RAS and Biofiltration Intro

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What is a recirculating aquaculture system (RAS)?

- **General description**
  - A land-based aquaculture system that recycles and reuses water through treatment devices for the culture of aquatic organisms (assumed indoors for this talk)

- **Categories**
  - Fairly well defined → less exchange needed means more efficient water usage
Highly condensed version – will elaborate over the course of ABC

- Carrying capacity needs to be high in order to be more helpful in improving ROI.
- RAS can/should push 0.5/1.0 pound of fish per gallon of tank water to improve economic viability of the system.
- Education/research systems often much lower densities than commercial.
RAS daily water exchange percentages

• >20% is not very common
• Average 7 – 15%
• 2 – 5% has been achieved commercially
• 0% is not very common and is currently expensive to achieve (at least on a large scale)
A system design/considerations (SRAC 451)

Fish Culture Tanks

- Fine & Dissolved Solids Removal
  - Foam fractionator

- Aeration or Oxygenation
  - Air stone
  - Packed column

- Waste Removal (Settleable & Suspended)
  - Bead filters
  - Swirl separators
  - Screen filters

- Biological Filtration (Nitrification)
  - Fluidized bed filters
  - Trickling filters
  - Mixed bed filters

- CO₂ Removal
  - Air stone diffuser
  - Packed column

- Disinfection
  - UV light
  - Ozone

*Heat exchangers
*De-nitrification filters
*Back-up generators
*Alarm systems
Solids – two main concerns in RAS

- **Settleable solids**: Mass of particles settled out after one hour of settling time
- **Suspended solids**: Mass of particles retained in water column after one hour of settling time
- Easily understood that settleable solids are easier to remove than TSS
- Want solids to settle! Proper design
- Species can make things harder or easier
Tank Design

- I mentioned round tanks being most common
- Why when you can fit more rectangular tanks in a single room and can harvest easier??
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Tank Design

- You can fit more rectangular tanks in a single room and can harvest easier, however…
  - They aren’t as efficient at self-cleaning (uniform WQ)
  - No beginning and no end to a round tank
  - Self-supporting wall
  - Adjust water flows/filtration better
- Large (fewer) round tanks in a given ft² increasingly common
Tank Design

• You can fit more rectangular tanks in a single room and can harvest easier, however…
  • They aren’t as efficient at “self-cleaning”
  • Many species like the “no beginning and no end” to a round tank (no turning around really necessary and can actually improve growth)
  • Self-supporting walls aren’t there
  • Raceways?
  • Mixed-cell raceways?
General water flow in a RAS

*Disinfection, degassing, aeration, pH, & temp*

**Fish Culture Tanks**

*Dual drain culture tank design is common and efficient*

Disinfection, degassing, aeration, pH, & temp. control

Make-up

Bio-filter (nitrification)

Removal of fine & suspended solids

90 – 95%

Removal of settleable solids

5 – 10%

Sludge treatment

5 – 10%

= Type of filtration!
Why is filtration so important in a RAS?

- Approx. half the feed consumed is excreted as solid waste.
- That waste must be removed because it is **toxic** to the fish.
- Multiple filters improves efficiency (size specific).
Filtration

• Approx. 25-50% of the feed consumed is excreted from the fish as waste solids
• Ammonia is excreted from the fish gills
• That waste must be removed because it is toxic to the fish
• Multiple filters improves efficiency (micrometer size specific)
• Each filter will have a specific job…
• All heavy solids to settle out, convert ammonia/nitrite to nitrate by species of bacteria (nitrification process), CO2 removal, sterilize, etc.
Feed affects the system by...

- Increasing the oxygen demand of a system
- Producing waste solids that need removed
- Producing CO2 and acidifies system (bi products)
- Altering water quality
- “Feeding” the bacteria
- Promoting fish growth
What happens when you feed in fish in an RAS?

- **0.4 – 0.9 lb Alkalinity**
- **2.2 lbs Feed**
- **0.6 – 2.2 lbs Oxygen**
- **0.8 – 3.0 lbs Carbon Dioxide**
- **0.6 – 1.1 lbs Waste Solids**
- **0.05 – 0.12 lbs TAN**
Bio-filters

- Actually consumes oxygen and produces nitrite!
- The good thing is that if properly managed (good establishment of bacteria, high oxygen concentration, and proper pH) the bacteria that run the system will eventually break the waste-water down into “harmless” nitrate.
- Filtration systems are numerous and many many different types are used in commercial operations.
Manufactured media for bio-filters
Need a high surface area…
How much do you need?
You’ll often see it as X ft²
Numerous others used...

- Sand
- PVC Shavings
- Coarse Twine
- Burlap sacks
- Woodchip bioreactors (effluent treatment)
- Sponges
- Pillow filling (spun nylon)
- Anything with a high surface area that won’t leach

*Certain plastic is most common since it lasts for a long time, has a calculable surface area, and withstands bleaching
Positives of RAS

• **Environmental stewardship**
  • Environmentally independent
  • “Remove” mother nature from the equation (if indoors)
  • < water required and < TMDL discharged
  • Can sell waste
  • < water per pound
  • Protection (indoors)
Positives of RAS

- Improved control, year-round production
- Temperature and light manipulation
- Water quality control
- Artificially spawn if desired (light and temperature)
- Feed directly on their heads
- Perfect flow – species dependent
- Different size fish in each tank
Positives: improved biosecurity/survival

- **Limited pathogens**
  - The best water source for outdoor aquaculture is ground water. Surface water usage is a risk!
  - Indoor systems can use ground water or potentially tap (may not be suitable or need treating before adding to the system)
Positives: improved biosecurity/survival

- **Limited predation**
  - Fish raised outdoors commonly fall prey to
    - Waterfowl and other migratory birds
    - Resident herons/egrets
    - Snakes, turtles, otters, humans
Negatives of RAS: economics

Engle and Sapkota 2012

Hybrid Striped Bass

FIGURE 2. Probability distributions of break-even prices above total costs for 1 million hybrid striped bass fingerlings in (a) a 1.2-ha pond and (b) a 2,457-L tank. The values on the y-axis are estimated probabilities of occurrence.
How are RASs doing in the United States?

• Operational RAS in the US
  • 23 (61% of those are tilapia farms)

• Closed RAS in the US
  • 85 known and 17 of those were in Ohio

• From Weeks 2016, former RAES
Why?

- Lots of reasons that include:
  - Poor system design
  - Poor management
  - Poor species/market selection

Can someone else do the same thing as you but much cheaper?
What about aquaponics?

• Yup, it’s popular…
• We will talk more in the afternoon about ratios/designs
What about aquaponics?

- Many systems today are based on UVI; SRAC 454 and YouTube
“There have not been many well-documented successes in large-scale fish production in recirculating systems.”

- Losordo et al. 1998

…. Similar struggles now.
Start slow and small

• What are your goals?
• Research markets, don’t pre-determine your species
• Visit successful farms when possible
• Learn about fish husbandry and waste-water treatment
• Take a lot of classes/workshops – raising fish isn’t easy
• Large scale plans? Get a well-respected engineer involved (and another to review their plans)
Lots of **good free University** information online

- Dr. James M. Ebeling has a lot of fantastic PowerPoints available online that go more in depth (for example Biofiltration-Nitrification Design Overview)
- Recirculating Aquaculture Systems (Yellow Book) and Cornell RAS class (online?)
- SRAC publications (RAS and Aquaponics systems designs and considerations)
Questions?

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