Utilizing Bacteria Augmentation to Reduce Organic Bottom Sediment and Nutrients.

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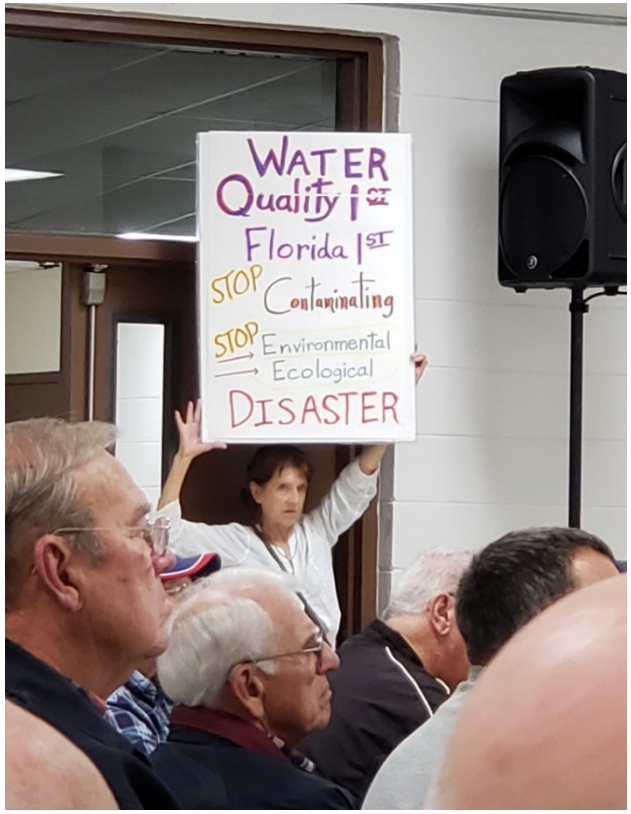
Trace Wolfe & Linda Defee: Operational Evaluations

Purpose

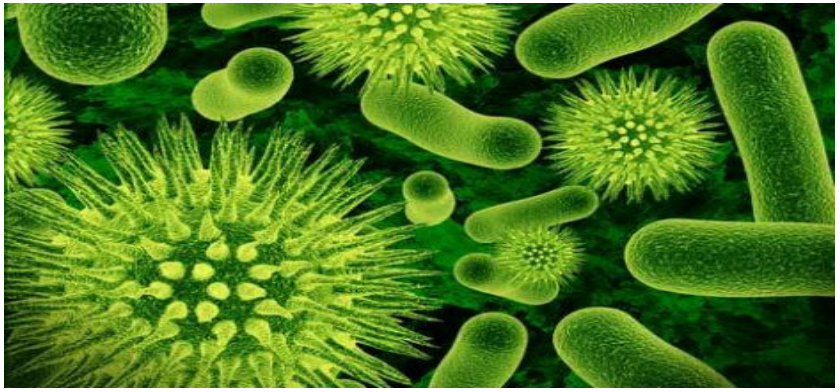
- Provide Background information on Bacterial Augmentation
- Present Observations and Data from: Operational Analyses, Field Trials
- Spark Interest in Bacterial Augmentation as an Integrated Management Component



Bacteria

Bad Actors

- Food Poisoning
- Infectious Diseases
- Forest/Ag Diseases

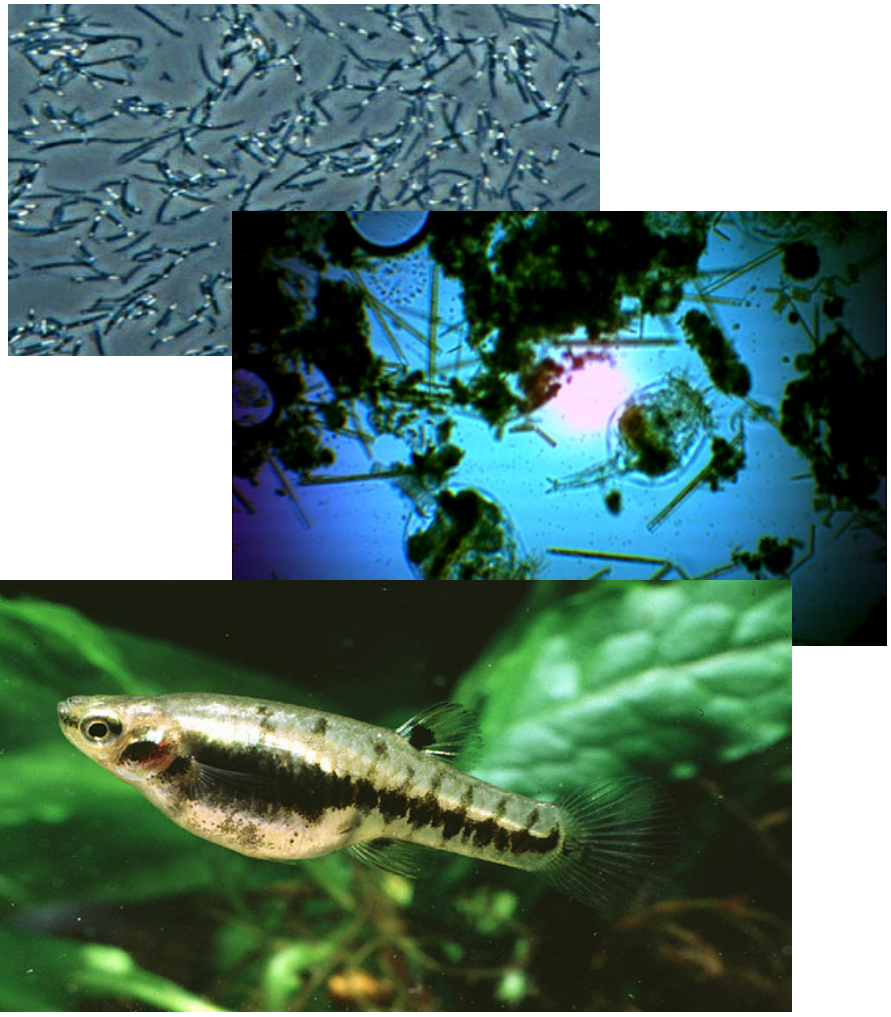


Beneficial Bacteria

- Health Benefits
- Food Production
- Oil Spill Cleanup
- Wastewater Treatment
- Nutrient Cycling
- Decomposition

