

Hydrilla verticillata

- Grows to 25 ft long, creating dense floating mats of vegetation.
- Reproduces from fragments (one leaf whirl adequate)
- Reproduces from Turions (“Seeds”)
- Reproduces from Tubers on roots (subterranean turions, like small potatoes)

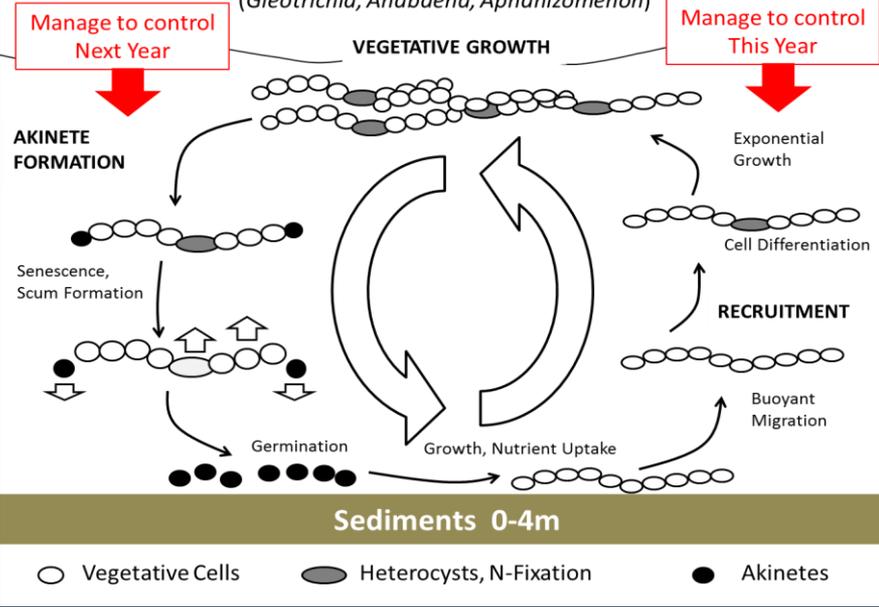
Photo from
MI SeaGrant

Do fragments re-root, does it reproduce like an annual, like a perennial? YES

(Modified from Kortmann, 2015)

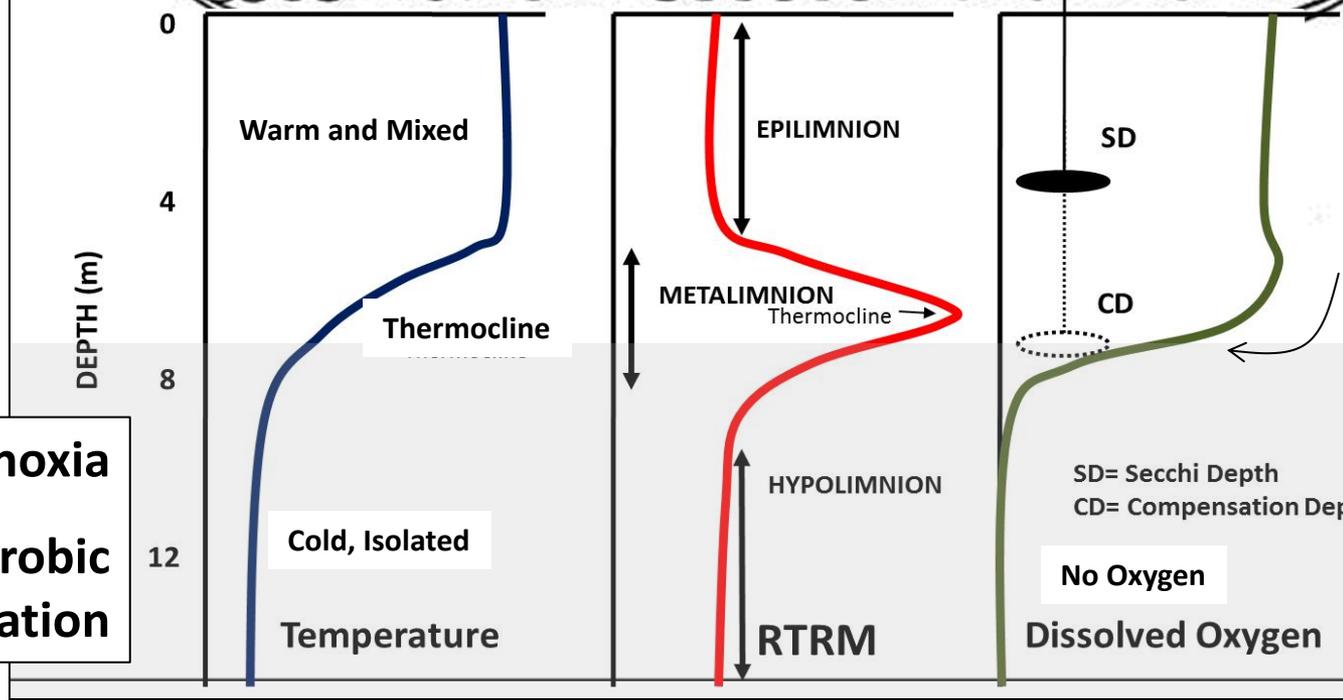
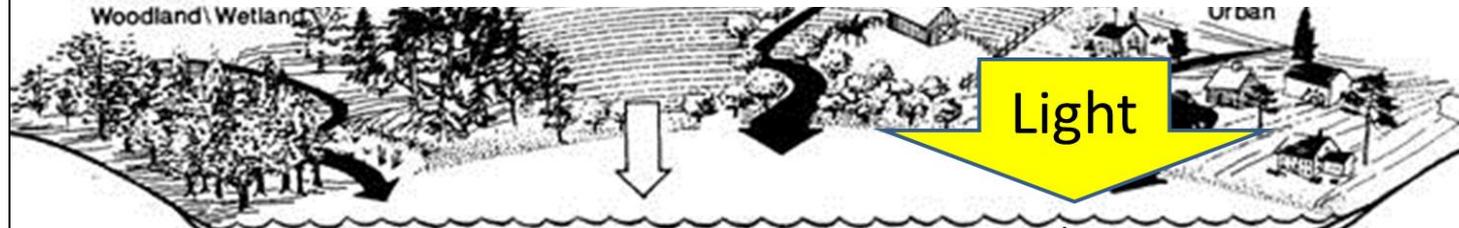
Life Cycle of N-Fixing Akinete-Forming Cyanobacteria

(*Gleotrichia*, *Anabaena*, *Aphanizomenon*)



Cyanobacteria

Thermal Stratification: *May to September*



Anoxia
Anaerobic Respiration

Phosphorus
Ammonia-N
Iron (Fe)
Sulfide, Manganese
CO₂

Deep water becomes devoid of oxygen and accumulates:

- Soluble Reactive **Phosphorus** (SRP)
- **Ammonia Nitrogen** (from amino acid breakdown and lack of nitrification)
- Reduced **Ferrous Iron** (Fe^{+2}) Manganese (Mn) and Sulfide ($S^{=}$)
- Carbon Dioxide (which decreases pH)

Concerns about a Herbicide Treatment during Summer Stratification

(Originally planned for July, actually conducted August 10-11)

- Killing 9 acres of aquatic vegetation could result in a large load of decaying organic matter (detritus) which could intensify the demand for dissolved oxygen, increase anaerobic respiration, increase internal nutrient loading from sediments and stimulate Cyanobacteria.
- Nutrients and organic matter would be released from dead plants, stimulating heterotrophic bacteria and Cyanobacteria.
- Water transparency could decrease, and adequate light penetration for oxygen production by photosynthesis may no longer penetrate the thermocline, adversely effecting cool water habitat for fish and the animals that graze on algae

(Note: Copper-based algaecides should be avoided at Coventry Lake).

