Danish Experience on Recirculation – From the AquaCircle network

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How it All Started

• The Dream of Eelfarming in Denmark
  - Frederiksværk Åleeksport
• Energy Conservation
  - Not water nor Environment
• Danish Shell: Diversification
• Early Eighties
• A 20 tons / yr pilot facility constructed in Hørsholm
What Happened? Eels in Europe

- A capacity of up to 10,000 tons/yr
- Mainly supplied by AquaCircle members
- Eelfarming now in jeopardy
  - Too few Glasseels
AC Equipment Suppliers Business

• 174 Installations
• Production Capacity: 25-50,000 Tons/yr
• Smolt Capacity: 340 million Smolt/yr
• Turnover: App. 250 mio. Dkr/yr
AC Turn-Key Suppliers Group

- UNI-Aqua A/S
- Aquahouse A/S
- Inter Aqua Advance Aps
- Billund Aquakultur Service Aps
World of AquaCircle: 174
AquaCircle in Chile

- Merluza
- Salmon Hatchery
- Salmon Fry
- Salmon Smolt
- Abalone
- Kingfish
- Test Facility
Salmon Smolt in Europe: 13

Salmon Smolt
Modeldambrug: Recirculation in Fresh Water Ponds

- 3 times more fish with 10 times less water
- Economy is ok
FREA: Fully Recirculated Trout Farm to be Constructed

- Capacity 3000 tons small trout/yr (350 g)
- Water Exchange: 25-75 l/s
- Production costs inclusive finance/depreciation: 13 Dkr/kg
AC Start: The Sorry State of Danish Aquaculture?

Stagnation! Misguided Environmental Concerns
Industry & Politicians Acted

1. Fresh water & Seafarm National Committees reported 2002 & 2003
2. Recommended R/D in recirculation
3. Konference on: "Need & Opportunities for establishment of a Danish Center of Knowledge for recirculation technology in aquaculture". Over 100 participants from the sector (autumn 2005).
4. Industry took the drivers seat
5. And is now providing the R&D needs
Can Norwegians Take Advice

- **Existing Situation: Reverse Pyramid**
- R&D reversely correlated with production?
- R&D only one important industry factor
- The equipment suppliers and farm managers know best!
New Experimental Fish Farms Are Expensive Toys!?

- Is it necessary to build new pilot scale facilities?
- Do they have to be situated in far away places?
- And how to choose suppliers in a professional manner?
- Does a Norwegian experimental farm necessarily have to be supplied by a Norwegian Company?
- Can we make a Nordic project? European:EATP
Benchmarking / Auditing

- There are many recirculated farms out there
- How do they do?
  - Design capacity >< Realised capacity
  - Projected economy >< realised economy
  - Impartial benchmarking / auditing is needed
- Better and more complete measurements on existing farms
Call for the Engineer

- The suppliers, often biologists, are:
  - Empirical
  - Somewhat calculation challenged
- We need hard-core engineers
- To make mathematical models of the fish farm and the treatment processes
- Using on-line measurement equipment to know the dynamics

Kinetik i biofiltre
0. ordens proces i biofilm

Omsætning i vandfasen udenfor biofilmen:
0. ordens tilfældet: $\beta > 1$

\[
q_s = k_{st} \cdot L
\]

\[
r_s = k_{st} \cdot \sqrt{S}, \quad k_{st} = \sqrt{D \cdot k_{st}}
\]

\[
q_s = \text{areal} \text{specifik} \text{omsætningshastighed} \text{ i vandfasen} \quad [\text{g} \cdot \text{m}^{-2} \cdot \text{d}^{-1}]
\]

\[
q_{st} = \text{omsætningshastighed} \text{ i biofilm} \quad [\text{g} \cdot \text{m}^{-2} \cdot \text{d}^{-1}]
\]

$L$ = biofilmens tykkelse [m]

0. ordens tilfældet: $\beta < 1$

\[
q_s = k_{st} \cdot \sqrt{S}, \quad k_{st} = \sqrt{D \cdot k_{st}}
\]

\[
r_s = \text{areal} \text{specifik} \text{omsætningshastighed} \text{ i vandfasen} \quad [\text{g} \cdot \text{m}^{-2} \cdot \text{d}^{-1}]
\]

\[
k_{st} = \frac{1}{2} \text{, ordens hastighedskonstant} \quad [\text{g} \cdot \text{m}^{-3} \cdot \text{d}^{-1}]
\]

$S$ = substrat koncentrationen i vandfasen [gS/m³]

$D$ = diffusionskonstant, $S$ [m²/d]

$k_{st} = \text{omsætningshastighed} \text{ i biofilm} \quad [\text{g} \cdot \text{m}^{-2} \cdot \text{d}^{-1}]
\]

Henze et al. (2000). Wastewater treatment, biological and chemical processes

Danish Recirculation Technology
- the future of Aquaculture now
Financing and Management of R&D

- A strong and profitable industry finances its own R&D
- Universities to deliver basic research and good candidates
- Industry and suppliers will do the rest
- Support realistic productions
- Do not reinvent the wheel
The Future of Recirculation in Aquaculture

• Expensive fish: eel, tuna, pikeperch, hatcheries etc.
• Higher degree of recirculation for small trout
• Cheap whitefish: Tilapia, not cod
• Production of big fish for consumption: In open systems / seafarms
• Let’s work together
Discussion