Fish Rearing Units

The obvious (1)

1) All fish must be grown in one kind of container or other. It must be able to hold water.

2) Containers come in many shapes, sizes and dimensions.

3) Primary Shapes:
   A. Round and Oval
   B. Rectangular
4) Two Main Flow Patterns:
   A. Circular (mixing)
   B. Plug flow (gradient)

5) Representatives
   A. Round Tank
   B. Raceway

"Examine what is said, not him who speaks"
## A Comparison

<table>
<thead>
<tr>
<th>Raceway</th>
<th>Round</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Requires 1.5 – 3.0 x Wall Area</td>
<td>Largest Volume To Wall Ratio</td>
</tr>
<tr>
<td>2. Water Quality Gradient</td>
<td>Homogeneous = Mixing</td>
</tr>
<tr>
<td>3. Uniform Velocity</td>
<td>Variable Velocity</td>
</tr>
<tr>
<td>4. Low Velocity</td>
<td>Can Be High or Low</td>
</tr>
<tr>
<td>5. Velocity Flow Rate Dependent</td>
<td>Velocity Independent of Flow Rate</td>
</tr>
</tbody>
</table>
A Comparison (Cont’d)

Raceway

6. Not Self-Cleaning

7. Can Operate at Very High Exchange Rate (R value)

8. Poor Fish Distribution

9. Easy to Corner Fish

Round

Can Be Self-Cleaning

Limited Water Exchange Rates

More Even Distribution

Difficult to Harvest Fish
<table>
<thead>
<tr>
<th>Raceway</th>
<th>Round</th>
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</thead>
<tbody>
<tr>
<td>10. Difficult Feed Distribution</td>
<td>Easy Feed Distribution</td>
</tr>
<tr>
<td>11. Can Compare Water Quality “In” with “Out”</td>
<td>Mixing of Water Quality (=) Homogeneous</td>
</tr>
<tr>
<td>12. Hyperoxic Possible With Use of Pure (O_2)</td>
<td>Immediate Mixing of (O_2)</td>
</tr>
<tr>
<td>13. Complete Water Replacement (100%)</td>
<td>Partial (65%) Replacement</td>
</tr>
</tbody>
</table>
A Comparison (Cont’)

14. Raceways require less floor space than round tanks

15. Other? (Discussion)

“When you have to make a choice and don’t make it, that in itself is making a choice.”
Further Discussion

Selecting the type of rearing unit a very significant decision! This will come back to “haunt” us.

A Few Diagrams:

I. Circular
   Swedish
   Raceway
   \{ Wall Area
II. Self-Cleaning Raceway
III. Circular with double drain
     (Good for partial recirc.)
Rearing tanks should incorporate excellent features for solid waste management = "gently" dispersing it. But:

"Everything should be made as simple as possible, but not simpler" (Einstein)

(KISS Principle)
The Linear Raceway

Has Low Velocity ($v$):

1. Not Self-Cleaning
2. In-Pond Pollution – Solids settle, are resuspended, break down, leach.
3. Low $v$ – No Conditioning of Fish

$$v = \frac{lm \times R}{36} \quad \text{or} \quad \frac{lf \times R}{3600}$$

$= \text{cm/s}$ \quad $= \text{ft/s}$
Example: Raceway 100’ x 10’ x 2.5’

\[ RV = 2500 \text{ ft}^3 \]

For \( R = 2 \)

\[ v = \frac{100 \times 2}{3600} = 0.056' \text{/s} \]

\[ Q = \frac{RV \times R}{8} = \frac{2500 \times 2}{8} = 625 \text{ gpm} \]

For \( R = 4 \)

\[ v = 0.112' \text{/s} \]

\[ Q = 1250 \text{ gpm} \]

Recommend Minimum Velocity: 0.1’/s
The Linear Raceway

\[ v = 0.1'/s \quad \text{or} \quad 3.0 \text{ cm/s} \]

For \( R = 4.0 \)

\[ L = \frac{v \times 3600}{4} = 90' \quad (27 \text{ m}) \]

Need velocity of 3.0 cm/s (0.1’/s) for “Good” hydraulics, but this is far too low for channel cleaning. Almost all raceways function as settling chambers! For cleaning, need velocities 10 – Fold.

**Very Important:** Fecal matter must not be destroyed! It’s specific gravity is only 1.19. A particle of 100 um (0.004”) requires + 50 min to settle a depth of 2.5’ (0.76 m) It will drift out of the raceway.
The Linear Raceway

Example of High Flow Rate (High R Value) and Low Velocity:

Raceway (Tank): 30' x 3' x 2' (180 ft³)

For R = 10

\[ Q = \frac{180 \times 10}{8} = 225 \text{ gpm} \]

\[ v = \frac{30 \times 10}{3600} = 0.083' / \text{s} < 0.1' / \text{s} \]
For MAO = 25 \hspace{1cm} \text{And} \hspace{1cm} R = 4

\[ L_d = \frac{3.8 \times 25 \times 100}{114 \times 1.0 \, \text{(%BW)}} = 83 \, \text{lb/gpm} \]

\[ D = \frac{L_d \times R}{8} = \frac{83 \times 4}{8} = 41 \, \text{lb/ft}^3 \]

The balance between $L_d$, $D$ and $R$ is not appropriate.

