

## Aquaculture Rearing Systems

- Configuration is part of the system
- Exchanges of water
- Waste management
- Space needs
- Available water
- Species and size of fish

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## Intensive Rearing systems

- Circular Tanks
- Ponds (earthen, circular, rectangular)
- Raceways

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## Round Tanks



- Good mixing of the water, resulting in easy oxygenation; and less contact of the fish with the tank sides and bottom, due to a higher ratio of tank volume: tank wall and bottom.
- Many species prefer the consistent current of a round tank to other systems.
- The disadvantages of round tanks include poor use of land area and difficulties in management (fish removal, screen cleaning), especially in tanks with a diameter larger than 5 meters.

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## Circular Tank Rearing

- Circular tanks make good culture vessels because they can provide a uniform culture environment, can be operated under a wide range of rotational velocities to optimize fish health and condition, and can be used to rapidly concentrate and remove settleable solids.
- The flow inlet and outlet structures and fish grading and/or removal mechanisms should be engineered to reduce the labor requirements of handling fish and to obtain effective tank rotational characteristics, mixing, and solids flushing.

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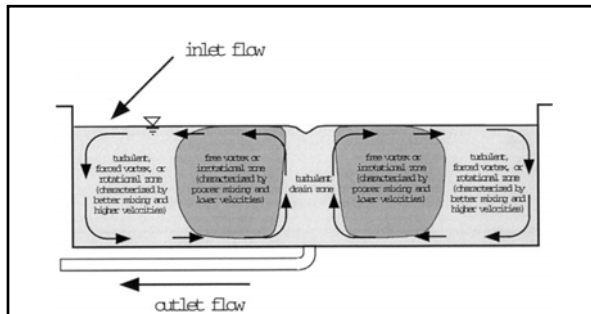


Fig. 1. The 'primary' rotating flow (not shown, but created by injecting the flow tangential to the tank wall) creates a 'secondary' rotation that flows radially (shown here) and carries settleable solids towards the tank's bottom center drain in a phenomenon called the 'tea-cup effect'.

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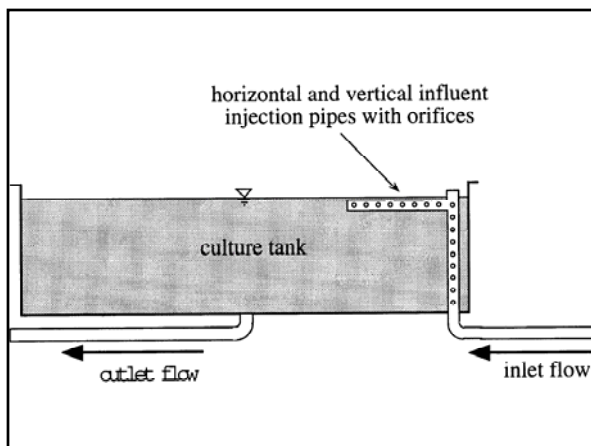
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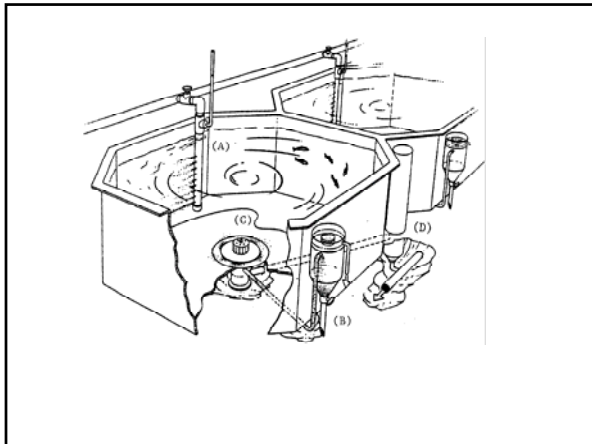
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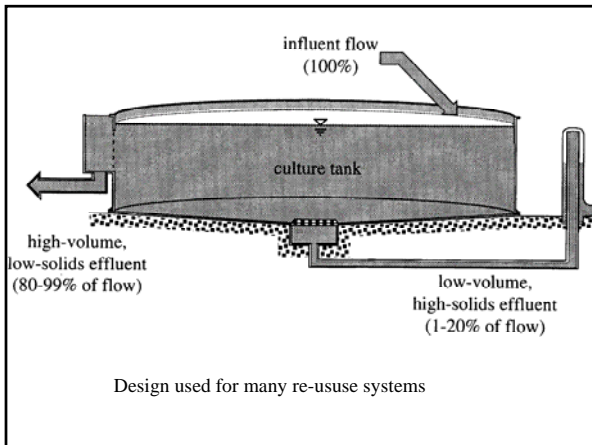
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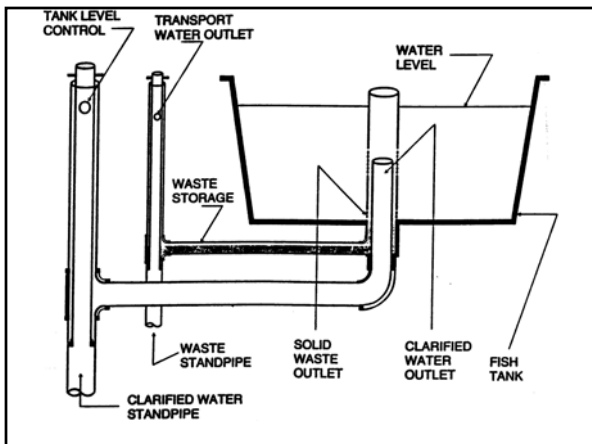
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## Raceways



