients
    - o Dissolved Nutrients
    - o Metals
    - o DOC, Chlorophyll a*
- • Class B & C bottle set fill order

- o Color, Alkalinity*
- o Total Nutrients, TOC
- o Dissolved Nutrients, Chlorophyll a*

*Chlorophyll a and Alkalinity are not collected in bottom samples.

Lake samples will be filtered for chlorophyll *a,* dissolved organic carbon, and soluble phosphorus. Filtered samples are prepared after the unfiltered sample (raw water) containers are filled. A known volume of raw water (see Table 6 below for volume guidance) from the surface sample is filtered through a glass fiber filter (0.7μm pore size) for chlorophyll *a* analysis (due to the lack of light penetration chlorophyll *a* is not analyzed for in hypolimnion samples). The chlorophyll *a* filter is folded in quarters and wrapped in aluminum foil and transferred to a glass vial and submitted for laboratory analysis. Samples for soluble phosphorus and dissolved organic carbon, a 0.45 μm Cellulosic filter is used and the filtrate is transferred to the subsample bottle and submitted for laboratory analysis.

All filtrations are performed as described in the NYSDEC Lake Sampling SOP; SOP 203-19: Collection of Lake Water Quality Samples.

Table 6: Volume of Water to be filtered for Chlorophyll a Analysis

Secchi Disk Depth	Volume of raw water to filter
< 1 meter	250 ml
>1 & < 2 meters	500ml
> 2 meters	1000ml

*This table provides only a guide to a reasonable compromise. If staff can filter more water without seriously increasing the filtering time they should do so. If the filter is noticeably green and staff has not filtered the specified amount, then less water may be filtered. The actual volume of filtered water needs to be recorded in the electronic field form (and/or paper field sheet) and on the laboratory chain of custody form. This information is used in the calculation of chlorophyll *a* concentration.

Sample containers and preservatives used for the analytes measured in this sampling program are listed in

Table 7.

Field Sheets/Forms
The electronic field data collection form (and/or paper field sheet) provides a record of each sampling event (sampling event is a unique date/lake combination). The electronic field data collection form (and/or paper field sheet) is used to record: (1) field measurements of basic water quality parameters (water temperature, dissolved oxygen, pH, and conductivity), (2) other notable field observations, including water clarity,

weather, aquatic macrophyte species observed or collected, and other information about the actual sample, (3) indicate semi-quantitative (ordinal scored) observations of lake perception; and (4) additional comments to evaluate analytical sampling results.

The data recorded in the electronic field data collection form (and/or paper field sheet) is sent to the LCI Primary Program Coordinator. Once received by the Primary Program Coordinator, the Primary Program Coordinator (or one of the designated Primary Samplers) will use the electronic field data collection form (and/or paper field sheet) to enter information into a central database. An electronic record of each survey is stored on the Department of Environmental Conservation ArcGIS Online account, and paper field sheets are also maintained in hard copy by the Primary Program Coordinator.

All field sheets (electronic or physical) include spaces for writing lake name and/or site description, sample identification number (linking it to the analytical results), sampling date, weather condition (wind, sky), macrophyte identification listings and qualitative assessment of densities/extent of aerial coverage, water clarity, water color (qualitative), volume of water filtered for chlorophyll a and sounding depth.

Field Observations/Lake Perception Survey

Samplers complete the field perception portion of the electronic field data collection form (and paper field sheet) before collecting any samples or performing any field measurements, this is to prevent introducing bias into their perception of the lake. These assessments were developed as part of the Citizens Statewide Lake Assessment Program (CSLAP) and allow comparison of perception data across programmatic lines and to document perceived field conditions for future sample analysis. These surveys are used to evaluate perception of lake conditions (necessary to evaluate impairments to aesthetic and recreational use impacts that are not otherwise measurable through the LCI monitoring program).

General Lake Assessment

The General Lake Assessment is completed at the Regional reference site before collecting any samples or performing any field measurements, this is to prevent introducing bias into their perception of the lake.

a) How many times have you visited this lake?
- Once or twice (low familiarity)
- Several times (moderate familiarity)
- Many times (high familiarity)

b) What type of recreational activities do you observe, or know occur here? (select all that apply)
- Motor boats
- Jet skies
- Non-motorized (e.g., kayaks, canoes)
- Swimming
- Fishing
- Hiking

- Camping
c) Describe the boating intensity
  - Low Intensity
  - Medium Intensity
  - Hight Intensity
d) Record percentage of land comprising the shoreline using the following categories: Forest, Grass, Shrubs, Wetland, Beach, Agriculture, and Bare Ground
  - None (0%)
  - Rare (<5%)
  - Sparse (5-25%)
  - Moderate (26 to 75%)
  - Extensive (>75%)
e) Shoreline mods (docks, riprap, seawalls) (percentage of total shoreline)
  - None (0%)
  - Rare (<5%)
  - Sparse (5-25%)
  - Moderate (26 to 75%)
  - Extensive (>75%)
f) Development (residential, urban, campgrounds, marinas) (percentage of total shoreline)
  - None (0%)
  - Rare (<5%)
  - Sparse (5-25%)
  - Moderate (26 to 75%)
  - Extensive (>75%)
g) Do you see evidence of any of the following? (select all that apply)
  - Lakeshore development without vegetated buffers
  - Shoreline erosion
  - Sediment input from inlets
  - Dense aquatic plant growth
h) Are dirt or paved roads visible? (Yes or No)
i) Are power lines visible? (Yes or No)
j) Recreational suitability/aesthetics
  - Beautiful, could not be better
  - Very minor aesthetic problems; excellent for swimming, boating
  - Swimming and aesthetic enjoyment slightly impaired because of algae levels
  - Desire to swim and level of enjoyment of the lake substantially reduced because of algae levels (but boating is okay)
  - Swimming and aesthetic enjoyment of the lake nearly impossible because of algae levels
k) Physical condition (water clarity, algal levels)
  - Crystal clear water
  - Not quite crystal clear – a little algae present/visible
  - Definite algae – green, yellow or brown color apparent

- High algae levels with limited clarity and/or mild odor apparent
- Severely high algae levels with one or more of the following: massive floating scums on the lake or washed up on shore; strong, foul odor, fish kill

Aquatic Macrophytes: Aquatic macrophytes are collected using tethered two-sided rakes or hand collected from the boat or shoreline, identified in the field if possible, and densities are qualitatively assessed by observation from sampling vessels or through shoreline observations. Plant identifications to genus and, where possible, species level, are limited to the littoral zone at the boat launch site, the major inlet, the outlet, and transit to and from the sampling areas. When an invasive non-indigenous species or a rare-threatened or endangered species is found or suspected a single specimen or two of these macrophytes are placed in a plastic sealable bag with a moist paper towel. Other plant specimen not identifiable by the Primary Sampler will also be collected and retained in the plastic bag for office identification. Sediment, algae, or other debris should be removed, but any flowers, leaves, stems, and other plant parts useful for identification should be included. The bag is labeled with the Lake Name and Date. Specimens are kept cool until they can be brought or shipped to the LCI Program Coordinators or designees. Plant samples shall be discarded or preserved by December 31st, 2019.

Primary samplers confirm the identification of the species or consult with external botanists to confirm the identification of the species. After the identification is made the scientific name of the specimen will be entered into the corresponding electronic record that contains the field data collected in conjunction with the specimen. If a rare, threatened, or endangered plant species is found, information regarding the exact location and extent of the population will be submitted to the New York Natural Heritage Program at the NYSDEC offices in Albany by the Primary Sampler that observed the plant. If an invasive species is encountered, information regarding the exact location and extent of the population will be submitted to New York iMapInvasives. Additional details about aquatic macrophyte data collection for the LCI Program can be found in SOP 203-19: Collection of Lake Water Quality Samples.

Water Clarity: Water clarity measurements are collected with the use of a Secchi disk, a black and white quartered 20cm disk connected to a non-stretch vinyl line with gradations at 0.1 meters. The Secchi disk is lowered over the shady side of the boat. The depths at which the disk disappears and reappears, respectively, from sight are averaged and recorded, to the nearest 0.1 meters, as the Secchi disk transparency. If the Secchi disk is still visible while resting on the lake bottom, the measurement is qualified on the electronic field data collection form (and/or paper field sheet) with a greater than sign (>).

Field Parameter Measurements
Water temperature, dissolved oxygen, pH, ORP*, conductivity, turbidity, chlorophyll a*, and phycocyanin* are to be recorded in the appropriate places on the field sheets

(Figure 2). (*sensors for these analytes are not installed on all of the multiprobes used by the LCI program)

Vertical profiles are taken with an YSI ProDSS probe (primary), YSI EXO2 Multiparameter probe (primary), or Hydrolab MS5/DS5 Multi parameter probe (secondary) - hereafter all three will be referred to as "multiprobe(s)" as per SOP 211-19: Use, Calibration, Maintenance and Storage of Multi-probe Meters used to Measure Water Quality Parameters. In-situ data for dissolved oxygen, temperature, water depth, pH, chlorophyll, phycocyanin, specific conductivity, turbidity and ORP are collected at one-meter intervals from the surface throughout the thermocline and hypolimnion with a multiprobe. Calibration and calibration drift checks are conducted before and after each sampling trip and the multiprobes are standardized in the laboratory prior to the initiation of each sampling run. The multiprobes provide both digital readouts and data logging capabilities, with all parameters displayed simultaneously.

Dissolved Oxygen: D.O. measurements are taken after the equipment has been appropriately calibrated. The manufacturer's directions are followed when calibrating and using the meter. With the multiprobe, D.O. is standardized against barometric pressure (measured in the unit).

Specific Conductance/Conductivity: Conductivity measurements are taken after the equipment has been appropriately calibrated. The manufacturer's directions are followed when calibrating and using the multiprobe.

pH: pH measurements are collected after the equipment has been appropriately calibrated using standard buffers that reflect the expected pH of the lake (s). All multiprobes are standardized against pH 7 buffer; when acidic lakes are sampled, the units are also standardized against pH 4 buffer, while pH 10 buffers are used when alkaline lakes are sampled. The manufacturer's directions are followed when calibrating and using the multiprobe. Electrodes are rinsed well after each reading. If the readings of electronic meters are suspect, pH indicator strips with an accuracy of 0.3 pH units may be used in place of the electronic meter.

ORP: ORP measurements are taken after the equipment has been appropriately calibrated. The manufacturer's directions are followed when calibrating and using the multiprobe.

Turbidity: If the turbidity sensor is present on the multiprobe, measurements are taken after the equipment has been appropriately calibrated. The manufacturer's directions are followed when calibrating and using the multiprobe.

Chlorophyll and phycocyanin: the probes are calibrated prior to the start of the sampling season using standards provided by the manufacturer and researchers.

The manufacturer's directions are followed when calibrating and using these probes. YSI probes use a rhodamine dye solution to calibrate the Total Algae sensor (chlorophyll *a* and phycocyanin). For those probes with phycocyanin measurement capabilities, phycocyanin readings are logged and/or recorded alongside the chlorophyll column on the field sheet (Figure 2).

Hydrolab probes utilize a solid standard which is calibrated against extracted laboratory chlorophyll measurements.

Water Temperature: Water temperature measurements are collected with a multiprobe. The temperature is factory calibrated on all multiprobes used for LCI monitoring.

Air Temperature: Air temperature measurements are collected with either a multiprobe or an ASTM approved non-mercury glass bulb or dial thermometer. Air temperature measurements are taken in a shaded area that is protected from strong winds but open to air circulation. The calibration cup on multiprobe units are replaced with the sensor guard before air temperature readings are taken.

Sample Information
Water depth (depth range for integrated sample) and text descriptions of color, odor, and comments specific to the sample/the collection of the sample are recorded on the Field Sheet.

Aquatic plant sampling.
Aquatic plant surveying sites are outlined in SOP 203-19: Collection of Lake Water Quality Samples. This includes survey launch site, the major inlet, the outlet, and the littoral zone transiting from these locations to the reference water quality monitoring site as prescribed in SOP 203-19: Collection of Lake Water Quality Samples. Relative aquatic plant densities are recorded in the electronic data collection form (and paper field sheet). Individual aquatic plant species are labeled on the map and form, and common and/or scientific names are cited on the form (if known); plant identifications in the office are transcribed to the electronic field data collection forms (and paper field sheets) as needed.

Harmful algal bloom (HAB) sampling
HABs shore bloom samples are to be collected if HABs are visually apparent anywhere on the lake. These procedures are established in SOP 212-19: Collection of Harmful Algal Bloom Samples and the sampling event should be reported to the HABs Program immediately using the NYHABs online notification and reporting system, available on the NYSDEC website. Alternatively, a report can be sent by email to HABSInfo@dec.ny.gov. The email should include the date and time of the report, the name and county of the lake, the latitude/longitude, and the extent and location of the bloom. Attach a picture of the bloom to the email.   HAB sample

names are provided on the field sheet, corresponding to the labels affixed to the HAB sample bottles.

Bathymetric Mapping

The protocol for bathymetric mapping is described in the BioBase EcoSound User Reference Guide (Navico, 2019) (See Appendix A). Bathymetric mapping will be completed on a subset of lakes during the intensive site visits. Priority will be given to larger lakes with motorboat access due to the required time and equipment and to those waterbodies with higher expected nutrient loading according to screening samples taken the previous year.

Bathymetry and morphology are key parameters for defining the hydrological, physical, chemical, and biological characteristics of lakes and non-wadable streams. Water level, volume, area, and stage curve relationships provide spatial quantitative information. They also impart a governing role on hydrodynamics, chemical reactions and biotic distribution and productivity. Furthermore, temporal comparisons between bathymetries can be used as an indicator of environmental change by providing information on ecosystem functioning, changes in water turnover times and storage, and catchment erosion-sedimentation rates. Obtaining baseline characteristics, hence, becomes imperative considering future activities aimed at a better understanding of lake dynamics and health through time. High accuracy depth (bathymetric) maps are obtained using a hydroacoustic instrumentation interfaced with a global positioning system mounted on a vessel. The combined unit provides a high resolution and precision survey of the complex bathymetry and morphology of lakes and non-wadable streams. The data collected in the field is in x, y and z format – latitude, longitude, and depth. The sampling strategy involves bisecting the water body, at low speed (<10 mph), along its longest axis, then subsequent continuous transects are conducted parallel (lakes and rivers) and perpendicular (lakes only) to this initial transect along the longest axis.

Notes and Remarks

Any conditions/observations, that the sampling team deems pertinent to making an informed assessment of the water quality status and/or designated uses, are noted on the electronic data collection form (and paper field sheet).

Sampling Equipment Cleaning and Rinsing

Cleaning and Rinsing of sampling equipment will be handled as per the SOP 103-19: Sampling Equipment Decontamination/ cleaning.

Figure 2: LCI Field Data Sheet

LAKE CLASSIFICATION AND INVENTORY SURVEY (LCI) FIELD SHEET

Lake Name _____ Sampling Basin and/or County _____ Sample Date _____

Field Crew _____ GPS CORD. of Sampling Site _____ , _____
(GPS to WGS84 with WAAS enabled | record coordinates in decimal degrees)

Current Weather _____ Past 48h _____
(sun, wind, precipitation)

PERCEPTION: (circle 1 per line)

		1	2	3	4	5
QA	(Water clarity)	(Crystal Clear)	(Not quite CC)	(Algal Greenness)	(High AG)	(Severe AG)
QB	(Weed coverage)	(None visible)	(Below surface)	(At surface)	(Dense at surface)	(Cover surface)
QC	(Recreation)	(Could not be nicer)	(Excellent)	(Slightly Impaired)	(Greatly Impaired)	(Not usable)

Impacts to Recreation _____

Evidence of Current Uses _____
(specifically swimming, boating, fishing)

Secchi Disk Depth(m)	Secchi Disk Visible on Bottom	Yes No	Max Sounding Depth (m)	Sample Site Sounding (m)

Depth Profile Information

Meter Brand And Model #	Sonde SN	File Name	Barometric Pressure	Air Temp.

