Aquaculture Webinar Series

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

NATIONAL Aquaculture ASSOCIATION

North Central Regional Aquaculture Center NCRAC

U.S. AQUACULTURE SOCIETY — A CHAPTER OF THE WORLD AQUACULTURE SOCIETY

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Indoor Shrimp Aquaculture

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National Aquaculture Association

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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

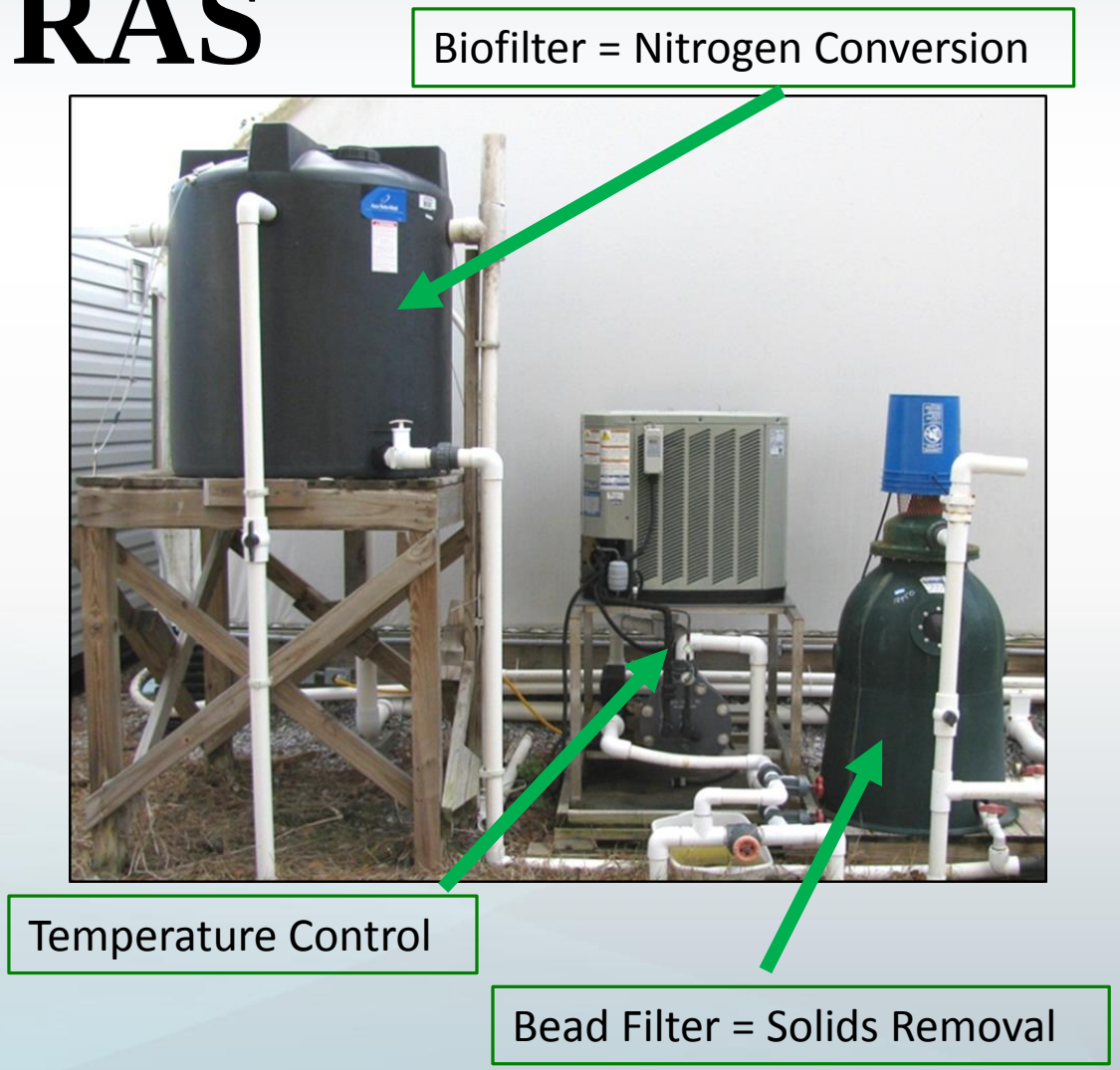
How do I Grow Shrimp Indoors?

