NORTHWATER CONSULTING

Fish Lake Conservancy District

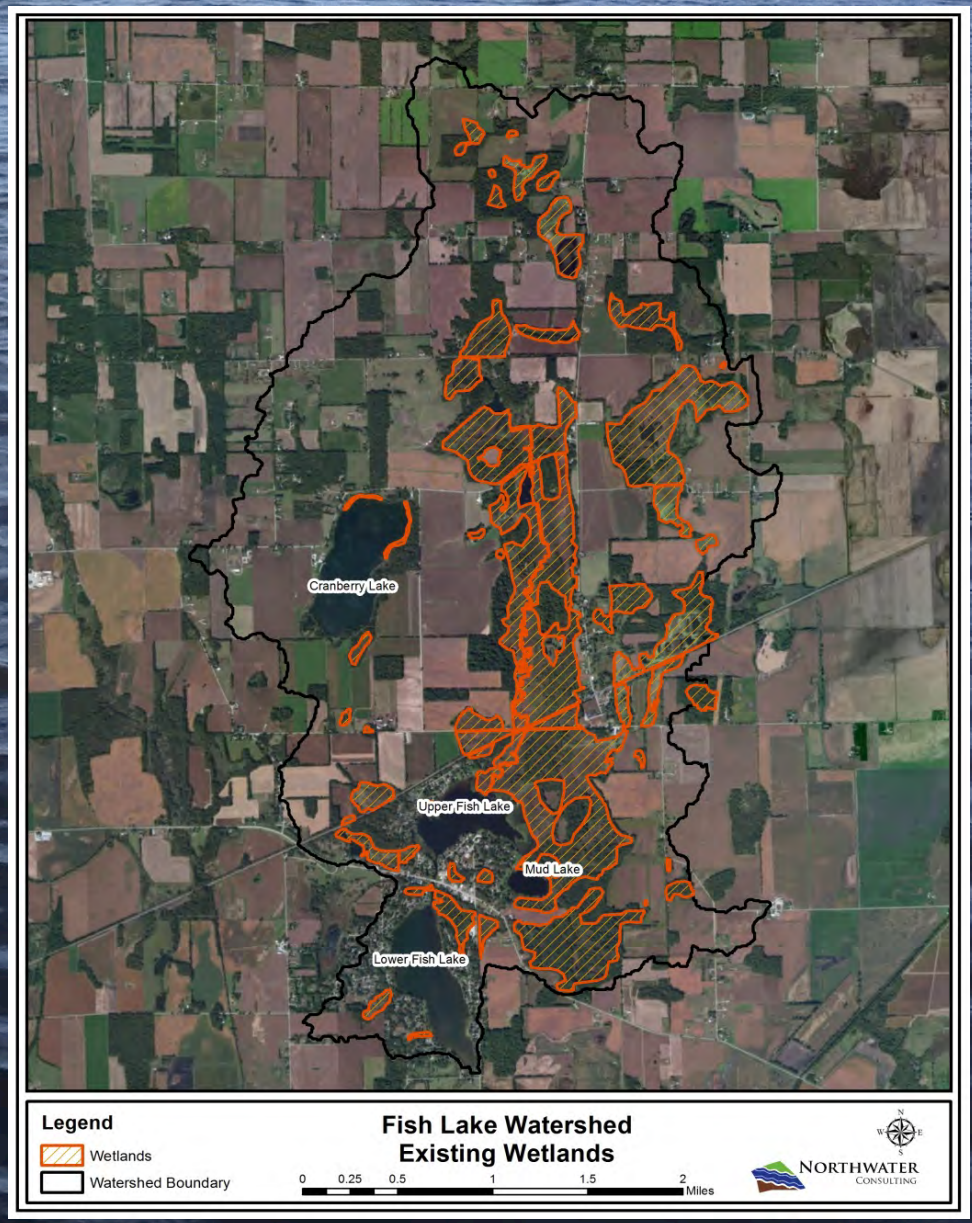
Muck Munching:

a two-year feasibility study for in-lake organic sediment management

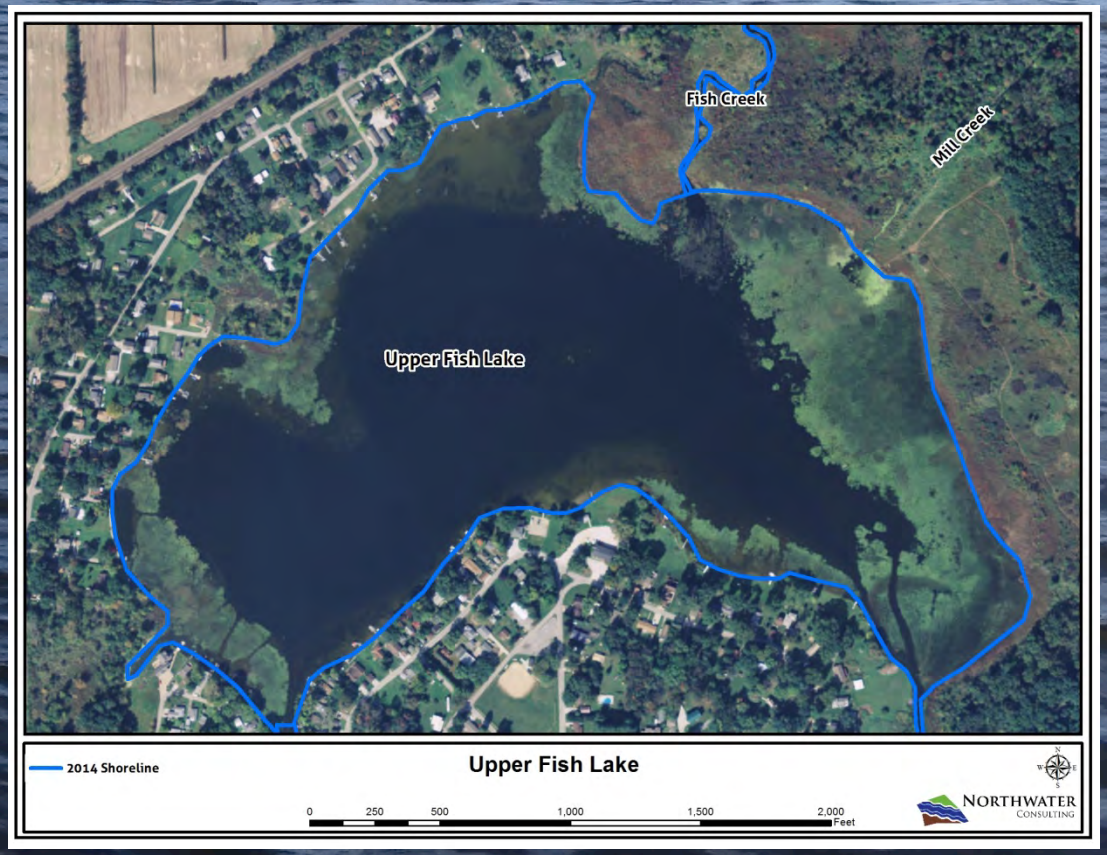
Upper Fish Lake, LaPorte County, Indiana

