Commercial Recirculating Aquaculture Systems: Design Basics and Economic Realities

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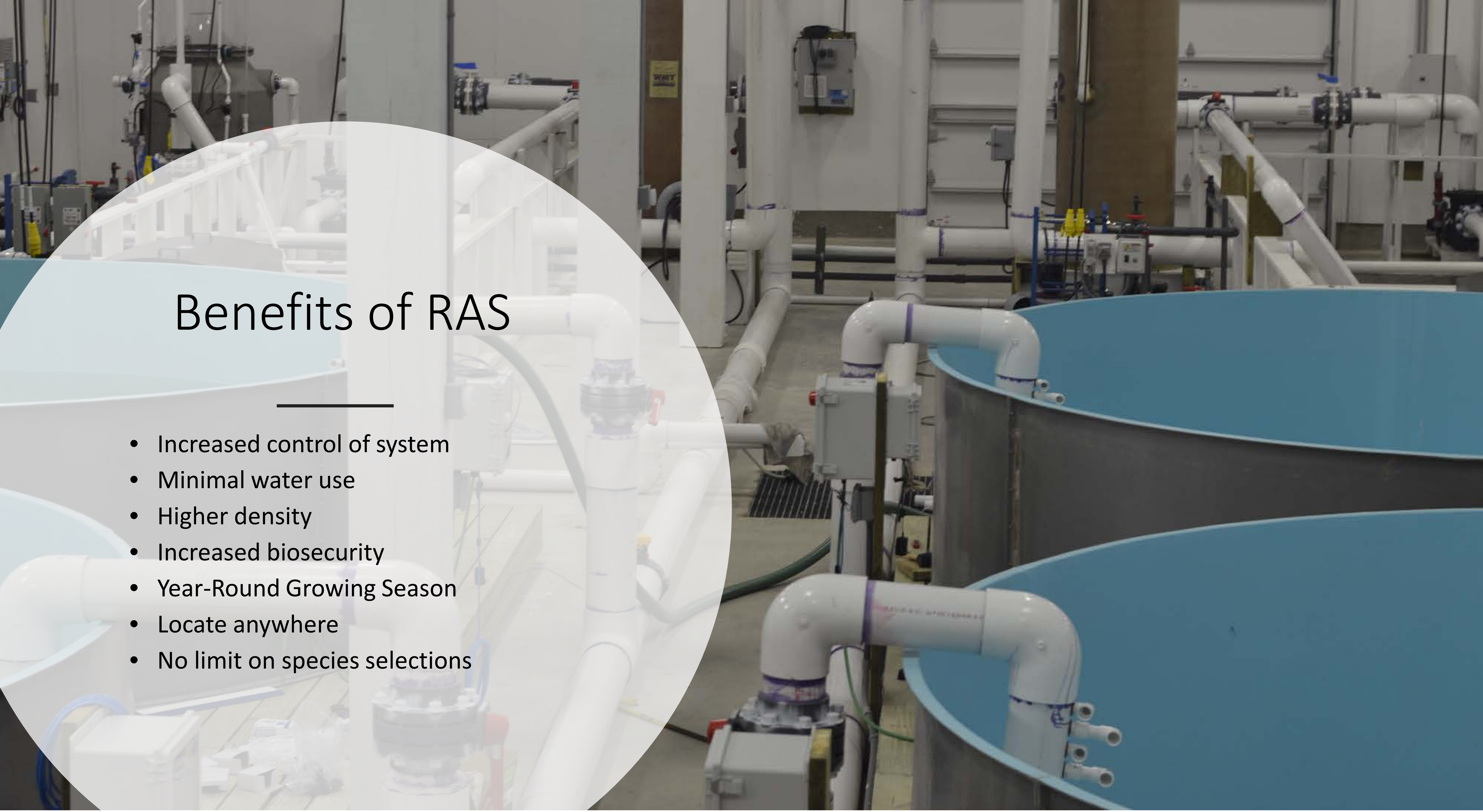
Global Aquaculture Supply