- To be self cleaning, raceways must be operated at high flow rates and/or high stocking densities, where the movement of the fish keep the faeces and uneaten feed from settling.
- Disadvantages of raceways are brought about primarily by poor mixing, and include the gradual deterioration of the water quality along the length of the raceway (whereas round tanks tend to be more even).

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## Raceway Designs Vary

- Raceways are usually built with a width to depth ratio of between 2:1 and 4:1, with the length limited either by the amount of fish that can be held in a single holding unit or the deterioration of water quality.
- The even nature of raceways means that they are somewhat flexible, allowing screens to be placed anywhere along the length of the raceway, thus dividing a single unit into 2 or more smaller units.
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## Exchange Rates

- In a raceway tank, an almost complete water exchange can be achieved with one equal volume of water. As the water flows into the system, it pushes the old water ahead of it. Self cleaning may be accomplished with high stocking rates and low
- Modifications to the designs include rounded bottoms to concentrate solids for ease of cleaning by vacuuming - especially where small fish are involved.

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## Rectangular Ponds

- Burrows or other types
- Better use of land
- Larger units for handling fish
- Problems with removal of wastes, mixing and cleaning

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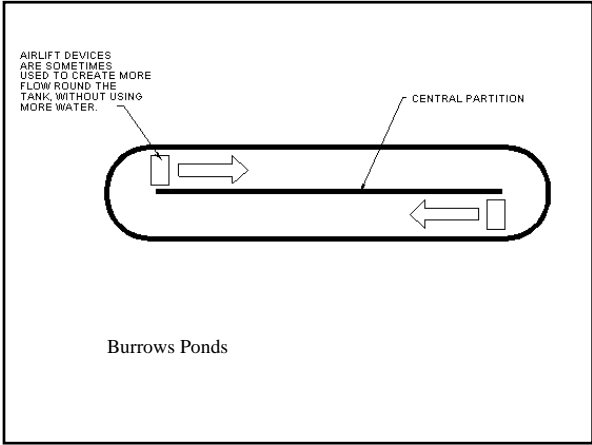
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## Air and Help Move Water

- **OIL-LESS AIR COMPRESSORS.** The primary difference between the names blowers, air pumps and compressors is the pressure to which they can compress air. All air compressors used for aquaculture purposes should be "oil-less"

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## Problems with all Designs

- New Concepts – a new design has not been developed for many years...
- Barnaby Watten, hatchery engineer, Mid 1990s did pivotal design work

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## Mixed Cell Raceway System

- The MCR can take advantage of the solids removal ability of circular tanks and can be managed as either a partial reuse or intensive recirculation system.