Depth (m)	Temp (°C)	DO (mg/l)	DO(% Sat)	pH	SpCond (μS/cm)	ORP(mV)	Chl.a (ug/l)
0							
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
QC Check 0							

Sample Information

Surface Sample ID	Chlorophyll a Volume	Bottom Sample ID
Integrated ____ m to ____ m	____ ml	Depth ____ m
Grab ____ m		Time _____
Time _____		Odor/ Color _____
Odor/ Color _____		QA Sample Type and ID _____

Comments _____
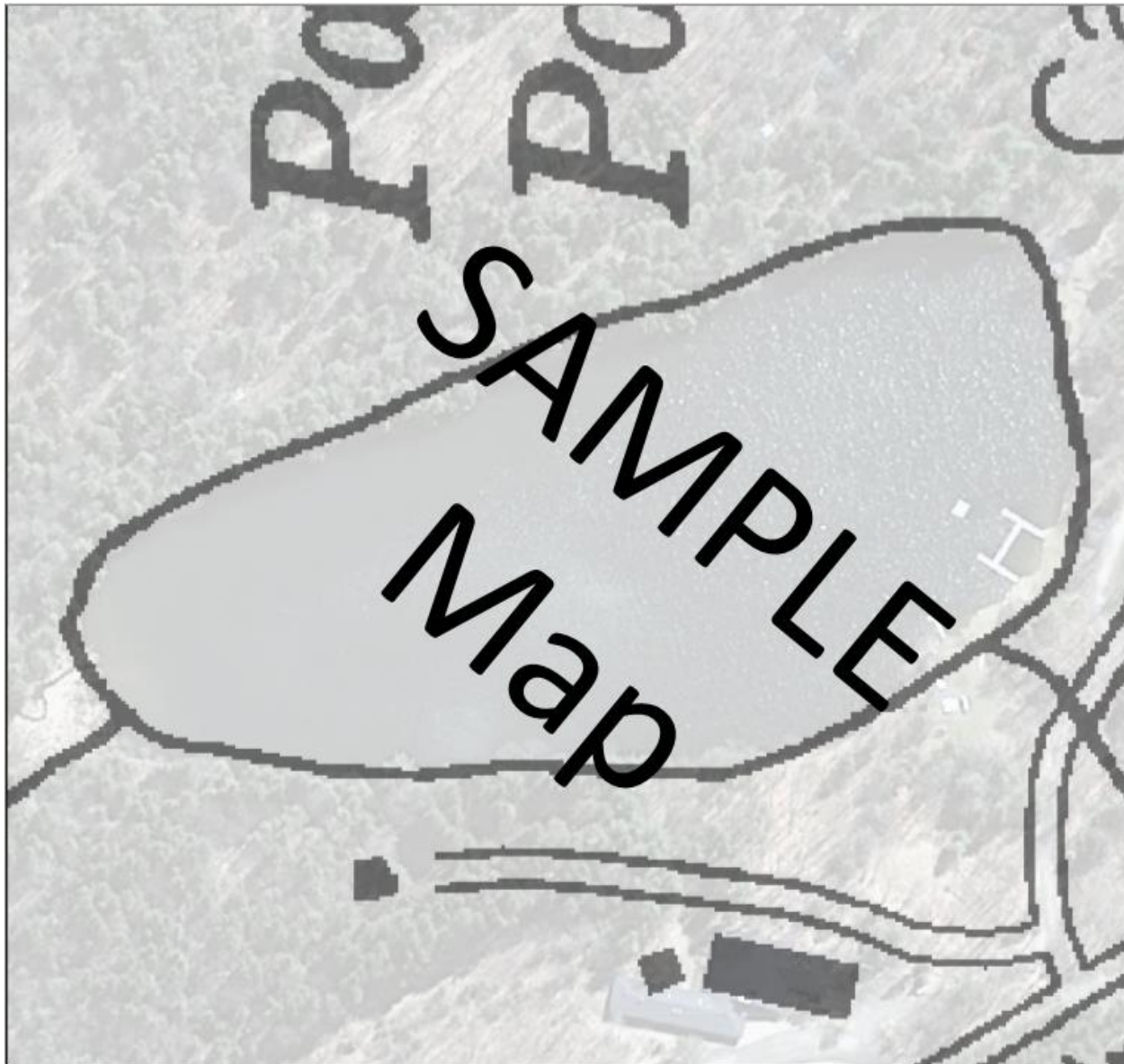
Macrophytes   Photo Y/N

A. _____

B. _____

C. _____

D. _____

E. _____

F. _____

G. _____

H. _____

I. _____

Plants Retained

Y ☐   N ☐

BGA Present

Y ☐   N ☐

Open Water
Sample ID _____

Shoreline
Sample ID _____

Bloom
Extent _____

Bloom
Description_____

BGA Photo(s) Taken

Y ☐   N ☐

Outline the location, size and
extent of blooms ⟨BGA⟩ indicate
blooms sample location Ⓧ

Instructions: Indicate approximate launch location Ⓛ , approximate sample location Ⓩ
Draw a line to approximate the path taken from launch to sample site and back to launch
Indicate with letters, from the right, where plants were observed, also indicate density:
t = trace, s = sparse, m = medium, d = dense

3. Equipment Testing, Maintenance and Calibration Procedures

Field instruments and equipment testing, inspection and maintenance will be performed in this sampling program as per the most recent version of the NYSDEC SOP 103-19: Sampling Equipment Decontamination/ cleaning, and per the manufacturer's instructions.

Contract lab instrumentation will be operated per NYS DOH ELAP certification requirements. Parameters for which NYS DOH ELAP does not issue certificates, contract lab instrumentation will be operated per the instructions in the NYSDEC Prescribed Analytical Protocol-Volume 5 (2016).

Storage

All sampling bottles and equipment related to sampling will be stored and maintained by LCI Monitoring Program sampling staff so that the results obtained from their use will not be questioned. Prior to use, all equipment will be checked to ensure good operating conditions and cleanliness. After sampling has been completed, the equipment will be cleaned (as described below) and kept ready for use. Manufacturer's specifications will be followed in carrying out routine maintenance.

Rinsing

All sampling equipment (buckets, churn, sampler, etc.) will be well rinsed with a distilled (de-ionized) water wash before and after each day's use. At each sampling location, field equipment will be rinsed with ambient water before a sample is collected and lab equipment is rinsed with distilled water after sampling is completed so equipment will be ready for use at the next monitoring location. Whenever possible, samples are collected from the least contaminated to the most contaminated site.

Cleaning

Equipment should be washed every two weeks using a phosphate free detergent and water scrub followed by a distilled water rinse as needed. Whenever equipment is cleaned with a phosphate free detergent a notation is made in the equipment's log book.

Calibration

When calibrating a multiprobe fresh reference buffers are used and the origins of each buffer are noted in the log book for the multiprobe.

Multiprobes are calibrated before each sampling run, and recalibrated if the type of waterbodies (acidic versus alkaline) change over the course of the sampling run. Specific instructions regarding the calibration of multiprobes are provided in the Operation Manuals for each instrument.

Multiprobe calibration procedures are described in the NYSDEC SOP 211-19: Use, Calibration, Maintenance and Storage of Multi-probe Meters used to Measure Water Quality Parameters.

Back-up Equipment and Spare Parts
Duplicates of most of the sampling equipment are kept in the field vehicle. In addition, a complete set of all sampling equipment is kept in the prep laboratory on the 6th Floor of 625 Broadway for instances where multiple field teams may be deployed. Spare parts for the multiprobes are kept either with the probes and or in the prep laboratory.

4. Sampling Handling and Custody

The collection method, sample container, preservative method, and holding time for all of the analytes are provided in

Table 7. Samples are either shipped overnight or hand-delivered to the laboratory.

Chain of Custody
All sample handling, transport, and custody procedures are detailed in NYSDEC-DOW SOP 101-19: Sample Handling, Transport, and Chain of Custody, Sample Handling, Transport, and Chain of Custody. Individual sample containers are labeled with pre-printed water proof labels to identify the four-digit project year and drainage basin, sample ID number, lake name, collection date, and location within the water column (Figure 3).

Figure 3: Sample Container Label Examples

YYY LCI SampleID: *YYBBBXXX* Name: *Lake Name* (*surface/hypo*) Mm /dd / yyy HH : mm _____ _____ _____ (*Analyte*)	2019 LCI SampleID: 19LHB002 Name: Lawsons Lake (hypo) Mm /dd / yyy HH : mm _____ _____ _____ (TOC)

A *Chain of Custody Record/Form* will be completed by sampling personnel and submitted to analytic laboratories with the samples (see Figure 4 for an example chain of custody form).

ALS Environmental's Chain of Custody form also serves as a request for analysis (Figure 4). All sections of the Chain of Custody/Laboratory Analysis Request must be fully completed, including project name (LCI), project contact (LCI Primary Program Coordinator), sampler's name and signature, sample ID, date and time of sampling, sample matrix (water), the number of containers per sample analysis requested, lake

name with location within the water column, and sample relinquished by. For HABs Samples a separate Chain of Custody is sent to the Upstate Freshwater Institute along with the shore bloom sample.

Table 7: Water column sampling specification

Parameter	Medium	Collection Method	Sample Container	Preservation Method	Holding Time
Alkalinity	Lake	Depth Integrated or Grab	120 ml plastic	Chill$<6^0$ C	14 days
Harmful Algal Blooms	Lake	Depth Integrated or Grab	250 ml glass	Chill$<6^0$ C	2 days
Major Anions (Cl, SO4)	Lake	Depth Integrated or Grab	250 ml plastic	Chill$<6^0$ C	28 days
Total Phosphorus (TP), NO_3+NO_2	Lake	Depth Integrated or Grab	250 ml plastic	H_2SO_4 Chill$<6^0$	28 days
Total Dissolved Phosphorus (field filtered filtrate)	Lake	Depth Integrated or Grab, Filtered	250 ml Plastic	H_2SO_4 Chill$<6^0$	28 days
NH3, TKN	Lake	Depth Integrated or Grab	250 ml Plastic	H_2SO_4 Chill$<6^0$	28 days
Major Cations (Na, K, Ca, Mg, Fe, Mn)	Lake	Depth Integrated or Grab	500 ml Plastic	HNO_3 Chill$<6^0$	28 days
Other Metals (As)	Lake	Depth Integrated or Grab	500 ml Plastic	HNO_3 Chill$<6^0$	28 days
Total Organic Carbon/Dissolved Organic Carbon (field filtered filtrate)	Lake	Depth Integrated or Grab (filtered for DOC)	250 ml Plastic	H_2SO_4 Chill$<6^0$	14 days
True Color	Lake	Depth Integrated or Grab	150 ml Plastic	Chill$<6^0$	2 days[#]
Chlorophyll *a* (field filtered filter)	Lake	Depth Integrated, Filtered	Filter (volume to be filtered see Table 6)	Chill$<6^0$	24 days

| UV-254 | Lake | Depth Integrated and/or Grab | 250 ml Plastic | Chill<6^0 | 2 days[#] |
| Aquatic Macrophytes | Lake | Rake Sample | NA | Chill<6^0 | 2 months |

[#] The 2-day holding time for True Color and UV-254 is recognized and every effort is made to have samples at the lab within the holding time although this may not always be possible. Results from samples analyzed past their holding time will be given a qualifier which will be maintained within the division's database

Transport and Shipping Procedures
All LCI water chemistry samples, except for parameters measured in the field and HAB samples are submitted to ALS Environmental- Rochester (address below). All LCI samples are shipped in large plastic coolers within the holding time of the included parameters. To safely ship chilled samples, the following guidelines are followed:

1. The cooler is carefully inspected. Broken and/or leaking coolers are replaced. Drain spouts are sealed.
2. All shipping coolers are lined with a plastic bag if using fresh ice.
3. All bottle caps are tightened.
4. To prevent breakage when samples are sent in coolers, all glass containers are placed in a foam sleeve, or its equivalent.
5. Generally, fresh ice is used to keep the sample chilled during shipping. Ice is placed in a plastic bag or otherwise contained.
6. During the summer, the coolers are pre-chilled. Then the samples are packed with fresh ice or ice packs.
7. The laboratory chain of custody sheets are placed in a plastic bag and fastened to the underside of the cooler's lid with tape.
8. All containers from the same site are grouped together in a plastic bag
9. The plastic liner bag is carefully sealed and the cooler taped shut.
10. All samples from a site are mailed in the same cooler

Table 8: Analytical Laboratories

LABORATORY NAME	LOCATION	LABORATORY SPECIALTY
ALS Environmental- Rochester (Former Columbia Analytical Services)	Rochester, NY	Dilute water systems
Upstate Freshwater Institute	Syracuse, NY	Harmful Algal Blooms

Mailing addresses for LCI Monitoring Program analytical laboratories are:

ALS Environmental- Rochester (Water column samples)

- ALS Environmental, ATTN: Janice Jaeger
  1565 Jefferson Road
  Building 300, Suite 360
  Rochester, NY 14623
  Telephone: (585) 288-5380

UFI Upstate Freshwater Institute (HAB samples)
- UFI
  Attn: Gina Kehoe
  224 Midler Park Drive
  Syracuse, NY 13206
  Telephone: (315) 431-4962

All samples are either hand deliver to the laboratory or one of the laboratory service centers shipped overnight by UPS.

Figure 4: Laboratory Chain of Custody Form

Sample Identification
Samples will be identified by a unique identification number assigned to each sample. See the Documents and Records section above for details on how Sample Identification numbers are assigned.

5. Analytical Methods

Analytical methods used in this sampling program are provided in the Table 2. Samples will be analyzed as per the NYSDOH ELAP certification and the NYSDEC Prescribed Analytical Protocol-Volume 5 (2016).

6. Quality Control

Quality Control Sampling
The objective of the LCI Monitoring Program quality control methodology is to establish and maintain standards that will ensure the validity of the data. An integral part of sample quality is collection of representative samples. The usefulness of the data obtained from any monitoring program depends upon how accurately that data actually describes the characteristics of the waterbody being studied. The samples that are collected for analyses must accurately represent the studied waterbody and be unaffected by collection procedures, sample preservation and sample handling.

To monitor the integrity of this sampling effort, the LCI Monitoring Program quality control effort uses Matrix Duplicate, Matrix Spike, Equipment Blank, and Laboratory Control Samples.

Matrix Duplicate Samples involve the independent analysis of two aliquots of a homogeneous sample by one laboratory. This sampling is used to determine the precision of the overall sampling process, from the collection of the sample through the analysis for a given matrix.

Matrix duplicate samples are collected at one site during each week of sampling. This frequency corresponds to between five percent (5%) and ten percent (10%) of the samples collected. Matrix duplicates are analyzed for each of the sample analytes.

Matrix Spike Samples are collected along with regular water quality samples and spiked in the analytic laboratory with a known concentration of analyte. The samples are then analyzed to determine the accuracy (percent recovery) of the analytic results for a given matrix.

Matrix spike samples are collected at one site during each week of sampling. This frequency corresponds to between five percent (5%) and ten percent (10%) of the samples collected. Matrix spikes are analyzed for each of the sampled analytes.

Equipment Blank Samples are collected after sampling equipment has been rinsed using standard operating procedures by running deionized/distilled water through the sample collection equipment and preserving the sample. The sample is then analyzed

to help identify possible contamination from the sampling procedure (equipment, sample containers, preservatives and handling) and to document the rinsing of sampling equipment.

Equipment blank samples are collected at one site during each week of sampling. This frequency corresponds to between five percent (5%) and ten percent (10%) of the collected samples. Equipment Blank Samples are analyzed for each of the sampled analytes.

Laboratory Control Samples are used to help identify the accuracy of analytic methods. Control samples verify calibration standards of known concentrations, to determine if the analytic instruments and overall laboratory performance (or field instruments/procedures) are within expected specifications.

Analysis of internal analytic laboratory quality control samples is conducted for each week that samples are to be analyzed or per SDG or per group of 15-20 samples. Each analytic laboratory is responsible for maintaining internal quality control as a part of their quality assurance plan. Each laboratory provides LCI Monitoring Program personnel with an evaluation of the internal quality control of the lab each year.

7. Quality Control Evaluation

The quality control results are evaluated according to SOP 108-19: Data Validation.

When QC samples fail to comply with the criteria established in SOP 108-19: Data Validation, the LCI Monitoring Primary Program Coordinator will initiate an investigation of the laboratory with the NYSDEC Division of Water Quality Control Coordinator and the corresponding laboratory manager to conduct procedures necessary to correct the problems contributing to violating these criteria. If these procedures prove inadequate to solve the problems, the Primary Program Coordinator and DOW Quality Assurance Officer will determine if this laboratory needs to be replaced by an alternative laboratory that has successfully completed these QC checks as part of a recent monitoring program.

8. Supplies and Consumables

Inspection of supplies and consumables must be made upon arrival of new materials and immediately before their use in the field or laboratory. For newly arrived supplies and consumables all materials must be in their original packaging and free of noticeable damages. For materials already obtained and about to be used no noticeable defects will be allowed. The Primary Samplers are responsible for assuring the quality of all supplies and consumables for each of their sampling trips.

9. Data Management

Sample collection information (station, collection date, time) and field parameter measurements (temperature, dissolved oxygen, pH, conductivity, ORP, water clarity, water depth) will be transferred from the electronic field data collection form (and/or

paper field sheet) into an Excel data sheet by NYSDEC staff or downloaded into CSV files from the logging device associated with the Hydrolab or YSI field probes. Bathymetric data will be loaded into a single ArcGIS project which is stored on the LMAS folder in the L: Drive.

