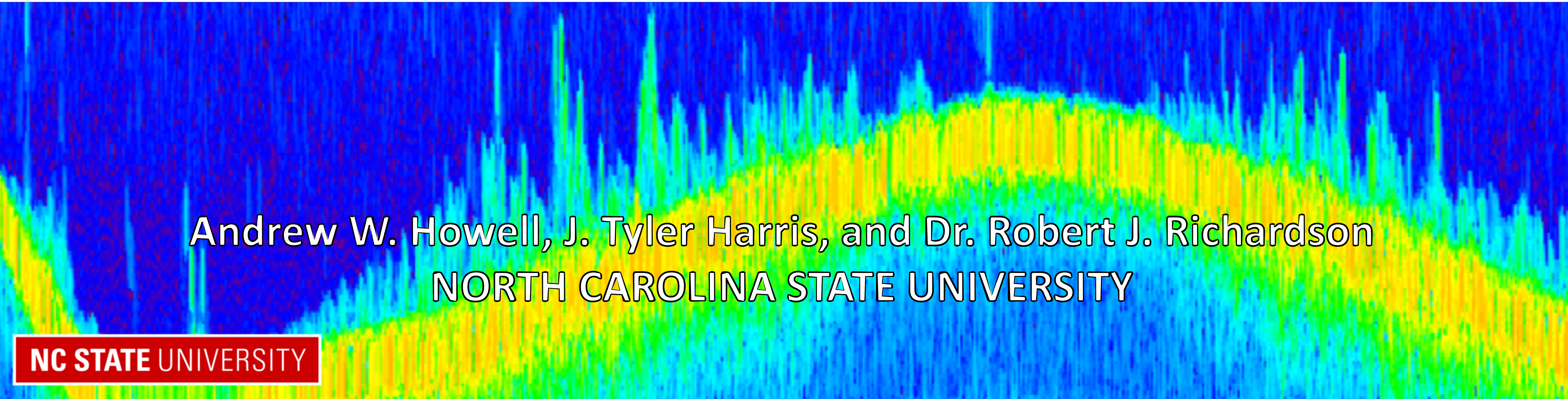
Improving *Lyngbya wollei* Surveys Using non-Destructive Echosounding Measures



Andrew W. Howell, J. Tyler Harris, and Dr. Robert J. Richardson
NORTH CAROLINA STATE UNIVERSITY

NC STATE UNIVERSITY

Lyngbya wollei

- Mat-forming, benthic cyanobacteria
- Rapid biomass development
- Difficult to manage and quantify

Single Cells

Survey Rake

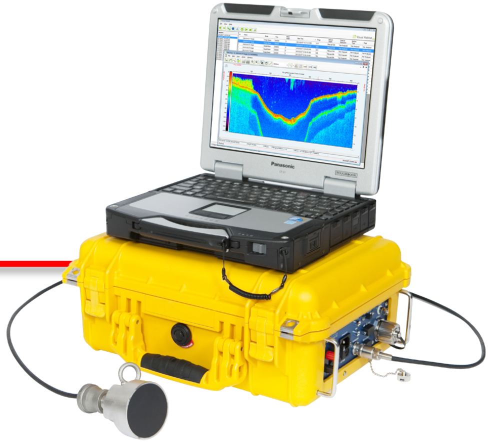
Lake Gaston, NC

Objectives for Improved Survey

Three primary goals:

1. **Provide more precise and repeatable survey option**
2. **Monitor varying herbicide treatment effects over time**
3. **Increase objectiveness of seasonal lyngbya abundance**

Echosounding Overview

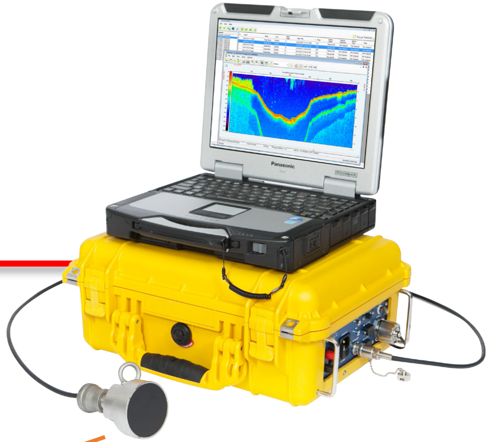


I. **Background information**
II. **Autonomous survey strategy**
III. **Echosounding measures**
IV. **Methods and examples for quantifying biomass**
V. **Management implications**

BioSonics MX Aquatic Habitat Echosounder

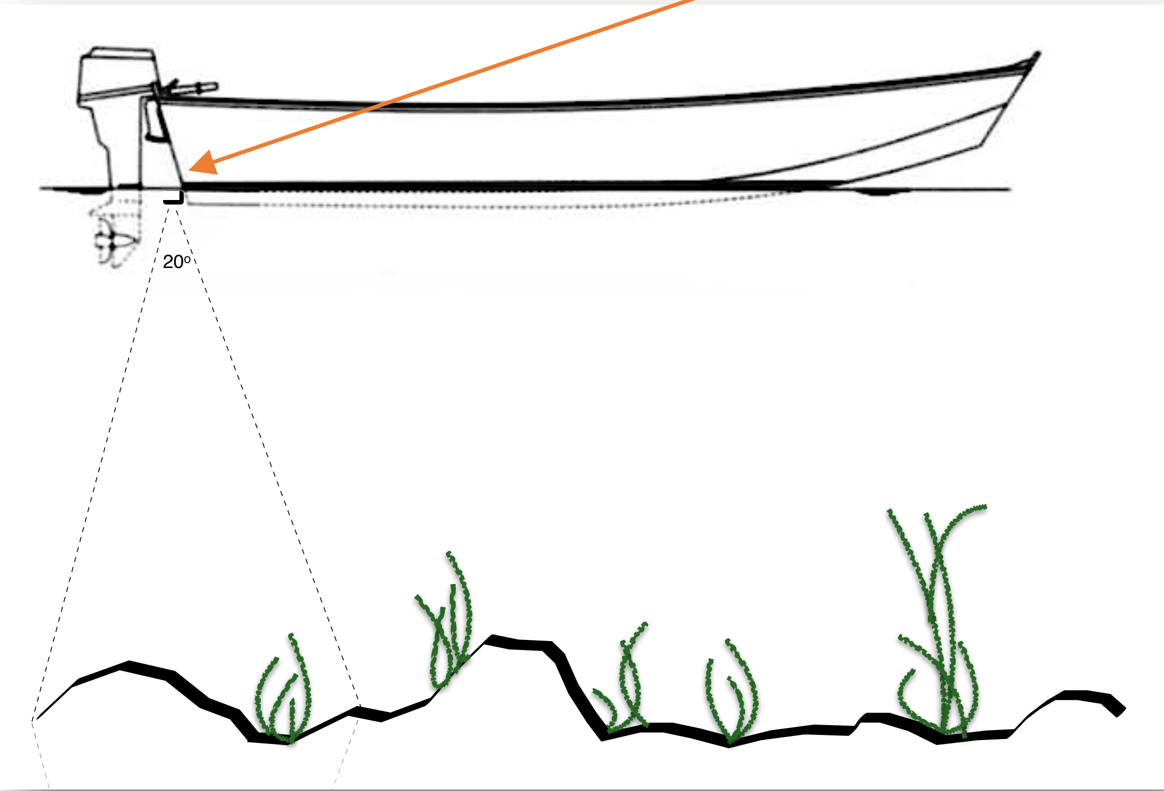
Single frequency – 204.8 kHz
Beam angle – 8.5 degree conical
Ping rate – 5 per second

What is Echosounding?



Using SONAR (echosounding) for detecting, locating, and measuring submersed objects [vegetation].

- **Active acoustic technology**
- **Sound travels through water, encounters different media densities and returns back to the original source**



