Internal phosphorus loading as a key driver in cyanobacteria blooms

Ken Wagner, PhD, CLM, Water Resource Services

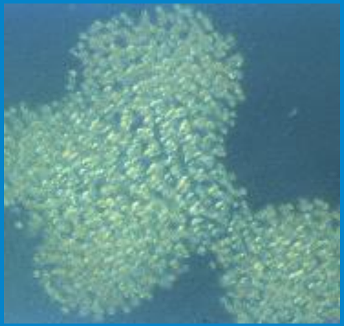
Synthesis of what we have learned

- P control is the most reliable means of preventing CB
- Reduction of external P load is helpful but usually not sufficient to prevent CB
- Much externally loaded P must be processed in the lake before it is available
- Internal P loading is a more important P source than previously recognized
- Internal P loading is ideally suited to fostering CB

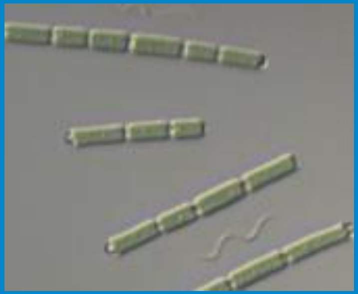
Oscillatoria

Gloeotrichia

Dolichospermum



Microcystis

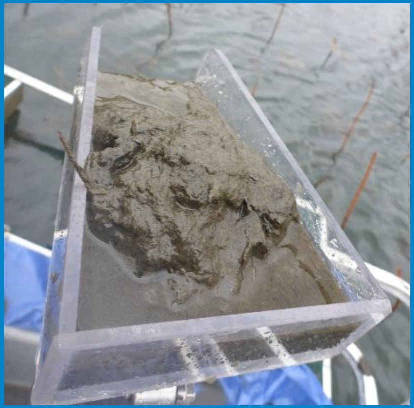


Pseudanabaena

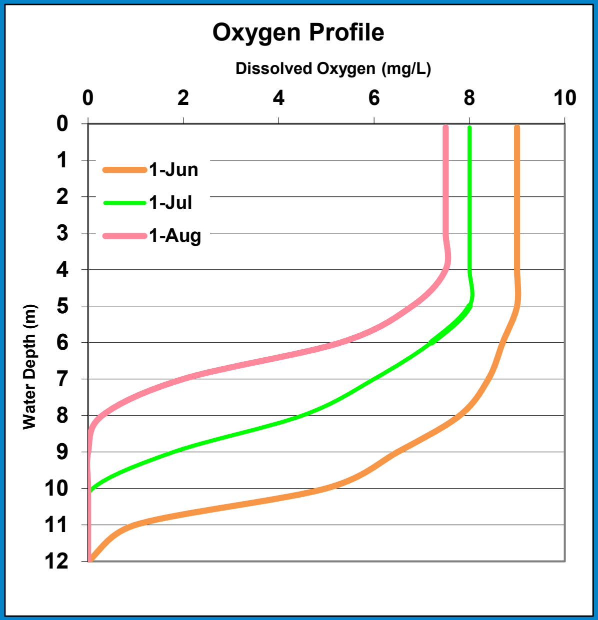
Planktothrix

Modes of internal P loading

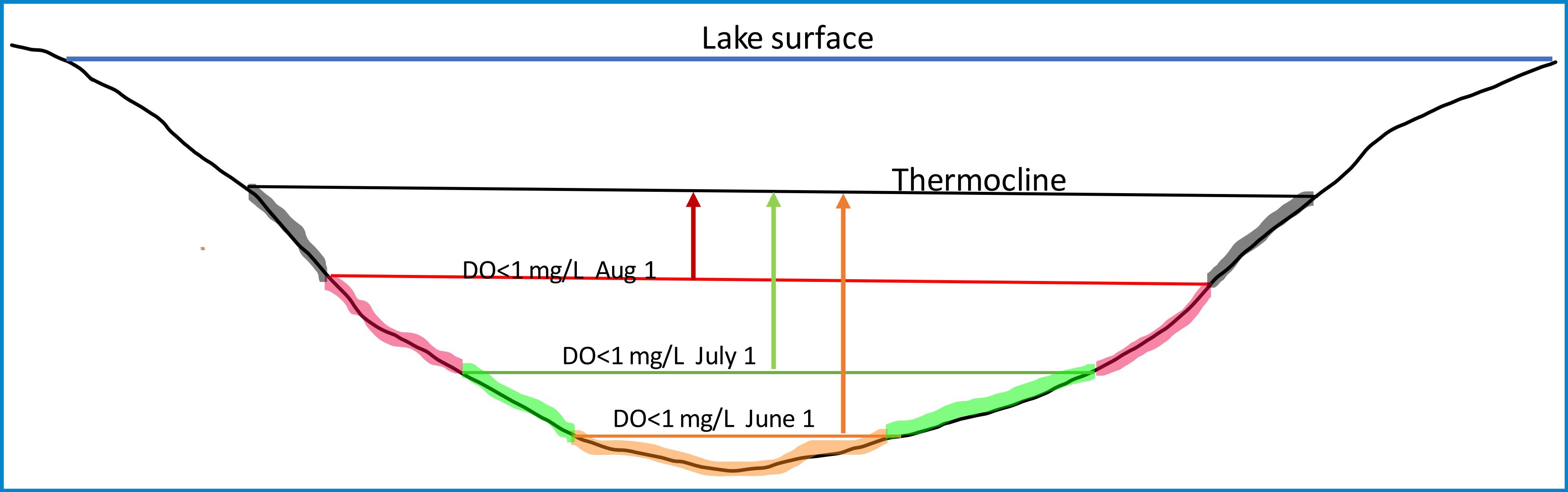
- Resuspension of bottom sediment with some dissociation of P
- Consumption of sediment with excretion by fish or invertebrates
- Release from vascular plants, especially during senescence
- Decomposition of organic matter containing P
- Release from sediment through redox reactions

