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

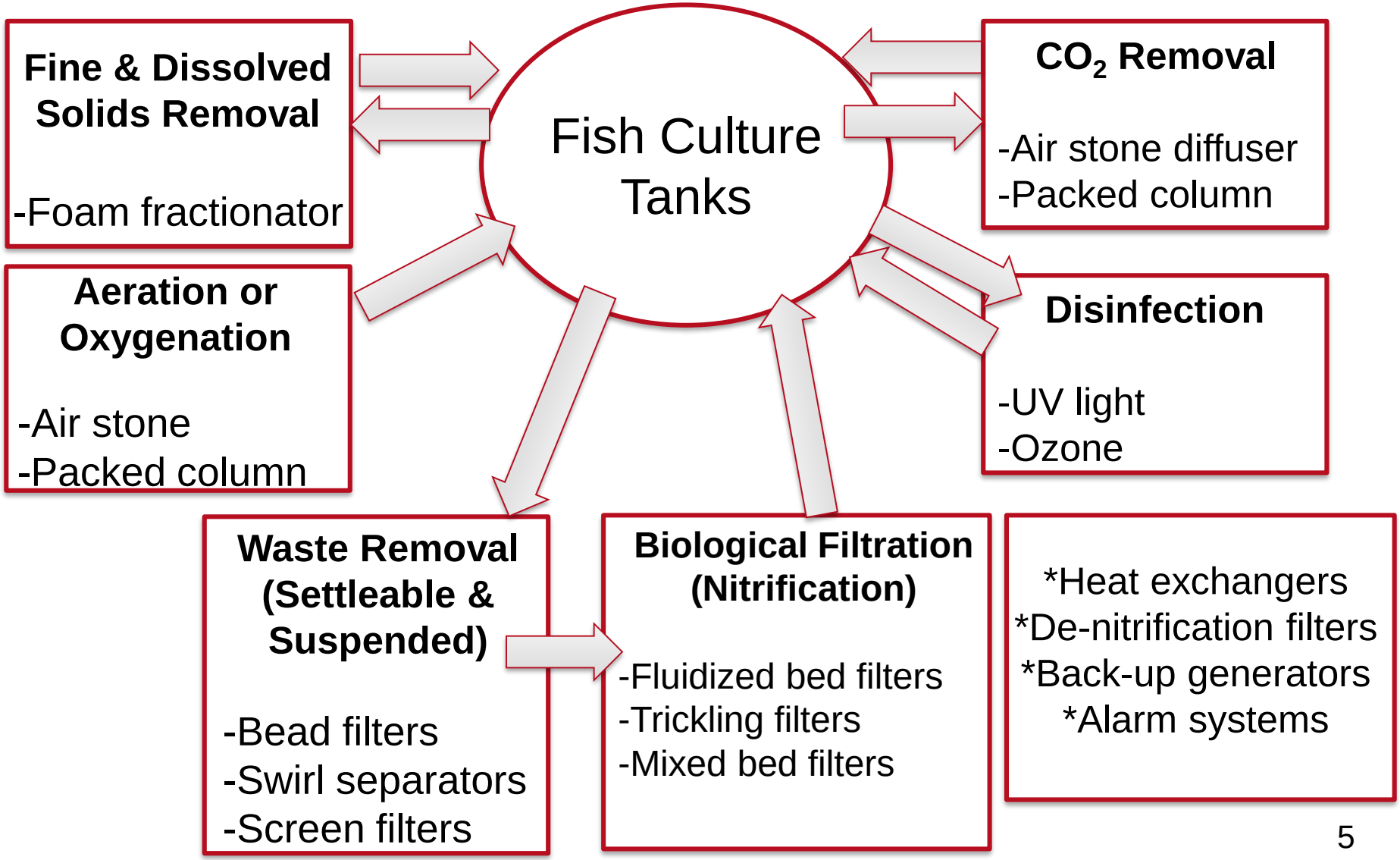
Highly condensed version – will elaborate over the course of ABC

- Carrying capacity needs to be high in order to be more help improve 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)