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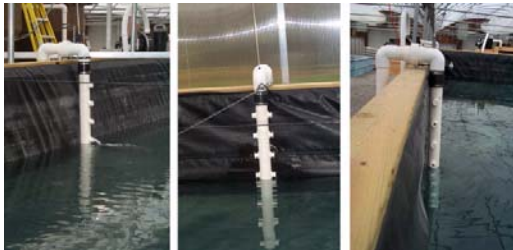


Fig. 2. Vertical jet port manifolds arranged along the side walls of the MCR. On the far left, a single-sided manifold composed of five nozzles directed across the width of the raceway. Middle and far right pictures show the double-sided manifolds composed of 10 nozzles directed tangentially to the raceway wall

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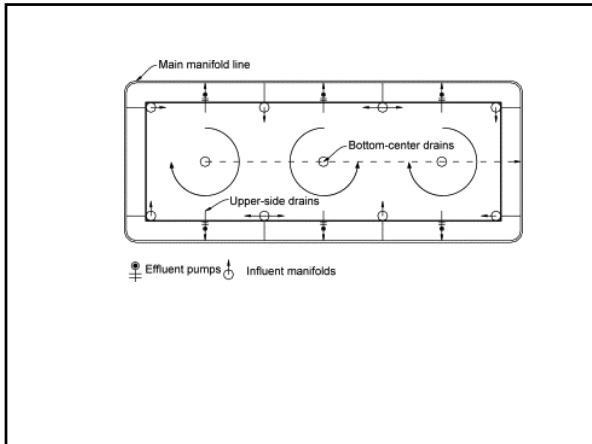
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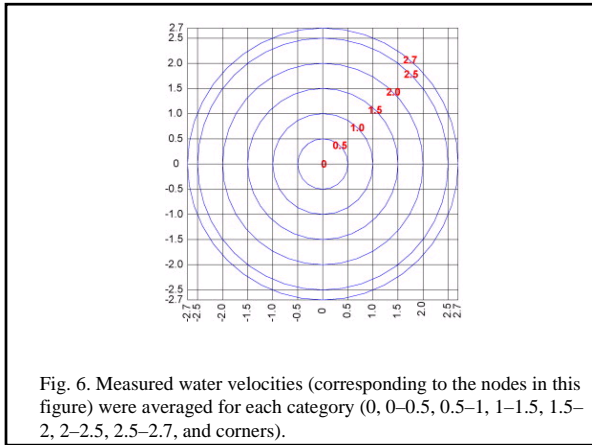


Fig. 6. Measured water velocities (corresponding to the nodes in this figure) were averaged for each category (0, 0–0.5, 0.5–1, 1–1.5, 1.5–2, 2–2.5, 2.5–2.7, and corners).

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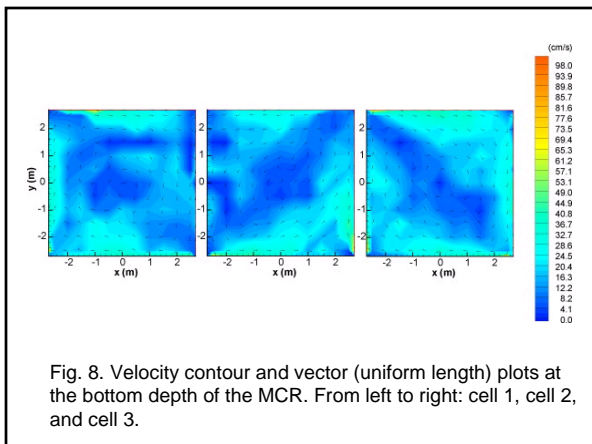


Fig. 8. Velocity contour and vector (uniform length) plots at the bottom depth of the MCR. From left to right: cell 1, cell 2, and cell 3.

