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
**“Normal Parameters”**

- **Dissolved Oxygen**: saturation (Pond: > 5 mg/L)
- **Carbon Dioxide**: < 20 mg/L
- **pH**: 6.5 – 9.0
- **Total Ammonia Nitrogen**: < 1 mg/L
- **Unionized Ammonia Nitrogen**: < 0.05 mg/L
- **Nitrite**: 0 mg/L
- **Nitrate**: < 20 mg/L
- **Total Alkalinity**: > 100 mg/L
- **Total Hardness**: > 20 mg/L

<table>
<thead>
<tr>
<th>Fresh Water</th>
<th>Salt Water</th>
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<tbody>
<tr>
<td><strong>Saturation</strong></td>
<td><strong>Saturation</strong></td>
</tr>
<tr>
<td>Pond: &gt; 5 mg/L</td>
<td>&lt; 0.05 mg/L</td>
</tr>
<tr>
<td>&lt; 20 mg/L</td>
<td>0 mg/L</td>
</tr>
<tr>
<td>6.5 – 9.0</td>
<td>&lt; 50 mg/L</td>
</tr>
<tr>
<td>&lt; 0.5 mg/L</td>
<td>&gt; 250 mg/L</td>
</tr>
<tr>
<td>&gt; 20 mg/L</td>
<td>&gt; 250 mg/L</td>
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</table>
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

mg/l DO
5
4
3
2
1

Happy, healthy fish
↑ heart rate
↑ resp
↓ activity

Stress

Death
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

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 CO₂**
  - Inadequate aeration
  - Overcrowding (with inadequate aeration)
- **Toxicity**
  - > 20 mg/L indicative of problem
  - > 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

\[ \text{CO}_2 + \text{H}_2\text{O} \leftrightarrow \text{H}_2\text{CO}_3 \leftrightarrow \text{H}^+ + \text{HCO}_3^- \leftrightarrow \text{H}^+ + \text{CO}_3^- \]
PH, Alkalinity and Hardness

PH is a measure of Hydrogen Ion concentration
- 0-7 = acid (\(\uparrow H^+\))
- 7=neutral
- 7-14 = basic or alkaline (\(\downarrow H^+\))

Alkalinity is the measure of carbonate buffering capacity
- Measured as Ca\(\text{CO}_3\)

Hardness is a measure of minerals in the water
- Measured as Ca\(\text{CO}_3\)
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, $\text{Ca}^{2+}$ & $\text{Mg}^{2+}$

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

Photo credit: D Petty
The Nitrogen Cycle

Nitrification Review

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

Nitrate ($\text{NO}_3^-$)  Ammonia

Consumption of oxygen and alkalinity by nitrite oxidizing bacteria

Nitrite ($\text{NO}_2^-$)

Consumption of oxygen and alkalinity by ammonia oxidizing bacteria
Total Ammonia Nitrogen (TAN)
\[ \text{NH}_3 + \text{H}_2\text{O} = \text{NH}_4^+ + \text{OH}^- \]

NH\(_3\) = ammonia = unionized ammonia (UIA)

NH\(_4^+\) = ammonium = ionized ammonia

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

\[
\begin{align*}
\text{pH} & \uparrow \quad \text{UIA} \uparrow \\
\text{Temperature} & \uparrow \quad \text{UIA} \uparrow
\end{align*}
\]

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

<table>
<thead>
<tr>
<th></th>
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<th>Pond</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce stocking density</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Harvest frequently</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Don’t overfeed</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Maintain optimal DO</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Add biofiltration</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Water change</td>
<td>X</td>
<td>X</td>
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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 NO₂⁻
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")
Hepatocarcinoma in a Rainbow trout (caused by Aflatoxin-contamination in the 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