Analytic results from contract laboratories will be reported to NYSDEC in a complete data document (Sample Delivery Group, or SDG, package) that includes summaries of data validation conducted by the analytic lab. Any inconsistencies in the data files are flagged for review and correction by the LCI Project Coordinator. Once the sample collection information (station, date, time, and parameter) has been verified, the water quality result values are reviewed. Values are compared against assessment criteria, including established parameter-specific limits. If reported values exceed the established limit, the result is flagged for further investigation.

Investigation of laboratory values may result in confirmation of the results by the analytical laboratory, comparison of the value against other results from the same site, inserting an appropriate data qualifier, and/or accepting the value without qualification. Data qualifiers have been established for laboratory values that are known to be suspicious, less than the reported value, or affected by QA/QC equipment blank contamination. Once data results have been reviewed, water chemistry data are in the Lake Monitoring and Assessment Section's database (currently a FileMaker Pro database).

III. ASSESSMENT AND OVERSIGHT

Program assessments will be conducted to evaluate the validity of the field data collection and analytical activities conducted as part of this monitoring program. All field staff will be provided training by one of the Primary Samplers at the onset of the monitoring program, likely during the initial sampling run at one of the program lakes. Random field audits of field staff may be conducted by the LCI Quality Assurance Officer, NYSDEC QA Officers and/or the Lakes Monitoring and Assessment Section Chief and will be used to assess the performance of the sampling operations. Laboratory audits are conducted annually by the laboratory QA staff. These may include evaluation of proficiency standards. Results for these assessments will be reported to the Program Manager and the Primary Program Coordinator, who will provide recommendations for any necessary corrective actions (from retraining and modifying procedures to replacing staff associated with the sampling team to modifying the choice of contract laboratories) to the Directors of the Bureau of Water Assessment and Management and the Director of the Division of Water. The responsibility for ultimately approving these corrective actions lies with these Directors.

1. Performance and System Audits

NYSDEC contract laboratories are audited on an annual basis by the NYSDEC Quality Assurance Officer (QAO) or to determine the laboratory's compliance with the requirements of the Prescribed Analytical Protocol (PAP) for all DEC programs submitting samples. Performance evaluation samples are analyzed by contract laboratories prior to contract award. According to NYS Public Health Law 502, the laboratories also must be certified by the New York State Department of Health. This program involves semi-annual performance evaluation samples and biennial on-site audits. NYSDEC QAO/ audit subcontractor laboratories on an as-needed basis. The NYSDEC QAO will conduct project specific field audits and report the results of these audits to the Project Manager.

2. Corrective Actions

Revisions to the Quality Assurance Project Plan are to be approved by the Primary Program Coordinator who will notify those on the distribution list of the revision.

Major sources of errors may include analytical and equipment problems and those resulting from the deviation from intended plans and procedures. If these problems occur in the field, corrective actions should be taken as described in SOP 210-19: Collection of Water Column Samples for the Rotating Integrated Basin Studies (RIBS) Project as part of the Statewide Ambient Water Quality Monitoring Program. For contract laboratories, the PAP and applicable analytical methods contain the procedures the laboratory is to follow when problems are encountered in the chemical analysis of samples.

Deviation from intended plans and procedures should be noted by the person observing the deviation and reported to project staff responsible for the operation or analysis in question. The appropriate project personnel shall (1) develop a corrective action plan to ensure that future sampling, analyses, etc. are conducted in accordance

with the QA procedures presented in this QAPP; (2) rerun procedures in the appropriate manner and re-analyze samples, if sufficient sample material is available and holding times are not exceeded; and (3) report all problems and deviations to the LCI Program Manager, who will also be consulted during the development of any proposed corrective action plans. All deviations from intended plans and procedures are to be recorded in the appropriate field or laboratory notebooks.

3. Reports to Management

The Quality, Standards & Analytical Management Section will perform a full data validation review on a minimum of 5% of all SDG packages from the LCI program. Additional SDG data validation reviews will be performed as identified by LCI staff in their initial review of the data. This evaluation together with the analysis of the completeness, precision, and accuracy of the LCI program will provide a level of confidence to the data set and to the interpretations and conclusions drawn from the data.

The complete data packages provided to the Project Manager and the Quality Control Officer by the analytical laboratory will report on analytical methods, sample holding times and laboratory preparation techniques that have deviated from the methods contained in this QAPP.

As soon as possible after receipt of data packages from the analytical laboratories, data are reviewed, compiled, and assessed using the established criteria and other procedures defined in the most recent version of the Consolidated Assessment and Listing Methodology (CALM) (NYSDEC 2017) and individual data reports.

4. Project Fiscal Information

The budget for the LCI project is maintained as part of the overall spending plan of the NYSDEC Division of Water SWMP.

5. Data Validation and Usability

Water Chemistry Parameters and HABs Parameters

Water Chemistry results and HABs results, generated by the analytical laboratories for the LCI Monitoring Program, are reviewed at three separate stages. First, analytic laboratory staff will follow specific laboratory protocols to ensure the quality and validity of the data. For additional information, see NYSDEC Prescribed Analytical Protocols (PAP, 2016). Second, the LCI Primary Program Coordinator reviews data results during the input and processing of data files. As previously discussed, this review includes confirmation of suspect values and the possible qualification of data results. And third, the LCI Quality Assurance Officer evaluates all the quality control data results for the LCI Monitoring Program to quantify the overall precision, accuracy, completeness and validity of the LCI sampling data.

Field Parameters

Field results generated by the LCI Monitoring Program are reviewed at two separate stages. First, the LCI LCI Quality Assurance Officer reviews field data results during

the input of the data into an electronic format. As previously discussed, this review includes confirmation of suspect values and the possible qualification of data results. Second, the LCI Quality Assurance Officer evaluates quality control data results for the LCI Monitoring Program to quantify the overall precision, accuracy, completeness and validity of the LCI field sampling data.

Bathymetric Data
Bathymetric data generated by the LCI Monitoring Program are reviewed according to the BioBase EcoSound User Reference Guide (Navico, 2019).

6. Verification and Validation Methods

Data in this monitoring program will be verified and validated by the LCI Quality Assurance Officer. Data for each of the parameters will be compared with the detection limits and precision/accuracy data provided in Section I; the analytical laboratory performs these comparisons on results that they generate. In general, data verification and validation methods were discussed in the Data Management section (above).

If data validity cannot be verified, these data will be qualified in the database according to SOP 108-19: Data Validation. This information will be noted in the final QA/QC report.

7. Reconciliation with use Requirements

As noted in Section III, uncertainty in the data allowed for use in the monitoring programs end- product will be limited to that found acceptable in the data verification and validation process.

8. Reporting

After the QC calculations and examinations have been performed for all media, the results will be summarized in a final report. The QA/QC section of the final report will include a discussion and summary of the accuracy, precision, completeness, comparability, and representativeness observed during the study.

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NYSDEC. 2019. Standard Operating Procedure: Use, Calibration, Maintenance and Storage of Multi-probe meters used to Measure Water Quality Parameters, NYSDEC SOP #211-19. Division of Water, New York State Department of Environmental Conservation, 625 Broadway, Albany, New York.

NYSDEC. 2019. Standard Operating Procedure: Collection of Harmful Algal Bloom Samples, NYSDEC SOP #212-19, Division of Water, New York State Department of Environmental Conservation, 625 Broadway, Albany, New York.

Appendix A
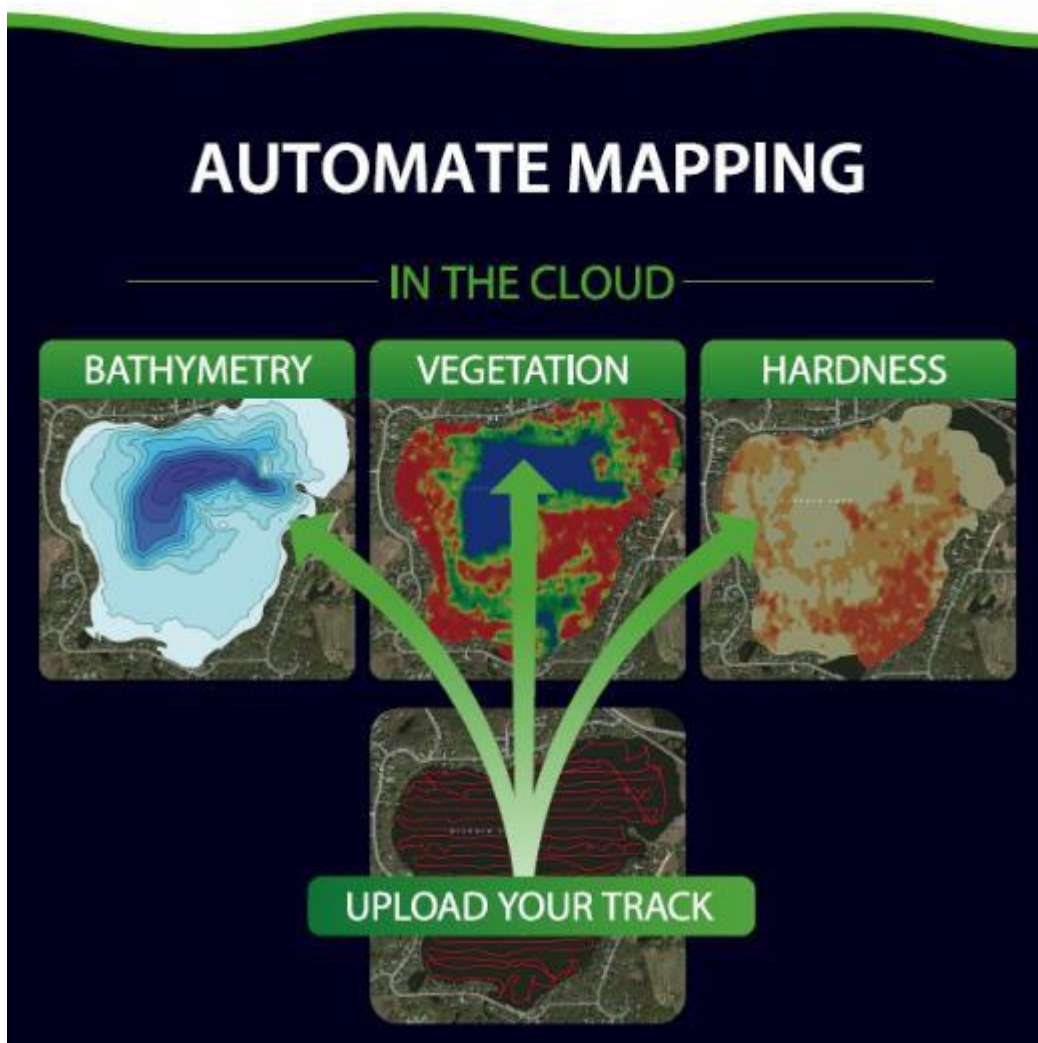
User Reference Guide

Created by Navico, Inc.

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Contents

Figure Captions

Figure 11. Example of blanked output along tracks where data do not meet minimum detection requirements (too shallow). If the user clicks on the vegetation tab, they will not see any data highlighted (notice error in upper right of the screenshot) in the location of the orange dot because

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BioBase EcoSound System

Overview

BioBase removes the time and labor required to create aquatic habitat maps. BioBase EcoSound leverages log file formats recorded to micco SD cards using today's Lowrance™ and Simrad Sounders and Chartplotters. Data collected while on the water is uploaded to an online account where it is processed automatically by bottom detection algorithms on BioBase servers. We rely on automation to make aquatic habitat mapping cost effective by reducing the technical skills, staff, and hours to produce maps from raw sonar and GPS collection. With the human element gone, you get quantitative and repeatable mapping at near real time!   The result is uniform outputs that can be combined and crowd sourced for objective aquatic resource decision making.

Biological Significance of Percent Vegetation Biovolume

A primary EcoSound output is maps of aquatic plant biovolume. Percent vegetation biovolume (also known as Percent Volume Inhabited or PVI) represents the percent of the water column occupied by plant matter at each GPS location (point features). Biovolume is plant canopy height divided by water depth multiplied by 100 averaged over 5-30 pings bound to each GPS location along a traveled path. Biovolume ranges from 0% (bare bottom) to 100% (vegetation growth near to the surface). In addition to being visually intuitive, biovolume is an indicator of recreation nuisance conditions (e.g., surface growth), changes due to invasive species introductions (which typically grow closer to the surface than native species), and fish habitat conditions. Numerous research studies have demonstrated that fish feeding success and prey availability depends on how many visual barriers are present in the water column. Some biovolume is needed to support prey communities and water quality (50% is a good rule of thumb), but too much (>80%) can promote overly abundant and stunted fish communities and create recreational nuisances. EcoSound produces a visually intuitive biovolume map and data that can help manage lakes for multiple uses.

For researchers interested in estimating aquatic plant variables of a known volumetric dimension for ecosystem models, plant height and water depth data can be exported to Geographic Information Systems (software) for estimation of the total volume of water in cubic meters in which plants grow. BioBase can be "turn-key" for management applications and rapid decision-making as well as a powerful tool for researchers.

Installation of Your Depth Finder

We recommend following the Lowrance™ unit installation instructions that accompany your unit. Permanent installation to Lowrance™ specifications will give you the most reliable and consistent signal. Still, a key feature of EcoSound is the portability of Lowrance™ depth finders, thus giving users the

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ability to survey small or remote water bodies where equipment must be transported some distance over land.

Transducer

Incorrect installation of the transducer will affect sonar signal and prevent you from gathering accurate data. If using a suction cup (which is not recommended due to its lack of stability), it should be placed according to the permanent installation procedures to avoid interference from the boat hull or the boat motor (cavitation interference from the prop). For optimum depth and vegetation detection, transducers should be in direct contact with the water. Still, some thru-hull applications may give robust depth readings in vegetation-free bottoms. Additionally, Lowrance offers special thru-hull transducers to best suit your survey set-up.

Do not mount skimmer transducers less than 1 foot from your lower unit unless you are using a slow-moving manual or battery-powered vessel. You must also be sure that the location of your transducer will not interfere with the hauling of your boat. The face of the bottom of the transducer must be aligned parallel with the ground to send and receive clear soundings. The centerline of the transducer should be even with the bottom of the boat hull to prevent interference with the transom. When mounting your transducer to a boat with a veehull, be sure that the transducer center line is aligned with the bottom of the hull while also making sure that the face (bottom) of the transducer is parallel to the ground. Refer to your Lowrance or Simrad owner manual for more information. Although correctly installing Navico brand transducers is not difficult, we recommend having your transducer installed by a Marine Service Professional.

After launching the boat with the transducer installed, make note of the depth of the transducer below the water's surface. This depth (usually about 12-18 inches) can be used to adjust the entire set of the bottom depth and vegetation biovolume data after initial processing in EcoSound. The offset, when applied to correct the transducer depth, will increase the overall depth of the contours and volume calculations.

On your Lowrance or Simrad, navigate to the Sonar main menu and select the appropriate model transducer model. *Failure to specify the transducer model connected to the display could affect the quality of EcoSound outputs*.

Prior to and throughout the data collection process, monitor the 200 kHz SONAR screen on your Lowrance or Simrad multi-function display (MFD) at different speeds. If you consistently see poor signal, stop data logging and investigate potential causes of the problem. EcoSound algorithms are designed to handle periodic losses of signal due to water column noise interference, but will not generate outputs where there are long stretches of undecipherable signal (e.g., when you see a blank screen or flashing zero depth). A good rule of thumb to follow is a clear signal to you means a clear signal to the algorithms.

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GPS

Lowrance™ and Simrad MFDs come with a powerful and highly accurate internal GPS antenna that corrects satellite position using Wide Area Augmentation System (WAAS). According to the Federal Aviation Administration WAAS is an extremely accurate navigation system developed for civil aviation. Before WAAS, the U.S. National Airspace System (NAS) did not have the potential to provide horizontal and vertical navigation for approach operations for all users at all locations. With WAAS, this capability is a reality. GPS signals from satellites are corrected by a large network of reference stations with known locations and a master station that sends corrected signals to WAAS-enabled GPS receivers. You can read a full description of WAAS at:

http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/waas/

Lowrance cites accuracy measures of approximately 5 meters. However, actual accuracy along traveled paths is typically better than this conservative estimate. Users can gauge qualitative accuracy by examining the smoothness and placement of their trip path. You can be assured you have a highly accurate signal if your trip path is smooth and precisely falls within known boundaries (e.g., a shoreline or a marina).

