Optimizing Aeration Tower Design for Salmon Hatcheries

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My Goal:

- To give you tools that you can use to improve your aerators and evaluate different aerator designs.
- The results of decades of research by many people, following first principles of engineering design.

Why do we need to Aerate?

- Low in DO
  - Poor health, slow growth, reduced capacity
- Super-Saturated with Nitrogen/Total Gas
  - Can cause tissue bubble formation, Gas Bubble Trauma/Disease

What is the Optimal Aerator?

- Equalizes Gas Pressures
  - Brings O2 and N2 near to saturation (~100%)
- At Lowest Cost
  - Operating cost (Energy and Labor)
  - Capital cost (Construction and Durability)

Paradox of Aerator Design

- The Problem: conflicting needs
  - Low Oxygen: likes high pressure to force oxygen into solution (turbulence or supplementation)
  - High Nitrogen and Total Gas Pressure: needs low-pressure to suck gas out of solution (vacuum)
- The Compromise Solution:
  - Keep Air Pressure at Ambient
  - Maximize the air/water surface area
  - Maximize the exposure duration

What Controls Gas Pressure?

- Temperature
  - More soluble at lower temperatures
- Pressure
  - More soluble at high pressure
  - Altitude = low pressure
  - Depth = high pressure

What Controls Aeration?

- Surface area per Flow (Flux)
  - – Thin layer of water aerates better
  - – Thicker layer requires more time (height)
- Pressure - Water and atmosphere
  - – Ambient pressure aerates and de-gases
- Ventillation
  - – Provide new gas to equilibrate N and O

How do Aerators Work?

- Uses Energy to Overcome Surface Tension
  - Limit of Energy available depends on Head
  - Aim for maximum surface area of exposure
  - **Energy is Wasted in Free Fall**
  - Aim is to control descent through the device
- Slows water transit through aerator
  - Allows for increased time for gas exchange

Design Process

- Goal
- Objectives
- Measures of Effectiveness
- List Components
- Generate Alternatives for Components
- Evaluate and Select
- Monitor and Adjust

Design Process

- Goal –
  - Healthy Fish
- Objectives –
  - Adjust O2 and N2 to ~100%
- Measures of Effectiveness
  - Performance – Gas Exchange Efficiency
  - Cost
    - Operations Cost (Energy and Labor)
    - Capital Cost

Design Process

- Components
  - Thin-Film Generation
  - Flow Distribution
  - Ventillation
  - Minimize Free Fall
- Generate Alternatives for Components
- Evaluate and Select
- Monitor and Adjust

Objectives of SEP Aeration

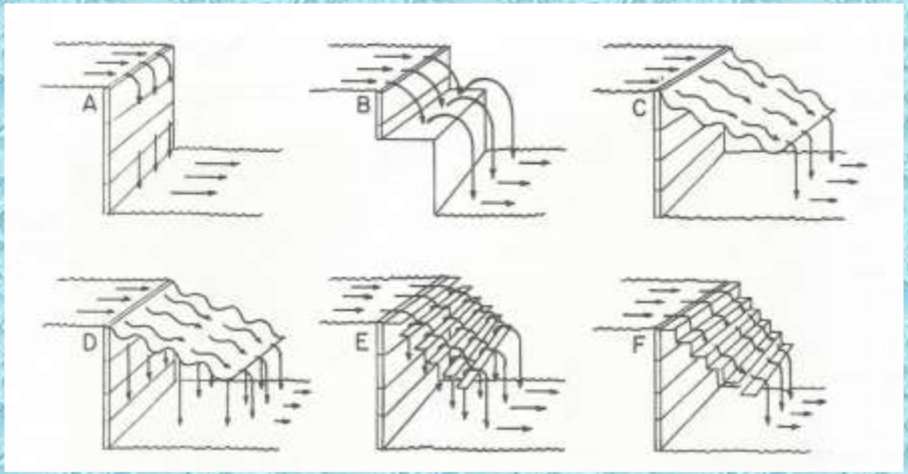
- Aim for 100% Saturation to avoid GBT
  - Use most efficient aerator available
  - Keep operation simple and sustainable (low maintenance, no reliance on oxygen supplementation)
- Minimize energy required
  - Provide sufficient but not excessive aeration
  - Consider energy cost of components (supply pipe, head requirement, replacement, maintenance)

