

Water Quality in Stormwater Ponds

Linking Nutrients, Algae and Dissolved Oxygen

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What is “water quality”?

- Many technical definitions for water quality.
- Based on many different measurements.
 - Nutrients
 - Algae
 - Dissolved oxygen
 - Suspended sediments
 - pH and alkalinity
 - Heavy metals
 - Organic toxins (pesticides, etc)
 - Pathogens (e.g., E. coli)
- Currently, **no regulatory standards exist** for any WQ measurements in stormwater ponds.
- Consequently, ponds are managed for water quality based on homeowner aesthetics.

POOR Water Quality:

Mostly we know it when we see it.



Symptoms:

- Looks like pea-green soup
- Can smell bad
- No fish or bottom life
- Soft, mucky bottom

Pea-green soup = excessive growth of algae

Algae: Microscopic, single-celled “plants”



Water quality measurements focused on in this talk:
Nutrients → Algae → Dissolved Oxygen

(A story of basic pond ecology in three acts...)

What are nutrients?

- Essential “building block” elements for all of life.
- Nutrients are required to make plants grow (such as algae in ponds).



- **Nitrogen** and **Phosphorus** are the two **most important** nutrients in aquatic environments (Potassium is always plentiful).
- Both the **quantity** and **relative proportion** of nutrients are important in determining plant growth.
 - Algae need **N** & **P** is a specific ratio: **16** atoms of **N** for every **1** atom of **P**

Typical sources of nutrients to ponds:

Most nutrients enter into ponds when carried from land by stormwater runoff

Rainfall (mostly nitrogen)

Decaying plant matter (nitrogen & phosphorus)

Weathering of soil / rock (mostly phosphorus)

Mostly
Natural

Fossil fuel combustion (mostly nitrogen)

Fertilizers (nitrogen & phosphorus)

Soaps and detergents (phosphorus)

Animal waste (human, pet, waterfowl, wildlife, etc.)
(both, but very high in phosphorus relative to nitrogen)

Mostly
due to
humans

Linking nutrients and algae:

- Plants (algae) are the base of the food chain.
 - without nutrients there would be no algae
 - without algae, ponds cannot support fish, wildlife, etc...
- Problem becomes “too much of a good thing.”
 - Excessive and/or noxious algal growth
 - Decomposition of algae causes oxygen depletion, leading to fish kills
 - Leads to potential water quality problems for receiving waters

The Goldilocks dilemma:



No nutrients = no life in pond.

“Right” amount of nutrients = healthy, balanced pond ecosystem.

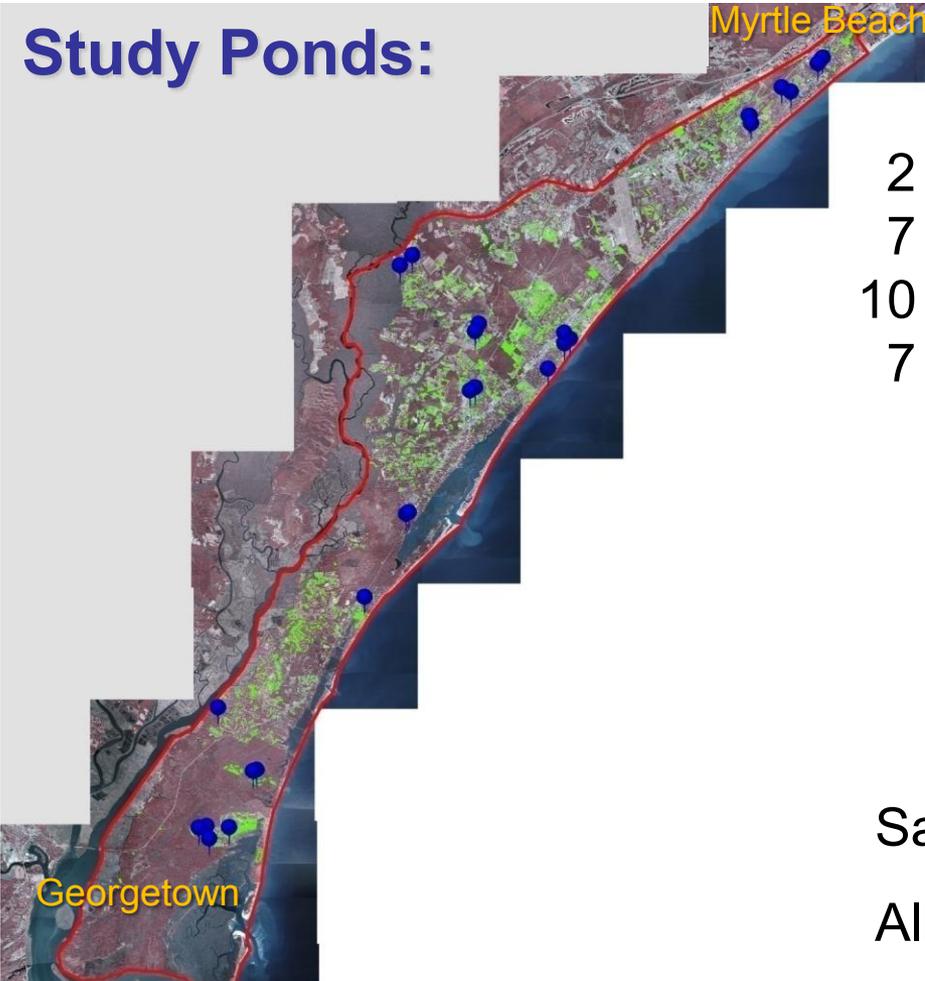
Too much nutrients = unbalanced, dysfunctional pond ecosystem.

How do nutrient concentrations vary among ponds?

How do ponds respond to varying nutrient concentrations?

