RAS for Atlantic salmon smolts

How far have we come in Norway?

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Agenda

• What did we think about RAS in Norway in 2006?
• Extent of RAS in Atlantic smolt production today?
• Why has RAS become the standard so quick?
Status Norway 2006

- 220 smolt plants
  - 3 with RAS (1 %)
- 160 million smolt
  - 720’ smolt/plant

"in general little acceptance to use RAS..."
"we still assume 10 new RAS by 2015..."
Status Norway 2013  (2006)

- 195 (220) smolt plants
  - 30 (3) with RAS (15%) (1%)
- 310 (160) mill smolt
  - 1,6 (0,7) mill smolt/plant
Status rest of the world in 2013

• Large new projects
  – UK
    • MH 11 mill smolt
    • GSF 10 mill smolt
  – Canada
    • GSF 5 mill smolt
    • MH 3,6 mill smolt
  – Chile
    • All in for RAS...

The use of RAS in Grieg Seafood ASA is illustrative for the general RAS development
Future scenario for Norway?

Assumption 7% growth per year

Relative production volume

Year

RAS
FTS
Why has RAS become the standard so quick?

- FTS was not a real option for extensive volumes
- Technology was already “off the shelf”
- “Third generation” RAS developed
- Benchmarking showed that RAS worked
- Global aquaculture companies
RAS advantages “on paper”

- **Fish welfare**
  - Controlled water quality
  - Optimal flow factor
  - Improved biosecurity

- **Resources (environment)**
  - Water use
  - Discharge

- **Productivity**
  - Optimal growth temperature all year
## Actual RAS fish welfare

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>StDev</th>
<th>Min</th>
<th>Maks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>14.4</td>
<td>1.5</td>
<td>9.1</td>
<td>17.5</td>
</tr>
<tr>
<td>Feeding (kg)</td>
<td>589</td>
<td>302</td>
<td>0</td>
<td>1 304</td>
</tr>
<tr>
<td>Makeup (l) per kg feed</td>
<td>810</td>
<td>2 572</td>
<td>125</td>
<td>59 040</td>
</tr>
<tr>
<td>pH</td>
<td>7.29</td>
<td>0.06</td>
<td>6.97</td>
<td>7.48</td>
</tr>
<tr>
<td>TAN (mg/l)</td>
<td>0.51</td>
<td>0.25</td>
<td>0.00</td>
<td>1.74</td>
</tr>
<tr>
<td>Ammonia NH3-N (mg/l)</td>
<td>0.0022</td>
<td>0.0012</td>
<td>0.0001</td>
<td>0.0079</td>
</tr>
<tr>
<td>Nitrite NO2-N (mg/l)</td>
<td>0.18</td>
<td>0.10</td>
<td>0.01</td>
<td>0.75</td>
</tr>
<tr>
<td>Nitrate NO3-N (mg/l)</td>
<td>18.5</td>
<td>8.4</td>
<td>0</td>
<td>44.0</td>
</tr>
<tr>
<td>Alkalinity CaCO3 (mg/l)</td>
<td>207.0</td>
<td>67.4</td>
<td>10.0</td>
<td>425.0</td>
</tr>
</tbody>
</table>

### Graphs

- **TAN & NO2-N (mg/l)**
- **Feed per day (kg)**

- **Max of feeding (kg)**
- **Max of TAN-N (mg/l)**
- **Max of Nitrite NO2-N (mg/l)**

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Actual RAS resource use

- Water use
  - 2 200 m³ tank volume
  - 7,4 days turnover time
  - 99,4 % reduction
    - 60 min turnover time in tank

- Discharge

<table>
<thead>
<tr>
<th>Parameter, per kg produced fish</th>
<th>Norwegian RAS</th>
<th>Icelandic FTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water use, m³</td>
<td>0.8</td>
<td>95.0 (38 – 330)</td>
</tr>
<tr>
<td>Energy consumed, KWh</td>
<td>4.1</td>
<td>4.3 (0.0 – 9.7)</td>
</tr>
<tr>
<td>Waste load, g:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspended solids</td>
<td>16.6 (3.9 – 60)</td>
<td>806 (41 – 1612)</td>
</tr>
<tr>
<td>BOD₅</td>
<td>8.5 (2.7 – 26)</td>
<td>14.1 (5.4 – 36)</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td>2.3 (1.2 – 6.2)</td>
<td>-</td>
</tr>
<tr>
<td>Total nitrogen</td>
<td>19.7 (9.4 – 80)</td>
<td>72.3 (26 – 115)</td>
</tr>
</tbody>
</table>

Water consumption, effluent treatment and waste load in flow-through and recirculating systems for salmonid production in Canada – Iceland – Norway

A. Bergheim¹, H. Thorarensen², A. Dumas³, A. Josang⁴, O. Alvestad⁵ & F. Mathisen⁶

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Actual RAS productivity

Temperature

Smolt deliveries Norway

Feeding

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Thank you for your attention!