Fish Lake Watershed

- LaPorte County
- 6490 acre watershed, 18% wetland
- Fish and Mill Creek
- Peat mining in Cranberry Lake until early 90's
- 3 Lakes: Upper Fish, Mud and Lower Fish

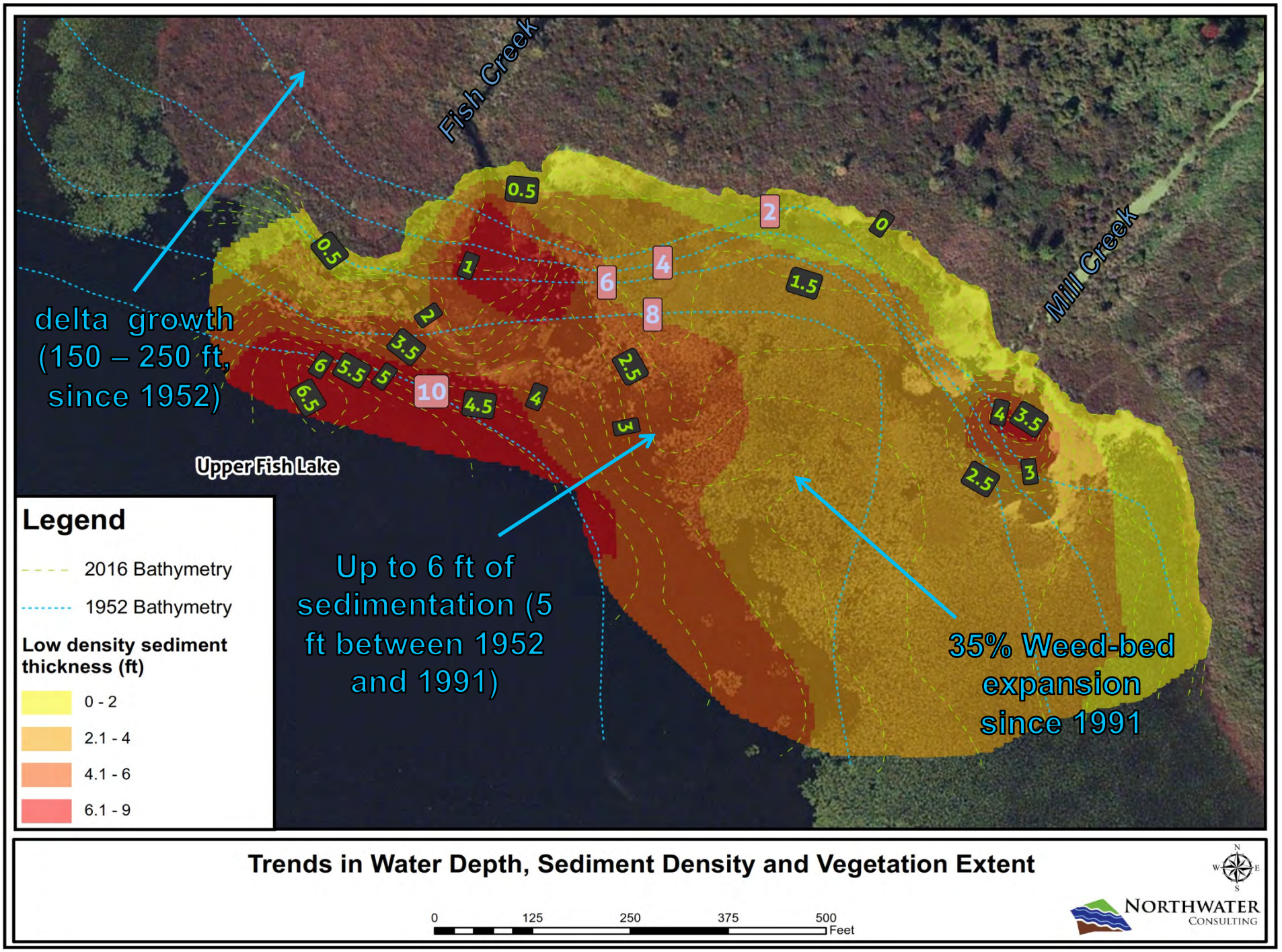


Upper Fish Lake



- First of three in Fish Lake Chain
- Natural glacial lakes
  - Concrete spillway ~1950 at Lower Fish
- Surface and groundwater fed
  - Fish and Mill Creek

