Lake Management: Internal Nutrient Loading and Mitigation Strategies



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Outline

- Phosphorus
- External loading basics
- What is internal loading?
- Management of Internal Load
- Conclusions

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Disclaimer!!

- Internal loading is extremely complicated! There is a lot of advanced chemistry, biology and physics that goes into this topic.
- Talk is geared to lake homeowners who have never heard of internal loading or how lake chemistry works.
- I will be skipping over/glossing over many specifics on these processes
- What I would like you to get out of this talk:
  - **What is internal loading?**
  - **Why is internal loading important?**
  - **What techniques are out there to control internal loading?**

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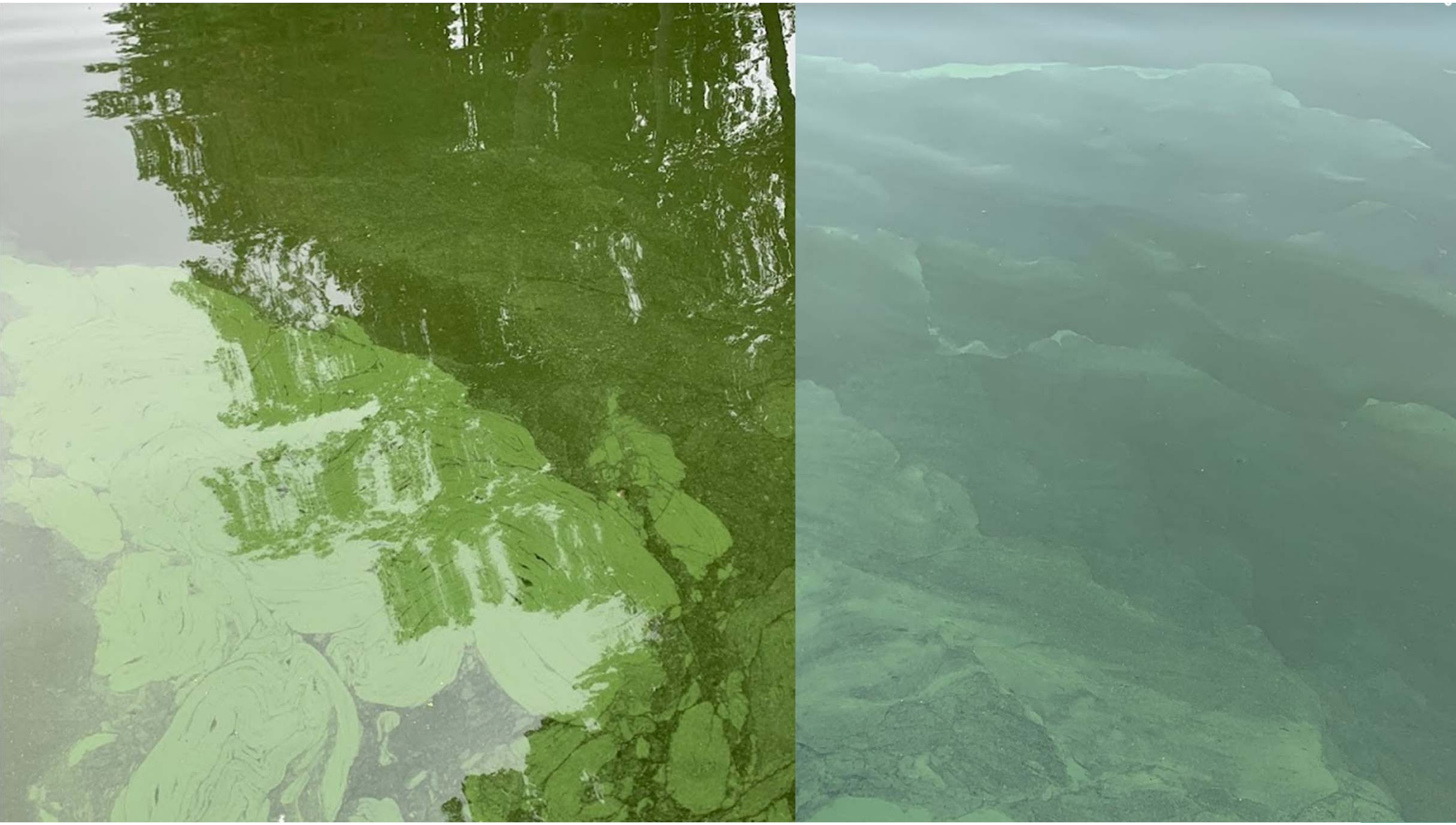