Always ensure that WAAS (or EGNOS for Europe) is enabled in the GPS Configuration screen within the HDS unit. Satellite reception and estimated precision accuracy (EPE) can be monitored by selecting the "Satellite" screen within the System submenu of the main menu on your HDS unit. This screen also gives you estimates of Horizontal Dilution of Precision (HDOP), which is a technical term for describing how the position of the satellites above will affect your positional precision. Values less than 5 generally indicate high confidence that positions will not be greatly affected by satellite orientation. Ensure you have an acquired position prior to logging data.

Figure 1. Boat path navigating between boatlifts on Grand Lake O' The Cherokee's near Tulsa, Oklahoma. Use the placement of the boat path as a qualitative gauge of your GPS accuracy and precision.

The internal antenna in Lowrance units is sufficient for most lake survey operations. However, users have the option of purchasing an external WAAS-enabled GPS receiver antenna

to mount in unobstructed areas of their survey vessel or directly above the transducer, which is critical for accurately lining up sonar signals with GPS position. GPS position can be monitored and overlain onto any Sonar Page using "overlay" options in each page menu.

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Still, despite high accuracy and precision of GPS receivers supported by EcoSound, survey precision and repeatability are limited more by the logistics of sampling on top of a moving medium like water than the accuracy of the GPS. Consequently, we do not recommend designing surveys with a target precision of less than 1 m. By default, EcoSound uses a 5-m grid cell in all map outputs. Changes in the grid cell resolution can be made by the user by changing the buffer size in the [Trip Reprocessing](#) or [Merge Trips](#) tabs. The grid cell size is approximately 1/5th of the buffer size.

Survey Pre-Planning

Although EcoSound does not require any trip planning, to leverage its full capabilities as a powerful survey tool, surveys should be designed with the following things in mind:

Minimum and Maximum Scale of Interest and Transect Spacing

The recommended spacing and design of EcoSound transects depends on four primary factors:
   a) Size of the waterbody of interest
   b) Output of primary interest (bathymetry, vegetation, bottom hardness)
   c) Time and Labor resources available for data collection
   d) Primary scale of interest (e.g., resolving plant abundance in front of lakeshore properties vs a bird's eye view of the overall condition of plant growth in the lake)

Whole-lake surveys in small lakes (fewer than 500 acres)

If an overall snapshot of plant growth in a small lake is the primary objective, then we recommend that transects cover the entire waterbody and be separated by no more than 40 m (130 ft). By default, EcoSound buffers a 50-m area around traveled paths and creates a contiguous grid of 5-m grid cells within the buffered area. Thus, a full lake map will be created if transects are spaced 40-m a part and are spread across the entire lake. Based on research findings in multiple fields of study, predictions up to a resolution of 1/10th the transect spacing (i.e., 1/5th on either side of adjacent transects) should be relatively robust. Thus, the default EcoSound resolution of 5 m should be sufficient for most lake survey applications. Closer spacing of transects will increase the confidence in map predictions in not sampled locations. It is important to keep in mind the difference between interpolation and extrapolation. Kriging will extrapolate outside of your trip path as well as interpolate; thus, users should keep this in mind, especially when trying to type nearshore environments less than 2.4 feet (the shallow limit for vegetation typing by EcoSound). If the last traveled transect near shore had surface growth of plants, then the shore parallel to the track will display red even if in truth, there were no plants growing in these locations. To more accurately display nearshore vegetation, the user should add [manual vegetation coordinates](#).

Whole-lake surveys in large lakes (greater than 500 acres)
Users who desire to sample a very large area, but have limited resources to cover areas as intensively as recommended in small lakes, can adjust the buffer area and grid cell resolution according to survey objectives and the 1/5th rule (e.g., a survey with 100-m spaced transects would be buffered 50-m on

each side and gridded at a 10-m grid cell resolution). This can be done in the Trip Reprocessing or Merge Trips tabs.

If the area mapped is large and homogeneous, users can increase travel speed up to a maximum of 10 mph and still get all three EcoSound map layers (Depth, Vegetation, and Composition). Savings gained by traveling faster (while still maintaining good signal) can be applied to making transects as close as possible. EcoSound will map depth as long as there is a good signal. However, EcoSound caps depth mapping at precisely 20 mph, vegetation detection at 10 mph, and bottom hardness at 10 mph.

Local area of interest surveys
Some users may desire to focus surveys in a small area of a lake or reservoir and may require higher precision in specific areas of interest (e.g., microhabitat areas, treatment or experimental areas). In these cases, users should tighten transect spacing or slow their boat speed to achieve the desired survey resolution. EcoSound produces map outputs only over areas the user covers. For maximum resolution, users can change the trip buffer to 5-m in the Trip Reprocessing tab and thus create 1-m grid cell estimates of data attributes. Starting and stopping files deliberately at sites of interest and renaming them with descriptive titles will create the most organized file management structure.

Transect design for depth mapping and smooth contour generation
To generate optimal bathymetric maps, users should design transects parallel to shore and record data along a concentric path starting at close to shore and working their way inward to the middle of the water body (Figure 2).

Figure 2. Example of concentric circle transect design for optimal bathymetric sampling in a stormwater retention pond.

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Further, efforts should be made to travel parallel to any narrow thalweg or deep channel (Figure 3).
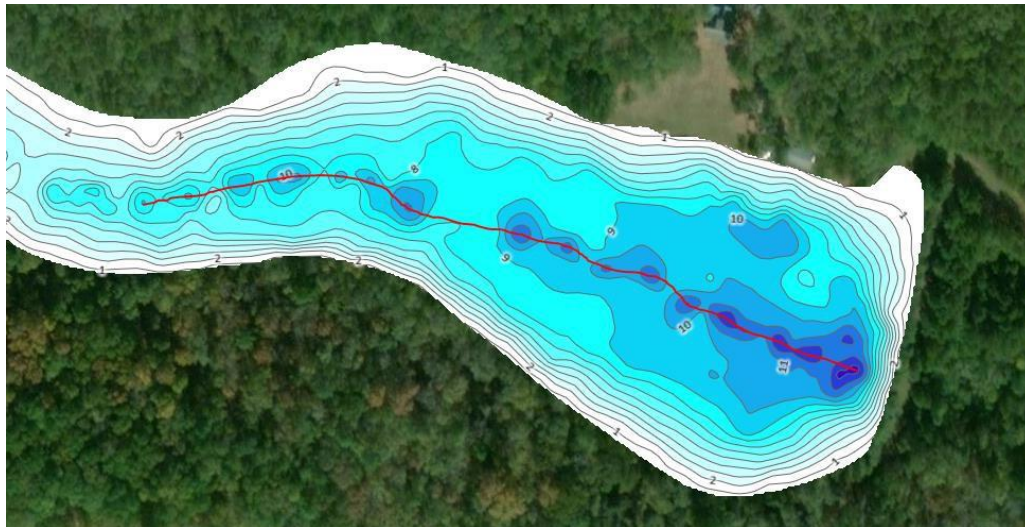

Figure 3. Red line depicting the direction of travel needed to smoothly map riverbed channels.

Transect design for aquatic vegetation mapping

For optimum mapping of the extent and cover of aquatic vegetation biovolume, users should record data along transects perpendicular to the longest shoreline. This design ensures that the maximum depth of aquatic vegetation growth (which is an important ecological parameter) is precisely mapped, thus enabling monitoring change of the zone of plant growth (i.e., the littoral zone) over time (Figure 4).
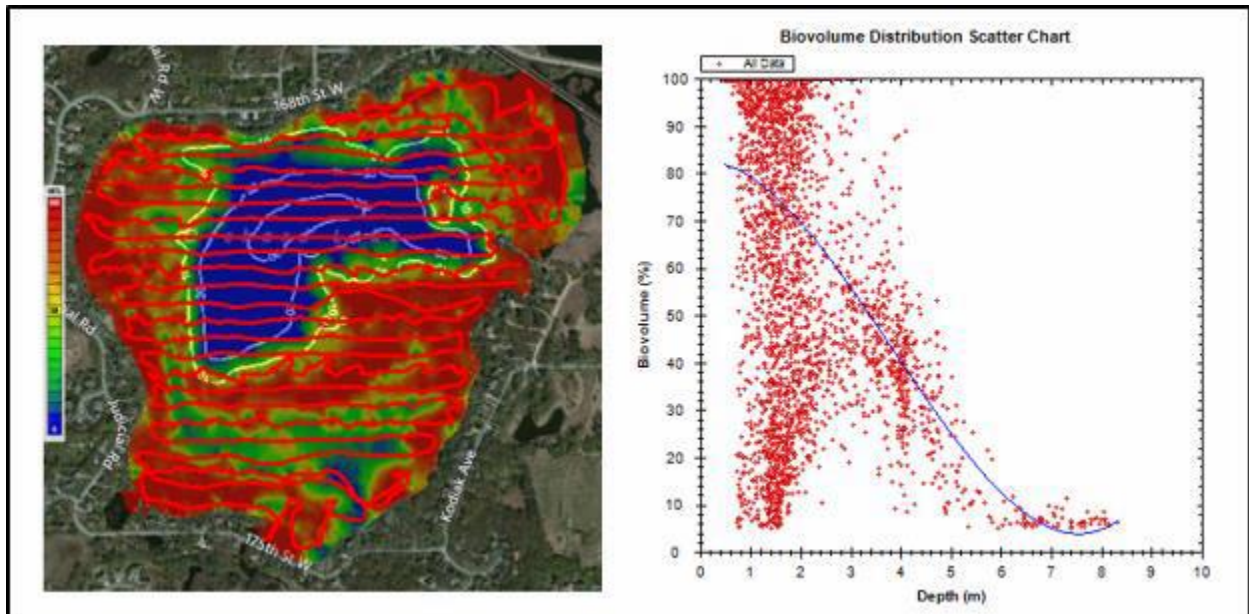
Figure 4. Example transect design and processed vegetation % biovolume heat map (left) and scatter chart of Biovolume as a function of depth (right). In this example, vegetation does not grow much deeper than 6 m (19.7 ft).

Transect design for bottom hardness (composition) mapping

Like aquatic vegetation mapping, users should travel perpendicular to the longest shore or perpendicular to slopes to generate the best bottom hardness maps. Steep slopes present a challenge for bottom typing because the acoustic beam is intercepted at an angle. A soft bottom will typically be generated if the user records data parallel to a steep slope even if the slope is actually hard. Accurate bottom hardness readings on slopes require a perpendicular recording path.

Creating and uploading survey transects and points to Lowrance™ units

ESRI's ArcGIS and other open source GIS software (e.g., QGIS, Google Earth) have multiple options for creating uniform or random survey points or transect shapefiles. Typically, these are add-on extensions that can be searched and loaded from user forums (e.g., "Fishnet" for ArcGIS). Shapefiles can be converted to GPS eXchange format files (.gpx) using a range of free third-party platforms. Save .gpx files to an SD card and insert the card into your Lowrance or Simrad MFD. In the file page, select the file from your card and import. The transect or point shapefile will now be imported into your unit as a trail or waypoints. Although many third-party options exist for executing surveys, BioBase offers only limited support for third-party software platforms

Other Notes on Transect Design

One of the primary strengths of the kriging process in EcoSound is that it takes irregularly spaced data points and creates a smooth GIS raster map based on the geostatistical properties of the input data. This allows apples-to-apples comparisons of multiple surveys that covered the same general area, but vary in their transect design and precise location. The following considerations may be of use to users planning to survey a waterbody:

- If known, areas of high bottom or plant complexity should be sampled more intensively than gently sloping or homogeneous areas.
- Often, shallow areas of lakes are more complex than deep areas. Therefore, narrower transect spacing is recommended in shallow areas than in deep areas.
- Gently weaving in and out while traveling parallel to shore along changing slopes allows the algorithm to better pattern depth and reduce bottom loss in shallow densely vegetated habitats.
- In most environments, we recommend users employ a variety of transect designs (e.g., perpendicular and parallel to shore, concentric circles) where possible to account for the various ways bottom topography and plant growth varies within a lake. Users should experiment with different designs and merges and go with the design that produces the best output for their needs

Data Collection

EcoSound analyzes data from any Lowrance, Simrad, or B&G multifunction display (MFD) and transducer capable of recording a 200 kHz Broadband signal to a sonar file (must be .slg, .sl2, or .sl3). Specifications

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of BioBase-compatible sounders and GPS can be browsed on each brand's website. A wide range of first- and third-party (Airmar) transducers and beam angles are compatible with all hardware options and BioBase processing. Previous testing demonstrates accurate bottom tracking with the 200 kHz frequency in depths as shallow as 1.1 ft and the signal usually "finds" bottom even in dense vegetation beds (although extremely dense vegetation canopies can extinguish acoustic signals and periodically give false bottom readings). Minimum depth for vegetation detection with BioBase is 2.4 ft. For more details about specifications and MFD settings, please see BioBase Configuration Specifications.

Data should be logged directly to high-capacity SD/MMC cards and not to the relatively small capacity internal hard drive of users' MFD. All channels should be saved in .sl2 file format. Sonar ping data are automatically combined and matched to GPS locations for plotting. Users should log no more than one hour of data per file to hedge against data loss should a file become corrupted. Multiple files can be combined by merging trips. Changing the ping speed has a dramatic effect on file size. The ping speed is adjustable on a sliding scale on the MFD itself. The default ping speed is 20 pings per second (pps) and will generate the highest possible resolution, but will create very large files. Most users will not notice the difference between 10 pps and 15 pps ping rates in their map outputs or sonar logs.

In general, a clear signal on your sonar screen generally translates to a clear signal to EcoSound. Boat speed controls the spatial proximity of pings and GPS reports and affects the size of the window used for characterizing depth at a specific location. For homogeneous bottoms, users can travel at a relatively high rate of speed and still get very accurate map results. However, excessive speed in areas of complex bottom topography or vegetation may result in a poor-quality map. In complex bottom or shallow vegetated areas speeds should generally not exceed 6 mph.

Recording Sonar

Prior to logging, users should ensure that the 200 kHz Broadband frequency is the primary sonar channel. To record sonar, users must have the Broadband SONAR menu active and select the Log Sonar option (Figure 5). The Log Sonar options box will pop up and allow you to change the name of the file and choose where to save the sonar log. You can change the file name, which will appear in your account under each upload. Be sure to save to MEMORY CARD.
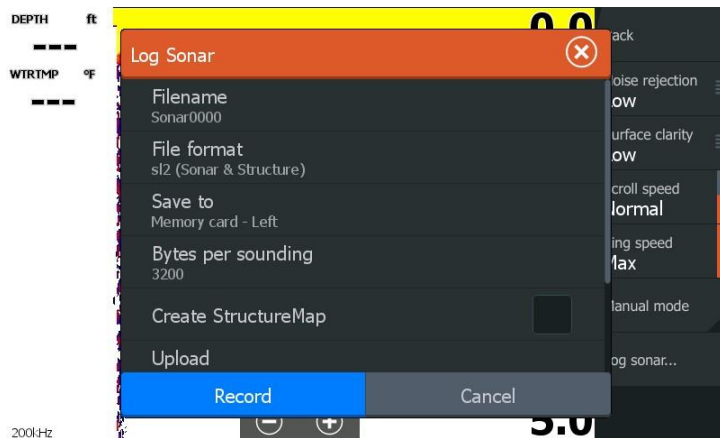
Figure 5. Log Sonar screen that allows users to save .sl2 files to an external memory card. Ensure Memory Card is selected prior to logging. The internal memory on Lowrance and Simrad MFDs are small and will fill up quickly.

All other settings can remain unchanged. If you have not yet inserted your memory card, the SAVE TO option will be limited to INTERNAL. Insert the memory card, exit the log sonar options box then start from the beginning. Once you have created a file name and selected SAVE TO Memory

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Card, select RECORD. In rare circumstances, SD cards become corrupt and the unit cannot recognize them. If this happens, try a different card.

To stop recording, select LOG SONAR and select STOP LOGGING (Not Stop Sonar; Figure 6). If any adjustments to the transducer or MFD need to be made, stop logging, make the adjustments, then start a new file. Making transducer or setting adjustments while logging risks file corruption and data loss.
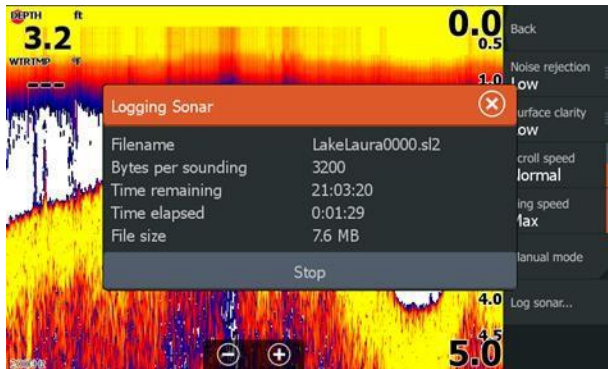
Figure 6. Example dialog to stop data recording on a Lowrance HDS Gen2 Touch. Users should note that "Stop Sonar" does not stop recording.

