Water Quality and Non-Infectious Diseases

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The Plan:

3 Lectures, with homework…

1. Introduction to Fish Health Management
   - Include Quarantine and Biosecurity

2. Water Quality and Non-Infectious Diseases
   - Nitrogen Cycle, Dissolved Gases

3. Infectious Diseases and Treatments
   - Common diseases and treatments
   - Regulatory concerns

Introduction to Fish Health Management

Developing a Fish Health Management Program:

1. Water Quality/ Life Support
2. Nutrition
3. Sanitation
4. Quarantine/ Biosecurity

Basic Introduction to Water Quality

1. Sample Collection and Handling
2. Dissolved Gases: Oxygen and carbon Dioxide
3. The Carbon Cycle
4. The Nitrogen Cycle

Photo credits:
M Walsh

"Normal Parameters"

	Fresh Water	Salt Water
Dissolved Oxygen:	saturation (Pond: > 5 mg/L)	Saturation
Carbon Dioxide:	<20 mg/L	< 20 mg/L
pH:	6.5 – 9.0	7.8 – 8.3
Total Ammonia Nitrogen:	< 1 mg/L	< 0.5 mg/L
Unionized Ammonia Nitrogen:	< 0.05 mg/L	<0.05 mg/L
Nitrite:	0 mg/L	0 mg/L
Nitrate:	< 20 mg/L	< 50 mg/L
Total Alkalinity:	> 100 mg/L	> 250 mg/L
Total Hardness:	> 20 mg/L	> 250 mg/L

