Water Quality Management

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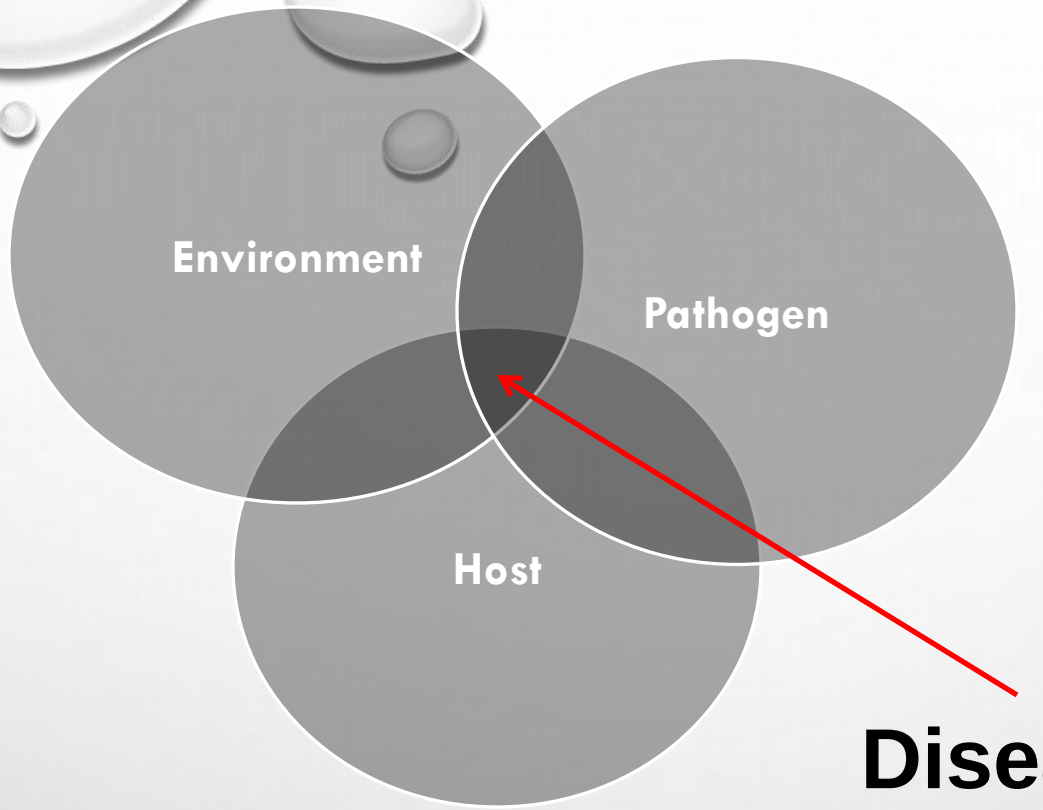
Water Resources

Inadequate water quality causes more losses than any other problem!

To a great extent water quality determines the success or failure of a fish farming operation

Importance to Disease Management

- The disease today is most likely related to a stress from 10-14 days ago!