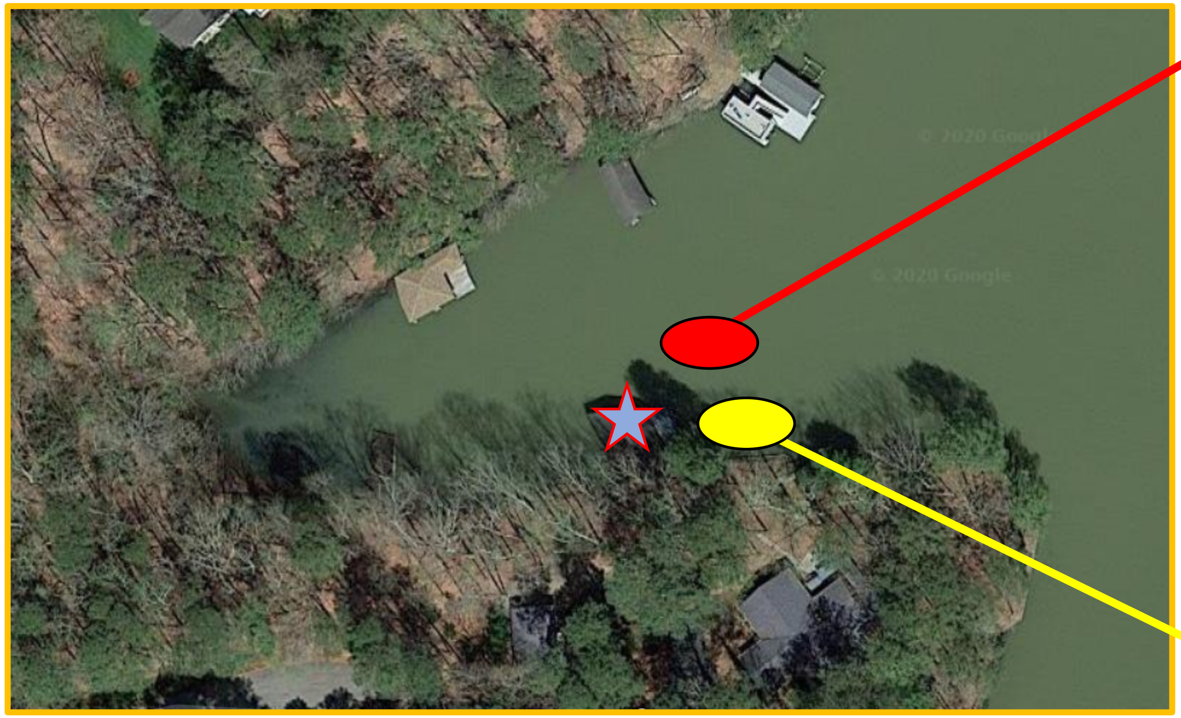
Premise for Lyngbya Management

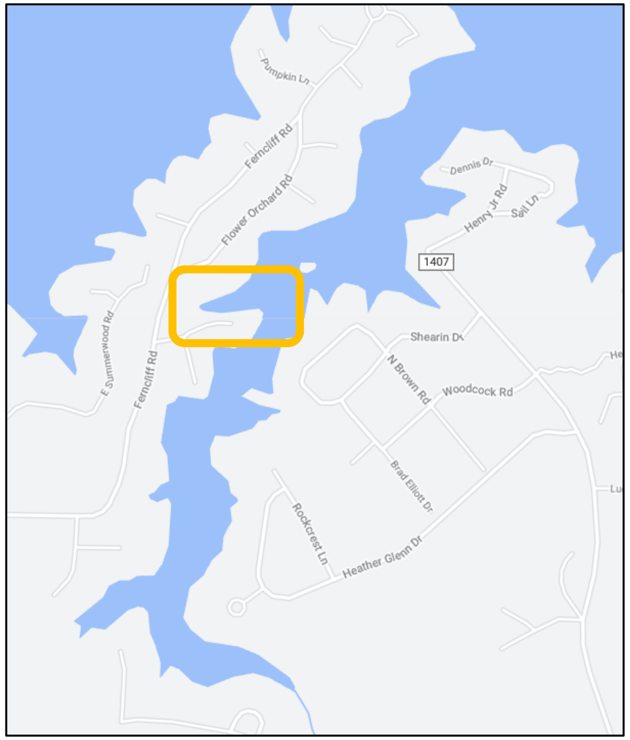
- **What's the desire for echosounding?**
- **What are some of the goals for management?**
- **Current stakeholders suggest strong need for research.**
- **EDRR: Early Detection, Rapid Response.**

Aerial Observation

Key Advantages: Resolution, Data Processing, and Repeatable as needed.

Point-Sampling Variability





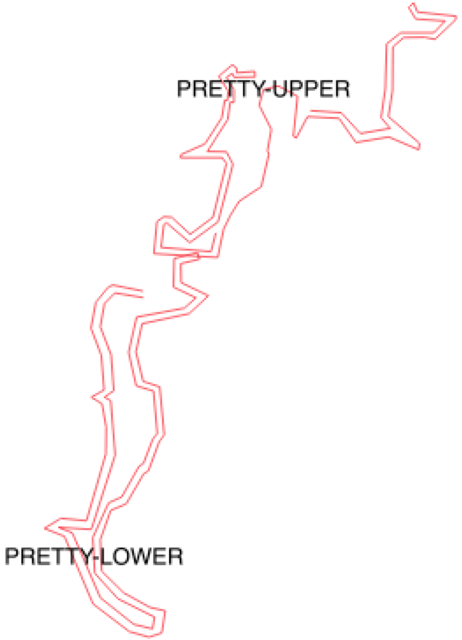
Biomass Site

Extra Rake Toss

Blue Boat House

Manned/Autonomous Survey

- 17’ aluminum V-hull vessel
- *Navigation Computer*: Lowrance Carbon HDS-7
- *Auto Steer:* MotorGuide Xi5 Trolling Motor with Sonar and Pinpoint GPS (24v system)
- *Mission Planning:* Import GPX files developed from previous tracks, GIS, or develop waypoint missions in-field
- *Vessel Speed:* 4.8 km/hr



*Cautionary Note: Transect spacing is critical... the tighter, the greater variance.

Autonomy Testing

- Shearon Harris and Jordan Reservoirs
- Provide optimal transect spacing for repeated sensing applications
- Tested vertex spacing and track length

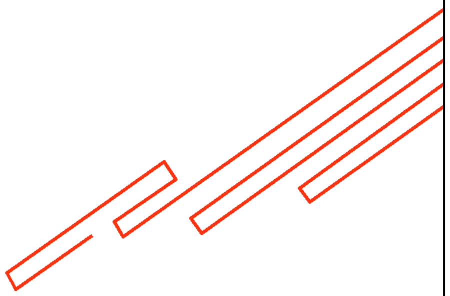
Spacings Tested: 10, 15, 20, 25, 50 meters