- 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

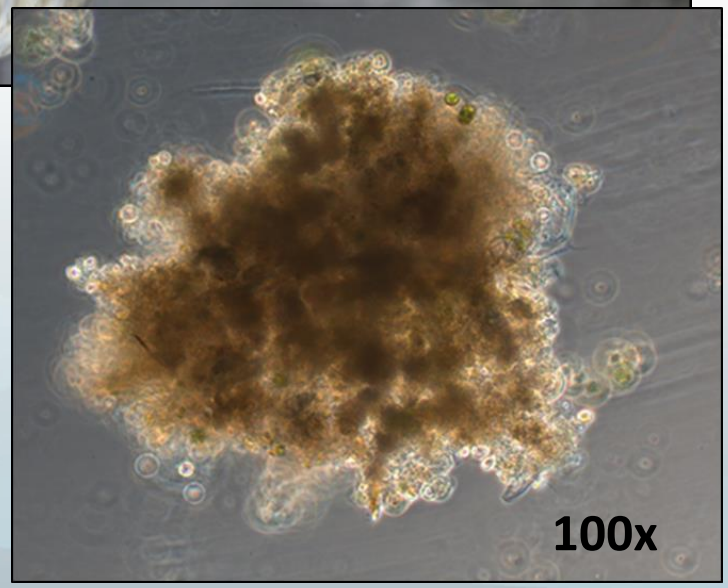
Clear-Water RAS

- 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



Biofloc Systems

- Allow Solids Accumulation
  - Still Must Control the Concentration
- Biofloc Particles Develop
  - Dense Microbial Assemblages
  - Held Together with Microbial Excretions
  - <u>This is the Biofilter</u> (Internal Biofiltration)
  - Also a Food Source for Animals Like Shrimp



Clear Water RAS

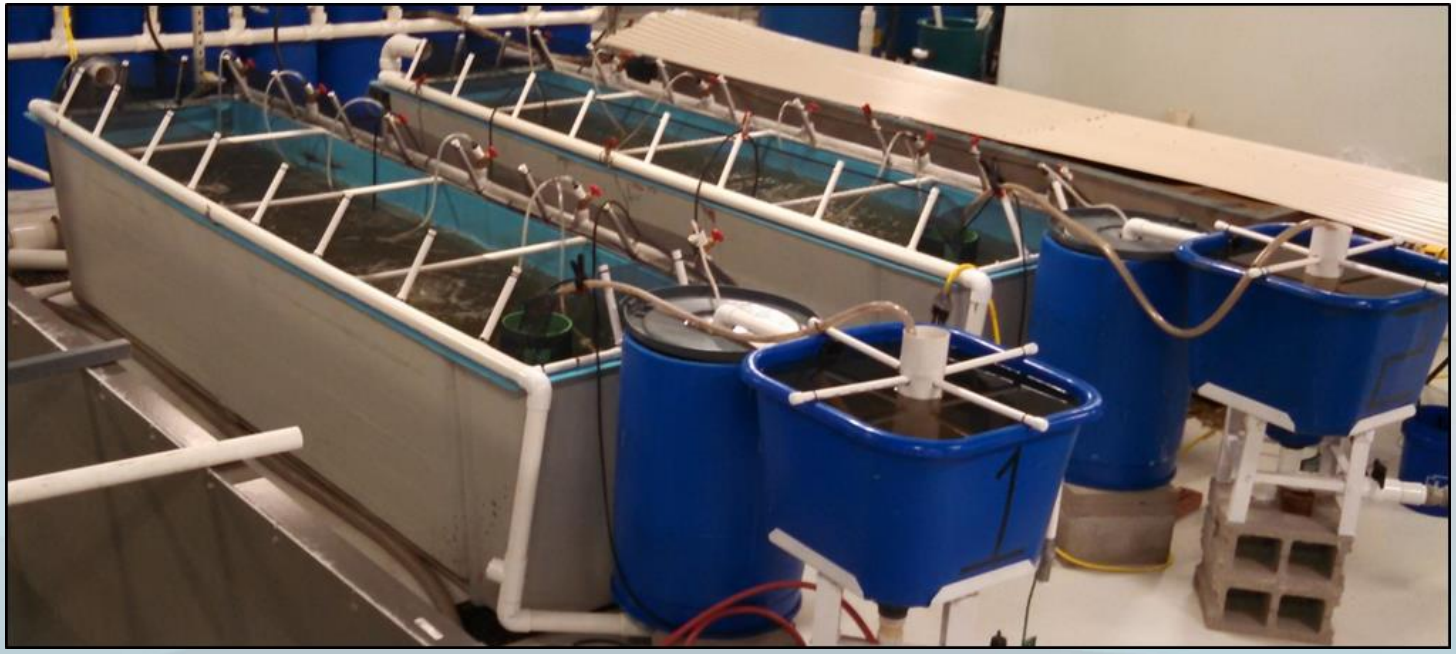
- More Equipment… Expense
- No Supplemental Food
- Greater Control
- Better Water Quality
- ⬇ Disease Potential?