GLOBAL AQUACULTURE SUPPLY

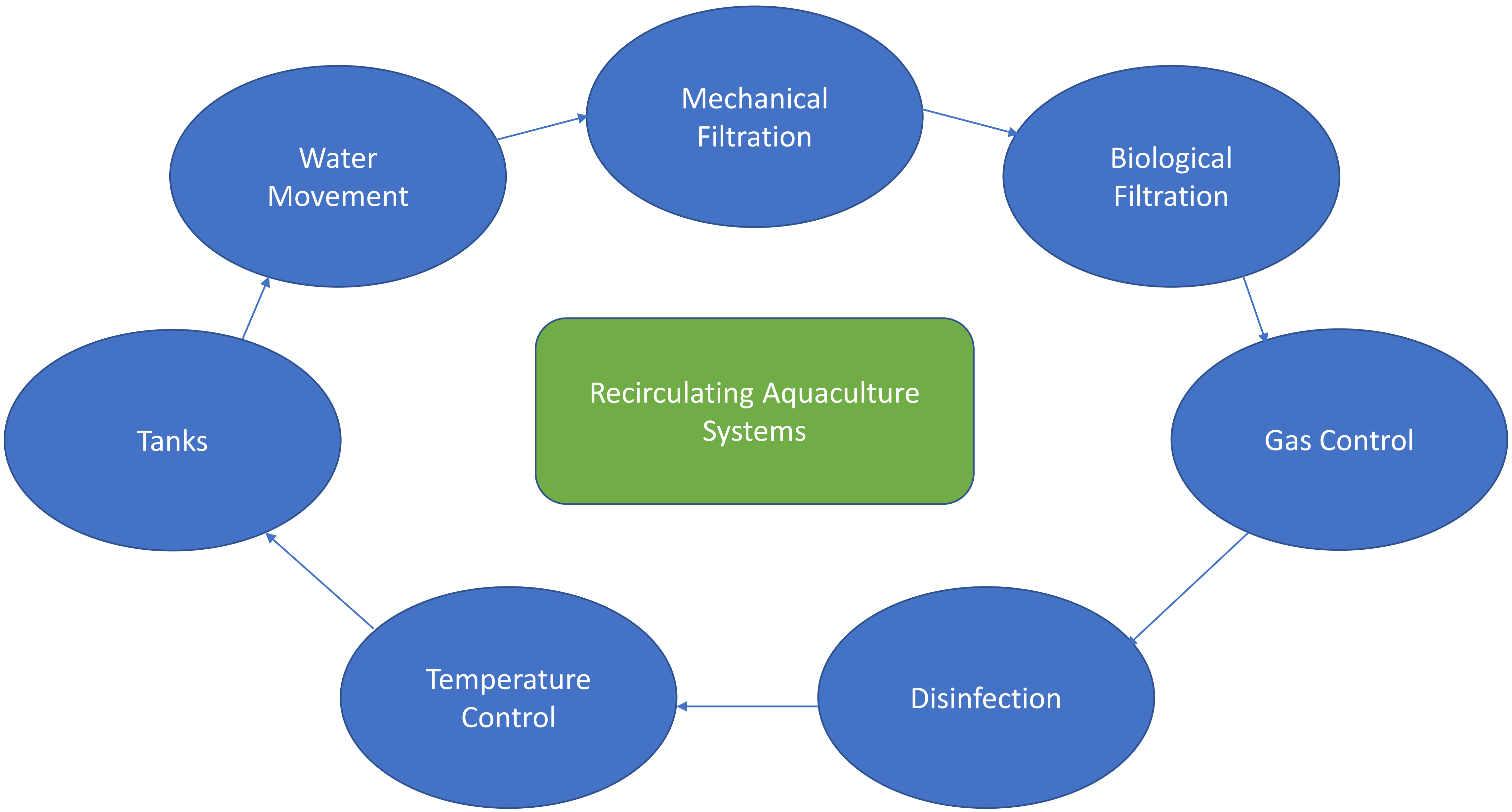


Benefits of RAS

- 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


Mechanical Filtration
Biological Filtration
Gas Control
Disinfection
Temperature Control
Tanks
Water Movement
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
  - Typcally 30-60 minutes
- Types include
  - Centrifugal
  - Vertical Turbine
  - Magnetic Drive
  - Submersible
- Proper Sizing drives system efficiency
- Utilize Gravity!

Pumps

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

- 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: O_2, 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?