It is recommended that each organization or user develop a meaningful naming convention for the sonar log filenames. In users' EcoSound Dashboard, each processed file is uniquely identified by the date, local time, user name, waterbody, sonar log filename or any user-defined name after the upload. Due to the large amount of files processed for individual organizations and users and to assist in the identification of particular transects or trips, a unique and descriptive filename will create an easy way to find and select desired transects for review. If users have difficulties finding a specific trip, they can use various search functions and date filters in their Dashboard

Uploading data to BioBase

Once recorded, files can be saved to your local computer or uploaded directly from the micro SD card. To upload files to your account, you will either need to download the BioBase Upload Tool (Windows users only) from your BioBase Dashboard or use the Web Upload Tool. Prior to collecting data, ensure the upload tool installs correctly and you have the necessary security exceptions from your IT Department or Service Provider.

After installing the BioBase Upload Tool, a shortcut icon will appear on your desktop as shown on the right. This icon will launch the BioBase Upload Tool and allow you to select files for upload (Figure 7). EcoSound is only compatible with Lowrance, Simrad or B&G sonar files (.slg, .sl2, and .sl3).
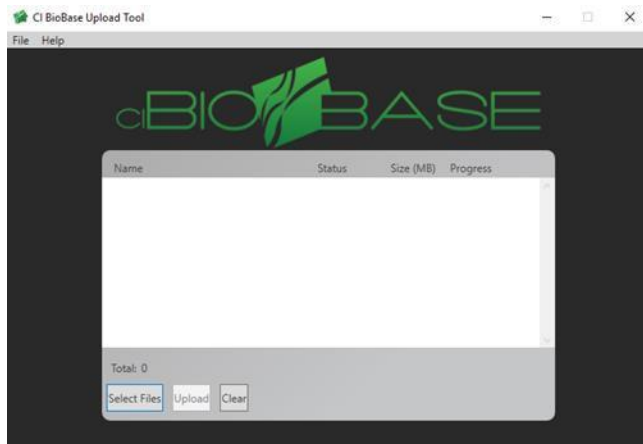

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Figure 7. By clicking on the "Select Files" button as shown above you will be allowed to select your collected log files.

Browse for your log files and click UPLOAD. The client upload tool will automatically compress your files via a temporary directory on your PC prior to uploading (ensure your hard drive has adequate space to store these temporary files or the upload will fail). You can upload an unlimited number of files at a time however upload times vary dramatically depending on file size and internet upload speed.

The easiest and most popular way to upload sonar files to BioBase is by using the Web Upload Tool. This can be done from your web browser on www.BioBaseMaps.com and does not require any download. The best browsers to use with BioBase are either Google Chrome or Mozilla Firefox; do not use Internet Explorer as this outdated browser is no longer supported. Also, most phones with an expandable storage micro SD card slot can upload sonar files straight from the phone!

The Web Upload Tool functions very similarly to the downloadable desktop tool. After clicking on the Web Upload Tool link on the right side of the Dashboard, select "Add Sonar Logs". Then, simply select your sonar files on your computer when prompted and click "Start Upload" to begin the process.

Users should also be mindful of their PC's power settings when running large unattended uploads. PC Sleep or Hibernation will terminate queued or in progress uploads. Windows automatic updates are also known to interfere with EcoSound uploads if the update automatically restarts the user's PC. When the trips are finished processing, an email will be sent indicating the trips are now viewable in the user's account.

Geostatistical Interpolation Description

Because surveys cannot provide 100% lake coverage, EcoSound utilizes a geostatistical procedure called kriging that analyzes various spatial properties of the data and models these relationships. These models are used to predict vegetation biovolume at not sampled locations and create a uniform map. Kriging creates a 'smooth' surface and actual data points may be slightly higher or lower than estimated values. Lake vegetation changes constantly throughout the year. Further, the fluid properties of water subject to wind, waves, and currents create a sampling environment where repeatability of survey results in less

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than a 1-m square area is unrealistic in most circumstances. Consequently, we employ kriging as a statistically robust way to characterize the general nature of bottom during the sampling trip. Users can increase the accuracy of output maps by driving slower and traveling along closely spaced transects. In these cases, actual depth and vegetation values in sampled locations will be preserved in the output grid. As neighbor points become more distant or variable, smoothing will increase. To minimize interpolation error, by default, map outputs are not generated out past 25-m of your track (Figure 8). Users can either collect more data in these "blanked" areas or increase the buffer in the Trip Reprocessing or Merge Trips tabs.
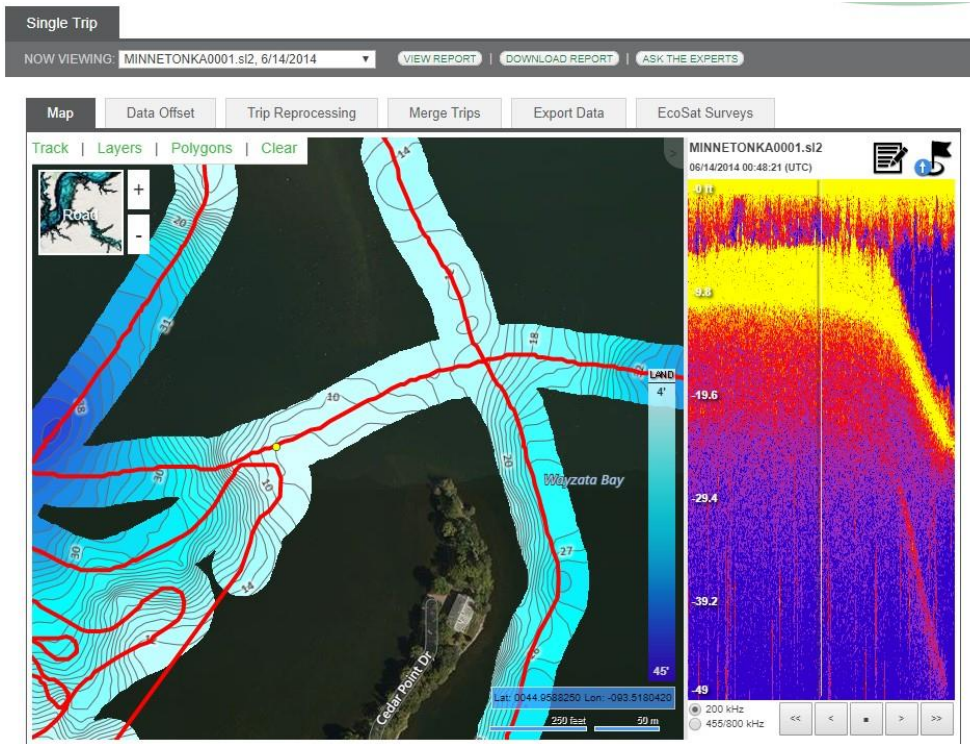
Figure 8. Gaps in map are a result of trip "blanking" that prevents the creation of map outputs too far from collected data. Maps are blanked past a distance of 5 times the grid or pixel size (default grid cell size is approx. 5 m and "buffer" size is 25 m). Increasing the buffer in Trip Reprocessing or Merge Trips will increase the grid cell size (decrease resolution) proportionately.

Our default kriged vegetation heat map has been tested in a variety of cases and should produce a robust snapshot of biovolume; however, researchers may want to look closer at the spatial relationships of the data and do their own modeling. They can do so by exporting the comma delimited point data along their GPS track from EcoSound and importing it into third-party GIS or statistical software. EcoSound kriging grids can also be exported within user accounts.

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Outputs and Features

After upload and automated processing of .sl2 files, data are displayed to a user in an interactive map through an online account. Data displayed will provide trip replay options, contour map generation, a vegetation biovolume heat map, and a bottom hardness map. Also provided is the ability to manually adjust coordinates or add additional details where data collection was not possible. Data along your GPS track is displayed below your map and synced with the sonar log for desktop verification of map outputs generate by the kriging geostatistical model.
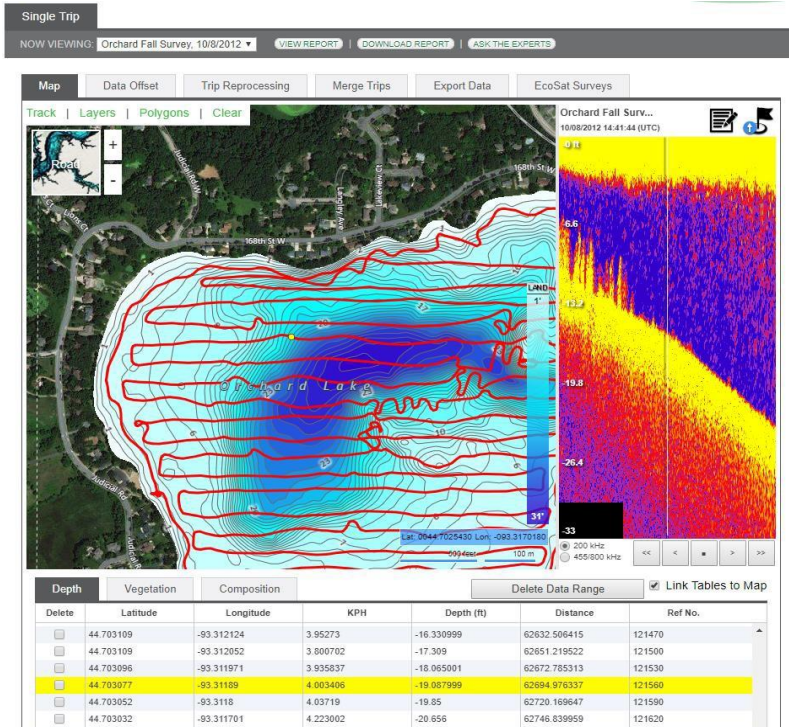
Figure 9. Interactive view of lake map layers processed by EcoSound (Bathymetry - left), georeferenced sonar log (right), and associated GPS coordinate data (below).

carefully mapping navigational hazards (e.g., rocks, shallow shoals).

Bathymetry

Contours in your accounts are generated using the data you collect. Depth data can be aggregated among all trips or users in an organization to provide constantly updated contours that improve over time. The kriging algorithm we use is an exact interpolator where adjacent data vary smoothly. The algorithm includes zero depths at shapefile boundaries and collected points to estimate depths where no data has been gathered. For higher accuracy and precision where bottom environments are highly variable, we recommend users slow their speed (< 3 mph) and intensify their coverage of bottom areas with complex topography, paying special attention to

Users can use the Trip Replay and bathymetry viewing tools to edit and "clean" their bathymetry maps to a desired smoothness. In other words, sometimes for various reasons, transducer signal can be lost and depth measures can be affected thus creating "donuts" in the bathymetry (see below). Sometimes these donuts are legitimate and due to a quick change in depth and crossing a contour interval. For instance, a 10 ft donut will show up in a sequence of depths with 1 ft intervals reading 11.6, 11.7, 11.5,

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11.2, 10.8, and 11.3. Users may choose to delete the 10.8 data point to remove this donut and make the bathymetric map smoother. For more information on how to edit data, see the Data Verification and Editing section below.
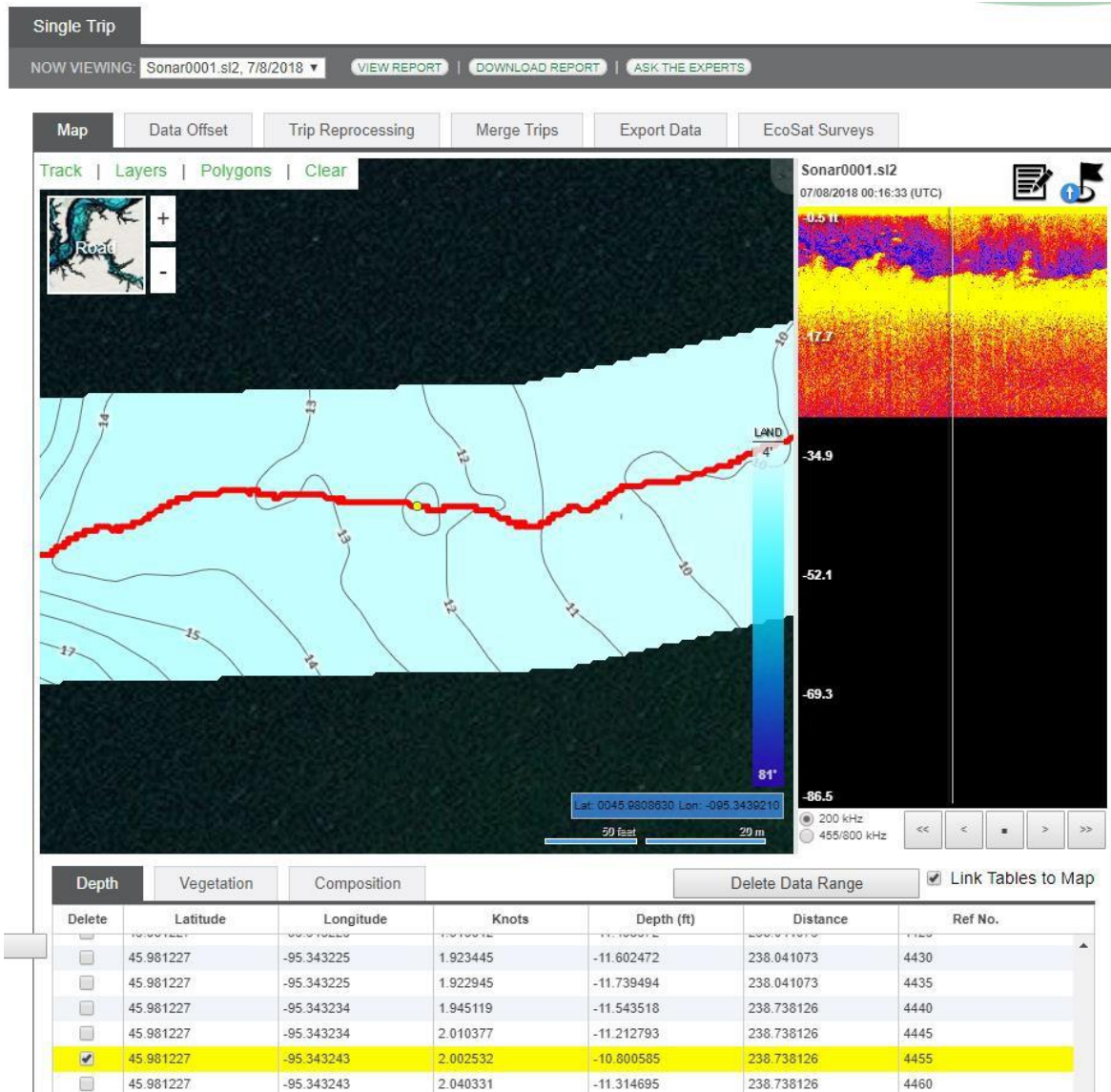

Figure 10. Review and delete "donuts" caused by transducer signal loss or temporary jump into a different contour interval. The trip must be reprocessed for the map and summary report to be updated.

Waterbody Boundaries

BioBase's Quality Control (QC) Team updates shoreline boundaries according to the latest Bing imagery. If a user determines that the boundary of their map is not accurate (perhaps due to outdated or poor imagery), users are encouraged to contact the BioBase support team via the "Ask the Experts" link in the trip of interest and request a

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change to the boundary. This can be done relatively quickly and the trips and reports will be automatically reprocessed by QC staff.

Any output by the BioBase system may not be used for navigation purposes. By using the BioBase system, you agree to hold Navico, Inc. and its partners and affiliates harmless for any injury or damage caused to personal property.

Biovolume Heat Mapping

The raw acoustic signals in .sl2 files carry information about the tallest plant (i.e.,plant canopy) intercepting the acoustic cone. Plant height data is rendered as the average proportion of plant height to water depth (% biovolume) in a collection of pings for a GPS coordinate point (typically 5 to 30 signals per GPS point and GPS point every second). Aquatic plant growth to the surface of lakes is a common condition in shallow areas of lakes and generates high acoustic interference throughout the acoustic range. These signals are automatically interpreted as surface aquatic plant growth and indicated by the color red (i.e., biovolume = 100%). If aquatic plant length for a collection of pings is less than 5% on average, then this is within the margin of detection error and biovolume is set to zero (blue). Green and yellow map colors represent intermediate subsurface vegetation growth. If the signal does not meet certain minimum requirements (e.g., too shallow or fast), a map output will not be produced and no data will be highlighted in the attribute table for the layer of interest (often the case if users travel for long periods of depths < 2.4 ft; Figure 11).

