

Global Trends in Commercial Salmonid RAS

.....seen from a RAS supplier point of view!!!

Who is Billund Aquaculture

- Billund Aquaculture is a Danish company located in Billund, Denmark and in addition we have offices in Norway and Chile. In total we are 103 employees.
- Billund Aquaculture have a large and well documented reference list which document more than 30 years of experience in design, installations, operation and service of intensive RAS.
- Worldwide Billund Aquaculture has built more than 118 projects (> 500 RAS).
- Billund Aquaculture have been working with 25 different salt- and freshwater species, but currently 80 % of our turnover are related to the salmon industry.
- Within the last 30 years Billund Aquaculture have been implementing RAS projects in 26 different countries, right now we have projects in the following country's:
 1. Armenia - Trout
 2. Chile – Salmon smolt
 3. China – Salmon, Trout
 4. Denmark – Pike perch, European Eel, Salmon
 5. Moldova - Sturgeon
 6. Norway - Salmon
 7. Tasmania - Salmon
 8. Turkmenistan - Sturgeon

Global Trends in Commercial Salmonid RAS

Increasing numbers of RAS worldwide !!!

1. Smolt RAS: eggs → approx. 80-100g - Freshwater
2. Post-smolt RAS: approx. 80-100g → 250g/500g/750g/1000g - Saltwater
3. RAS for Lump fish production (for sea-lice treatment) - Saltwater
4. Salmon & Trout Grow-out - Saltwater



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RAS suppliers to the salmon smolt industry face higher requirement from the customers regarding Water Quality:

Water quality requirement for RAS in Norway:

Oxygen (O_2):	80-100% - (outlet from fish tanks)
Carbon dioxide (CO_2):	12-15 mg/l (size dependent) - (outlet from fish tanks)
Nitrogen ($N_{2(gas)}$):	max. 100% (Vacuum degassing) - (inlet to fish tanks)
Suspended solids (SS):	less than 5 mg/l - (inlet to fish tanks)
TAN:	less than 2 mg/l - (outlet from fish tanks)
Ammonia (NH_3-N):	less than 0,002 mg/l - (inlet to fish tanks)
Nitrite (NO_2-N):	0,4 mg/l - (inlet to fish tanks)
BOD ₇ :	less than 5 mg/l - (inlet to fish tanks)

Water velocity in fish tanks must be adjustable in order to provide different velocity depending on the actual fish size.

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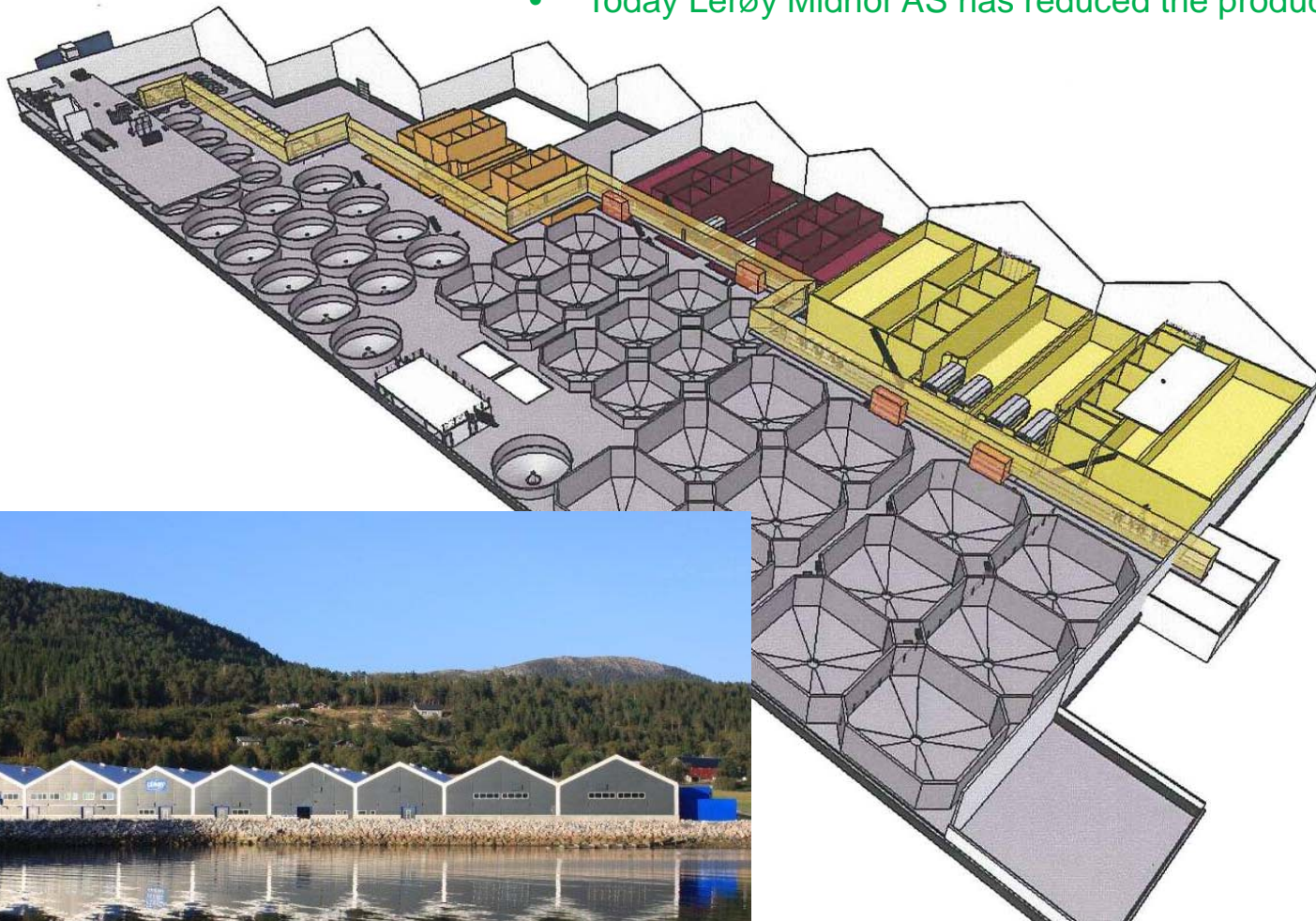
1. Salmon smolt RAS: eggs → approx. 80-100g