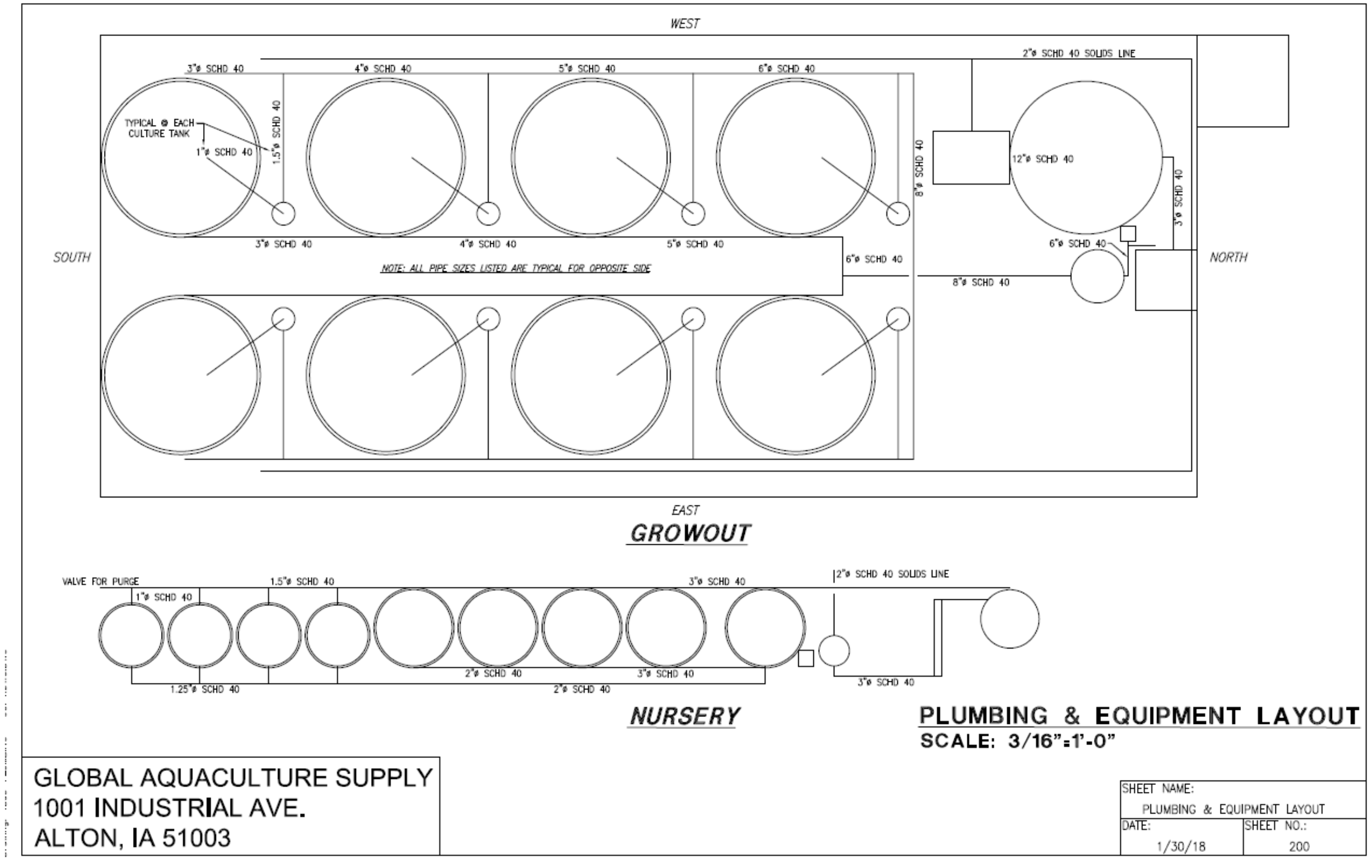
KNOW YOUR MARKETS!!!!!