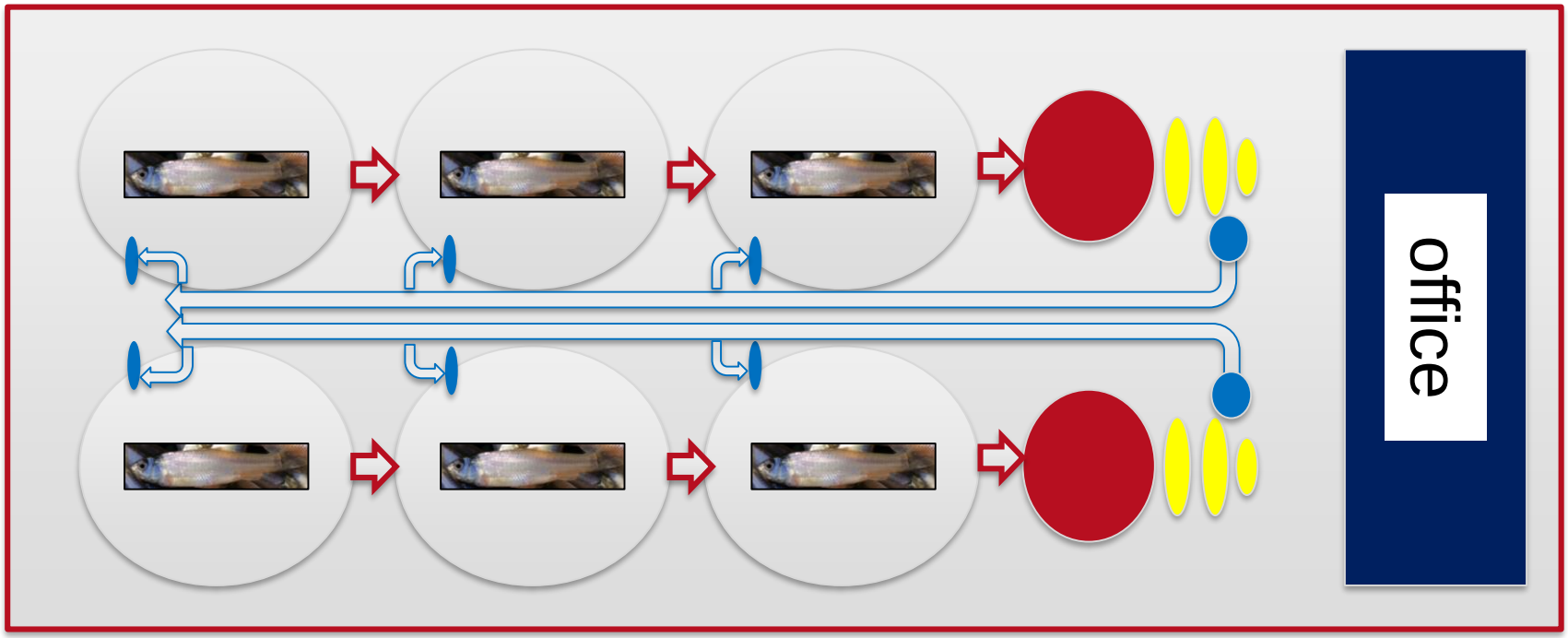


Solids – two main concerns in RAS

- 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