Need to design Multi-Pass Serial Reuse

Fix $D$ at 5 \hspace{1cm} \rightarrow \hspace{1cm} \frac{41}{5} = 8 \text{ series} \hspace{1cm} AO = 3.1 \hspace{1cm} *$

Fix $D$ at 10 \hspace{1cm} \rightarrow \hspace{1cm} \frac{41}{10} = 4 \text{ series} \hspace{1cm} AO = 6.25 \hspace{1cm} *$

*AO per series = MAO \hspace{1cm} # \text{ series}

Will cover in detail Unit V!  \hspace{1em} IV-13
Table 1. Flow rate limits for plug-flow rearing units (raceway, tank and trough) based on maximum flowrate capacity per cross-sectional area ($MQ_{c/s}$) in lpm/m$^2$, and minimum selected operational velocity ($v$) in cm/s. Raceway (RW): $MQ_{c/s} = 1500$; Tank (TK): $MQ_{c/s} = 1000$; and Trough (TR): $MQ_{c/s} = 750$. Velocities are 3.0, 2.0, and 1.0 cm/s respectively.

<table>
<thead>
<tr>
<th>Type</th>
<th>$l$ m</th>
<th>$w$ m</th>
<th>$d$ m</th>
<th>RV m$^3$</th>
<th>c/s m$^2$</th>
<th>$Q_{c/s}$ lpm</th>
<th>$R_{c/s}$ #/h</th>
<th>$R_{v}$ #/h</th>
<th>$Q_{v}$ lpm</th>
<th>$L_d$ kg/lpm</th>
<th>$D_v$ kg/m$^3$</th>
<th>$D_{c/s}$ kg/m$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>RW</td>
<td>30</td>
<td>3.0</td>
<td>0.8</td>
<td>72</td>
<td>2.4</td>
<td>3600</td>
<td>3.0</td>
<td>3.6</td>
<td>4320</td>
<td>2.0</td>
<td>120</td>
<td>100</td>
</tr>
<tr>
<td>TK</td>
<td>10</td>
<td>1.0</td>
<td>0.6</td>
<td>6.0</td>
<td>0.6</td>
<td>600</td>
<td>6.0</td>
<td>7.2</td>
<td>720</td>
<td>1.0</td>
<td>120</td>
<td>100</td>
</tr>
<tr>
<td>TR</td>
<td>3</td>
<td>0.3</td>
<td>0.4</td>
<td>0.36</td>
<td>0.12</td>
<td>90</td>
<td>15.0</td>
<td>18.0</td>
<td>108</td>
<td>.05</td>
<td>125</td>
<td>150</td>
</tr>
</tbody>
</table>

$$ Q_{c/s} = MQ_{c/s} \times C/S $$

$$ R_{c/s} = (Q_{c/s} \times 0.06) / RV $$

$$ R_{v} = (v \times 36) / l $$

$$ Q_{v} = (RV \times R_{v}) / 0.06 $$

$$ L_d = (5.0 \times 100) / (250 \times %BW) $$

$$ D = (L_d \times R_{v}) / 0.06 $$

Recommended Rearing Denities:

- RW = 60; TK = 40; TR = 25

Series: RW = 2; TK = 3.0; TR = 5.0

AO = 5.0

%BW = 1.0 (RW)

2.0 (TK)

4.0 (TR)
Figure 1. Enclosure area (wall space) comparison between different types of fish rearing units.

ROUND TANK

- Diameter is 8.0 m
- Operating depth is 1.2 m
- Free-board is .3 m
- Rearing volume is 60 m³
- Wall area is 37.7 m²

SQUARE TANK

- Dimensions are 8.0 x 8.0 m
- Operating depth is .94 m
- Free-board is .3 m
- Rearing volume is 60 m³
- Wall area is 39.7 m²

RECTANGULAR RACEWAY

- Dimensions are 24 x 2.4 m
- Operating depth is 1.05 m
- Free-board is .3 m
- Rearing volume is 60 m³
- Wall area is 77.7 m²

Ratio of round to square to raceway = 1.0 to 1.05 to 2.06.
Figure 2. Linear raceway (a) and round tank (b) flow pattern and dissolved oxygen characteristics.

![Diagram of linear raceway](image1)

![Diagram of round tank](image2)

Figure 3. Burrows Pond design.
Figure 4. Diagrams of the cross-flow fish rearing tank.

a) Longitudinal view  b) Cross-sectional view
Figure 5. Raceway equipped with baffles.

Figure 6. Solids settling characteristics in raceway solids settling section behind fish retaining barrier.
'Cornell-type' dual-drain tank

Courtesy of Red Ewald, Inc. (TX)

Fig. 1. Sketch of the wastewater treatment system i.e. the newly developed tank and the REKO static bowed screen.

Fig. 2. Sketch of the system in which the removal efficiency was determined.