Phosphorus: The Culprit

- Algae blooms occur for multiple different reasons
  - **Light**, **Heat**, and **Nutrients** are usually considered the three big factors.
  - Nutrients can include multiple different elements
    - N, P, K, Ca, Si
- Phosphorus is generally considered to be the most important nutrient for algae growth in freshwater.
  - Specifically for harmful cyanobacteria blooms
  - Ammonia also important!
- **Reducing P = Reducing Algae Blooms**

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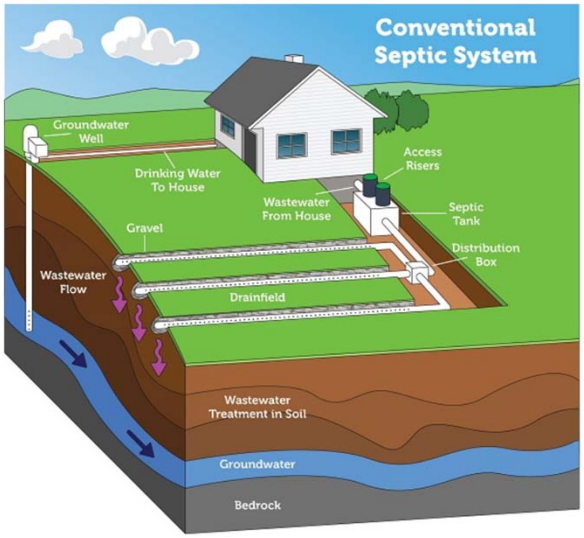
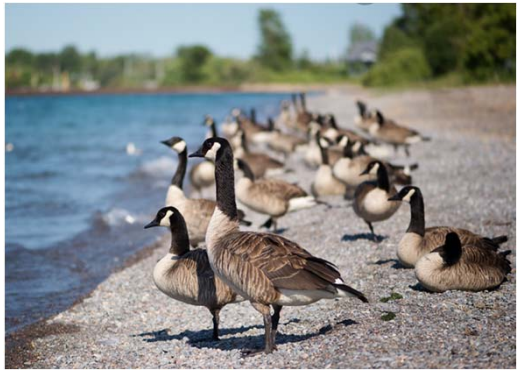
Sources of Phosphorus (External Loading)

- Almost all phosphorus in lakes originates in the watershed
- Natural sources include Atmospheric, wetland, soil erosion, rock weathering, waterfowl
- Human development in the watershed has accelerated the transport of phosphorus into lakes.
  - Sources include: Onsite wastewater, urban stormwater runoff, lawn and home practices, point-source pollution, agricultural lands
- **Lakes Accumulate P from the Watershed**





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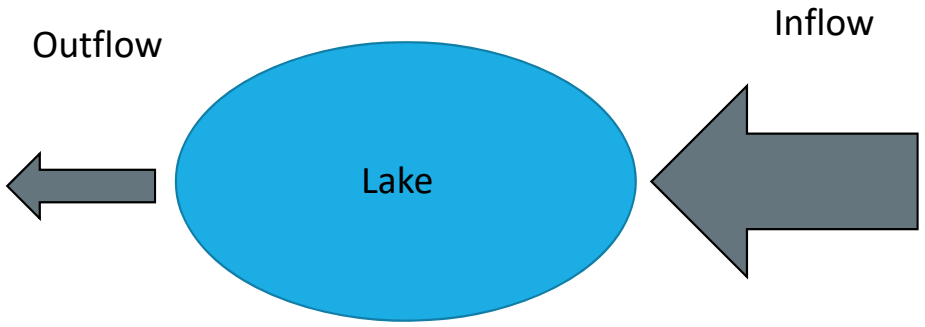
Fate of External Load

- Where does the phosphorus that enters a lake go?
  - Some right to algae and bacteria (Dissolved, soluble reactive fraction)
  - Some right to the bottom (Particulate, bound to sediments, clays, organic matter)
- **Lakes are accumulators, not flow through systems!!**
  - Over time, lakes grow in their total phosphorus content, especially in the sediment
  - Some phosphorus leaves the lake via the outlet, but a lot gets retained.