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
- 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

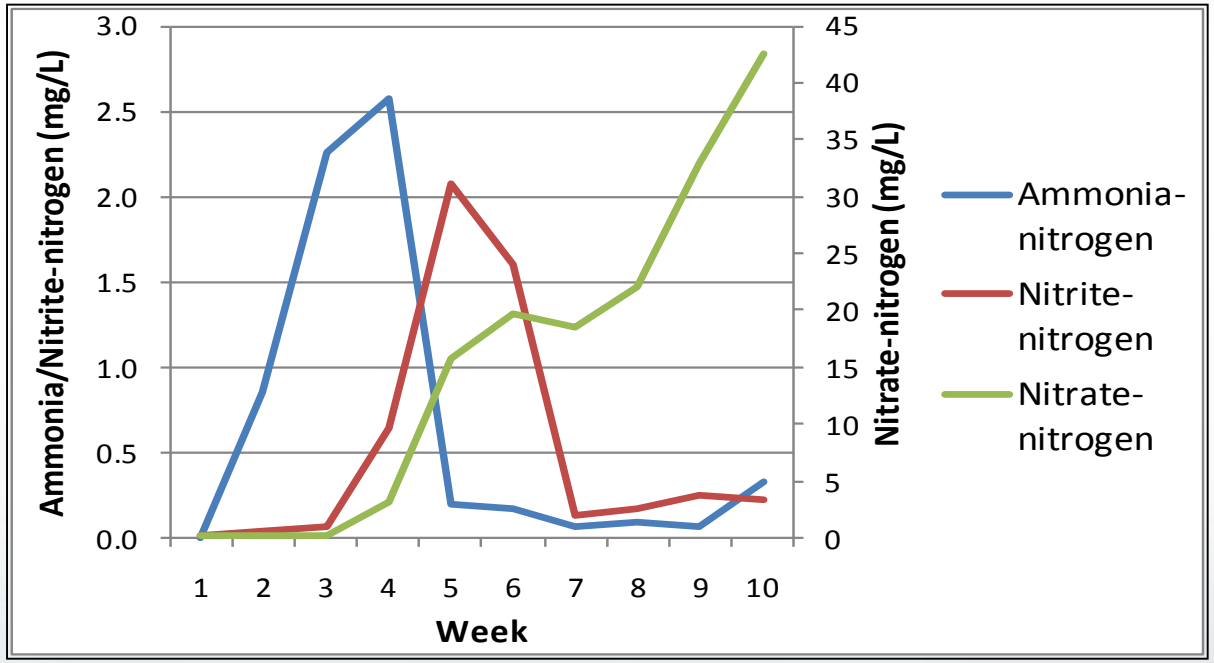
- Two Primary Pathways for Ammonia in Indoor Systems
  - Nitrification = Autotrophic
  - Assimilation = Heterotrophic