Bacteria in the Aquatic Environment

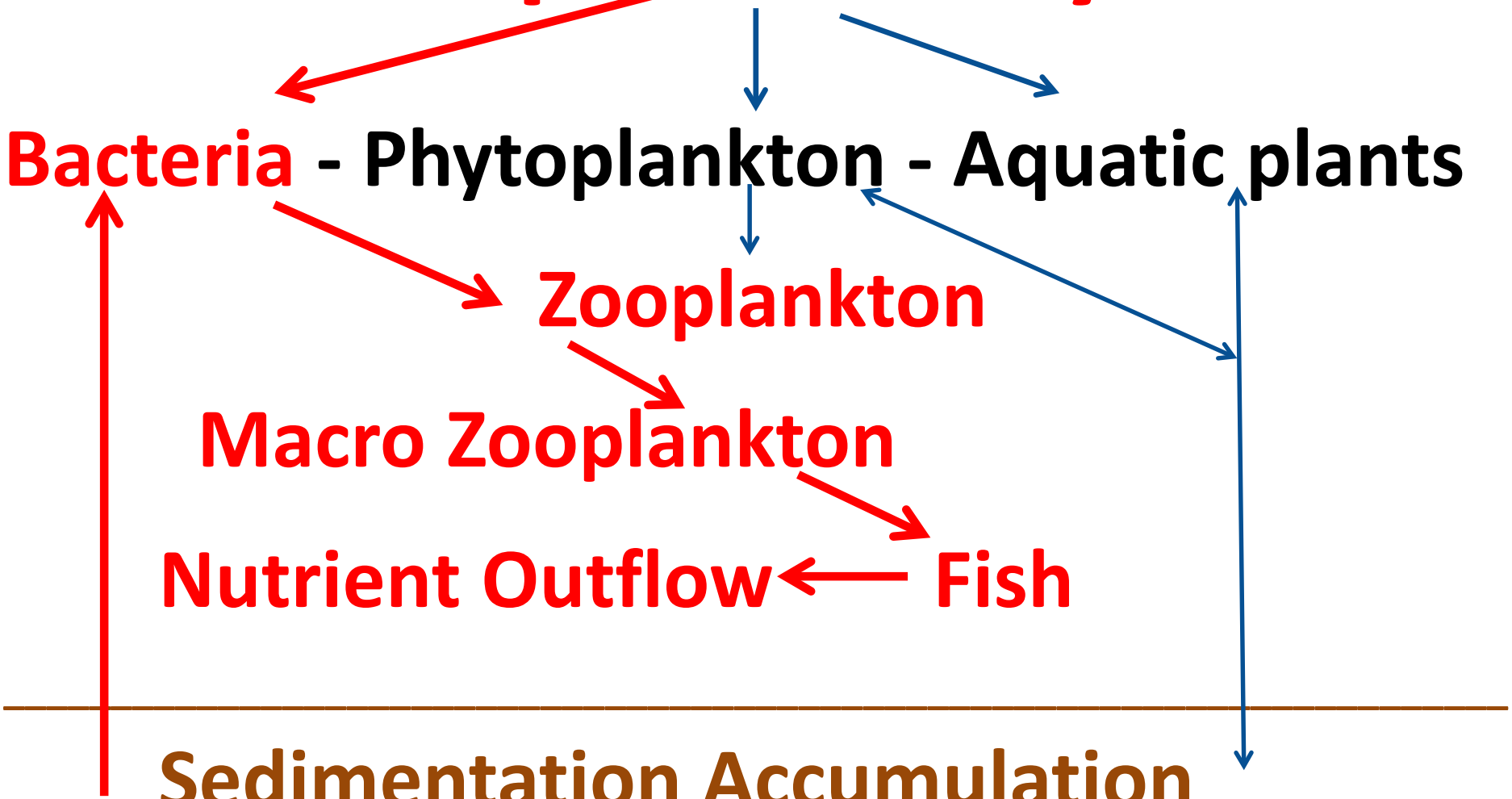
- Bacteria provide “the base” of food chain from bacteria to protozoa to fish, etc.
- They conduct critical roles in nutrient cycling (N&P).
- Bacteria reduce organic matter (sludge) by utilizing carbon compounds.
- Compete for nutrients.



Product Background: Microbes and a Partial List of Roles.

