VIDA
Webinar: Demonstration Vouchers
February 19th: 10-11

AQUACULTURE
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AquaCircle
Exactly how much feed is needed varies, depending on the quality and makeup of the feed, the health and age of the animal, the environment, and other factors.

1 pound of feed

Pounds of feed needed to produce one pound of body mass

6.8  Cattle*

2.9  Pigs

1.7  Broiler chickens

1.1  Fish**
Flow through systems

Fish + Water + Feed = Food + Pollution
Danish development over the last 15 years
Degree of re-circulation increasing use of technologies

- **Aeration**
- **Mechanical filtration** (removal of particles)
- **Biological filtration** (removal of ammonia & organic material)
- **Biological filtration (anaerobe de-nitrification)**
- **Disinfection** (UV, Ozone)
- **Removal of phosphor and brownish colour**
- **Oxygenation & degassing** (adding of $O_2$, removal of $CO_2$, $N_2$)

<table>
<thead>
<tr>
<th>Complexity</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>25%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100%</td>
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- **O**: Flow-through systems
  - 40,000 - 50,000 Litre of new water/kg fish produced/year
- **A**: Semi RAS
  - 2,000 - 5,000 Litre of new water/kg fish produced/year
- **B**: Moderate RAS
  - 400 - 700 Litre of new water/kg fish produced/year
- **C**: Intensive RAS
  - 50 - 400 Litre of new water/kg fish produced/year
A modern Danish ‘Model’ trout farm
Semi RAS (Danish trout farm)

Reduction pr. Kg fish produced

- 50% N
- 65% P
- 95% organic mat.

Improvement to FTS

- Bigger and more homogeneous production
- Better feasibility - up to 13% (average before 5-6%)
- Less outlet of medicine and chemicals due to disease control and increased turnover time in cleaning facilities
Technology reduces nutrient outlet
Definition of Re-Circulation

Water exchange per amount of feed put into the system per day is the most accurate definition.

Water exchange per kg feed = \( \frac{\text{Water exchange/day (m}^3/\text{day)}}{\text{Feeding/day (kg/day)}} \)

Water exchange per kg feed = \( \frac{120 (\text{m}^3/\text{day})}{300 (\text{kg/day})} \)

Water exchange per kg feed = 400 l/kg feed

The water consumption per kg fish produced is thus depending on the farmers skill:
If feed conversion ratio (FCR) is 1, the water exchange per kg fish produced will be 400
If FCR = 0.9 consumption will be 360 litre per kg fish produced
If FCR = 1.1 consumption will be 440 litre per kg fish produced
RAS started with Eel-farming 30 years ago in Denmark
RAS – Advantages 1

Low water requirement
- can utilise small water sources and/or be connected to the public water supply

<table>
<thead>
<tr>
<th>Type of farm</th>
<th>Liter new water per kg fish production</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Traditional pond farming</td>
<td>40 - 50.000</td>
</tr>
<tr>
<td>2 Reuse – moderate</td>
<td>25.000</td>
</tr>
<tr>
<td>3 Reuse – intensive</td>
<td>10.000</td>
</tr>
<tr>
<td>4 Partly Re-circulation</td>
<td>5.000</td>
</tr>
<tr>
<td>5 Moderate Re-circulation</td>
<td>500</td>
</tr>
<tr>
<td>6 Intensive Re-circulation</td>
<td>50-400</td>
</tr>
<tr>
<td>1 kg beef</td>
<td>15.500</td>
</tr>
<tr>
<td>1 liter of milk</td>
<td>150</td>
</tr>
<tr>
<td>1 kg of pork</td>
<td>4.800</td>
</tr>
<tr>
<td>1 kg of chicken</td>
<td>3.900</td>
</tr>
<tr>
<td>1 kg of rice</td>
<td>3.400</td>
</tr>
<tr>
<td>1 kg potatoes</td>
<td>900</td>
</tr>
</tbody>
</table>
The system can achieve optimal temperature and enables optimal and stable production all year round, independent of seasonal variation, this makes the production predictable for 365 days.
The required area for a given production is relatively small, because a very high density and a high growth rate is possible in the controlled environment.