- Both Processes Occur in Most Systems… Bacteria

Biomedia in an External Biofilter

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

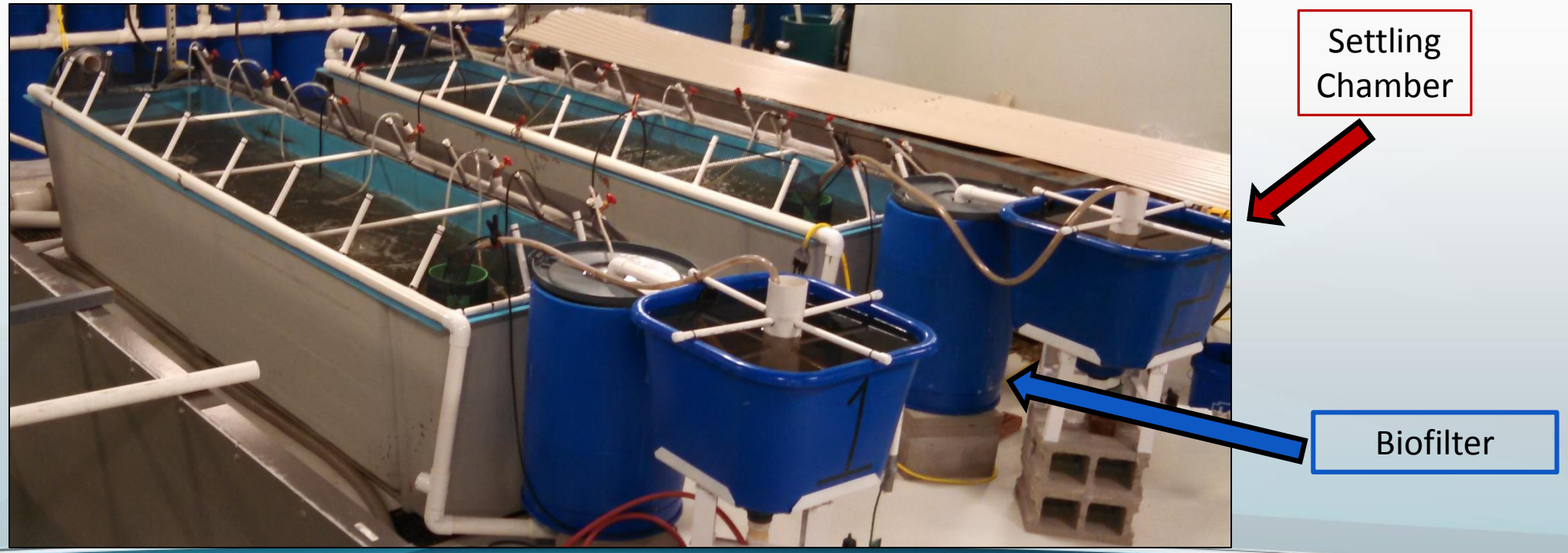
- Higher C:N Ratio (> ~12:1)
  - Carbon = Energy
  - Nitrogen = Protein
- Low Protein Feeds?
- Additional Carbon Sources… Sucrose is Good
- Add sugar during start up versus continually
- Increase of Biomass
  - Must be Removed = More Solid Waste
- High Oxygen Demand, CO_2 Production
- ↓ Nitrate