Test kits

Collecting the water sample

- No air!
- Promptly put on ice (not frozen) and shipped for next day arrival

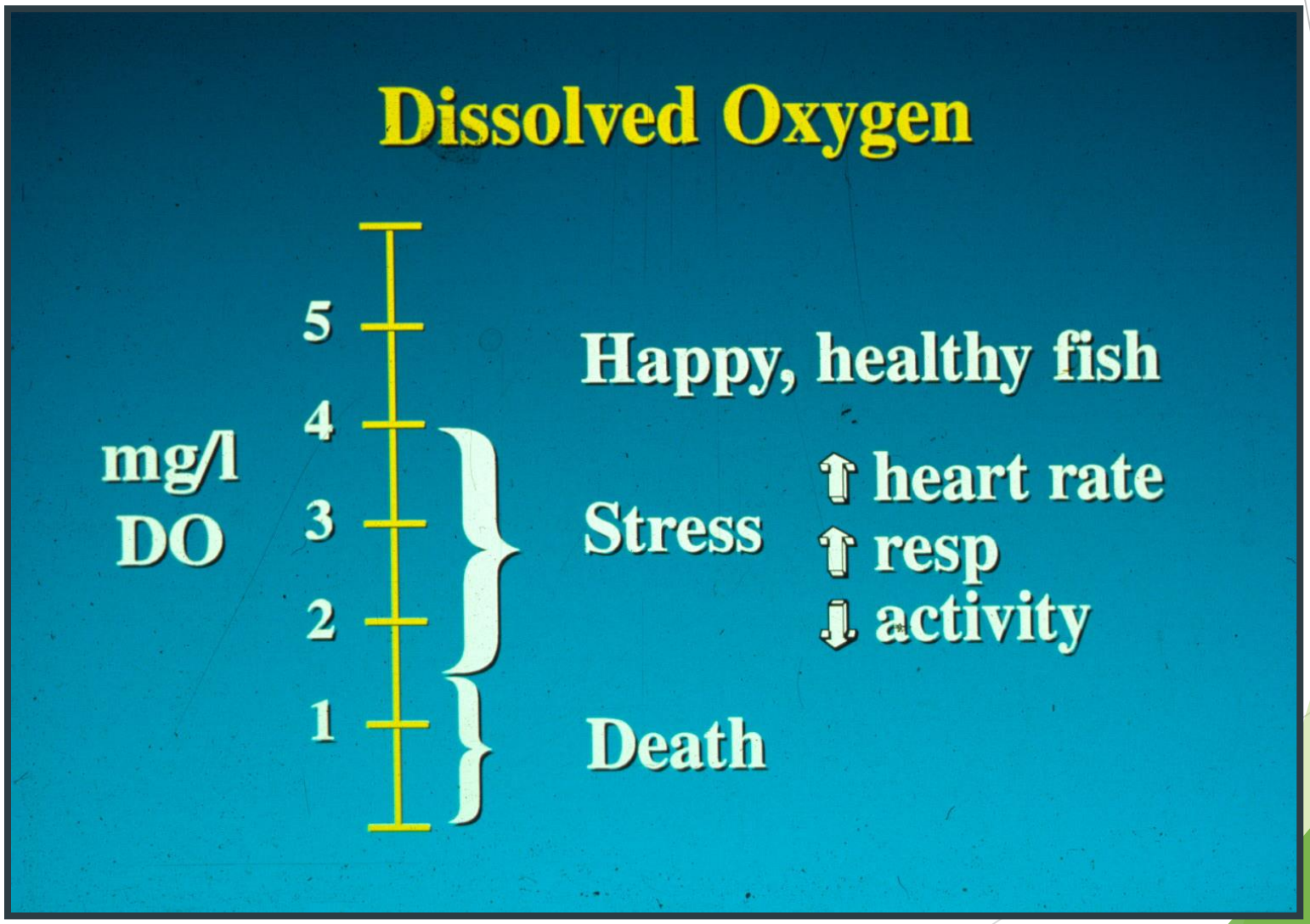
Properly Collected Water Samples

Improperly Collected Water Samples

Analysis

- Must be analyzed within 24 hrs of collection, preferably immediately after collection
- Allow chilled water samples to warm up
- First test dissolved gases immediately on opening container
  - Dissolved oxygen
  - Carbon dioxide

Dissolved Gases: Oxygen and Carbon Dioxide



Dissolved Oxygen: Indoor Systems

- ***Sources***
  - Atmospheric Oxygen
  - Gas exchange facilitated by aeration system
- ***Desirable Range***
  - Saturation
    - usually 7-8 mg/L
    - Less in marine systems

Dissolved Oxygen: Outdoor Ponds or Systems

- Sources
  - Photosynthesis (green water system)
  - Wind/wave action
  - Aeration
- Desirable Range
  - > 5 mg/L

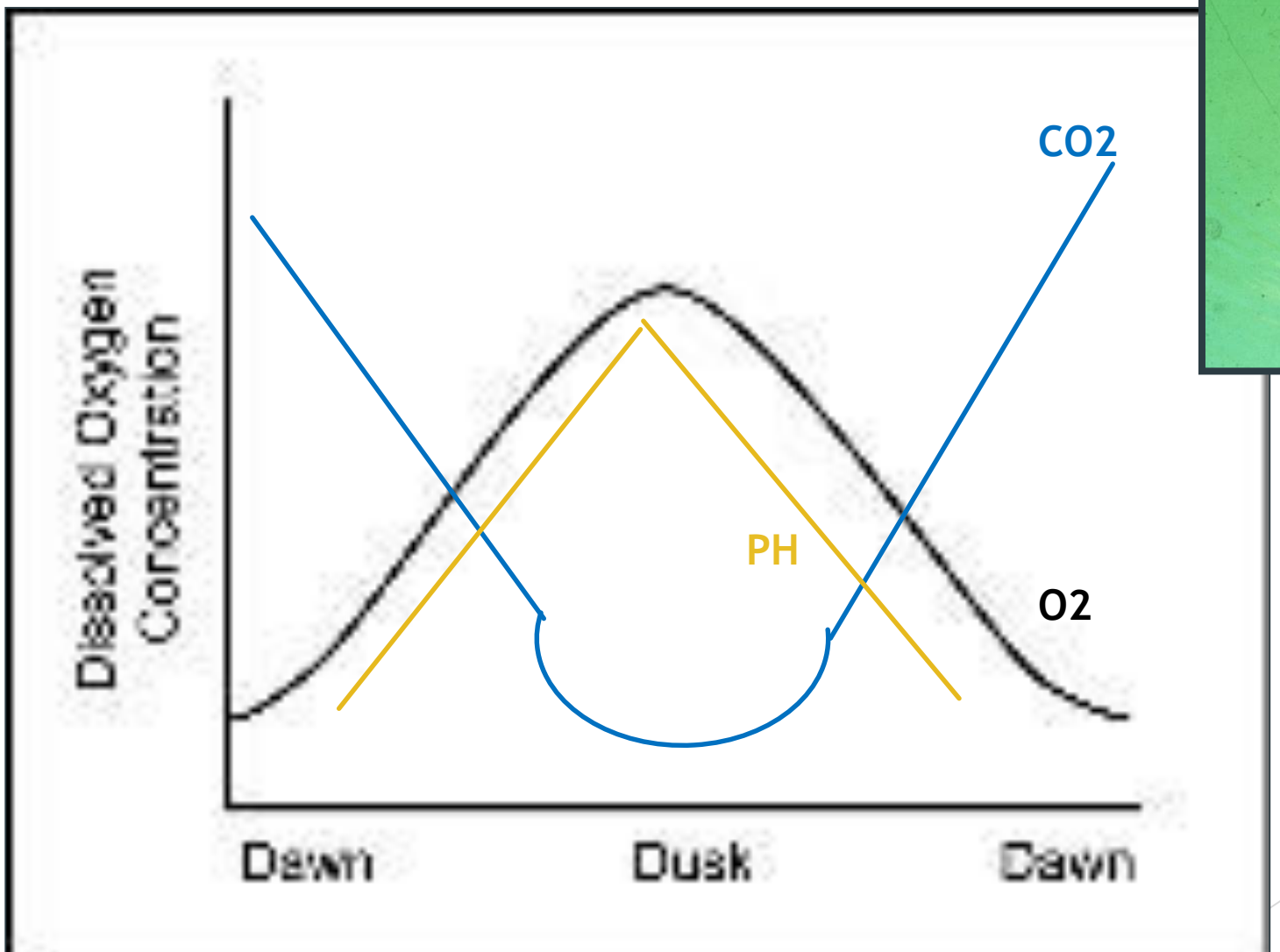
- Causes of Low D.O.
  - Time of day (early am)
  - Algal die off