20 m transect spacing appropriate for our study implementation

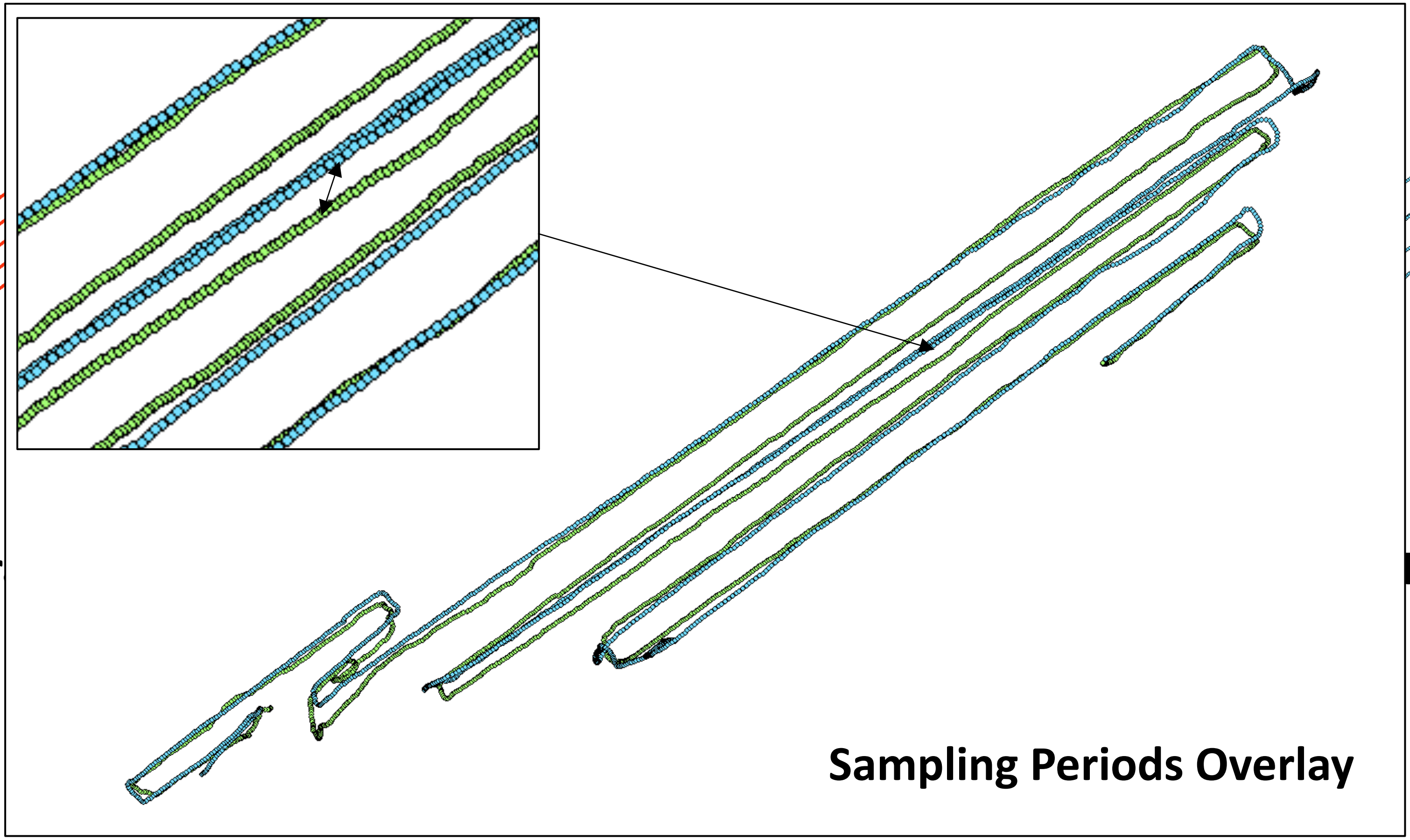
In-mission

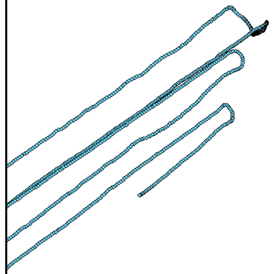
Post-mission

Autonomous Survey Example



Proposed Tr





Transect

GPS variation between sampling periods: 1-7 m

Echosounding Measures

Primary Differences Among Transducers and Processing

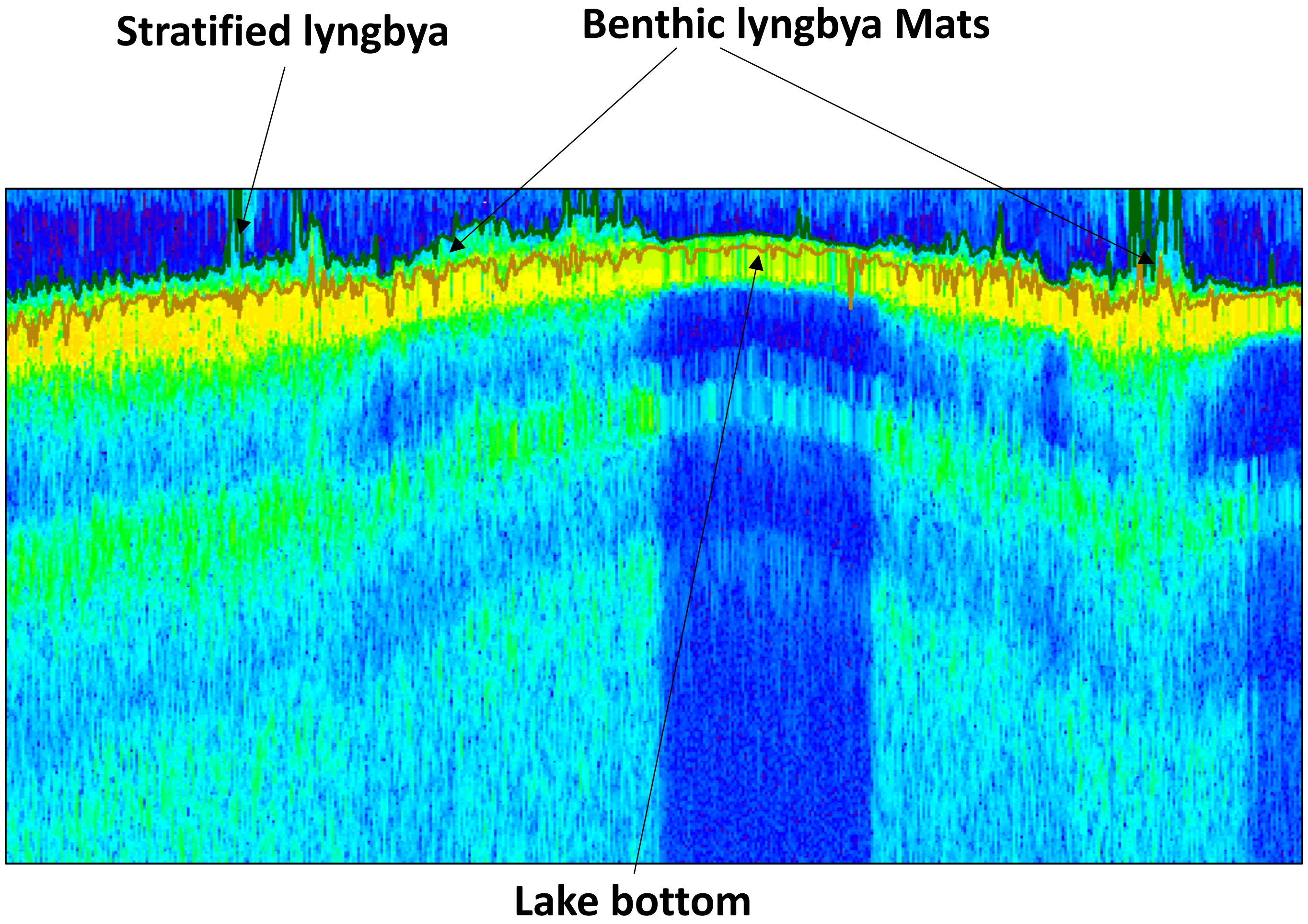
Physical Settings	Biosonics MX Transducer	Lowrance Transducer
Transducer Frequency	*204.8-kHz*	*200-kHz*
Ping Rate s^{-1}	*5*	*10-15*
Beam Angle*	*8.5^{o}*	*20^{o}*
Computer	*Toughbook Laptop*	*Most Lowrance Units*
Data Acquisition*	*Visual Acquisition*	*Internal*
Data Processing*	*Visual Habitat*	*Cloud-based (optional)*

https://www.chsmith.com.au/news/My-Beam-Angle-is-wider-than-yours.html

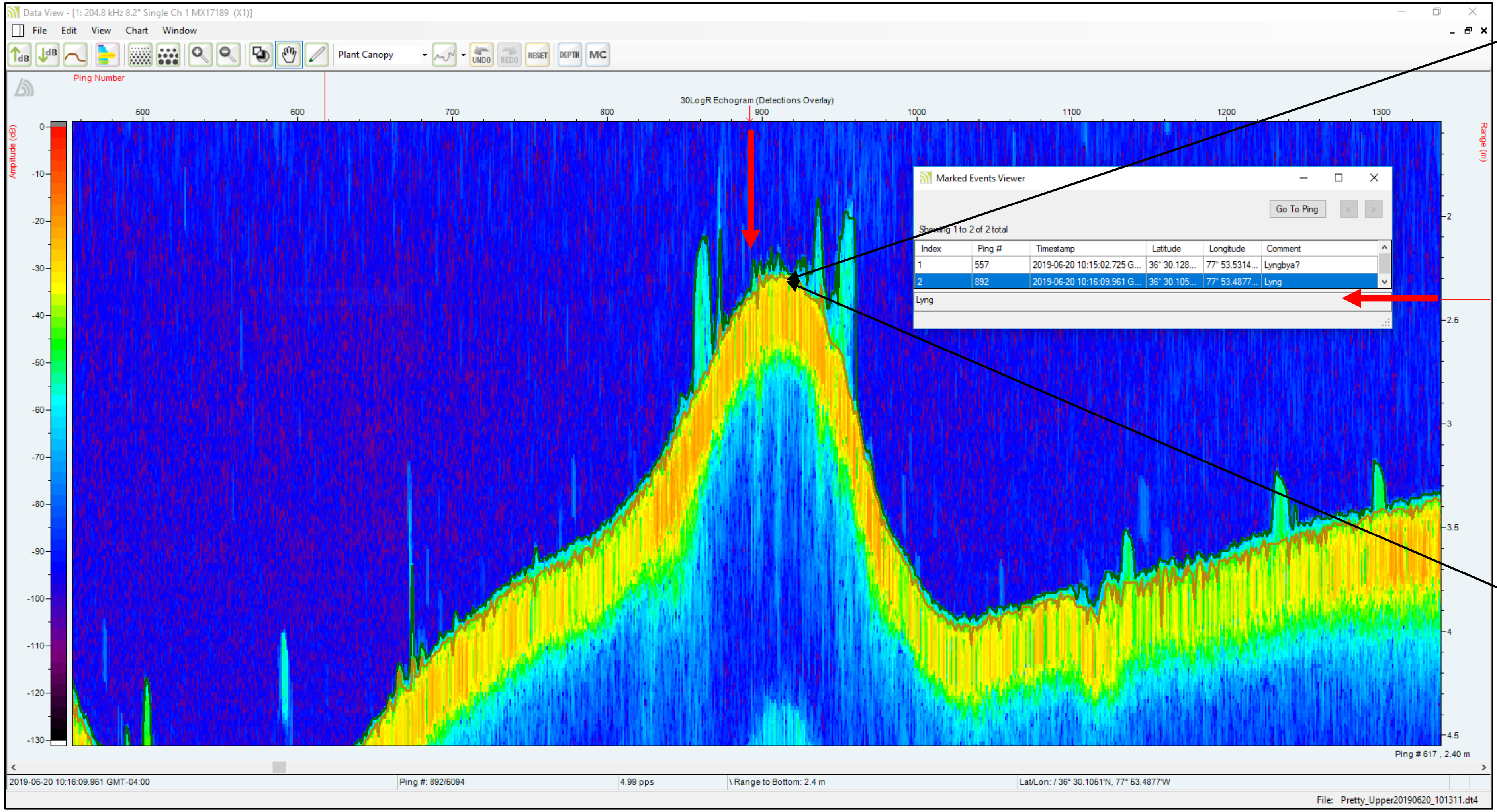
***Ability to tailor acquisition and processing settings for specific study site, environmental factors, or vegetation type.**

Echosounding Background

- Tyler Harris testing MX unit
- Shearon Harris and Lake Gaston– Summer and Fall ‘18
- Testing ability to map SAV using historical lakewide survey maps
- Vegetation recognition in regions previously documented to contain lyngbya
- Confirmed with rake-toss



Lyngbya Confirmation *in situ*



Notate observations at given waypoint or desired ping output.

Echosounding Methodology

BioSonics MX Echosounder	Biomass Sampling	Processing and Statistics

• Bottom detection
  • Rising edge threshold: -50 dB
• Plant height detection
  • Max Depth: 5 m
  • Report Plant Height: 0.1 m
  • Values <10 cm = 'No Plants'
• All other settings set at default
	• Modified Johnson and Newman Rake
	  • Hard rake on 3.5 m pole
	• 14 treatment sites
	• Four points per site
	• Two samples per point
	• Samples rinsed of detritus
	  • Fr Wt biomass recorded
		• Visual Habitat software
		• ArcGIS– IDW with fixed search
		  • Interpolation: Dependently weighted neighborhood
		  • Search Radius: 10 m
		  • Grid Cell Size: 1 m
		• R Studio
		  • Correlation measures

Sampling Timepoints (Monthly)

05-2019 → 06-2019 → 07-2019 → 08-2019 → 09-2019 → Senescence

Howell, A.W. and Richardson, R.J., 2019, *Correlation of consumer grade hydroacoustic signature to submersed plant biomass.* Aquatic Botany. 155, 45-51.