What We Do at Kentucky State University

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

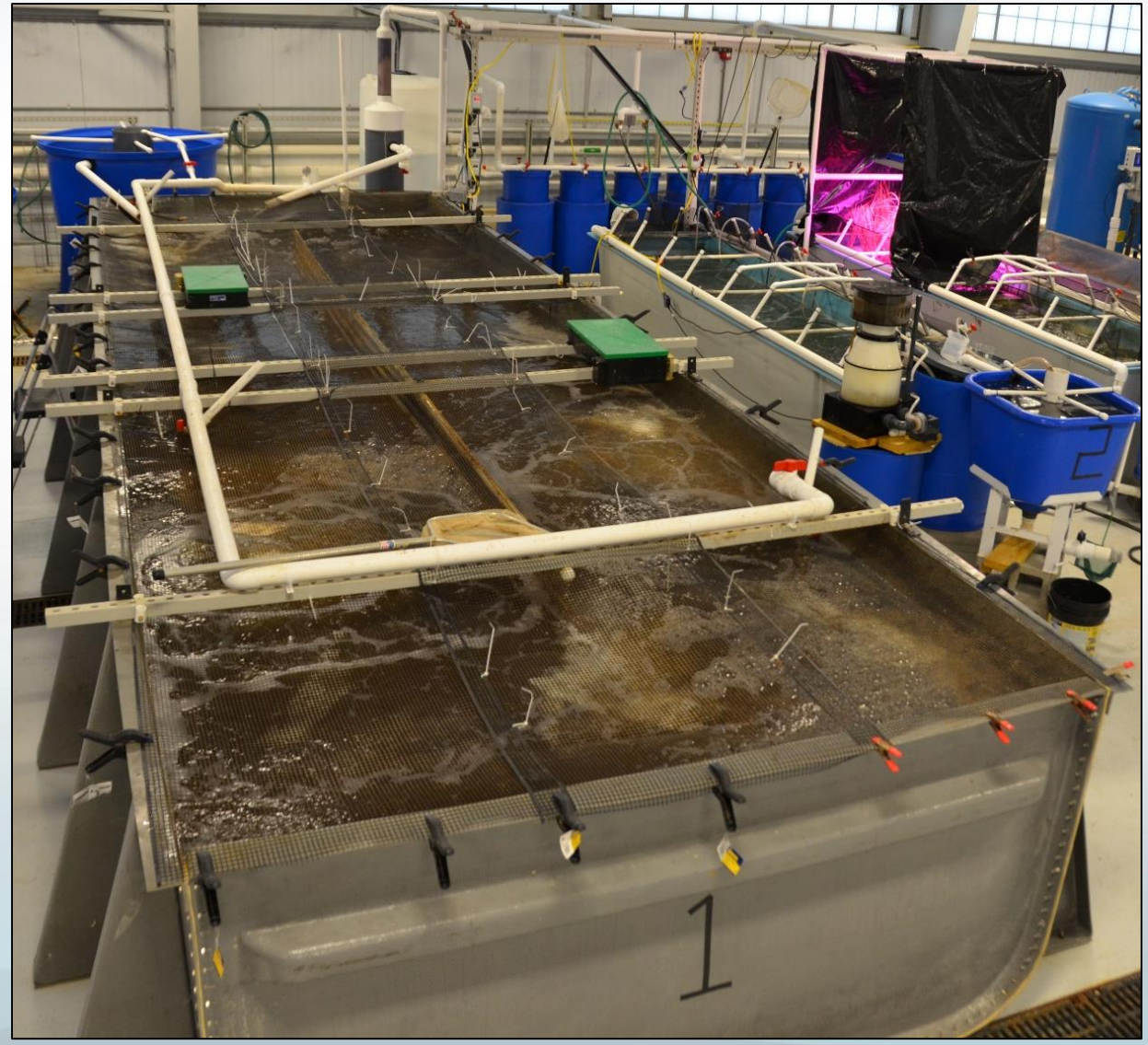
Nurseries

- 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

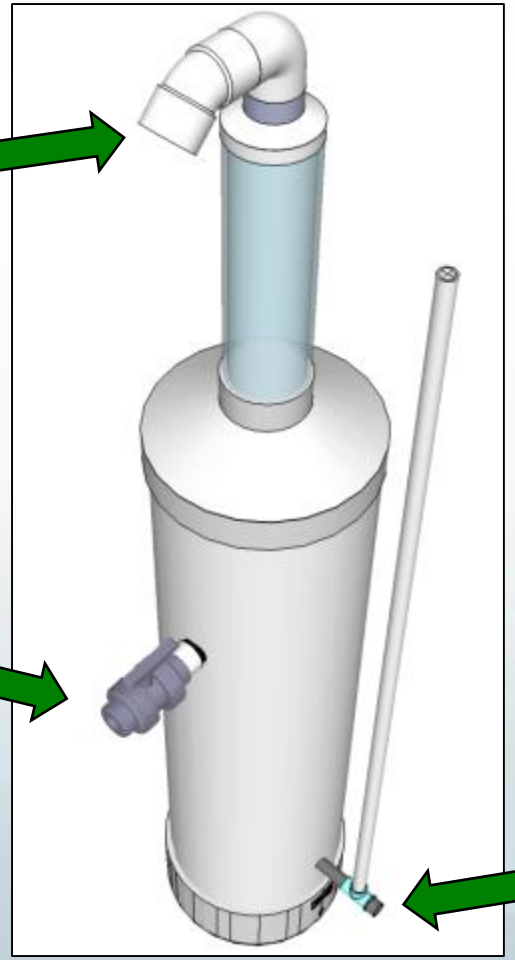
- 20 m^3 Fiberglass Tank
- Scale-Up Research
- 1 HP Pump
  - A3 aeration system
- Dividing Wall in Center
  - Water is Pumped Around This
- Electric heat
  - Is what's available
  - Insulated Building (~74° F)
- 3 hand feedings, feeders at night (~30% of Daily Ration)