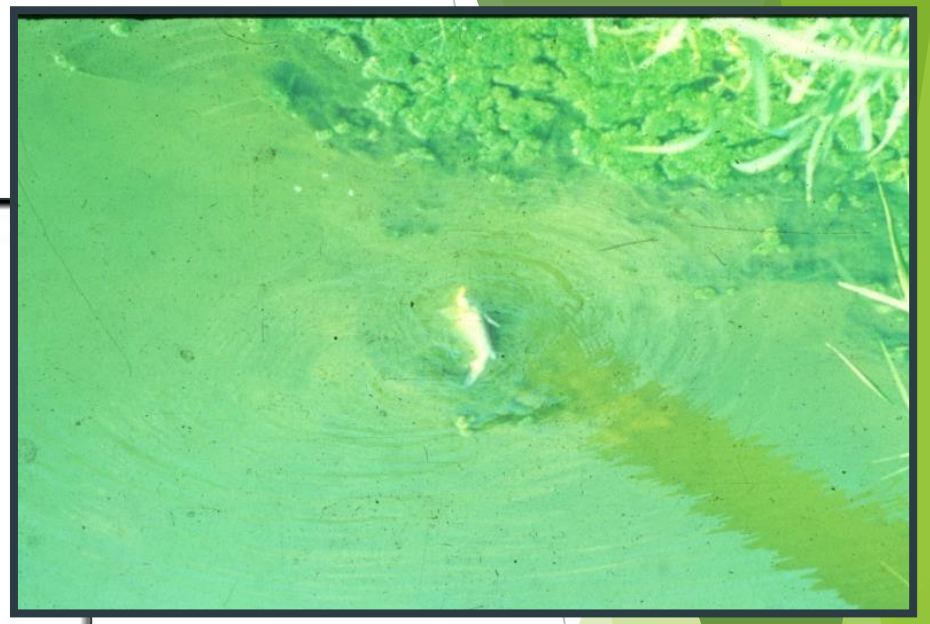
    (Includes chemical tx)
  - Cloudy weather
  - Formalin Tx
  - Stratification/ Pond turnover
- Causes of High D.O.
  - Time of day (afternoon)
  - Heavy algal bloom (afternoon)

Carbon Dioxide

- Source
  - Respiration by fish, plants etc.
  - High in some well water
- Causes of High CO_2
  - Inadequate aeration
  - Overcrowding (with inadequate aeration)
- Toxicity > 20 mg/L indicative of problem
  - $\geq$ 40 mg/L clinical disease likely
- Treatment…Increase aeration!!!

The Diurnal Oxygen Cycle





D.O. Fluctuation Amplified in Green water (Secchi < 18 in)

The Carbon Cycle

$$CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^- \leftrightarrow H^+ + CO_3^-$$

PH, Alkalinity and Hardness

PH is a measure of Hydrogen Ion concentration

- **0-7 = acid (↑ H+)**
- **7=neutral**
- **7-14 = basic or alkaline(↓ H+)**

Alkalinity is the measure of carbonate buffering capacity

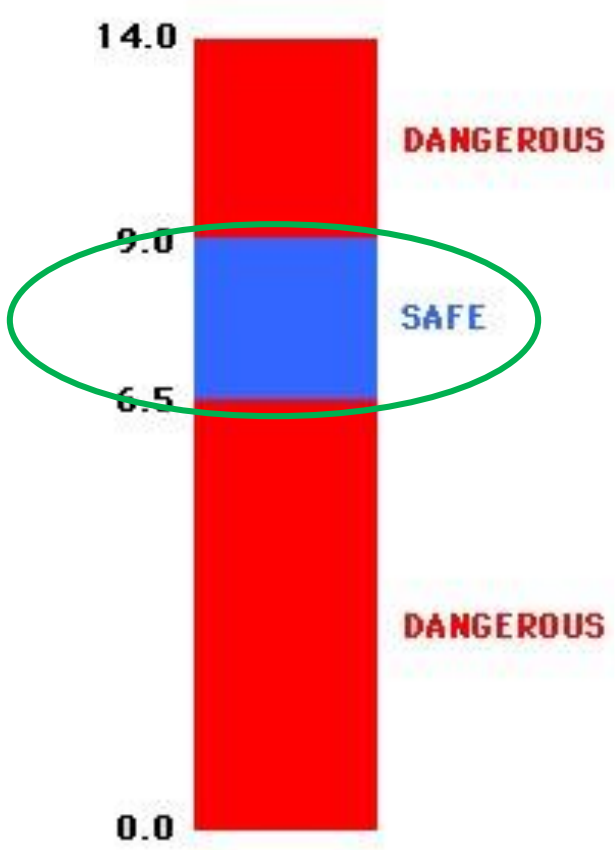
- **Measured as $CaCO_3$**

Hardness is a measure of minerals in the water

- **Measured as $CaCO_3$**

pH

- Measure of the hydrogen ions
- High pH
  - Hypertrophy of cells in the gill
  - Damage to the cornea