- 126 acres
- Max depth 23 ft


Fish Creek
Mill Creek
Upper Fish Lake
delta growth (150 – 250 ft, since 1952)
Up to 6 ft of sedimentation (5 ft between 1952 and 1991)
35% Weed-bed expansion since 1991
Legend
2016 Bathymetry
1952 Bathymetry
Low density sediment thickness (ft)
0 - 2
2.1 - 4
4.1 - 6
6.1 - 9
0.5
0.5
1
2
6
4
2
0
1.5
8
3.5
6
5.5
5
10
4.5
4
6.5
2.5
3
4
3.5
2.5
3
Trends in Water Depth, Sediment Density and Vegetation Extent
0
125
250
375
500
Feet
N
W
E
S
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Fish Lake Diagnostic Study

- Stream sediment loading likely greater prior to 1992 when peat mining ended

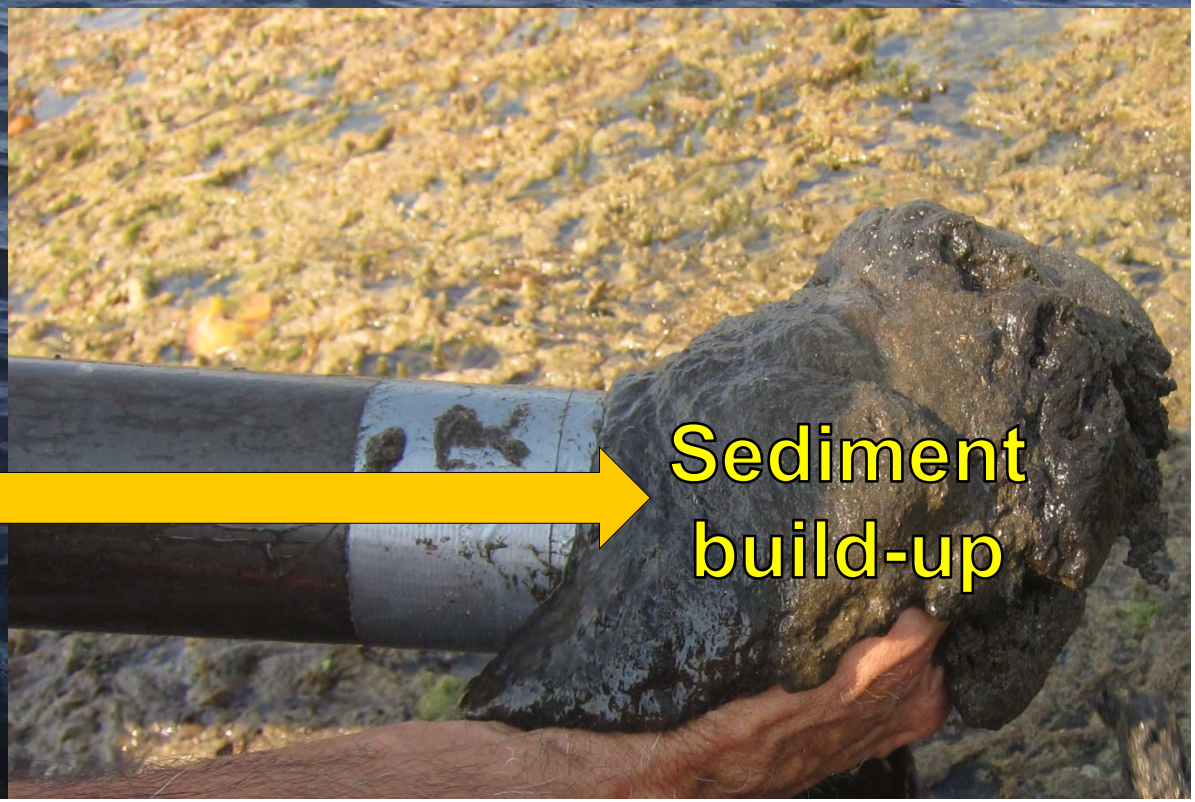
- Sediment and nutrients primarily internally sourced
  - Weed kill at peak growth
  - Storm-flow suspended sediment low (8 mg/L)

- Low dissolved oxygen near sediment-water interface

“Muck”

- High organic content, low density
- Algae and Eurasian Water Milfoil dominate
- Low dissolved oxygen (DO)

