The implementation of the WFD in Norway - Mitigating hydropower effects on fish stocks

Roy M. Langåker, Norwegian Environment Agency
Main pressures in Norway - from regional plans

- Water storage - hydropower
- Acid rain
- Agricultural runoff
- Runoff from scattered houses
- Invasive species
- Runoff from urban areas
- Pollution - sewage plants
- Run off - other sources
- Water abstraction
- Point source pollution - industry

Main pressures - no of surface water bodies

- Svært stor
- Stor
- Middels
Main issues in Norway

Photo: NVE, Eilif Brodtkorb
Mitigation measures in process to reduce hydropower impacts by 2021-2033

- Political signals on hydropower and biodiversity from parliament (2016)
  - Increase revision of terms
  - Modernise legal possibilities for mitigation requirements

- Plans adopted by Ministry (July 2016)
  - 387 water bodies specified in decision
  - Flow measure in more than 50 rivers 2021-2033 (revision required)

### Mitigating impacts from hydropower in priority water bodies by 2021-2033 (as a minimum)

<table>
<thead>
<tr>
<th>River basin districts</th>
<th>Flow measures</th>
<th>Other measures</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glomma/Västerhavet</td>
<td>35</td>
<td>33</td>
<td>68</td>
</tr>
<tr>
<td>Vest-Viken</td>
<td>35</td>
<td>56</td>
<td>91</td>
</tr>
<tr>
<td>Agder</td>
<td>17</td>
<td>8</td>
<td>25</td>
</tr>
<tr>
<td>Rogaland</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Hordaland</td>
<td>10</td>
<td>13</td>
<td>23</td>
</tr>
<tr>
<td>Sogn/Fjordane</td>
<td>13</td>
<td>48</td>
<td>61</td>
</tr>
<tr>
<td>Møre/Romsdal</td>
<td>12</td>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>Trøndelag</td>
<td>8</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>Nordland</td>
<td>16</td>
<td>23</td>
<td>39</td>
</tr>
<tr>
<td>Troms</td>
<td>8</td>
<td>21</td>
<td>29</td>
</tr>
<tr>
<td>Finnmark</td>
<td>4</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td><strong>Norway</strong></td>
<td><strong>160</strong></td>
<td><strong>227</strong></td>
<td><strong>387</strong></td>
</tr>
</tbody>
</table>
Mitigating impacts from Hydropower
- Flow measures to modernise environmental requirements

Flow measures by revision of terms in priority water bodies by 2021 - 2033

<table>
<thead>
<tr>
<th></th>
<th>2021</th>
<th>2027</th>
<th>2033</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catchment areas*</td>
<td>18</td>
<td>30</td>
<td>31</td>
</tr>
<tr>
<td>Started by 2017</td>
<td>17</td>
<td>17</td>
<td>5</td>
</tr>
</tbody>
</table>

* May include many water bodies and 1 to 7 licenses

Authority: Norwegian Water Resources and Energy Directorate (NVE)
Mitigation measures and monitoring without impact on hydropower production

- Legal possibility for starting mitigation measures and monitoring in most licenses (pressure pays principle)
  - By standards for nature management conditions in licences for Hydropower developments

Salmon Rivers:
- 2017 mitigation and monitoring programs in 50 Rivers

- 2021 New mitigating programs in minimum 6 Rivers
  - Started by 2017
    - Diagnosis of impact, mitigation measures, monitoring

Authority: Norwegian Environment Agency
Objective for fish stocks in Regulated Salmon Rivers: normal fishery without stocking

- **Strategy:** Restore as much as possible by
  - Habitat measures
    - in combination with environmental flow
      - two different management processes
  - Fish migrating measures - up/down

- In Rivers without modern measures
  - the fish stocking will continue
    - until new measures give a fish population big enough to have a fishery

- When fish stocking is still needed
  - we try to use fish eggs
Habitat measures and Environmental Flow - tools

Handbook:

- ...how to explore, develop and implement measures
- that improves conditions for Atlantic salmon in regulated rivers
- in optimal trade-offs with hydropower production
Design solutions

Water use or habitat measures

– often in combinations
Case River Aurlandselva – Identify bottlenecks and mitigation measures

- Too little spawning grounds/supply with spawning gravel
- Too little hide/need mitigation
Measures in River Aurlandselva
- 500 m² of new spawning gravel

Before

After

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Measures to improve habitat for juvenile fish

Figur 1 Harving av pakket og fast bunnsubstrat (armeringslag) ndf. E 16 bro 2011.