From LaDon Swann, www.aquanic.org

Alkalinity

- Buffering capacity of water
  - Carbonate, bicarbonate, & hydroxide ions
- Optimum alkalinity:

  Freshwater: 75-200 mg/L, but not <20 mg/L

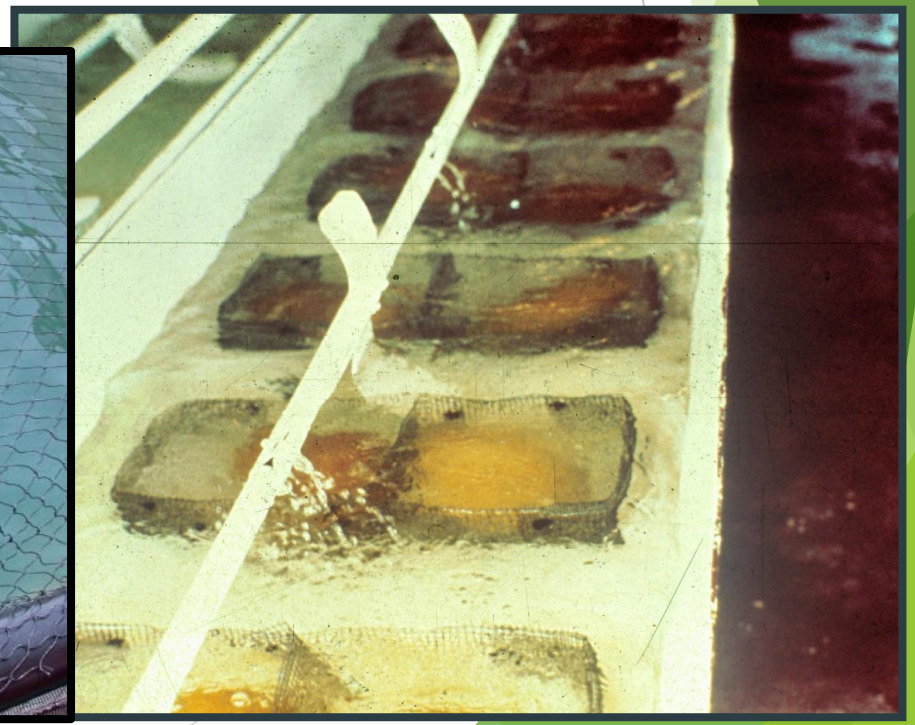
  Saltwater: > 200 mg/L common

  (Note that some coastal communities can be much higher)
- Water with low alkalinity
  - Extreme fluctuation of pH
  - Adverse effect on nitrifying bacteria (7.14 g for each 1 mg/L ammonia)
  - Copper based chemicals are more toxic!
    - Never use copper based treatments in freshwater if alkalinity < 50 mg/L.

