Aerating Culture Ponds

to Improve Water Quality

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Realism Rule #1

A stressed fish is a dead fish…eventually.

- Severe/Acute stress is typically caused by a sudden event, causing death within minutes, hours, or up to a day.
- Chronic stress is longer term exposure to poor living conditions, causing impairment to the immune system.
  - A chronically stressed fish is a diseased fish and then, eventually, a dead fish.

Shamelessly pirated from Lynch (2013)

Realism Rule #2

Must closely match production goal (pounds) and subsequent feed use with the system's ability to remove waste.

- In recirculating aquaculture systems (RAS), production is based on gallons of water (living space) and the capacity of the filtration systems.
- In flow-through systems, production is essentially based on gallons of water and exchange rate: the ability to flush wastes.
- In **aerated** Midwest ponds, a realistic production goal is 3,000 pounds of fish per acre. Above that requires increasing the pond's ability to digest additional wastes.
  - An important feature of the ability to process waste is the presence of dissolved oxygen (DO).

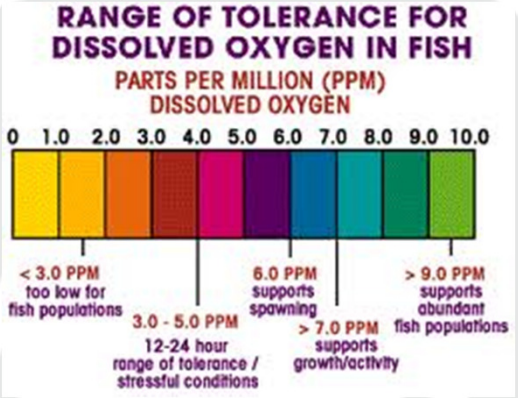
Shamelessly pirated from Lynch (2013)

Water-quality parameters to monitor:

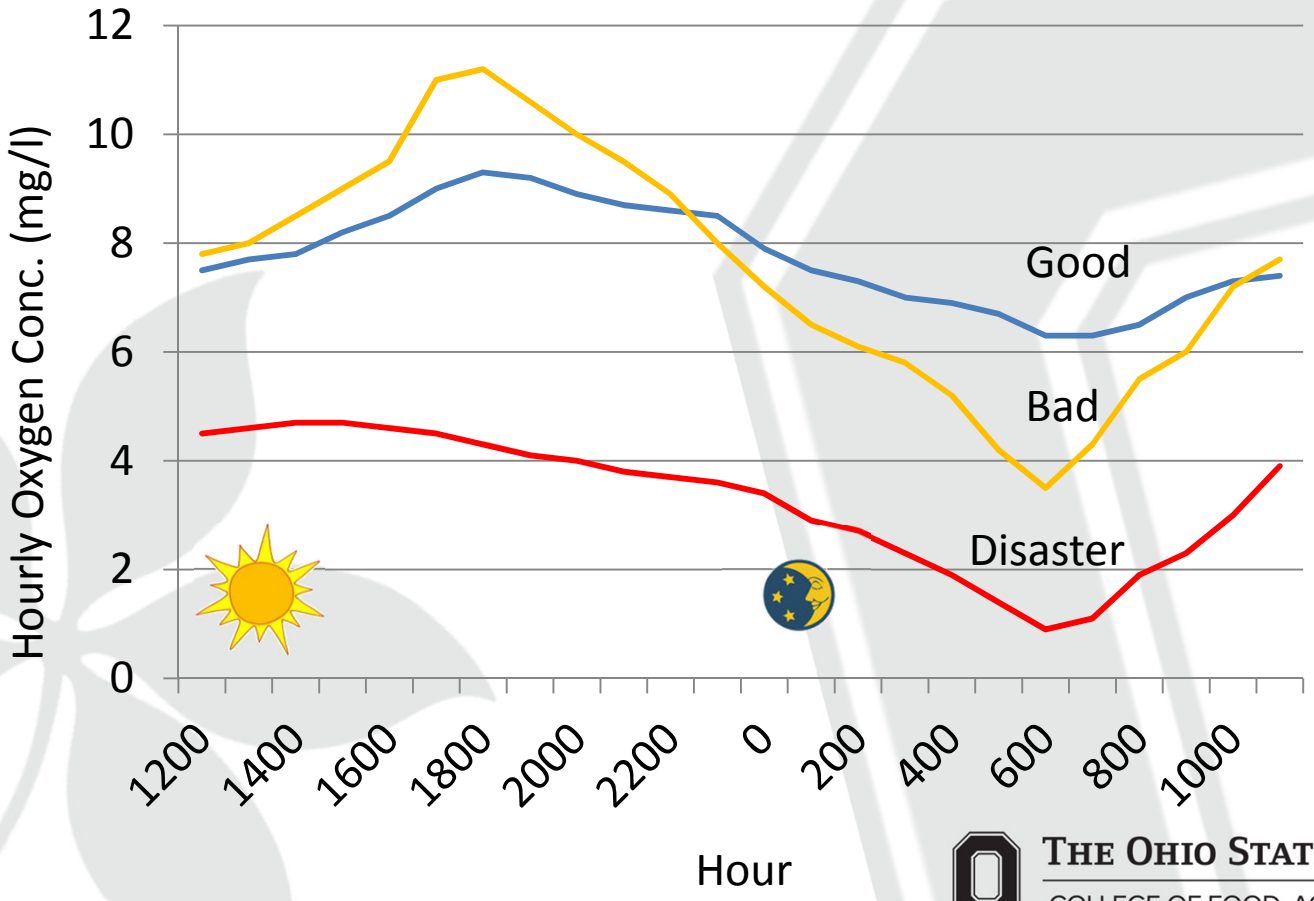
- Water temperature
- Dissolved oxygen (DO)
- pH
- Nitrogen compounds
  - Nitrite
  - Ammonia
  - Un-ionized ammonia
- Alkalinity
- Carbon dioxide

Dissolved oxygen (DO)

- Dissolved oxygen (DO) used by fish, plants, and bacteria.
- Less than 5 ppm can lead to chronic fish stress; less than 3 ppm can lead to fish deaths.
- Bacteria most efficient in degrading wastes need oxygen: i.e., aerobic bacteria.
- Strong pattern of daily and seasonal variation.