- Benefits:
 - Controlled environments - fish only use energy for growth!!
 - Higher production per volume (higher densities)
 - Improved feed conversion
 - Less mortality
 - Higher quality of smolt to be transferred to net-cages
 - Less staff per produced smolt
 - Less pollution (discharge can be treated, sludge be thickened and utilized for energy of fertiliser)
 - Reduced production time in the sea

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Lerøy Midnor AS, Belsvik: Capacity 14 million smolt per year, 11.000 m², biological filter 8,5 tons feed per day

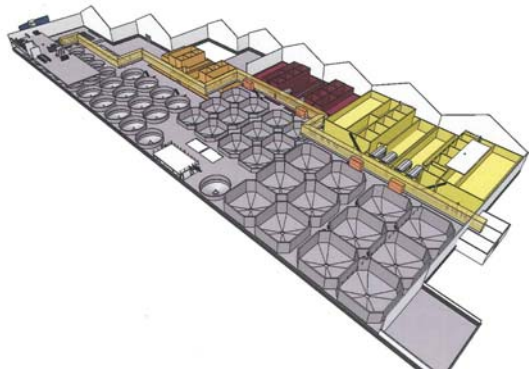
- Total investment for turnkey project ~ 47 million USD
- Today Lerøy Midnor AS has reduced the production costs by 40%



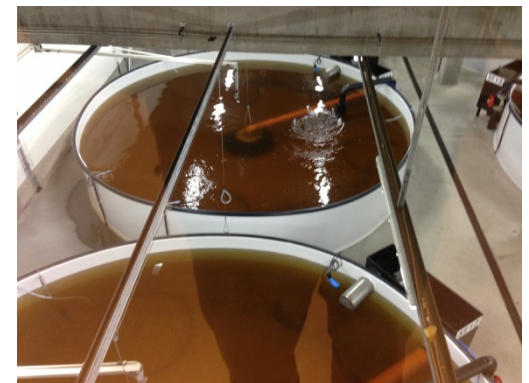
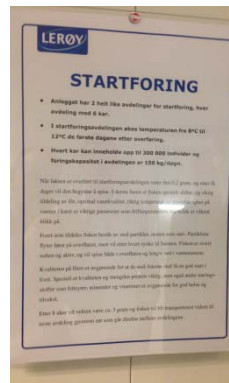
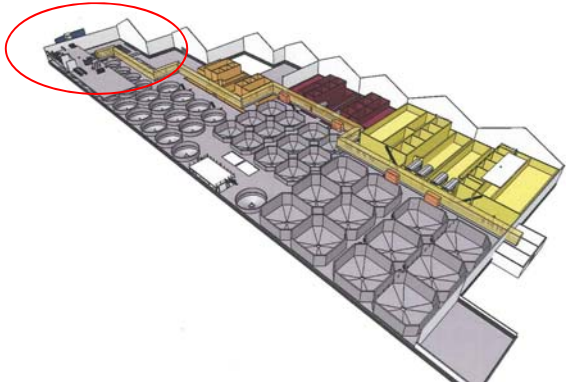