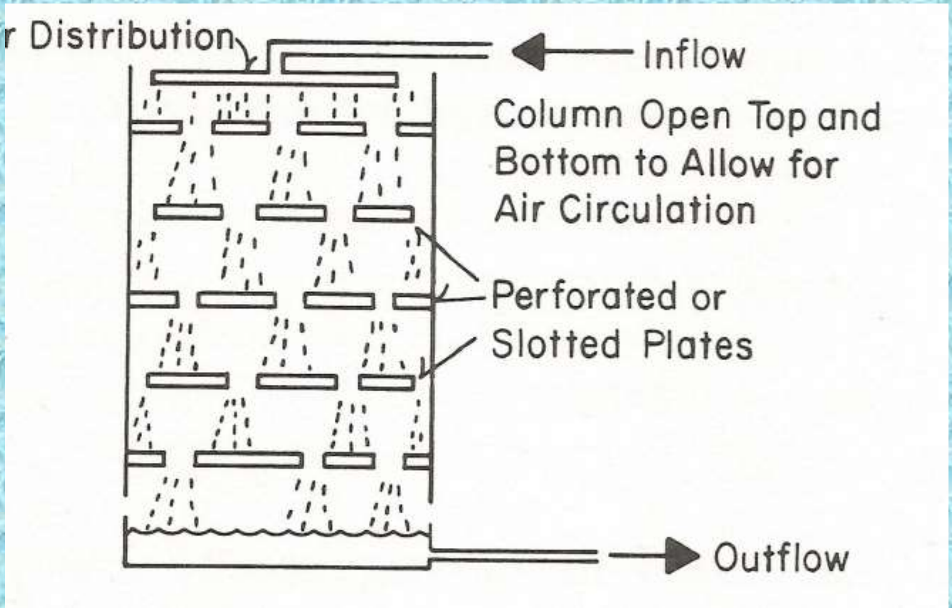
Active Aerators
Cost More Energy ($)

