NORTHWATER
CONSULTING

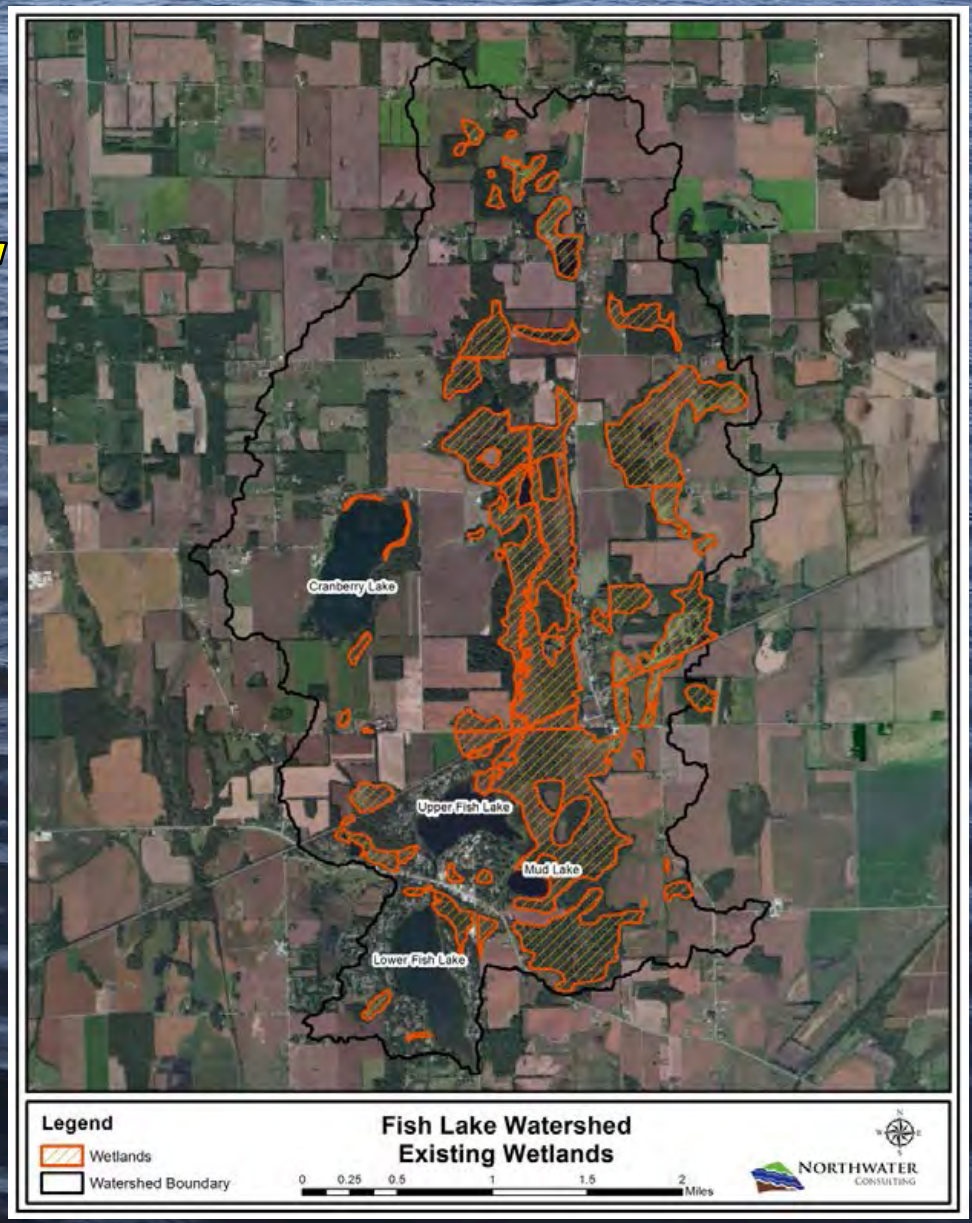
Muck Munching:

a 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

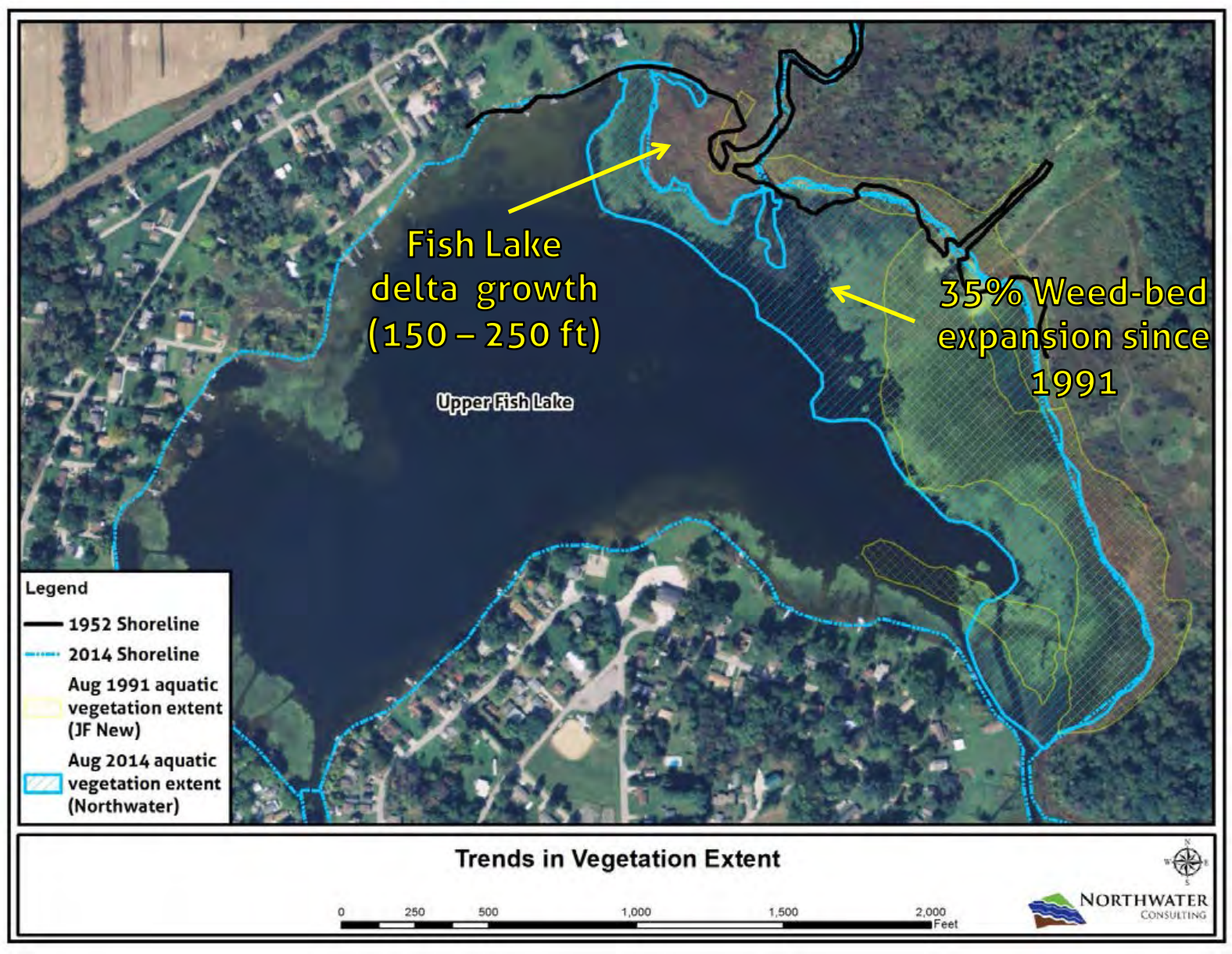


Upper Fish Lake

- 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 20 ft

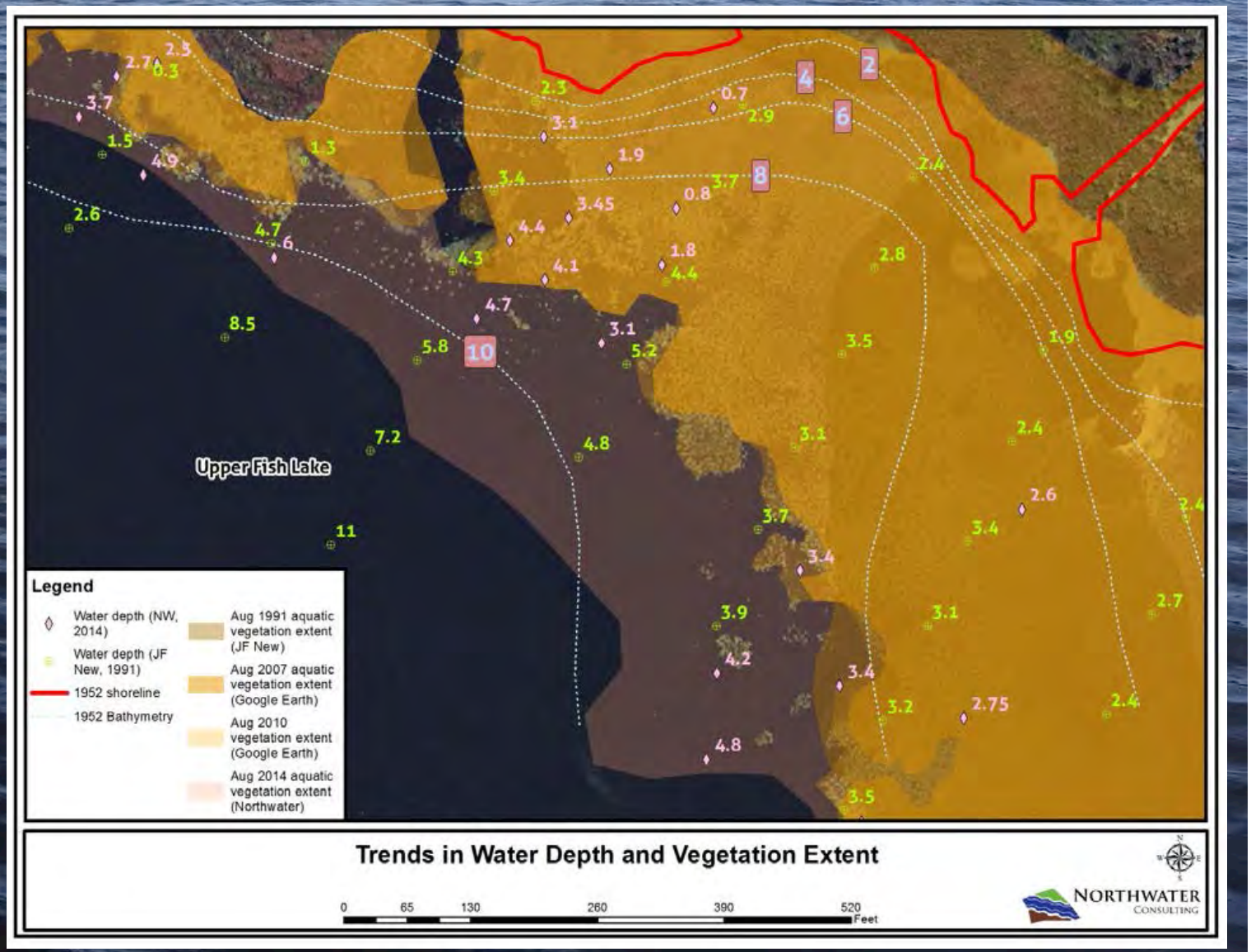
Upper Fish Lake



Depth and Vegetation

Up to 5 ft of sediment deposition since 1952

Areas of gain and loss since 1992 and end of peat mining



Fish Lake Diagnostic Study