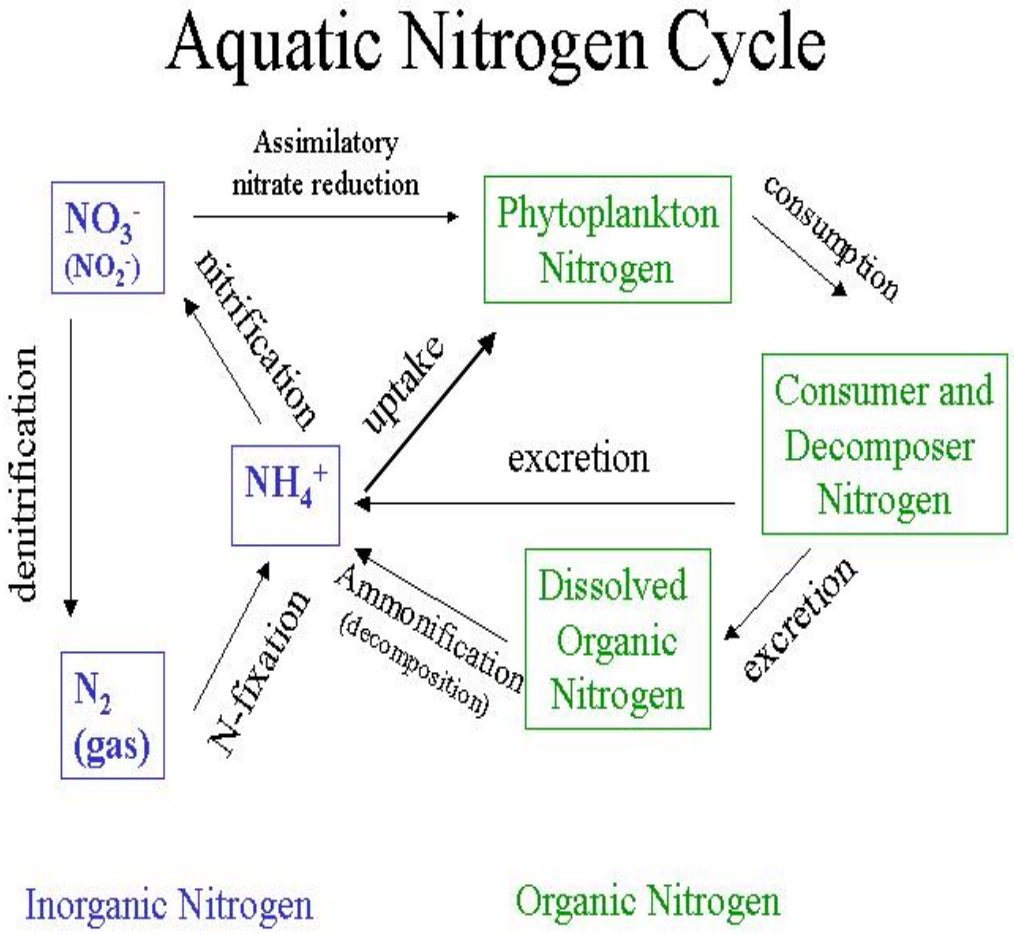
- ***Nitrosomonas***
  - reduces NH_3 to NO_2
- ***Nitrobacter***
  - NO_2 to NO_3
  - both are soil bacteria; both are required for nitrification and both need aerobic conditions
- ***Aerobacter aerogens***
  - aerobic
  - oxidizes carbohydrates C+(H_2O) (sugars, starches and cellulose) and short organic acid chains to CO_2 and H_2O
  - when O_2 is limited it ferments carbohydrates which become food for *Pseudomonas* sp.
- ***Bacillus subtilis***
  - degrade polymers such as protein, starch, and pectin, therefore, they are thought to be an important contributor to the carbon and nitrogen cycles. Important in digestion in the gut of animals
- ***B. licheniformis***
  - produces a variety of extracellular enzymes that are associated with the cycling of nutrients in nature.
- ***B. amyloliquefaciens***.
  - oxidizes carbohydrates, organic acids, fats, oils, proteins and starches
  - active in the soil, its enzymes degrade organic material
  - denitrifying bacteria (NO_3 to NO_2 to N_2)
- ***Cellulomonas biazotea***
  - converts cellulose to soluble carbohydrates which serve for growth of *C. biazotea* and other bacteria
- ***Pseudomonas denitificans*** and ***P. stutzsri***
  - reduces level of nitrate nitrogen under anaerobic conditions
  - oxidizes and degrades organic compounds

Phosphorous Cycle



Known Players

- *Nitrosomonas* spp.
  - Ammonia (NH3) to Nitrite (NO2)
- *Nitrobacter* spp.
  - Nitrite (NO2) to Nitrate (NO3)
- *Pseudomonas* spp.
  - Nitrate (NO3) to Nitrogen Gas (N2)



Naturally Occurring Bacteria

- Beneficial bacteria populations have naturally maintained aquatic balances, but now are overwhelmed given:
  - exponential nutrient inputs,
  - habitat disruption,
  - oxygen depletion.
- Muck contains phosphorus, nitrogen, carbon and other components
- Bacteria naturally can manage muck as it occurs in many lakes without excessive nutrients.

Bacteria Aquatic Management Systems

- Science has Identified key microorganisms.
- R&D has resulted in bacteria production methods and delivery systems.
- These are needed due to increased pressures on waterbodies.

- **Potential Benefits:**
  - Increased Clarity
  - Reduced Odor
  - Reduced Chemical Use
  - Nutrient Competition
  - Sediment Reduction
  - Phosphorous and nitrogen reduction

Bacteria Product Use

- Currently operational for 15 aquatic management companies in Florida and the US. This Represents 20,000 managed waterbodies totaling in excess of 60,000 surface acres.
- Primary use has been golf course waterways, private lakes, and municipal drainage networks in Florida.
- Results are reduced nutrients, shifts in sediments from muck to sand, decreased sprinkler clogging, and aesthetic benefits. All have been observed and documented.