- Venturi Aspirators
- Paddles
- Sprays
- Oxygen Supplementation

Thin-Film Generation

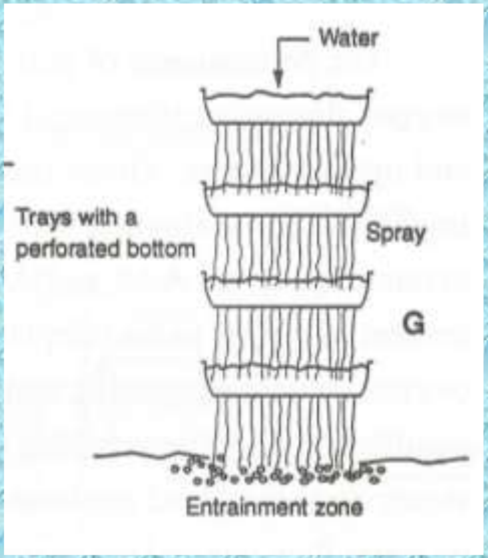
- Cascades
- Slopes
- Slats



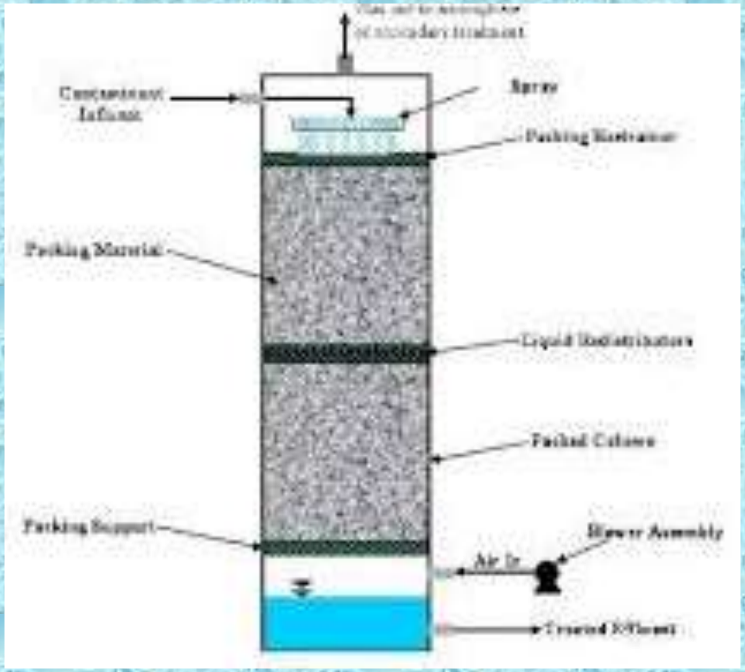


Thin-Film Generation

- Screens



- Packed Columns



Aerator Comparisons

- Dave Owsley at Dworshak (1973-1979)
  - Tested Spash Plates, Spray Nozzles, Perforated Plates, Perforated Buckets, Swedish Degasser, Mechanical Paddle
  - Found Packed Column **Media Bed** out-performed all other passive aerators, whether small (4”) or large (3’) diameter
  - 1.5” Rings were best medium

*Also studies by: Bouck, Colt, Watten, McLean, Boreham, etc.

Thin-Film Generation

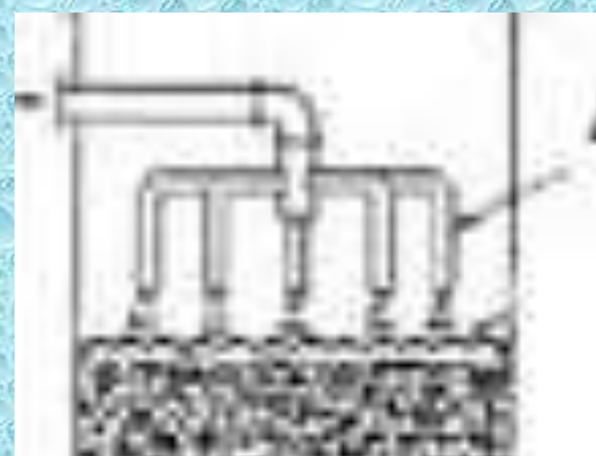
- Media Beds (Packed Columns) always outperform Free-Fall aerators due to increased resistance to flow, leading to a thinner film of water and longer falling time.
- If you want to improve the performance of your Free-Fall Aerator, add Media