DO: daily variation



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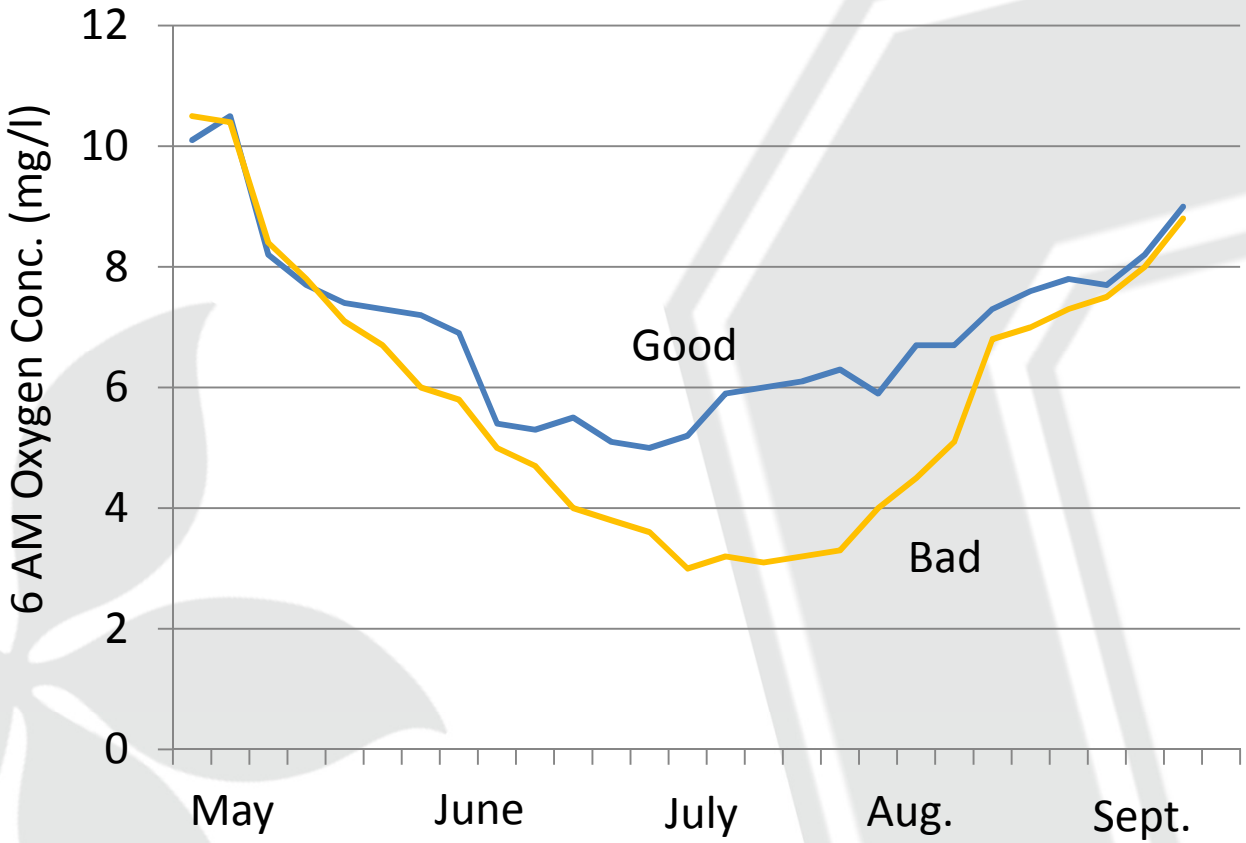
DO: growing season variation



A few definitions

- **Epilimnion**, literally “surface lake”: The top-most water mass of a stratified water body/pond.
- **Hypolimnion**, literally “bottom lake”: The bottom-most water mass of a stratified water body/pond.
- **Thermocline**, literally “temperature gradient”: Transitional zone of the water column between the epi- and hypolimnion.
- **Photosynthesis**: The process by which plants and algae convert sunlight to sugars for energy. A byproduct of photosynthesis is oxygen.