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

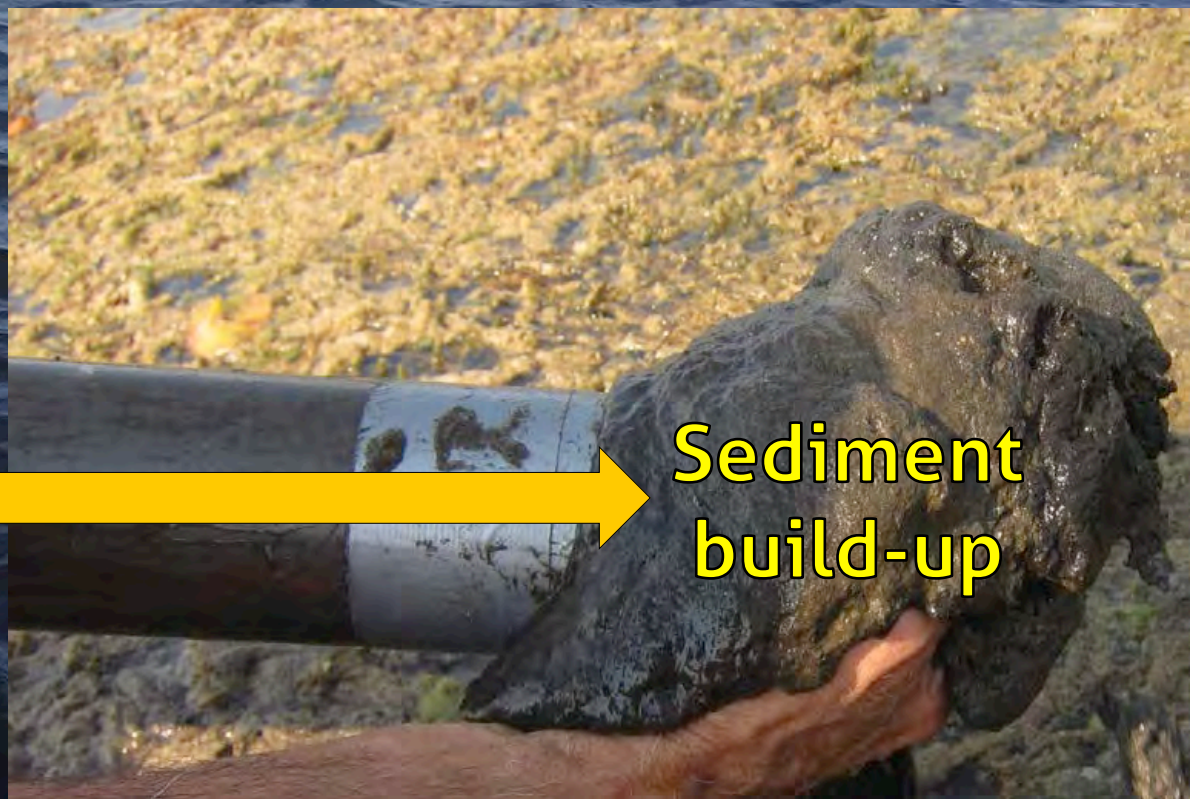
- Sediment and nutrients primarily internally sourced
  - Weed kill at peak growth
  - Storm-flow suspended sediment low (8 mg/L)

- 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.

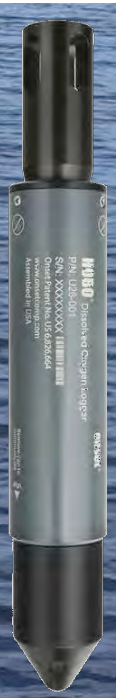
- Mechanical aeration (SolarBee™)
- Microbial augmentation (Biodyne Environoc 301)
- Control

Experimental Layout

Monthly Monitoring

- April – October, 2015
- Two dissolved oxygen data loggers
- Monthly injection of bugs into top 12" of sediment at 25 ft spacing
- Sediment measurement:
  - Depth to first resistance
  - Depth to 0.2, 0.4 and 0.6 pounds per square inch
- Sediment core for visual, density, and organic content

