Effect of environmental factors on the development of deformities in Atlantic halibut

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• Halibut hatch at a very premature stage of development

• Halibut has a very long yolk sac stage compared to other marine fish

→ susceptible to environmental stressors
Duration of yolk sac stage

Newly hatched halibut larvae → Halibut larvae at first feeding

50 days

Newly hatched cod larvae → Cod larvae at first feeding

8 days
Deformities in farmed Atlantic halibut

Variable, but often high frequencies (0-100%)

• Gaping jaws most prominent
• Yolk sac edema
• Other skeletal deformities (head, jaw, tail)
First feeding - halibut

Normal larvae

Gaping jaw and yolk sac edema

Photo: Trine Galloway, Biomar, Norway
1) Normal jaw
2) Gaping jaw
3) Pug nose
Small scale experiments at AKVAFORSK

- 3 liter glass jars
- Many replicates (4-5)
- Temperature 4°C
- Water filtered to 0.2 micron, UV-treated
- Oxytetracycline added
- Larval density 75-90/L
- Stagnant water
- Water exchanged two times during yolk sac period
Constant temperatures I

Effect of temperature

Effect of light

Bolla & Holmefjord, Aquaculture, 1988
Constant temperatures II

Survival and functionality

Type of deformity

- Survival
- Functional larvae
- Gaping jaw
- Yolk sac edema
Temperature increase at different ages

Experimental setup

Days post hatching

10 °C
8 °C
4 °C

0 10 20 30 40
Different periods at 4 °C

Survival and functionality

<table>
<thead>
<tr>
<th>Temperature C</th>
<th>Survival</th>
<th>Functional larvae</th>
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</thead>
<tbody>
<tr>
<td>0</td>
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Type of deformity

<table>
<thead>
<tr>
<th>Temperature C</th>
<th>Gaping jaw</th>
<th>Yolk sac edema</th>
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<tr>
<td>0</td>
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</table>
Constant salinity from hatching to first feeding

![Graph showing the survival and functional larvae of a species at different temperatures. The x-axis represents the temperature in degrees Celsius (24, 27.5, 31.5, 35.3, 39.3), and the y-axis represents the percentage. The graph indicates the survival and functional larvae rates at each temperature.]
Increase in salinity at different ages

• The larvae were held at 35 ppt (ambient salinity) for 30 days p.h.

• At day 30 p.h. The larvae were transferred to nine different salinities.
Different salinities from day 30 p.h. to first feeding.
Effect of water flow

• One exchange of total water volume every three days

• Start flow at day 6, 16 and 24 days p.h.

• Control kept stagnant from hatching to first feeding
Age of larvae at start of water flow

Days post hatching (4°C)

Percentage

Survival

Functional larvae
Effect of different materials

• 3-liter glass jars used as experimental units
  4 replicates per treatment

• Water filtered through 0.2 micron filter and UV-treated

• Small pieces (5x5 cm) of different materials placed at the bottom of each unit after hatching
Effect of different materials

![Graph showing survival and percentage of functional larvae for different materials: Lexan, PVC, PC, PMMA, GFIB, ALU, PE, Glass. The y-axis represents percentage, and the x-axis represents materials. The bars show a clear trend with Glass having the highest survival and percentage of functional larvae.](image-url)
Conclusions - environmental factors

- Different environmental stressors applied during the first 2-3 weeks p.h. causes increased frequencies of deformities in halibut larvae.

- The halibut larvae become more tolerant to environmental stressors approximately 3 weeks p.h.

- The increased tolerance to environmental stress coincides with the completion of major organ structures.
Atlantic halibut - juveniles

Normal pigmentation and eye migration

Malpigmented halibut juvenile with poor eye migration (high ARA)
**Pigmentation:**

Related to feed composition, especially DHA-content and DHA/EPA-ratio, phospholipids?

Halibut and turbot have lower requirements for ARA than other marine species such as seabass and sea bream

**Eye migration:**

Seems to be more related to total energy intake, but also correlated with feed composition, especially fat classes (phospholipids/triglycerides)
Skeletal deformities in farmed halibut

Leah M. Lewis, Dalhousie University, Halifax, NS
Further perspectives

- Need for more knowledge about the effect of environmental factors during first feeding and juvenile stages of Atlantic halibut

- Need for more knowledge about the nutritional requirements of Atlantic halibut during early life stages with regard to deformities
Arctic cod

- 415 day-degrees p.h.
- Alicarin red
Atlantic cod - Examples of deformities

- Bent neck
- "Star watcher"
- Lordosis
Ongoing experiments on cod

• Eggs are incubated at three different temperatures

• Larvae are first-fed at three different temperature regimes:
  1) 8 °C until metamorphosis
  2) 12 °C until metamorphosis
  3) Gradually increase from 6 to 12 °C
### Frequencies and types of deformities 414 d° p.h.

<table>
<thead>
<tr>
<th>Temp regime</th>
<th>Neck area</th>
<th>Vertebral column</th>
<th>Head/jaw</th>
<th>Tail</th>
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</thead>
<tbody>
<tr>
<td>6–12 °C</td>
<td>2.5</td>
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<td>7.5</td>
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<td>8 °C</td>
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<td>13.0</td>
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<tr>
<td>12 °C</td>
<td>13.0</td>
<td>10.0</td>
<td>7.5</td>
<td>10</td>
</tr>
</tbody>
</table>
Growth of cod larvae fed at different temperatures

- 12°C
- 8°C
- 6-12°C

SL (mm) vs. Hatching, First feeding, 215 doC, 315 doC, 415 doC.
Arctic cod
460 d°p.h.

Ossification of cleithrum and anterior vertebrae

Ossified bones coloured with Alicarin red
Thank you for your attention!

Thanks also to:
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