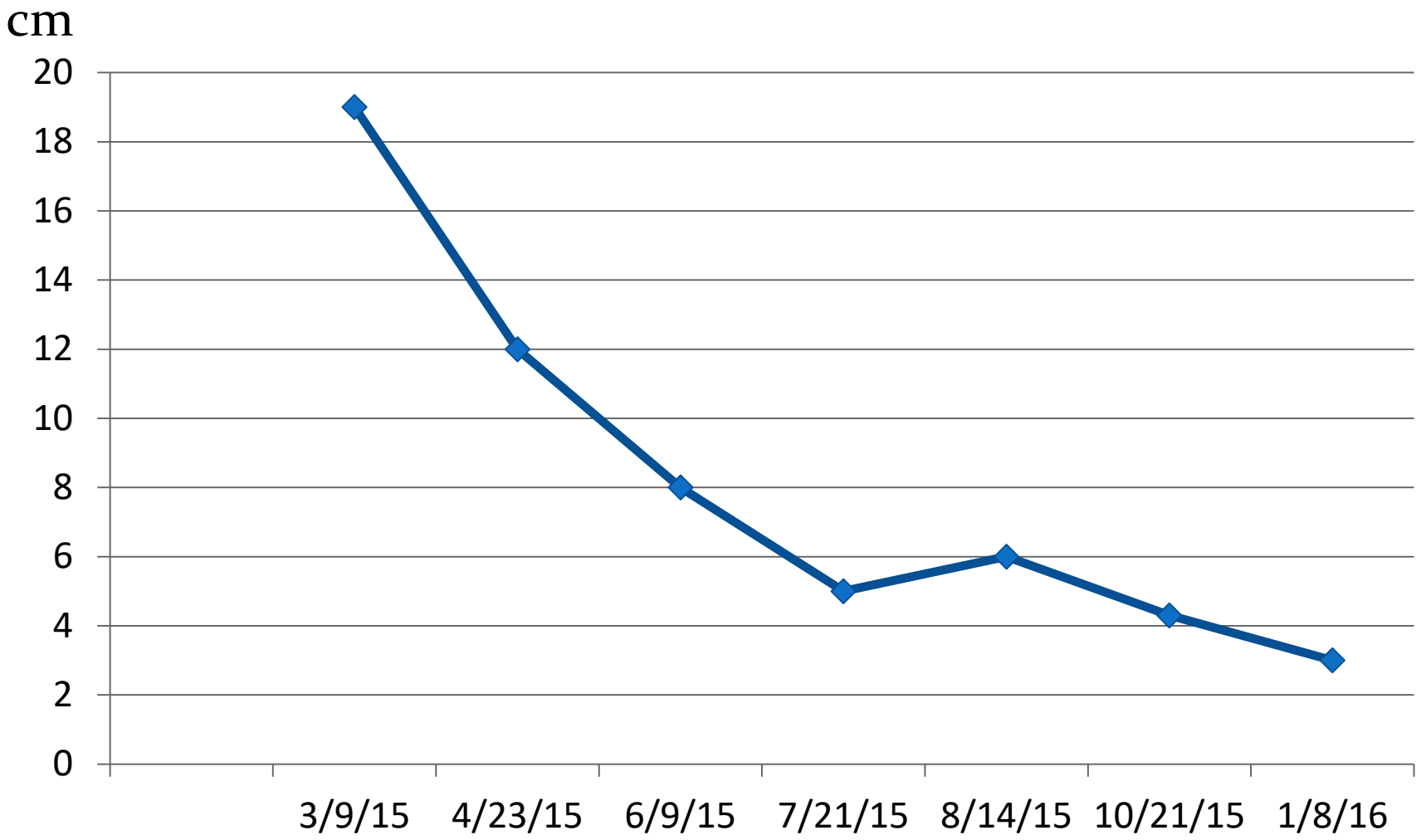
Bio-Incubator - Field Evaluation Methods

- **Inoculation Methods**
- **Bacteria can be incubated in a bio-incubator and distributed directly as living organisms with active enzymes.**
  - Temperature can be controlled.
  - Product can be bacteria, food, spores in sock.
  - 4.5 lb. Socks are exchanged monthly.

- **Monitoring Methods**
  - Permanent stations designated.
  - Quarterly sediment depth measurement taken with meter stick/Tube.
  - Depth measured to nearest Cm.
  - Muck and Water Sample Analyses.

Port Saint Lucie E8 Basin
Organic Sediment Removal

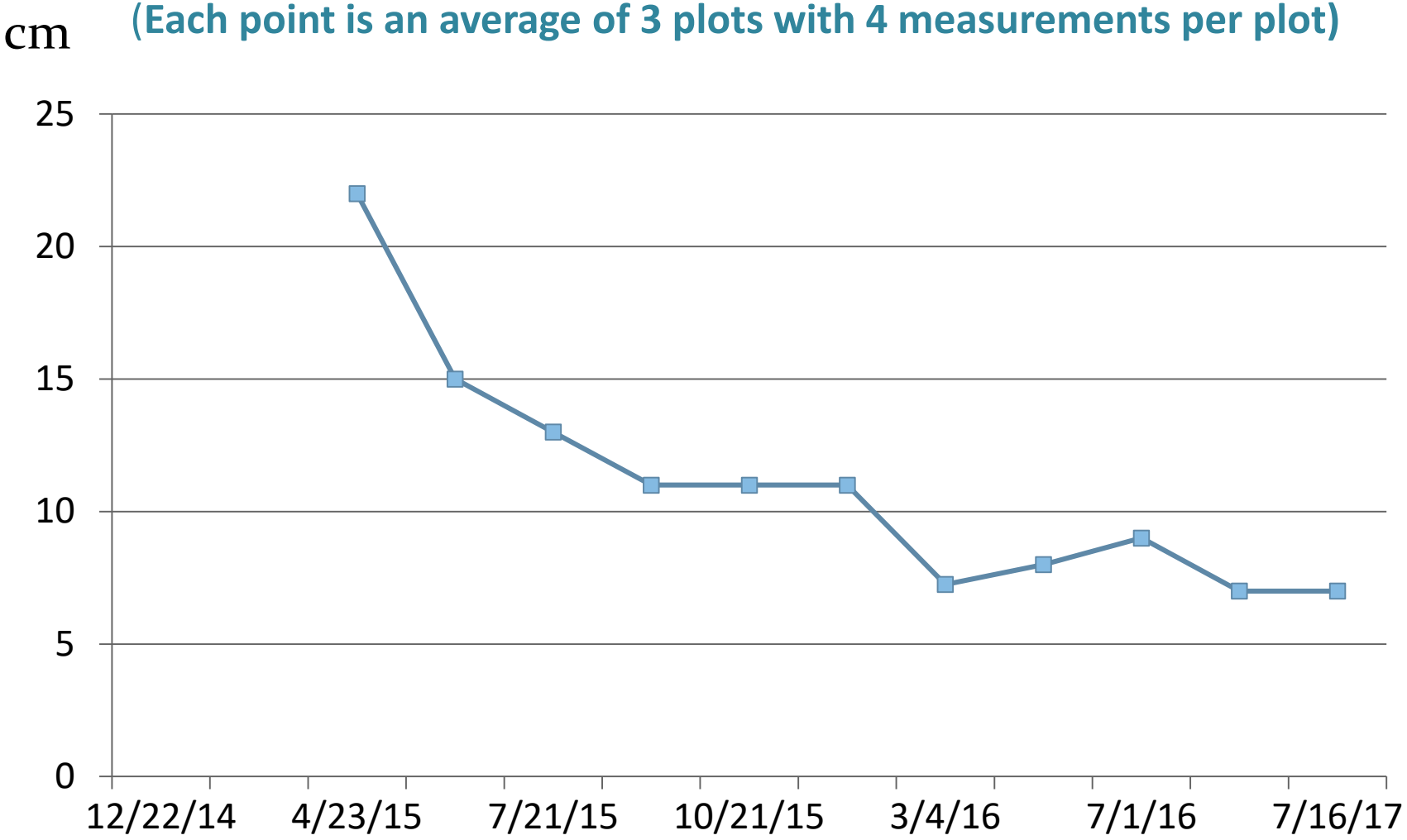
(Each point is an average of 3 plots with 4 measurements per plot)