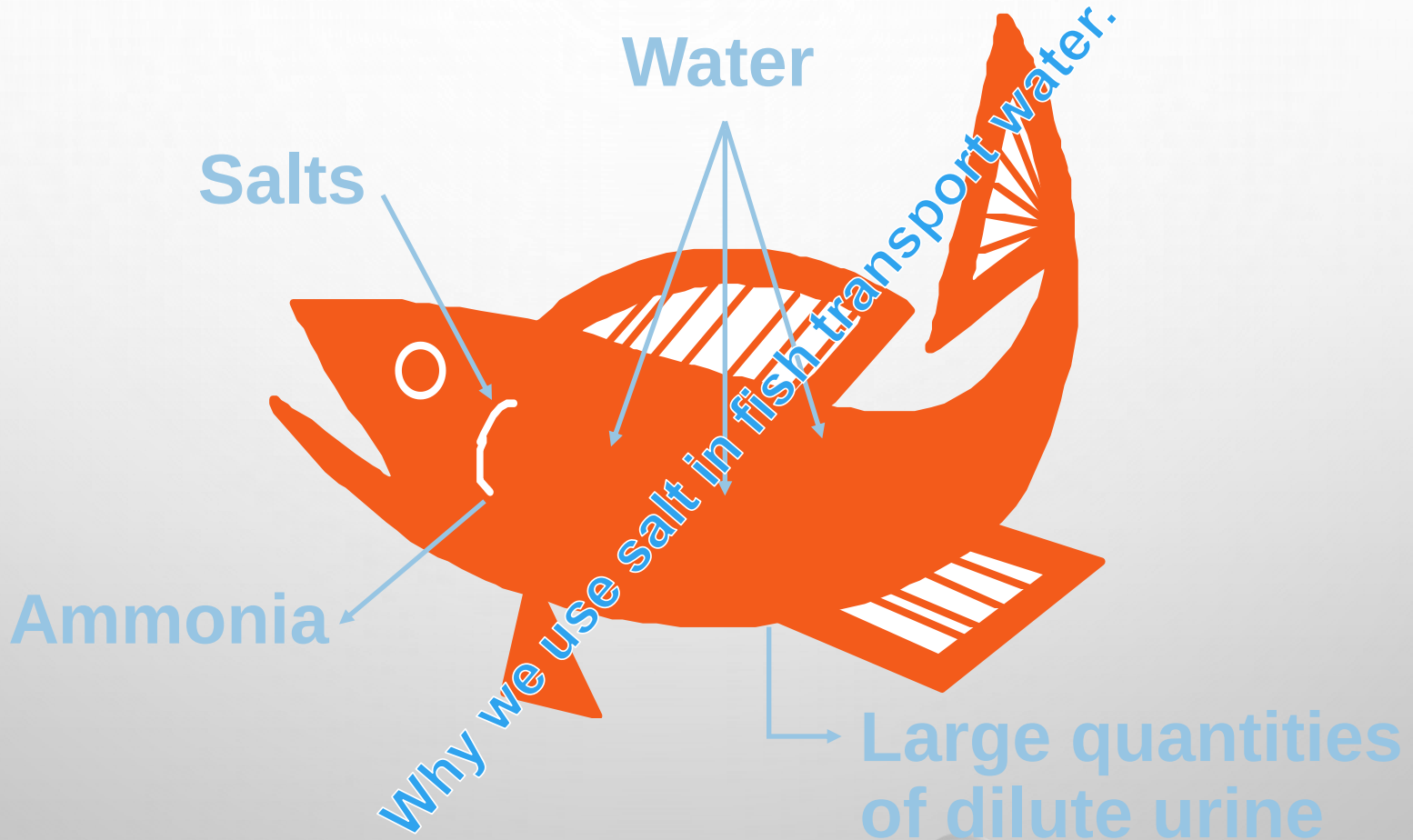


Disease Occurs

Fish perform all bodily functions in water

- Eat
- Breathe
- Excrete wastes
- Reproduce
- Take in and lose salts

Water Balance in Freshwater Fish



Water Quality

Water quality in aquaculture describes the hospitableness of a water body for the culture of desirable aquatic species.

Physical

Chemical

Range requirements are species specific

Water Quality Parameters

Physical

- Temperature
- Turbidity
  - light penetration

Chemical

- pH
- Salinity (salts)
- Dissolved Oxygen (DO)
- Chlorine
- Nitrogen
  - Ammonia
  - Nitrite
  - Nitrate
- Nutrients: Phosphorus and Nitrogen
- Alkalinity (carbonates)
- Hardness (dissolved cations)
  - Calcium
- Others

Temperature

- Affects the metabolism of most aquatic organisms
    - Q10 Rule
    - Each species has optimal range for growth
- Affects chemical parameters in water
    - Dissolved Oxygen
    - Ammonia Nitrogen
- Measured in °C or °F

Temperature Extremes

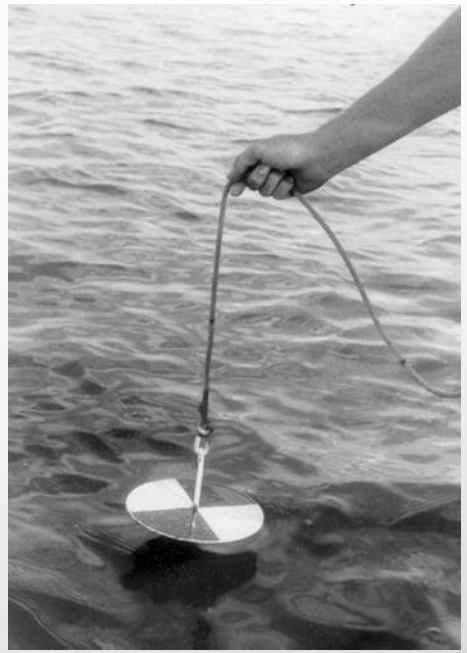
- Causes
  - Excessively warm water causes mortality in trout
  - Excessively cool water causes mortality in tilapia and other tropical fish
  - Water outside optimal growing range
    - Affects growth rates

Symptoms of Temperature Extremes

- Symptoms
  - Loss of appetite.
  - Loss of equilibrium.
  - Acute mortality
- Treatment
  - Maintain temperature at desired range.
  - Flush fresh water into ponds or tanks.

Turbidity

- A measure of light penetration into the water,
  - Affects photosynthetic activity
    - Organic – phytoplankton
    - Inorganic – Suspended soil particles
      - Runoff
      - Biological
    - Secchi disk
    - Turbidimeter



Chemical

- pH
- Salinity (salts)
- Dissolved Oxygen (DO)
- Chlorine
- Nitrogen
  - Ammonia
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- Phosphorus
- Alkalinity (carbonates)
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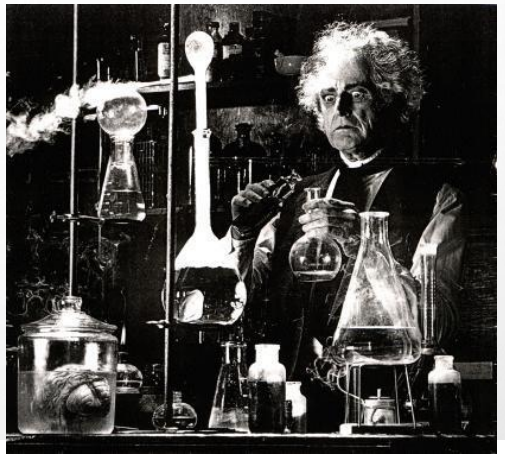
- Others



pH

- A measure of the ionic hydrogen concentration of a liquid.
  - Surrogate measure of the primary production of a water body

  - Photosynthesis = increased pH (afternoon)
  - Respiration = decreased pH (morning)
  - Acceptable range between 6 and 9
  - Fluctuation governed by alkalinity levels

Concentration of Hydrogen ions compared to distilled water		Examples of solutions at this pH
10,000,000	pH= 0	Battery acid, Strong Hydrofluoric Acid
1,000,000	pH = 1	Hydrochloric acid secreted by stomach lining
100,000	pH = 2	Lemon Juice, Gastric Acid Vineger
10,000	pH = 3	Grapefruit, Orange Juice, Soda
1,000	pH = 4	Acid rain Tomato Juice
100	pH = 5	Soft drinking water Black Coffee
10	pH = 6	Urine Saliva
1	pH = 7	"Pure" water
1/10	pH = 8	Sea water
1/100	pH = 9	Baking soda
1/1,000	pH = 10	Great Salt Lake Milk of Magnesia
1/10,000	pH = 11	Ammonia solution
1/100,000	pH = 12	Soapy water
1/1,000,000	pH =13	Bleaches Oven cleaner
1/10,000,000	pH = 14	Liquid drain cleaner