What to Watch to determine whether impacts occurred:

- Increase in Heterotrophic Bacteria (breaking down the dead plant material)
- Increase in Dissolved or Total Organic Carbon
- Increase in Iron (Fe) – Anaerobic Respiration Product
- Increase in Manganese (Mn) – Anaerobic Respiration Product
- Increase in Total Phosphorus (esp. in deep strata)
- Increase in Nitrogen Compounds (esp. in deep strata)
- Increase in Cyanobacteria (AKA Blue Green Algae)
- Decrease in Secchi Disk Transparency (water clarity)

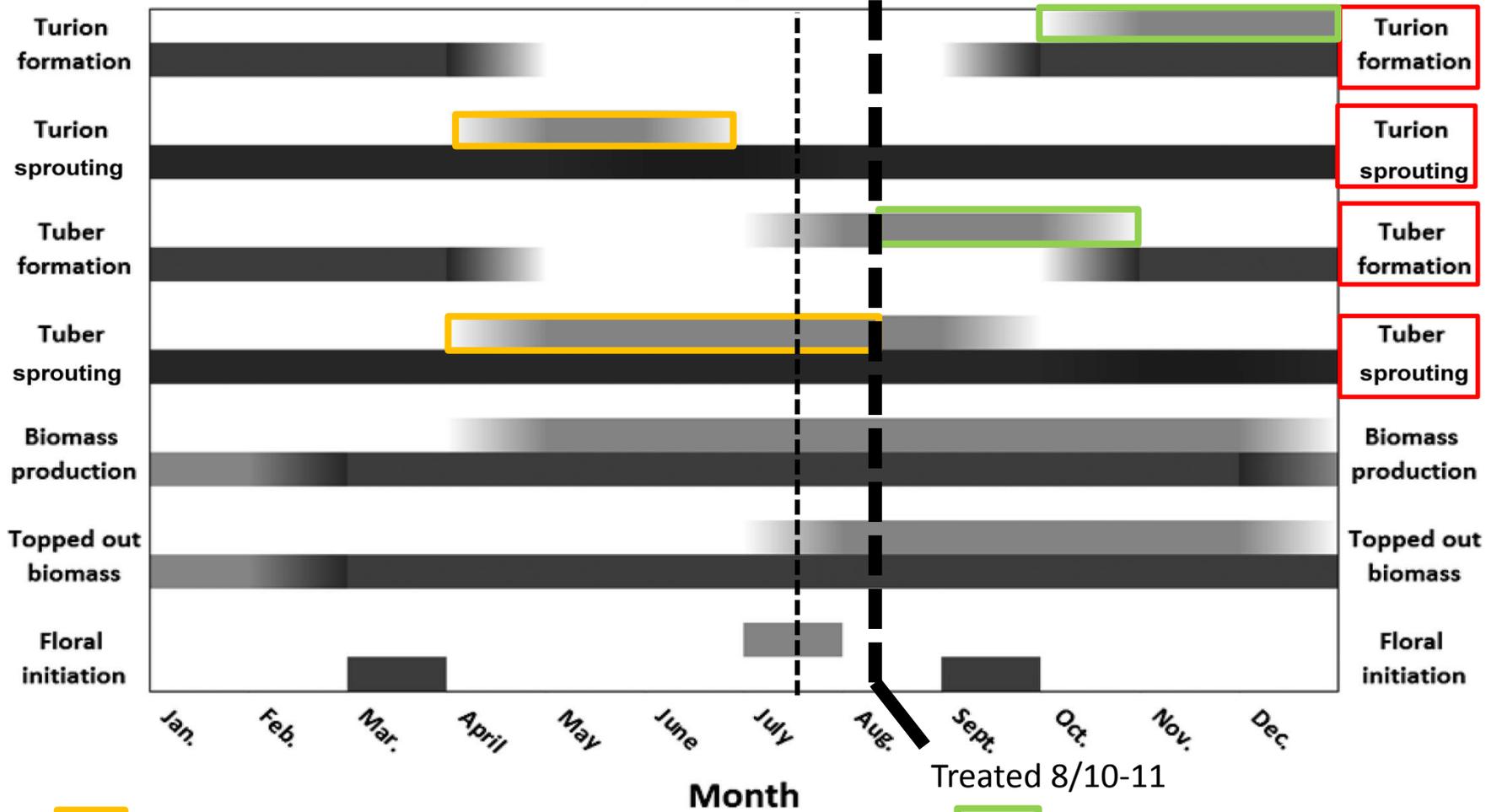
What to Watch to determine whether impacts occurred:

- Heterotrophic Bacteria: more than doubled at 3m, 6m, and 11m deep.
- Total Organic Carbon: remained at similar concentrations.
- Iron (Fe) increased 13x in deep strata.
- Manganese (Mn) increased approximately 60% in deep strata.
- Total Phosphorus (TP) increased 6x in deep strata, modest increases at 1m and 3m deep.
- Nitrogen Compounds:
 - Total Nitrogen increased 3.6x in deep strata;
 - Ammonia-N increased 330x in deep strata
- Cyanobacteria increased 7.8x
- Secchi Disk Transparency (Water Clarity) decreased a modest 2.3 ft.; Turbidity and Total Suspended Solids more than doubled in deep strata.
- The post-treatment Total Phosphorus (TP) concentration in deep strata was the highest August-September concentration observed over the past decade (approximately twice the next highest concentration).
- The post-treatment Total Phosphorus (TP) concentration in deep strata was the highest recorded TP concentration in any sample, from any depth, on any date, since 1999.
- The Iron (Fe) concentration in deep strata following treatment was the highest observed over the past decade.
- The Manganese (Mn) concentration in deep strata following treatment was the highest observed over the past decade.
- The Cyanobacteria density, although exhibiting a significant post-treatment increase, was not unusually high compared to August and September densities observed since 1999.

Thermal Stratification

Originally planned July Treatment

Monoecious hydrilla in NC
 Dioecious hydrilla in FL



Aquathol kills vegetative portions, desired timing is when maximum vegetation is exposed

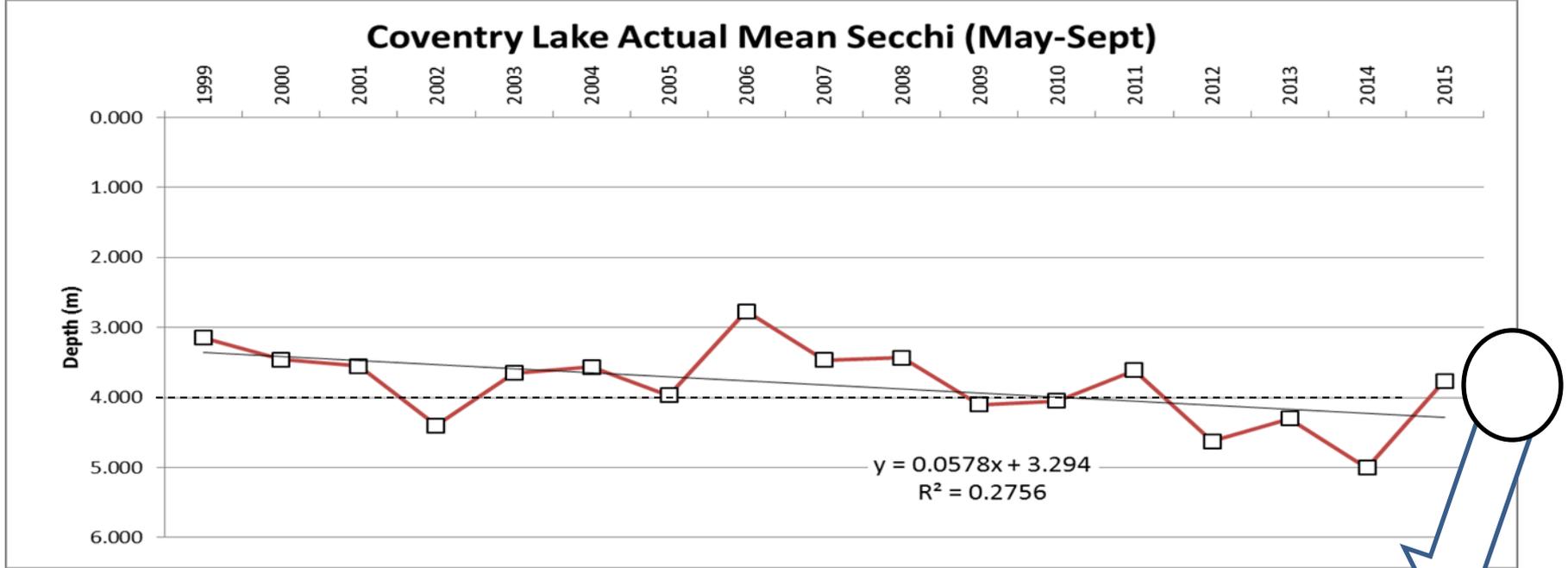


Treatment is desired before significant production of Turions and Tubers

Treated 8/10-11

Further North sprouting is likely delayed, turion and tuber formation may be earlier.