Operational Evaluation-PGA Pond

Organic Sediment Removal

(Each point is an average of 3 plots with 4 measurements per plot)



Institute of Food and Agricultural Sciences
Analytical Services Laborat
UNIVERSITY OF FLORIDA
ories
Livestock Waste Testing Laboratory, Gainesville, FL

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Gainesville, FL 32622
(352) 392-1950
FAX (352) 392-1960

Livestock Waste Analysis Grower Report

Clarence Elroy Timmer
482 SW Deer Run
Port St Lucie, FL 34953

PHONE: 561-249-4628

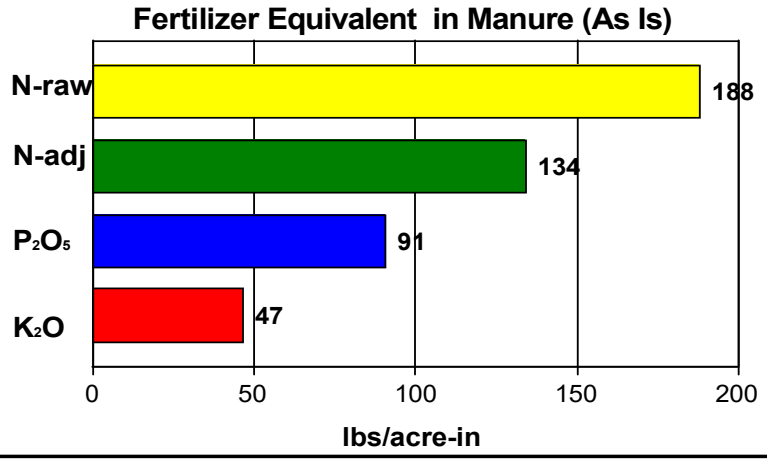
Lab #	**9007**
Sample Label	**IS #1**
Date Collected	**April 29, 2016**
Date Delivered	**May 4, 2016**
Date of Report	**May 16, 2016**
County of Sampl	**Palm Beach**
Collected By	**0**

Sample Type: Dairy waste collected from lagoon.
Crop or Use: #N/A
Application Equipment:Applied through center pivot
Incorporation #N/A
Previous Applications #N/A

***Nutrient Content in Manure as Delivered to Laboratory

Nutrient Constituent	Raw Sample	Adjusted For Application Losses of N	Units
Nitrogen (N):	188	134	lbs/acre-in
Phosphorus (P2O5)	91	91	lbs/acre-in
Potassium (K2O):	47	47	lbs/acre-in