A study of 26 residential ponds with varying development density

Study Ponds:



- 2 Undeveloped
- 7 Low residential development
- 10 Medium residential development
- 7 High residential development

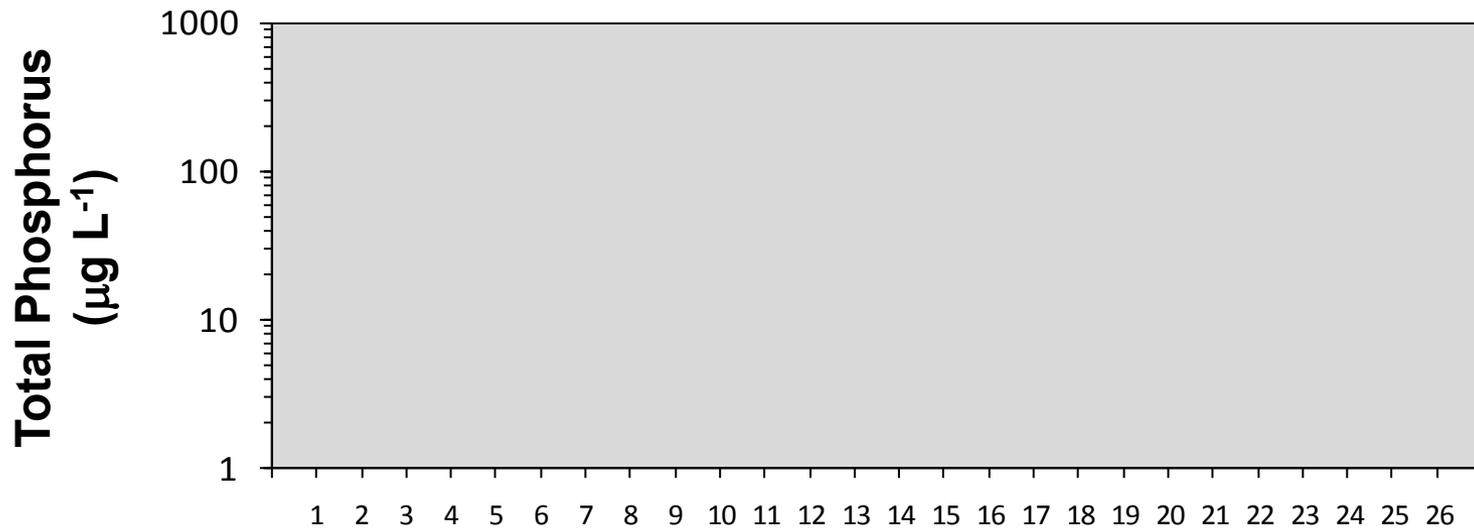
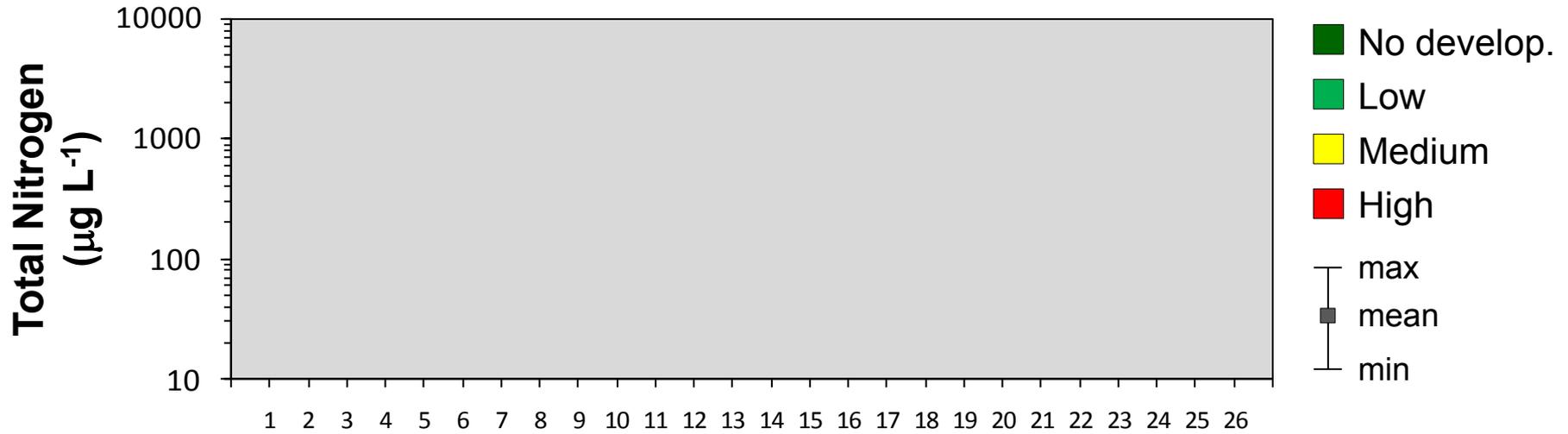
Pond size : 0.2 – 18.5 acres
median = 2.2 acres