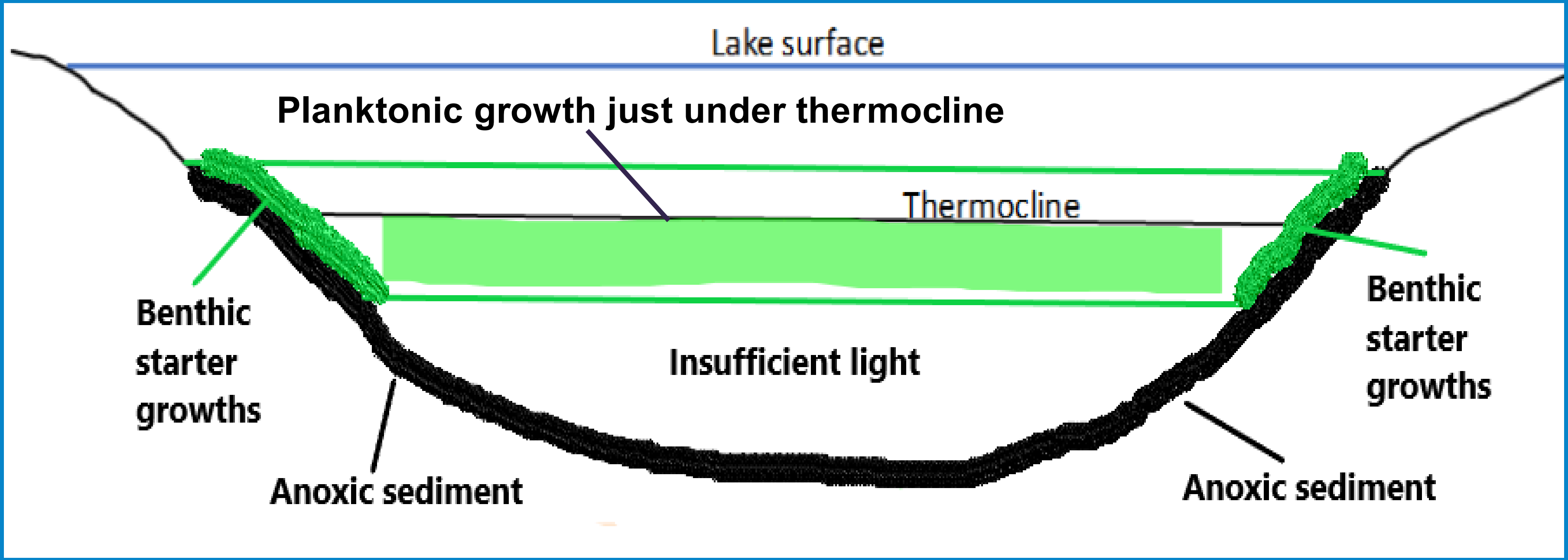
Derivation of internal P load by redox



As the top of the anoxic zone rises in the water column, the portion of the lake bottom exposed to anoxia increases and the distance to the thermocline (where light is available) gets shorter.

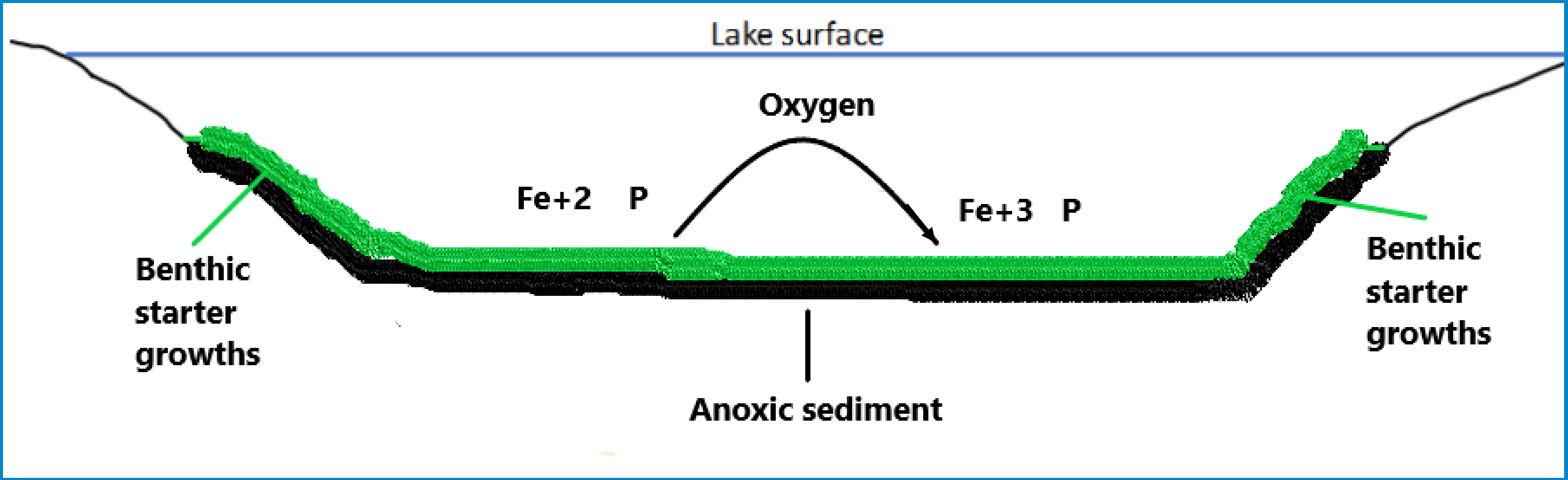


How internal P loading supports CB



- Growth requires nutrients and light, both available at intermediate depth
- Growths may be benthic or metalimnetic
- N:P ratio, Fe and light all favorable to CB there