Water Distribution

- Spray Bar

Head

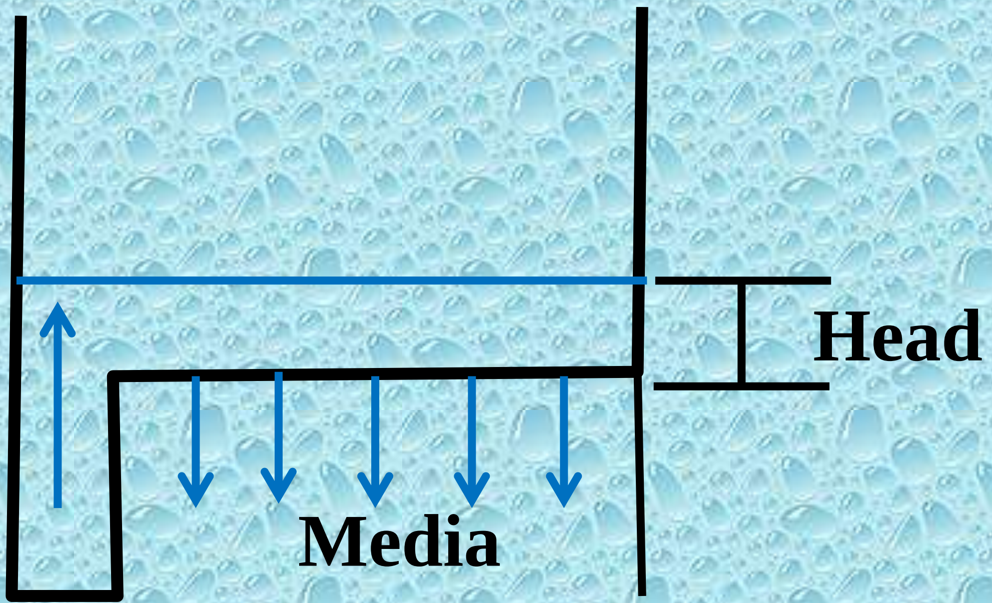
- Header Manifold



Head

Water Distribution

- Calibrated Distribution Plate
- Stilling Box



Ventillation

- None
- Holes
- Segmented

Ventillation

- Louvres

Media

Media Type

- Many different kinds of aeration media

Media Orientation

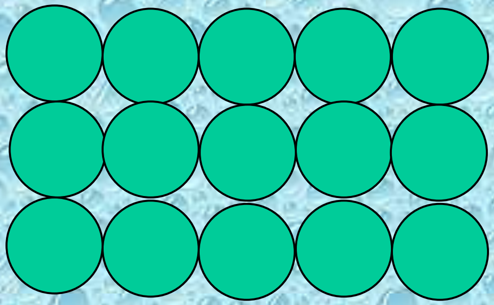
- Random Packing

Ventillation

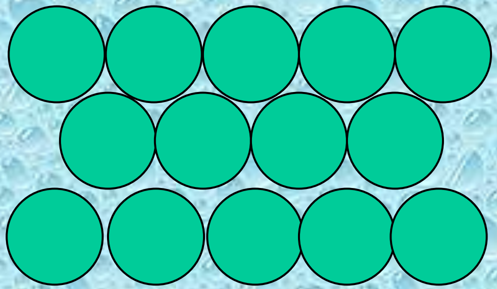