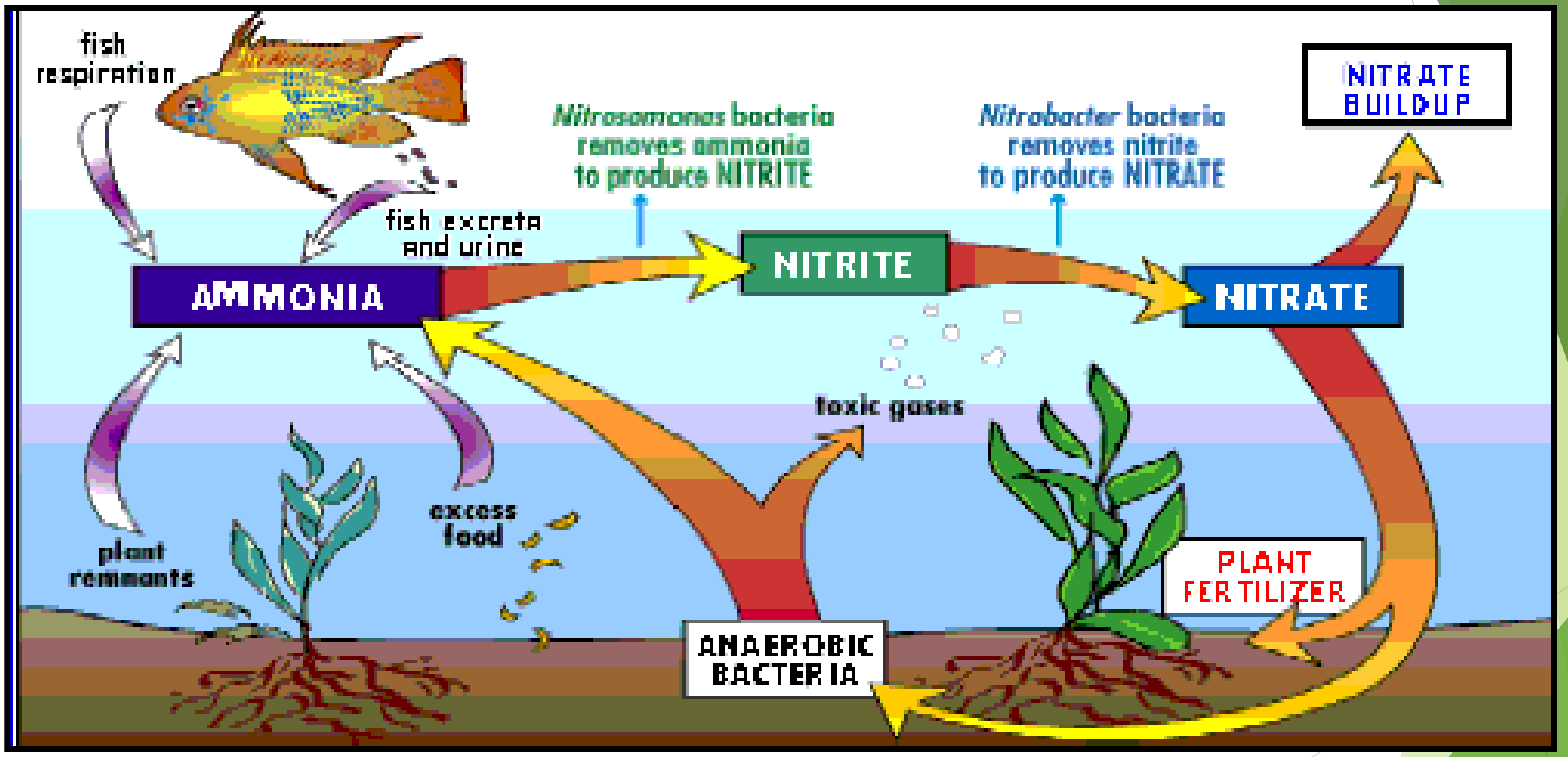
Hardness

In water, consist of divalent cations, Ca^{2+} & Mg^{2+}

- Easy for freshwater fish to pull Ca^{2+} & Mg^{2+} as needed from water for osmoregulation
- **Juvenile fishes must have calcium for proper growth**
- **Egg hatchability** adversely affected by hard water in some species



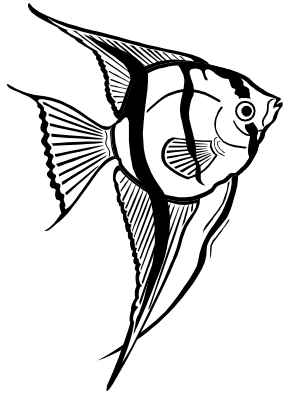
The Nitrogen Cycle



- Thanks to http://www.pondenterprises.com/filter/nitrogen.html for the picture.

Nitrification Review

Actions above dashed line occur in tank or pond.
Actions below dashed line occur in the biofilter.



Ammonia

Nitrite (NO_2^-)

Nitrate (NO_3^-)

Consumption of oxygen and alkalinity by ammonia oxidizing bacteria

Consumption of oxygen and alkalinity by nitrite oxidizing bacteria

Total Ammonia Nitrogen (TAN)

$$NH_3 + H_2O = NH_4^+ + OH^-$$

NH_3 = ammonia = unionized ammonia (UIA)

NH_4^+ = ammonium = ionized ammonia

Toxicity is pH & temperature dependent. DO is a limiting factor.

pH↑ UIA↑ **Temperature↑ UIA↑**

Ammonia toxicity due to UIA may occur as low as 0.05 mg/L.

Adverse Effects of Ammonia

- Increases ammonia level in bloodstream and tissues
  - Osmoregulation is affected
  - Blood pH increases
  - Need for oxygen increases
  - Oxygen transport decreases
- Chronic low level ammonia
  - Inhibits growth
  - Increases susceptibility to disease