Dissolved Oxygen

- The amount of oxygen available for respiration in water
  - Used in the breakdown of energy-storing molecules
  - Has a natural saturation equilibrium in water
    - Temperature ↑ DO level at saturation ↓
    - Salinity ↑ DO level at saturation ↓
    - Elevation ↑ DO level at saturation ↓
  - Minimum DO requirements
    - Warmwater 2-3 mg/L
    - Coldwater 5 mg/L
  - Supersaturation (>100%)
    - gas bubble disease
    - unstable phytoplankton community

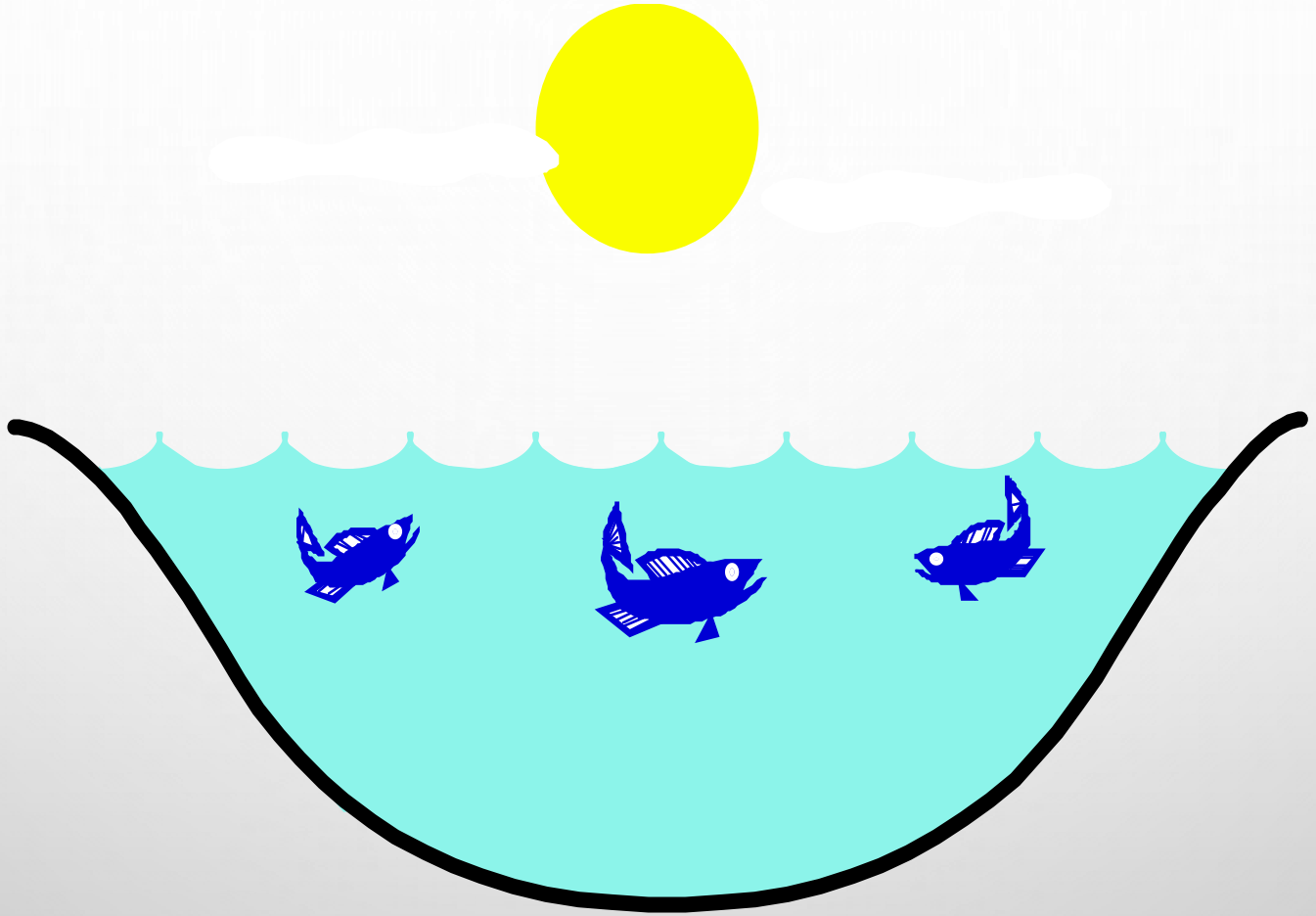
Dissolved Oxygen

- Percent saturation is as important as concentration.
- Small fish use more oxygen than large fish per mass.
- Oxygen consumption doubles for each 18 degrees rise in temperature.
- Bacteria and algae consume more oxygen than fish.