Retention = Inflow - Outflow

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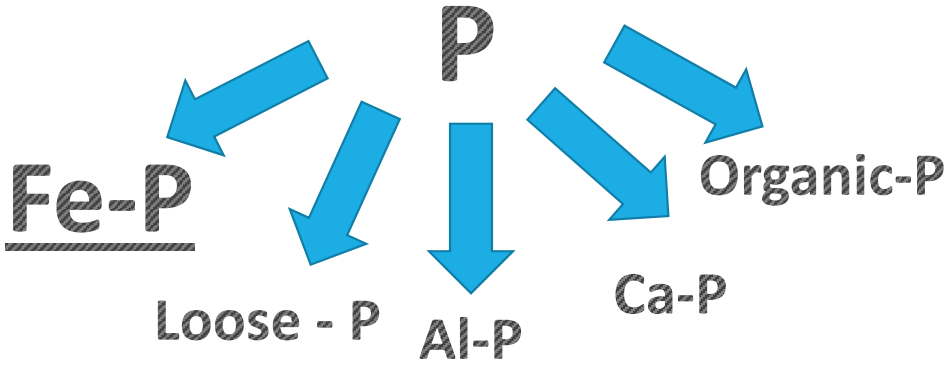
Lake Sediment (Unseen Adversary)

- Ultimate fate of organic and inorganic material in lakes
- Can vary in metal and organic composition
  - Important for selecting management techniques
  - Full of bacteria
- **<u>Many times more P and N in sediment than overlying waters</u>**
- A certain proportion of P can be available to algae and bacteria during the recreational season.



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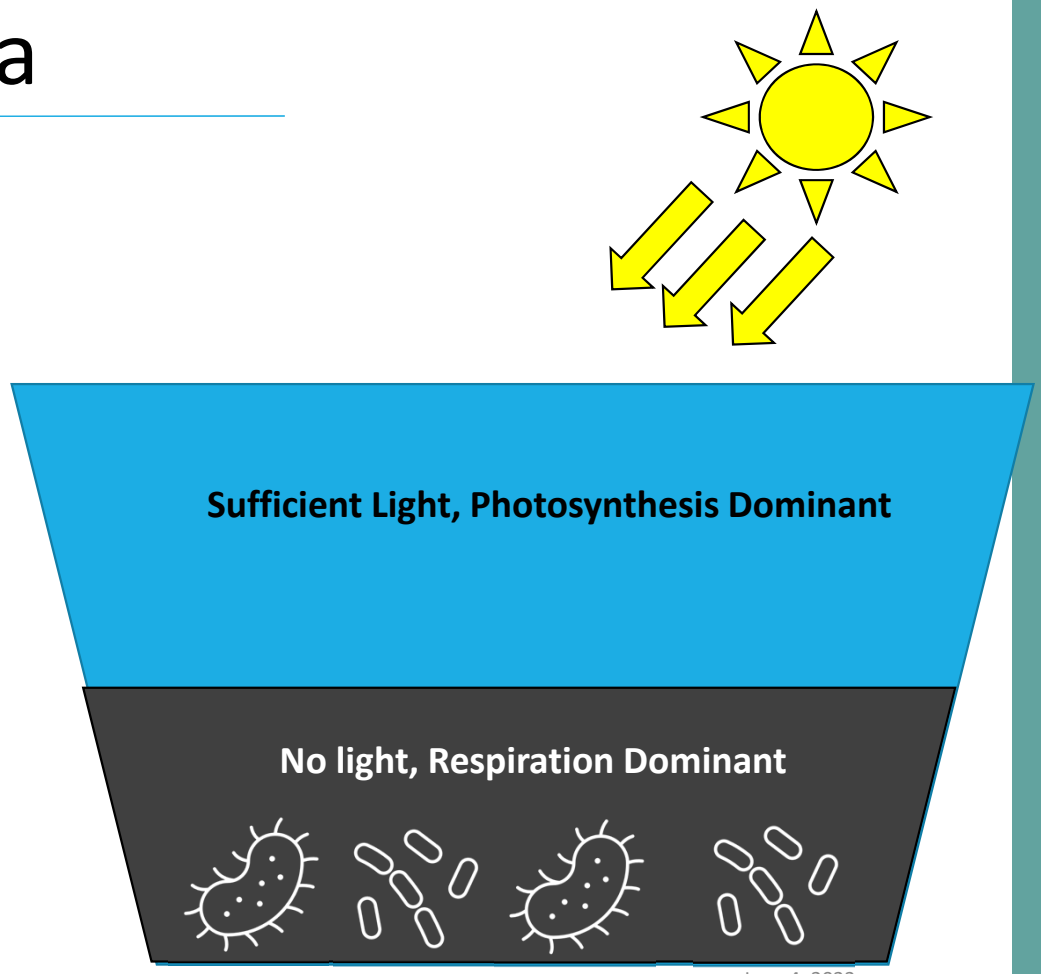
Oxygen Loss and Anoxia