<table>
<thead>
<tr>
<th>Fish size (gram per fish)</th>
<th>Biomass (kg per m³ water)</th>
<th>Density (individuals per m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>22</td>
<td>11.000</td>
</tr>
<tr>
<td>10</td>
<td>35</td>
<td>2.833</td>
</tr>
<tr>
<td>50</td>
<td>60</td>
<td>1.200</td>
</tr>
<tr>
<td>100</td>
<td>50</td>
<td>500</td>
</tr>
<tr>
<td>2,000</td>
<td>75</td>
<td>38</td>
</tr>
<tr>
<td>5,000</td>
<td>85</td>
<td>17</td>
</tr>
</tbody>
</table>
Reduced risk of diseases
- All incoming water can be filtrated and afterwards UV-disinfected
- All entrance to the fish farm is through a disinfection room
- The incoming water can be further treated to achieve the desired quality
- If the water is not suitable for fish farming undesirable substances like iron, manganese, aluminium etc. can be feasibly removed - because very little water is used

Control and traceability
- Digital Monitoring and Surveillance
Optimal and stable production conditions
- Securing high and stable quality of the fish
Due to low water consumption in RAS also the discharged water volume is minimal and can be controlled and treated.

Sludge from the system can be concentrated to desired dry matter content and appear as an odour free fertiliser, can even be used for biogas-production or pyrolysis to generate bio-charcoal with a high content of phosphorous.

The fish farm can be established near cities and thereby close to market
This means less transportation costs and less CO$_2$ footprint
The transportation costs for 1 kg fresh salmon from Norway to USA by airfreight is approx. 1½ US$, to China app. 2 US$
RAS – Challenges & Draw-backs

- Advanced system
- Security system in function at any time
- Regular power supply with back-up necessary
- RAS requires skilled staff for management

The traditional pattern of doing a good day’s job on the fish farm and then going home……has changed into: Tuning a machine that runs constantly 24/7!!

This require full focus on the daily routines.
The RAS is relatively expensive to establish and has a relatively high energy consumption. Therefore, the RAS requires a minimum production capacity for an economical operation.

<table>
<thead>
<tr>
<th>Type of farm</th>
<th>Liter new water per kg fish production</th>
<th>kWh pr kg fish produced per year (new-old)</th>
<th>Water treatment</th>
<th>Total investment per 1 kg production capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>50,000</td>
<td>0</td>
<td>None</td>
<td>?</td>
</tr>
<tr>
<td>Reuse – moderate</td>
<td>25,000</td>
<td>1-3</td>
<td>+ aeration + degassing of CO₂</td>
<td>2 Euro</td>
</tr>
<tr>
<td>Reuse – intensive</td>
<td>10,000</td>
<td>1,5-5</td>
<td>Pure oxygen + mechanical filtration</td>
<td>2-3 Euro</td>
</tr>
<tr>
<td>Partly Recirculation</td>
<td>5,000</td>
<td>1,5-3</td>
<td>+ biological filtration</td>
<td>3-4 Euro</td>
</tr>
<tr>
<td>Moderate Recirculation</td>
<td>400 - 700</td>
<td>2-8</td>
<td>+ indoor + UV disinfection + temperature control</td>
<td>8-10 Euro</td>
</tr>
<tr>
<td>Intensive Recirculation</td>
<td>50 - 400</td>
<td>2-8</td>
<td>+ nitrate removal + phosphor removal + sludge thickening</td>
<td>10-12 Euro</td>
</tr>
</tbody>
</table>
The stable water condition achievable in a RAS is ideal for pathogens too
- The footprint of facilities is big
- Energy demand is high
- Needed investment high
- Off flavour and taste
- Early maturation (salmon males) cascade effect
- Design with several separate water treatment sections to be recommended for reducing risk of wiping out the entire stock if a disease or toxicity hits
RAS – Challenges & Draw-backs

- Feed waste and other particles stays in the system – calls for better filtration and customised feed
- Hydraulic design to be improved – especially for saltwater RAS – to reduce risk of sludge piling up in anaerobic areas and generate toxic gasses (e.g. H₂S & N₂O)
- Strong – and acute – need for skilled personnel
TREND: GROWING
SMOLTS BIGGER

- Salmon smolts are grown to bigger size before transferred to sea-cages for grow-out. 60 → 120 → 250 → 500 → 1000 gram
- Better ‘equipped’ for life in sea-cages, shorter time in net-cages
- Better use of MTB’s
TREND: FULL LIFE-CYCLE IN LAND-BASED RAS

• Controlled environment
• Close to market
• Low/no transportation cost
• Story telling – No lice, no escapees
TREND: SUITABLE FOR MANY SPECIES

- New species in RAS
- Pikeperch
- Seriola
- Grouper
- Barramundi
- Bluefinned Tuna
- .....
- .....

Danish Recirculation Technology - the future of Aquaculture now
Pikeperch!
Tropical fish in the cold north
TREND

- More extensive use of ozone
- AOP/ECO
- Smaller mesh-size in drum-filters
- Improved de-gassing
That’s all folks!

Unzip the potential…..RAS!
Farm fish everywhere with very little water and a very low environmental footprint.