Northern aquaculture;
modern vaccine- and gene technology giving
health and welfare to the fish and well-being
to the farmer

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Oslo, Norway
## Northern salmonid mariculture

<table>
<thead>
<tr>
<th>Country</th>
<th>Tons (2014) harvest weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>1 341 000</td>
</tr>
<tr>
<td>Faroe Islands</td>
<td>70 893</td>
</tr>
<tr>
<td>Scotland</td>
<td>169 210</td>
</tr>
<tr>
<td>Canada</td>
<td>120 000</td>
</tr>
<tr>
<td>EU-27</td>
<td>628 230 (2007)</td>
</tr>
</tbody>
</table>
## Norway aquaculture in comparison

<table>
<thead>
<tr>
<th>Annual meat production</th>
<th>1000 tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmonid aquaculture, Norway</td>
<td>1341</td>
</tr>
<tr>
<td>Finfish aquaculture EU-27 (2007)*</td>
<td>628</td>
</tr>
<tr>
<td>Sheeps +goats, EU-28 *</td>
<td>808</td>
</tr>
<tr>
<td>Beef, Germany*</td>
<td>1128</td>
</tr>
<tr>
<td>Pork, Denmark*</td>
<td>1587</td>
</tr>
</tbody>
</table>

2014 Norwegian Directorate of Fisheries ; Eurostat *
Producer prices in comparison

<table>
<thead>
<tr>
<th>Meat type</th>
<th>2015 so far</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantic salmon</td>
<td>4,0-4,8 Euro/kg</td>
</tr>
<tr>
<td>Beef, Germany (young bulls)</td>
<td>3,7-4,0 Euro/kg</td>
</tr>
<tr>
<td>Pork, Germany</td>
<td>1,3-1,5 Euro/kg</td>
</tr>
</tbody>
</table>
Comparative sales of antibacterial drugs in Norway 2014

<table>
<thead>
<tr>
<th></th>
<th>Kg active substance</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquaculture</td>
<td>ca. 1590</td>
<td>1%</td>
</tr>
<tr>
<td>Terrestrial animals</td>
<td>ca 5300</td>
<td>14%</td>
</tr>
<tr>
<td>Humans</td>
<td>ca. 44 200</td>
<td>85%</td>
</tr>
</tbody>
</table>

Vaccination stopped antibiotic use

- New vaccine formulations

Graph showing salmon production and antibiotic usage from 1991 to 2010.
The "breakthrough of fish vaccination"
1991-1993

- Multivalent, oil adjuvanted vaccine technology
  - highly effective against bacterial diseases, even against furunculosis
  - long-lasting immunity (through harvest)

<table>
<thead>
<tr>
<th>Year</th>
<th># smolts</th>
<th># doses</th>
<th>coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>40 mill</td>
<td>17.5 mill</td>
<td>43%</td>
</tr>
<tr>
<td>1992</td>
<td>60 mill</td>
<td>30.5 mill</td>
<td>51%</td>
</tr>
<tr>
<td>1993</td>
<td>60 mill</td>
<td>53.5 mill</td>
<td>90%</td>
</tr>
</tbody>
</table>
It did not happen by itself

• 3% R&D levy on sales accepted for 3 years by the veterinary pharmaceutical industry (voluntarily…….?)
• Large-scale field trial with vaccines under development (prototypes) accepted by the Norwegian Medicines Agency
• Scientifically convincing results obtained
• Propaganda campaign ”stop furunculosis” was financed by the Salmon Farmer’s marketing co-operative
We could have given up, but didn’t
Viral diseases – a different story

IPN -vaccine

Source: AquaGen AS; based on data from National Veterinary Institute / FHL
Breeding for disease resistance

A high priority in current Atlantic salmon breeding programs

- selection for resistance to bacterial infections since 1995 (5 generations)
- up to 60% of the basis for selection in AquaGen production stocks of certain years *
- Selection for resistance to IPN virus included since 2002

* A. Storset, pers. comm.
From fenotype- to genotype–based selection

Fenotype

Genotype
Markers – “plots” on the genomic map

Q: IPN resistance gene

Salmon Louse resistance gene ????

PD resistance Gene (?)
"Super-resistant" offspring
Selection based on genomic marker resolved the problem

Source: AquaGen AS; based on data from National Veterinary Institute / FHL
Other viral infections remain a challenge
(Naked) DNA virus vaccines

- A mobile genetic element (plasmid) makes target cells produce a specific protein (antigen)
- A plasmid is not a complete organism (bacterium or virus), conventional vaccines are
- Cannot live or replicate on itw own (outside the target cell)
- Protein (antigen) production stops when the host cell dies
DNA (plasmid) veterinary vaccines

- Infectious Hematopoietic Necrosis virus vaccine for salmon (Novartis Animal Health, now Elanco Canada)  
  - Licensed in 2005

- West Nile virus vaccine for horses (Fort Dodge, USA)  
  - Licensed in 2005

- Canine Oral Melanoma gene therapy vaccine (Merial, USA)  
  - Licensed in 2010

Büsum 11 Juni 2015
Vaccines against novirhabdovirus diseases in salmonids (Egtvedt disease, IHN)

- Scientific documentation showing high and long-lasting vaccine protection
- Extensive research in Aarhus (DK) and Seattle (USA)
- A DNA vaccine for salmon was launched in B, Canada in 2005
- Intramuscular injection
- ≈ 100 million fish vaccinated to date
- No reported adverse effect
- No reported clinical outbreaks in vaccinated fish
Genetic fingerprinting for identification of escapees

Gene profile of both parents $\approx 100\%$ correct parentage

+ database of distribution of eggs through the farming chain

= verification or falsification of putative escapees

Kjøglum S., Lien S., Kent M.; Grove H.; Lie Ø.

Büsum 11 Juni 2015
45 mill ”Green track” salmon eggs delivered in 2014-15

Total amount used in Norway:
360-380 mill eyed eggs
Conclusions

1) If you want people to eat more (aquaculture) fish, look for innovative solutions! Focus on blocking hurdles tend to kill rather than to support.

2) Without mass vaccination, aquaculture is neither profitable nor sustainable in the long run!

3) Modern gene technology does not equal genetic modification! And can support all kinds of aquaculture operations (ECO as well as conventional).
Acknowledgements

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