Limited benthic decomposition



Sediment build-up

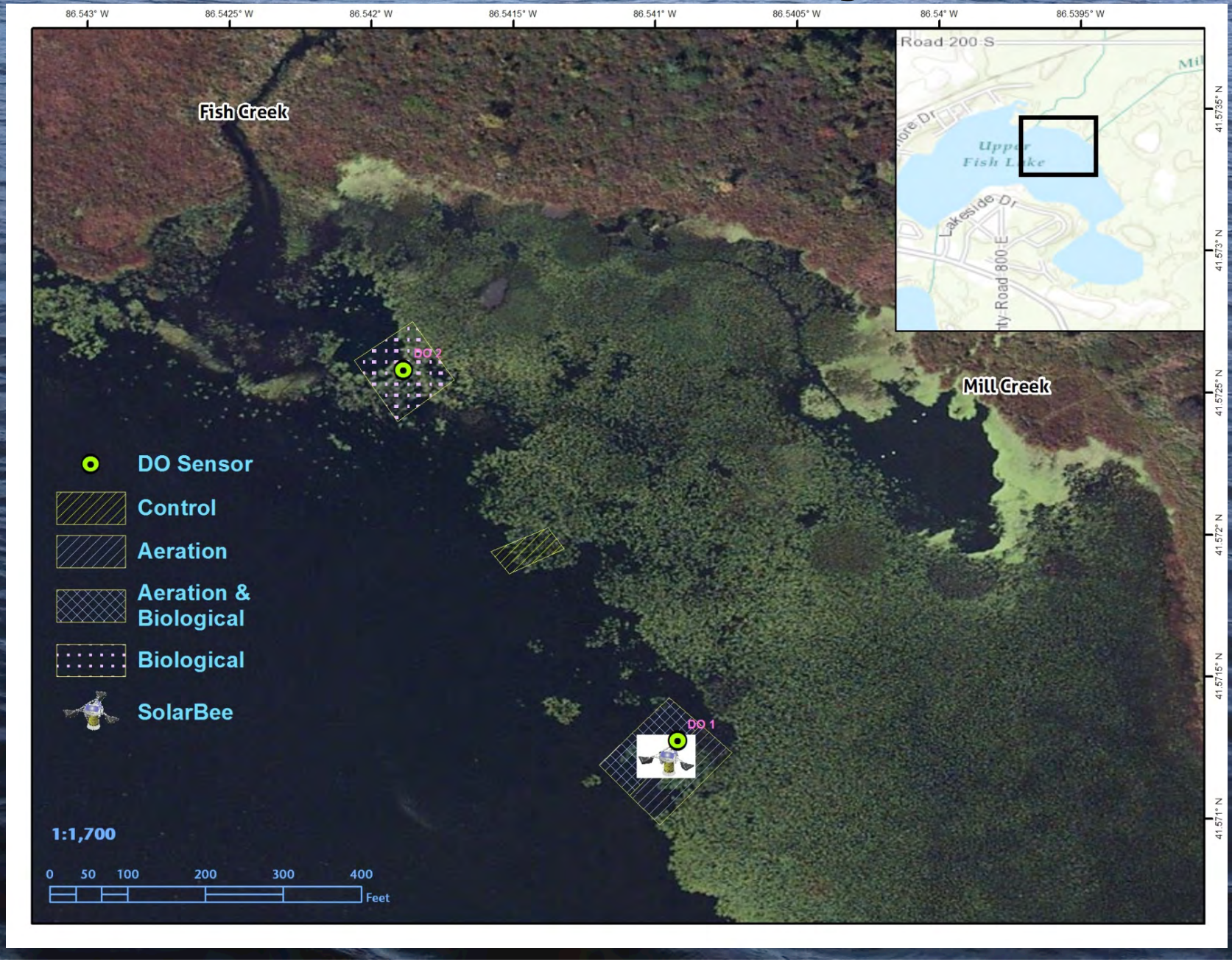
The Muck Study

HYPOTHESIS: Low dissolved oxygen and/or a lack of benthic microorganisms is limiting organic sediment decomposition, resulting in sediment build-up.

METHODS: Apply aeration and additional 'bugs' in specific areas and compare to a control area.

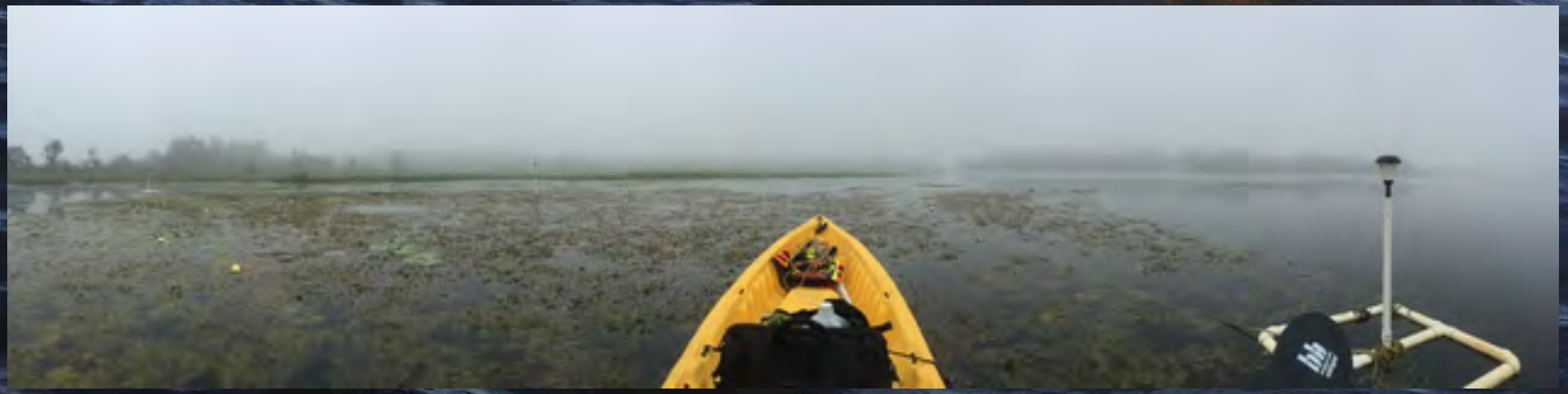
- Mechanical aeration (SolarBee™)
- Microbial augmentation (Biodyne Environoc 301)
- Control