Pond depth : 3 – 14 ft
median = 5 ft

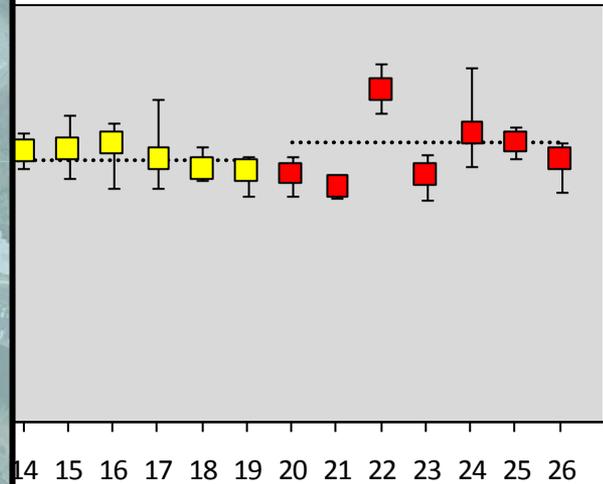
Sampled 8 times from May – Sept. 2010

All ponds are freshwater

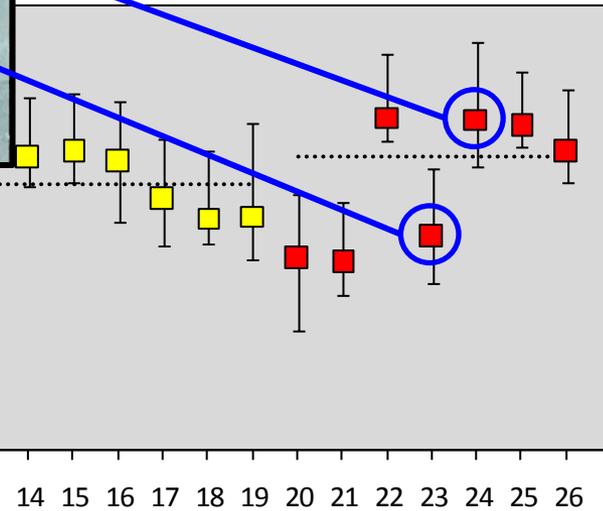
How do nutrient concentrations vary among ponds?



How do nutrient concentrations vary among ponds?



- No develop.
- Low
- Medium
- High
- max
- mean
- min



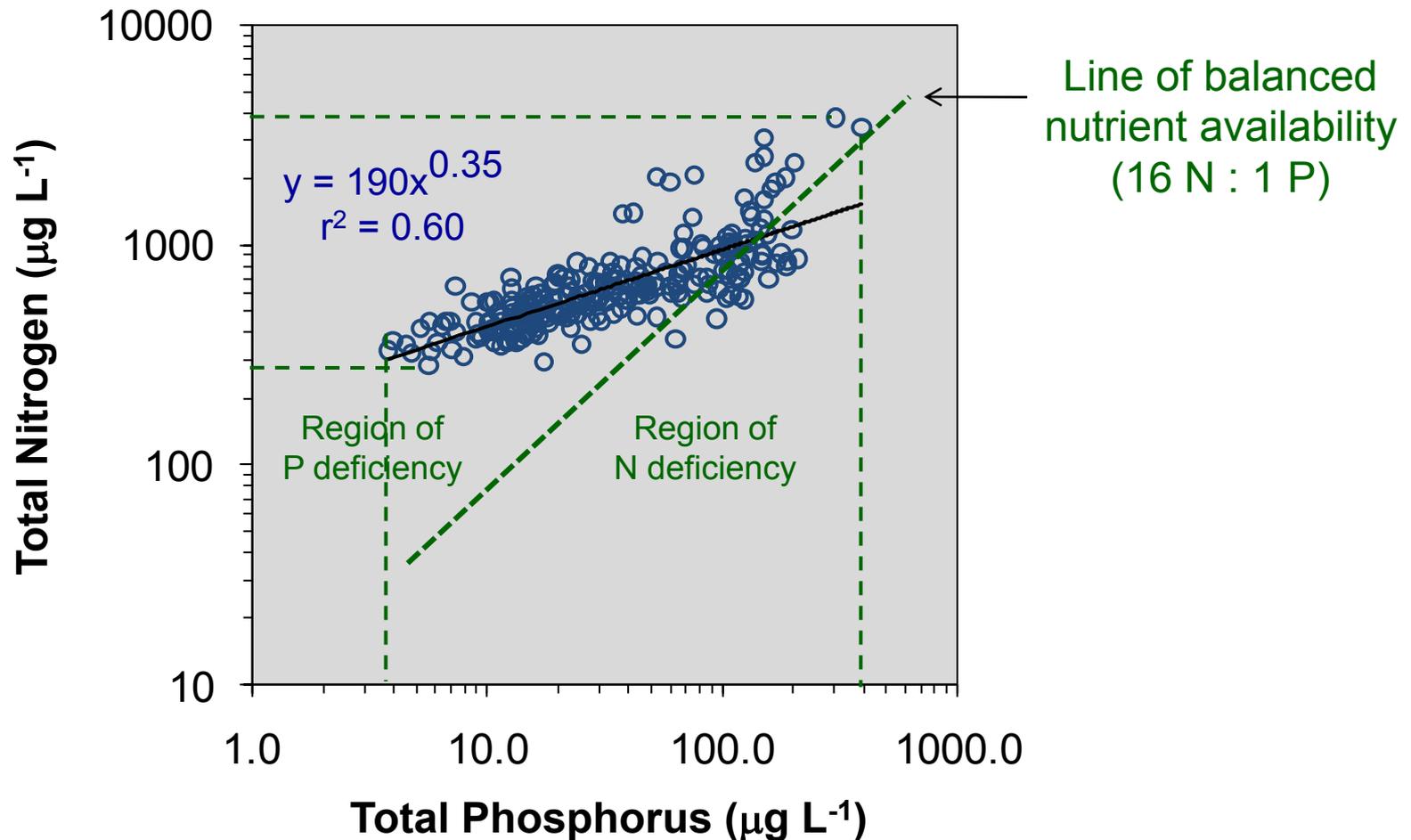
**Pond 24
six times
higher in TP
than pond 23**

Total Phosphorus (µg L⁻¹)