- Lakes are balances between photosynthesis and respiration (gaining oxygen and losing oxygen)
  - Photosynthesis: Plants and Algae
  - Respiration: **Bacteria**, Zooplankton, Fish, Plants
- Shifts between oxygen surplus and depletion on daily and seasonal timeframe.
- Lake bottoms have less light and contact with the surface (stratification), making them ideal areas for bacterial respiration.
- Eventually, bottom waters are devoid of oxygen **Termed Anoxia**



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External load contributes organic and inorganic matter

Load settles to bottom to form nutrient rich sediments

Low light and high bacterial decomposition drive O2 down

In the Sediment

Ferric Iron/Phosphorus -> Ferrous Iron + Phosphorus

Phosphorus is Released Into the Water Column Ready for Algae to Use!!!!!

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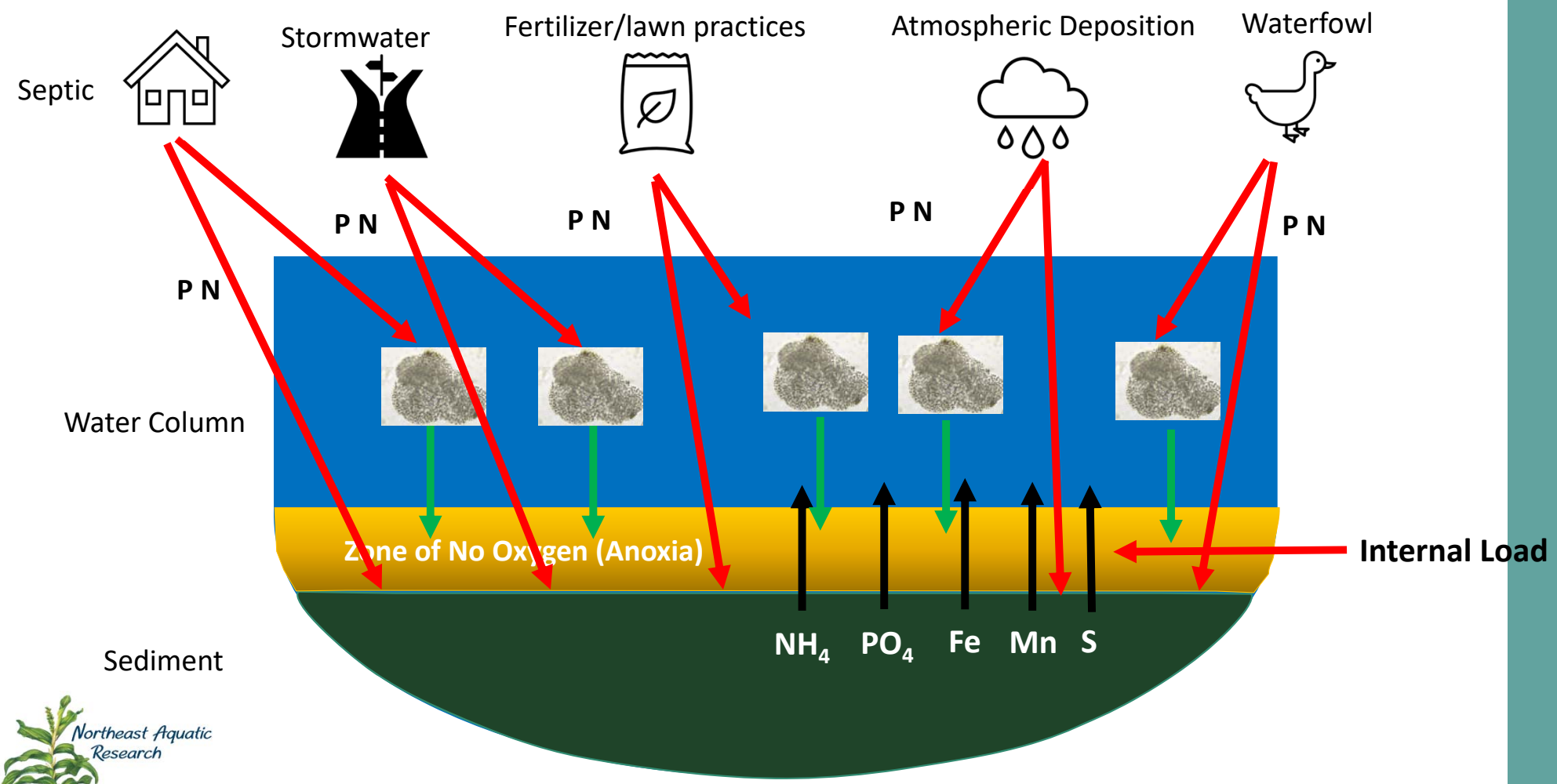
Sources of Phosphorus and Nitrogen