Aquatic Vegetation Mapping
Along Transects
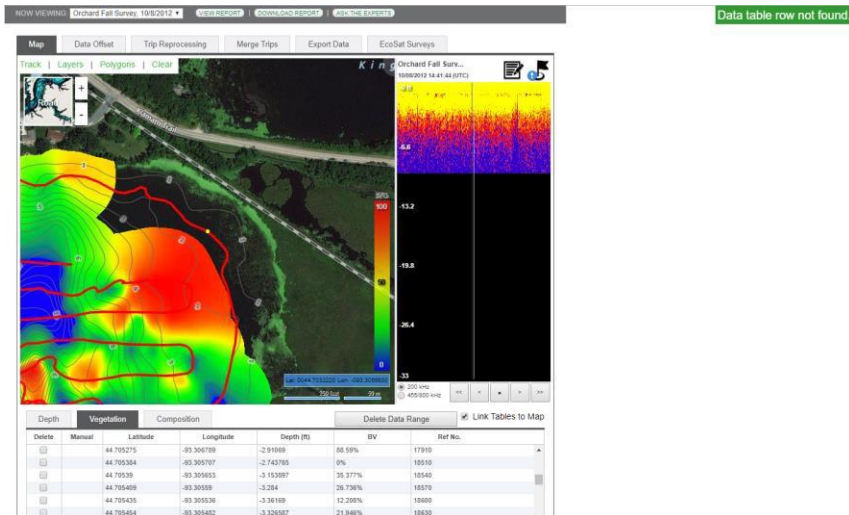
Figure 11. Example of blanked output along tracks where data do not meet minimum detection requirements (too shallow). If the user clicks on the vegetation tab, they will not see any data highlighted (notice error in upper right of the screenshot) in the location of the orange dot because coordinate data does not exist in that location (although interpolated map results may "bleed" into these areas).

Users may choose to collect aquatic plant biovolume data along predetermined transects (Figure 12). The resultant vegetation biovolume heat map is visually informative but based mostly on extrapolation. Therefore, users should use the resultant grid data with caution. Rather the coordinate point data along the track/transect and summarized in automated reports are likely more robust if the user traveled at a consistent speed along the entire transect. The transect application is popular on large lakes where

complete area coverage is not feasible or passively logging sonar data while collecting other data (e.g. vegetation sampling).
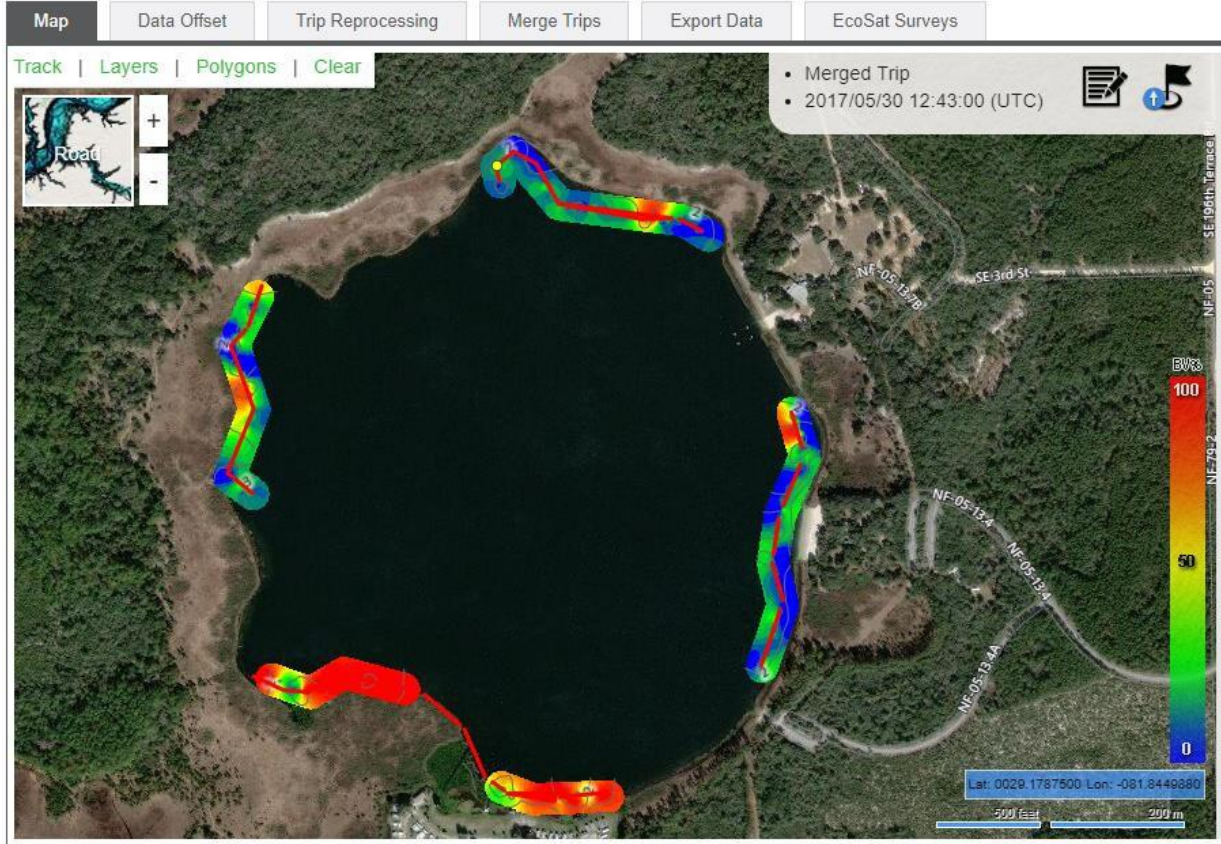

Figure 12. Vegetation mapping along pre-determined transects. The heat map from these surveys is visually informative but is largely data extrapolation. Provided consistent spacing of data points along the transect, users should use point data (not grid) for their data summaries and analysis.

Full Coverage Aquatic Vegetation Mapping

Full coverage mapping in specific survey areas or whole lakes/bays is the most conventional application with EcoSound. EcoSound is scalable to users' objectives. If you need a full lake map for a very large lake, you can travel relatively fast with wide spaced transects and use a large buffer. This will give you a high-level overview of your area of interest. If you have local-scale questions, you can drive slow over narrowly spaced transects and select a narrow buffer. Both designs will generate robust grid statistics at the appropriate scale but users should exercise caution when using data collected at a coarse level to answer local scale questions (e.g., inferring invasive aquatic plant abundance in front of a property from a map with 300-m spaced transects that weren't close to the property of interest).

Contrary to Transect Mapping, users should generally use the grid data and statistics for analysis and summaries because data dispersion along full coverage surveys is often unbalanced and statistics could

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be biased. For instance, if you idled in surface growing plants while sampling aquatic plants but traveled quickly over barren areas while logging, your coverage and biovolume statistics will be biased high.

Adding Manual Vegetation Coordinates in Unmapped Areas

Sometimes, users may encounter large areas that are less than 2.4 feet deep or where the vegetation is too dense to navigate a traditional prop powered outboard. In those situations, users can add manual biovolume coordinates to regular or merged trips by right clicking on the area of interest in the interactive viewer and adding in a desired biovolume quantity (Figure 13). Users must reprocess the vegetation and standard reports for the data to become fully integrated and mapped. By default, a 25-m buffer will be applied to manual vegetation coordinates and users will have to add enough to "fill in" areas of concern. Manual biovolume inputs should be added as whole number between 0 and 100. Once all manual changes have been entered, reprocess the vegetation and standard report. The kriging model and reports will be re-run with the manual data incorporated. NOTE: if there were errors in the automated vegetation detection, users must first delete the erroneous coordinates (see the Data Verification and Editing section), then add the manual coordinates, then reprocess the veg map layer and standard report.
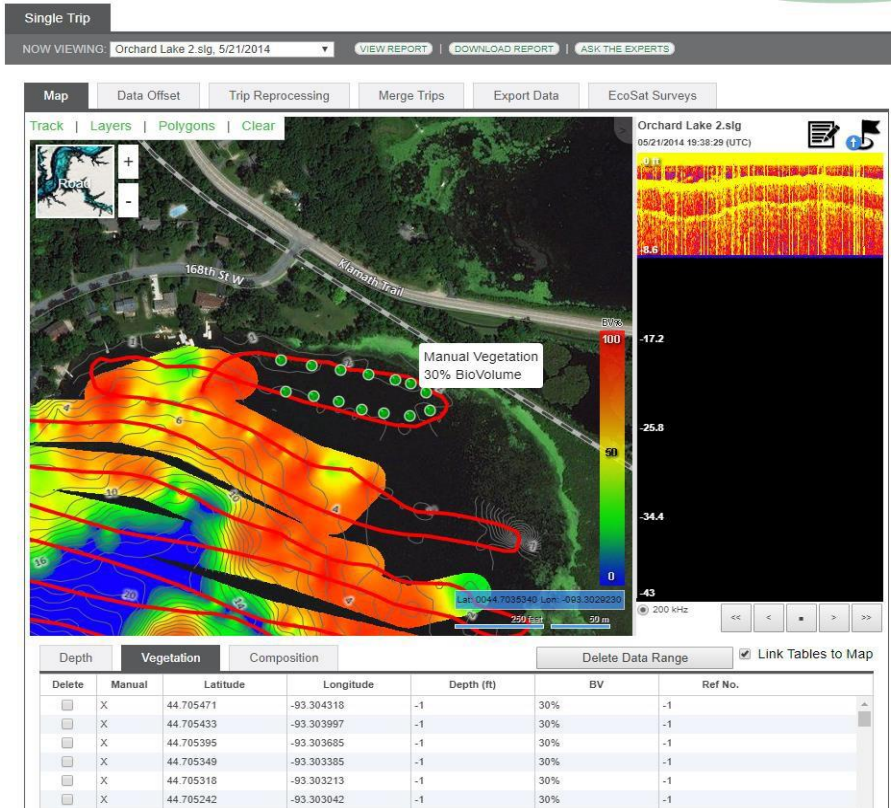
Figure 13. Map demonstrating the manual vegetation coordinate feature. Users can right-click on shallow areas or other areas not mapped and add estimated percent biovolume values. When the vegetation map and standard report are reprocessed, the points will be incorporated into the map and summary reports.

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Bottom Hardness (Composition)

EcoSound also analyzes the acoustic 'reflectivity' of bottoms and creates a bottom hardness map simultaneously along with bathymetry and vegetation layers. The hardness data generated is on a relative but continuous scale that ranges from 0 – 0.25 (soft), 0.25 – 0.4 (medium) to 0.4 – 0.5 (hard). Soft bottoms include muck or loose silt or sand. Hard bottoms are compacted sand, gravel, and rock (see below). Like vegetation, hardness typing is more difficult on steep slopes than relatively flat bottoms. Confidence in bottom hardness classifications increases if users travel parallel along steeply sloping areas. Often bottom hardness is patchy, and the best maps are generated when users slow their mapping speed when encountering hard-looking areas on their SONAR screen and do multiple passes in multiple directions to clearly delineate the edges of rock outcroppings, deltas, or mucky depressions (Figure 14). Bottom hardness data will not be generated in areas where vegetation biovolume exceeds 60%.
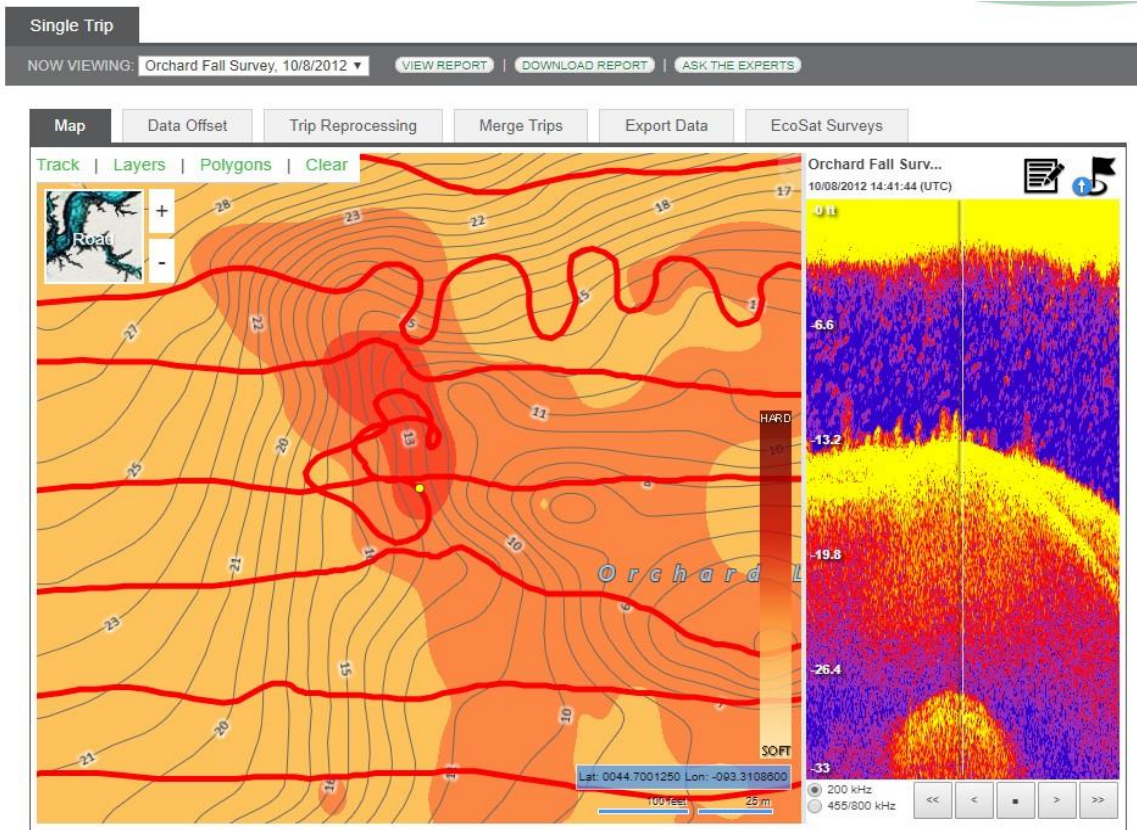
Figure 14. Patch of hard bottom surrounded by softer overlying muck. Notice the double echo near the bottom of the sonar chart on the right. The red dot on the left represents location of the sonar recording on the right. Further, notice the more concentrated GPS trip path over the hard bottom features.

Trip Replay

Data processed by BioBase servers is provided back to the user in his or her account. The map is matched with the trip path and the precise area on the sonar log where the data were derived. Thus

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maps are not "black box" outputs whereby the user must trust the output as is, but rather users can verify the automated outputs and edit if necessary (Figure 15).
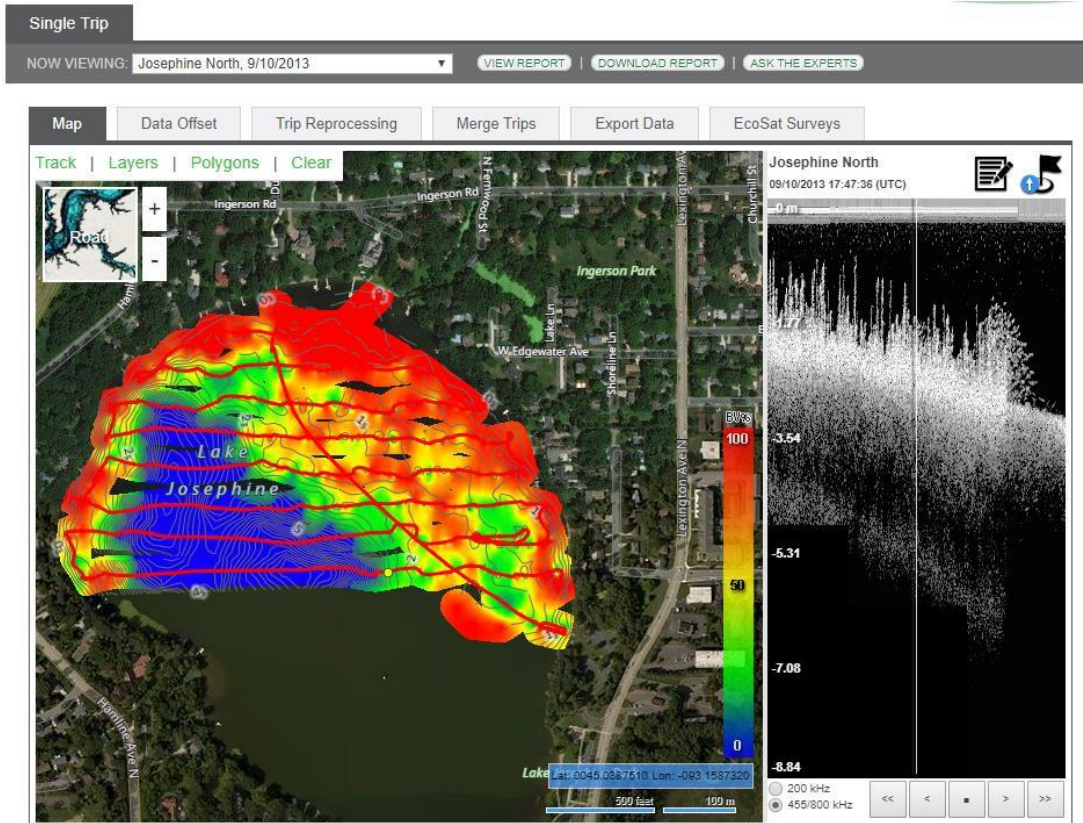

Figure 15. Example of BioBase's Trip Replay feature that sync's your GPS track data, processed map output, and regenerated sonar log imagery. This allows users to verify map outputs and edit if necessary. Notice the high detail of plant images and fish targets at the edge of the vegetation bed displayed with DownScan.