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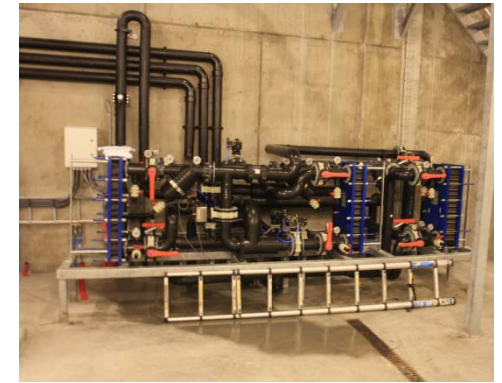
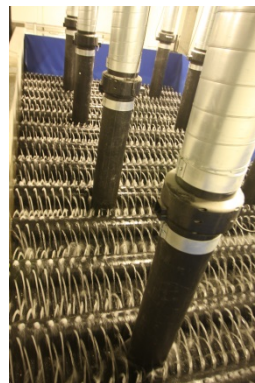
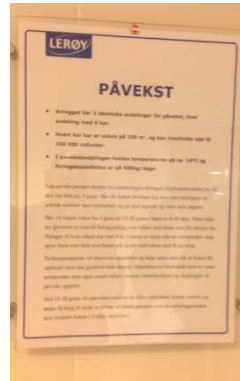
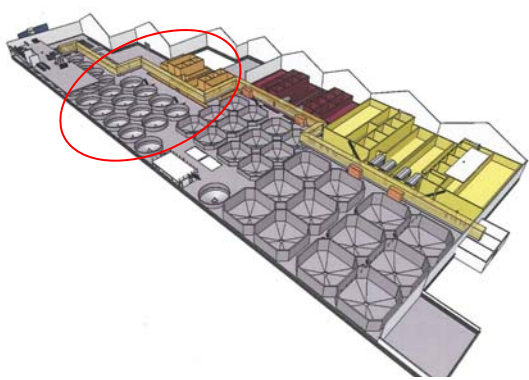
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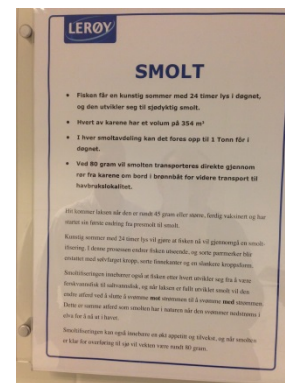
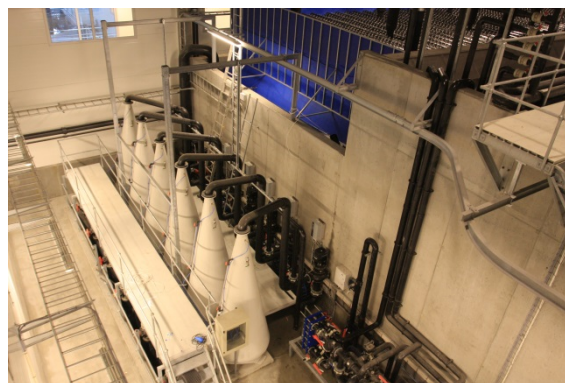
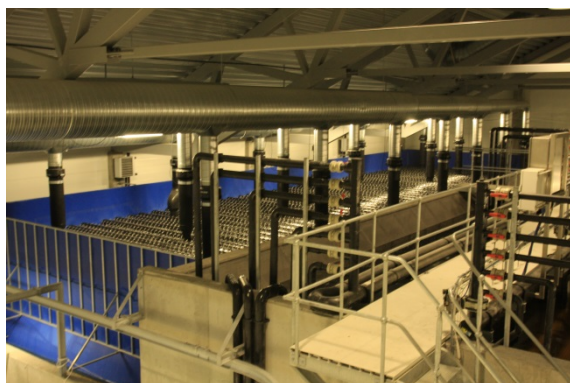
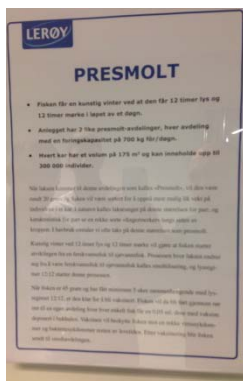


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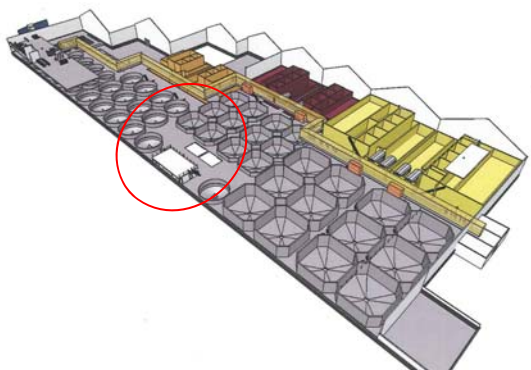


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Tassal – Tasmania: Capacity 5 million 150 gram smolt per year (picture from 28th of September 2015)