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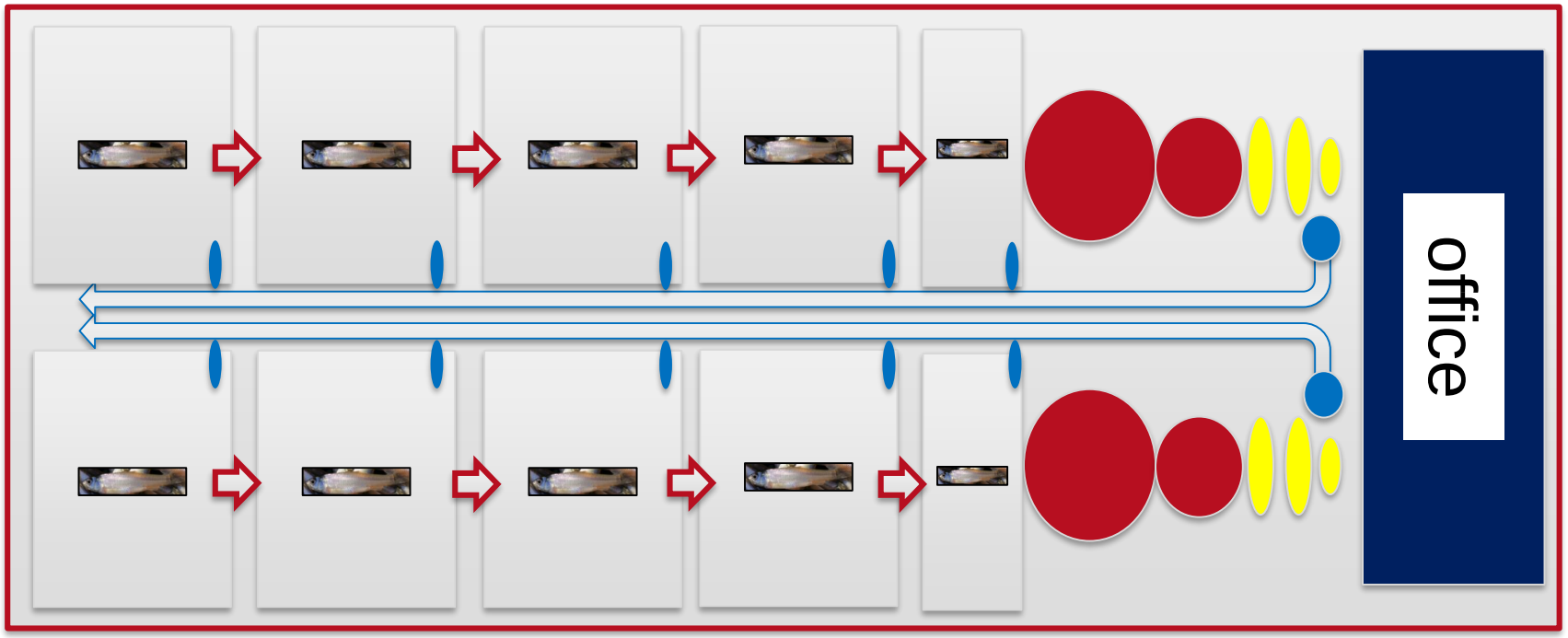
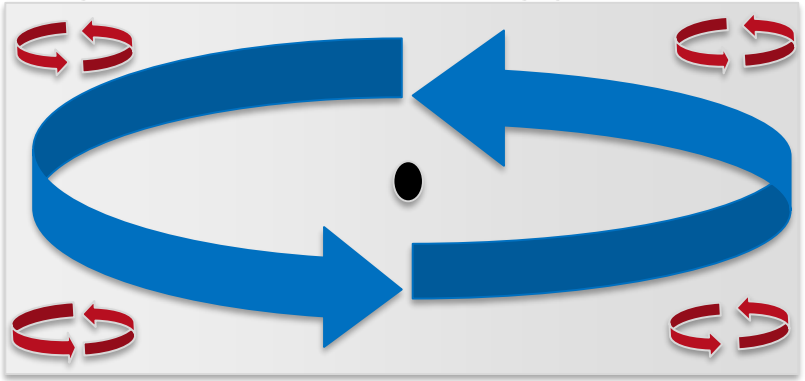