Nitrogen & Phosphorus tightly correlated across all ponds

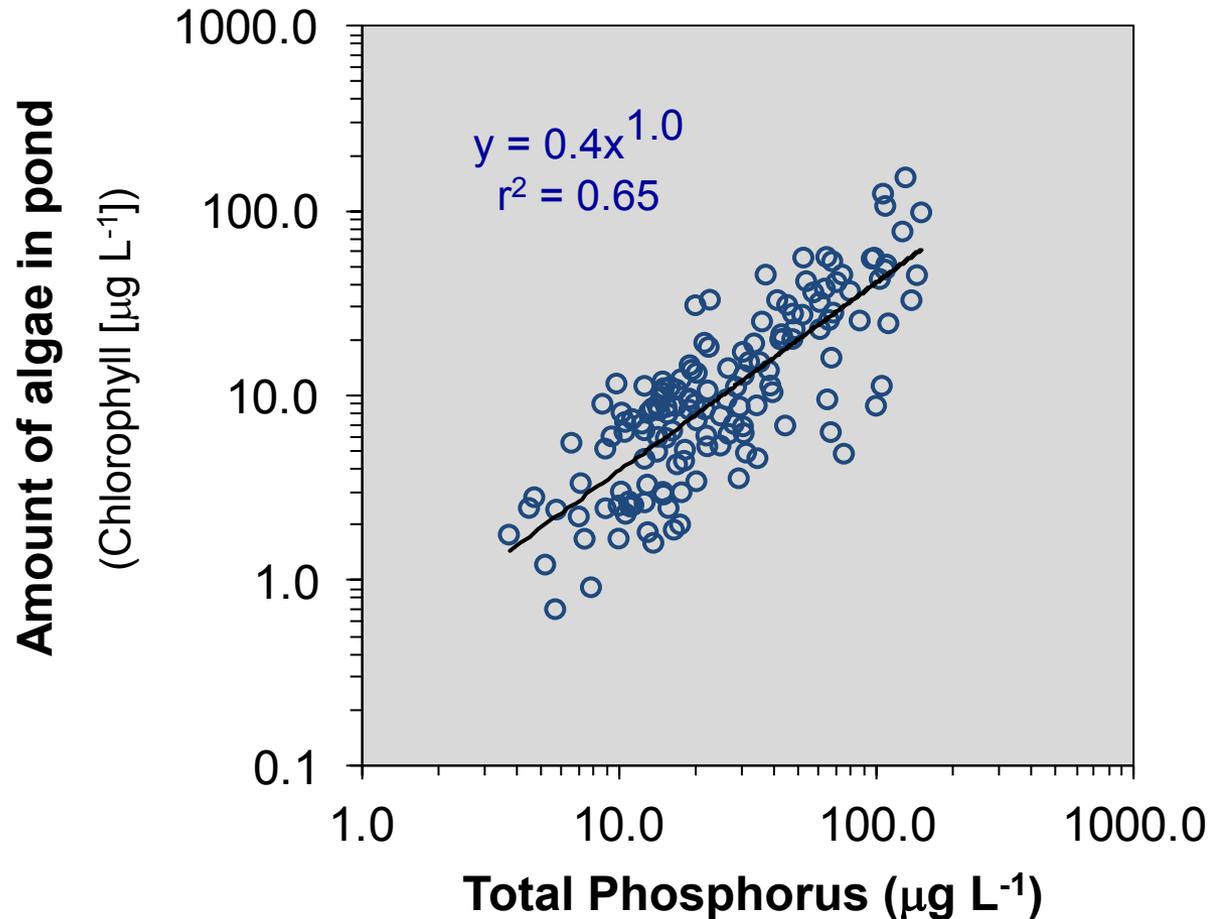
But: Nitrogen is much less variable than phosphorus.

Nitrogen is relatively more abundant than phosphorus in most ponds.
→ *suggests algae should be limited by phosphorus availability in most ponds.*



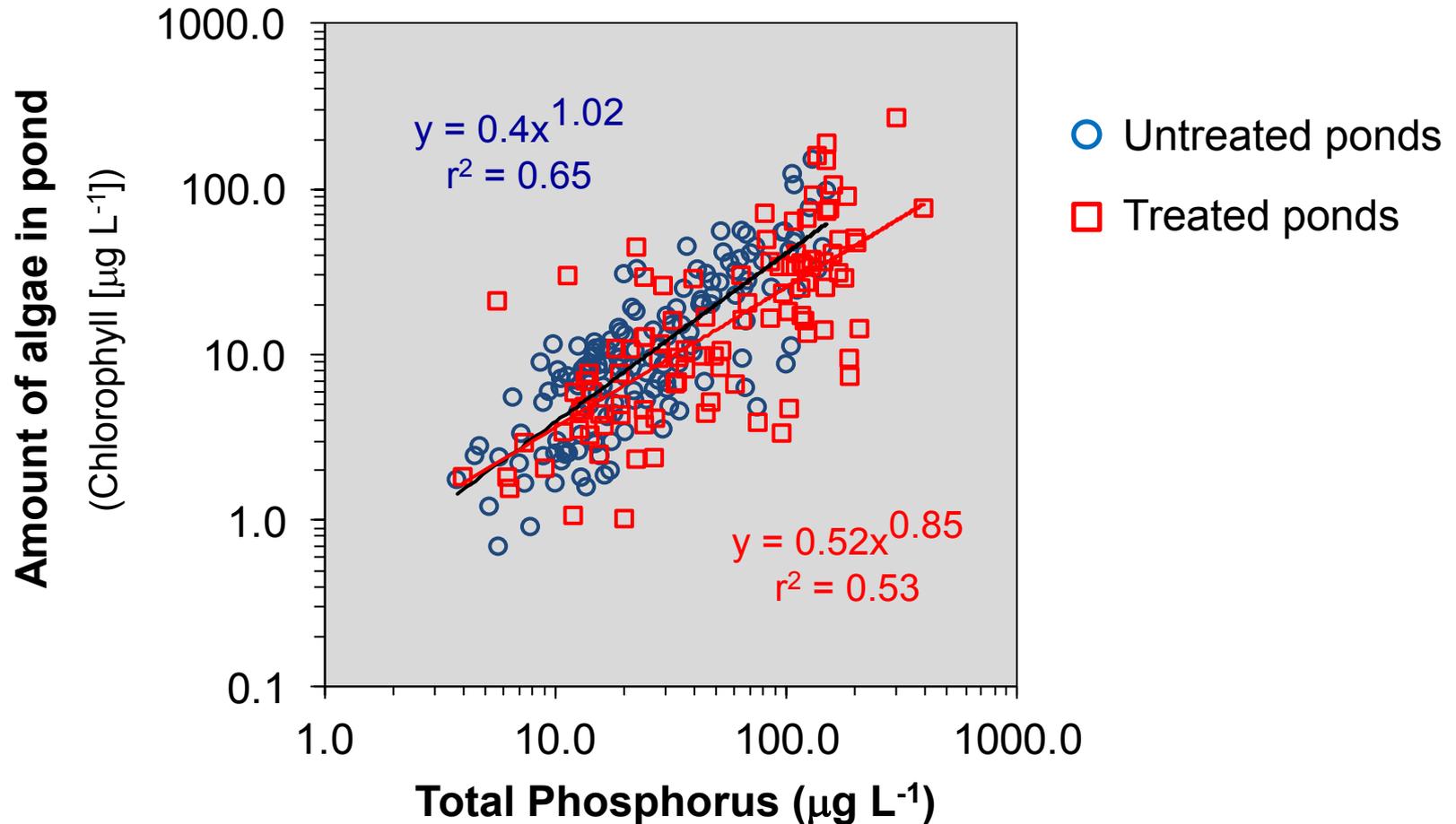
Total Phosphorus is a strong predictor of algal abundance