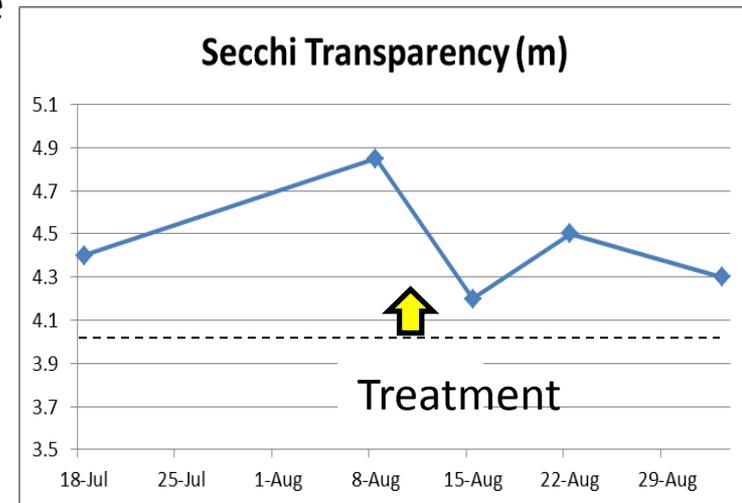
Sarah True-Meadows, et. al., 2016. *Monoecious hydrilla—A review of the literature*, *J. Aquat. Plant Manage.* 54: 1–11



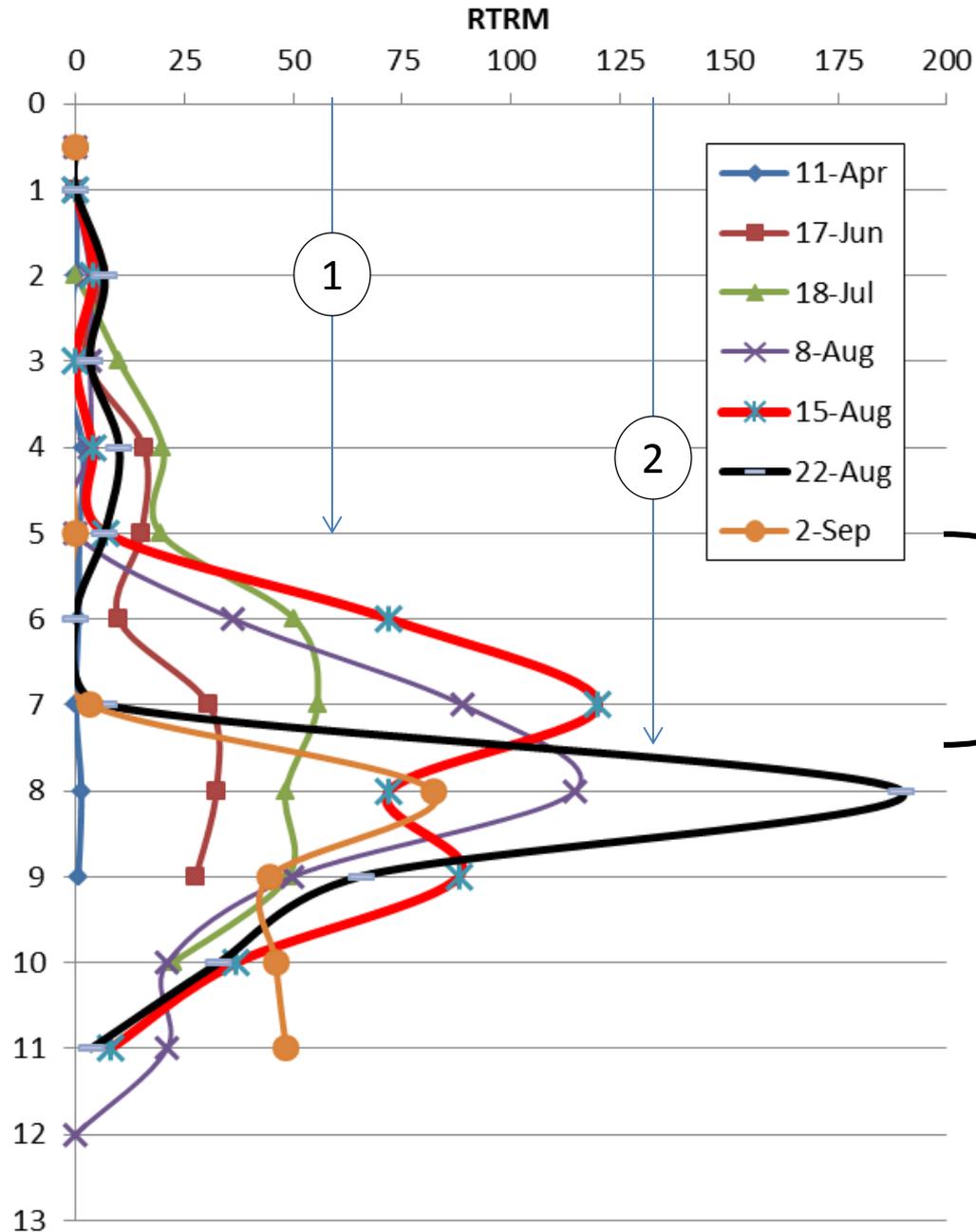
Secchi disk transparency (light penetration) decreased by approximately 2.3 feet after the Hydrilla treatment. That decrease could have been due to the intense heat wave we experienced and intense lake use. Although treatment may have contributed to the modest transparency decline, Secchi transparency remained greater than 4m.

Aquathol appears to be slower-acting than the Clipper Treatment at Eagleville Lake and elsewhere (both are contact herbicides that kill vegetative portions of the plants). Hence, detrital load (dead organic matter) tends to be more gradual.

2016



Coventry Lake 2016 RTRM Profiles



The warm, well-mixed, surface layer in Coventry Lake typically extends down to approximately 5m for most of the summer (1).

Between August 15 and 22 a mix-down occurred, pushing the thermocline approximately 2m deeper (2).

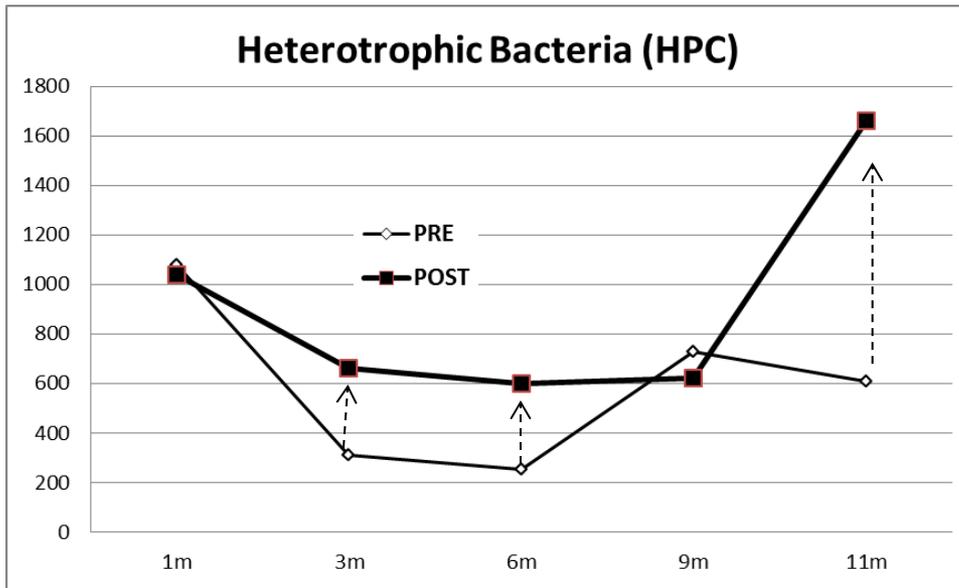


Coventry Lake 8/22/16

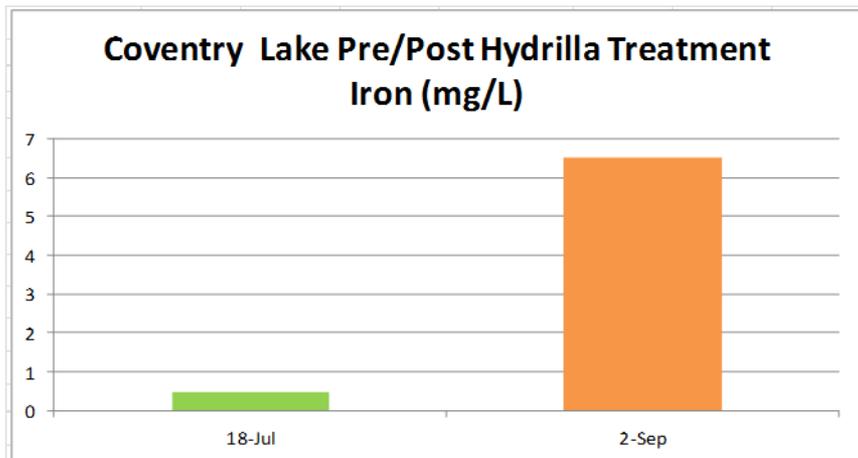
Submerged macrophytes in the treated bay were collapsing.