Tank Design

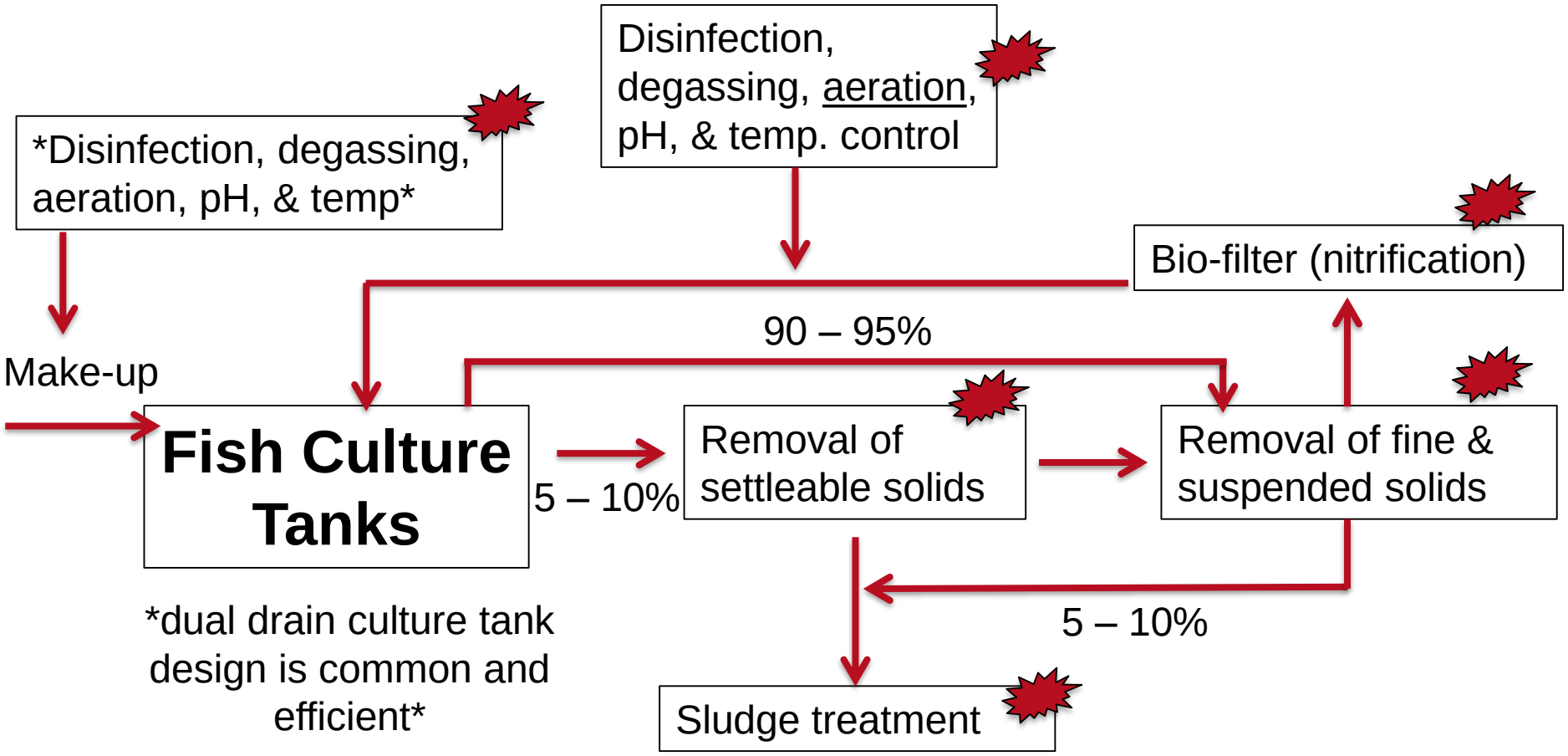
- You can fit more rectangular tanks in a single room and can harvest easier, however…
  - They aren't as efficient at self-cleaning (uniform WQ)
  - No beginning and no end to a round tank
  - Self-supporting wall
  - Adjust water flows/filtration better
- Large (fewer) round tanks in a given ft^2 increasingly 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?