Leveraging StructureScan Imagery

StructureScan is an optional add-on transducer available for many Lowrance™ fishfinder/chartplotter units. StructureScan employs a 180-degree view of bottom environments with two available frequencies 455 khz and 800 khz. Two channels are viewable and recordable on HDS units: A side looking view and a down looking view. If EcoSound users select "Log All Channels" from their recording screen, all views (including the traditional broadband channel) are logged to the .sl2 file format and can be uploaded to BioBase (NOTE: files with StructureScan are much larger than 200 kHz broadband-only files and will require larger capacity SD cards when logging large volumes of data. Due to their size, StructureScan files will take longer to upload but carry much more information and detail about bottom features than the 200 kHz frequency alone.)

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In the current version of EcoSound, only the DownScan signal is analyzed for depth agreement with the traditional signal and available for playback in the Trip Replay. DownScan uses a very narrow beam angle of 1.1 degrees to focus the energy of the wider StructureScan signal to better resolve features directly below the transducer. If users drive a slow trolling speed (< 4mph), very high-resolution images of plants can be generated and allow cover-typing of vegetation given ground-truth samples (Figure 15). To use EcoSound to cover-type, see the section on Waypoint Upload Tool below.

Data Verification and Editing

The "Map" tab allows you to view the data associated with a point on the traveled boat path in the map viewer. To view/edit data associated with a trip, users must first load the data from the BioBase database (click on the desired layer tab to initiate load – load times will depend on file size and internet speed, Figure 16). Clicking on a spot on the map highlights the coordinate in the table and vice versa. Tables can be cross-walked with the map by examining the "Ref. No." which tells the user where they are in the Sonar Log and is a close representation to the ping number in the .sl2 file. Users can walk through each coordinate by clicking on a table row and see the sonar log move in sequence or vice-versa.
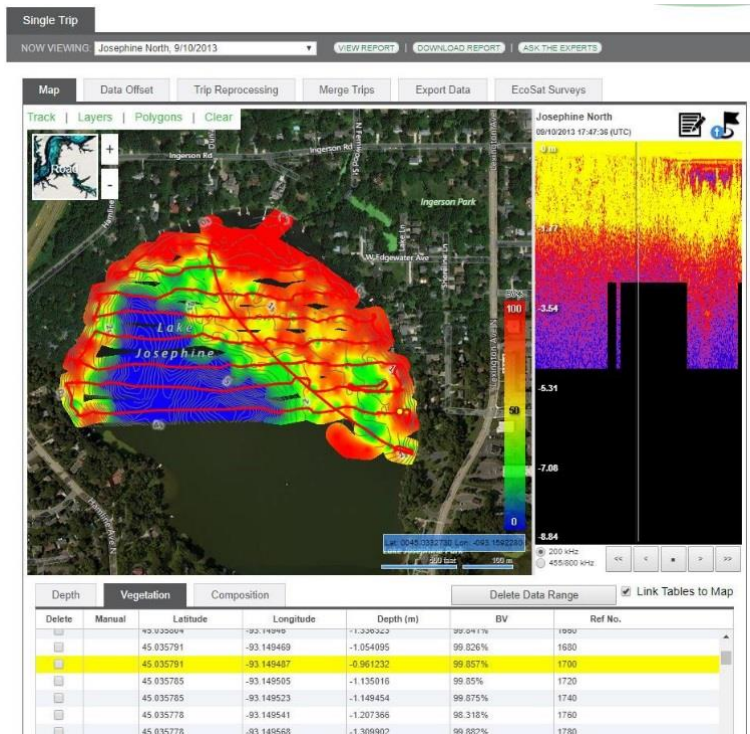
Figure 16. To begin verifying and editing load the data for the map layers in need of editing. Vegetation map layer and data are shown in the figure.

If users need to delete a large range of data, they can use the "Delete Data Range" tab within the table of interest (Figure 17). This must be repeated for all three layers if the user desires to delete all data

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from all three layers. If the user would like to delete only small ranges of data, they can do so by clicking
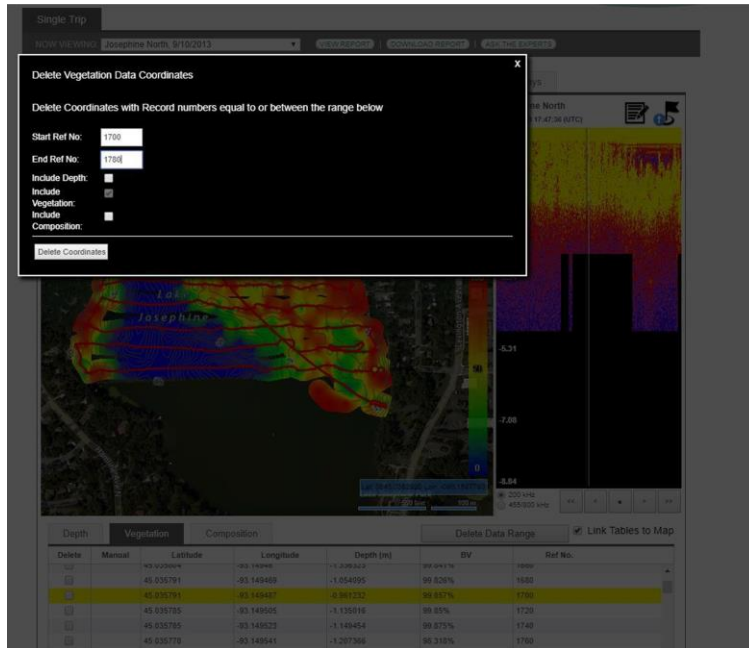
on the check box on the left of the table and selecting "Delete"

Figure 17. Bulk delete tool in EcoSound that allows users to delete ranges of data for each map layer. In this example approximately 100 pings are deleted which translated to 5 data points. After deletion, the layer must be reprocessed for changes to be incorporated into the map and report.

If no rows are highlighted in the Data tab where you have placed the orange dot along the track, this means that data did not meet quality control tests and no data points exist for that location. If coordinate data points do not exist in small areas with no data (EcoSound blanks large areas of no data), then those values are interpolated or extrapolated from neighboring points but only out to the set buffer. If no data persists beyond this buffer, no map output is created (although the track will still be mapped).

Delete	Manual	Latitude	Longitude	Depth	BV	Ref No.
☐		45.03574	-93.150109	4.92	58.157%	2700
☐		45.03574	-93.150118	4.78	32.215%	2720
☐		45.03574	-93.150136	5.54	0%	2740
☐		45.035746	-93.150145	5.52	0%	2760
☐		45.035746	-93.150154	5.46	26.663%	2780
☐		45.035746	-93.150163	5.11	37.445%	2800
☐		45.035753	-93.150181	4.92	25.899%	2820
☐		45.035753	-93.15019	5.18	24.487%	2840
☐		45.035759	-93.150217	4.98	18.048%	2880
☐		45.035759	-93.150235	5.22	29.627%	2900
☐		45.035759	-93.150244	5.56	35.477%	2920
☐		45.035759	-93.150262	5.66	92.068%	2940
☐		45.035765	-93.150271	5.7	75.056%	2960
☐		45.035765	-93.150289	5.75	22.586%	2980
☐		45.035765	-93.150298	5.8	6.929%	3000
☐		45.035772	-93.150316	5.7	13.477%	3020
☐		45.035772	-93.150325	5.4	29.886%	3040

(Tabs: Depth | Vegetation | Composition | Delete Data Range | ☑ Link Tables to Map)

Figure 18. Data tab for vegetation biovolumes from EcoSound where BV is the percent of the water column occupied by vegetation. Biovolume represents the average length of the plant signals in a GPS coordinate point standardized to the average depth declaration for the same set of pings and multiplied by 100 to express as a percent. To get point specific plant heights multiply biovolume (expressed as a proportion) by the depth.

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Waypoint Upload Tool

Manual GPS marked waypoints or a batch survey points can be bulk uploaded to any EcoSound trip through the trip viewer or added to the map by right clicking on the spot of interest and selecting "Add Waypoint." Alternatively, users can upload up to 1,000 points of interest (Figure 19) as a .csv file with the following requirements:

Uploaded layers must have at least 4 data columns but no more than 8 data columns. Prerequisite data columns must be labeled: "Latitude," "Longitude," "ID," and "Date" in the format of mm/dd/yyyy. Up to 4 data columns (text or numerical) may be uploaded as well. If you wish to upload data from a single file with more than 8 columns/attributes, then the data must be parsed into separate files, saved as .csv "layers", and uploaded separately. The Waypoint Upload tool is designed to be simple and waypoint data should be cleansed by the user prior to uploading (e.g. removing/changing any blank cells).
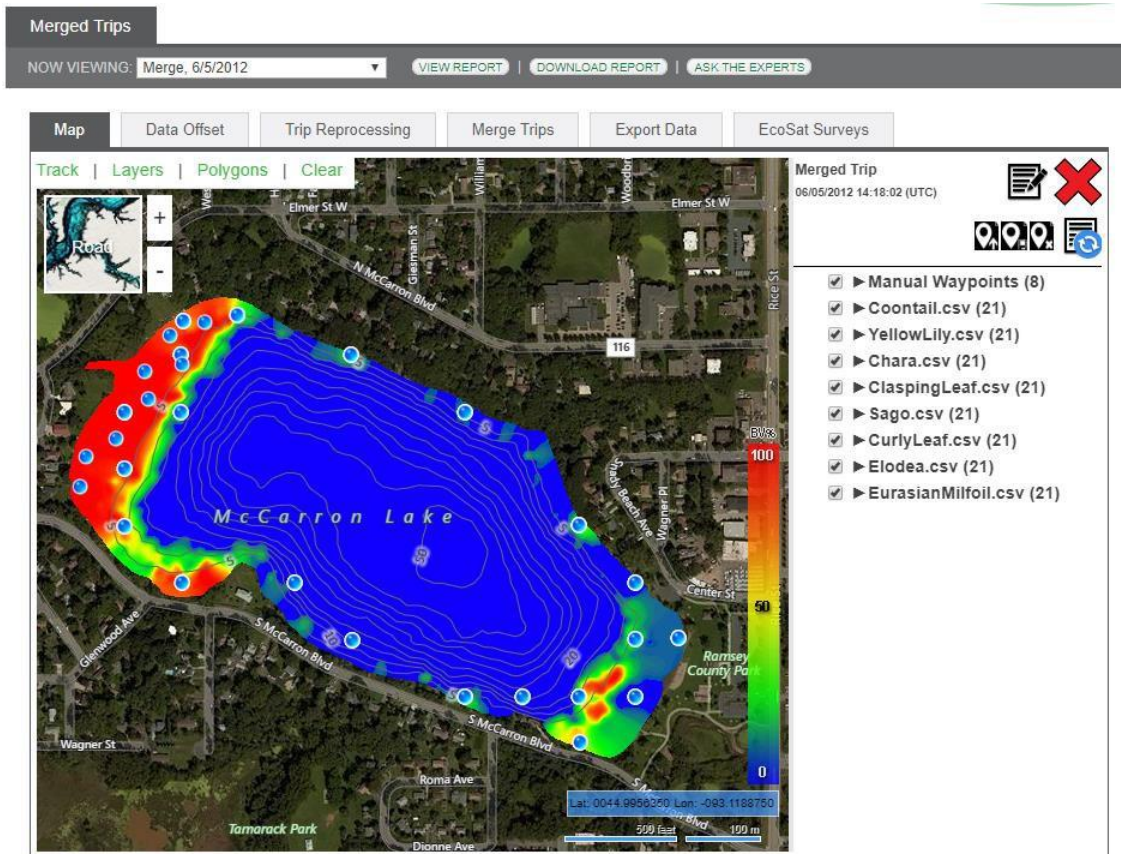
Figure 19. Example of waypoint upload tool that allows users to upload up to 1,000 waypoints and up to 8 data columns per file (no limit on file or "layers" uploads). Files must be in comma-delimited .csv format.

To incorporate points into automated reports, click the reprocess icon on the right hand side of the trip viewer. Each layer will be incorporated into the report as a collapsible view where it can be shared via a

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link. Collaborators can highlight layer data and paste it into a spreadsheet and thus obtain the waypoint layer data in a form that is analysis friendly.

Manual Depth Offsets

Bathymetric and biovolume outputs can be adjusted to defined depths. These adjustments may vary from offsetting outputs to the depth of the transducer or to adjust outputs to a standard or simulated water elevation. For example, some users may want to set outputs to a standard ordinary high-water mark or pool elevation. Establishing a benchmark water elevation and applying the appropriate offsets to trips prior to merging is critical for trips that span time periods where water elevation has changed significantly.

Positive offsets will uniformly make depths deeper, while negative offsets will make depths shallower. Simply add offsets to account for both the transducer and water elevation (e.g., if your benchmark elevation is 1 ft lower than the depth on the trip date, but your transducer is 1 ft below the surface, then these values cancel each other out and no offset is needed). In the automated reports and polygon tool calculation, depth values now on land will receive a zero-depth value and thus not included in water volume analyses. Note: Positive offsets will not "spill over" the banks of the shapefile boundary used in the mapping process.

Biovolume is also adjusted with offsets. For instance, biovolume will increase (i.e., the heat map will get hotter) if a negative offset is applied (or if tide offsets bring the water elevation down) because the plant length now occupies more of the water column. With a negative offset, if the water depth decreases beyond the plant height, then biovolume will be 100%. With a positive offset, Biovolume will always be less and thus be "cooler" in the biovolume heat map. For example, a one-foot positive offset will reduce a 100% biovolume reading in two feet to 66% (i.e., plant height in this case equals 2 ft and water depth now equals 3 ft). This same offset applied to a 100% biovolume reading in six feet would result in an adjusted biovolume of 86%. Consequently, this results in an arc-like pattern of maximum biovolume values in the summary reports.

Data offsets are always applied to the original data and each time a value is adjusted, the trip is queued for reprocessing. *Offsets cannot be applied to merges and must be applied to individual trips prior to being merged.*

Automated Tide Offsets

One of the biggest challenges of mapping coastal habitats is their tidal influence with depths changing harmonically based on the moon phase and other factors. Fortunately, however, widespread tide stations and large public databases of tide predictions allow for accurate and precise offsets to georeferenced and time-stamped sonar logs uploaded to EcoSound. EcoSound immediately queries the nearest tide station to your upload (up to 75 km) and adjusts your depth and seagrass or kelp biovolume to the Mean Lower Low Water (MLLW) datum every 5 minutes. Please take note that that when in a tidal estuary with a large and rapid tide there will be a lag depending on the distance from the tide

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Figure 20. Automated tide offset to Mean Lower Low Water (MLLW) combined with a transducer depth offset. In this instance, depths were decreased on average by 3.5 feet to represent the state of habitat at MLLW tide.

station and the characteristics of tide. Tidal statistics (Avg., Min, Max, Start, End) are archived in your account for each trip (Figure 20).

Merging Trips

Merging trips represents the heart of the BioBase's concept of "crowd-sourcing." That is, multiple users in an organization can contribute data to a centralized account and trip data can be merged to form a uniform output. For instance, in the case of bathymetry in a well-studied large lake, over-time, the

bathymetric map will become increasingly accurate and precise if users log data each time they are on the water cumulatively covering greater areas. If multiple users within your organization collect data within a defined time frame, data sets can be combined for a full lake view of the bathymetry and aquatic habitat.

In the merge trips tab in EcoSound, the user will see all EcoSound files uploaded to their BioBase account either from them personally or others in their organization if they have been granted access to share data (Figure 21). The user determines which files should be merged and buffer to use.

Figure 21. Merge trips dialog in EcoSound. Multiple files from single or multiple users can be combined to create a uniform map.