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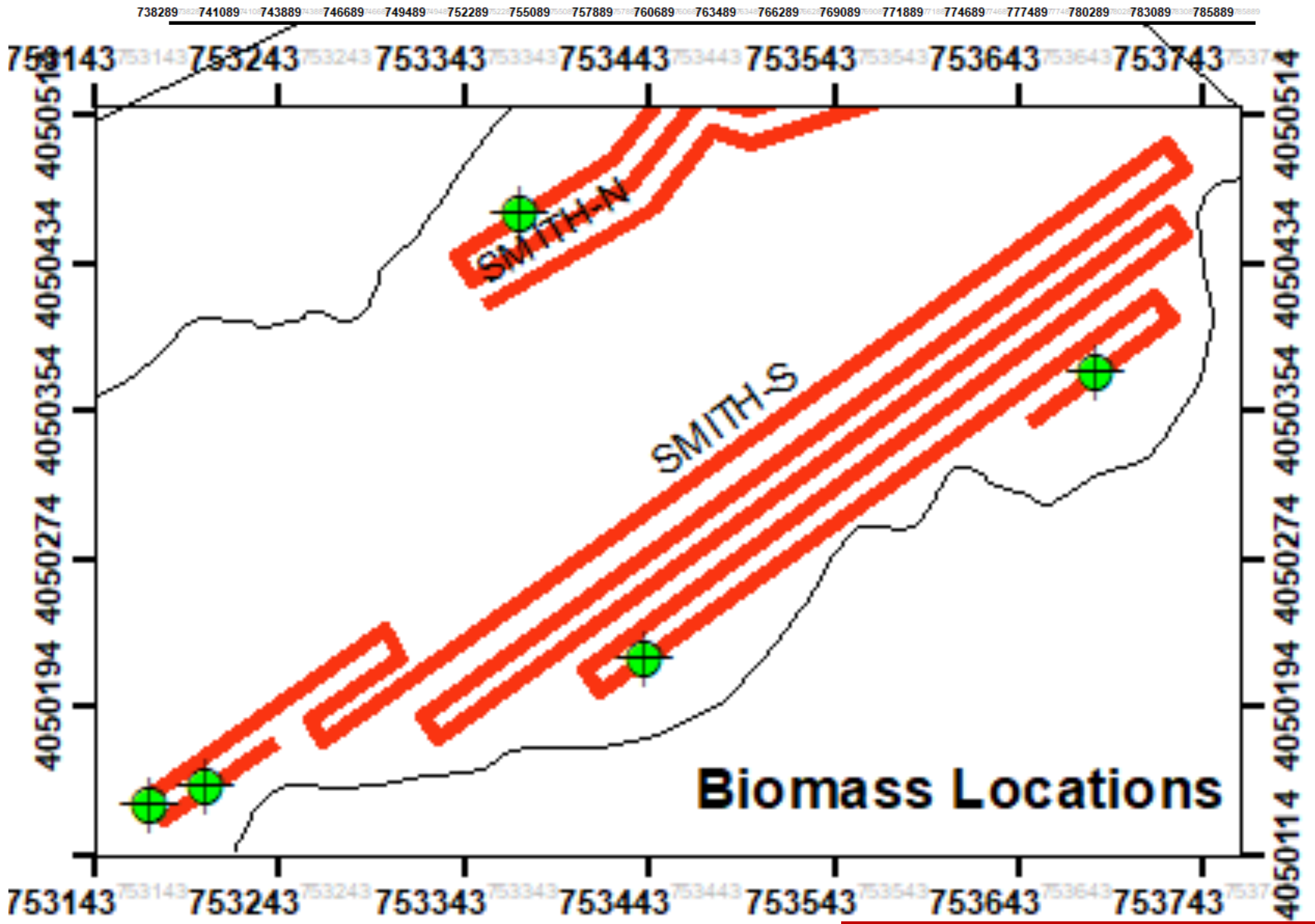
Lyngbya Sampling: 2019 Example



Smith Creek South

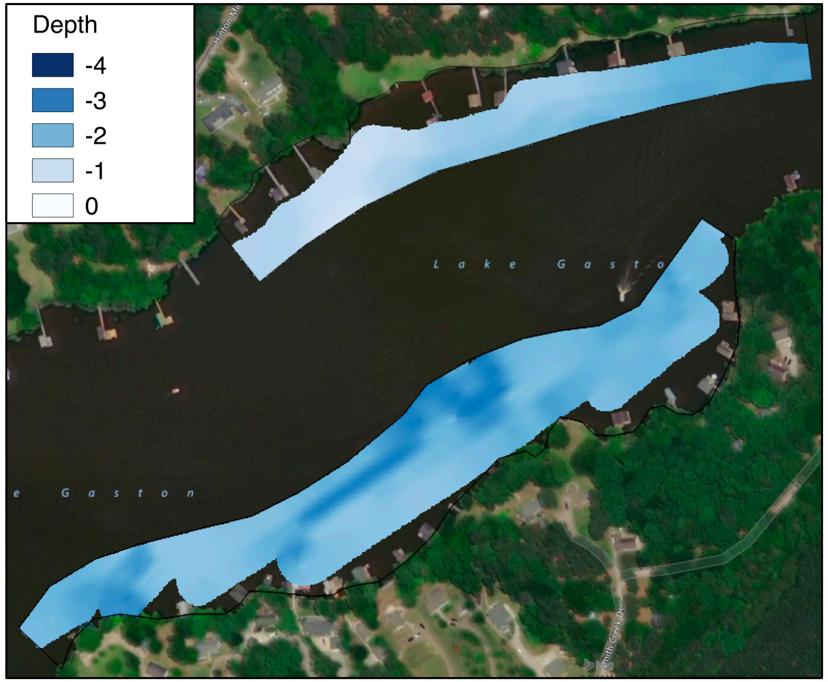
Treatment Area: ***4.86 ha/12 ac***
Route Length: ***2.83 km/1.76 M***
Route Spacing: ***20 m/ 65.6 ft***
Biomass Collected: ***Planned autonomous survey transects***