Chara appears to have been affected.

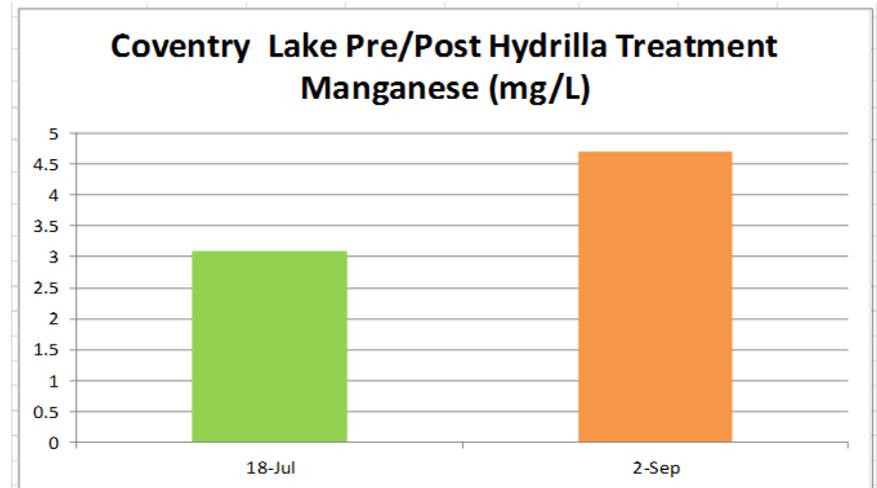
One dead floating walleye observed, not related to the treatment- probably catch-release mortality.



Heterotrophic Bacteria (HPC) increased at 3m, 6m, and over-bottom following the Hydrilla treatment.

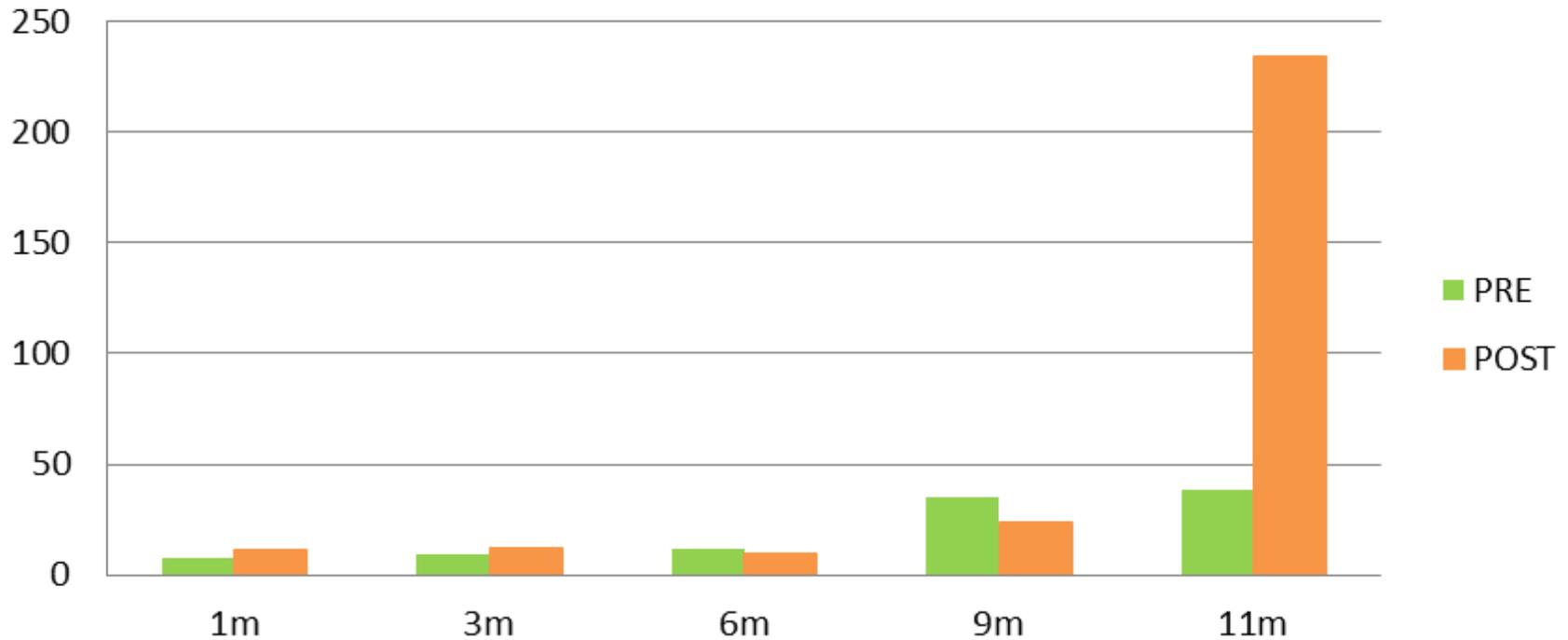


Over-Bottom Iron increased 13 x following treatment.



Over-Bottom Manganese increased by 1.6 mg/L following treatment.

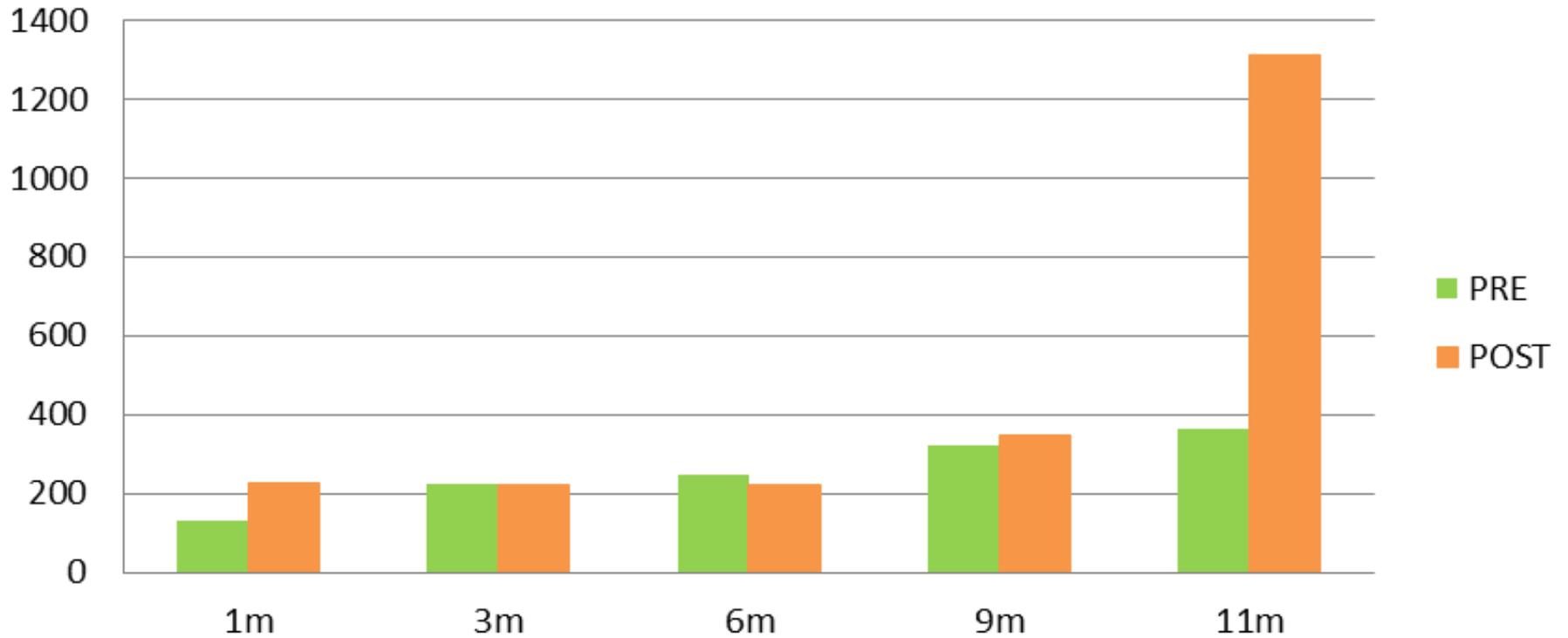
Total Phosphorus ($\mu\text{g/L}$)



Total Phosphorus as P ($\mu\text{g/L}$)		
Depth (m)	18-Jul	2-Sep
1m	8	11
3m	9	12
6m	12	10
9m	35	24
OB	38	234

Total Phosphorus exhibited a significant increase in deep strata following Hydrilla treatment.