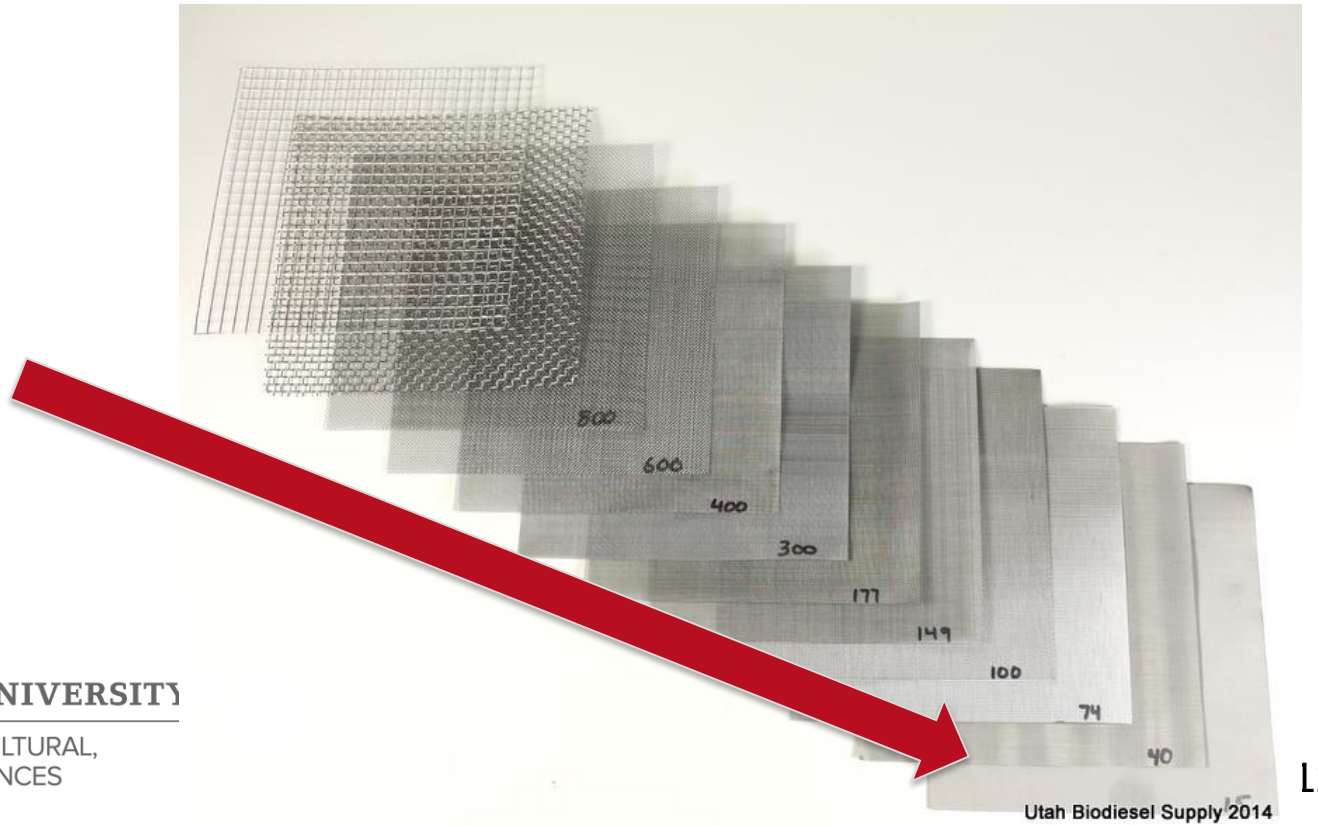
General water flow in a RAS



= Type of filtration!