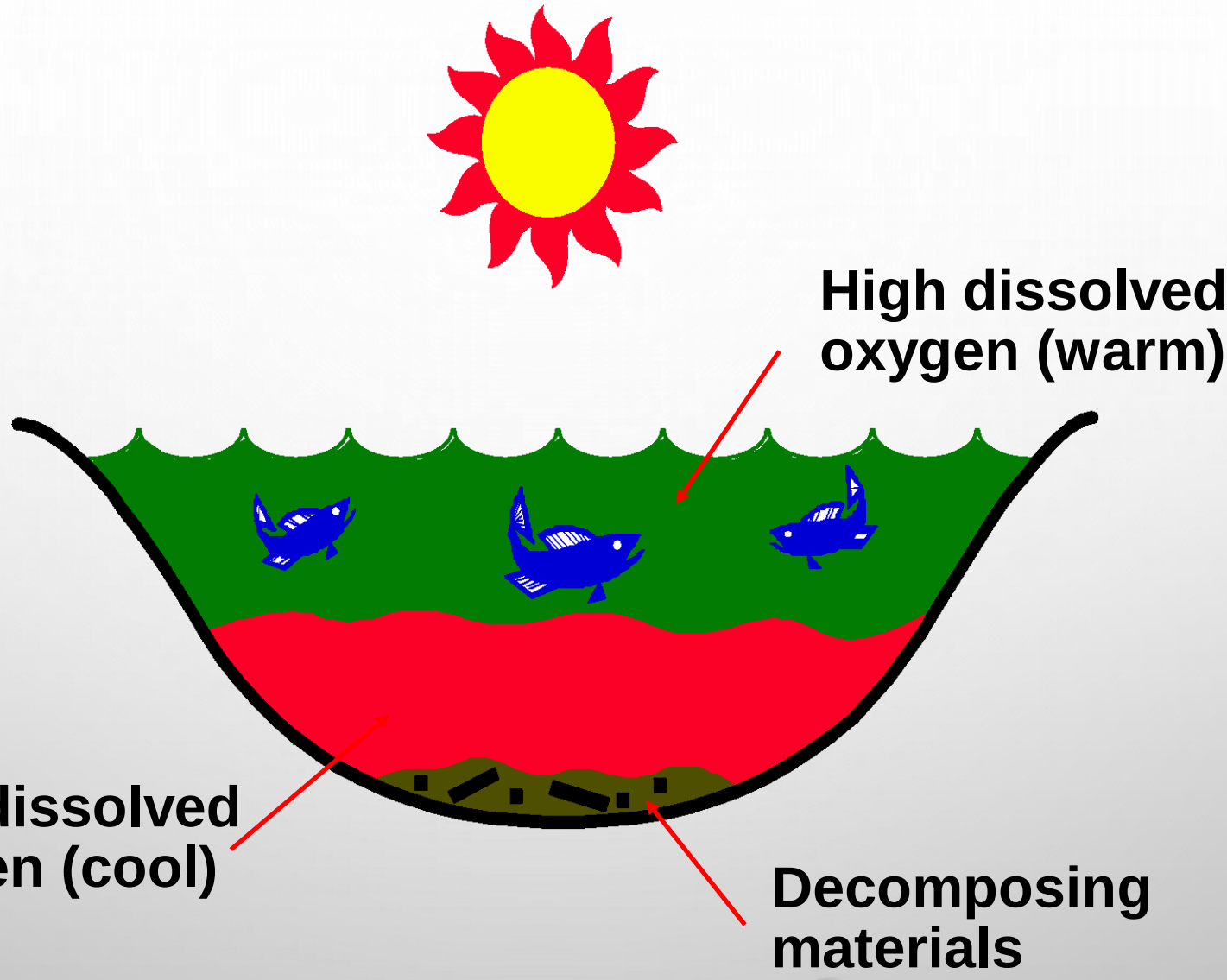
Dissolved Oxygen Depletion

- Algae dying
- Overstocking
- Overfeeding
- Cloudy or rainy weather (pond turnover)
- Equipment failure
- Signs
  - Fish go off feed.
  - Fish gasping for air at the surface (piping).
  - Change in water color from green to brown.
  - Large fish die first.