Factors affecting DO levels

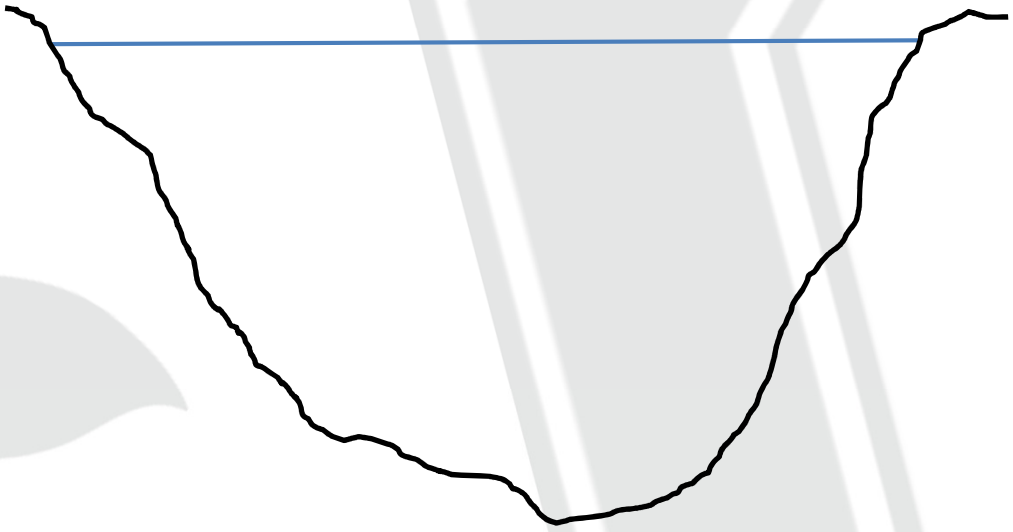
- Sunlight
  - Sunlight produces oxygen, biological oxygen demand (BOD) uses oxygen at night.
  - Cloudy days lower daylight oxygen production, affecting night levels.
  - Solstice: losing daylight after 21 June.
- Green stuff: biomass of aquatic plants and algae/planktonic algae
  - Photosynthesis: a byproduct is oxygen.
  - “Choked” greenery elevates daytime oxygen to very high levels, but night levels are very low and can crash (BOD).
  - Sudden die-off of planktonic algae is a major cause for concern.
  - Aquatic plants and filamentous algae are not likely to die-off suddenly unless you do it!
- Water temperature: seasonal variation
  - Warm water can hold less oxygen than cool water.
  - Warm water increases many biotic processes and thus BOD.

More factors affecting DO levels

- Feeding
  - Lower oxygen levels during periods of heavy feeding.
  - Begin to elevate a pond's BOD quickly once feeding exceeds 15 lbs per day per acre.
  - There is a feed–waste cumulative effect.
- Fish size
  - 2nd year growout translates to higher feed amounts in June, July, and August in comparison to 1st year fingerlings.
- Aeration
  - Nighttime oxygen levels can be raised with vigorous surface aeration.
- Volume of anoxic water
  - Increased volume of **hypolimnion** lacking oxygen lowers night levels.

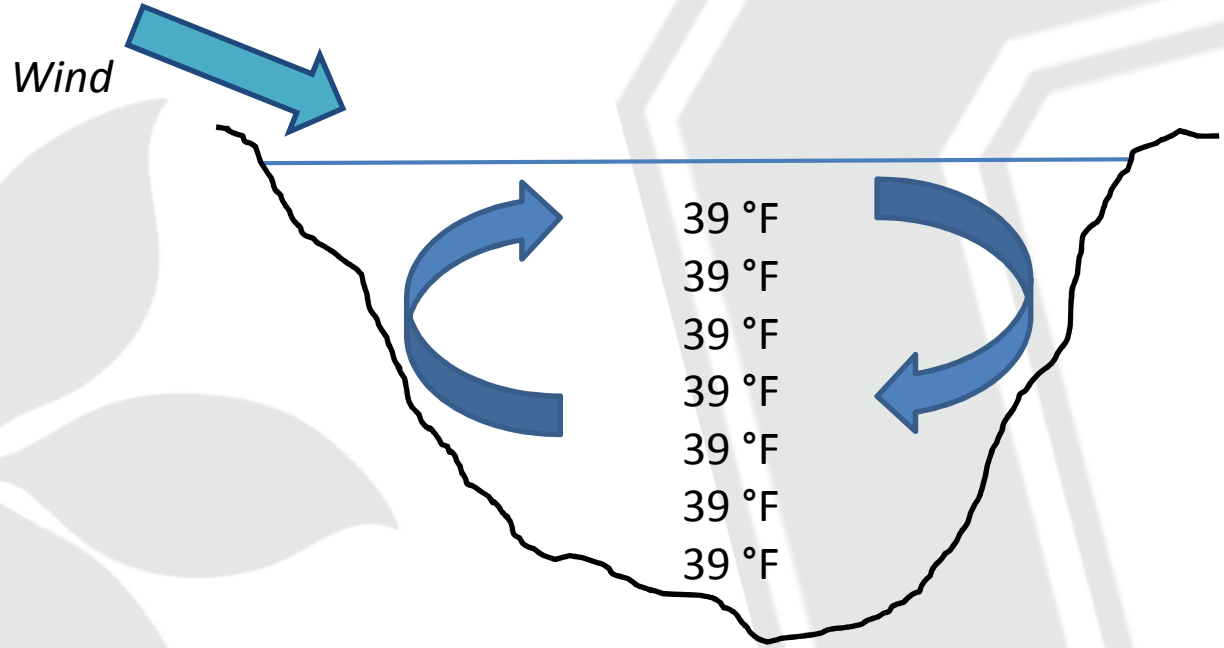
Unmanaged stratification

- The hypothetical pond-basin schematic:



Unmanaged stratification

- Spring turnover (mixed):