Experimental Layout

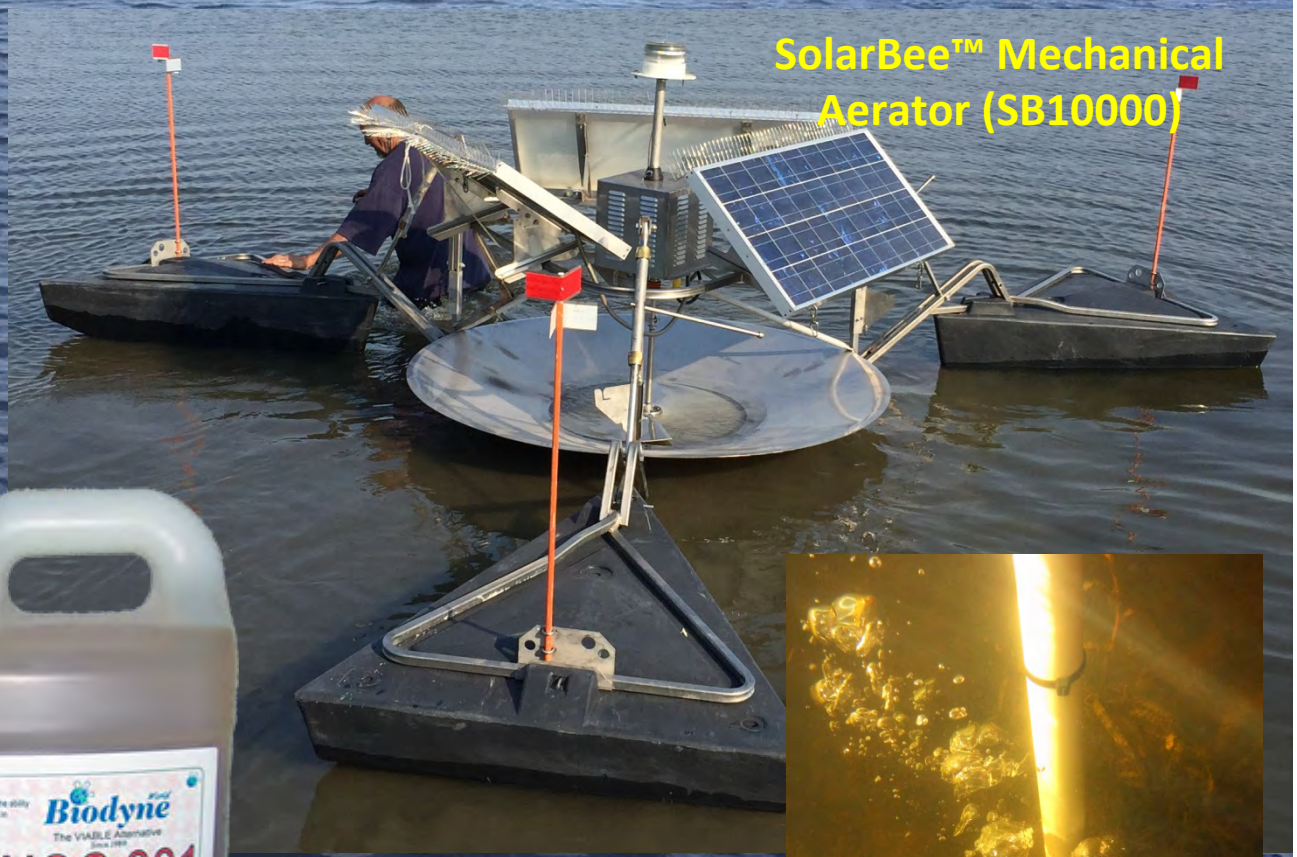


Monthly Monitoring

- April – October, 2015 & 2016
- Two dissolved oxygen data loggers
- Monthly injection of bugs into top 12” of sediment at 25 ft spacing
- Water and sediment depth measurement (spring & fall)
  - 50 in^2 and 10 in^2 disk with variable weight
- Sediment core for visual, density, and organic content
- Water quality and vegetation



Materials



SolarBee™ Mechanical Aerator (SB10000)

Results: Sediment

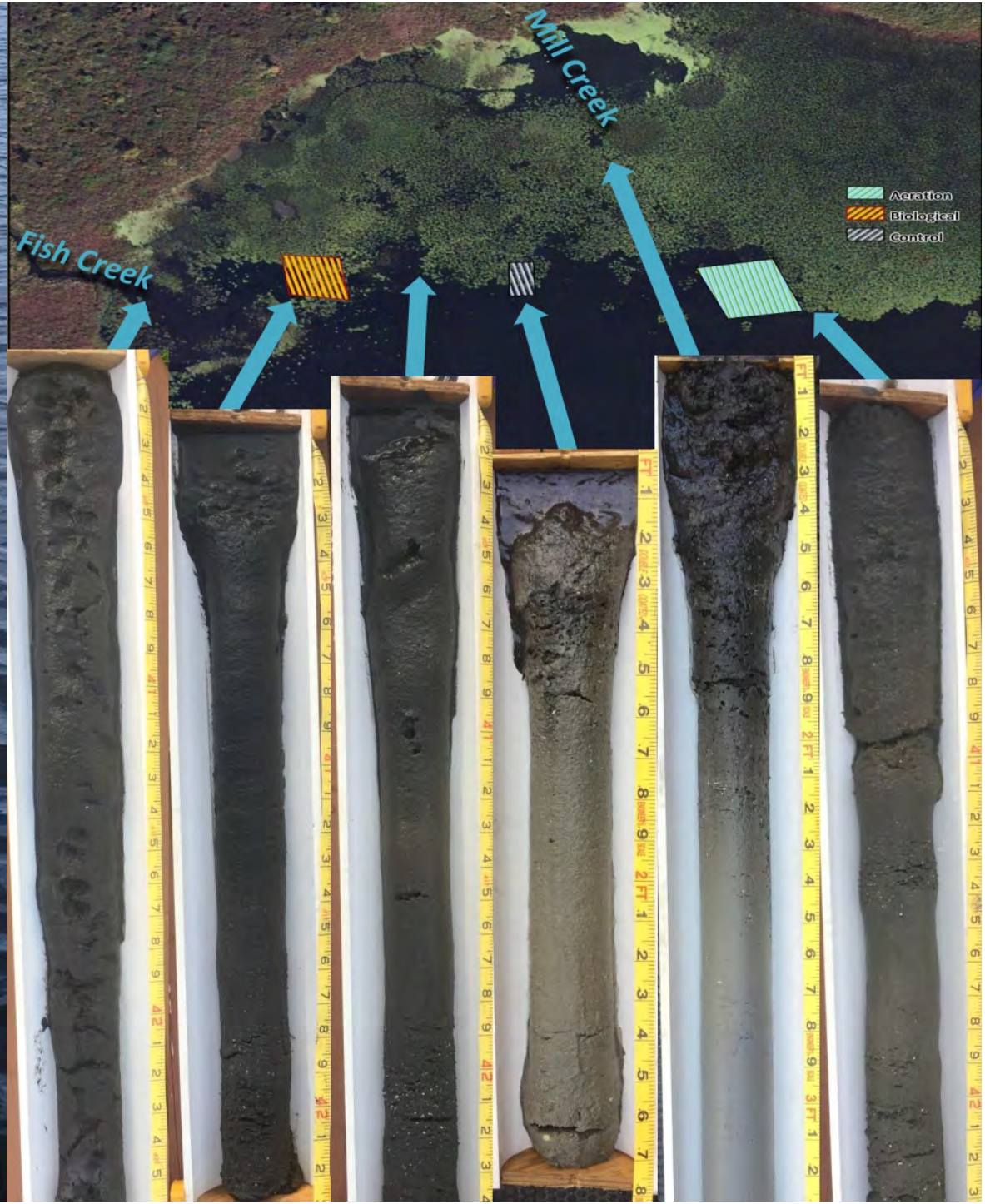
Key Point:

- Highly organic sediment primarily near Fish Creek

High dissolved oxygen consumption

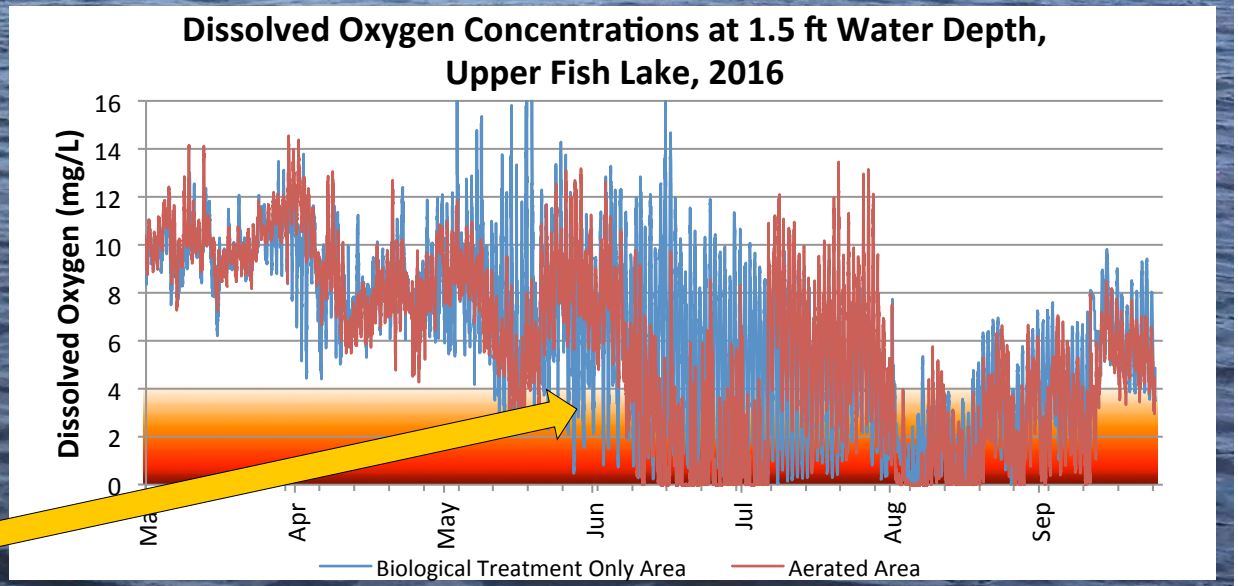
Increased algae and invasive weeds

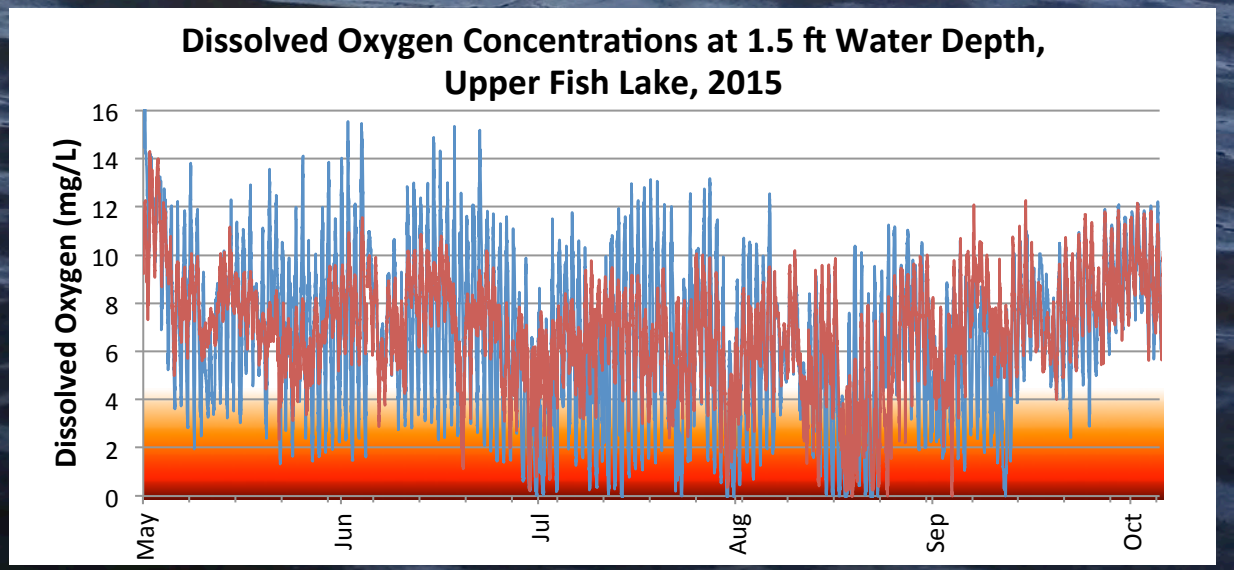
High vegetative output dies and can't decompose - adds to sediment