Materials



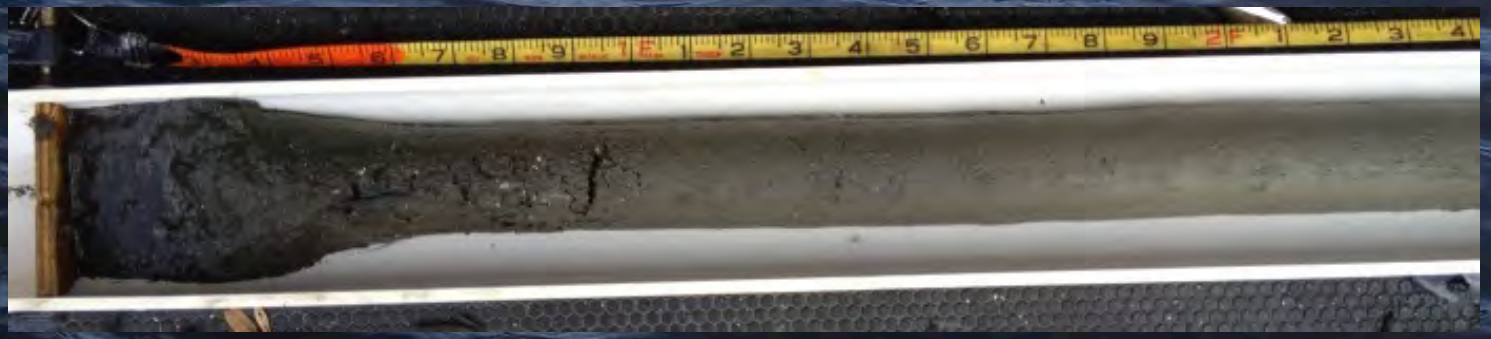
SolarBee™ Mechanical Aerator (SB10000)

Results: Sediment Coring

Microbial augmentation zone (near mouth of Fish Creek

Aerated zone

Control zone



Sediment Characteristics

Key Points:

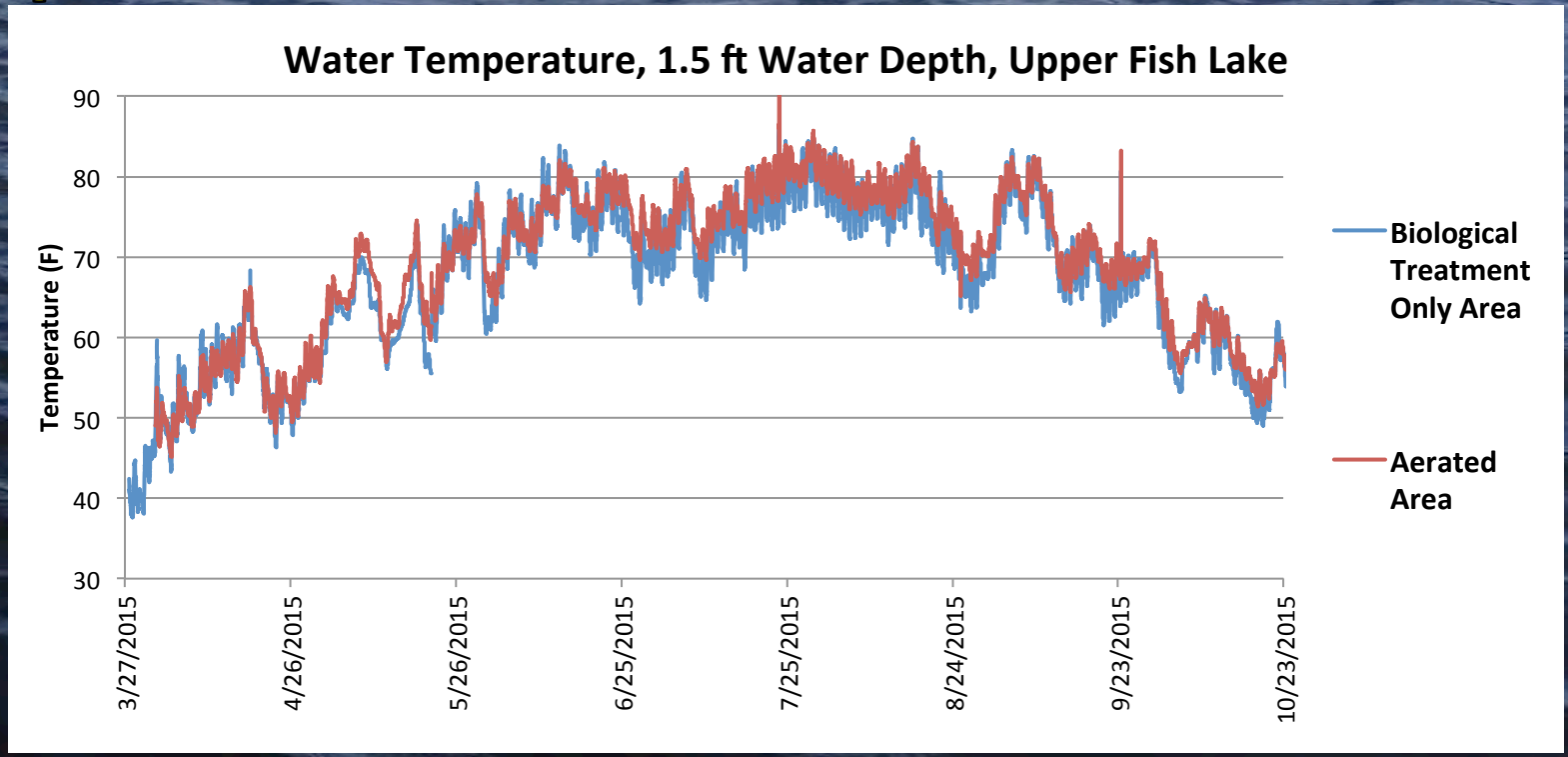
1. Organic content decreases, while density and inorganic carbon increases away from Fish Creek
2. Sediment characteristics vary widely and may require multiple strategies (aeration, dredging, etc)