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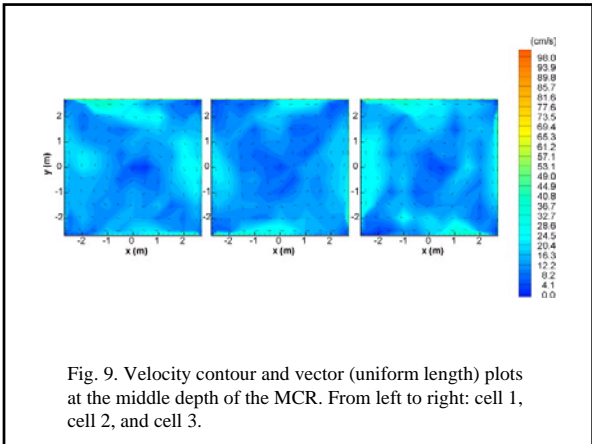
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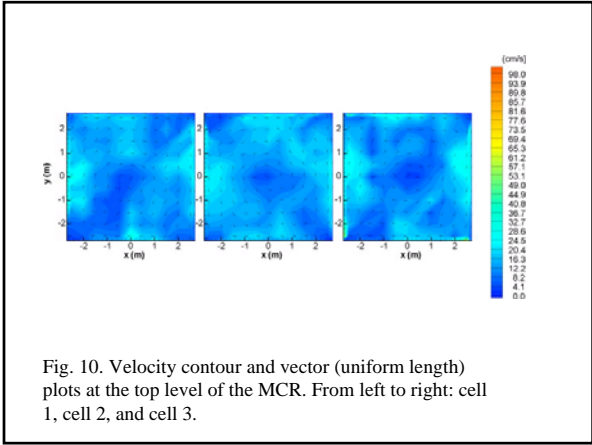
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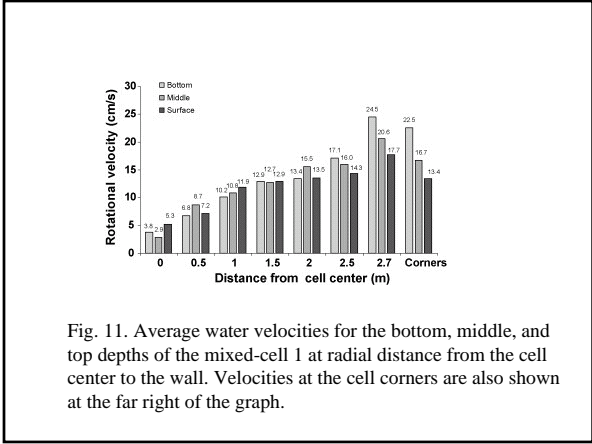


Fig. 11. Average water velocities for the bottom, middle, and top depths of the mixed-cell 1 at radial distance from the cell center to the wall. Velocities at the cell corners are also shown at the far right of the graph.

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## Several Papers Published

- Limited use- East Coast and Europe

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## DNFH- justification

- Problems with Burrows Ponds
  - Built in 1970s, Never worked well
  - High solids accumulation
  - Fish health issues
  - Labor issues
  - NPDES issues when brushed

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## Fall 2007, Winter 2008

- New Hatchery Manager contracted with the Freshwater Institute to evaluate options for the system redesign and configuration
- Consulting Engineer recommended mixed cell system.
- Prototype design prepared, and implemented in summer to fall 2008

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Removing center wall



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## Completed in late Nov 08

- Barnaby and U of Idaho
- Went to watch filling operation and test the flows

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Filling of first Unit

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**Evaluation steps**

- NaCl tracer to introduce and follow removal through the system
- Modeling of flows in the cells to validate computational models
- Introduce fish
- Evaluate fish health, growth, and effluent quality
- Evaluate removal of unwanted elements eg invasive species or other contaminants

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Testing of Flows



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Tracer introduction



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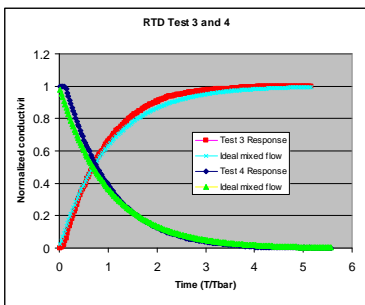
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Loading and Depletion Followed Computational Models

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Characteristic	Circular tanks	Linear raceways
• Shape	Circular	Rectangular
• Hydrodynamics	CMF	Plug-flow
• Construction	Difficult	Simple
• Cost	High	Low
• Harvesting and husbandry	Difficult	Simple
• Surface area per volume of water	Low	High
• Velocities req'd for:		
Growth and food conversion	Good	Insufficient
Fish stamina	Good	Insufficient
Tank self-cleaning	Good	Insufficient
• Distribution of dissolved oxygen and metabolites	Good	Poor (gradient)
• Distribution of fish	Uniform	Poor (uneven)

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