Relationship for ponds not subject to routine algaecide treatments



Total Phosphorus is a strong predictor of algal abundance

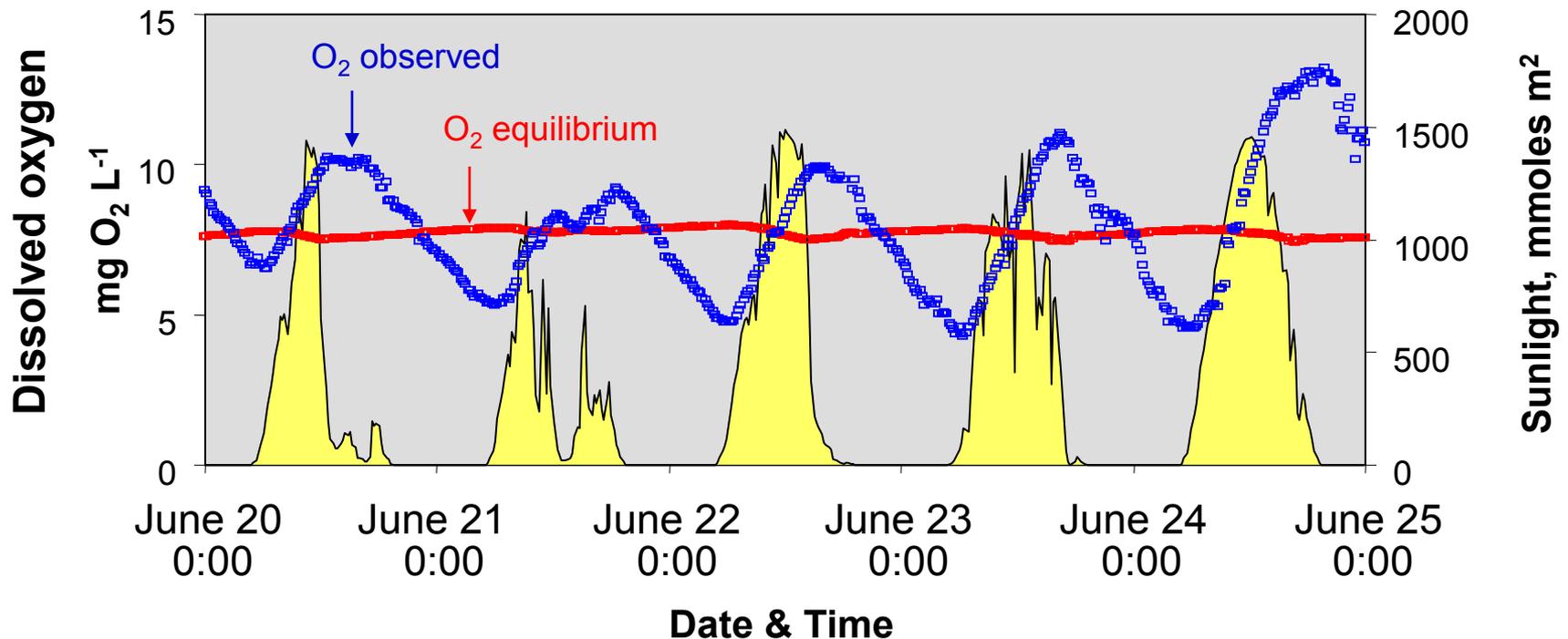
Relationship does not significantly change for ponds treated with algaecide



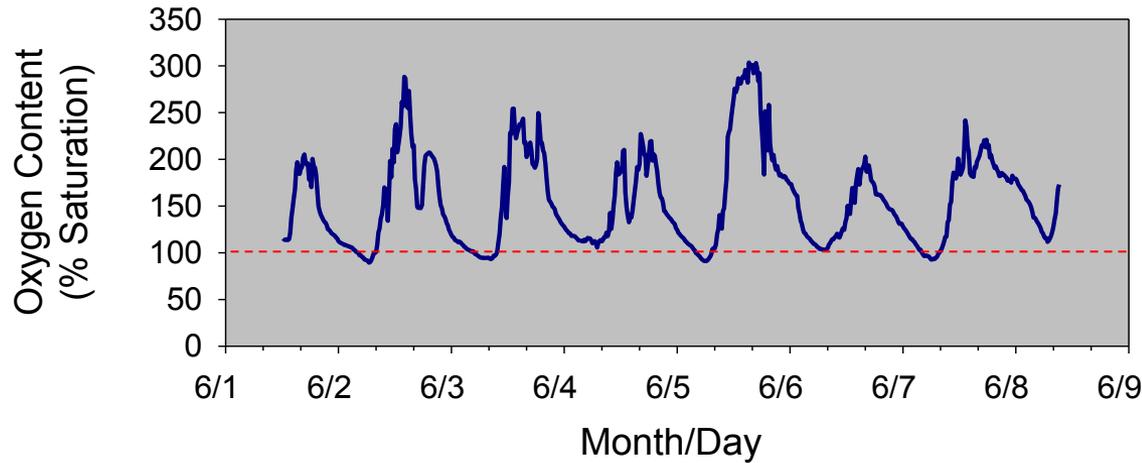
Linking nutrients, algae and dissolved oxygen dynamics:

Nutrients + sunlight make algae grow = $\left\{ \begin{array}{l} \text{CO}_2 \text{ consumption} \\ \text{O}_2 \text{ production} \end{array} \right.$

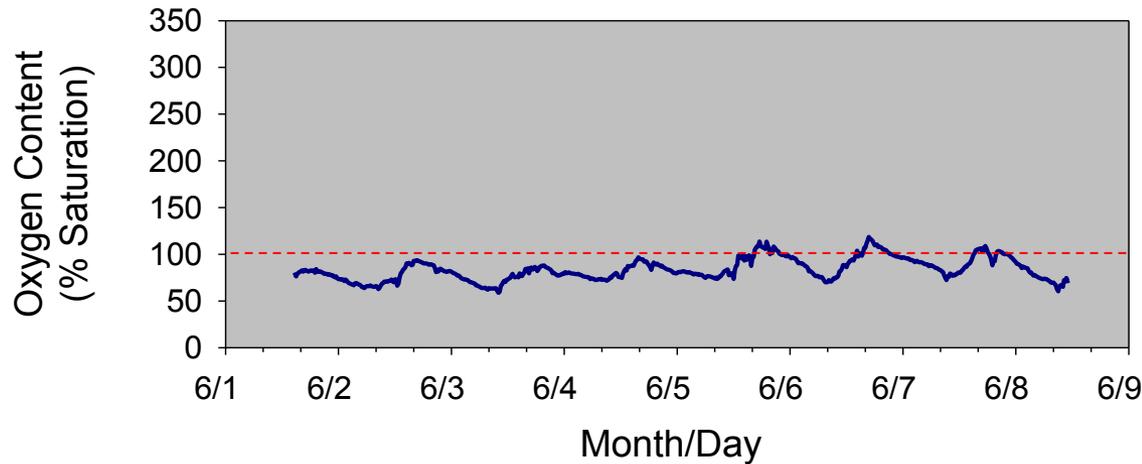
Algae produce organic matter that 'fuels' growth of natural bacteria = $\left\{ \begin{array}{l} \text{CO}_2 \text{ production} \\ \text{O}_2 \text{ consumption} \end{array} \right.$



Surface water oxygen concentrations in two ponds with contrasting amounts of algae



Pond with **HIGH** amount of algae

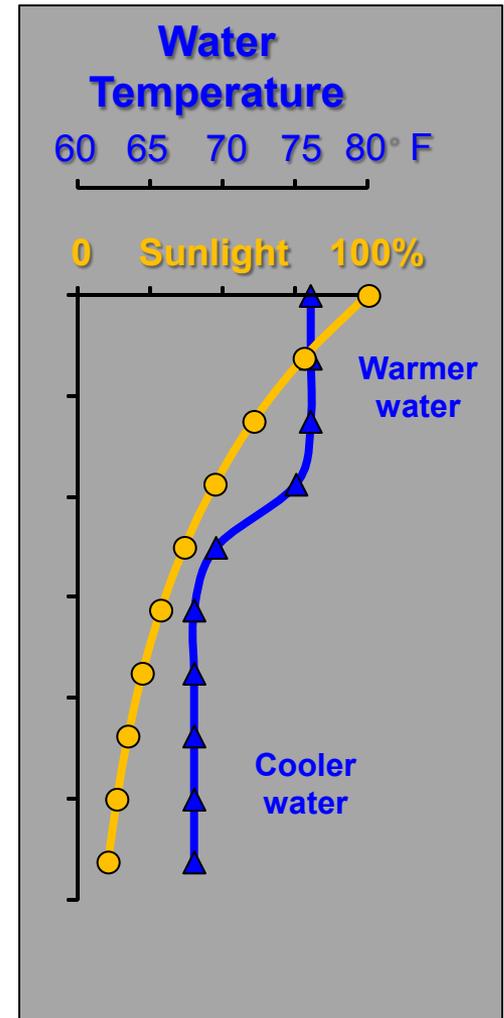
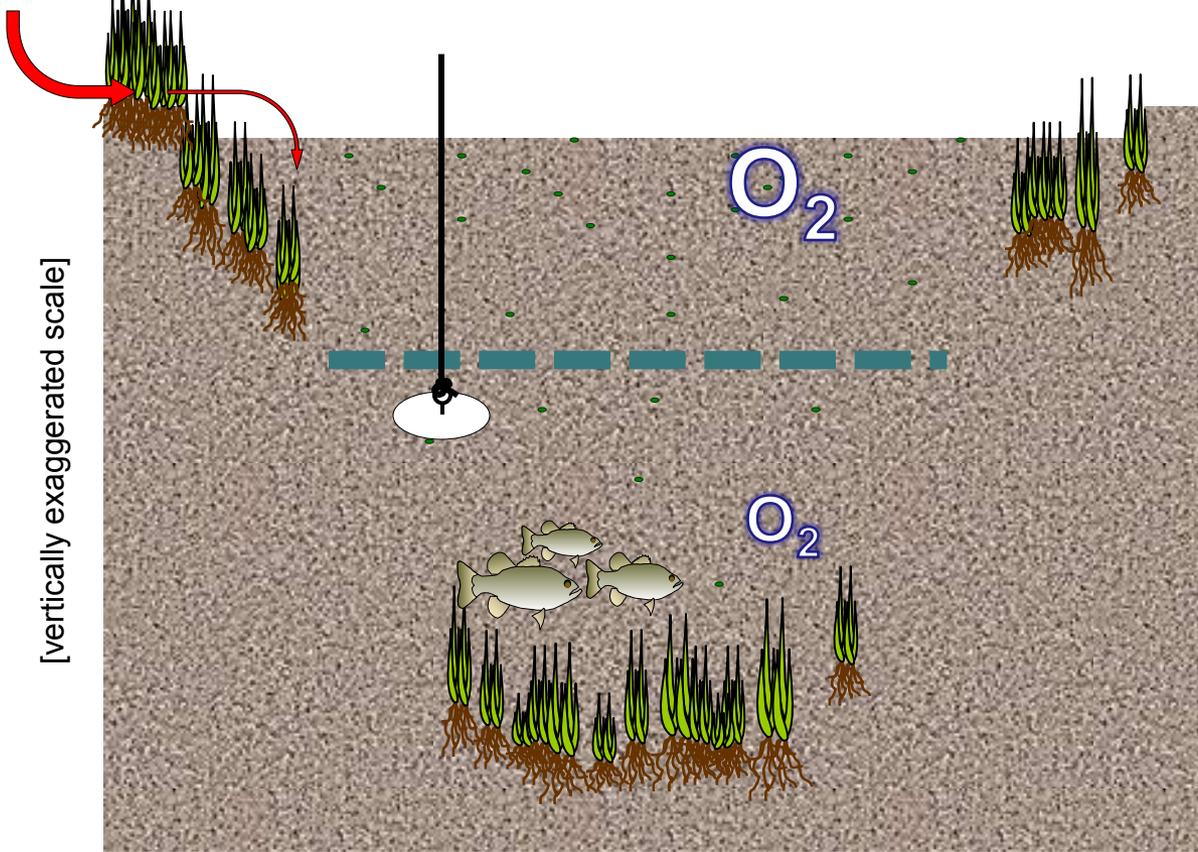