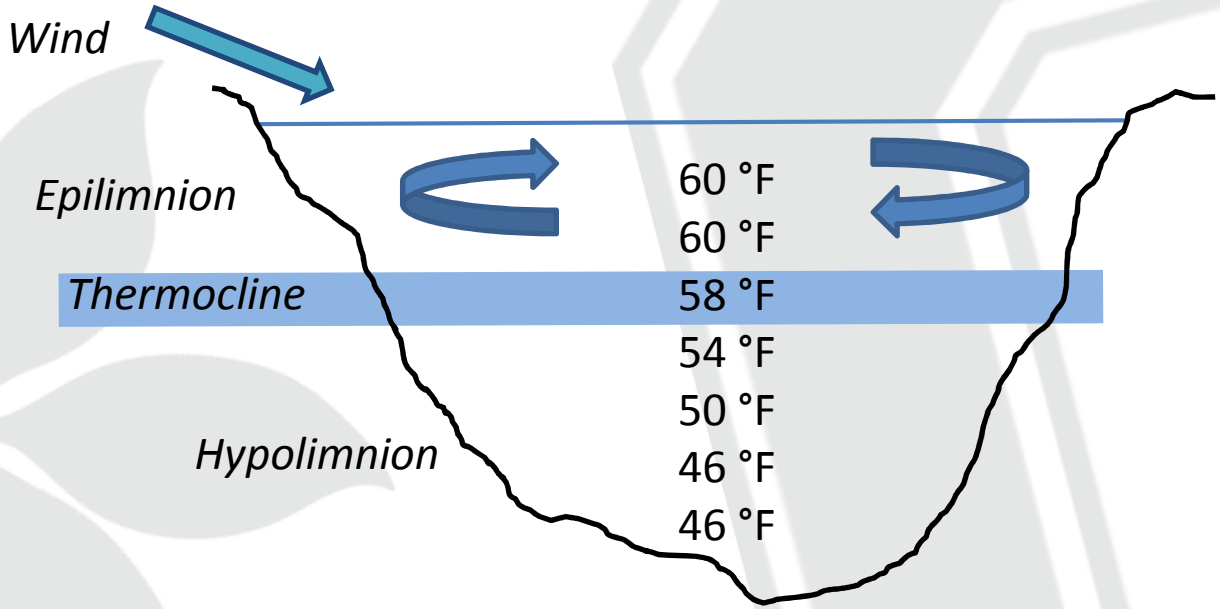


Unmanaged stratification

- **Pop quiz!** Which is denser/"heavier": warm or cold water?
  - For the most part, water's density increases (water gets "heavier") with decreasing temperature.
  - *The most important temperature in the world:* However, water is densest at approx. 39 °F, density again decreasing as temperature falls below that level. This fact makes life possible. Why?
  - Freezing at 32 °F, ice is less dense than cold water and floats rather than freezing from the bottom up.

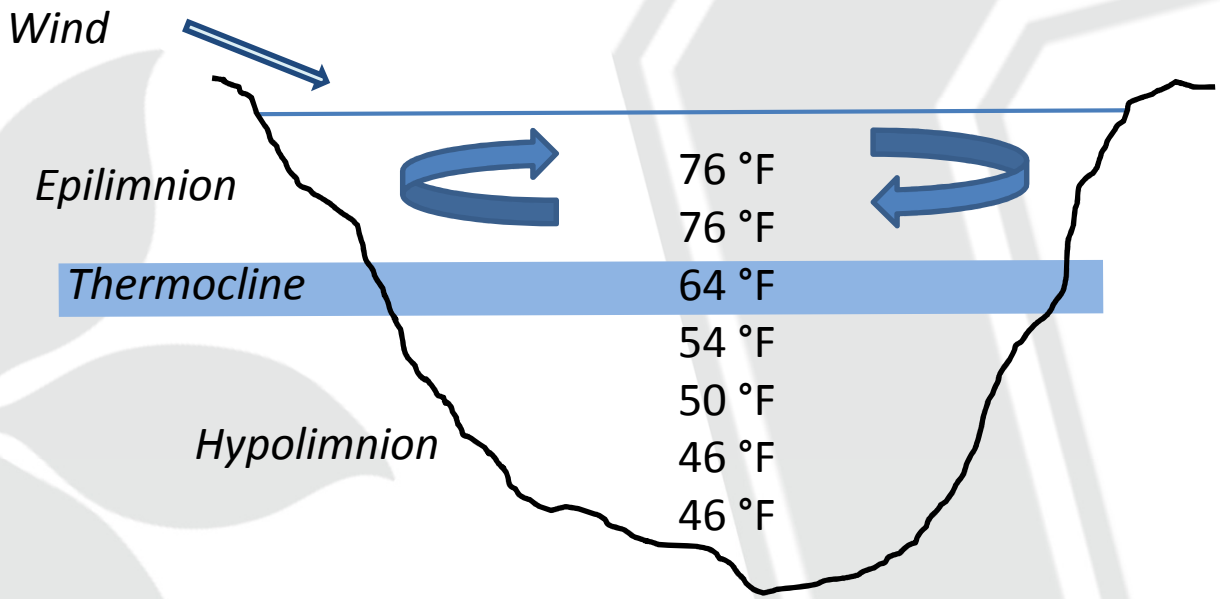
Unmanaged stratification

- Late spring (initial stratification):