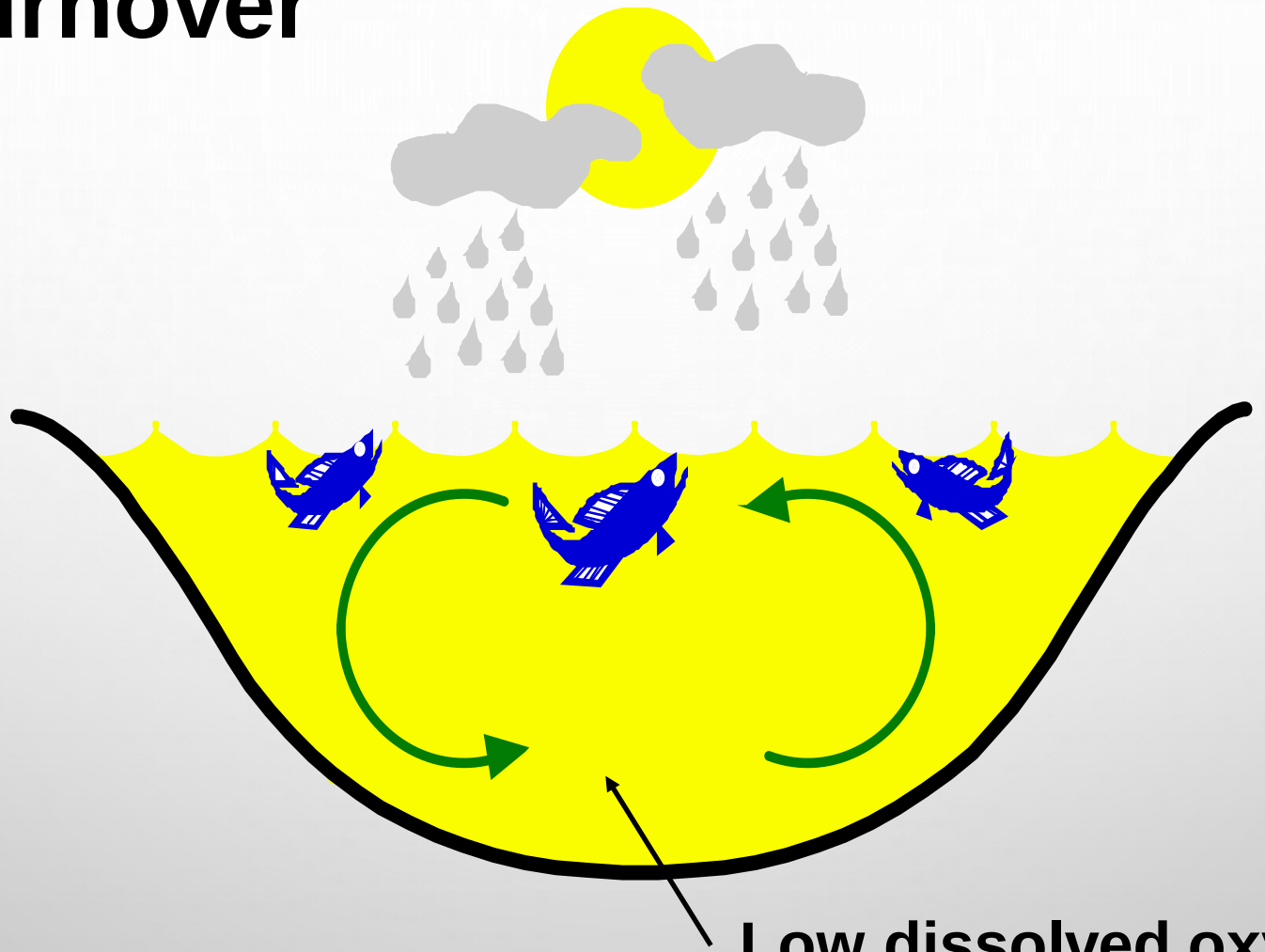
Stratification



Uniform dissolved O_2 in pond


High dissolved oxygen (warm)
Low dissolved oxygen (cool)
Decomposing materials

Turnover

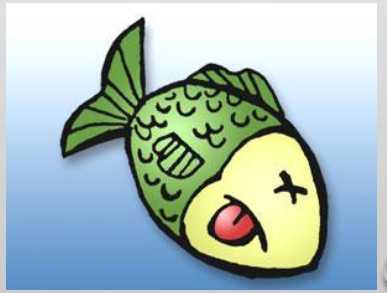


Treatment for D.O. Depletion

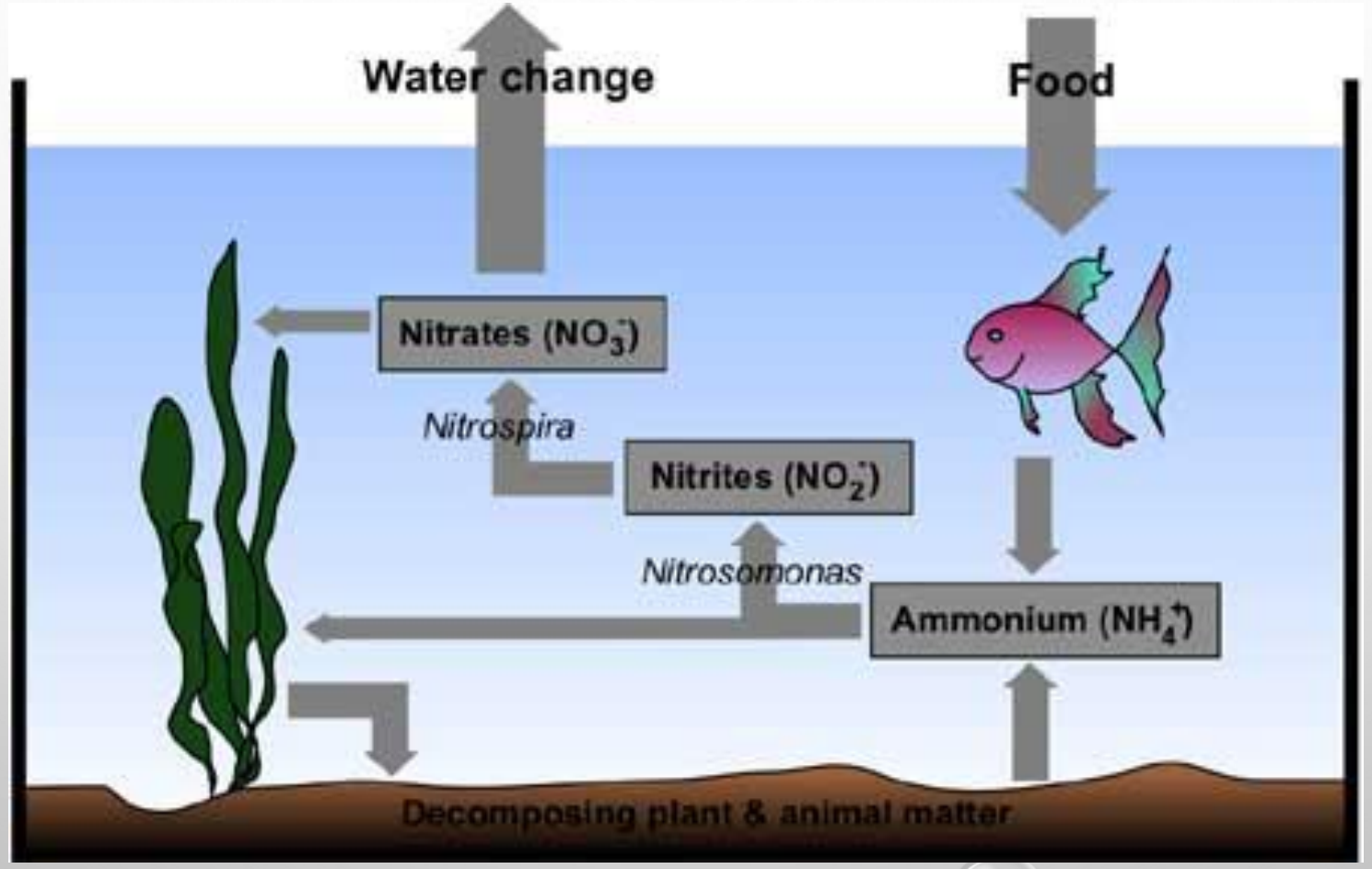
- Monitor DO levels = Key!
- Use emergency aeration.
- Flush with fresh oxygenated water.
- Stop feeding until levels increase.