- 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

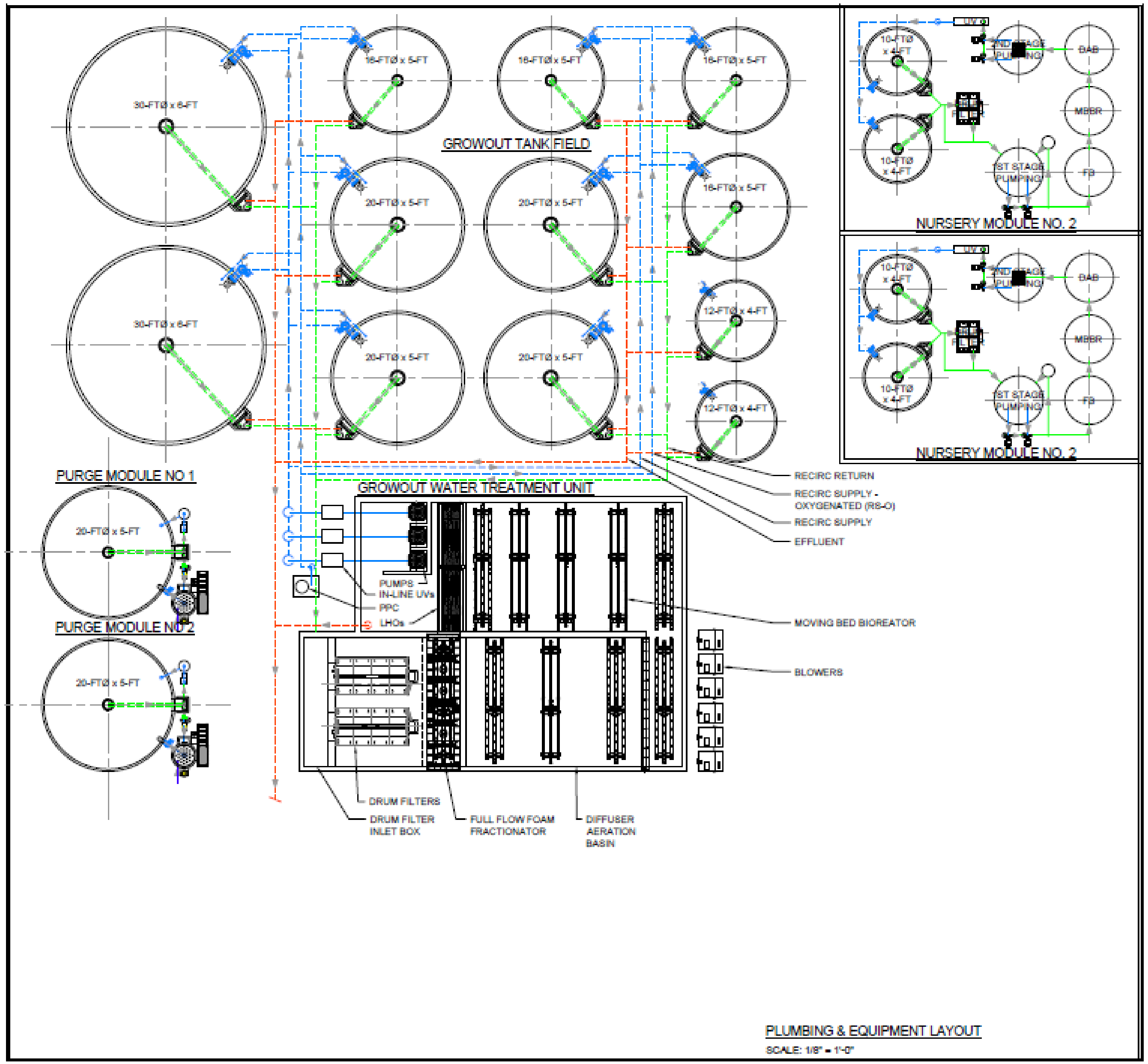
- System Design Load: ½ Lb/Gallon (60 kg/m3)
- Stocking Events: 1 tank monthly
- Max standing biomass: 6,000 lbs
- Species: Tilapia
- Fish size at stocking: 40g
- Fish size at harvest: 600g
- Monthly Harvest: 1,200 lbs
- Annual Harvest: 14,400 lbs
- Price per lb: $7.00
- Annual Revenue: $100,800

- 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

System Economics Example 2

- 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: $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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- System Cost: $1.3-$1.7 million
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- Building ???
- Total Expenses: $1.2 million+
- Revenue @ $7/lb: $1,600,000
- Profit @ $7/lb: $400,00/year

Questions?

Special thanks to Donald Bacoat, Fort Valley State University