Foam Fractionator

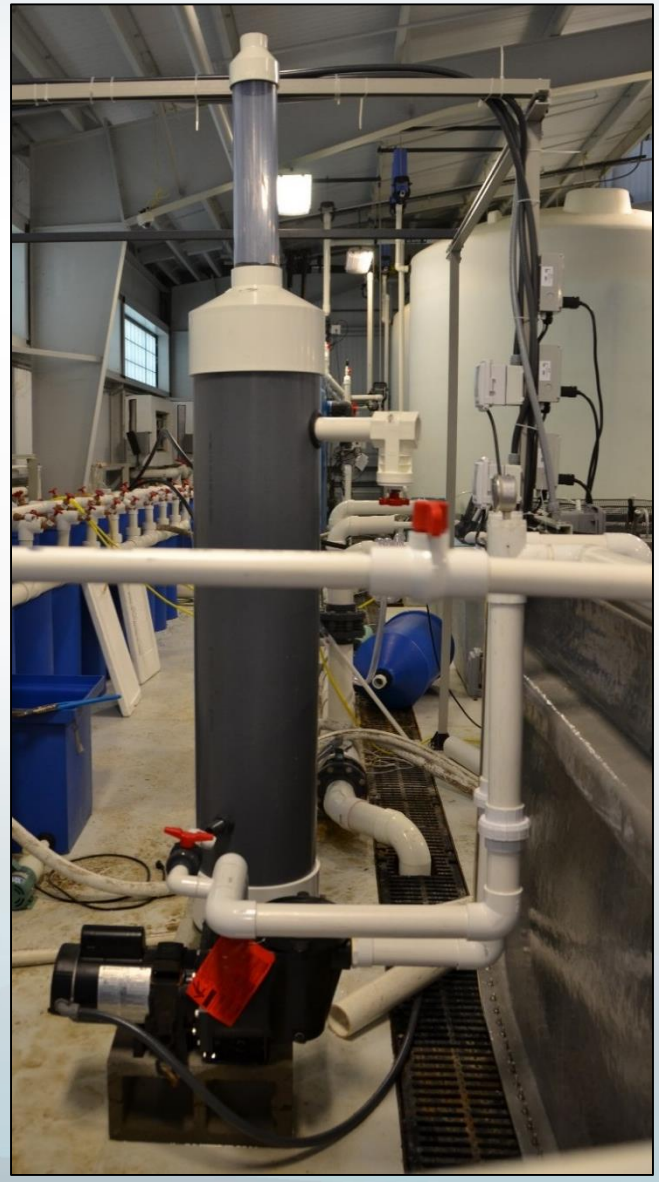
Foam Overflow
- Foam with Particulates

Valve
- Controls Water Level in Chamber



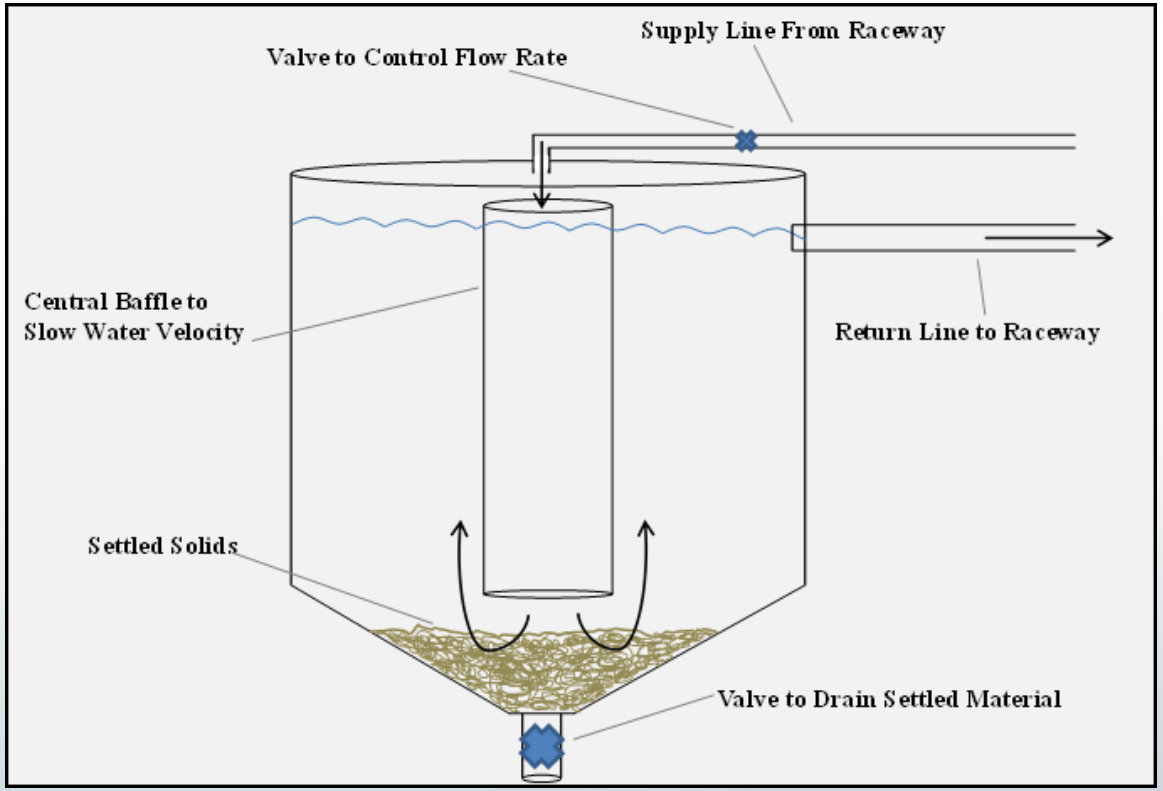
- Effective Solids Removal
- Home-Made Units are Inexpensive
- Can "Fine-Tune"
- Moved to Using this Almost Exclusively

Injection Nozzle
- Water with Very Fine Bubbles



Settling Chamber

- Effective at Removing Especially Larger Solids



KSU Production Example

- Shrimp Nursed to 0.55g
- Moved to Production Tank
- Stocked at 250 Shrimp/m^3
- 20 ppt. Salinity
- 98 Days
- Nitrification-Based System
  - No Added Sugar