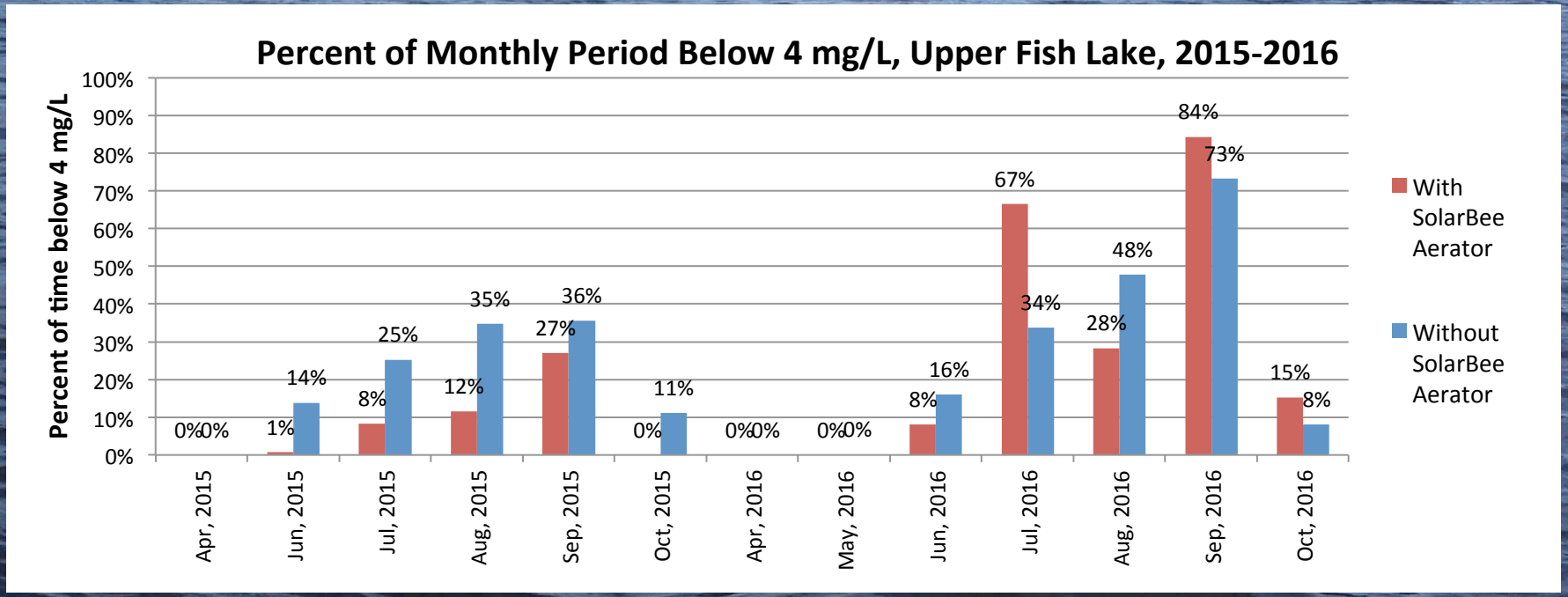
Results: Dissolved Oxygen

- Diurnal swings reduced by circulation
- Dense vegetation growth 'chokes' the flow of aerated water by early summer
- 2016 worse than 2015
- Prior to vegetation growth, aeration was effective





Results: Dissolved Oxygen



Mechanical aeration creates better conditions for sediment decomposition, however:

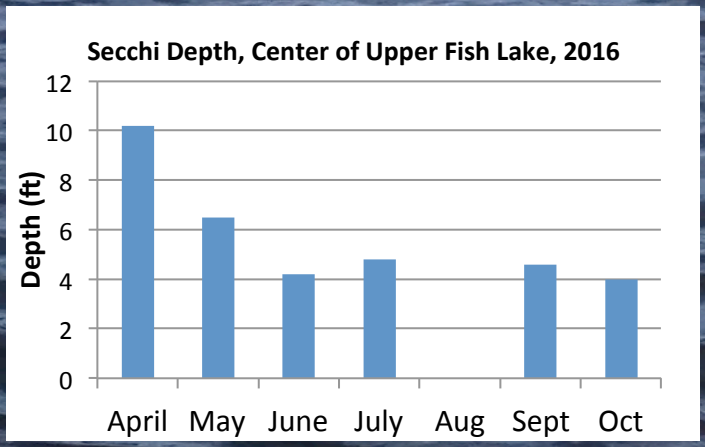
- Free water column and total water depth are critical factors in aerator effectiveness.
  - For FL, dredging could help *both* factors