Media Orientation

- Structured Packing

Square Lattice



Hexagonal Lattice



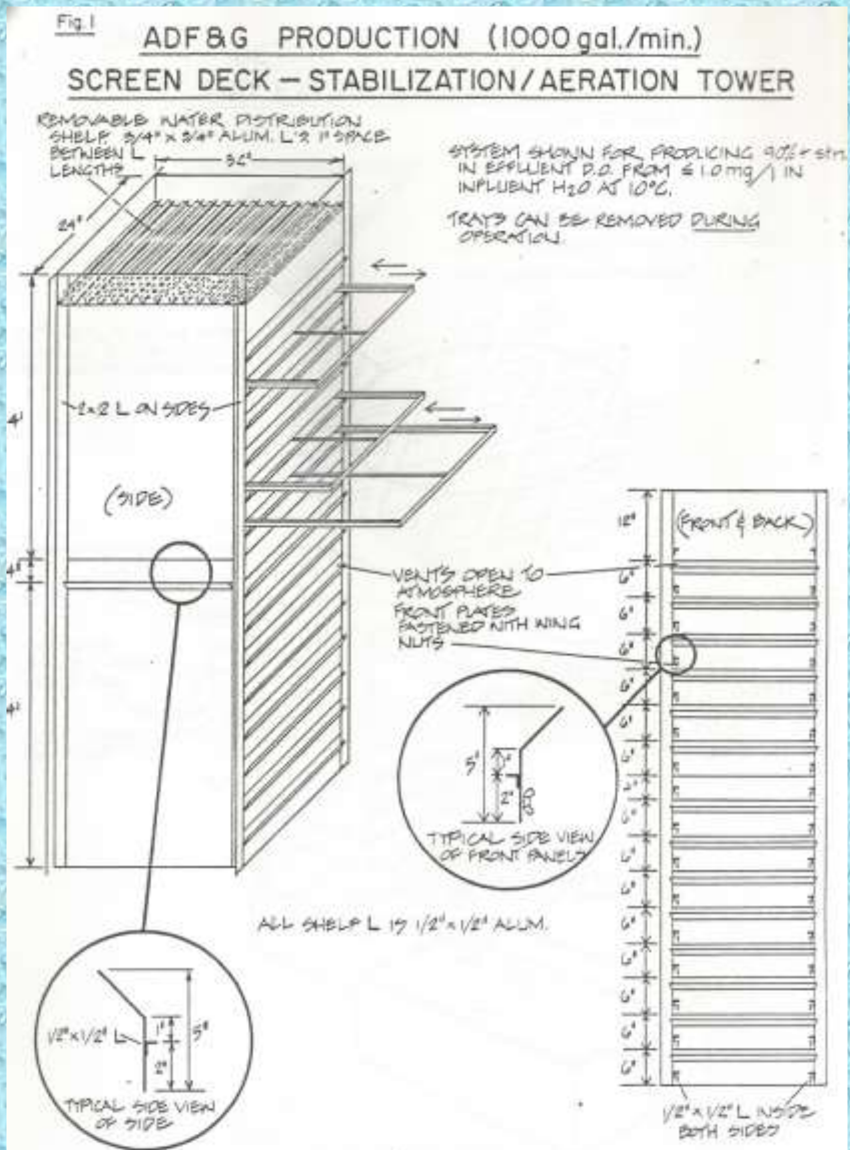
Ventillation

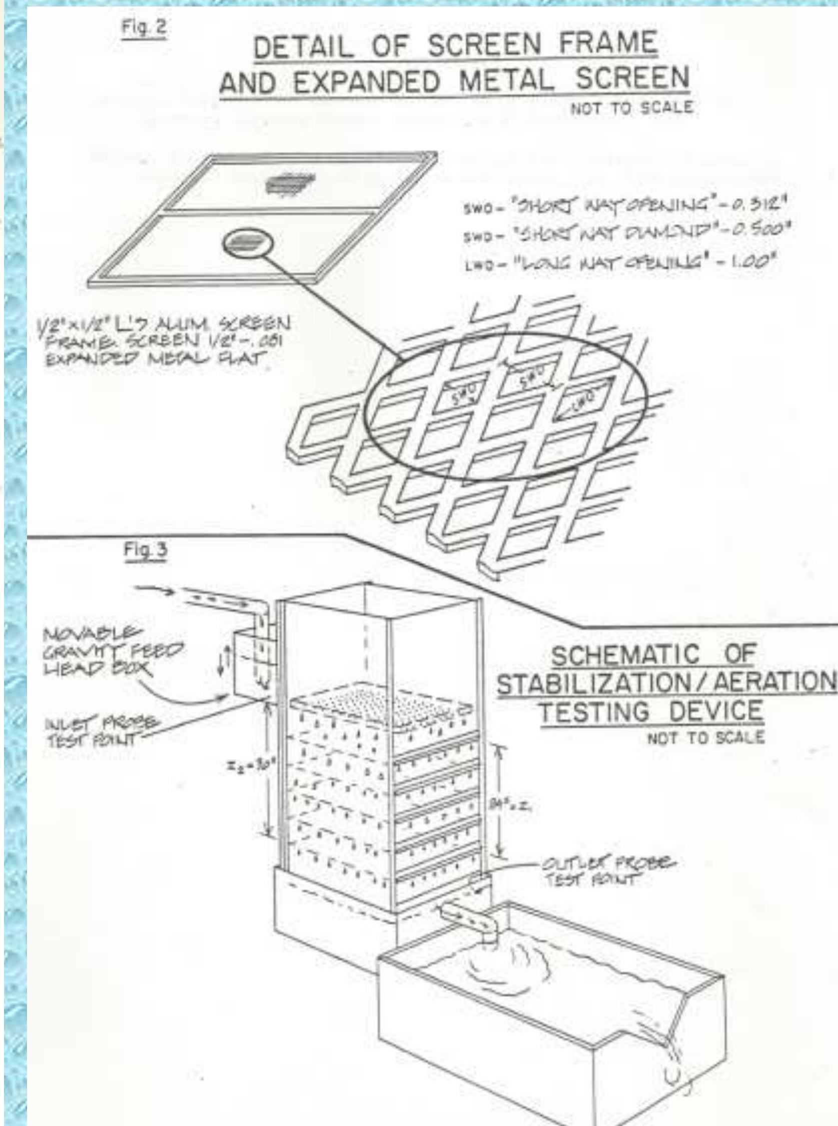
- Structured Media Bed

Evaluation of Aerators

- Where is Energy (Head) Wasted (Free Fall)?
- How is Water Spread Out?
- How is Transit Time Extended?
- Which Materials can be Replaced?
  - More durable
  - Cheaper
- How can Problems be Reduced?