	Biological Only	Biological with Aeration	Aeration Only	Control
Wet bulk density (lb/ft3)	70	79	82	78
Dry bulk (lb/ft3)	29	31	30	32
Percent Solids (%)	12%	28%	28%	35%
FOC (%)	23%	6%	6%	4%
IC (%)	2%	6%	6%	7%
TC (%)	25%	12%	12%	12%
OC/IC	9.7	1.1	1.2	0.8

Sample average of top 12 inches of sediment in each study zone

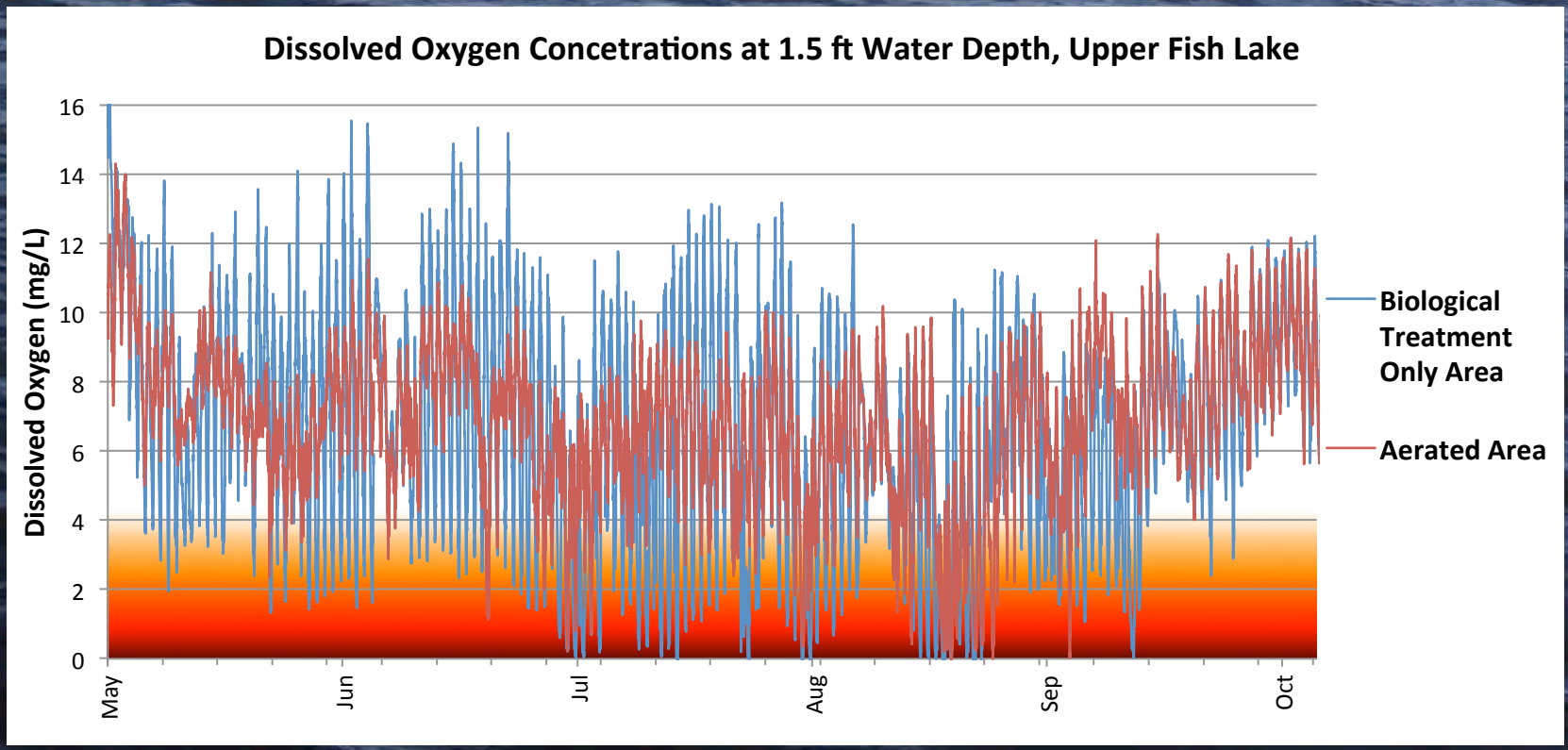