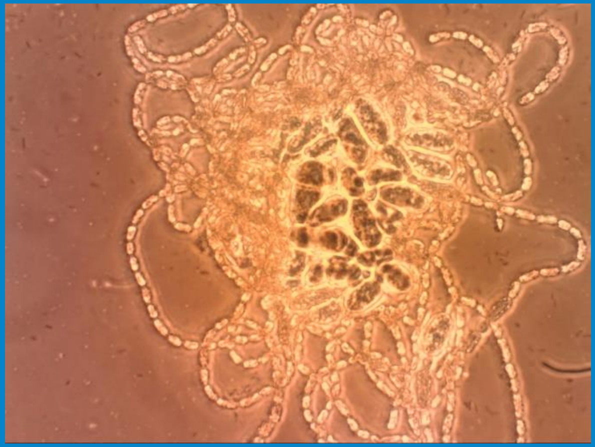
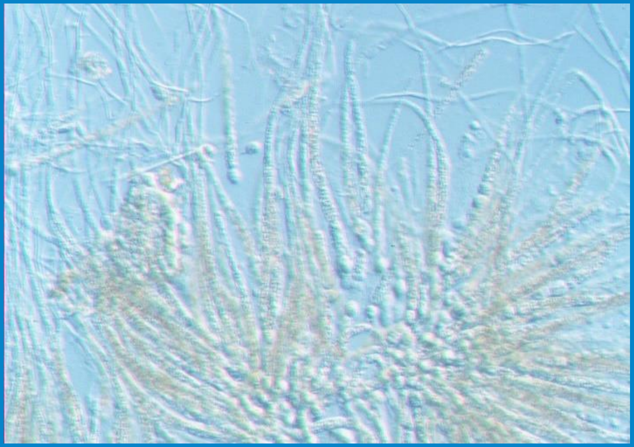
How internal P loading supports CB



- Not just a deep lake phenomenon
- Most of bottom can be a P source and substrate for benthic starter growths in shallow lakes

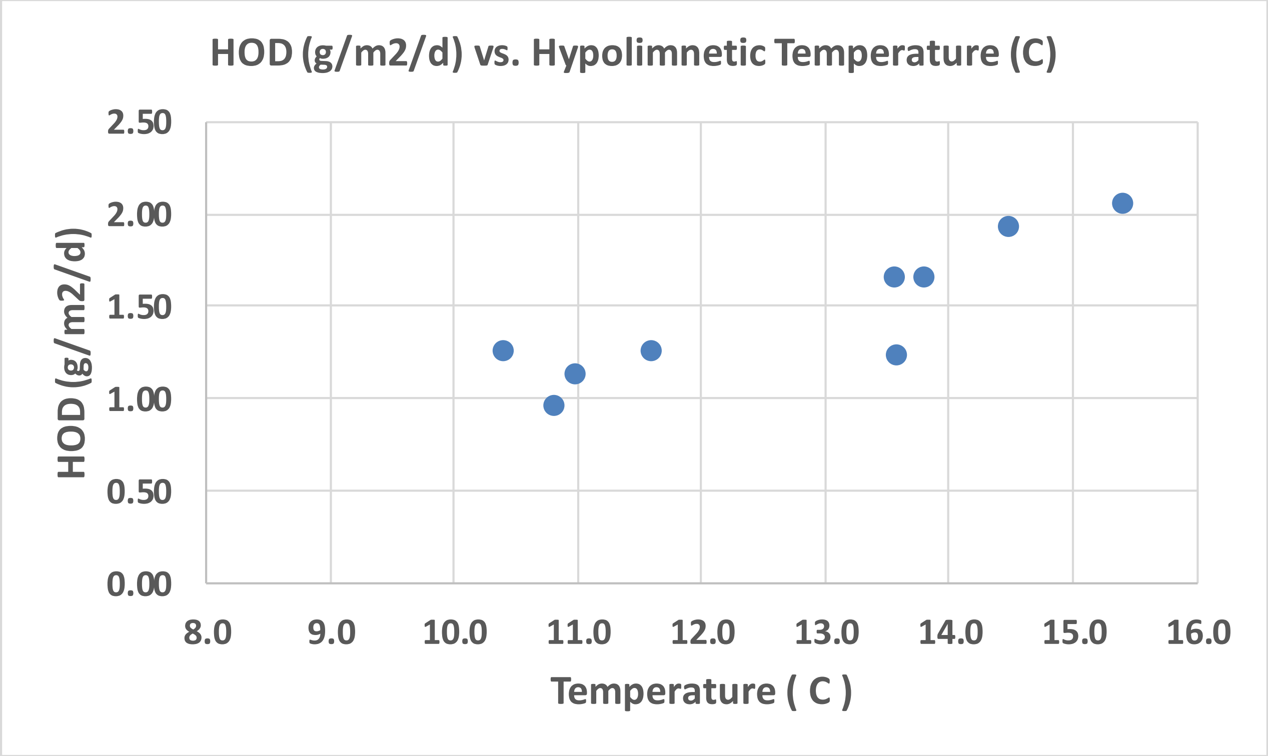
Why cyanobacteria are more linked to internal loading than other algae