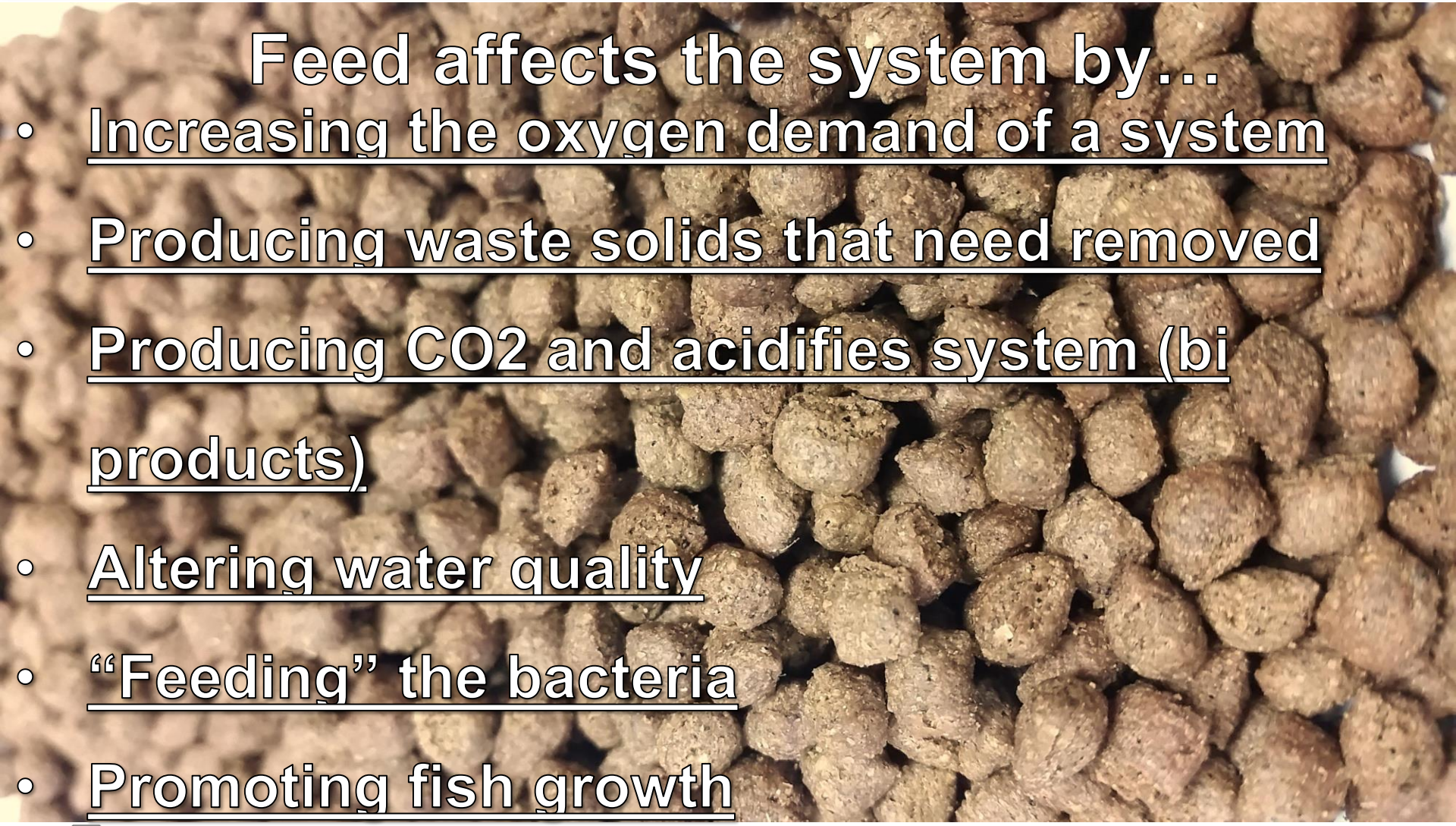
Why is filtration so important in a RAS?