Temperature

- Shows effect of mechanical aeration mixing the water column
- Colder dips in the spring likely due to stream input of colder water



Dissolved Oxygen

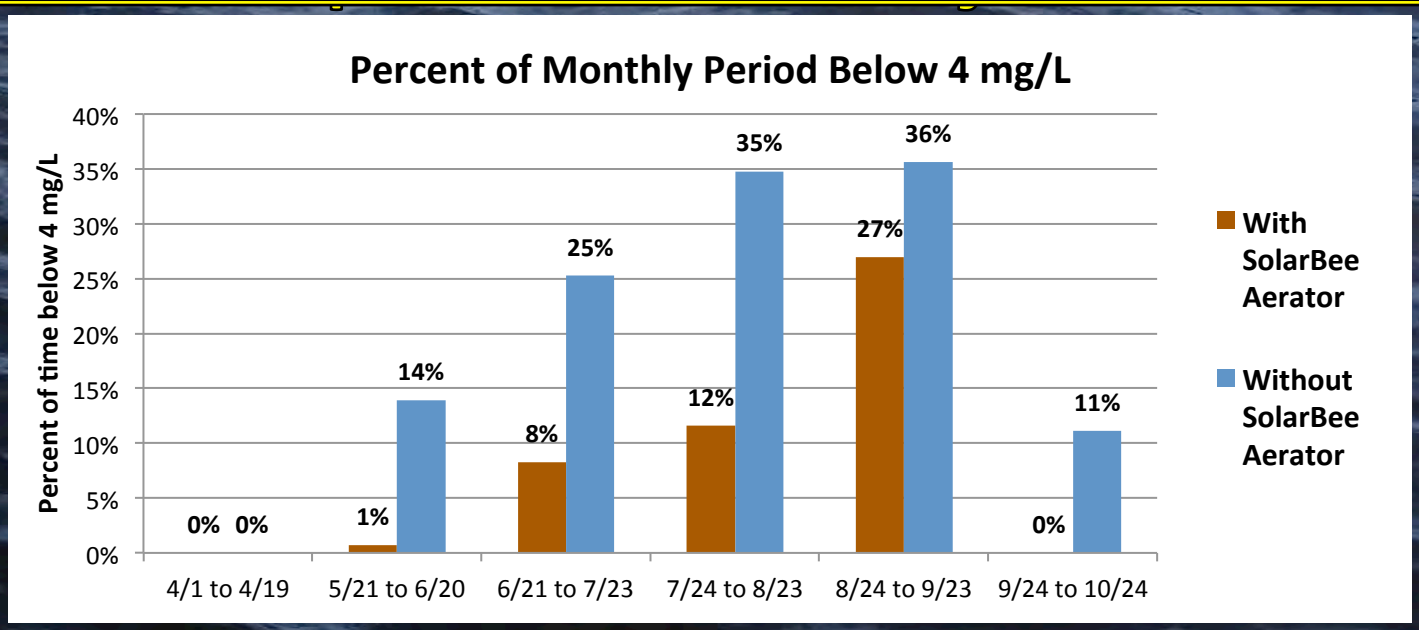
- Diurnal DO swing greatly reduced with mechanical aeration
- DO levels below 4 mg/L 23.9 % of time without aeration, but only 9.4% of time with aeration



