Why Grow Shrimp?

• #1 Most Popular Seafood Item in Many Developed Countries
• Most is Imported
  – Trade Deficit
  – Food Security?
  – Food Safety?
• Hard to Get Fresh Shrimp
  – No Processing with Fresh
• Inconsistent Domestic Supply
• Short Supply – High Demand
Why Marine Shrimp?

• Decades of Selective Breeding
• Fast Growth
• Disease Resistant
• Low Cannibalism = Good at High Density
• Most Popular Shrimp (Familiar Among Consumers)
  • Texture
  • Appearance
  • Flavor
Why Grow Shrimp Indoors?

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

• Control
  • Consistent Conditions = Predict 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

• A Variety of Systems
  • Clear-Water RAS
  • Biofloc
  • Hybrids of These
Clear Water RAS

- More Equipment... Expense
- No Supplemental Food
- Greater Control
- Better Water Quality
- ↓ Disease Potential?

Biofloc

- Less Filtration... Lower Upfront $
- Supplemental Food
- Less Control
- More Attention to Water Quality
- ↑ Bacterial Abundance
Hybrid Systems

- Not Clear Water
  - Do Not Try to Get All Solids Out
  - Simple Settling Chamber, Possibly a Foam Fractionator
- Add Biofilter
- Potential for Good Water Quality, Along with Some Supplemental Food
Hybrid Systems

• Seem to be a Good Option for Those with Limited Aquaculture Experience

• Home-Made Filters for Small or Large-Scale Farms
  • Settling Chambers
    • Large Particles
  • Fractionators
    • Small Particles
Insulated Space = Year-Round Production
Greenhouses

- Poorly Insulated Usually
- Extend Growing Season Outdoors
  - Some Supplemental Heat Possible
- Inexpensive

- Combine with an Indoor Nursery
  - Larger Shrimp
- Rotate Crops?
- Couple With Horticulture?
Shrimp in High Tunnels – Solar Powered!!

- ~10 kW Photovoltaic Array
- ~6 kW Aeration Blowers
Indoor Shrimp Research

- 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)
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/m$^3$)</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)
- KSU and Purdue ≈ $6 to $ 9/pound total cost of production

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

• Problem after 3 or 4 crops
  • ~300 mg/L
• Plants… need to be salt tolerant
  • KSU Exploring Several Species
• Swiss Chard?
• Scurvy Grass?
• Salicornia?
• Marsh Grass?
**Issue: Nitrate**

- Denitrification
  - Anaerobic Process
  - Nitrification in Reverse
  - PVC Tubes with Substrate
  - Be Careful!
    - Sulfide, Ammonia
- Sequence Batch
  - Aerobic ⇔ Anerobic
- Raise the C:N
  - Internally… Externally
- Inexpensive Salts
How to Learn More

- 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
- Recorded Webinars: http://usaquaculture.org/webinars
- SRAC Website... A lot of info on aquaculture