Commercial Recirculating Aquaculture Systems: Design Basics and Economic Realities

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Global Aquaculture Supply
Benefits of RAS

- Increased control of system
- Minimal water use
- Higher density
- Increased biosecurity
- Year-Round Growing Season
- Locate anywhere
- No limit on species selections
Basic System Components

- Tanks
- Water Movement
- Mechanical Filtration
- Biological Filtration
- Gas Control
- Disinfection
- Temperature Control
Tanks

Water Movement

Mechanical Filtration

Biological Filtration

Gas Control

Temperature Control

Disinfection

Recirculating Aquaculture Systems
Tanks
- The most important component of your system
- Two main materials used in RAS
  - Fiberglass
  - Plastic
- Lined metal and wood tanks are also sometimes seen
- Fiberglass is most common, but most expensive
- Plastic tanks work well up to roughly 2,500 gallons
- Lined tanks can be very economical, but need to be installed properly
Tanks

• 2 Crucial Factors
  • Drain Design
  • Width to Height Ratio

• Simple tanks use a single bottom drain

• Optimal drain design is the “Cornell Dual Drain”
  • One drain on the side receiving the majority of flow
  • One drain in the bottom receiving the majority of solids
Tanks
Water Movement

- Pumps are the most common device
- Sizing depends on system volume and turnover time
  - Typically 30-60 minutes
- Types include
  - Centrifugal
  - Vertical Turbine
  - Magnetic Drive
  - Submersible
- Proper Sizing drives system efficiency
- Utilize Gravity!
Airlifts

• Some systems utilize airlifts for water movement
• These generate very low head pressure, but can move water efficiently when properly designed
• Simply inject air into a column of water
Mechanical Filtration

• Used to remove solid waste from system
• Sizing Criteria:
  • Flow Rate
  • Micron Size
• Well designed systems can pull solid waste from the water within minutes.
• Mechanical filtration comes in many varieties
Radial Flow Settlers

- Radial Flow/Swirl Separators
  - Passive Filtration
  - No Energy Use
  - Excellent for removing large solids
  - Must be combined with another filter for small solids
Sand/Bead Filters

- Fixed Bed Filters
- Backwash accomplished by reversing water flow
- Medium-High Pressure
- Simple operation
- Readily Available
Bag Filters

- Very simple
- Low cost
- Utilize a fabric filter sock placed in a vessel housing
- Somewhat maintenance intensive
- Manual backwash/cleaning
- Lack of maintenance can cause flow loss
Drum Screen Filters

- Most commonly used in medium-large RAS systems
- Available in a variety of screen sizes and flow rates
- Gravity fed, low pressure
- Self Cleaning, Low Maintenance
Biological Filtration

- Filters create habitat for nitrifying bacteria
- Bacteria convert Ammonia to Nitrite then Nitrate
- Most Common Biofilter Types Include
  - Moving Bed Bioreactors
  - Fluidized Sand Bed
Biological Filtration

• Moving Bed Bioreactors
  • Utilize a heavily aerated media bed
  • Media is constantly in motion
  • Very low head pressure
  • Take up large amounts of space
  • Scaleable from small to large systems
Biological Filtration

- Fluidized Sand Beds
  - Vertical Columns filled with sand
  - Sand is kept in motion via water flow from bottom to top
- Low Floor Space Requirements
- Low-Medium Head Pressure
- Sand provides excellent surface area-volume ratio
- Require more experienced operator
Gas Control

• Aeration/Oxygenation
  • O2 is provided to fish via air or oxygen
  • Air is typically used smaller or lower density systems
  • Oxygen is used in systems of all sizes
  • O2 allows higher density and better water clarity
Aeration

• Air is provided via mechanical pumps
  • Regenerative Blowers are most common
  • Other types include
  • Diaphragm Pumps
  • Linear Piston Pumps
  • Compressors
  • Centrifugal blowers
Oxygen

• Oxygen is provided via liquid oxygen or O2 Generators

• Choice depends heavily on site specific conditions
  • Typically, O2 Generators require higher initial investment but can be cheaper in long term

• Oxygen is injected into water under pressure using one of the following:
  • Spece Cones
  • Ceramic Diffusers
  • Low Head Oxygenators
UV

- Disinfection is primarily accomplished via UV or Ozone
- UV systems utilize ultraviolet light to render organisms unable to reproduce
- Operation is simple, and does not require much maintenance
- Can be sized for many different pathogens
Ozone systems generate Ozone gas and inject it into the water.

Ozone is a strong oxidizing agent and has many benefits for water quality and pathogen control.

Ozone systems require expert sizing and multiple components.
Aquaponics

• Aquaponics provides a unique opportunity
• Can generate a secondary crop while removing final waste products
• Systems have the ability grow many different plants
• Requires additional staff and knowledge
• May require additional permitting
Monitoring and Controls

- All RAS systems should be equipped with monitoring
- At harvest densities, systems can crash within minutes, resulting in significant loss
- Parameters Monitored should be: O2, pH, Temperature, Salinity, ORP, Flow, and possibly more
- Test other parameters like Ammonia, Nitrite, Nitrate by hand
Saltwater Systems

• Saltwater Systems are very similar to freshwater, with two main differences
  1) Higher Grade Stainless Steel
  2) Foam Fractionation
     • Foam Fractionators and very fine solids.
RAS Economics

- Major Costs Include:
  - Feed ($0.75-1.00/lb)
  - Labor
  - Electricity
  - Fingerlings
  - Building/Site

- All of these need to be considered and accounted for in a business plan prior to building a farm.

- Can you sell fish at a price that covers this cost plus a profit?
One of the most common failures of aquaculture producers is not knowing their market, or overestimating their market.
Example System 1

- 8x 2,500 Gallon Tanks

System Cost:
$175,000-$225,000
System Economics Example 1

- System Design Load: ½ Lb/Gallon (60 kg/m³)
- Stocking Events: 1 tank monthly
- Max standing biomass: 6,000 lbs
- Species: Tilapia
- Fish size at stocking: 40g
- Fish size at harvest: 600g
- Monthly Harvest: 1,200 lbs
- Annual Harvest: 14,400 lbs
- Price per lb: $7.00
- Annual Revenue: $100,800

- Annual Costs:
  - Feed: $10,800
  - Fingerlings: $9,600
  - Electricity: $8,500 (estimate)
  - Leaves $71,900 for Labor, Building, Insurance, Updates, and payment on system.
  - No Mortality Loss Considered
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Max standing biomass: 6,000 lbs
Species: Tilapia
Fish size at stocking: 40g
Fish size at harvest: 600g
Monthly Harvest: 1,200 lbs
Annual Harvest: 14,400 lbs
Price per lb: $4.50
Annual Revenue: $64,800

Annual Costs:
Feed: $10,800
Fingerlings: $9,600
Electricity: $8,500 (estimate)
Leaves $35,900 for Labor, Building, Insurance, Updates, and payment on system.
No Mortality Loss Considered
Example
System 2
Large Coolwater System Economics Example

- 220,000 lbs/year
- System Cost: $1.3-$1.7 million
- Labor: $290,000/year
- Electric: $400,000/year @ $0.16/kw
- Oxygen Cost: $23,000/year
- Operating Cost (Feed, chemicals, production supplies, office equipment): $400,000/year
- Building ???
- Total Expenses: $1.2 million+
- Revenue @ $12/lb: $2,600,000/year
- Profit @ $12/lb: $1,400,00/year
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- Profit @ $7/lb: $400,000/year
Questions?

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