Results: Dissolved Oxygen

- Aerator very effective during most of season
  - Loses efficacy when submerged vegetation reaches peak growth (September)
- Most significant benefit in May - August

Mechanical aeration creates better conditions for benthic decomposition which may reduce sediment

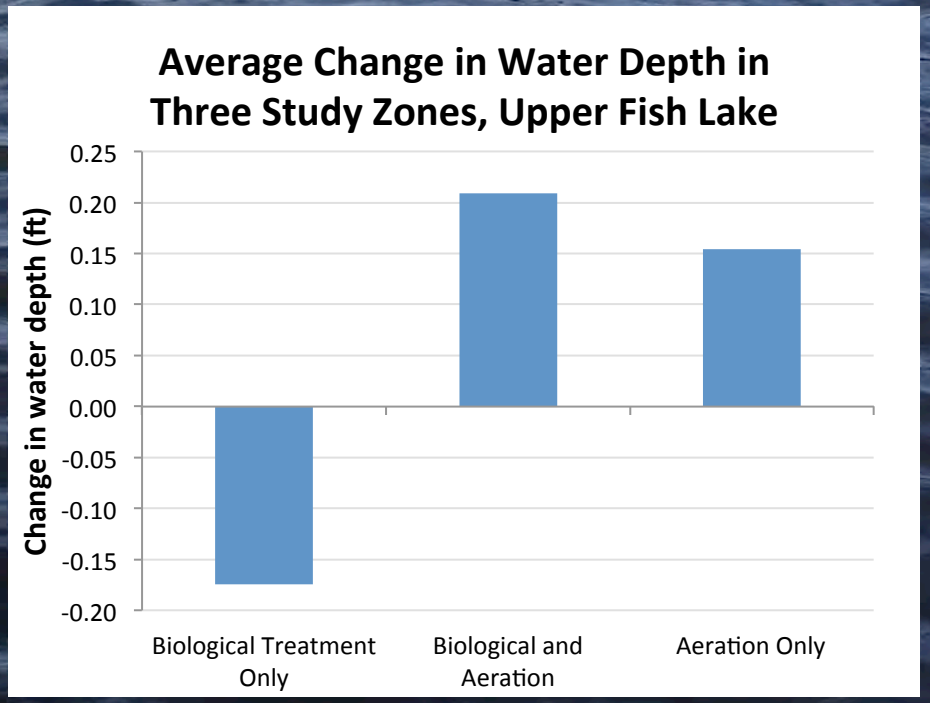


Results: Sediment Reduction

- 2-inch reduction of sediment with aeration & bugs
- 1.5-inch reduction with aeration only
- Slight sediment increase with bugs only, likely due to increased algae and vegetation and proximity to Fish Creek

Sediment thickness and density difficult to measure due to the expansive submerged vegetation

April and October: best times to measure depth



Conclusions

1. Mechanical aeration resulted in significantly improved dissolved oxygen conditions
2. Aerated zones achieved sediment reduction compared to zones without aeration where little to no sediment reduction was observed
3. Microbial augmentation appears to supplement additional reductions only when paired with aeration
4. Vegetation growth affects both mechanical aeration efficiency and the accuracy of depth measurement

Recommendations

1. Additional year of study, beginning April 2016 to better determine
    1. whether microbial treatment is effective without aeration
    2. and if it provides sufficient benefits when paired with aeration to warrant the extra expense
    3. relationship between late Fall and early spring sediment after weed die-back and winter settlement
    4. Month-to-month comparison, i.e. April 2015 to April 2016 and October 2015 to October 2016
2. Dredging study to evaluate feasibility of removing relatively higher density sediment in some locations to 'kick-start' the aeration process by reducing submerged vegetation


Questions?