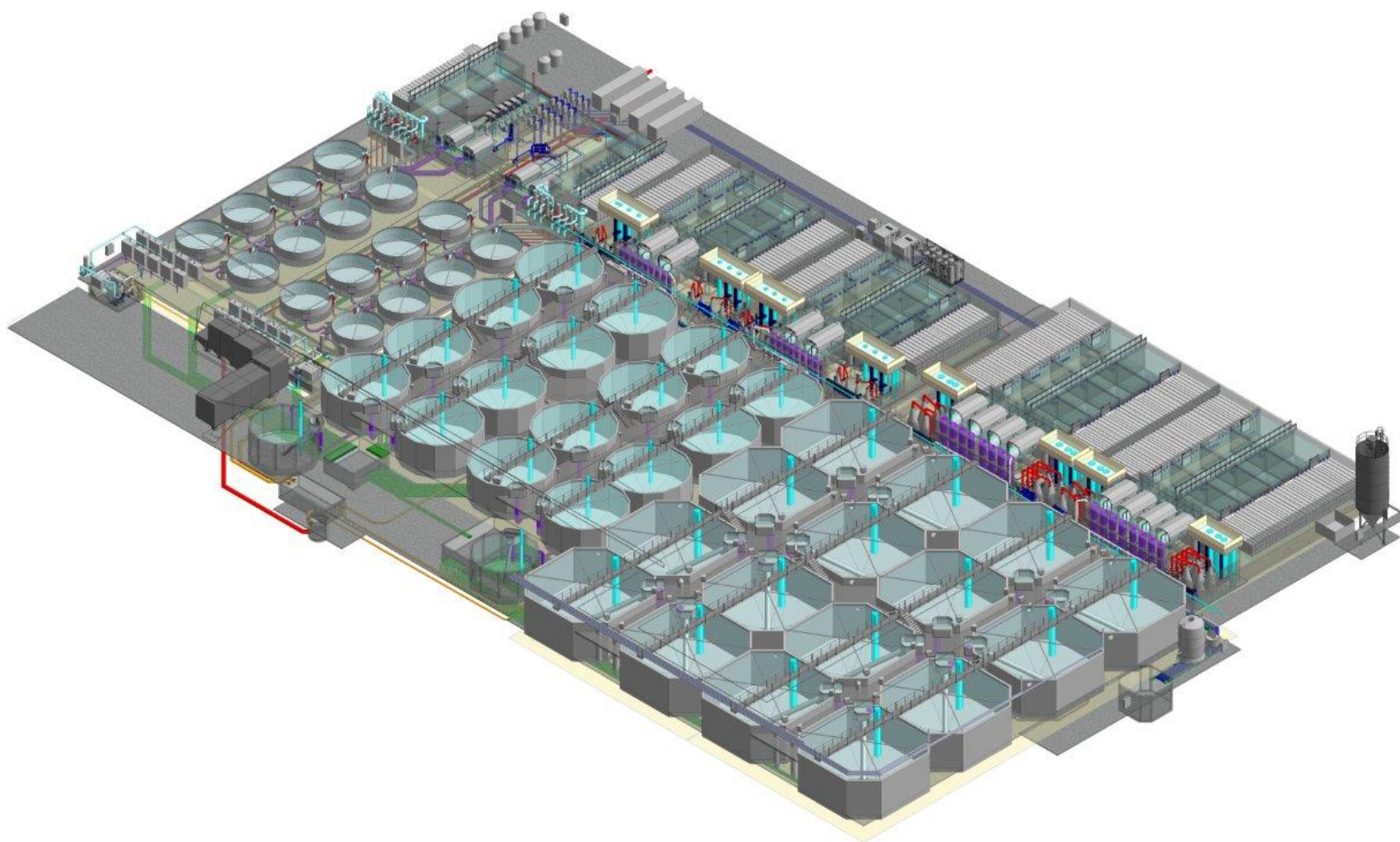


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SalMar – Norway: Capacity 15 million smolt per year, 11.000 m², biological filter 11 tons feed per day

Shipping of equipment from Denmark equal to 95 pcs. 40 ft. containers

SalMar total investment for turnkey project ~ 67 million USD



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2. Salmon Post-smolt Facilities: approx. 80-100g → 250g/250g/500g/750g/1000g

- Benefits:
 - Controlled environments - fish only use energy for growth!!
 - Higher production per volume (higher densities)
 - Improved feed conversion
 - Less mortality
 - Higher quality of smolt to be transferred to net-cages
 - Less staff per produced smolt
 - Less pollution (discharge can be treated, sludge be utilized)
- A more robust fish
- Reduced production time in the sea – equal to 6 month from a 250 gram
- Better utilisation of the net cages → higher production
- Less or NO treatment against sea-lice
- Reduced production costs
- In 2015 - If all smolt should be post-smolt (300g) in RAS it's equal to a standing stock of 330.000 tons!!!!

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3. Lump fish for sea-lice treatment:

Sea lice costs Norwegian salmon farming industry a whopping \$380 million annually

Treatment costs and losses on larger fish are taking huge toll.

Kjersti Kvile / FriskenbladetFiskaren

Published: 07.09.2015 15:11 Updated: 07.09.2015 14:35

Sea lice are becoming increasingly problematic in the Norwegian farmed salmon sector, and researchers want to know what's behind the rise in cost, and what exactly the industry is spending on fighting lice.

Nofima and Kontali were engaged by the Norwegian Seafood Research Fund (FHF) to carry out a qualitative study in which researchers interviewed farmers and suppliers to find out what was driving the higher costs.

Associated Articles

- Aqua Nor blog 2015: Recap on all the news from the show here
- IntraFish Salmon Summit: Prospects for growth, battling diseases, feed alternatives and more
- Marine Harvest restructures Belgium division, sees signs of life elsewhere

"Costs have risen 40 percent in real values from 2011 to 2014. Half of that increase appeared in the last two years," said Audun Iversen, researcher at Nofima, in a presentation of a research project on costs in the marine farming industry at Aqua Nor in Trondheim, Norway, last month.

The main cause for the increase in costs lay in higher feed prices, a weakened Norwegian kroner and crippling costs from salmon lice treatments.

Costs on a slaughtered market-ready fish went up NOK 5 (€0.54/\$0.60) between 2012 and 2014.

According to the researcher, large fish mortality is to blame; it's not just about the number of deaths, but the fact that big fish are dying. When big fish die, big money dies with them.

Possibly the biggest expense lies in lice treatments. In 2014 researchers estimated salmon lice cost the industry NOK 3.2 billion (€347.9 million/\$386.5 million), and Iversen said this is a conservative estimate, as loss of growth, for example, is not included in the calculation.

"There has been a slight increase in all items, but it's clear that the health cost is the major driver," said Iversen.

For one of the producers in the project, lice costs per produced kilo amounted to NOK 0.70 (€0.08/\$0.08) – NOK 0.80 (€0.09/\$0.10), and last year this went up to NOK 2.20 (€0.24/\$0.27), which is close to the average for the producers.

The treatment itself is a comprehensive, expensive operation. Counting the lice takes about one day per week. With two people doing this job, it amounts to 70-80 full-time equivalents (FTE) for the entire industry.

"It usually takes three or four days, and they often employ three or four boats and eight to ten people," said Iversen.

All this can quickly run up a bill of between NOK 3 million (€326,070/\$362,028) and NOK 4 million (€434,760/\$482,704) to de-louse a large farm site, according to the researcher.

Use of hydrogen peroxide has also increased in the last few years, and this treatment costs more than others.

Use of cleaner fish has been a success that many have great faith in, but they also cost money to purchase and keep alive.

In total, all cost items for the marine farming industry have increased: raw materials, smolt, wages, disease and treatments.

"What we have discussed in the report, is about whether this is long-term," Iversen said. "What significance this has for the future competitive ability of the industry? What the regulations mean for the way costs develop?"

He mentioned the treatment regime isn't one the producers themselves would have chosen, preferring one that required less handling.