Production and Marketing

Parameter	Value
Final Weight (g)	24.3
Growth Rate (g/wk.)	1.7
Biomass (kg/m^3)	4.6
FCR	1.3
Survival (%)	69.1

- 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)

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

Issue: System Startup

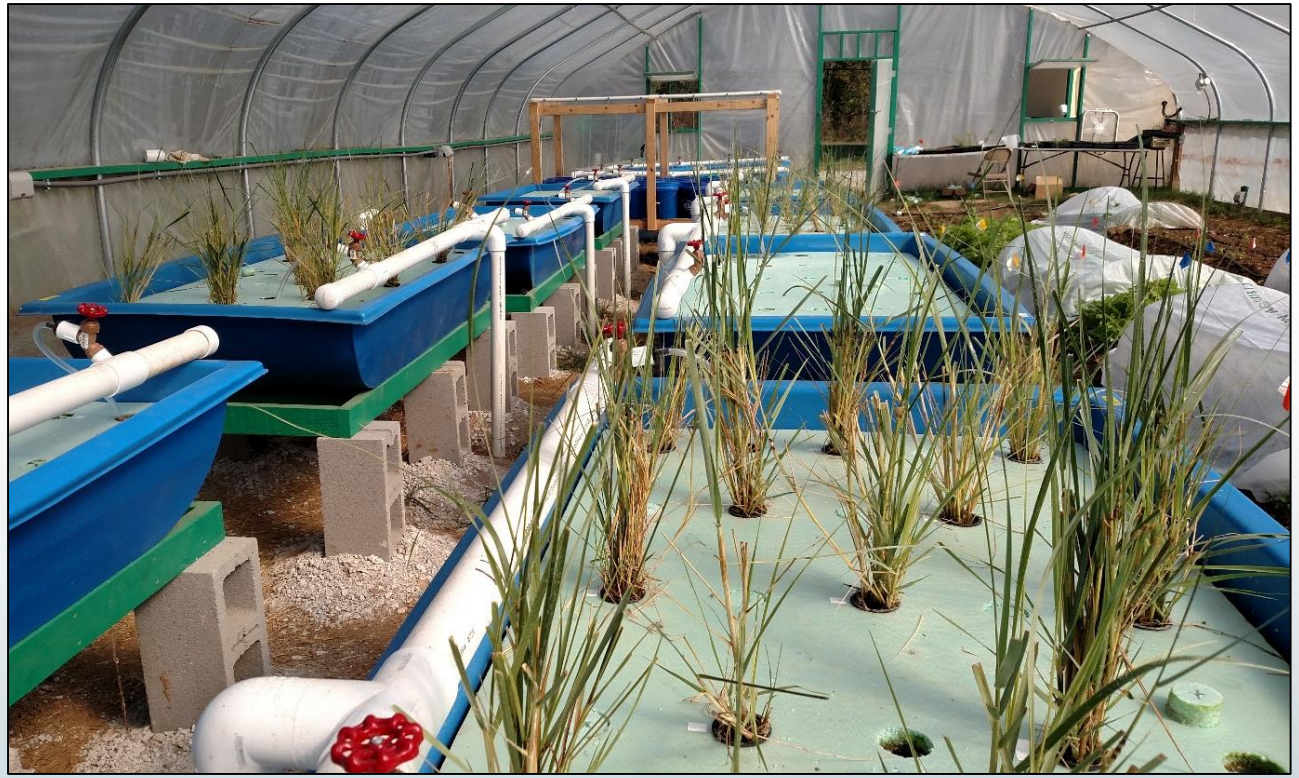
- Tough With Biofloc
- No Substrate Naturally at First
  - Bacteria Need it
- Add Artificial Substrate
  - Remove?
  - Leave it in?
  - Use Conditioned Substrate or Biomedia
  - Shrimp Generally Improved With Substrate
  - Harvest Issues
  - Circulation Issues

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/
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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
- The North Central Regional Aquaculture Center www.ncrac.org/video
- United States Aquaculture Society http://usaquaculture.org/webinars