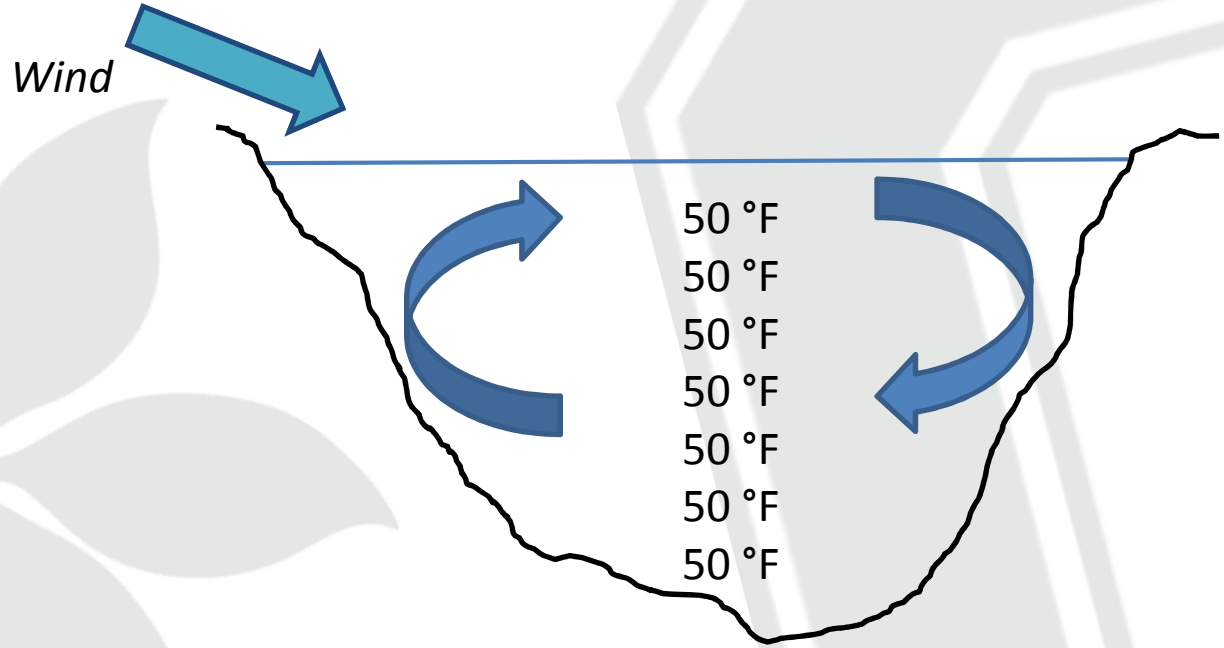
Unmanaged stratification

- Summer (strongly stratified):



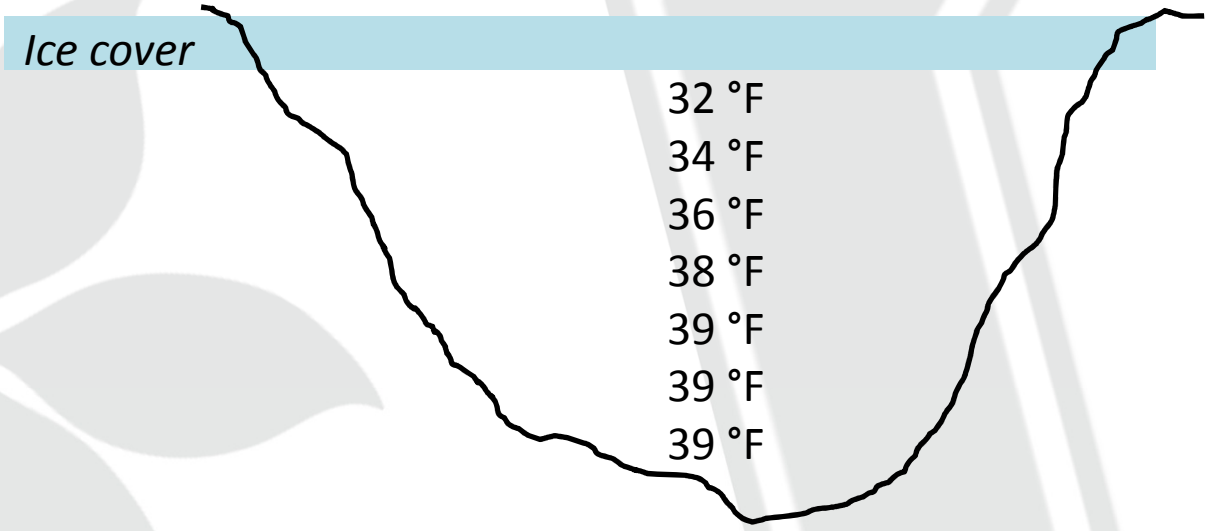
Unmanaged stratification

- Fall turnover (mixed):



Unmanaged stratification

- Winter (kinda stratified):



Factors effecting stratification

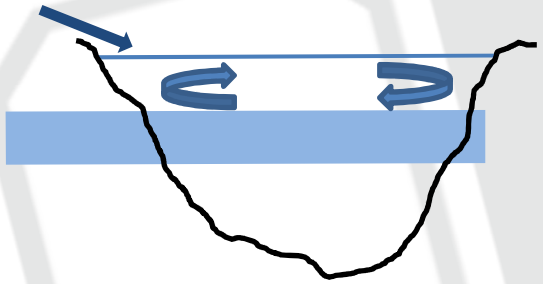
- **Pond depth:** Likelihood or strength of stratification increases with depth.
- **Wind:** Stratification delayed, thermocline driven deeper, and/or seasonal mixing initiated earlier with increasing wind energy.
- **Weather/Season:** During calm, hot summers, the interaction of temperature and lack of wind lead almost all ponds (even if very shallow) to stratify.