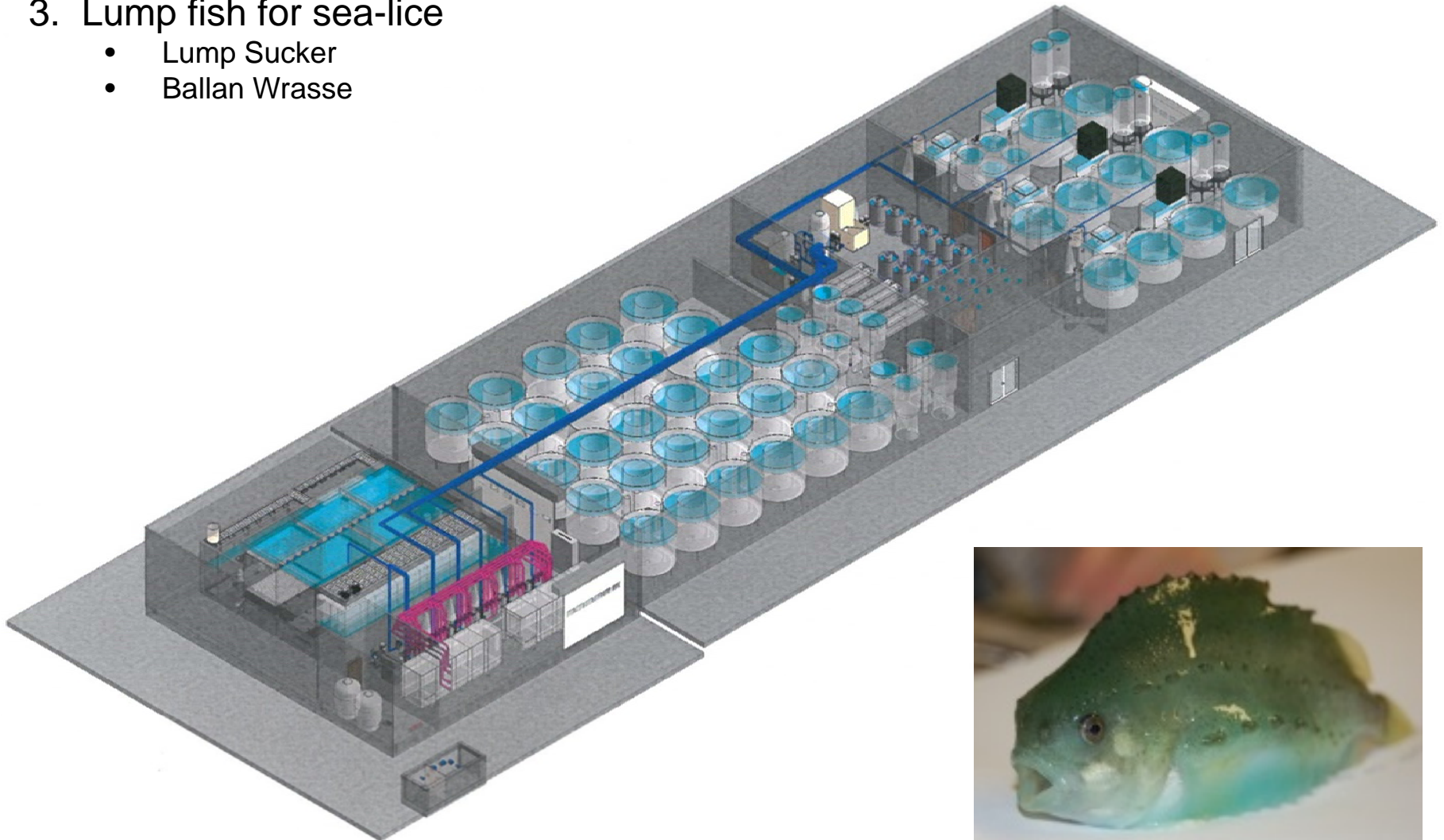
"They do that for the wild fish and the legitimacy of the industry," said Iversen. "Then we possibly have to stop up and ask ourselves if we have dimensioned the treatment well enough."

"At present it's a dilemma that the salmon is treated so much out of consideration for the wild fish, that it becomes a fish health problem for the farmed salmon. Then it's important to set the right limit values for determining when treatment should take place. We don't have a particularly clear-cut knowledge basis for this."

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3. Lump fish for sea-lice

- Lump Sucker
- Ballan Wrasse



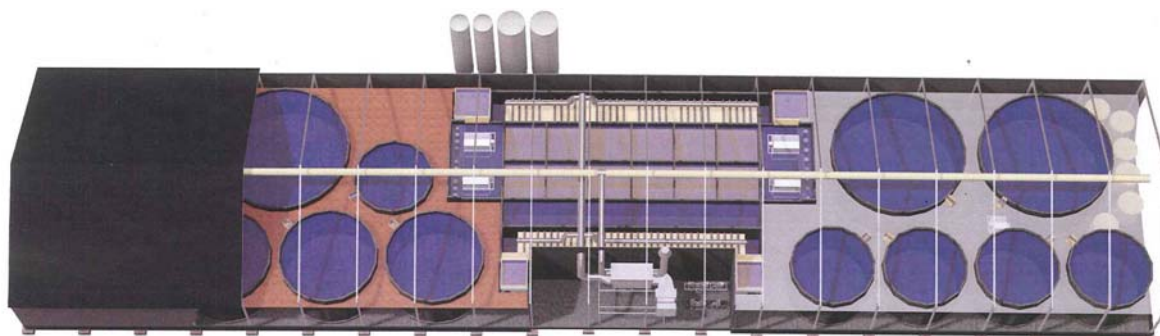
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Atlantic Salmon & Trout Grow-out:

1. Langsand Salmon, Denmark – capacity 1.000 tons per year
2. Danish Salmon, Denmark – capacity 2.000 tons per year
3. Yantao Salmon Farm, China – capacity < 1.000 tons per year
4. Namgis First Nation, Canada – capacity ? tons per year
5. XinJiang, China - capacity 1.000 tons per year
6. Jurassic Salmon, Poland - capacity 1.000 tons per year
7. Åland (Finland/Sweden) – Trout – capacity 3.000 tons per year
8. Swiss Alpinne Fish AG – Trout – capacity 700 tons per year
9. Etc.