Figur 2 Harvingen sett under vann. Gravemaskinen mistet tenner i skuffen grunnet det harde armeringslaget.

Figur 3 Pakket og fast bunnsubstrat med få hulrom. Steinene kunne ikke snus med håndmakt (armeringslag).

Figur 4 Samme substratet etter harving – masse nye hulrom tilgjengelig for fisk.

before

after

© Bjørn Barlaup, UNmiljø
Connectivity - downstream migration

Last 10 years: bypass measures in 6 Rivers (without 100 % barrier - rack)

- Results: bypassing 50 - 80 % smolt of Salmon and Sea trout

New Hydropower licences - physical barrier (rack) and bypassing system

Case: River Tovdalselva

*SafePass*: ongoing research program

Fish: Safe up and down migration through Hydropower developments

Design solutions and recommendation to:

the hydropower industry and the authorities
Hydro-peaking and impacts on fish - stranding

- Regulated Rivers in Norway
  - gentle peaking only allowed in most modern licenses (operational measure)
  - and voluntarily in many rivers (Statkraft).

- A New study on Hydro-peaking (published in 2016) shows that restrictions give results on fish stocks (salmonids)
  - developed a system for environmental adapted hydro-peaking operations

- The knowledge gives the hydropower industry and the authorities a new tool:
  - identify impacts
  - how to mitigate
## Water temperature and supersaturation
- Example on impacts we need more experience and testing

<table>
<thead>
<tr>
<th>Typical hymo impacts</th>
<th>Alteration of physico-chemical conditions downstream of reservoir</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deep water intake</td>
</tr>
<tr>
<td></td>
<td>E.g. altered water temperature or quality in rivers</td>
</tr>
<tr>
<td>Typical ecological impacts</td>
<td>Altered composition or growth of biological quality elements</td>
</tr>
<tr>
<td></td>
<td>Reduced survival/growth rate of fish in particular</td>
</tr>
<tr>
<td>Success criteria - mitigation</td>
<td>Mimicking more natural physico-chemical conditions</td>
</tr>
<tr>
<td></td>
<td>Increased growth and survival of fish and macroinvertebrates</td>
</tr>
<tr>
<td></td>
<td>More natural composition of biological quality elements</td>
</tr>
</tbody>
</table>

- Mitigation for physico-chemical alteration
- Multiple intakes at different heights in reservoir dam
- Installing flexible intake
- Managing reservoir level
- Mitigating oversaturation

and
Mitigation measure to reduce effect of low Temperature from environmental flow in summer

Case: River Eidfjordvassdraget Western Norway

For 30 years:
- water from two tributaries was collected by tunnels to the main reservoir (Sysen)
- Environmental flow:
  - Reservoir; bottom water

Last 10 years:
- Experiments to let (some of) the water go directly to the main river from the two tributaries

Effects:
- Temperature: +1 - 2 C
- Fish stocks: increased survival and growth of salmon and trout.

Regulated by Statkraft
Supersaturation - Causes

- **Supersaturation (Total Gas Pressure TGP)** happens when:
  - Gas + liquid + pressure and reduction of pressure
  - Natural rivers usually 100 - 110% saturation
  - Sparkling water 120 - 130% saturation

- **Biological effects**: Fish: Gass bubble disease
  - In rivers fish will be killed at 110 - 140%
  - Effects on behaviour and immune system under 110%

- **Hydropower induced**:
  - **Creek intakes**, tight intake grids, creation at the outlet channel +

More info: ulrich.pulg@uni.no
Supersaturation - monitoring and solutions

- Monitoring 9 Norwegian Rivers in the period from 2010 - 2015:
  - 7 with artificial Supersaturation
  - 4 with supersaturation dangerous for fish (110 - 170% TGP)

- Possible solutions
  - Reduced discharge at creek intakes, vacuum intakes, Grid cleaner, modification of spillways and channels, adjusted power operations

More info: ulrich.pulg@uni.no
Key message

- Approved regional plans and political signals to improve ecology in regulated Rivers
  - Mitigations measures including environmental flow in more than 50 rivers

- Good practise cases by use of environmental design like
  - Habitat measures (spawning grounds, young fish,)
  - Migrations measures (up/down)

- Need more development (+ cost/benefit) and research on measures like:
  - Altered temperature
  - Supersaturation
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