pH as Sampled	6.9
Moisture Content:	78.3%
Total Solids:	21.7%
Total Ash	18.8%

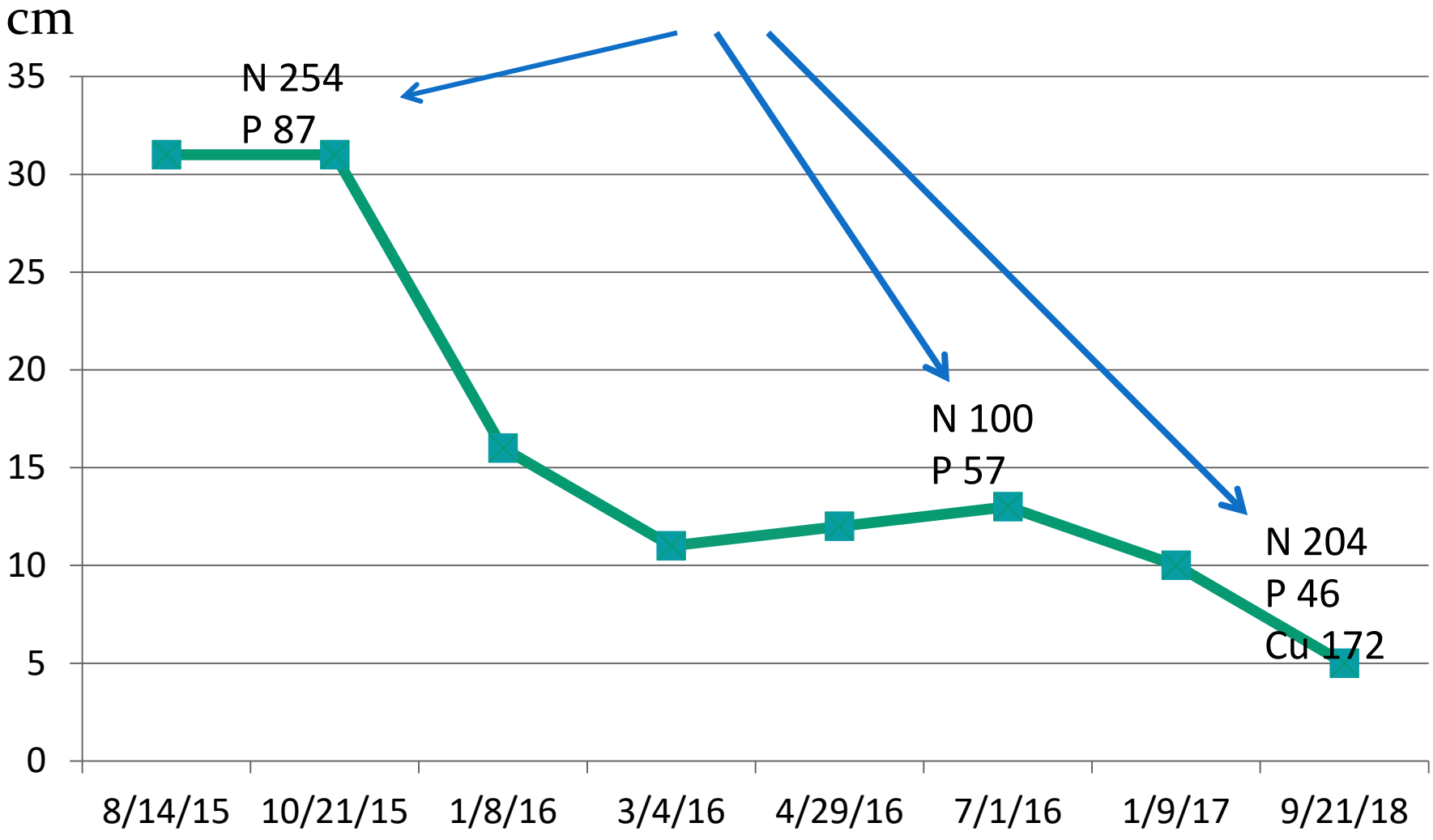


Lab Number	Sample Id	Cu mg/kg	Mn mg/kg	Zn mg/kg
L9813	I 5-1	40.20	10.23	9.5

Ibis Country Club Lake 10 - Organic Sediment Removal

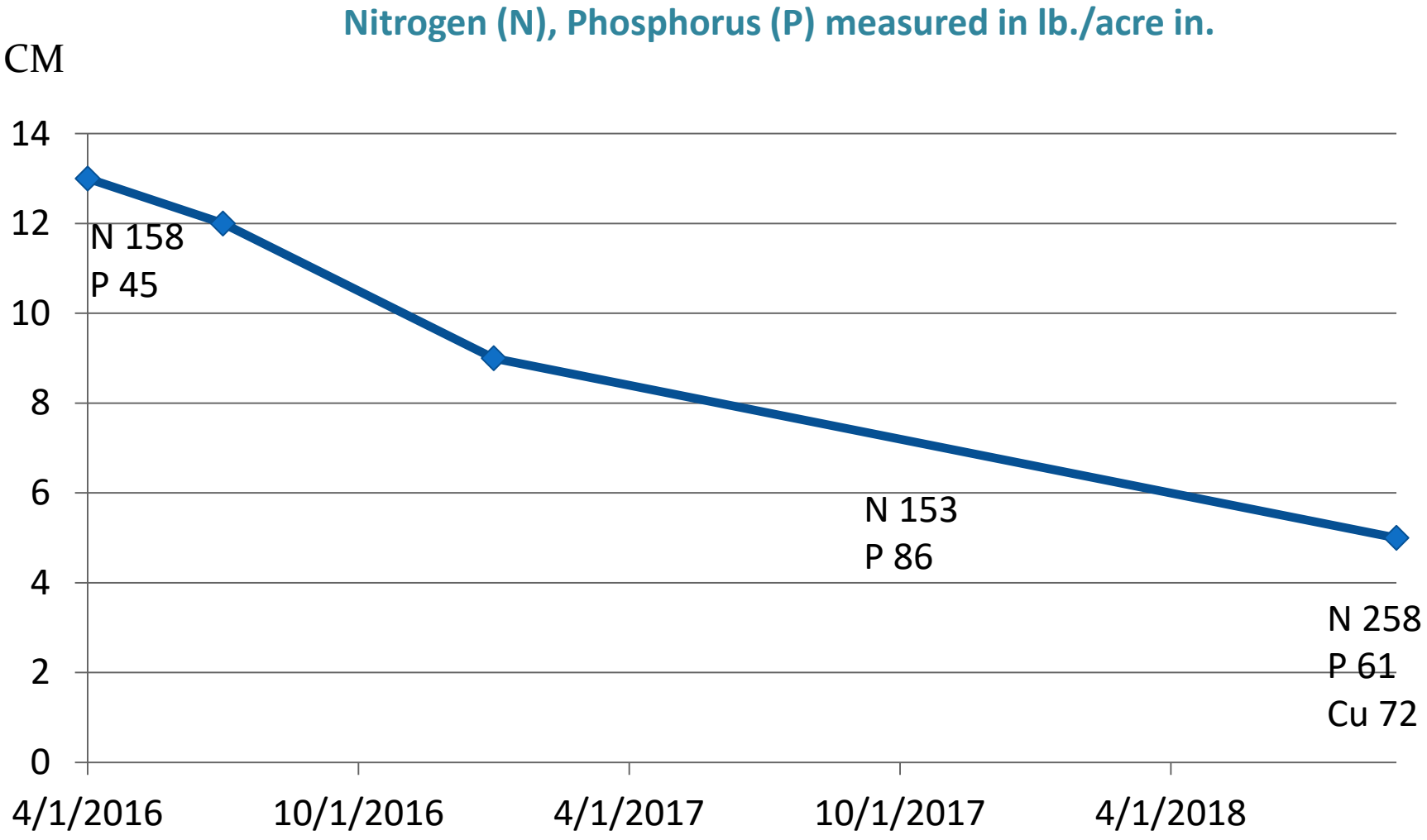
(Each point is an average of 3 plots, 4 measurements per plot)

Nitrogen (N), Phosphorus (P) (lb/acre in.) in muck sample



Ibis Country Club Lake 5 – Organic Sediment Removal

(Each point is an average of 3 plots, 4 measurements per plot)