Chlorine

- A toxic gas typically used in water treatment and wastewater treatment plants to disinfect water before and after human use
  - Biosecurity - disinfect aquaculture equipment
    - Bleach – Sodium hypochlorite (NaOCl)
    - Oxidizing agent
    - Chloramines
    - Crayfish and shrimp less susceptible
  - Removed by
    - Carbon filtration
    - Sodium sulfite
      - chloromines
    - Heavy aeration



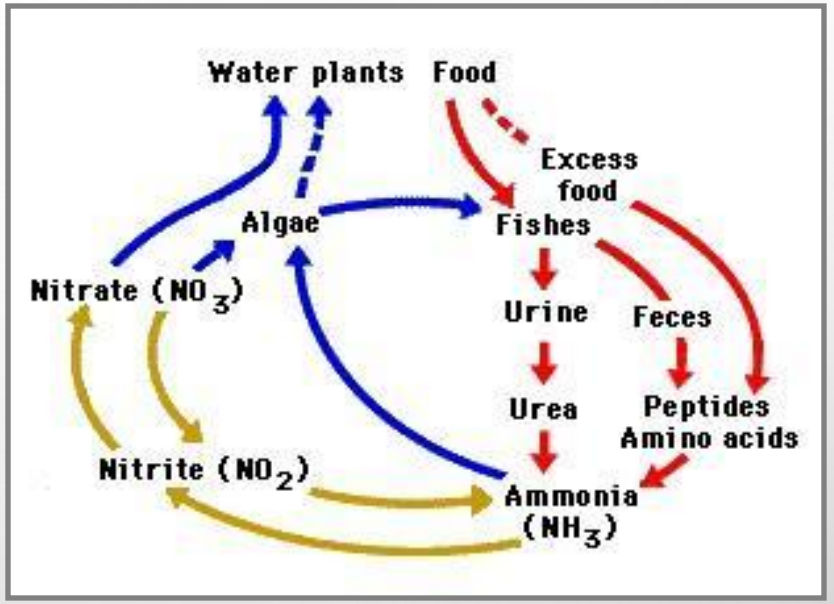
Nitrogen Cycle



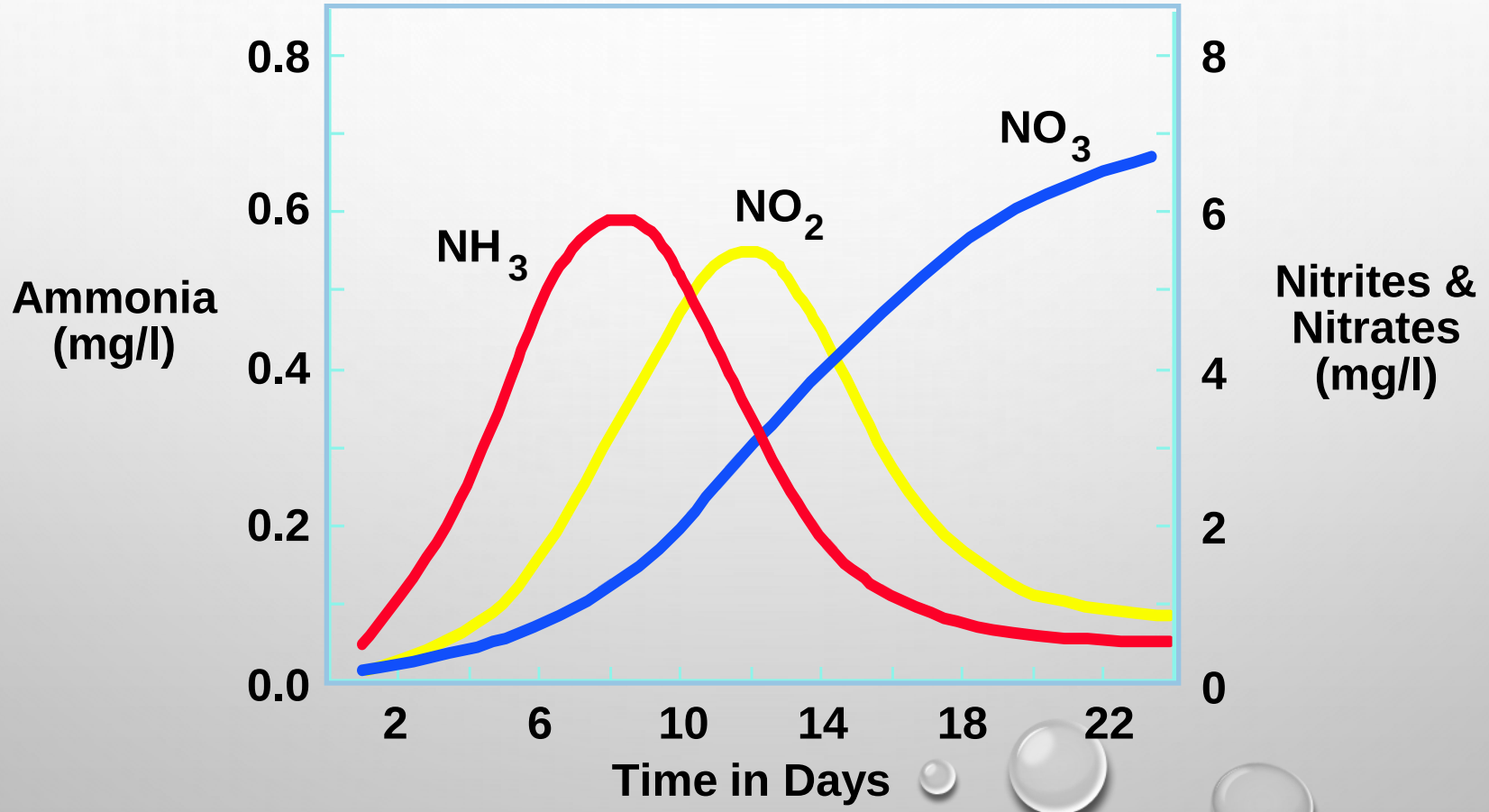
N_2 gas is also created through denitrification under anoxic conditions
Volatilized from water by aeration