Factors effecting stratification

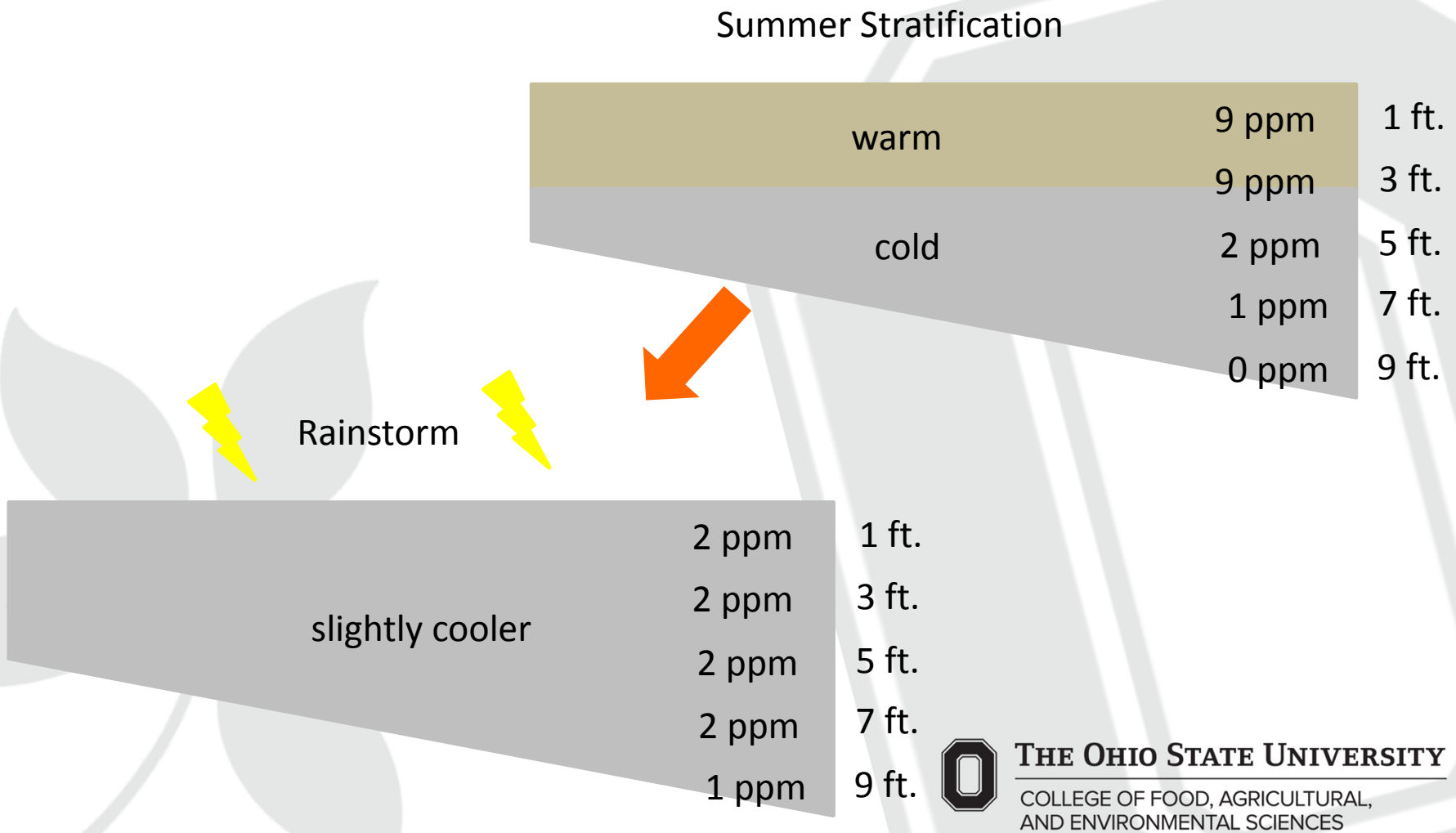
- **Weather/Season:**
  - **Premature/Early turnover:** Sudden, cold rainfall with late summer storms can chill epilimnetic water, increasing density and forcing it deeper into the water column, thus displacing and driving up hypolimnetic water.
    - Symptom is often dark grayish or blackish cloudiness of pond water as organic muck/sediment is stirred up with movement of bottom water.

Oxygen issues

- **Epilimnion** well mixed with atmospheric oxygen, but warm and often warmer than comfortable for many fish species.
- **Hypolimnion** isolated from atmosphere. *Biologically productive ponds are likely to consume limited supply of hypolimnetic oxygen.* A couple more definitions:
  - **Hypoxia:** Very low oxygen (often 2–4 ppm).
  - **Anoxia:** Insufficient dissolved oxygen to support aerobic life (right down to 0 ppm).



Premature summer turnover



Summer kill

Causes:

- Too much nighttime BOD: excessive vegetation.
- Sudden die off of planktonic algae.
- Poorly planned herbicide/algaecide treatments.
- Premature turnover or pond “flipping” following cold rain.

Prevention:

- Realistic production expectations.
- Conservative herbicide treatments, avoiding as season dictates: remove plants manually when possible.
- Prevent stratification.
- Have appropriate aeration at the ready!

Winter kill

Causes:

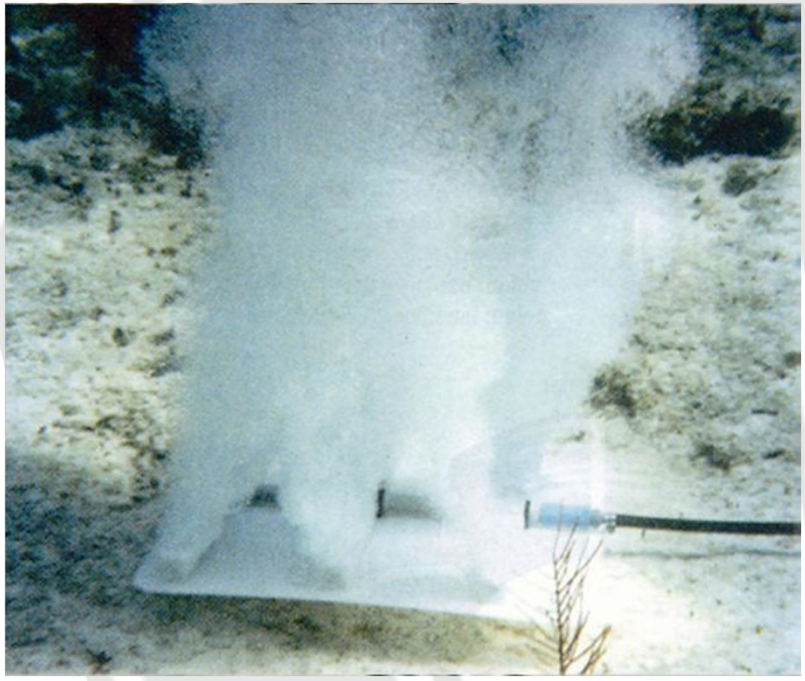
- Opaque ice.
- Any ice with heavy snow on top.
- DO lowers slowly, so may take weeks before fish are in trouble.