Example Findings: Depth

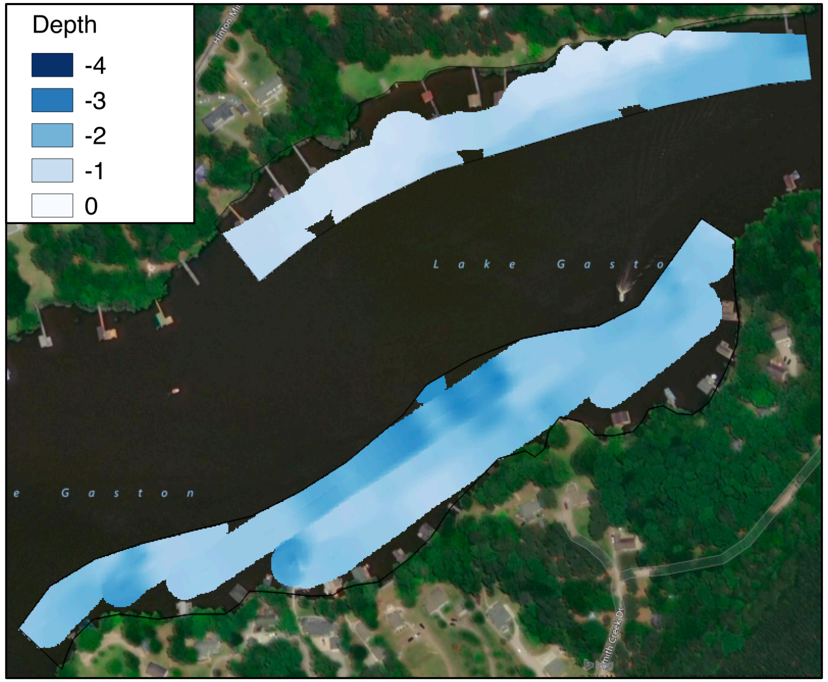
Raster comparisons

Correlation analyses

Depth Between Timepoints



Pre-treatment

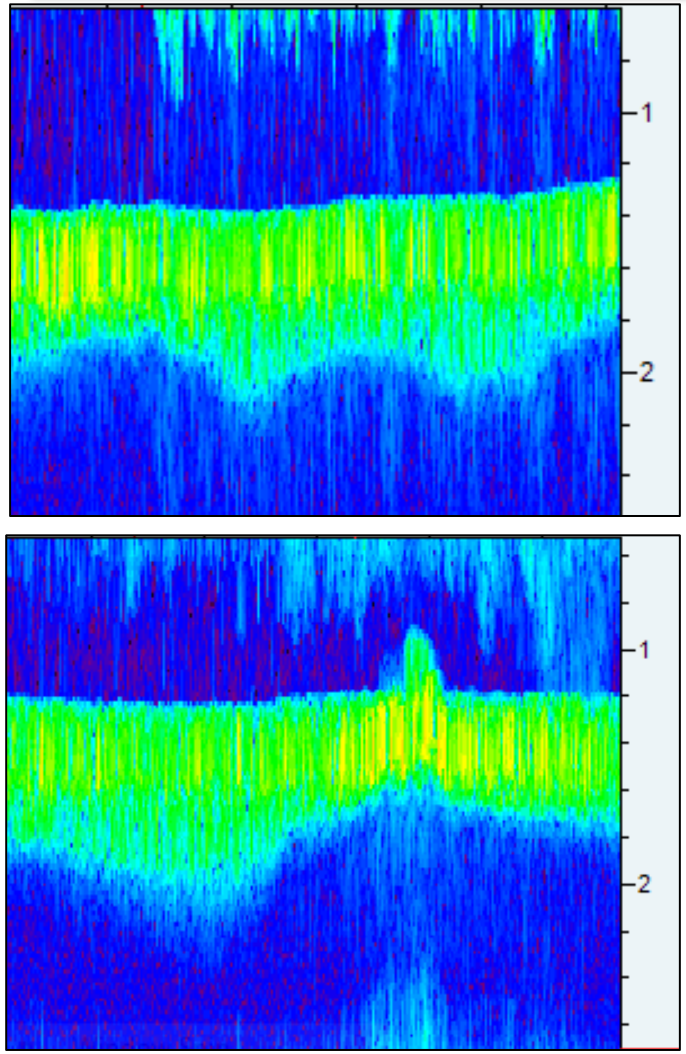


2WAT

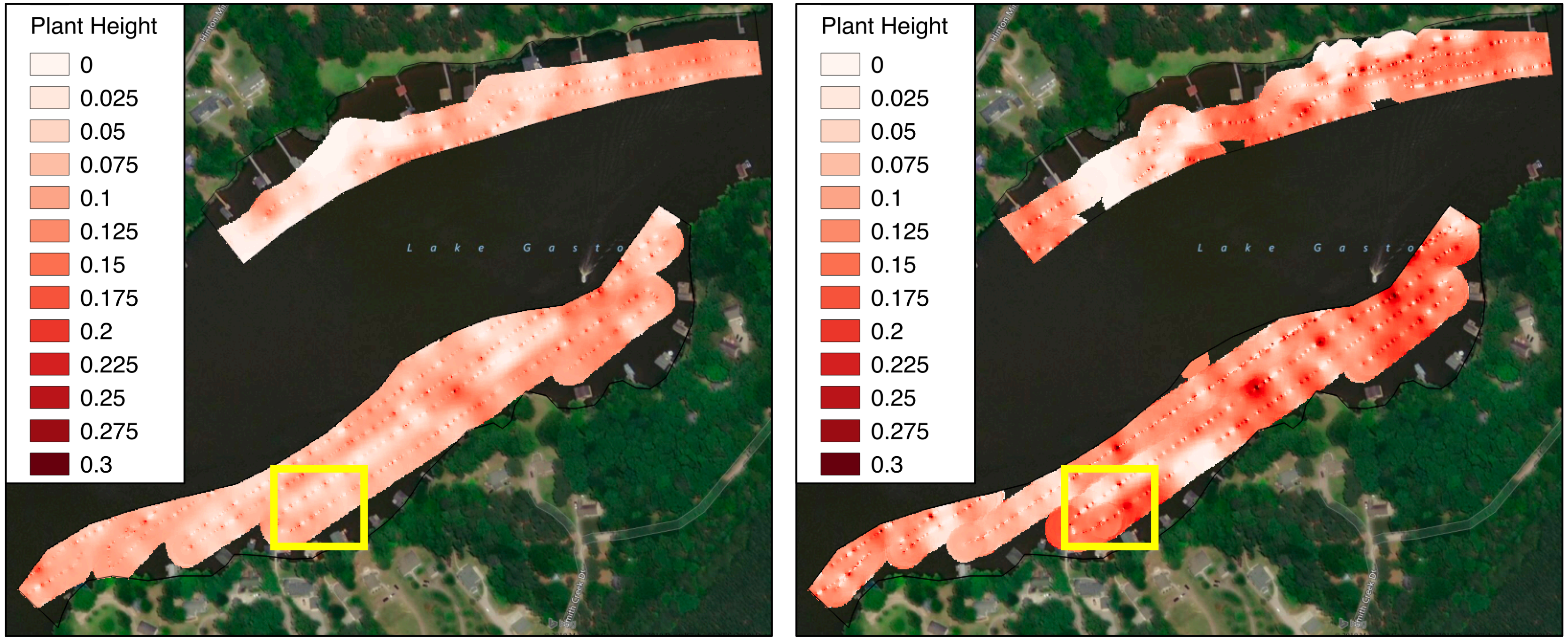
Example Findings: Height

Pre-treatment

2WAT



Lyngbya Height Between Timepoints



Pre-treatment

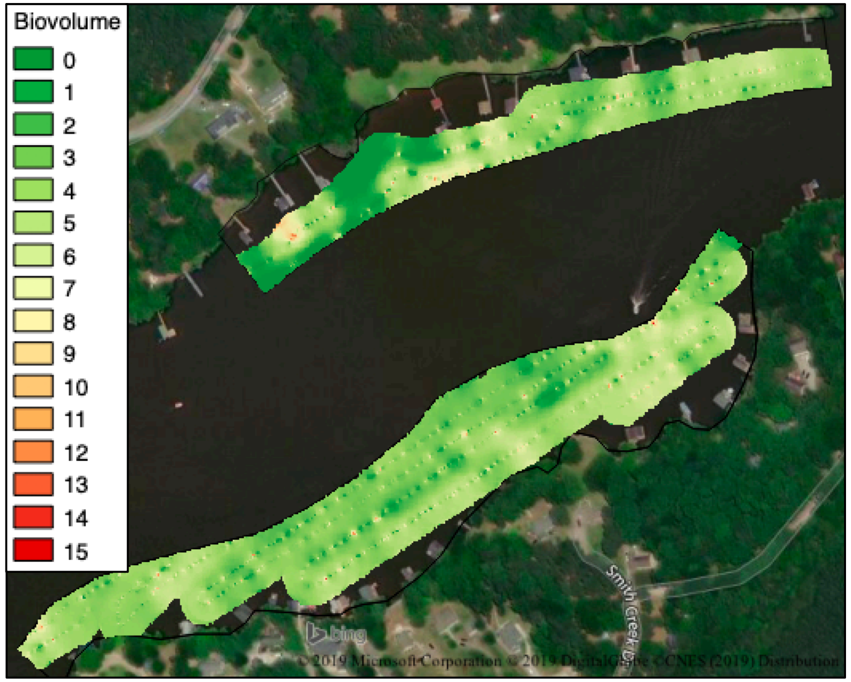
2WAT

Example Findings: Biovolume

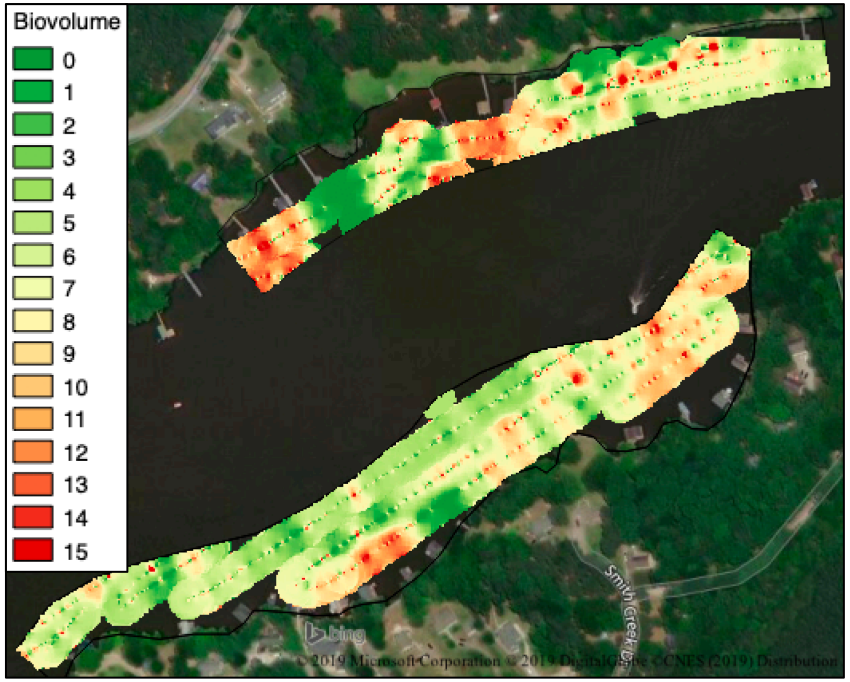
Raster comparisons

Correlation analyses

Biovolume Between Timepoints