Nitrogen Compounds

- Types
  - dissolved gas
  - ammonia
    - ionized
    - un-ionized
  - nitrite
  - nitrate



Time Required for Bio-Filter to Mature



Ammonia Nitrogen

- Primary metabolite of protein
  - Used in household cleaners – very toxic
  - Ammonia (NH_3) - toxic
  - Ammonium (NH_4^+) – non-toxic
- High pH and temperature make the proportion as NH_3 higher, and more toxic

	Temperature													
pH	42.0 (°F)	46.4	50.0	53.6	57.2	60.8	64.4	68.0	71.6	75.2	78.8	82.4	86.0	89.6
	6 (°C)	8	10	12	14	16	18	20	22	24	26	28	30	32
7.0	.0013	.0016	.0018	.0022	.0025	.0029	.0034	.0039	.0046	.0052	.0060	.0069	.0080	.0093
7.2	.0021	.0025	.0029	.0034	.0040	.0046	.0054	.0062	.0072	.0083	.0096	.0110	.0126	.0150
7.4	.0034	.0040	.0046	.0054	.0063	.0073	.0085	.0098	.0114	.0131	.0150	.0173	.0198	.0236
7.6	.0053	.0063	.0073	.0086	.0100	.0116	.0134	.0155	.0179	.0206	.0236	.0271	.0310	.0369
7.8	.0084	.0099	.0116	.0135	.0157	.0182	.0211	.0244	.0281	.0322	.0370	.0423	.0482	.0572
8.0	.0133	.0156	.0182	.0212	.0247	.0286	.0330	.0381	.0438	.0502	.0574	.0654	.0743	.0877
8.2	.0210	.0245	.0286	.0332	.0385	.0445	.0514	.0590	.0676	.0772	.0880	.0998	.1129	.1322
8.4	.0328	.0383	.0445	.0517	.0597	.0688	.0790	.0904	.1031	.1171	.1326	.1495	.1678	.1948
8.6	.0510	.0593	.0688	.0795	.0914	.1048	.1197	.1361	.1541	.1737	.1950	.2178	.2422	.2768
8.8	.0785	.0909	.1048	.1204	.1376	.1566	.1773	.1998	.2241	.2500	.2774	.3062	.3362	.3776
9.0	.1190	.1368	.1565	.1782	.2018	.2273	.2546	.2836	.3140	.3456	.3783	.4116	.4453	.4902
9.2	.1763	.2008	.2273	.2558	.2861	.3180	.3512	.3855	.4204	.4557	.4909	.5258	.5599	.6038
9.4	.2533	.2847	.3180	.3526	.3884	.4249	.4618	.4985	.5348	.5702	.6045	.6373	.6685	.7072
9.6	.3496	.3868	.4249	.4633	.5016	.5394	.5762	.6117	.6456	.6777	.7078	.7358	.7617	.7929
9.8	.4600	.5000	.5394	.5778	.6147	.6499	.6831	.7140	.7428	.7692	.7933	.8153	.8351	.8585
10.0	.5745	.6131	.6498	.6844	.7166	.7463	.7735	.7983	.8207	.8408	.8588	.8749	.8892	.9058
10.2	.6815	.7152	.7463	.7746	.8003	.8234	.8441	.8625	.8788	.8933	.9060	.9173	.9271	.9389

Causes of Ammonia Toxicity

- Nitrification
- Death of algae
- Decomposition of fish waste
- Decomposition of uneaten food
- Decomposition of bacteria
- Breakdown of chloramines

Symptoms of Ammonia Toxicity

- Symptoms
  - Fish swim erratically.
  - Fish may quiver when netted.
- Treatment
  - Reduce pH.
  - Reduce temperature.
  - Decrease stocking density.
  - Use biological filtration
  - Flush in fresh water.