Prevention:

- Monitor oxygen.
- Remove snow, or
- Aerate to open a hole:
  - Raise diffuser or suspend air stone approx. 2' below surface to avoid super-cooling bottom waters and stressing fish, or
  - Surface aerate (more expensive)
  - If bad winter expected, install early.

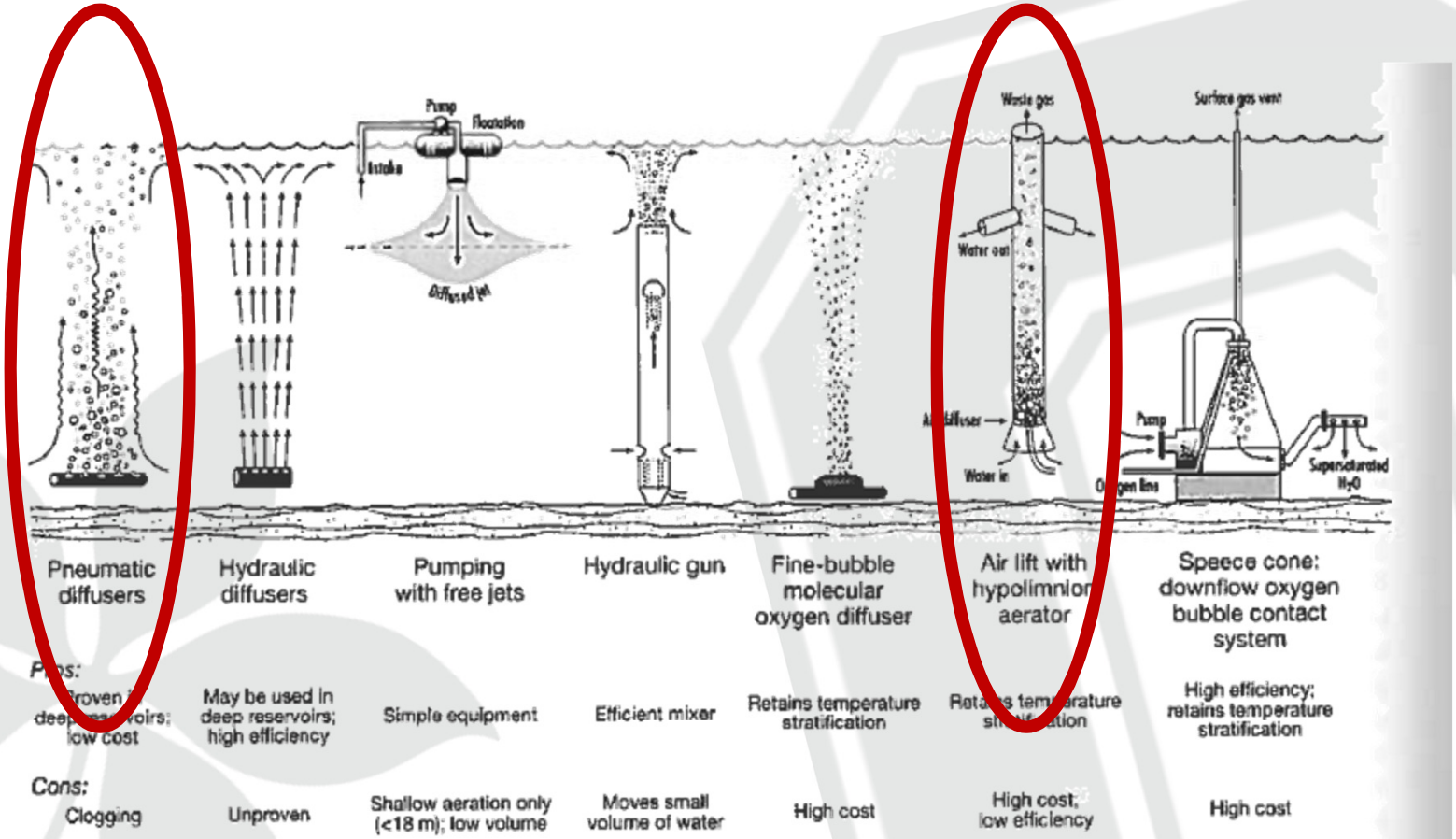
Not all aerators are created equal

Minimal nutrient management benefits
(but it is kinda pretty)



Maximum stratification management
benefits: Cheaper, efficient, and effective

Not all aerators are created equal



Kalff, J. 2002. Limnology: Inland water ecosystems. Prentice Hall, Upper Saddle River, NJ.