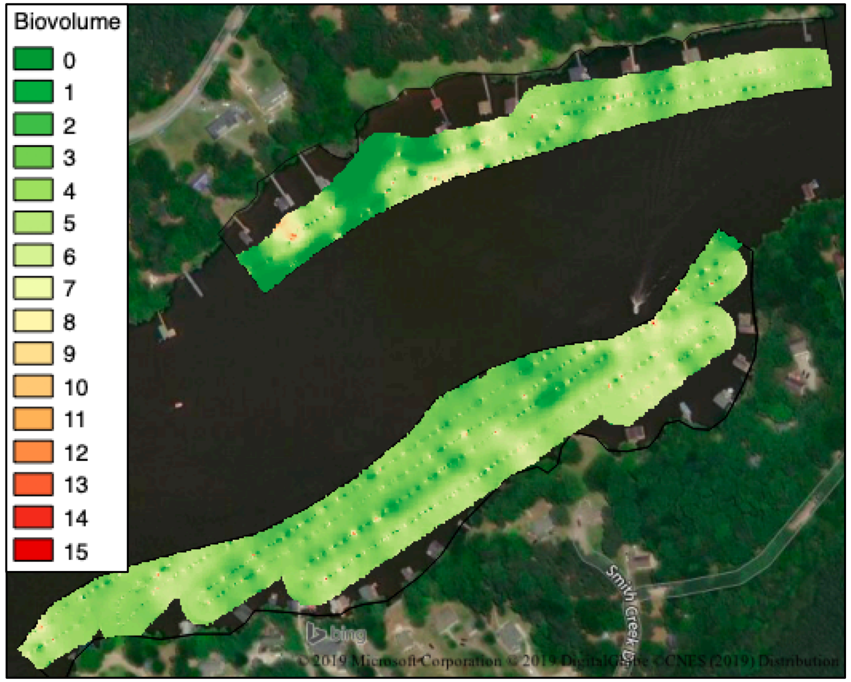
Pre-treatment



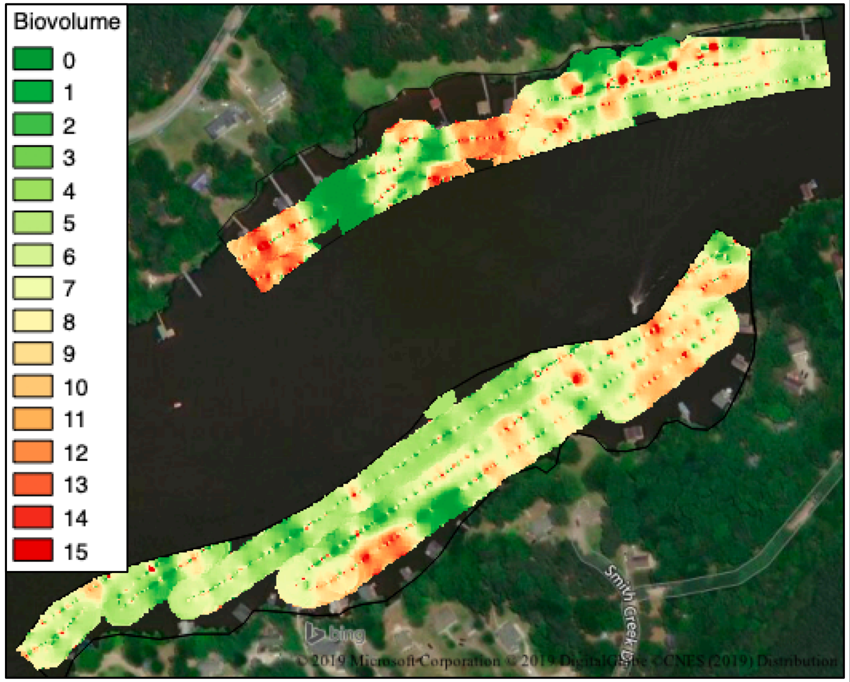
2WAT

Example Findings: Biovolume

Biovolume Between Timepoints

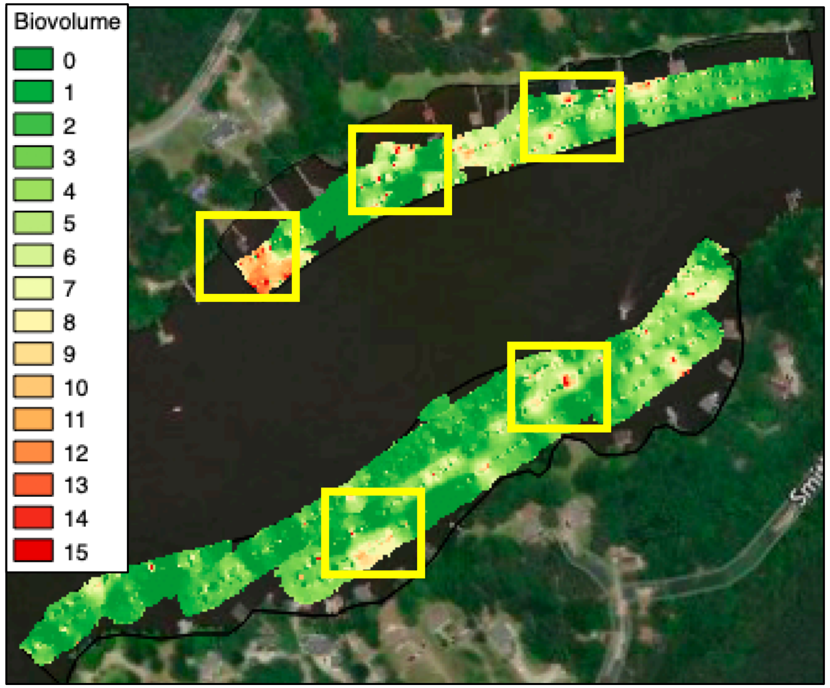


Pre-treatment



2WAT

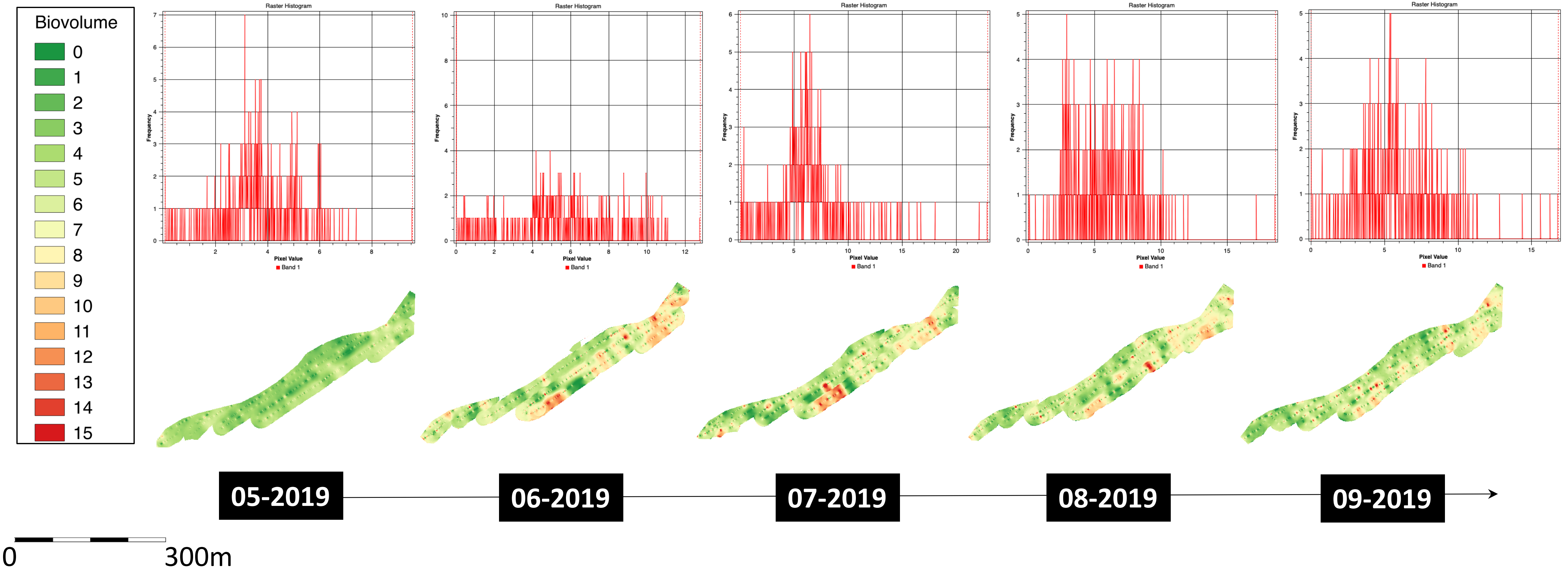
Biovolume Percent Change



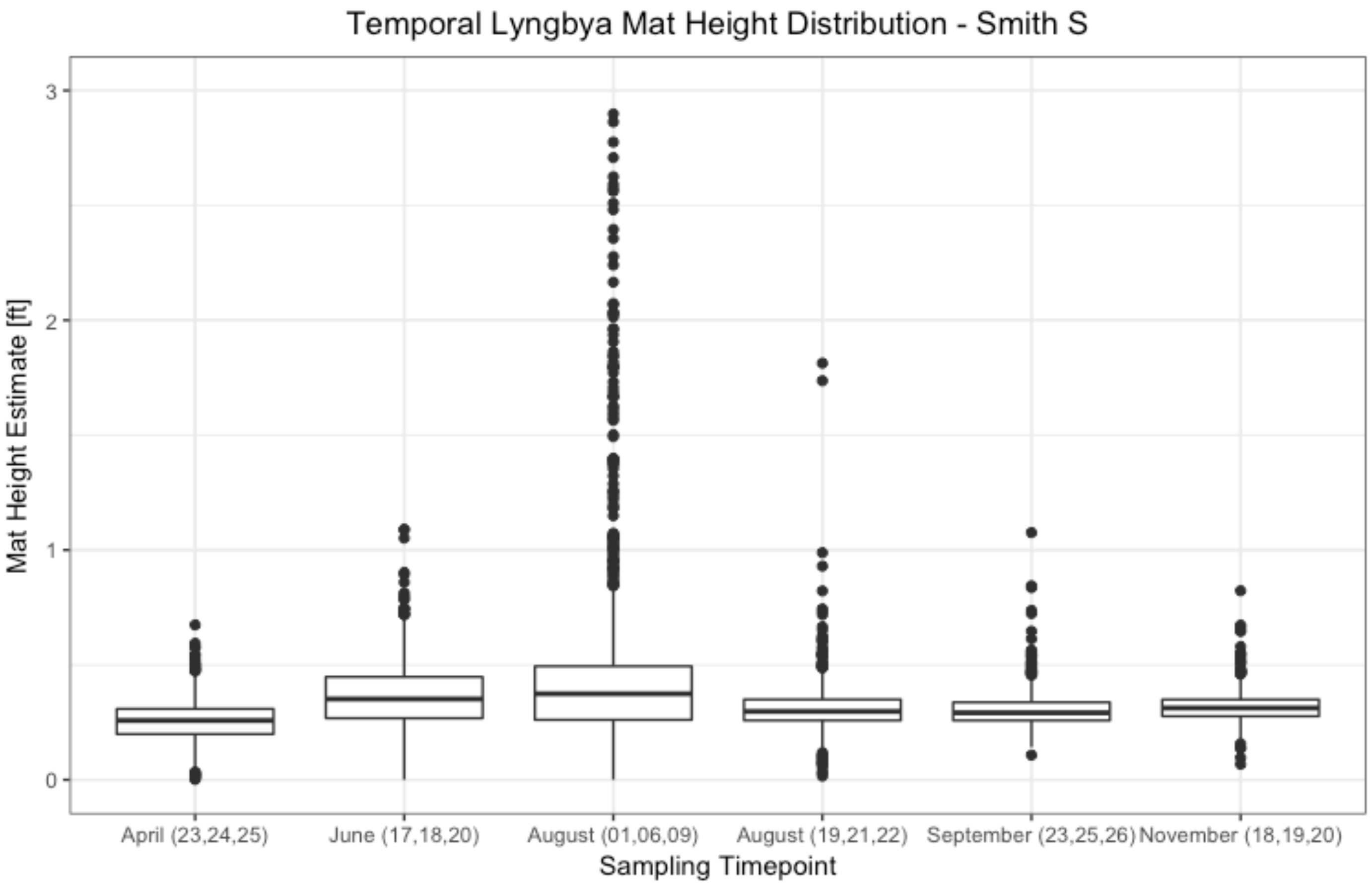
Pre-to-Post

Example Findings: Biovolume

Temporal Biovolume Trends



Example Findings: Means Separation



Mean lyngbya mat heights among treatment sites among BioSonics sampling timepoints.