Bio-Incubator Installation at City of Port St. Lucie Peacock Lake

PEACOCK LAKE

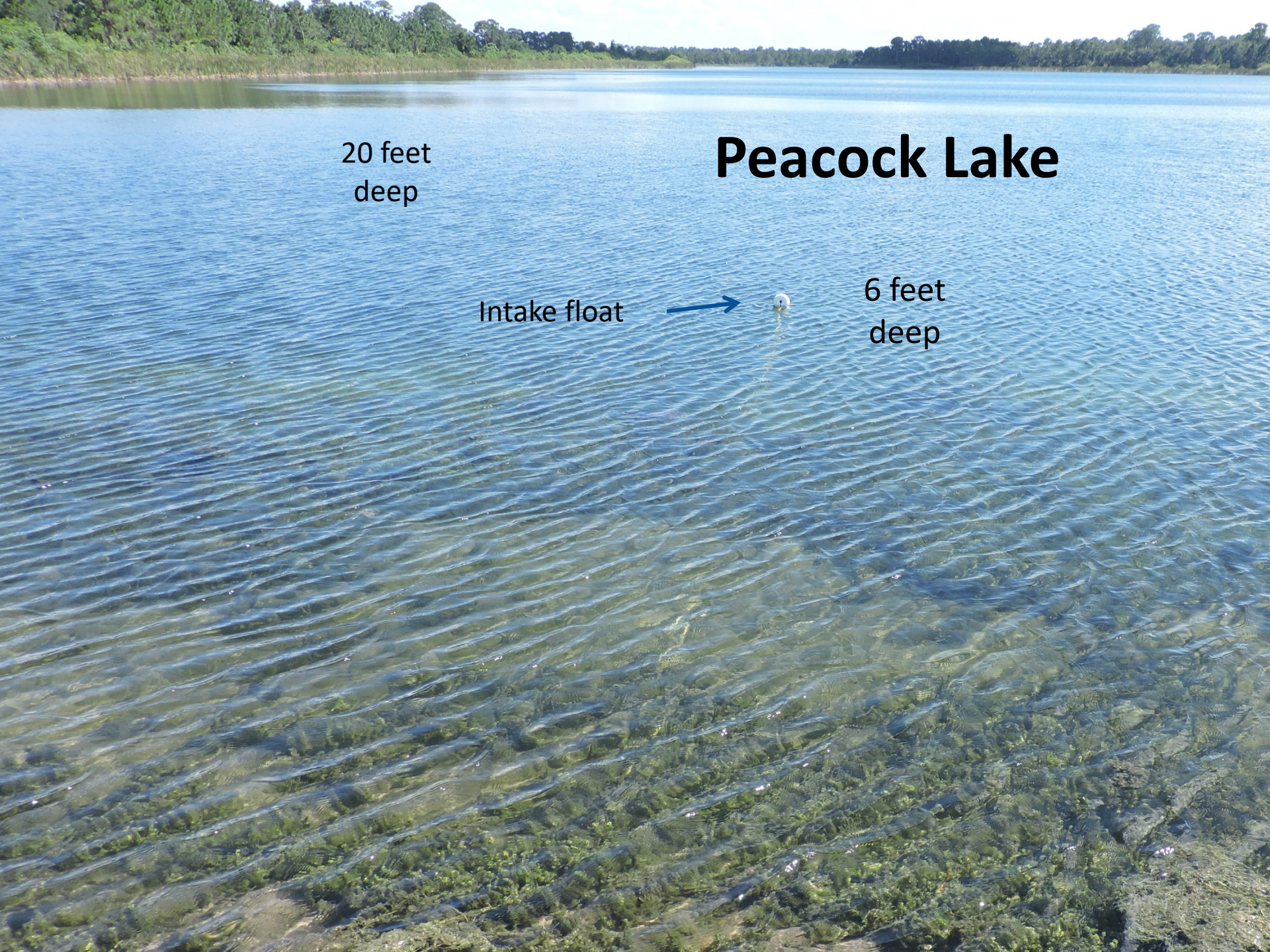
- Lake (100 acres) 18 foot depth.
- Lake is an enclosed system with no stormwater inputs.
- *Microcystis* bloom in December 2016.
- Objective: reduce total phosphorus.
- Weekly treatments of Bio-Zyme using bulk powder solids spread by airboat.
- Currently treated by a 200 gallon bio-incubator releasing every 72 hours if needed.

Peacock Lake 100 acres-

Total Phosphorus reduced from:

0.05 mg/l - 0 mat
0.015 mg/l - 6 mat
<0.005 mg/l - 18 mat

Date	Bio-Zyme Bulk	Laboratory	Total Phosphorous rate mg/l
1/9/17			
1/16/17	5 lbs.		
1/18/17		Pace	0.05
1/23/17	5 lbs.		
1/30/17	5 lbs.		
2/6/17	50 lbs.		
2/21/17		Flowers	0.04U
3/27/17	50 lbs.		
3/30/17		Jupiter Env.	0.024
4/9/17		Jupiter Env.	0.021
5/23/17	10 lbs.		
5/31/17	10 lbs.		
6/8/13	10 lbs.		
6/13/17	10 lbs.		
6/20/17	10 lbs.		
6/27/17	10 lbs.		
7/3/17	10 lbs.		
7/3/17		Jupiter Env.	0.015
7/11/18	300 lbs.	Jupiter Env.	<0.005


20 feet
deep
Peacock Lake
Intake float
6 feet
deep

Clear Waters, Inc.

Goal to Improve Water Quality and Reduce the Use of Copper

Clear Waters, Inc.