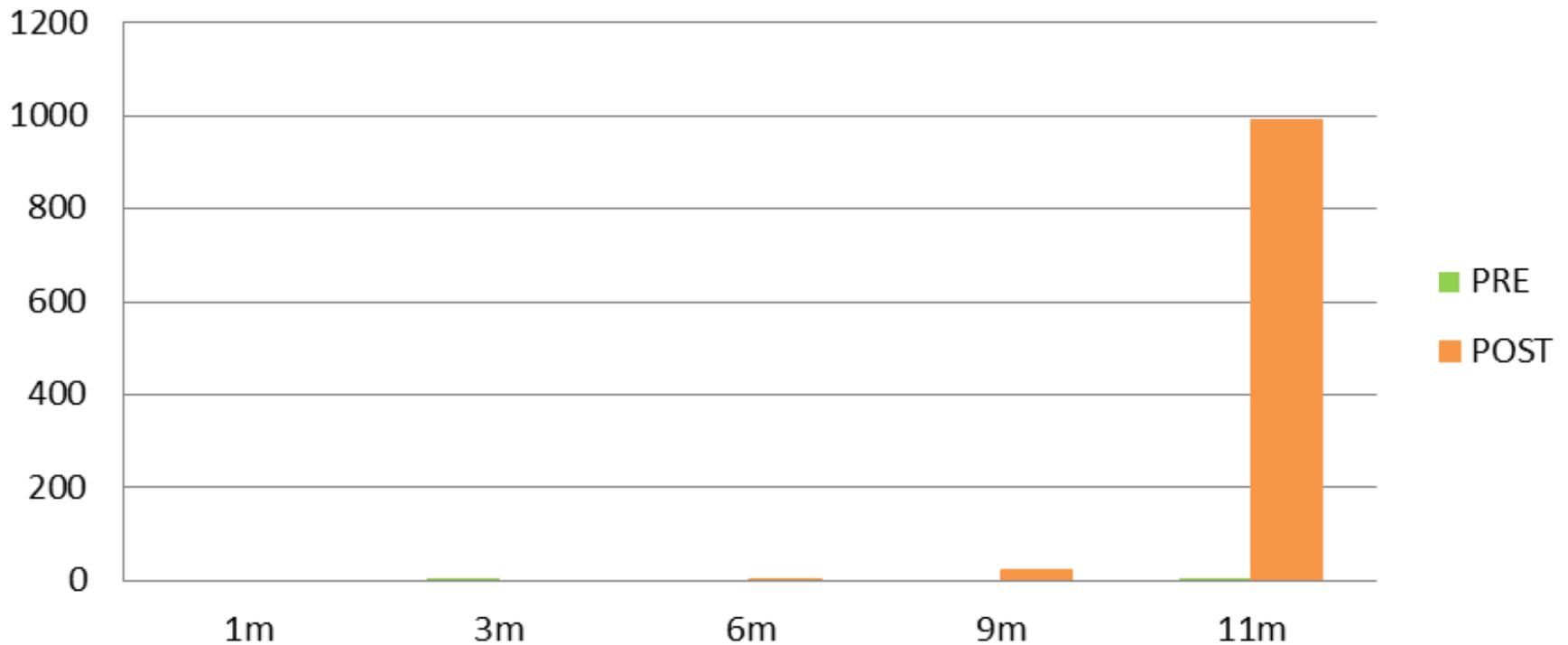
Total Nitrogen ($\mu\text{g/L}$)



Total Nitrogen ($\mu\text{g/L}$)		
Depth (m)	18-Jul	2-Sep
1m	130	229
3m	225	222
6m	249	224
9m	322	346
OB	362	1314

Total Nitrogen exhibited a significant increase in deep strata following Hydrilla treatment.

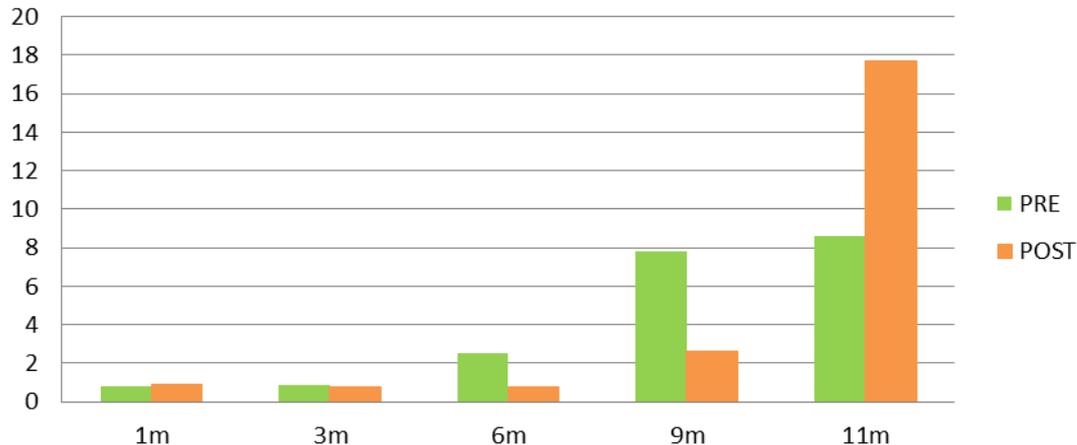
Ammonia as N ($\mu\text{g/L}$)



Ammonia as N ($\mu\text{g/L}$)		
Depth (m)	18-Jul	2-Sep
1m	ND	ND
3m	3	ND
6m	ND	4
9m	ND	23
OB	3	992

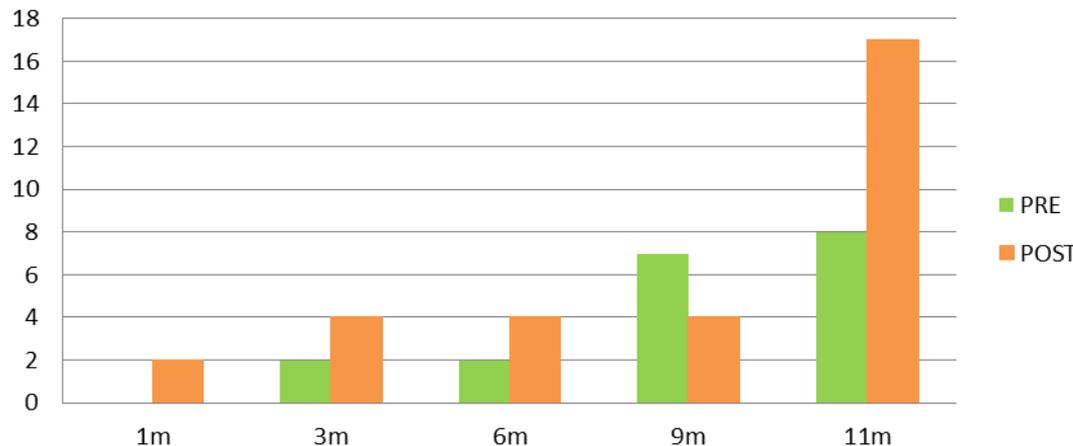
Ammonia-N exhibited a significant increase in deep strata following Hydrilla treatment.

Turbidity ($\mu\text{g/L}$)



Turbidity ($\mu\text{g/L}$)		
Depth (m)	18-Jul	2-Sep
1m	0.8	0.9
3m	0.9	0.8
6m	2.5	0.8
9m	7.8	2.6
OB	8.6	17.7