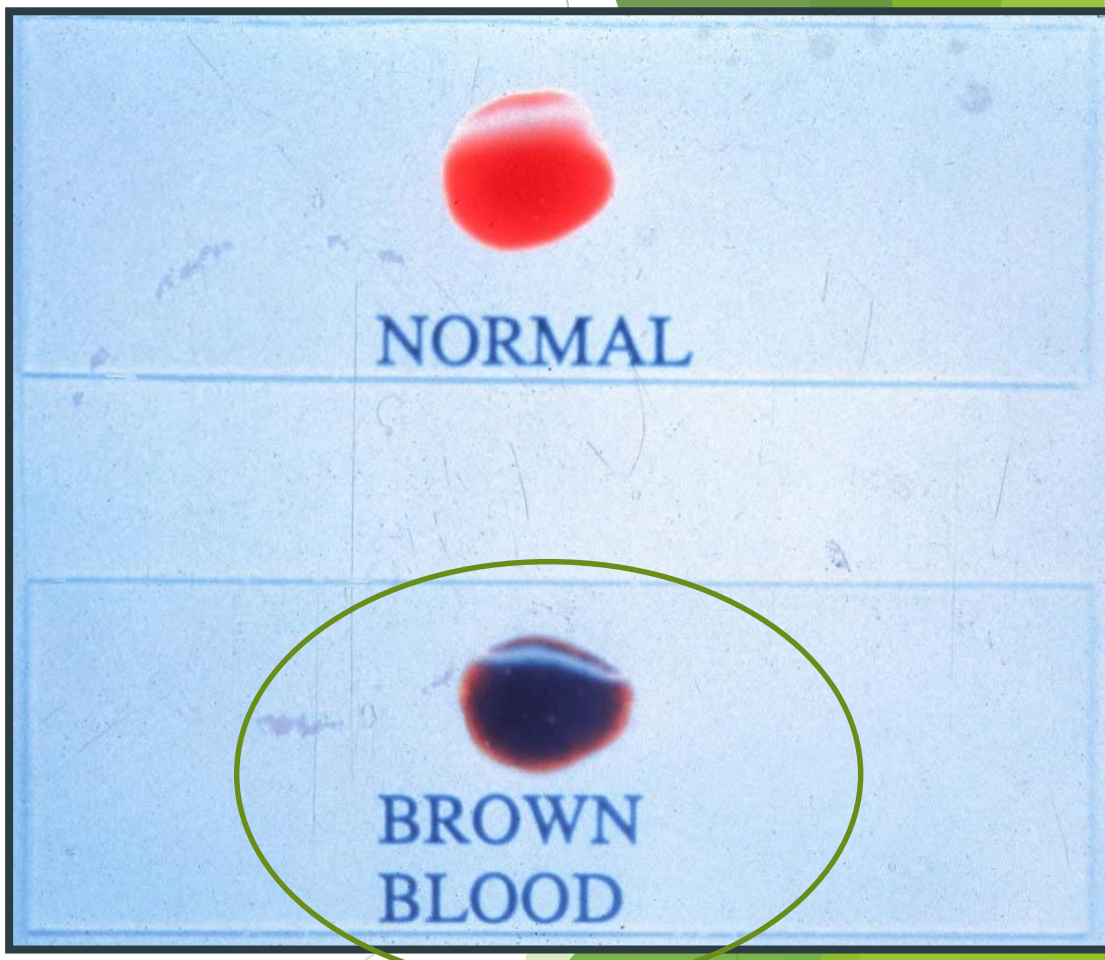
Management to Avoid Ammonia Toxicity

	Water Garden	Pond
Reduce stocking density	X	X
Harvest frequently		X
Don't overfeed	X	X
Maintain optimal DO	X	X
Add biofiltration	X	
Water change	X	X

Nitrite ("Brown Blood Disease")

- Nitrite is produced by the oxidation of ammonia
  - 1-2 ppm can be toxic
  - Fish symptomatic when Methb reached 40%
  - Drop in temperature can kill *Nitrobacter*
- Causes methemoglobinemia, or "brown blood disease"
  - Fish present as if hypoxic, piping etc
  - Some species resistant
    - Centrarchids (bass/ bluegill)
    - Some marine fish
  - Treatment for freshwater fish

