Aquaculture Webinar Series

Introduction: D. Allen Pattillo, USAS Board Member and NCRAC Extension Coordinator
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Indoor Shrimp Aquaculture

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Why Grow Shrimp in the US?

• #1 Most Popular Seafood Item in the US
• > 85% is Imported
  – Trade Deficit
  – Food Security?
  – Food Safety?
• Hard to Get Fresh Shrimp
• Inconsistent Domestic Supply
Why Grow Shrimp Indoors?

• Can be Located Anywhere… Warm, Salt Water Animal
  • Markets
  • Away from the Coast
  • Reused Infrastructure

• Control
  • Predictable Conditions = Predictable Results
  • Fresh, Never-Frozen
  • Large Shrimp = Higher Sale Price
  • Any Time of the Year
How do I Grow Shrimp Indoors?

• Use Recirculating Aquaculture Systems (RAS)
  • Defined as < 1% Water Exchange per Day... Much Less in Most Cases
  • Must Filter Solids and Nitrogen (Ammonia)
  • Biosecurity
  • Heat Retention

• There are a Variety of Systems
  • Clear-Water RAS
  • Biofloc
  • Hybrids of These
Clear-Water RAS

- Remove Nearly All Solids
  - Bead Filters
  - Foam Fractionators
  - Screens, Rotating Drums
  - Combination of Filters

- External Biofilter
  - Add Surface Area for Bacteria
  - Aerobic Container with Small, Plastic Beads

- Sterilization Techniques Can be Used
  - UV, ozone

Biofilter = Nitrogen Conversion
Temperature Control
Bead Filter = Solids Removal
Biofloc Systems

- Allow Solids Accumulation
  - Still Must Control the Concentration

- Biofloc Particles Develop
  - Dense Microbial Assemblages
  - Held Together with Microbial Excretions
  - This is the Biofilter (Internal Biofiltration)
  - Also a Food Source for Animals Like Shrimp
**Clear Water RAS**
- More Equipment... Expense
- No Supplemental Food
- Greater Control
- Better Water Quality
- \(\downarrow\) Disease Potential?

**Biofloc**
- Less Filtration... Lower Upfront $ 
- Supplemental Food
- Less Control
- More Attention to Water Quality
- \(\uparrow\) Bacterial Abundance
Hybrid Systems

• Not Clear Water
  • Do Not Try to Get All Solids Out
  • Simple Settling Chamber Possibly

• Add Biofilter

• Potential for Good Water Quality, Along with Some Supplemental Food
What is Bio-filtration?

• It is How We Deal with Ammonia
  • Ammonia = Metabolite Excreted by Animals

• Two Primary Pathways for Ammonia in Indoor Systems
  • Nitrification = Autotrophic
  • Assimilation = Heterotrophic

• Both Processes Occur in Most Systems… Bacteria
Nitrification

- External Biofilters
- Lower C:N Ratio (< ~9.5:1)
  - 35% Protein Feed ≈ 8.5:1
- **Ammonia to Nitrite to Nitrate**
  - Two Groups of Microbes
  - Build up nitrate!
- Usually Reliable Once Established
  - Long Establishment Time Though
Assimilation

• Higher C:N Ratio (> ~12:1)
  • Carbon = Energy
  • Nitrogen = Protein

• Low Protein Feeds?

• Additional Carbon Sources… Sucrose is Good

• Add sugar during start up versus continually

• Increase of Biomass
  • Must be Removed = More Solid Waste

• High Oxygen Demand, CO$_2$ Production

• ↓ Nitrate
What We Do at Kentucky State University

- Aquaculture Production Technologies Lab (APT)
- Sustainable Aquaculture Development Lab (SADL)
Nurseries

• Biofilters and Settling Chambers… Hybrid Systems
  • Shrimp (~PL 10) from Florida Hatchery
  • 30-45 days
  • Sample Shrimp at the End… Number and Weight
Production System

- 20 m³ Fiberglass Tank
- Scale-Up Research
- 1 HP Pump
  - A3 aeration system
- Dividing Wall in Center
  - Water is Pumped Around This
- Electric heat
  - Is what’s available
  - Insulated Building (~74° F)
- 3 hand feedings, feeders at night
  (~30% of Daily Ration)
**Foam Fractionator**

- **Foam Overflow**
  - Foam with Particulates

- **Valve**
  - Controls Water Level in Chamber

- **Injection Nozzle**
  - Water with Very Fine Bubbles

- **Effective Solids Removal**
- **Home-Made Units are Inexpensive**
- **Can “Fine-Tune”**
- **Moved to Using this Almost Exclusively**
Settling Chamber

