From endangered towards sustainable: Atlantic Salmon populations in Denmark

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In the 1980’ies the salmon populations in Denmark were assumed extinct
- except for River Skjern (spawning-run 50 – 100 / year)
- Sporadic catches in other rivers were interpreted as strayers
What went wrong?

Poulsen 1935
During 1940-1970 large land claim projects were carried out - destroying spawning and nursery areas, impairing migration.
Lots of small barriers - mills and fish farms
Fish farming, 1894 – 1975.

Caused habitat loss, habitat degradation and impaired migration.

About 800 in 1970, 150 left today.
Hydropower development, 1920-1970
Hydropower development River Gudenå 1921

River blockage prevented the salmon in reaching the spawning areas - the River Gudenå salmon vent extinct
Problems for downstream smolt migration at weirs

<table>
<thead>
<tr>
<th>Weir type</th>
<th>Mean smolt loss (%)</th>
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<tbody>
<tr>
<td>Water mills (n=5)</td>
<td>30</td>
</tr>
<tr>
<td>Fish farms (n=38)</td>
<td>42</td>
</tr>
<tr>
<td>Hydropower (n=7)</td>
<td>82</td>
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</tbody>
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Smolt loss when passing 3 fish farms in a river: \((1-(1-0.42)^3) = 80\%\)
Salmon landings in the estuary of River Skjern Å

Landings in Ringkøbing Fjord 1900 - 1978

Otterstrøm (1938) og Statistisk Årbog, Fiskerimisteriet
In the late 1990’ies a review combined with surveys of the salmon rivers for YOY, suggested that salmon populations still existed not only in River Skjern Å
DNA from old scales compared with DNA collected during 1993-2003

Old DNA (1910 - 1913)

Present
New status 2003 - four indigenous populations left

River Storå
River Skjern
River Varde
† River Sneum
† River Kongeå
† River Ribe
† River Brede
† River Vidå
† River Gudenå

Nielsen, Hansen & Bach (2001)
Resurge of the salmon populations - multi-faceted management

Management tools
- Restoration of habitats
- Fishery regulations
- Stocking
The salmon stocking programme was optimised
River Storå - stocking of native vs non-native origin

Nielsen, Hansen & Bach (2001)
Migration barriers have been removed and habitats restored

The weir and dam at Vilholt Mill was removed in 2008

What’s the effect?
Effects of barrier removal at a whole-system scale

*Full river restoration*
Spawning run of sea trout

Year

0 500 1000 1500 2000 2500 3000 3500 4000

2004 2009 2016

No. of sea trout

1 weir removed

All 7 weirs removed

DTU Aqua
Restored habitat in the ponded zone

Ponded zone – before

Ponded zone – after
Loss of habitat as a (overlooked) consequence

"Ponded zone"

- ↓ gradient
- ↓ flow
- ↑ sedimentation

- Increased depth
- Sedimentation
- Original stream bed
- Reduced flow

Distance from source

Height above sea-level

Loss in horizontal habitat

Birnie-Gauvin et al. 2017
Trout density before and after removal

**Upstream**

**Downstream**

* OLD
* YOY

Birnie-Gauvin et al. 2017
Habitat restoration - data

*Trout as model species*

A total of 71 projects:

- 29 eastern Jutland
- 27 Western Jutland
- 15 on the Islands
Habitat restoration - data

Trout as model species

YOY trout

The density increased averagely 175 %
The River Skjern Nature Project 2002
- Largest river restoration project in Northern Europe

Foto: Povl Toft ©
Dam removal
Dam removal
Fishery regulations

- In the estuaries and in the Wadden Sea
- Quotas in the rivers, 1SW+MSW (10% of spawning run) > C&R
- Reduced period 16. April - 16. October
Regulation of predators

Acoustic and radio tagged salmon smolts:
40 - 50 % tags recovered in one cormorant colony
(Koed et al. 2006, Jepsen et al. 2018).
The Danish salmon populations - development

The Danish salmon populations - the River Skjern

Result of an extensive, focused and knowledge-based effort

- Habitat restoration 1990’erne - now
- Regulation of cormorants in the estuary
- Optimisation of the stocking programme
- Fishery regulation i river and estuary
Status for River Storå 2017 and River Ribe Å 2023:

Self-sustaining salmon populations and no supportive stocking (TAC ~ 10 %)
Where to go from here?

Total salmon catches in 8 rivers (released fish included)
Adaptive Management Approach

a) Identify the rivers of highest priority - production potential and potential for recovery
b) Identify local threats - poor habitat, predation pressures, barriers, pollution etc.
c) Restore habitats for spawning and growth.
d) Remove barriers to movement or efficient fish passage
e) Fishery regulations and reduce predation
f) Perform systematic stock assessments to evaluate
More efficient regulation of predation?
Improving and expanding habitat
Improving and expanding habitat

Salmon Habitat Quality

- Ribe Å
- Varde Å
- Skjern Å
- Storå

Colors:
- SHQ 0
- SHQ 1
- SHQ 2
- SHQ 3
Continued focus on removing barriers
Conclusions

- Adaptive management and close collaboration and engagement of stakeholders, decision makers and researchers has been central for the positive development of the salmon populations in Denmark.

- All management approaches were applied simultaneously. Focus is now on barrier removal and habitat restoration.

- Stronger focus on tourism and socio-economic may me a positive contributor.

- Prioritisation of which tools to focus on:
  
  Management tools
  a. River restoration
  b. Fishery regulation(s)
  c. Stocking
Thanks for your attention!

Questions?

Further information on: http://www.aqua.dtu.dk and http://www.fiskepleje.dk