FUTURE FARMING
Recirculation Aquaculture Systems

...a presentation by Patrick Tigges, CEO at Billund Aqua Australia Pty Ltd
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FUTURE FARMING
Recirculation Aquaculture Systems

CONTENT PAGE

• Billund Aqua – company profile
• RAS – general introduction
• Commercial trends in salmon farming
• Recent developments & future trends
• Future aspects
Billund Aqua
company profile

- **Billund Aqua A/S** headquarter located in Billund, Denmark
- entities in Chile, Norway, USA and Australia (Tasmania)
- over **160 employees** covering 21 different nationalities
- over **30 years of experience** in design, installation, operation and service of RAS
- references of **more than 500 RAS** (125 projects) in 28 different countries
- RAS for over **25 different salt- and freshwater species** (90 % of current turnover related to salmon industry)
- 3 projects in Tasmania 2006 (Lonnavale), 2015 (Rookwood 2), 2017/18 (Whalepoint)
- currently projects in Chile, Denmark, Finland, Holland, Moldova, Norway, Scotland, USA, Australia
RAS – general introduction

**Definition of RAS:**
- Production unit where the same water is re-used in a closed circuit after passing through a treatment system

![Diagram of RAS system]

- **New Water**
- **Water Discharge**
RAS – general introduction

**Intensity of RAS:**
Daily water consumption (exchange) per kilo added fish feed

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Flow through systems</th>
<th>Oxygenation</th>
<th>Disinfektion (UV, Ozon)</th>
<th>De-nitrification</th>
<th>Removal of ammonia and organic material</th>
<th>Removal of particles</th>
<th>Removal of phosphorus and brownish colour</th>
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</thead>
<tbody>
<tr>
<td>Partial RAS</td>
<td>A 2.000 - 5.000 l/kg feed per day</td>
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<tr>
<td>Moderate RAS</td>
<td>B 300 – 600 l/kg feed per day</td>
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<tr>
<td>Intensive RAS</td>
<td>C 25 – 300 l/kg feed per day</td>
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RAS – general introduction

Multi stage water treatment:

- Mechanical filter
  Removal of particles

- Biological filter
  Ammonia ($NH_4^+$) to nitrite ($NO_2^-$) and nitrate ($NO_3^-$)
  Organic material to carbon dioxide ($CO_2$) and water
  Capture of small particles

- Trickling filter / Vacuum Degassing
  Removal of Carbon dioxide ($CO_2$) and Nitrogen gas ($N_2$)
  Aerating of water to approx. 100% oxygen ($O_2$)

Intensive RAS:

- Water consumption between 25 - 300 litre new water per day per kg feed
- Additional treatment: Ozone, Denitrification, coagulant, belt-filter, polymer and centrifuge (5 - 30% DM)
Multi stage water treatment:
- Mechanical Filtration
- Biological Filtration
- Degassing
- Disinfection
- Denitrification, Flocculation & TSS removal

Additional services:
- Oxygen
- Feed
- Lime, bi-carb, salt
- Coagulant, polymer
- Energy
- Grading & Vaccination
- Deadfish handling (silage)
Automation:

- Feed distribution
- Temperature regulation
- Centralized lime & salt dosing systems (> 1 ton/d)
- Oxygen supply
- Disinfection (UV & Ozone)
- Centralized dead-fish handling (silage)
- Grading
- Vaccination (up to 20,000 Smolt/h)
Commercial Trends in Salmon Farming

**Smolt RAS (hatchery)**
- eggs → Smolt (80-150g)
- Freshwater
- Improved growth rate
- Low mortality
- 2-way biosecurity
Commercial Trends
Smolt RAS (hatchery)

2014: Lerøy Midnor AS - Belsvik, Norway

• Capacity: 14 million 100gr Smolt/a
• Biological filter capacity: 8,5 tons feed per day
• Building area: 11,000 m²
Commercial Trends

Smolt RAS (hatchery)

2015/16: Tassal, Ranelagh, Australia (Tasmania)

- Capacity: 4.5 million 150 gram Smolt/a
- Biological filter capacity: 3 tons feed/d
- Building area: 7,500 m²
- No. of RAS: 3
Commercial Trends

Smolt RAS (hatchery)

2017: **Salmar, Tromsø, Norway**

- Production capacity: 15 million 120g Smolt/a
- Biological filter capacity: 10.8 tons feed/d
- Building area 12,000 m²
- No. of RAS: 8
- 6 batches per year (3x2)
**Commercial Trends in Salmon Farming**

### Smolt RAS (hatchery)
- Eggs → Smolt (80-150g)
- Freshwater
- Improved growth rate
- Low mortality
- 2-way biosecurity

### Post-Smolt RAS (nursery)
- → large Smolt (250g -1000g)
- Fresh-, Brackish-, Saltwater
- More robust fish (transition)
- Easy transfer
- Reduced ocean (pen) time

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FUTURE FARMING – Recirculation Aquaculture Systems
Post-Smolt RAS (nursery)

2018-22: Leroy Aurora, Laksefjord, Norway

• Stage 2: 5 Ras, 400g Smolt
• Stage 3: 1 Ras, 600g Smolt
• Stage 4: 9 Ras, 1.000g Smolt
• Saltwater
Commercial Trends

Post-Smolt RAS (nursery)

2018-19: Huon Aquaculture, Whalepoint, Tasmania

• Capacity: 600 gram Smolt
• Biological filter capacity: 10 tons per day
• Building area: 9,000 m²
• No of RAS: 2
• Fresh water
Commercial Trends in Salmon Farming
Recent developments & future aspects