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Significance of Internal Load

- **Every lake has some level of internal loading**
  - May not be Fe-P release, but biological or physical
- Timing of internal load coincides with other favorable algae conditions
  - High light and high temp
- Watershed loads (stormwater) often reduced during same time of internal loading
  - Increasing relative importance.
- Readily available form of phosphorus
  - Also ammonia and iron!!

What Can Be Done About The Internal Load???

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Managing the Internal Load

Remove the sediment/water

Bind P so it is not released

Improve oxygen conditions

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Dredging/Hypolimnetic Withdrawal

- Dredging: Removing the sediment
  - In theory, most effective technique for internal load
  - Either mechanical or hydraulic
  - Cost intensive/lots of permits
  - Significant change to ecosystem
- Hypolimnetic Withdrawal: Removing the water
  - Only works with dams with bottom release valves
  - Released anoxic and high nutrient water downstream
  - Significant downstream impacts

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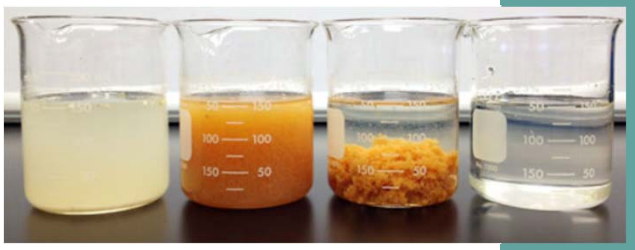
Nutrient Inactivation

- Binding P with an anoxia-insensitive mineral
  - Aluminum sulfate + water → aluminum hydroxide + hydrogen ions
    - (lowers pH of water, which is why buffering solution needed to stabilize pH)
  - Phoslock -> Lanthanum-modified bentonite
    - Forms insoluble Rabdophane
  - Applied as a slurry or as a liquid
  - Initially used as drinking water treatment technology (Alum)
  - Has been used around the world in lake restoration for 40yrs
    - Better technology and more successful treatments in last 15yrs.
    - Phoslock is relatively new (~10-15 years)



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Circulation

- Movement of water to increase atmospheric interaction that oxygenates, homogenize water quality, and disrupt algal growth.
- Most common through diffused air from the bottom.
- Under sizing is #1 issue
- Case studies show inconsistent results