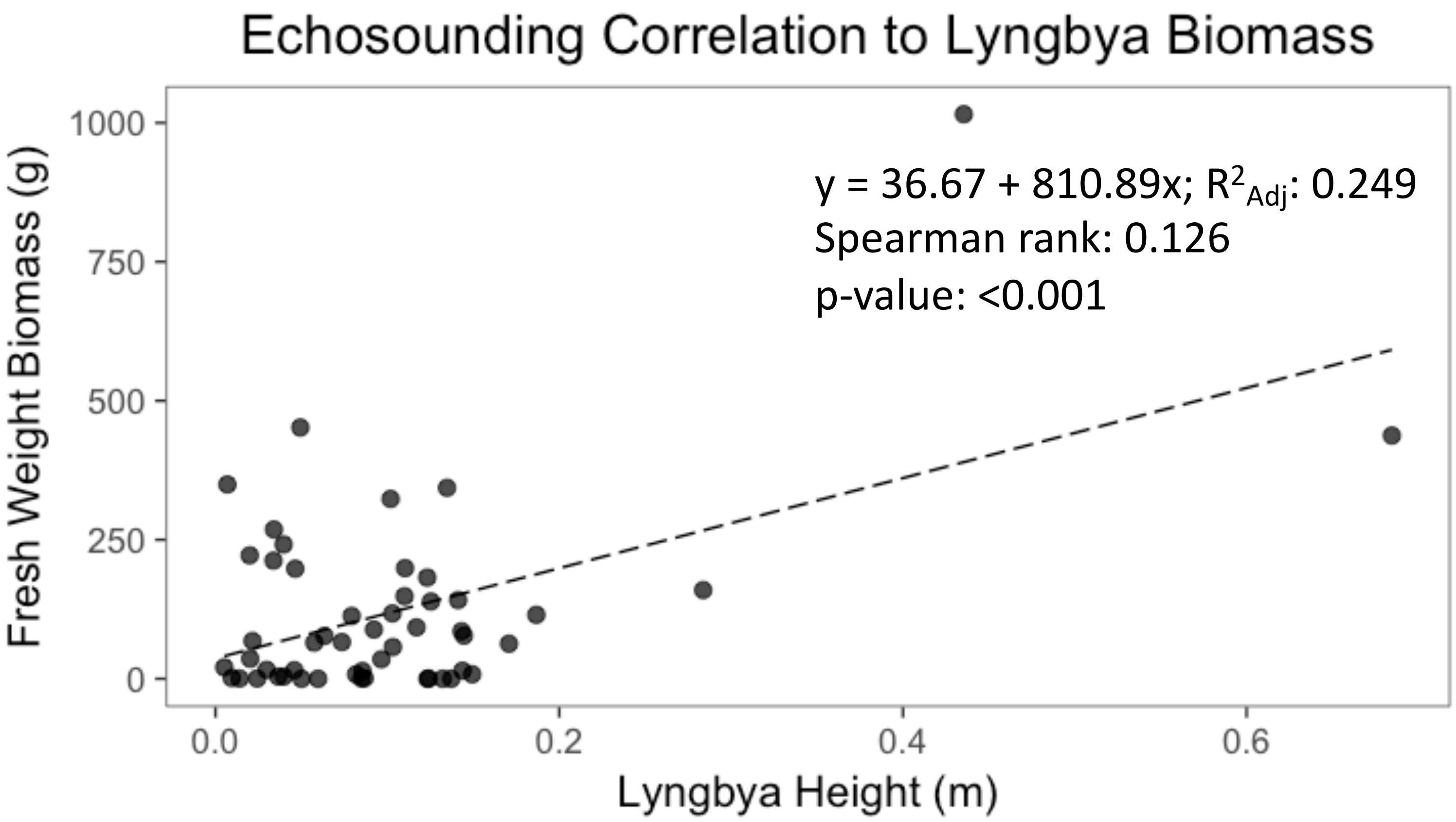
Timepoint	Mean Mat Height
April (23,24,25)	**0.23 a**
June (17,18,20)	**0.33 ab**
August (01,06,09)	**0.83 b**
August (19,21,22)	**0.36 ab**
September (23,25,26)	**0.22 a**
November (18,19,20)	**0.38 ab**

*Mat heights selected from each raster timepoint using the same coordinates as biomass sampling points (n = 4 per treatment site).
** Means within the same column followed by the same letter do not significantly differ (P < .05).

Example Findings

Raster comparisons

Correlation analyses



*Only one run of data shown with 52 observations.

2020 Preliminary Findings

- Conducted monthly echosounding scans since April

Lyons

	Mean Vertical Occupancy (in)		
Site	**April**	**May**	**June**
Hawtree Control	6.0 ± 1.7	5.4 ± 2.2	5.6 ± 1.4
Hawtree N	5.2 ± 4.5	4.6 ± 1.9	4.5 ± 1.9
Hawtree W	5.2 ± 2.1	5.4 ± 2.0	5.8 ± 2.1
Lees Creek 1	2.7 ± 1.8	3.9 ± 2.9	4.6 ± 2.4
Lees Creek 2	4.5 ± 4.6	3.1 ± 1.8	3.3 ± 2.1
Lees Creek 3	4.5 ± 2.0	4.2 ± 2.3	4.8 ± 2.5
Lyons	4.9 ± 2.5	5.1 ± 2.3	9.5 ± 7.9
Pretty Control E	4.5 ± 2.7	5.1 ± 1.7	5.4 ± 1.9
Pretty Control W	4.9 ± 4.2	6.0 ± 1.8	6.2 ± 2.1
Pretty Lower	5.4 ± 1.7	6.0 ± 1.1	5.4 ± 1.8
Pretty Upper 1	3.9 ± 1.6	3.9 ± 1.9	5.3 ± 2.3
Pretty Upper 2	3.8 ± 2.6	5.6 ± 2.1	5.3 ± 3.4
Rocky Branch	4.0 ± 1.6	5.5 ± 2.0	6.1 ± 1.7
Smith Control N	5.4 ± 1.7	5.6 ± 1.8	2.0 ± 2.2
Smith Control S	5.6 ± 1.6	6.0 ± 1.4	3.6 ± 2.2
Smith N	5.2 ± 2.2	5.3 ± 2.4	2.9 ± 2.2
Smith S	5.6 ± 3.0	6.0 ± 1.8	3.1 ± 2.6
St. Tammany	6.3 ± 3.1	5.4 ± 1.3	5.8 ± 1.3

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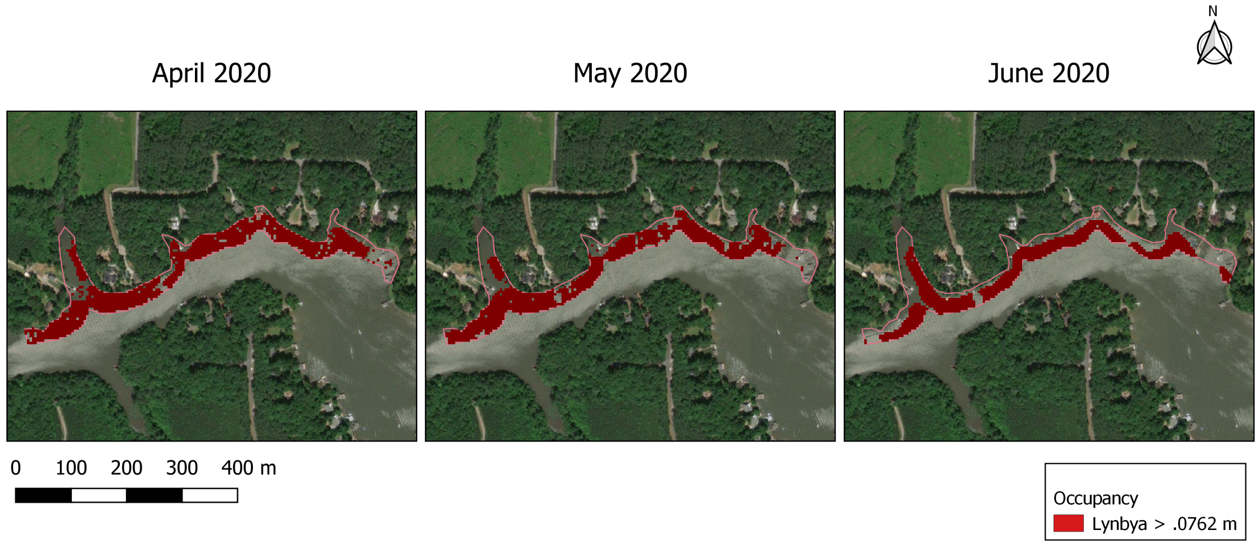
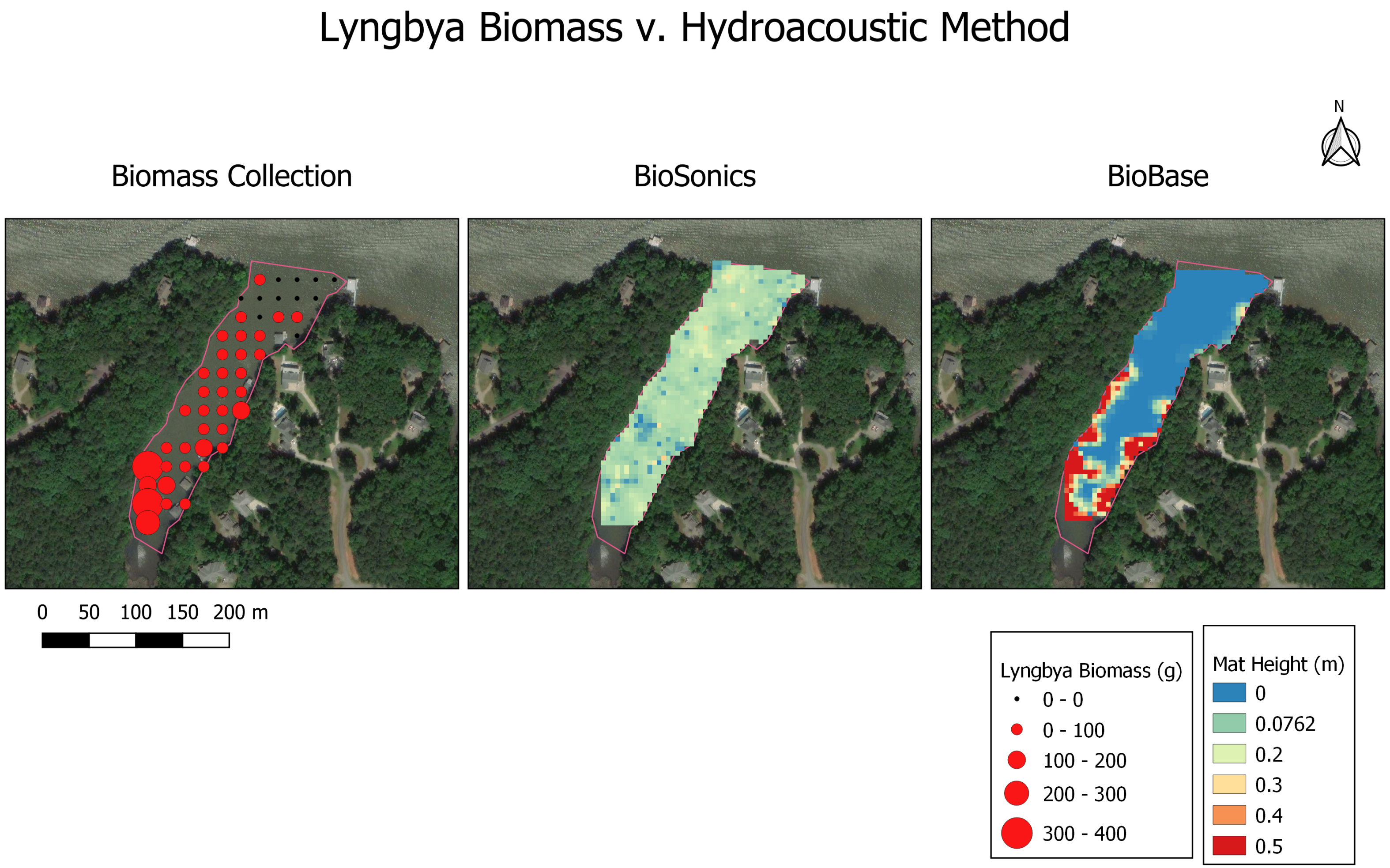