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Atlantic Salmon Grow-out: Langsand salmon, Denmark



Total building area:

- Incubation, Hatchery, Parr and Smolt-system: ~ 700 m²
- On-Growing system ~ 3.300 m² (120 m x 27,5 m)
- 4.000 m² ~ 4 m²/ton produced salmon

On-Growing System:

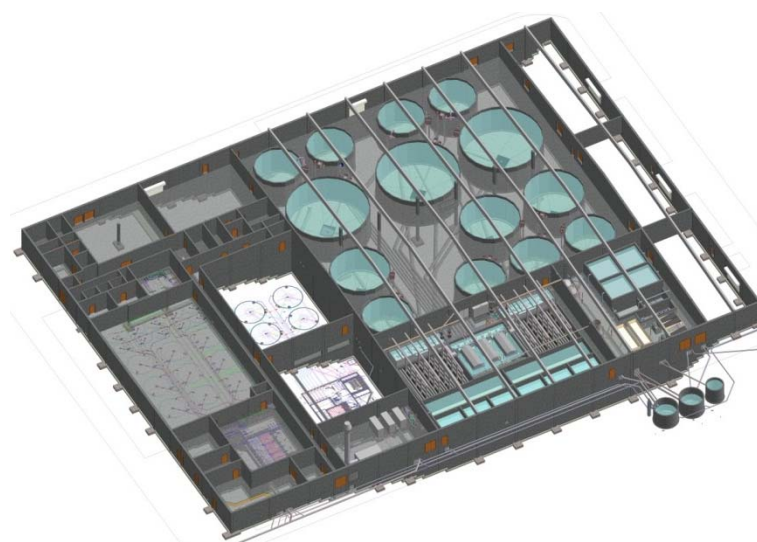
Total tank volume: 6.100 m³

- 4 pcs. Ø 7,8 m – water level 5,5 m – 260 m³ (off flavour)
- 4 pcs. Ø 8,5 m – water level 4,6 m – 260 m³
- 3 pcs. Ø 10,2 m – water level 5,5 m – 450 m³
- 3 pcs. Ø 14,2 m – water level 5,5 m – 870 m³



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Jurassic Salmon, Poland – 1.000 ton, 4 - 5 kg Salmon - Total area 7.725 m²



On-Growing System:

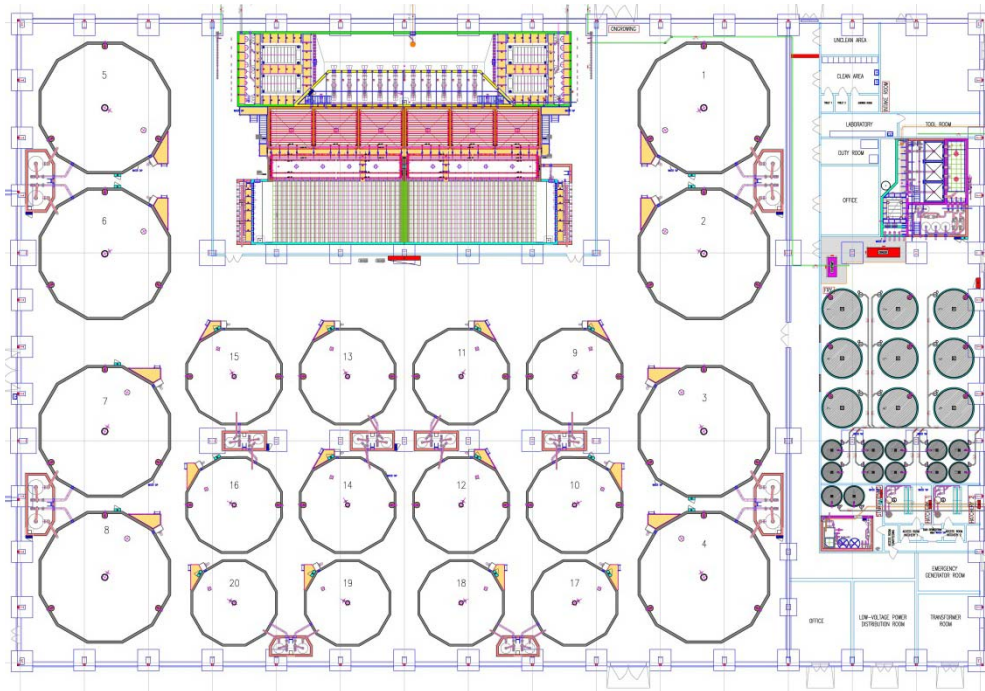
Total tank volume: 6.100 m³

- 4 pcs. Ø 8,5 m – water level 4,5 m – 260 m³
- 3 pcs. Ø 10,2 m – water level 5,5 m – 450 m³
- 3 pcs. Ø 14,2 m – water level 5,5 m – 870 m³
- 4 pcs. Ø 7,8 m – water level 5,7 m – 275 m³ (off flavour)



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XinJiang, China – 1.000 ton, 4 - 5 kg Salmon - Total area 9.500 m²



On-Growing System:

Total tank volume: 9.000 m³

- 8 pcs. Ø 11,0 m – water level 3,2 m – 300 m³
- 8 pcs. Ø 15,0 m – water level 4,0 m – 710 m³
- 4 pcs. Ø 10,0 m – water level 3,0 m – 225 m³ (off flavour)

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XinJiang, China – 1.000 ton, 4 - 5 kg Salmon - Total area 9.500 m²



Global Trends in Commercial Salmonid RAS

XinJiang, China – 1.000 ton, 4 - 5 kg Salmon - Total area 9.500 m²



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Future Focus Points within Salmon & Trout Grow-out:

- Early maturation
- Light regime / Photoperiod
- Fish handling & Grading – how, how often?
- Densities of fish (kg/m^3)
- Numbers of RAS for one facility – Cost/Benefit, biosecurity, size of one biofilter etc.
- Fish tank size – today max. $870 \text{ m}^3/\text{tank}$, future 5000 m^3 or more!
- Feed distribution systems – broken pellets, dust etc. when pellet size $> 8 \text{ mm}$
- Off-flavor – can it be reduced to under 8 days?