  is chloride (salt)
    - 6 ppm Cl^- : 1 ppm NO_2^-

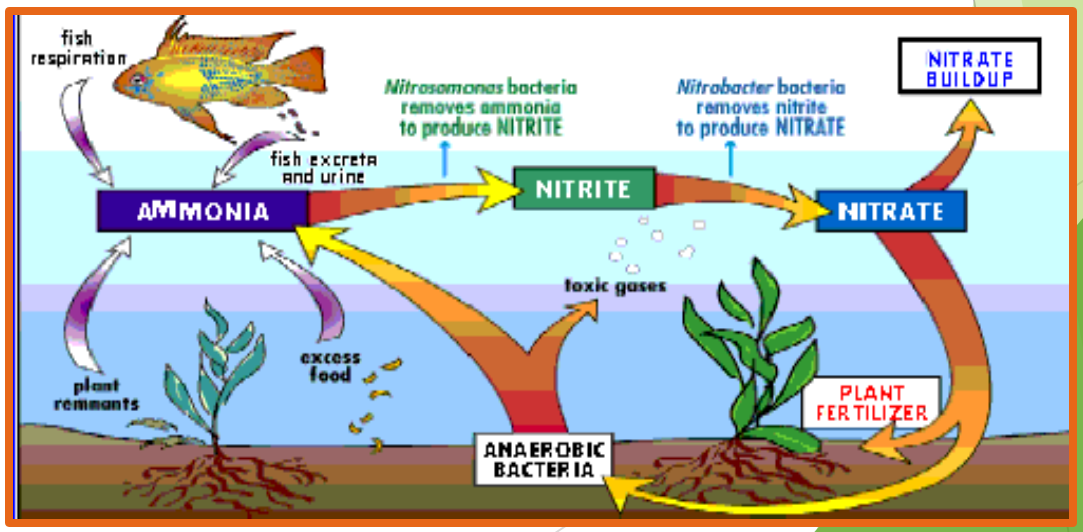


Nitrate

- Nitrate (NO_3) produced by oxidation of NO_2
- Nitrate removed by anaerobic bacteria, plants and water changes
- Big concern in marine systems
  - < 20 mg/ L considered “normal”
  - < 200 mg/L often considered “acceptable”
  - Concentrations of 400-600 mg/L sometimes occur

Let's Review……

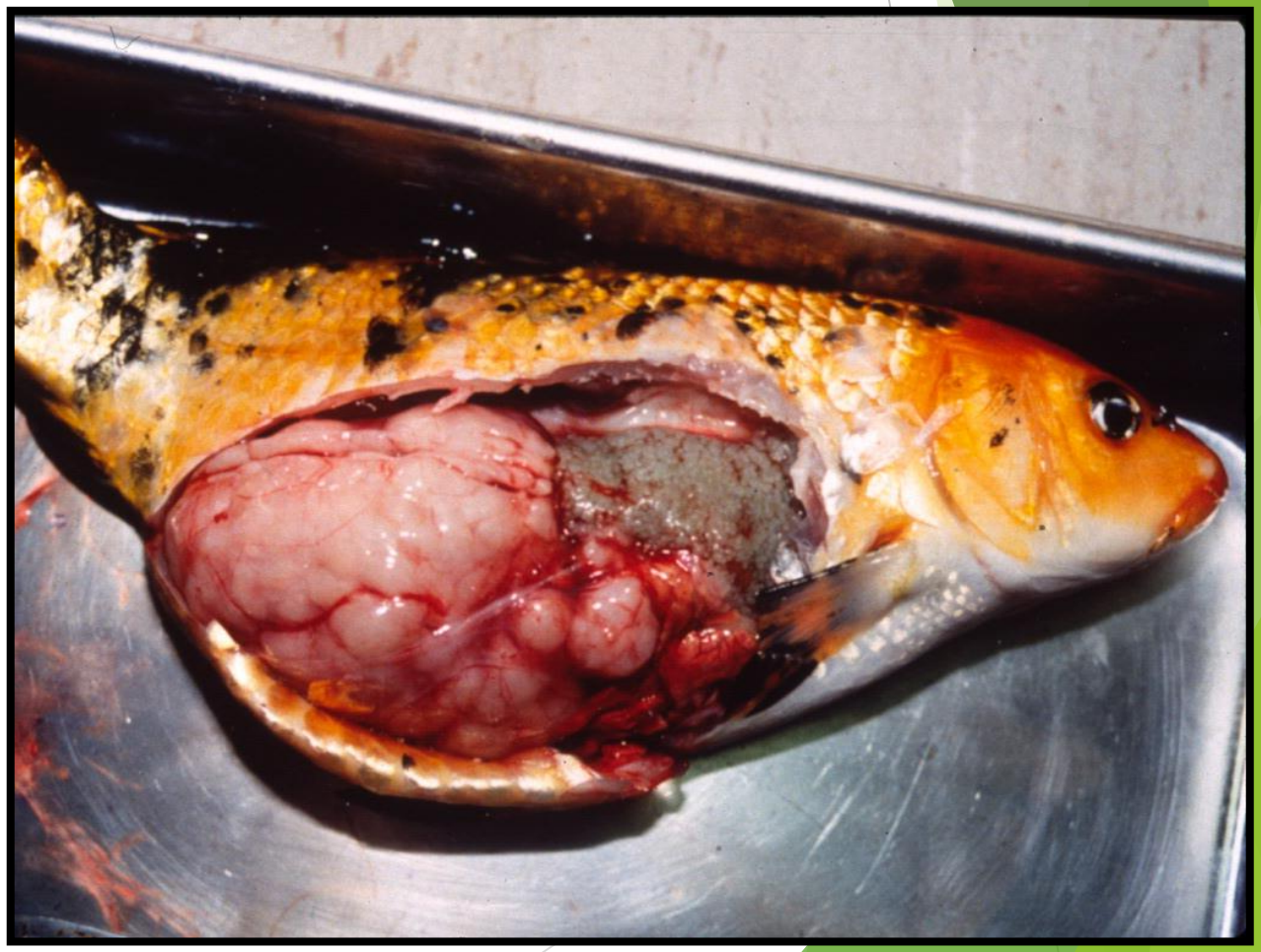
- Nitrate is end product of Nitrification
  - Aerobic Process
  - Driven by bacteria in biofilter
- Means to eliminate NO3 from aquatic system
  - Anaerobic denitrification
  - Plants
  - Water change