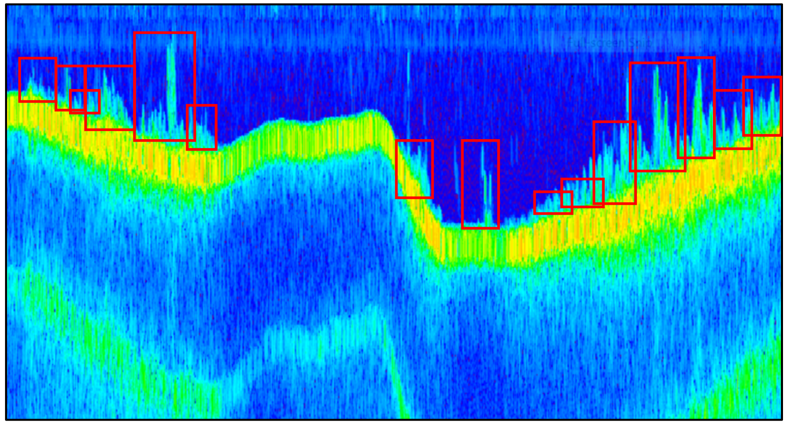
Site	Spatial Occupancy (Ac)					
	April		May		June	
Hawtree Control	0.97		1.01	*4%*	0.92	*-10%*
Hawtree N	0.73		0.64	*-12%*	0.79	*24%*
Hawtree W	0.68		0.68	*1%*	0.79	*16%*
Lees Creek 1	0.20		0.26	*34%*	0.30	*13%*
Lees Creek 2	0.19		0.21	*12%*	0.22	*2%*
Lees Creek 3	0.61		0.55	*-10%*	0.60	*9%*
Lyons	1.34		1.25	*-7%*	1.01	*-19%*
Pretty Control E	0.20		0.17	*-12%*	0.26	*48%*
Pretty Control W	0.51	--	0.69	*34%*	0.58	*-15%*
Pretty Lower	2.08		2.35	*13%*	2.12	*-10%*
Pretty Upper 1	0.63		0.53	*-16%*	0.54	*2%*
Pretty Upper 2	1.04		1.30	*25%*	0.98	*-25%*
Rocky Branch	0.20		0.32	*60%*	0.50	*60%*
Smith Control N	0.21		0.25	*18%*	0.05	*-80%*
Smith Control S	0.38		0.37	*-3%*	0.25	*-32%*
Smith N	0.90		1.07	*19%*	0.71	*-33%*
Smith S	1.29		1.23	*-5%*	0.90	*-26%*
St. Tammany	0.53		0.64	*22%*	0.57	*-11%*

2020 Lyngbya Biomass Pilot Study



Summary of Findings

- Transects allow repeated measures for spatial comparison pre- and post-treatment
- User-based processing provides ability to confirm lyngbya presence in-field
- Data processing allows discovery of mats which may otherwise go undetected using rake-toss and biomass methods alone
- Surface mats difficult to map using echosounding alone



Management Implications

I. Improve current monitoring efforts to provide quantifiable measure of presence and abundance for treatments
II. Provides savings in time and personnel effort
III. Repeatable and objective option for many traditional surveys
IV. Reduce risk of spread during monitoring

*EDRR: *Identification of nuisance, non-native, or invasive species to decrease environmental and economic risk.*

Acknowledgements & Reference

Dr. Richardson's Lab -- Steve Hoyle, Tyler Harris, Jessica Baumann

BioSonics Team

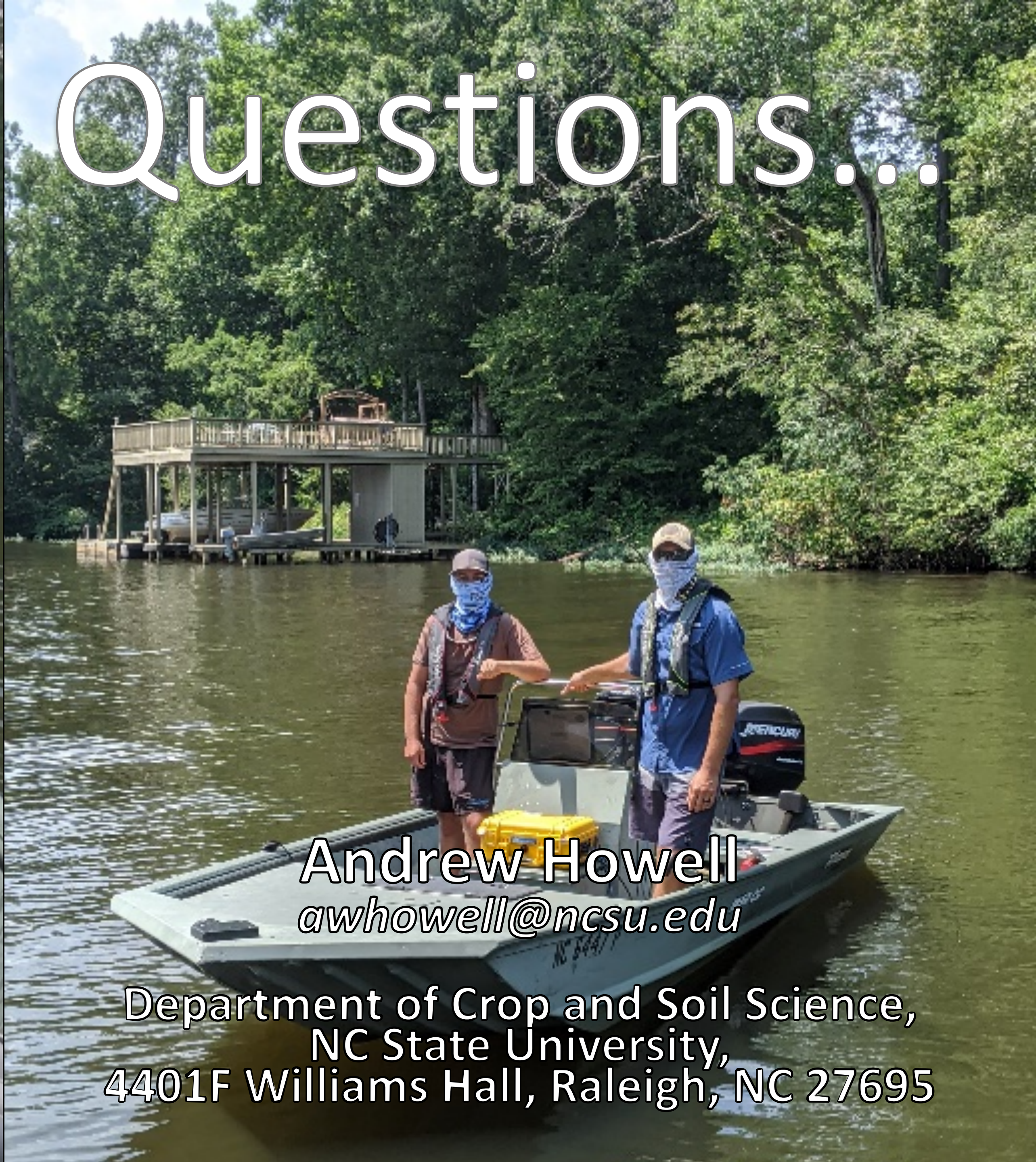
Lake Gaston Weed Control Council

Howell, A.W. and Richardson, R.J., 2019, *Correlation of consumer grade hydroacoustic signature to submersed plant biomass.* Aquatic Botany. 155, 45-51.

Patel, M., Jernigan, S., Richardson, R., Ferguson, S., and Buckner, G., 2019, *Autonomous Robotics for Identification and Management of Invasive Aquatic Plant Species*. Applied Sciences. 9, 2410.

Transducer Beam Angle Image: *chsmith.com.au/news/My-Beam-Angle-is-wider-than-yours.html*

Questions…



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