- 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?

2.2 lbs Feed

0.4 – 0.9 lb
Alkalinity

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 ft^2

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

- <u>Environmental stewardship</u>
  - 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 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

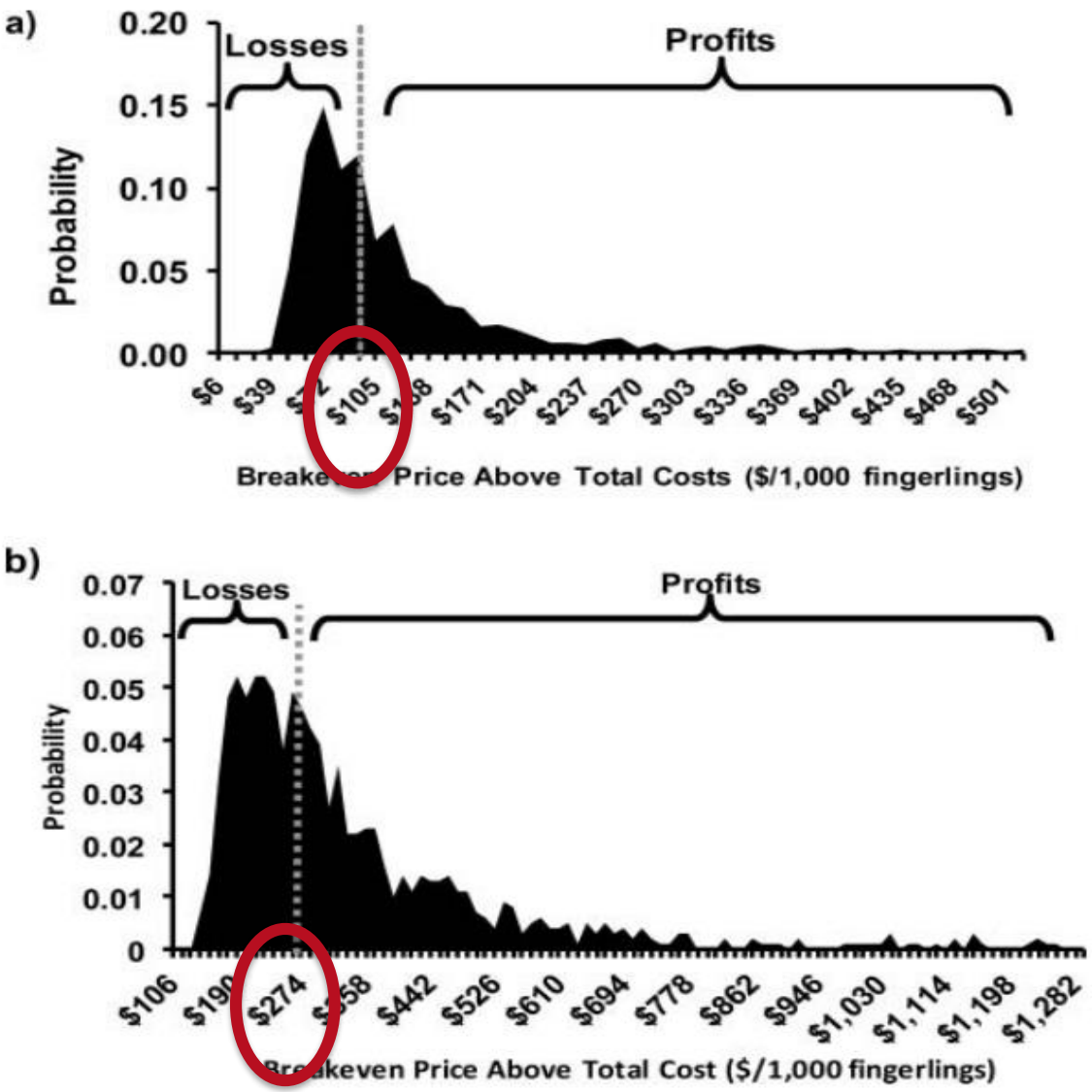


FIGURE 2. Probability distributions of break-even prices above total costs for 1 million hybrid striped bass fingerlings in **(a)** a 1.2-ha pond and **(b)** a 2,457-L tank. The values on the *y*-axis are estimated probabilities of occurrence.

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

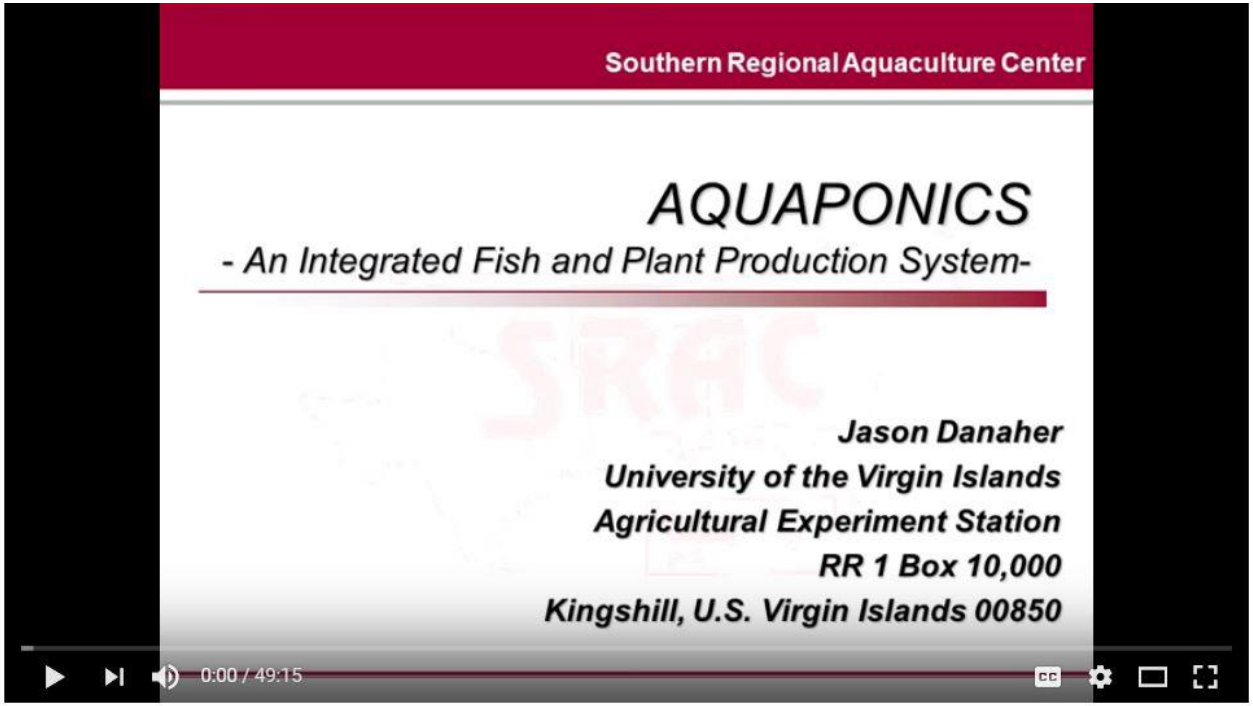
Can someone else do the same thing as you but much cheaper?

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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