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Economic of scales within Salmon & Trout Grow-out:

- Depends on location
 - Treatment of Intake water
 - Treatment of discharge water (removal of C, N and P etc.)
 - Sludge thickening and handling
 - Numbers and size of fish tanks
 - Concrete prices for fish tanks and biofilters
 - Temperature regulation for heating and cooling through the year (China -30°C → +50 °C)
 - Etc.
-
- Future even more focus on:
 - Energy consumption
 - Foot print

Global Trends in Commercial Salmonid RAS

Economic of scales within Salmon & Trout Grow-out – Scandinavia as an example!!

Estimated Investment & Production Costs for 4,5 kg Atlantic Salmon (4 batch of eggs per year)

Processing of the fish is NOT included!!

Investment Costs	1.000t	2.000t	3.000t
Buildings	3.305.000 EUR	5.175.000 EUR	6.227.000 EUR
Electrical installations	735.000 EUR	980.000 EUR	1.450.000 EUR
Other installations (ventilation, aircondition etc.)	610.000 EUR	775.000 EUR	1.075.000 EUR
RAS equipment (BA supply)	5.359.900 EUR	7.637.400 EUR	11.243.500 EUR
Concrete work (RAS and fish tanks)	1.540.000 EUR	2.025.000 EUR	2.600.000 EUR
Various	400.000 EUR	450.000 EUR	500.000 EUR
Total Investment	11.949.900 EUR	17.042.400 EUR	23.095.500 EUR
Investment pr. kg production	11,95 EUR	8,52 EUR	7,70 EUR

Global Trends in Commercial Salmonid RAS

Economic of scales within Salmon & Trout Grow-out – Scandinavia as an example!!

Estimated Investment & Production Costs for 4,5 kg Atlantic Salmon

Costs per egg/fish in Hatchery Systems				
Price per egg	EUR/egg	0,13	0,13	0,13
Input/year	fish	320.000	640.000	960.000
Mortality	%	20	20	20
Output/year	fish	252.800	505.600	758.400
Energy				
- Energy consumption per fish produced	kW/fish	0,05	0,05	0,05
Cooling				
- Cooling per fish	kW/fish	0,06	0,06	0,06
Total costs				
Input (egg)	EUR	0,157	0,157	0,157
Energy	EUR	0,005	0,005	0,005
Cooling	EUR	0,003	0,003	0,003
Total	EUR/fish	0,165	0,165	0,165

Global Trends in Commercial Salmonid RAS

Economic of scales within Salmon & Trout Grow-out – Scandinavia as an example!!

Estimated Investment & Production Costs for 4,5 kg Atlantic Salmon

Costs per fish in Smolt systems (Start feed & Fry/Smolt)				
Price per fish	EUR/fish	0,17	0,17	0,17
Start weight	g/fish	0,10	0,10	0,10
End weight	g/fish	100	100	100
Input/year	fish	252.800	505.600	758.400
Mortality	%	10	10	10
Output/year	fish	227.520	455.040	682.560
	ton	23	46	68
Feed				
- (FCR)	kg feed/kg growth	0,75	0,75	0,75
Oxygen				
- Oxygen from Cryo tank	%	100	100	100
- Oxygen consumption per kg fish produced	kg oxygen/kg growth	0,60	0,60	0,60
Energy				
- Energy consumption per fish produced	kW/kg growth	3,00	3,00	3,00
- Energy consumption for heat/cool	kW/kg growth	1,30	1,30	1,30
- Lime consumption per kg fish produced	kg/kg growth	0,10	0,10	0,10
Total costs				
Input (fish)	EUR/fish	0,182	0,182	0,182
Feed	EUR/fish	0,300	0,300	0,300
Oxygen	EUR/fish	0,019	0,019	0,019
Energy	EUR/fish	0,030	0,030	0,030
Heating/cooling	EUR/fish	0,013	0,013	0,013
Lime	EUR/fish	0,001	0,001	0,001
Total costs per fish	EUR/fish	0,544	0,544	0,544

Global Trends in Commercial Salmonid RAS

Economic of scales within Salmon & Trout Grow-out – Scandinavia as an example!!

Estimated Investment & Production Costs for 4,5 kg Atlantic Salmon

Costs per fish in Postsmolt system				
Price per fish	EUR/fish	0,54	0,54	0,54
Start weight	g/fish	100,00	100,00	100,00
End weight	g/fish	200	200	200
Input/year	fish	227.520	455.040	682.560
Mortality	%	1	1	1
Output/year	fish	225.245	450.490	675.734
	ton	45	90	135
Feed				
- (FCR)	kg feed/kg growth	0,90	0,90	0,90
Oxygen				
- Oxygen from Cryo tank	%	100	100	100
- Oxygen consumption per kg fish produced	kg oxygen/kg growth	0,50	0,50	0,50
Energy				
- Energy consumption per fish produced	kW/kg growth	2,50	2,50	2,50
- Energy consumption for heat/cool	kW/kg growth	1,30	1,30	1,30
- Lime consumption per kg fish produced	kg/kg growth	0,10	0,10	0,10
Total costs				
Input (fish)	EUR/fish	0,550	0,550	0,550
Feed	EUR/fish	0,135	0,135	0,135
Oxygen	EUR/fish	0,016	0,016	0,016
Energy	EUR/fish	0,025	0,025	0,025
Heating/cooling	EUR/fish	0,013	0,013	0,013
Lime	EUR/fish	0,001	0,001	0,001
Total costs per fish	EUR/fish	0,739	0,739	0,739

Global Trends in Commercial Salmonid RAS

Economic of scales within Salmon & Trout Grow-out – Scandinavia as an example!!