- Some other algae can utilize the same approach just not as well overall
- Many cyanobacteria adapted to low light, grow deeper
- Many cyanobacteria have a buoyancy mechanism to allow movement into the upper water
- Anoxic internal loading has a low N:P ratio and high Fe content that favors cyanobacteria
- Mainly a summer phenomenon, enhanced by warmer temperature which also favors CB

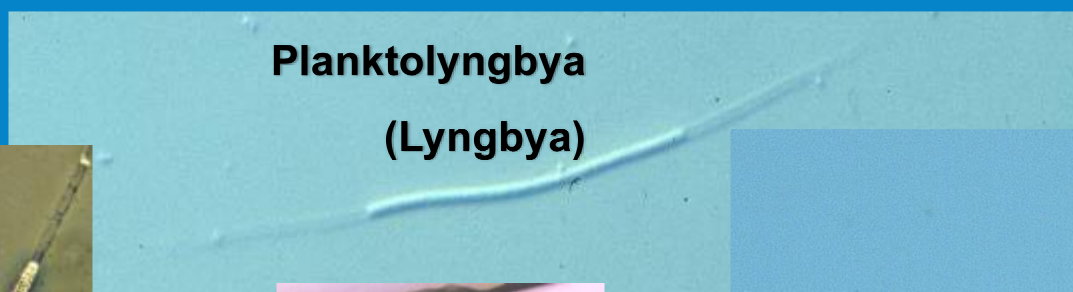

Oxygen demand and internal P loading

- Increased temperature leads to increased metabolism, faster decay, more oxygen demand
- Low oxygen can lead to greater P release from sediment
- Small changes in temperature could have big consequences
- Climate change may therefore be a major factor in CB through multiple temperature effects



Beyond internal P load

- Once in the upper water column, continued growth will exhaust cellular P reserves
- CB duration depends on P in surface water (internal or external sources), but CB initiation is not usually epilimnetic
- It may prove essential to combat both internal and external loading to limit CB, but it is possible to prevent CB with just internal lake management actions (dredging, oxygen, P inactivation)



Aphanizomenon

Woronichinia

Conclusions

- Warm water with high P and low N:P ratio is ideal for CB, although CB are known from wide range of conditions
- Internal P loading is fostered by exposure of sediment rich in Fe-P to anoxia and comes with low N:P ratio
- Warmer water increases decomposition and oxygen demand, which in turn increases potential P release
- CB are often initiated as a function of internal P loading, either through growth at sediment-water interface or near thermocline in stratified lakes, rising in water column by gas pockets or mixing events
- Duration of CB depends more on epilimnetic P availability, so watershed management is of value, but cessation of CB may require internal P controls