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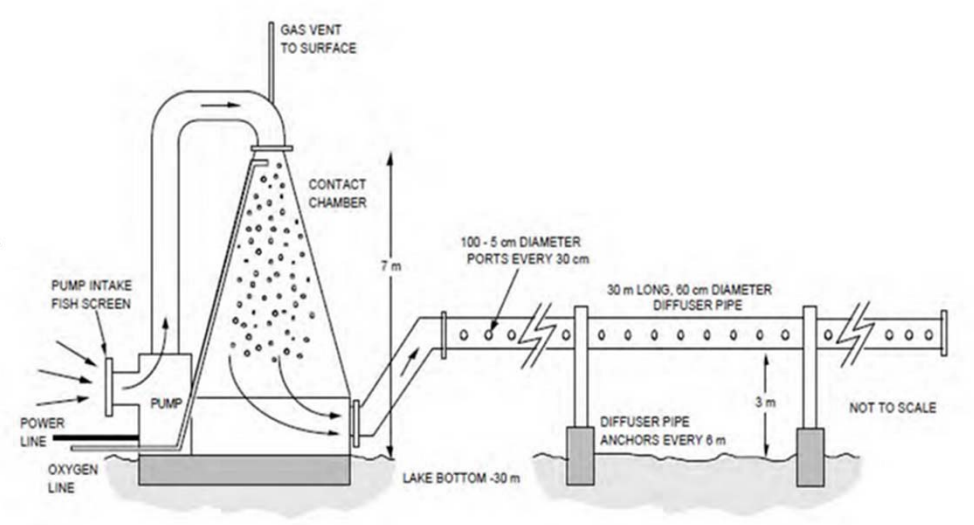
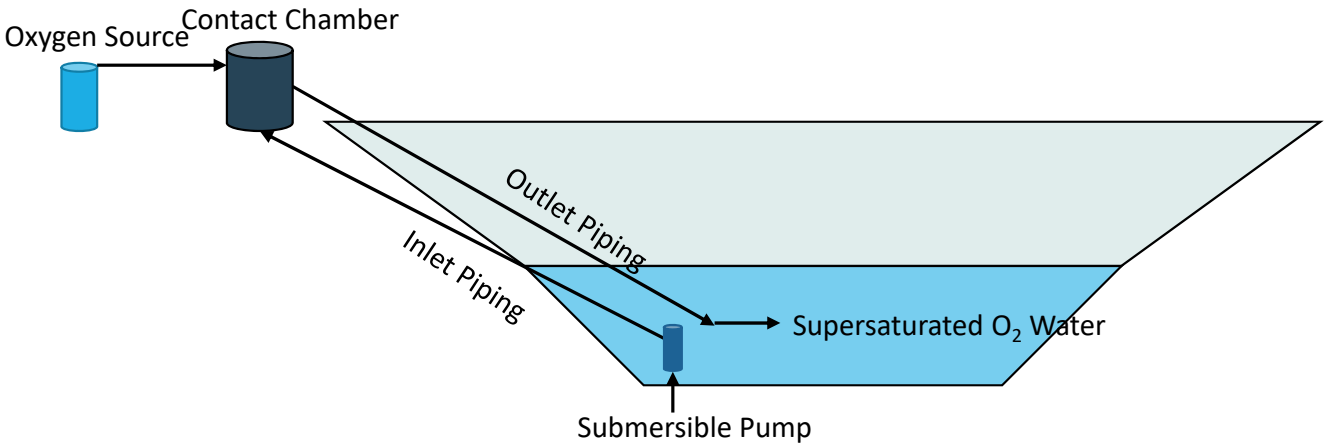
Aeration

- The addition of oxygen to deeper water in a thermally stratified like without disrupting that stratification.
- Most common in drinking water supplies, trying to reduce other compounds that are released during anoxia (Fe, Mn, Hg, S)
- Newer technology targeting shallower lakes





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Conclusions

- Internal loading is the regeneration of sediment nutrients back into the water column
  - Driven by low oxygen at the bottom of lakes
- Ultimate source is the watershed
  - Organic and inorganic materials
- Unseen source of nutrients
  - Not as evident as stormwater, waterfowl or septic systems
- **Cannot be ignored!!!**
  - Some lakes will not have improved phosphorus or algae conditions even if all watershed sources are controlled

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