Estimated Investment & Production Costs for 4,5 kg Atlantic Salmon

Costs per fish in Growout system				
Price per fish	EUR/fish	0,74	0,74	0,74
Start weight	g/fish	200,00	200,00	200,00
End weight	g/fish	4.500	4.500	4.500
Input/year	fish	225.245	450.490	675.734
Mortality	%	1	1	1
Output/year	fish	222.992	445.985	668.977
	ton	1.003	2.007	3.010
Feed				
- (FCR)	kg feed/kg growth	1,20	1,20	1,20
Oxygen				
- Oxygen from Cryo tank	%	100	100	100
- Oxygen consumption per kg fish produced	kg oxygen/kg growth	0,40	0,40	0,40
Energy				
- Energy consumption per fish produced	kW/kg growth	1,40	1,40	1,40
- Energy consumption for heat/cool	kW/kg growth	1,30	1,30	1,30
- Lime consumption per kg produced	kg/kg growth	0,10	0,10	0,10
Total costs				
Input (fish)	EUR/fish	0,746	0,746	0,746
Feed	EUR/fish	7,740	7,740	7,740
Oxygen	EUR/fish	0,533	0,533	0,533
Energy	EUR/fish	0,602	0,602	0,602
Heating/cooling	EUR/fish	0,559	0,559	0,559
Lime	EUR/fish	0,043	0,043	0,043
Total costs per fish	EUR/4,5 kg fish	10,224	10,224	10,224

Global Trends in Commercial Salmonid RAS

Economic of scales within Salmon & Trout Grow-out – Scandinavia as an example!!

Estimated Investment & Production Costs for 4,5 kg Atlantic Salmon

Staff Costs				
Production manager	EUR/year	100.000	100.000	100.000
Workers (3/6/9 pc.)	EUR/year	120.000	240.000	360.000
Engineer	EUR/year	100.000	100.000	100.000
Administration/financial	EUR/year	100.000	100.000	100.000
Total costs	EUR/year	420.000	540.000	660.000
Total costs per fish	EUR/4,5 kg fish	1,88	1,21	0,99

Global Trends in Commercial Salmonid RAS

Economic of scales within Salmon & Trout Grow-out – Scandinavia as an example!!

Estimated Investment & Production Costs for 4,5 kg Atlantic Salmon

Production Costs per kg fish				
Price per fish	EUR/4,5 kg fish	12,11	11,43	11,21
Fish size	kg	4,50	4,50	4,50
Yearly production	tons	1.000	2.000	3.000
Costs per kg part 1	EUR/kg fish	2,69	2,54	2,49
Sludge	EUR/kg fish	0,10	0,10	0,10
Enviromental inspections/analyzes	EUR/kg fish	0,05	0,05	0,05
veterinarian	EUR/kg fish	0,10	0,10	0,10
Chemicals	EUR/kg fish	0,03	0,03	0,03
Phosphor removal (included in sludge)	EUR/kg fish	0,00	0,00	0,00
Maintenance 2% of total investment	EUR/kg fish	0,24	0,17	0,15
Costs per kg part 2	EUR/kg	3,21	2,99	2,92
Insurance 1,7%	EUR/kg fish	0,20	0,14	0,13
Depreciation - 20 years	EUR/kg fish	0,60	0,42	0,38
Interests	EUR/kg fish	0,48	0,34	0,34
Total costs per kg fish the first 10 years	EUR/kg	4,48	3,90	3,77

Global Trends in Commercial Salmonid RAS

Economic of scales within Salmon & Trout Grow-out – Scandinavia as an example!!

Estimated Investment & Production Costs for 4,5 kg Atlantic Salmon

Operational Costs (first year of harvest)				
Biomass (max)	Kg	444.000	890.000	1.333.000
Value of biomass	EUR	1.050.863	2.106.270	3.148.523
other costs	EUR			
Staff	EUR	420.000	540.000	660.000
Sludge	EUR	44.400	89.000	133.300
Environmental inspections	EUR	50.173	100.347	150.520
Veterinarian	EUR	44.400	89.000	133.300
Chemicals	EUR	13.320	26.700	39.990
Denitrification	EUR	0	0	0
Phosphor removal (included in sludge)	EUR	0	0	0
Oxygen vessel rental	EUR	8.000	8.000	8.000
Maintenance	EUR	238.998	340.848	461.910
Total excl. insurance	EUR	1.870.154	3.300.164	4.735.543
insurance	EUR	31.793	56.103	80.504
Total	EUR	1.901.947	3.356.267	4.816.047
Operational cost (first year of harvest)	EUR	1.901.947	3.356.267	4.816.047
Total investment excl. egg production	EUR	11.949.900	17.042.400	23.095.500
Total investment incl. operational costs	EUR	13.851.847	20.398.667	27.911.547
Total investment incl. operational costs	EUR/Kg fish	13,9	10,2	9,3

Global Trends in Commercial Salmonid RAS

Huge request for Salmon & Trout Grow-Out:

- Billund Aquaculture makes minimum one quote on a weekly basis, in the near future projects will come in the following countries:
 - China
 - Denmark
 - Finland
 - India
 - Japan
 - Korea
 - Poland
 - Russia
 - South Africa
 - USA
 - Etc.....😊
- Biggest challenge in the future.....*staff to run the farm!!!!*

Thanks for your attention