Results: Vegetation & Water Quality

Early Summer

Lilly
EWM
Coontail
Stonewort/Chara

Filamentous Algae
EWM
Coontail



Peak Growing Season

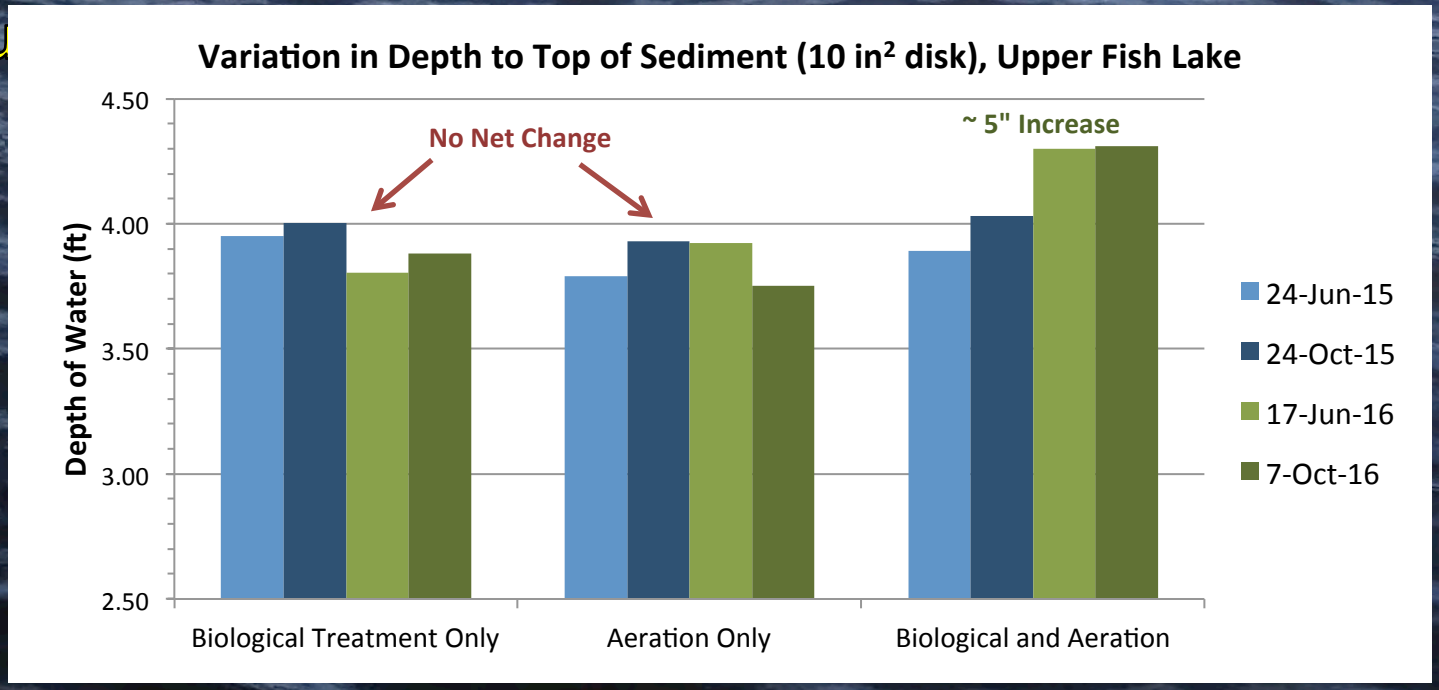
EWM
Coontail
Stonewort/Chara

EWM
Duckweed
Coontail
Wild Celery

Key Point: Emergent vegetation like lilies may appear dense, but also block light and *may* keep water column more open…

Results: Sediment Reduction

- Up to 5-inch reduction of sediment with aeration & bugs since spring 2015
- Reduction with only aeration in 2015 but not 2016
  - Aeration alone is effective during 'normal' years, but bu



Conclusions for Upper Fish Lake

1. Low dissolved oxygen is limiting decomposition of organic sediment
2. Aeration with biological augmentation is most effective at reducing sediment
3. Successful aeration relies on sufficient free water column – **need more depth**
4. Dredging (planning phase) will provide more suitable conditions for circulation of aerated water
5. Aeration and biological augmentation can significantly extend the dredging benefits

Cost-Benefit Analysis: Per Acre

Strategy (per acre, UFL)	Capital Investment	Annual Materials Cost	Annual Labor	Annual Power and Maintenance Cost	Total Annual Cost[1]	Annual Benefit[2]	Annual Benefit (sediment, yd^3)	Annual Cost-Benefit	Annual Cost-Benefit if all FLCD 'free' labor
Solarbee™	$15,000		$400		$1,000	$2,178	109	**$1,178**	**$1,578**
Solarbee™ with Biological Augmentation	$15,000	$900	$2,800		$4,300	$2,904	145	**-$1,396**	**$1,404**
Diffuser Aeration	$2,623	$50	$356	$464	$974	$2,178	109	**$1,204**	**$1,559**
Diffuser with Biological Augmentation	$2,623	$950	$2,756	$464	$4,274	$2,904	145	**-$1,370**	**$1,385**

[1] Includes capital investment considering a 25-year equipment lifespan, materials, labor, maintenance and power costs

[2] Based on current estimate of $20 per cubic yard of dredged sediment

Key Points: Labor cost 'makes or breaks' the bug component

>17 year life extension with bugs and aeration

>12 year extension with just aeration

Tips for Similar Lakes and Studies

1. Data is key
   a) Monitoring of dissolved oxygen
   b) Sediment variations (organic content, thickness)
2. No magic bullet solutions
   a) Aeration requires sufficient water depth and freedom to circulate
   b) Bugs need oxygen
   c) Vegetation types *may* alter circulation
   d) Vegetation control *may* add to organic sedimentation
3. Aeration and bio-augmentation are primarily *maintenance* techniques


Questions?
Thanks to the Fish Lake Conservancy District for having the foresight to fund this work and for logistical support during field work!