- Effective at Removing Especially Larger Solids
KSU Production Example

- Shrimp Nursed to 0.55g
- Moved to Production Tank
- Stocked at 250 Shrimp/m³
- 20 ppt. Salinity
- 98 Days
- Nitrification-Based System
  - No Added Sugar
Production and Marketing

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Weight (g)</td>
<td>24.3</td>
</tr>
<tr>
<td>Growth Rate (g/wk.)</td>
<td>1.7</td>
</tr>
<tr>
<td>Biomass (kg/m³ )</td>
<td>4.6</td>
</tr>
<tr>
<td>FCR</td>
<td>1.3</td>
</tr>
<tr>
<td>Survival (%)</td>
<td>69.1</td>
</tr>
</tbody>
</table>

• Produced about 200 Pounds
• Gave them to KY chefs, seafood distributors, and sold 83 pounds at the Franklin County Farmers’ Market in 1.5 hours
Farmers Markets
Do People Like the Product? Can $$$ be Made?

• Sold for $12/pound ($26.40/kg)
• Recurring Costs of Production ≈ $5.50/pound ($12.10/kg)

<table>
<thead>
<tr>
<th>Question (range of options)</th>
<th>Chefs (n = 5)</th>
<th>Consumers (n = 27)</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is your opinion of the KY-grown shrimp?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taste (1-5, where 1 is the best)</td>
<td>2.0 ± 0.0</td>
<td>1.3 ± 0.1</td>
</tr>
<tr>
<td>Texture (1-5, where 1 is the best)</td>
<td>2.2 ± 0.5</td>
<td>1.3 ± 0.1</td>
</tr>
<tr>
<td>Freshness (1-5, where 1 is the best)</td>
<td>1.0 ± 0.0</td>
<td>1.0 ± 0.0</td>
</tr>
<tr>
<td>Size (1-5, where 1 is the best)</td>
<td>2.2 ± 0.2</td>
<td>1.3 ± 0.1</td>
</tr>
<tr>
<td>Overall (1-5, where 1 is the best)</td>
<td>2.2 ± 0.2</td>
<td>1.1 ± 0.1</td>
</tr>
<tr>
<td>Appearance (1-5, where 1 is the best)</td>
<td>1.8 ± 0.2</td>
<td>1.1 ± 0.1</td>
</tr>
<tr>
<td>What would you expect to pay? (open question) - USD/Kg</td>
<td>21.6 ± 2.4</td>
<td>25.9 ± 2.3</td>
</tr>
<tr>
<td>What is the maximum you would pay? (set selections) - USD/Kg</td>
<td>26.0 ± 2.5</td>
<td>28.6 ± 1.5</td>
</tr>
</tbody>
</table>
Issue: System Startup

• Tough With Biofloc
• No Substrate Naturally at First
  • Bacteria Need it
• Add Artificial Substrate
  • Remove?
  • Leave it in?
  • Use Conditioned Substrate or Biomedia
• Shrimp Generally Improved With Substrate
• Harvest Issues
• Circulation Issues
System Startup

• Nitrification
  • Guide the Startup Period With Sugar Additions
    • Careful… too much will crash the DO
  • Probiotics… maybe
  • Reuse Biofloc Water (possibly as little as 10%)
  • Use Tilapia to Cycle the Tank… Less Expensive and Tougher (at Least With Ammonia)

• Heterotrophic
  • Start With High C:N Ratio
Issue: Nitrate

• Problem after 3 or 4 crops
  • ~400 mg/L
• Plants… need to be salt tolerant
  • KSU Exploring Several Species
• Denitrification
  • Anaerobic Process
  • Nitrification in Reverse
• Raise the C:N
  • Internally… Externally
How to Learn More

• Visit KSU
• YouTube Video:
  https://www.youtube.com/watch?v=IwbDqB0C_-Y
• KSU Aquaculture on Facebook:
  https://www.facebook.com/ksuaquaculture/
• KSU Website: http://www.ksuaquaculture.org/
• Contact Me: andrew.ray@kysu.edu
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Questions about this webinar series should be directed to brentoncontact@iastate.edu
Recorded webinars are available at:

• The National Aquaculture Association [www.thenaa.net/industry](http://www.thenaa.net/industry)

• The North Central Regional Aquaculture Center [www.ncrac.org/video](http://www.ncrac.org/video)

• United States Aquaculture Society [http://usaquaculture.org/webinars](http://usaquaculture.org/webinars)