Smolt RAS (hatchery)
- eggs → Smolt (80-150g)
- Freshwater
- Improved growth rate
- Low mortality
- 2-way biosecurity

Post-Smolt RAS (nursery)
- → large Smolt (250g -1000g)
- Fresh-, Brackish-, Saltwater
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Grow-Out RAS???
- → market size
- Saltwater
- Farming, harvesting, processing
- No disease or predators
- Close to market, niche area
Recent developments & future trends

Salmon Grow-Out

Survey of Grow-Out systems:

1. 2011 - Langsandlaks, Denmark
2. 2013 - Danish Salmon, Denmark
3. 2013 - Namgis First Nation, Canada
4. 2015 - Jurassic Salmon, Poland
5. 2015 - XinJiang, China (Trout)
6. 2016 - Swiss Alpine Fish AG
Recent developments & future trends

Salmon Grow-Out

2011: Langsandlaks, Denmark

• Capacity: (1000) **800 tons/a** (4,5 kg)
• Biological filter capacity (maximum): 3 tons feed/d
• Incubation, Hatchery, Parr, Smolt & Grow-Out
• Total tank volume: 6.100 m$^3$
• Total building area: 4000 m$^2$
• **850 KW Windmill, Sludge disposal to biogas plant**
Recent developments & future trends

Salmon Grow-Out

2015: **Jurassic Salmon, Poland**
- Capacity: (1.000) **800 tons/a** (4,5 kg)
- Total area 7.725 m²
- Total tank volume: 6.100 m³
- Sludge disposal to biogas plant

2015: **XinJiang, China**
- Capacity: 1.000 ton (4,5 kg) Trout
- Total area 9.500 m²
Recent developments & future trends

Salmon Grow-Out

“Lessons learned”

Economic profile:

- FCR: $1 - 1.2$
- Oxygen consumption: $0.5 - 1$ kg/kg produced salmon
- Energy consumption: $3 - 6$ kW/kg produced salmon
- Lime consumption: $0.1$ kg/kg produced salmon
- Coagulant & Polymer: $0.1$ l/l effluent & $3$ g polymer/ kg DM

Total production costs (egg to 4-5 kg salmon): $38$ DKK/kg HOG

(20-30 % premium)
Recent developments & future trends
Salmon Grow-Out

**Challenges**

**Growth rate (> 1 kg):**
- Stocking density (tank volume)
- Temperature profile (16°C > 12-14°C)
- Saltwater systems required

**Early maturation (5 – 30%):**
- Stable & higher salinity (24 – 35 ppt)
- Lower temperature (12-14°C)
- Photo manipulation
- Improved stocks (NOT IN AUSTRALIA)

**Environmental impact reduction:**
- Waste management (saltwater sludge?)
- Energy consumption

**Fish health & quality:**
- Biosecurity: Firewall, RAS & effluent disinfection
- Product quality: texture, taste (Off-flavoring)

**Water quality (fluctuations):**
- Feed digestibility
- Excrement stability
- Feed rate
- Feed dust

**Operational Management:**
- High-skilled staff
Recent developments & future trends

Salmon Grow-Out

Survey of Grow-Out systems:

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5. 2015 - XinJiang, China (Trout)
6. 2016 - Swiss Alpine Fish AG
7. 2018 - Langsandlaks Stage 2, Denmark
8. 2019 - Homestead “Bluehouse” Stage 1, USA
Recent developments & future trends

Salmon Grow-Out

2017-2018: Langsandlaks Stage 2, Denmark

- Total capacity: 2,000 tons/a (5 kg)
- Biological filter capacity: 5,4 tons per day
- Building area: 4,200 m$^2$
- No of RAS: 1 x Grow-Out
- 2 x additional Windmill
- Sludge for biogas plant
Recent developments & future trends

Salmon Grow-Out

2017-19: **Homestead Bluehouse, Miami, USA**
- Total Capacity: 8,500 tons/a - 5 kg Salmon
- Biological filter capacity: 35.3 tons per day
- Building area: 35,000 m²
- No of RAS: 13

2020-25: **Stage 2 & 3**
- Stage 2: 30,000 to/a
- Stage 3: 90,000 to/a
Recent developments & future trends

Future aspects

**Diversification**
- System adaption for different species
- Stock development (Reproduction & Broodstock)
- Species-specific feed

**Technological improvement**
- Oxygen consumption (low head oxygenator)
- Energy efficiency (integration of renewables)
- Environmental impact reduction (effluent/sludge, built into landscape)
Recent developments & future trends

Future aspects

2018: Finnforel, Varkaus, Finland

• Rainbow Trout
• Capacity: 1.000 to/a - 2,2 kg trout
• Biological filter capacity: 4,2 tons/d
• Building area: 9.072 m²
Recent developments & future trends

Future aspects

2018: Kingfish Zeeland, Groeneweg, Holland

- Yellowtail Kingfish
- Capacity: 500 to/a (2 kg)
- Biological filter capacity: 3 tons/d
- Building area: 5,000 m²
2006-2020: **Aquatis, Moldova**

- Bester, Beluga & Russian Sturgeon
- Capacity: 10 to/a caviar, 650 to/a sturgeon meat
- Building area: 40,000 m²
- **Effluent: Fertilizer (8000 m² greenhouse)**
Recent developments & future trends

Future aspects

2016: **Aqua Pri, Denmark**

- Pike Perch
- Total capacity: 700 tons (1,2 kg)
- Building area: 10,000 m²
- Fish farm built into the landscape
- Roof covered with solar panels
- Water consumption: 50 liter/ kg produced fish
Thanks for your attention