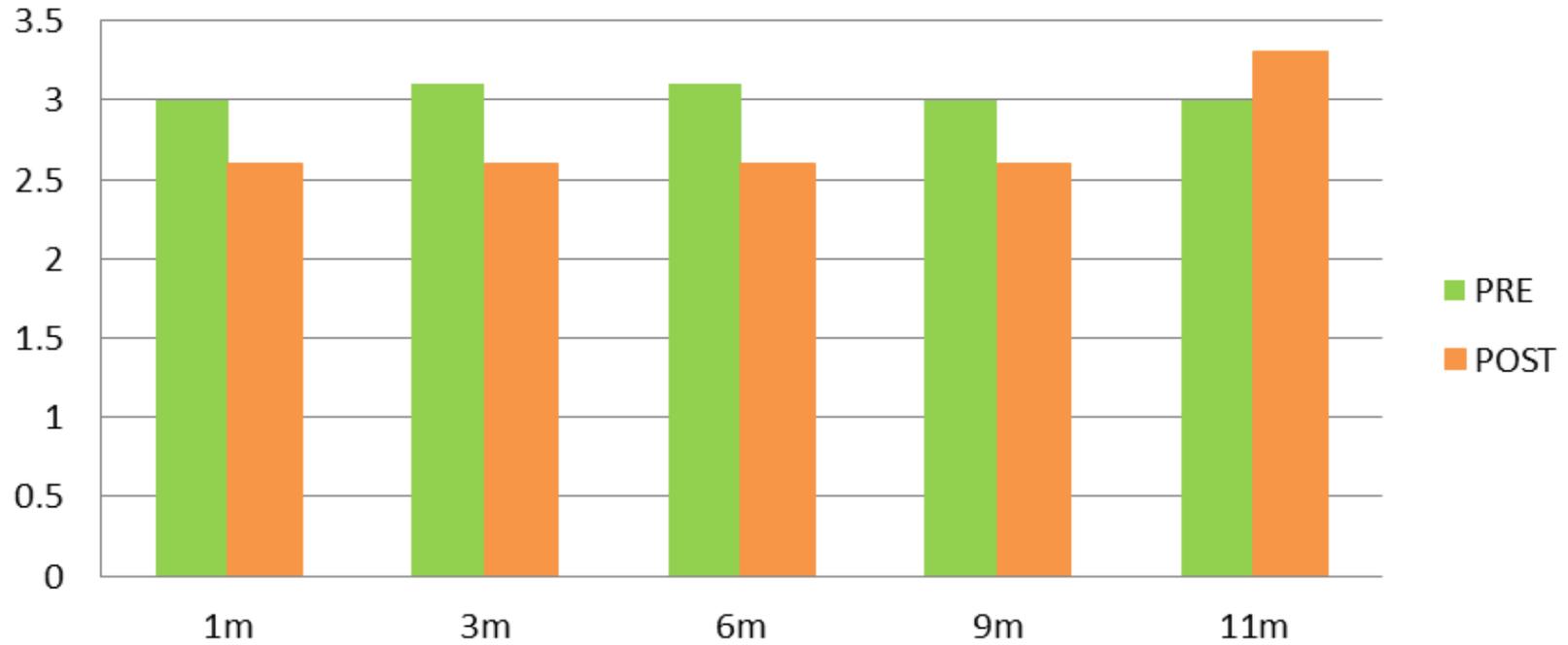
TSS (mg/L)



TSS (mg/L)		
Depth (m)	18-Jul	2-Sep
1m	ND	2
3m	2	4
6m	2	4
9m	7	4
OB	8	17

Turbidity and Total Suspended Solids exhibited significant increases in deep strata following Hydrilla treatment.

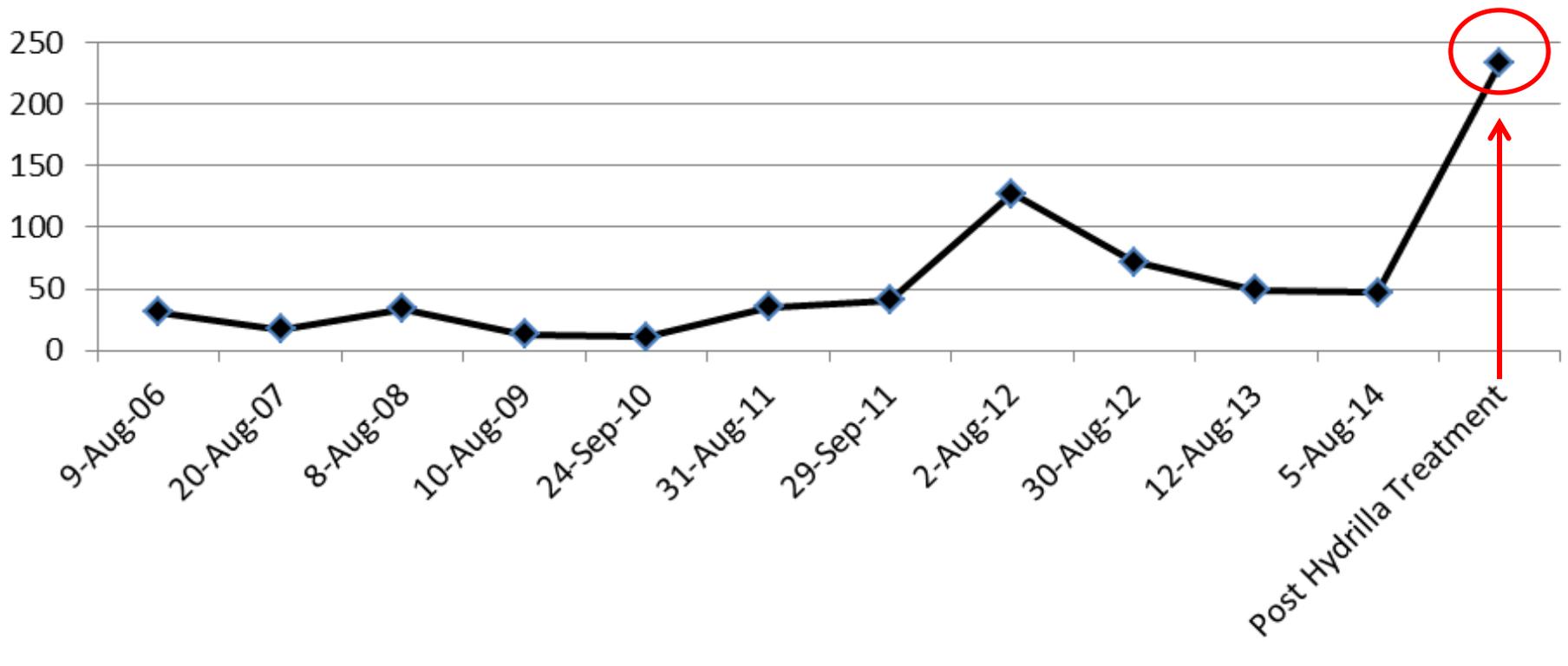
Total Organic Carbon (mg/L)



Total Organic Carbon (mg/L)		
Depth (m)	18-Jul	2-Sep
1m	3	2.6
3m	3.1	2.6
6m	3.1	2.6
9m	3	2.6
OB	3	3.3

TOC did not exhibit a significant change following Hydrilla treatment.

Deep Water TP Late Summer Past Decade



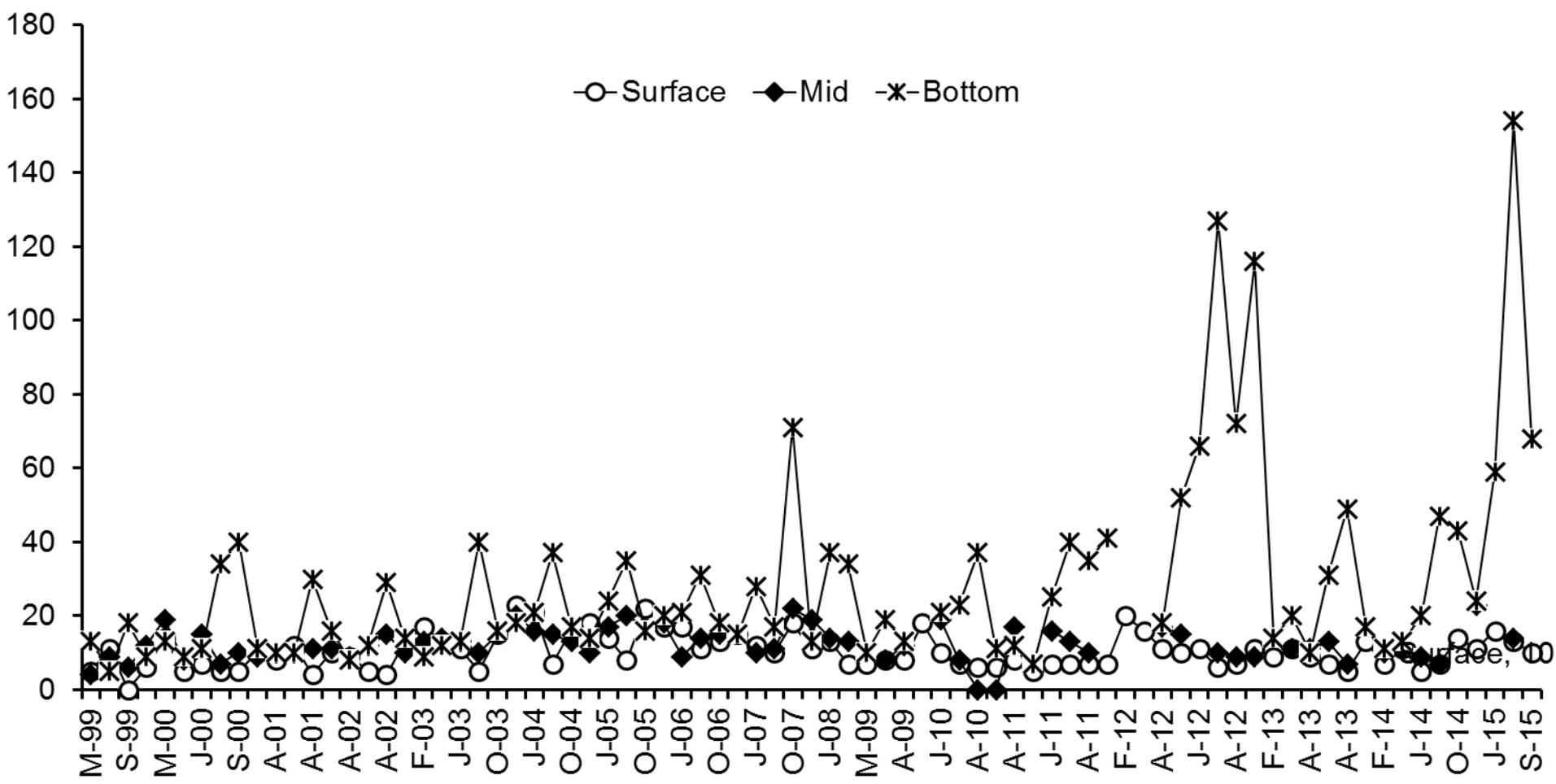
Total Phosphorus (TP) in the deep layer of Coventry Lake was higher than during any August or September sampling in the past decade.