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The track or map buffer can be adjusted (default is 25 m) in the case where a user's tracks are spaced by more than 50 m and the user desires a complete, non-blanked map. Any increase in the buffer will also increase the grid cell size by a proportional amount such that the resultant map becomes more smoothed or generalized with increases in buffer distance

To ensure the highest level of accuracy of merged data, BioBase users must ensure that all individual trips have been reviewed and quality verified with the sonar log and the proper offsets applied entering a merge to account for differences in transducer depths among data loggers and changing water levels.

In the BioBase database, merged trips reference the individual trips and any edits to individual trips will be reflected in the merged trips and vice versa. However, manually reprocessing both trips is required to update the data and imagery. Where possible, editing should take place on the individual trips so that the sonar log imagery can be used to verify edits (sonar log imagery is not produced for merged trips).

Data Reprocessing

After reviewing the initially processed data, there may be certain circumstances where a user will desire to reprocess a modified data set. Data modifications may include the removal of depth or vegetation data, the addition of manual vegetation biovolume data, access to newly released features such as automated report revisions, or updating a merged trip if edits are done on a component trip.

The track or map buffer can be adjusted (default is 25 m) in the case where a user's tracks are spaced by more than 50 m and the user desires a complete, non-blanked map. Any increase in the buffer will also increase the grid cell size by a proportional amount such that the resultant map becomes more smoothed or generalized with increases in buffer distance.

The reprocessing via the user interface does not reread the sonar log file, but rather reprocesses the processed values from the sonar log that are stored in the database, including those values that may have been removed, modified or added. The user can queue up an individual trip and will be notified via email when the reprocess job has completed. The time required to reprocess the data is substantially shorted than the initial process; however, processing times vary greatly based on trip size, waterbody size and multiple other factors. Applying new features such as bottom hardness or algorithm updates to files already in the system sometimes require a complete reprocessing of the .sl2 file. Contact the BioBase support team (info.biobase@navico.com) if you wish to have any of your trips reprocessed from scratch to get new features.

GIS Polygon Tool

EcoSound's polygon tool allows users to trace areas of interest on the map and generate statistics such as area, water volume, maximum and mean depth, percent cover of SAV, average biovolume, and with the appropriate subscription-level, generate aquatic herbicide prescriptions (Figure 22). Polygons are

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stored by waterbody and are the same polygon can be applied to multiple trips and accessible to all users in an organization. However, only polygon owners can delete polygons. To create a new polygon, click on the "New Polygon" icon, users can trace around an area of interest. By clicking "Close Polygon and Adjust" (wrench icon) after the first trace of the polygon, users can further fine tune the polygon border. Once finished, users can name and save the polygon by clicking on the "floppy disk" (older generations will remember those computing relics) icon to finalize edits and calculate polygon-area statistics. Polygon-area statistics are based on kriging-interpolated raster grid values. Once a polygon is saved, it cannot be edited. To see statistics, users should click on the check box to the left of the polygon name. To delete polygons, users should click on the drop-down menu and select "Delete Template".
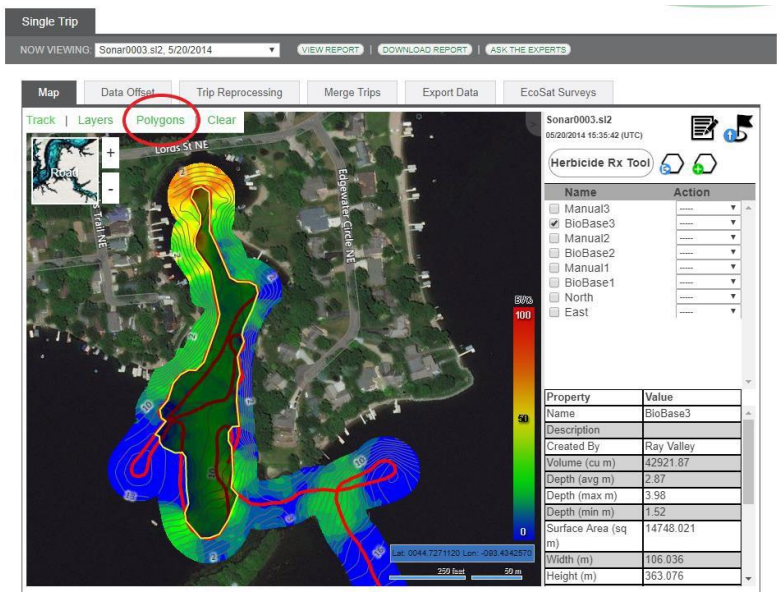

Figure 22. Use of the polygon tool around a hypothetical area targeted for treatment with aquatic herbicides. Care was taken not to include extrapolated areas outside of the track because submersed vegetation growth between the boat track (red line) and shore was not verified by the data collector. Areas statistics for the polygon area are shown on the below right These statistics are added as attribute fields in an exported polygon available for upload to GIS or opening in a spreadsheet (e.g., open .dbf file in MS Excel).

To apply an already-created polygon template by any user, select "Apply and Calculate" in the drop-down menu. This action will generate polygon statistics, if any map data exists within the polygon area (Figure 23). Users can export any organization polygons as shapefiles with the trip-associated statistics added as attribute fields by clicking on the export hexagon icon.
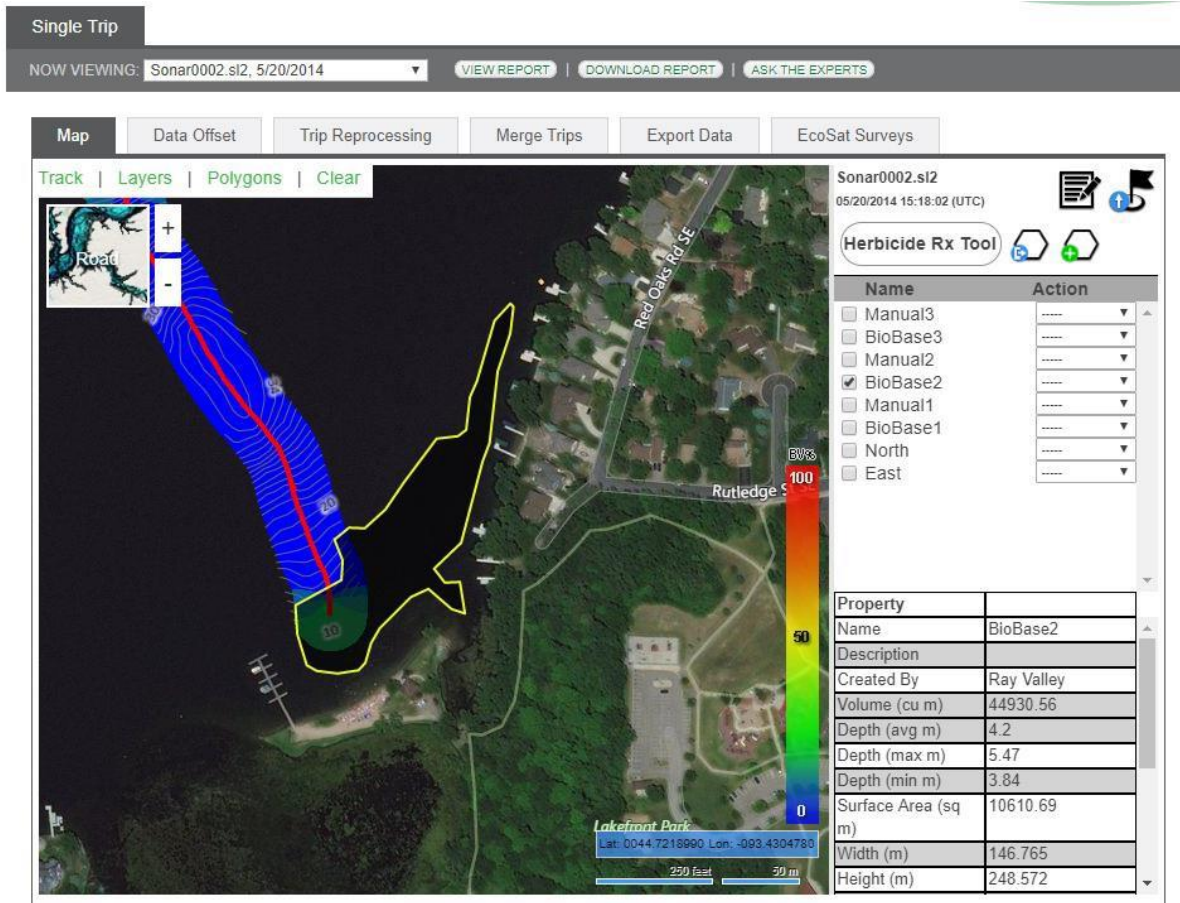
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Figure 23. Polygon statistics from an area where only a small proportion was sampled (red track). Users should interpret generated statistics in cases like these with extreme caution because statistics are based on only a very small sampled area and may not be representative of the remaining polygon area.

One of the many utilities for this tool is to highlight SAV treatment areas, calculate precise local water volumes where the acoustics sufficiently penetrated the vegetation, and establish before-after comparisons to evaluate whether local treatments are meeting desired objectives. These polygons are also available for exporting out of BioBase via a self-extracting executable file. These shapefiles can be viewed and analyzed in GIS, converted to .gpx trails and uploaded to your GPS, or the .dbf file can be opened in a spreadsheet.

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Exporting Data and Imagery

In the export tab, high resolution imagery can be exported and saved to a user's hard drive as a .png or .jpg image. Or if users prefer, they can export coordinate point or kriging grid data processed for depth, vegetation, and composition for further analysis in third-party statistical or GIS software. Exported data is provided as point-feature data files saved in a standard delimited format and in the WGS84 global coordinate standard. This allows users full control to project and convert their data into any desirable geospatial format. Point data exports the coordinate data visible in EcoSound datatables and includes all created data along a user's GPS track. Inspecting the point data in GIS will give the user advanced knowledge of data spacing, data cleansing, and data clustering.

Grid data represents the kriging grid cell node values that were produced from the point data. These data can either be converted to a raster dataset in GIS for advanced spatial analyses or map creation or be analyzed as is in GIS or a spreadsheet (e.g., each line in the grid spreadsheet represents a grid cell of a known size – default is approximately 5 m). EcoSound data are gridded in WGS84 coordinates, so grid cell sizes are not precise integers. For example, grid cells that are reported as 5-m in automated report metadata may actually be 5.2 m x 5.1 m grid cells. This might be important for generating precise custom water volume estimates from exported grid data and we recommend that users inspect their data in GIS to understand the precise data spacing.
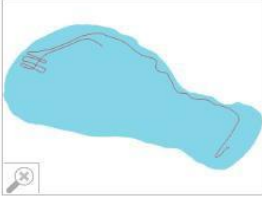
The BioBase support team provides limited support on file formats and operation of external GIS software.

EcoSound Summary Reports

Much of the details of this Operator Guide have been set to ensure accurate data collection to maximize the power of the EcoSound System as well as create a uniform collection standard across all users as part of a uniform report generation. Each file uploaded to your account is processed to include a report that is uniform across all system users (Figure 24). This helps provide a uniform output that can be compared city to city, county to county or state to state.
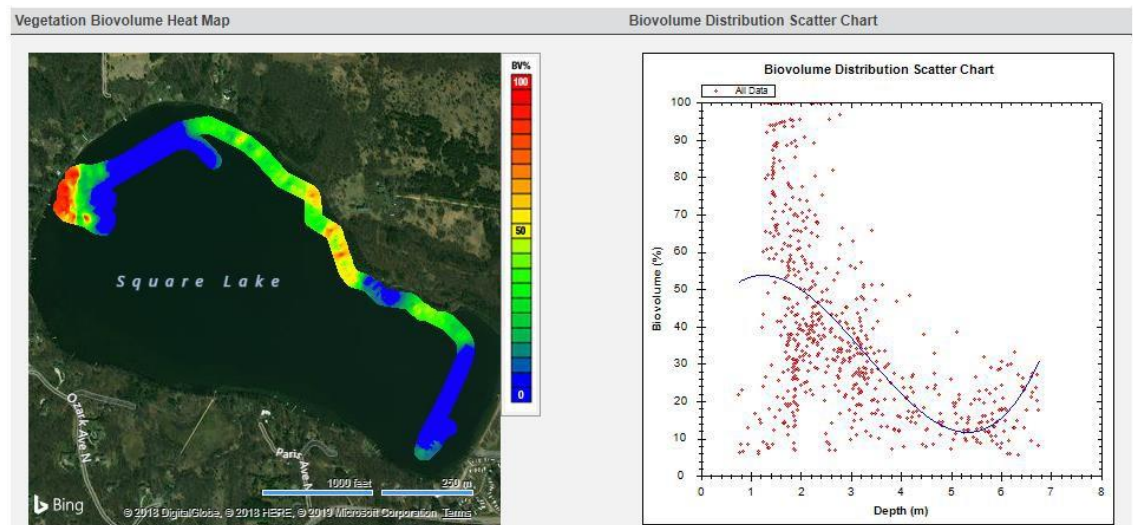
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Figure 24. Excerpt of automated vegetation reports created with every EcoSound upload. Important metadata, quality control reports and metadata are found at the top of the report.

Multiple files or "trips" logged to the same lake are considered unique "Areas of Interest" (AOI) if separated by more than 2 minutes between successive files. If files are more rapidly stopped and new ones are started, then they are all considered the same AOI. Several summary statistics are displayed for the full survey (all AOI's together) and each AOI including: Percent Area Covered (PAC) which is the percent of the coordinate points that had a vegetation signal within component pings that resulted in 5% biovolume or greater. Biovolume(plant) or BVp is the average percent biovolume of all coordinate points within a surveyed area where vegetation was present. Biovolume(water) or BVw is percent biovolume in the entire surveyed area including areas with no plants. Standard deviations are also presented which give an indication of how variable vegetation growth was within the surveyed area.

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Also, a breakdown of how biovolume is distributed throughout the waterbody is also presented. For instance, if 75% of the data points were biovolume greater than 80%, then most vegetation was dense and near the water surface. For aquatic plant and fisheries management purposes, it may be desirable to reduce the surface growth of vegetation and these reports provide a quick, objective way of determining whether management is meeting desired targets. Further, these reports present a breakdown of vegetation growth as a function of depth lending important insight into the maximum depth of vegetation growth which is an important indicator of water clarity.

Users will also see "Point" and "Grid" summary statistics. Point summaries represent basic statistical summaries on the coordinate points along the trip path. For linear transects traveled at a constant rate of speed, statistical summaries of the "point" data are preferred to the grid.

Grid summaries are statistical summaries derived from kriging and are most appropriate for whole lake surveys, irregular trip paths (e.g., merged trips), clumped coordinate data, or variation in data collection protocols of repeated surveys. Using statistical summaries from the point data are not recommended because irregular data spacing and clumping can bias statistical summaries. Kriging, by design addresses this issue.

Quality Control

Quality Control is an important component of the BioBase software service. Every upload is reviewed by trained staff to ensure the acoustic signal and outputs meet certain minimum standards. Quality Control staff will review sonar logs and communicate potential transducer installation problems for instance that the sonar signal may give away. Typically, any trip uploaded to BioBase will be reviewed by Quality Control staff within 24 business hours. To find the QC status on a trip, users should open their automated report and look in the top section to QC reviewer's comments. If a trip is deemed to have no glaring issues, the standard comment should read, "We have reviewed this trip. Please use the "ASK THE EXPERTS" button for this trip if you have any questions." Non-reviewed trips should be considered "provisional" and we recommend users wait to edit or merge their trips until our QC staffs have had a chance to review their trips. The intention of the QC review is to review and communicate issues that may affect the overall map quality. Users should still carefully inspect each uploaded trip and edit false or non-detects where needed.

BioBase Configuration Specifications

Log File Format: .slg, .sl2, .sl3

Minimum depth = 1.1 feet (0.33 m; bathymetry), 2.4 feet (0.73 m; vegetation and composition)

Maximum depth = see manufacture specification

Maximum depth of vegetation detection = the depth where 98% of all positive vegetation detections occur

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Maximum speed = 20 mph (bathymetry), 10 mph (vegetation), 10 mph (composition)

Frequency = 200 kHz

Range   =
Auto

Bytes per Sounding = 3200

Surface Clarity = Off

Noise   Rejection   =
Low

Fishing Mode = Shallow Water (for vegetation

detection) Plant Length Detection Threshold = 5% of

water depth GPS: Enable WAAS or EGNOS

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Navico, Inc. merely provides the BioBase System to process, interpret and warehouse the data and takes no responsibility of the same. Products or services offered using the BioBase System are solely created and controlled by the provider of services. Assessments and recommendations based on interpreted data is not a service offered by Navico. We leave it up to you or your consultant to make an independent assessment and/or recommendation using data from BioBase.

Any disputes shall be construed according to the laws of the State of Oklahoma, U.S.A. In the event that this agreement is breached, any and all disputes must be settled in a court of competent jurisdiction in the State of Oklahoma.

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