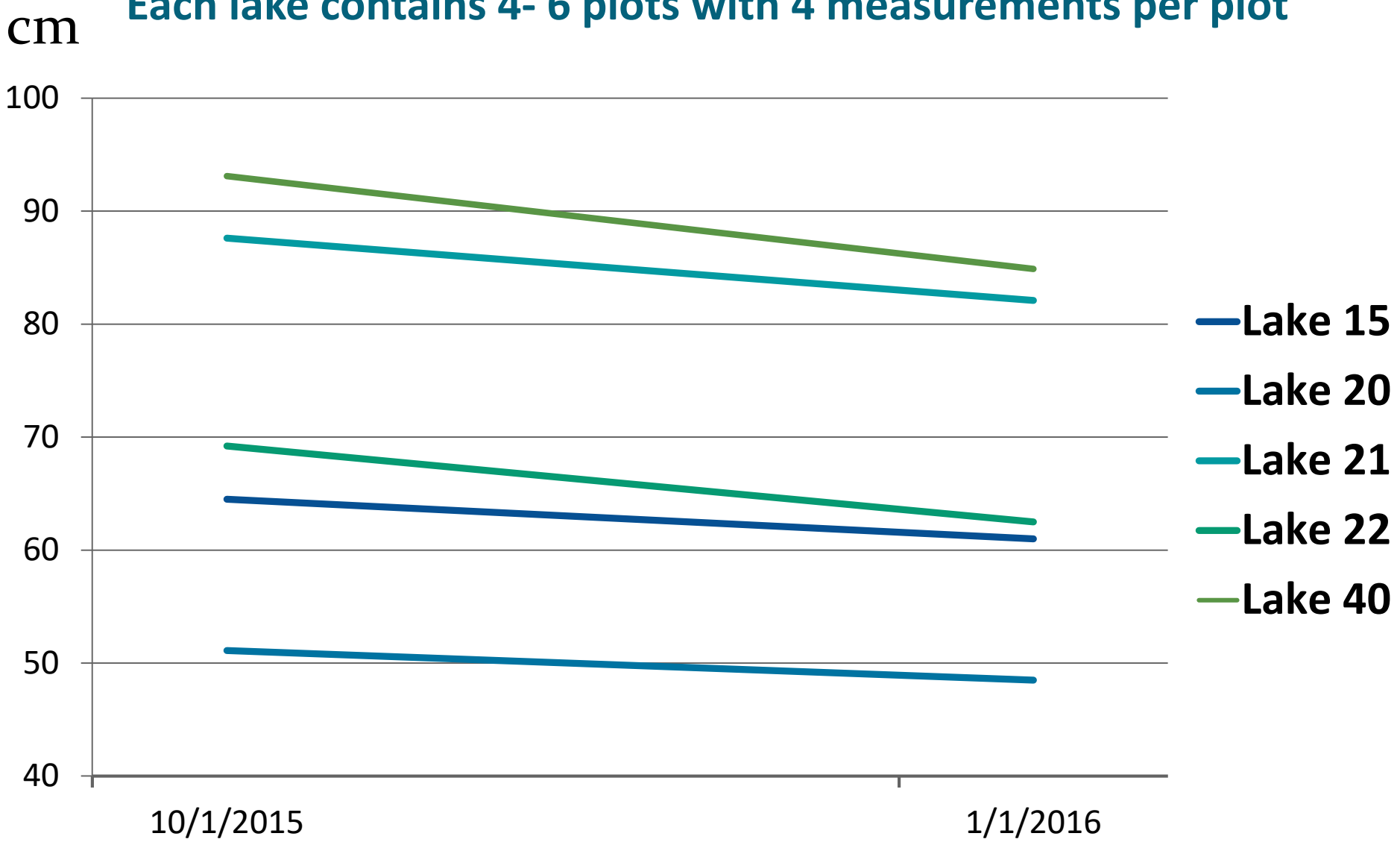
After 6 Months with Bio-Incubator

Players Club POA

Clear Waters, Inc.

Organic Sediment Removal 1.8 cm Per Month

Each lake contains 4- 6 plots with 4 measurements per plot



STAs and Constructed Wetlands Have Been Used for Years as Key Component of Restoration.

Benefits

- Nutrient Removal
- Water Storage
- Wildlife Habitat
- Research Opportunity
- Recreation Opportunity
- Public Education (PR)
- Urban Greenspace
- Downstream Restoration

Concerns

- Large Land Tracts
- Require Large Capital Investment
- Maintenance Expense
- Accumulate “muck”
- Accumulate Nutrients
- Require periodic drawdown
- May require periodic mechanical removal of “muck”

South Florida Water Management District Muck Reduction Trial

- AVC performed a muck reduction Field Trial in STA 1 West in 2016-17.
- Large areas of floating tussocks and waist deep muck.
- Some Tussocks were vegetated but most bare mud above the waterline with sparse vegetation.
- The visible water was 1-3 inches deep above the muck.

STA Field Trial and Results

- Treatment prescription was 500 gallons of incubated Bio-Zyme (12.5 lbs. + 2.5 gal, Nitrifier) per week via airboat.
- Each week a 25 acre plot within the 50 acre trial area was treated.
- Duration was 9 months July to March of 2017.
- The initial area impacted by the trial appears to encompass over 350 acres. Later the result spread to about 800 acres.


Floating Tussocks Before Treatment

March 2017 – After Treatment

Prior to initial application
Mud to the surface


March 2017
After Treatment

Summary;
Supported Observations

- Decreased depth of organic sediment layer.
- Increased water clarity and light penetration.
- Elimination of floating tussocks
- The bottom sediments became consolidated and firm compared to mush and soup.
- The water clarity was greatly improved.
- More fish were observed

In Closing: The Potential is Exciting!

Innovation- Repurposing Known Technology.

- **Lake Okeechobee**
  - Flocculent Management.
  - Organic Sediment and Nutrient especially P. Reduction.
  - Fish Spawning Area Restoration.
  - Increase Light Penetration to Promote SUV Growth.
  - Aquatic Plant Management - Cost Offset.

In Closing: The Potential is Exciting!

Innovation- Repurposing Known Technology.

- **STAs**
  - Organic Sediment Reduction/Consolidation.
  - Extend Cell Life Span and Reduce Management Costs.
  - Nutrient reduction
- **Private Land Discharges**
  - Pretreatment Option.
- **East and West Lagoons**
  - Reduce Lake Discharge Nutrients that Feed Toxic Algae.

Acknowledgements

- **Aquatic Balance**
  - Rick Anderson, President — 40 yrs. — 772-360-8115
  - *www.aquaticbalance.net*
- **Clear Waters Inc.**
  - Trace Wolfe, President — 45 yrs. — 386-767-4928
  - *www.clearwaterslakemgmt.com*
- **Aquatic Vegetation Control. Inc.**
  - Elroy Timmer, Senior Scientist — 60 yrs. — 561-248-4628
  - Linda DeFee — 10 yrs. — 561-845-5525
  - *www.avcaquatic.com*

Large data set and 1000's of sites are available for inspection

Thank You.

- TRM, Inc.
  - Bio-Zyme
- Martin County
- NPBCID
- Port St. Lucie
- SFWMD