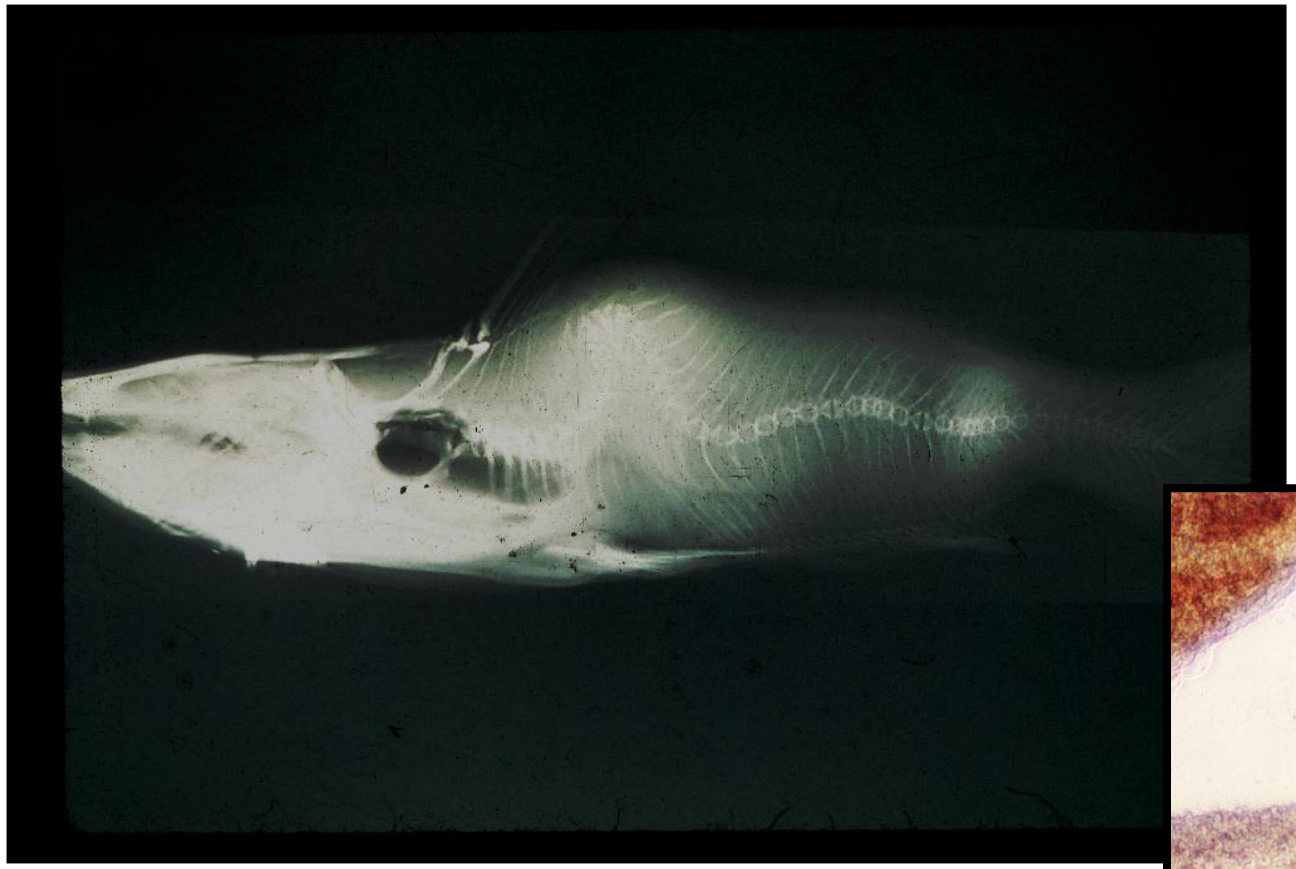
http://www.pondenterprises.com/filter/nitrogen.html

Other Examples of Non-Infectious Diseases

- ✓Cancer (Neoplasia)
- ✓Trauma
- ✓Nutritional Deficiencies
- ✓Toxins



Vitamin C Deficiency ("Broken Back Disease")



Hepatocarcoiinoma in a Rainbow trout
(caused by Aflatoxin-contamination in the feed)

Moldy feed

Photos courtesy:
D Petty

Review of Water Quality and Non-Infectious Disease

Basic water Quality Testing:

- Dissolved Gases
  - Dissolved Oxygen and Carbon Dioxide
- Carbon Cycle
  - PH, Alkalinity and Hardness
- Nitrogen Cycle
  - Ammonia, Nitrite and Nitrate
  - Total Ammonia (NH4) vs Unionized (Toxic) Ammonia (NH3)

Examples of Non-Infectious Diseases:

- Neoplasia (Cancer)
- Trauma
- Nutritional deficiencies
- Toxins

Photo credit: Univ AZ