Alaskan Screen Deck

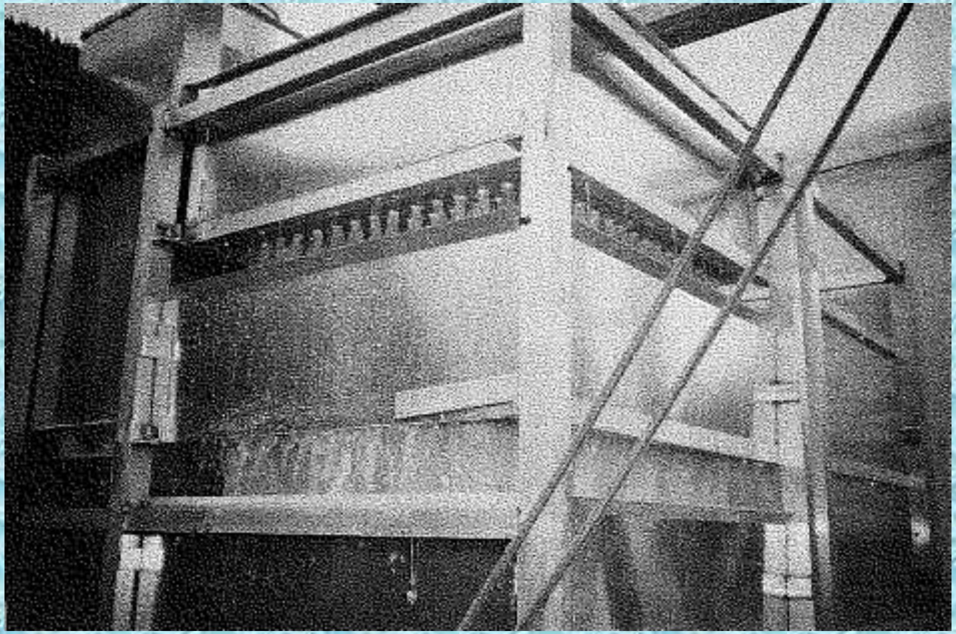




SEP Aeration Pots

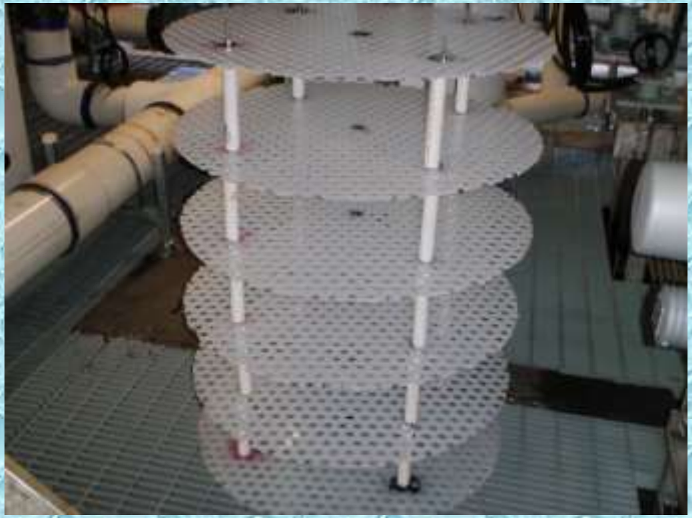
Before:

After:



Kitimat Perforated Plate Aerator

Before:



After:

Summary: Aerator Component Optimization

- Inflow Water Supply
  - Reduce turbulence, energy wastage
- Water Distribution
  - Even and self adjusting (to lower flows)
- Thin-film Generation
  - Slow water transit without restricting airflow
- Ventilation
  - Sufficient without encouraging splash (icing)

Thank You for Listening

Questions?