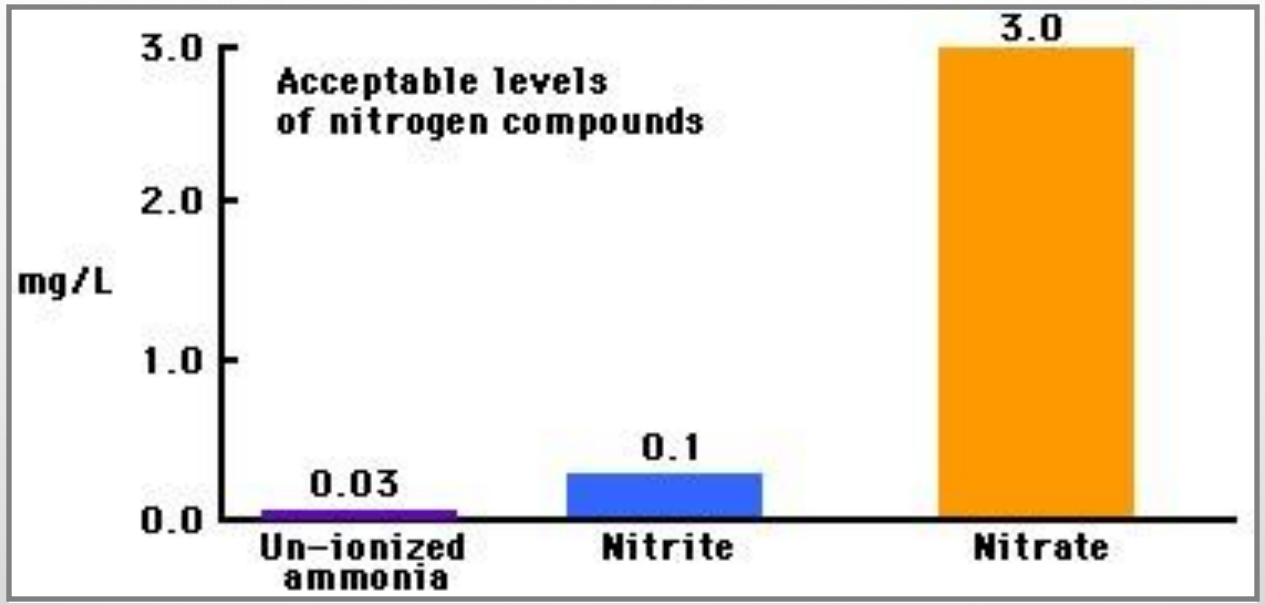
Nitrite Nitrogen (NO_2^-)

- SECONDARY METABOLITE OF PROTEIN
  - CAUSES BROWN-BLOOD DISEASE
    - ALTERS HEMOGLOBIN
    - LESS OXYGEN TRANSFER
    - EFFECTS WEAKENED BY ADDITION OF CHLORIDE IONS
      - NACL SALT
      - 10 CL^- TO 1 NO_2^- RATIO
      - 4.5 LBS OF NACL = 1 PPM CL^- PER ACREFOOT OF WATER

Nitrate Nitrogen (NO_3^-)

- Major Nitrogen fertilizer
  - Algal blooms
- Least harmful nitrogen ion
  - Can be toxic at extremely high concentrations
- Readily taken up by plants
  - Wetland mitigation
  - Aquaponics

RELATIONSHIPS



Physical Parameters

Alkalinity

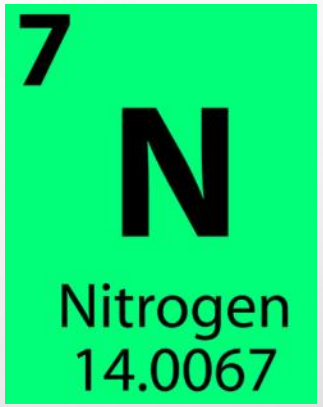
- Alkalinity is the capacity of water to buffer against wide pH swings
- Acceptable range 40-400 mg/L
- Measured in terms $CaCO_3$
  - If $NaCO_3$ the buffer capacity is less
- Solution to low alkalinity
  - Tanks
    - Add calcium bicarbonate (baking soda)
  - Ponds and raceways
    - More difficult to manage

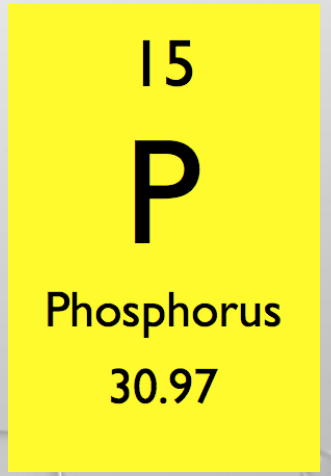
Hardness

- Hardness if the measure of divalent cations
  - calcium
  - magnesium
- Hardness is used as an indicator of alkalinity but hardness is not a measure of alkalinity
  - Ames water example
    - ~200 mg/L hardness but 12 mg/L alkalinity
- Importance to developing larvae and shell fish

Plant Nutrients

- Nitrogen
  - Amino Acids
  - Plants use nitrate (NO_3^-)
  - Unionized Ammonia (NH_3) is toxic
  - Nitrogen cycle
- Phosphorus
  - DNA, ATP, bone (Calcium phosphate), Lipids (fat)
  - Usually tightly bound to soil sediments, but can be released in the absence of oxygen
  - Generally, the most limiting nutrient for plant growth in aquatic systems
- Importance of N:P ratio in pond fertilization regimes





Daily or Weekly Measurements

- Dissolved oxygen
- Nitrogen compounds
  - ammonia
  - nitrite
  - nitrates
- pH
- Alkalinity
- Hardness
- Temperature
- Chorine

Importance of record keeping

Resources

- North Central Regional Aquaculture Center
  - http://www.ncrac.org/
- Southern Regional Aquaculture Center
  - https://srac.tamu.edu/index.cfm/event/CategoryDetails/whichcategory/25/
- Water Quality in Ponds for Aquaculture
  - by: Claude E. Boyd

Suppliers

- HACH
  - http://www.hach.com/
- LaMotte
  - http://www.lamotte.com/
- Yellow Springs Instruments (YSI)
  - http://www.ysi.com/index.php
- Aquatic Eco-Systems, Inc.
  - http://www.aquaticeco.com/
- Southern Aquaculture Supply
  - http://southernaquaculturesupply.com/