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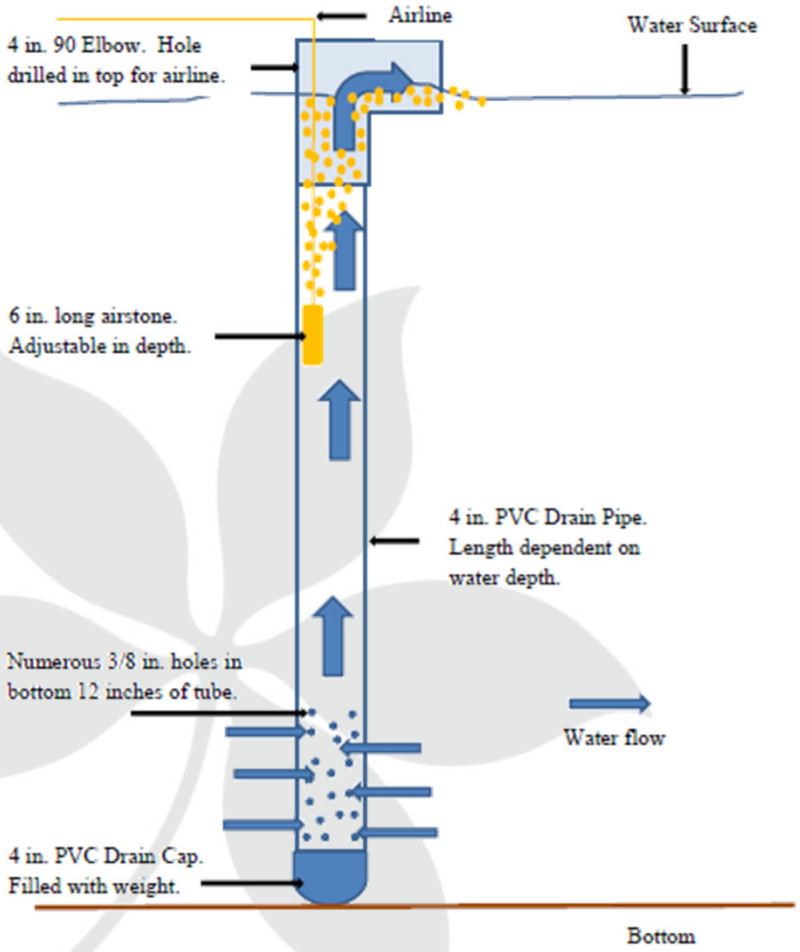
Aeration insight

- Bottom-bubble diffuser systems:
  - Efficient at mixing the water column.
  - Prevents stratification, allowing oxygen in deep water.
  - Can erode an opening/hole in winter ice.
  - **Not** an effective method to quickly add oxygen to water.
  - Low cost to operate.

Aeration insight



Fine-art credit: Bill Lynch

- Air-lift systems:
  - Efficient at mixing the water column using very little energy.
  - Prevents stratification by moving high volume of water, allowing oxygen in deep water.
  - Not an effective method to directly add oxygen to water (less so than diffusers).
  - Very low cost to operate and low maintenance needs.

Aeration insight

- Surface agitation
  - Very effective at rapidly adding oxygen to water: great tool for immediate response to low-oxygen events.
  - Not effective at preventing stratification (except in very shallow ponds).
  - Expensive to operate: nighttime operation alone may amount to > 10x the expense of 24-hr operation of diffuser or air lift.
    - Hypolimnion can still go anoxic each day with nighttime-only use: even brief anoxia can negatively impact water-quality issues: aerobic bacteria, nitrogen cycle, and phosphorus.

Why aerate to manage stratification?

- Specifically, regarding moderately coarse-bubble/pneumatic diffusers or air lifts:
  - Bubbles themselves directly introduce some oxygen, but contribution tends to be negligible.
    - The finer/smaller the bubble, the greater the surface area of bubbles *en masse* and the more oxygen directly introduced.
  - Coarser bubbles driving up from the bottom tend to drag water mass with them, creating circulation and disrupting stratification.
    - While very fine bubbles introduce more oxygen directly, they cannot move enough water to disrupt stratification.
  - Without the physical barrier imposed by dense hypolimnion, atmospheric oxygen is potentially able to penetrate to bottom waters, potentially eliminating anoxia in the hypolimnion where **anaerobic bacteria** would otherwise produce obnoxious, smelly gases and bottom muck.

Why aerate to manage stratification?

- **Oxygenating bottom sediments:**
  - Enhances production and efficiency of aerobic bacteria, thereby increasing efficient decomposition and shifting nitrogen cycle away from ammonia and towards nitrates.
  - Reduces possibility of summer and winter fish kills.
  - Reduces or eliminates internal cycling of phosphorus, enhancing favorable N:P ratio and limiting potential issues with toxic cyanobacteria/blue-green algae.

- **Circulating water mass:**
  - Circulates and suspends nutrients for rapid uptake into the planktonic food web.
  - Reduces nuisance algae and duckweed abundance through rapid nutrient uptake by planktonic algae (fueling beneficial food webs) and reducing sunlight penetration.

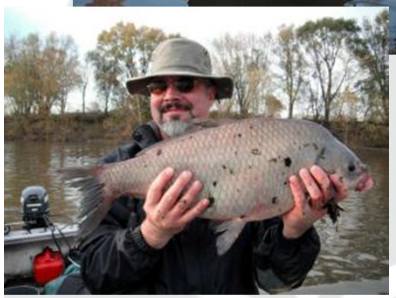
Why aerate to manage stratification?

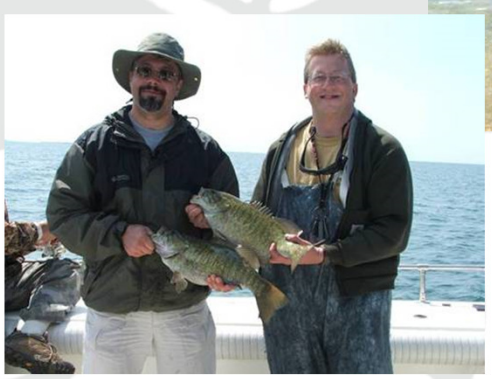
- Implement any diffuser or air-lift aeration program when waters are cool, namely in the spring.
  - Disrupting waters that have already strongly stratified for the season—paradoxically, even in trying to manage oxygen via aeration—has the potential to bring hypoxic/ anoxic water to the surface, causing premature turnover, oxygen crash, and a summer fish kill.

Questions?





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Pond management fact sheets available at:
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