Pond with **LOW** amount of algae

Water clarity, stratification and dissolved oxygen :

**Low
Nutrients**

Low nutrients → high light conditions
(a healthy, balanced pond ecosystem)

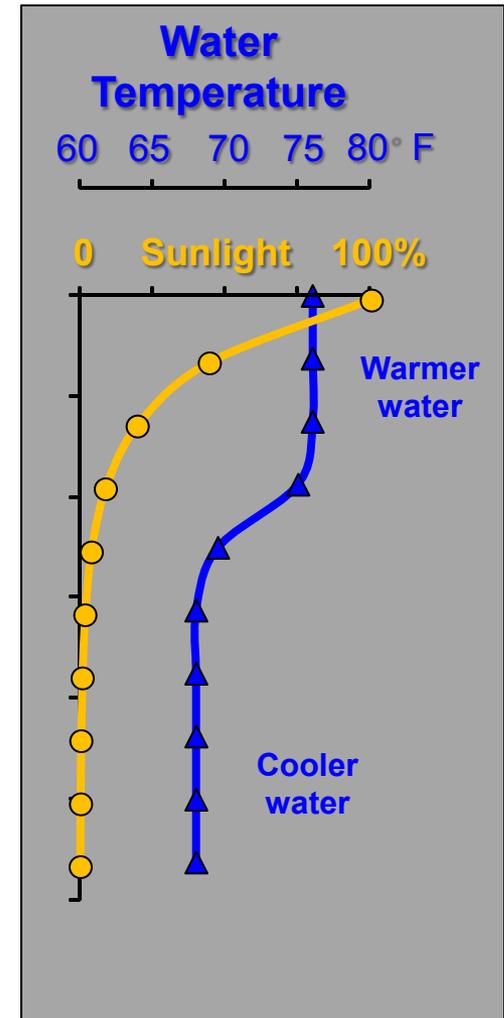
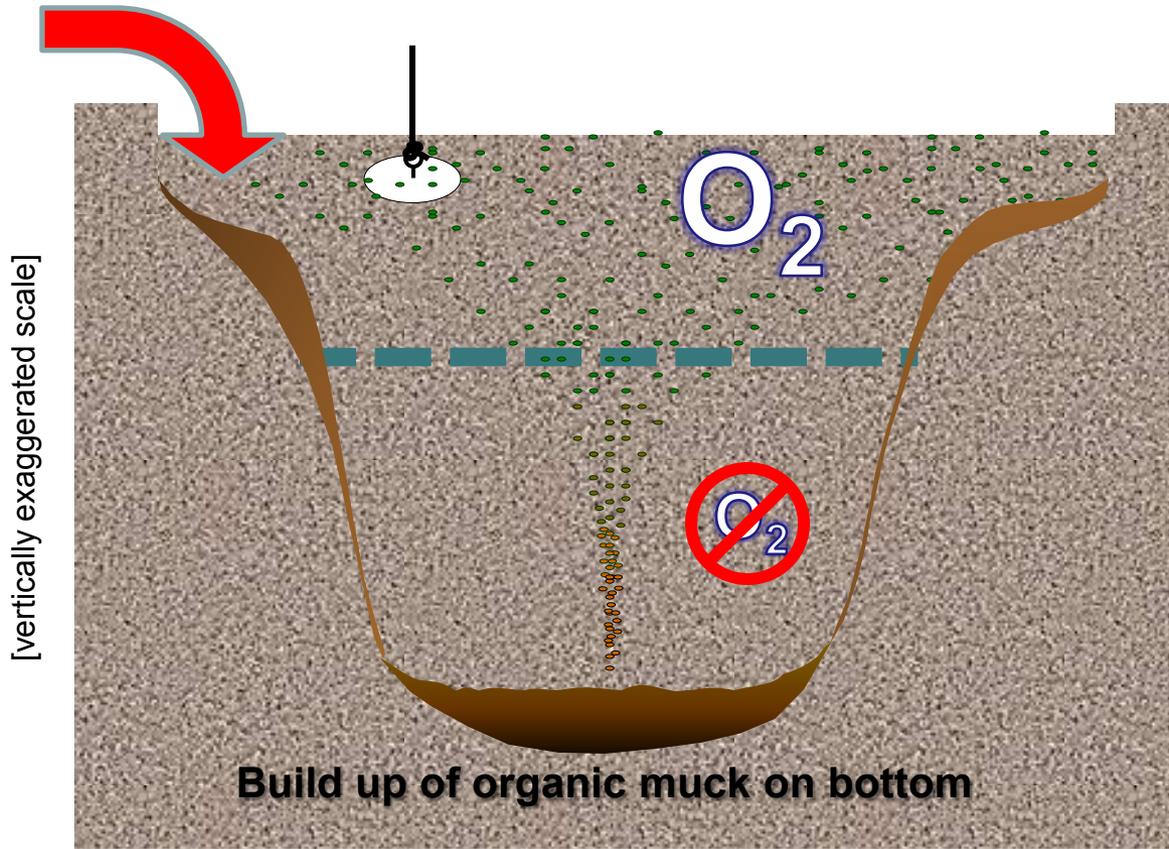