Deep TP Following Hydrilla Treatment = 234 $\mu\text{g/L}$

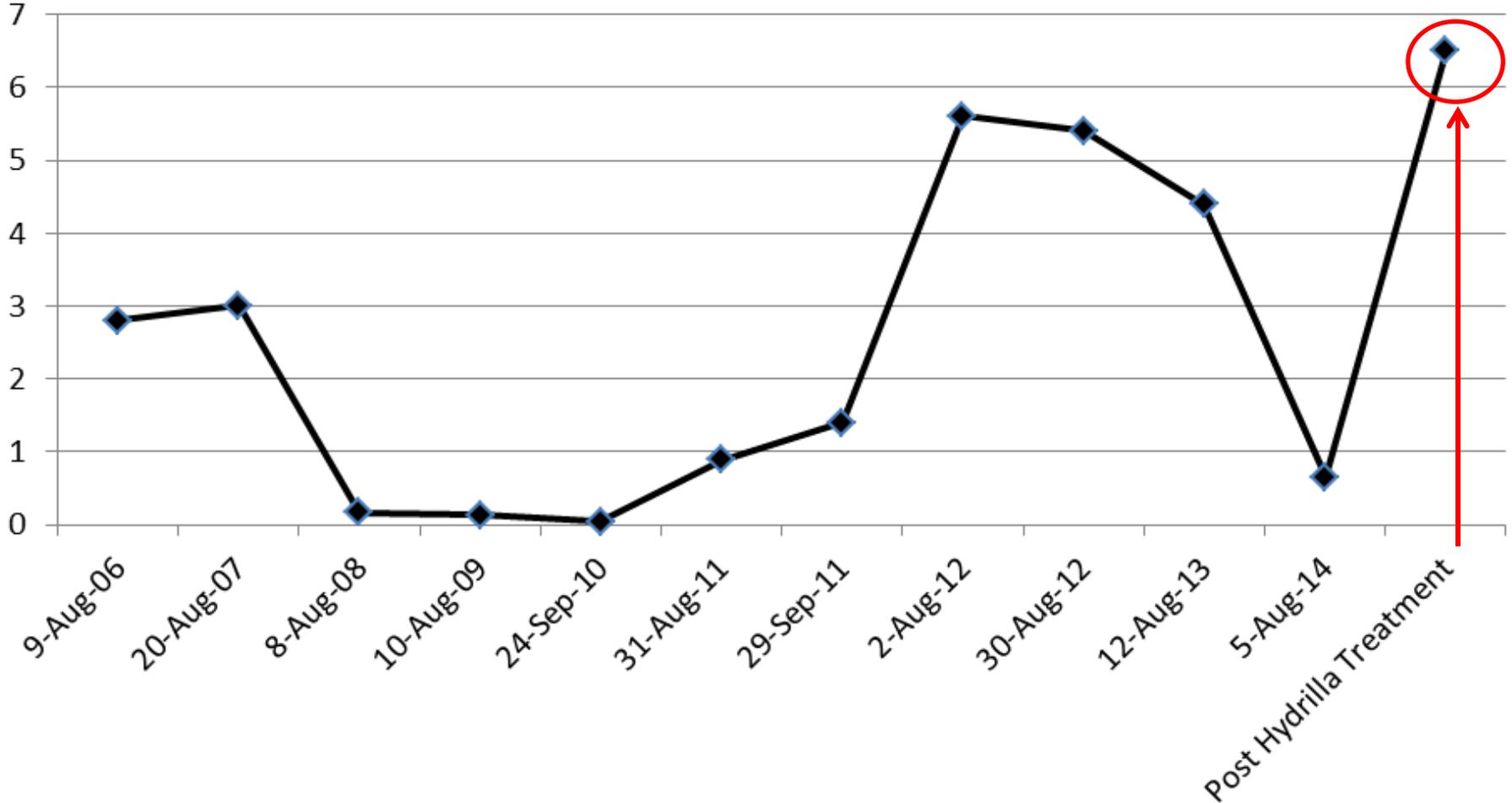
(Highest observed TP Concentration anywhere in the lake since 1999)