Light penetration is a function of concentration of algae (and suspended sediments)

Water clarity, stratification and dissolved oxygen :

**Increased
Nutrients**

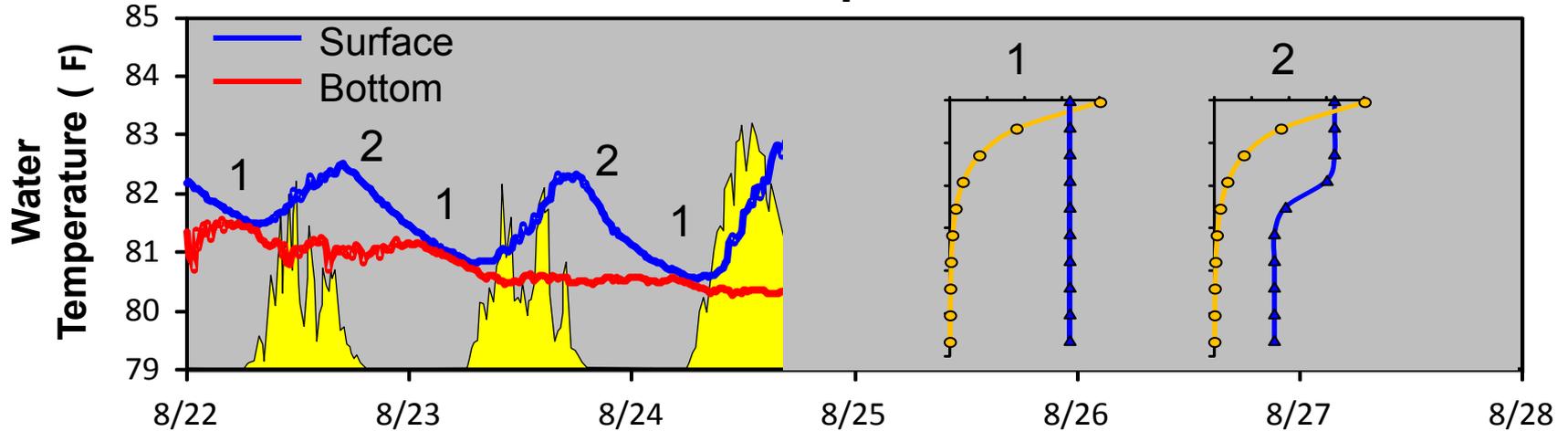
High nutrients → low light conditions
(Loss of bottom water oxygen & animal life)



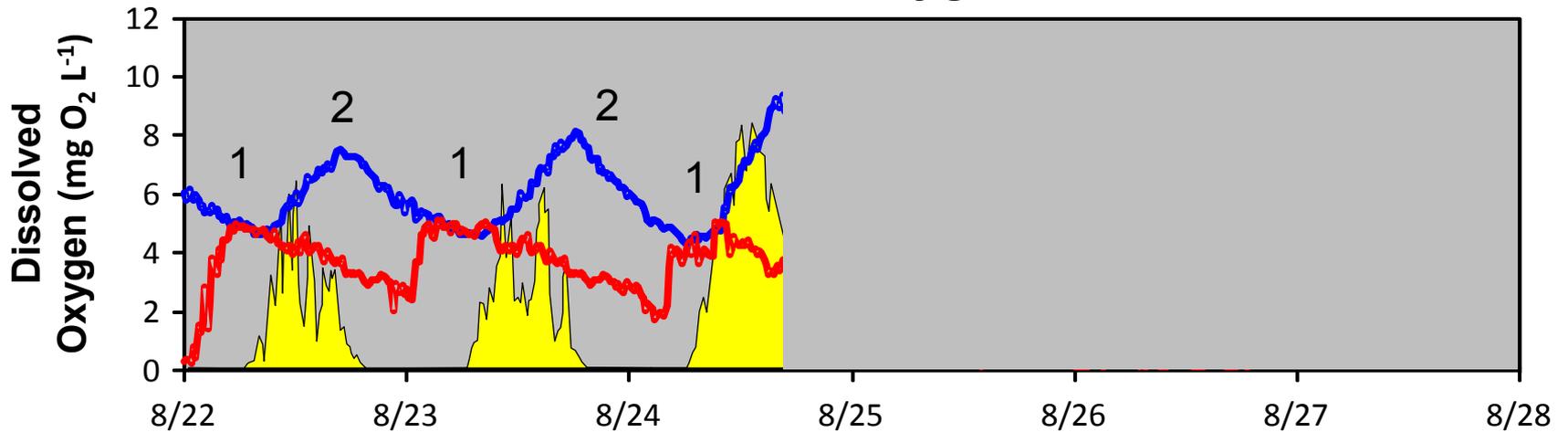
Light penetration is a function of concentration of algae (and suspended sediments)

Example of effects of pond stratification on oxygen:

Water Temperature



Dissolved Oxygen



Summary

- **Ponds have a large range in concentrations of nutrients and algae.**
 - **Development appears to increase phosphorus more than nitrogen.**
 - Relatively little variation in nitrogen within and across ponds
 - Substantial variation in phosphorus within and across ponds.
 - **Ultimately, controlling excessive algal growth in ponds requires controlling phosphorus input to ponds.**
 - Homeowner practices can affect the amount of phosphorus entering ponds (fertilizer use, feeding wildlife, types of vegetation around ponds).

- **Excessive algal growth leads to large swings in pond oxygen concentrations, and can lead to loss of oxygen in bottom waters.**
 - Controlling nutrient input (especially phosphorus) can control growth of algae and maintain a proper oxygen balance in pond waters.

Questions?

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