Coventry Lake Total Phosphorus ($\mu\text{g/L}$) 1999-2015

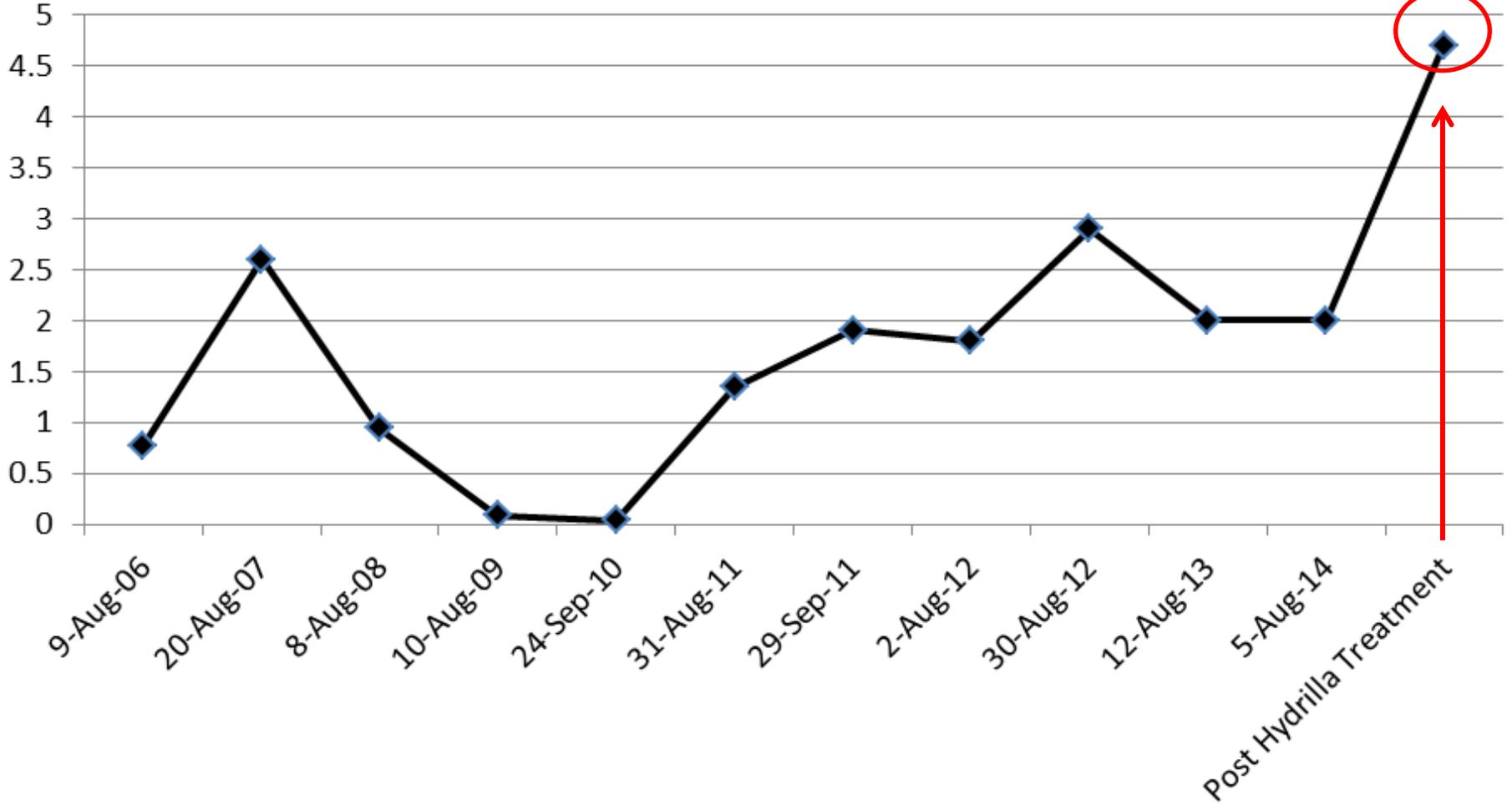


Deep Water Iron Late Summer Past Decade

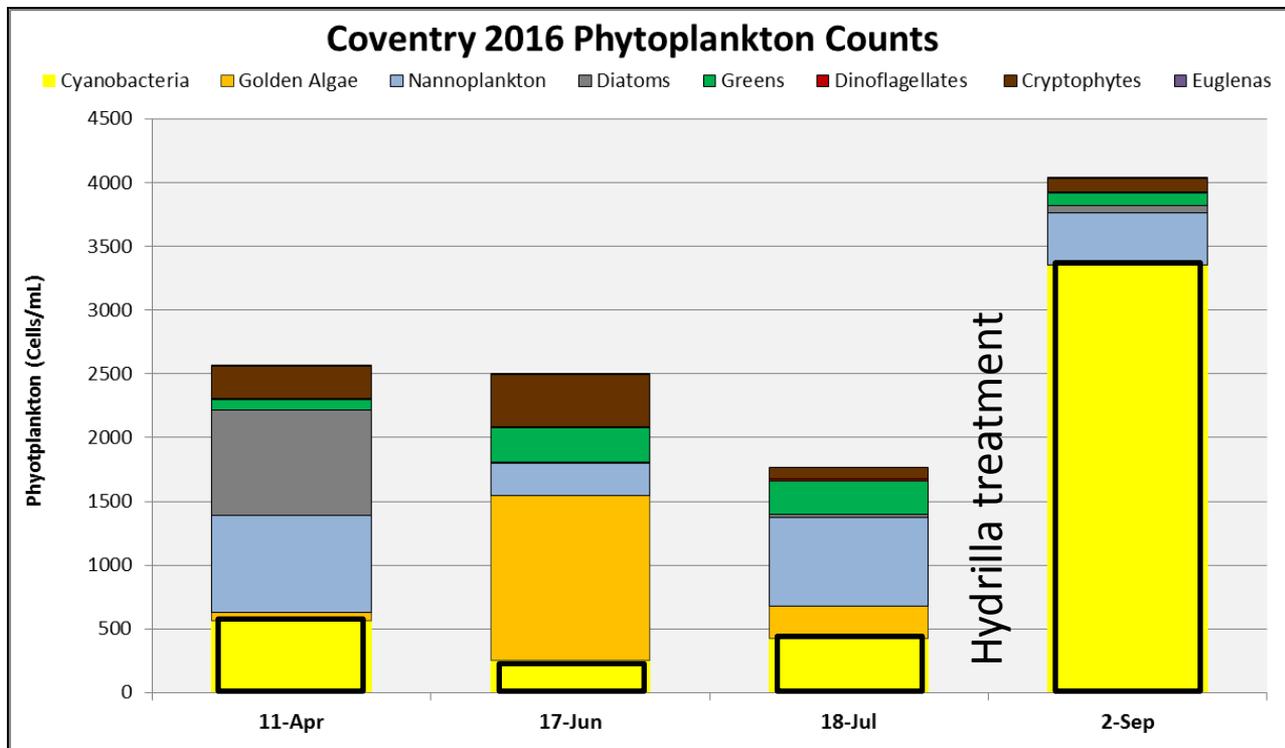


Iron (a product of anaerobic respiration) in the deep layer of Coventry Lake was higher than during any August or September sampling in the past decade.

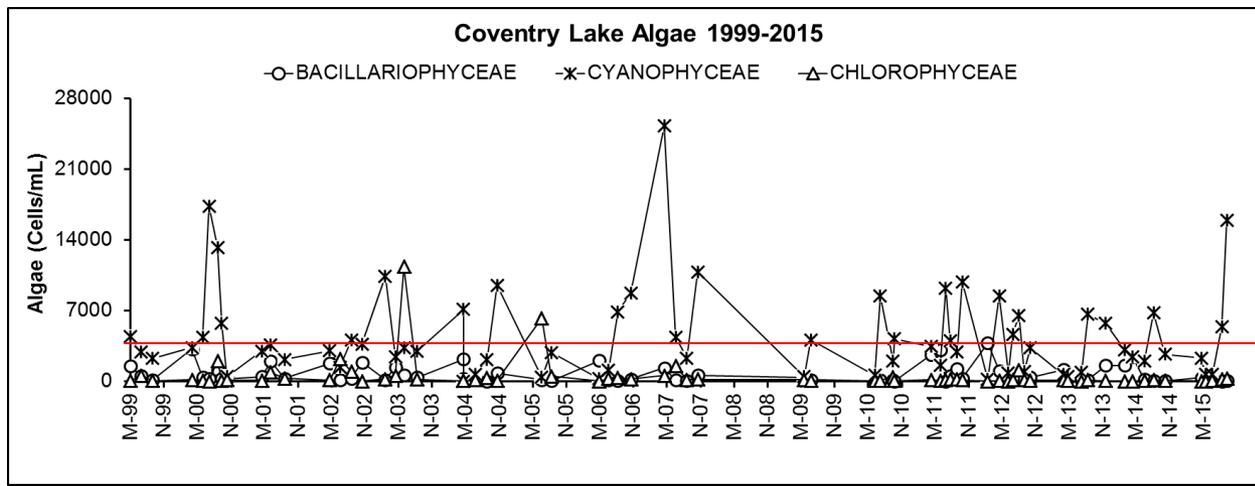
Deep Water Manganese Late Summer Past Decade



Manganese (a product of anaerobic respiration) in the deep layer of Coventry Lake was higher than during any August or September sampling in the past decade.



Cyanobacteria (commonly called Blue Green Algae) exhibited a significant increase following Hydrilla treatment. However, density following the Hydrilla treatment (3351 cells/ml) was not higher than is typically seen during late Summer in Coventry Lake.



3351 cells/ml

Conclusions :

- Although water clarity and light penetration decreased a modest amount following treatment, transparency remained excellent (>4m).
- Dead organic detritus related to treatment probably contributed to increased respiratory demand, resulting in some of the observed increases in heterotrophic bacteria, Fe, and Mn.
- Post-Treatment Total Phosphorus, Total Nitrogen, Ammonia Nitrogen, Iron, Manganese, Turbidity, Total Suspended Solids, all exhibited very significant increases in deep strata following treatment.
- Cyanobacteria density increased dramatically following Hydrilla treatment, but did not exceed cell densities typically observed during late Summer.
- Aquathol appears to take longer to kill vegetation than Clipper (used at Eagleville Lake) and the detritus load is less abrupt. On 8/22/16 treated plants were still collapsing, and the lake had begun to lose thermal stratification.
- A “Mix-Down Episode” occurred between August 15 and 22, extending the mixed surface layer 2m deeper and resulting in a very steep thermocline. That was weather-related, not due to treatment.
- The later than planned treatment, and early lake mixing episode, may have been “fortuitous”.
- Some of the “adverse effects of concern” were observed. However, the impacts do not appear to have been of a magnitude that would alter the ecology or water quality of Coventry Lake. Routine annual monitoring should continue.

Recommendations:

- Aquathol appears to be an appropriate herbicide for control of Hydrilla.
 - More selective than other contact herbicides (e.g. Clipper)- Less impact on native vegetation.
 - Slower acting than other herbicides (e.g. Clipper)- detritus load is more gradual
- Future treatments should not exceed the magnitude of the 2016 treatment.
- Future treatments should not be performed earlier in the Summer Stratification season.
- Copper-based algaecides or herbicides should not be used at Coventry Lake due to toxicity of copper to herbivorous zooplankton.