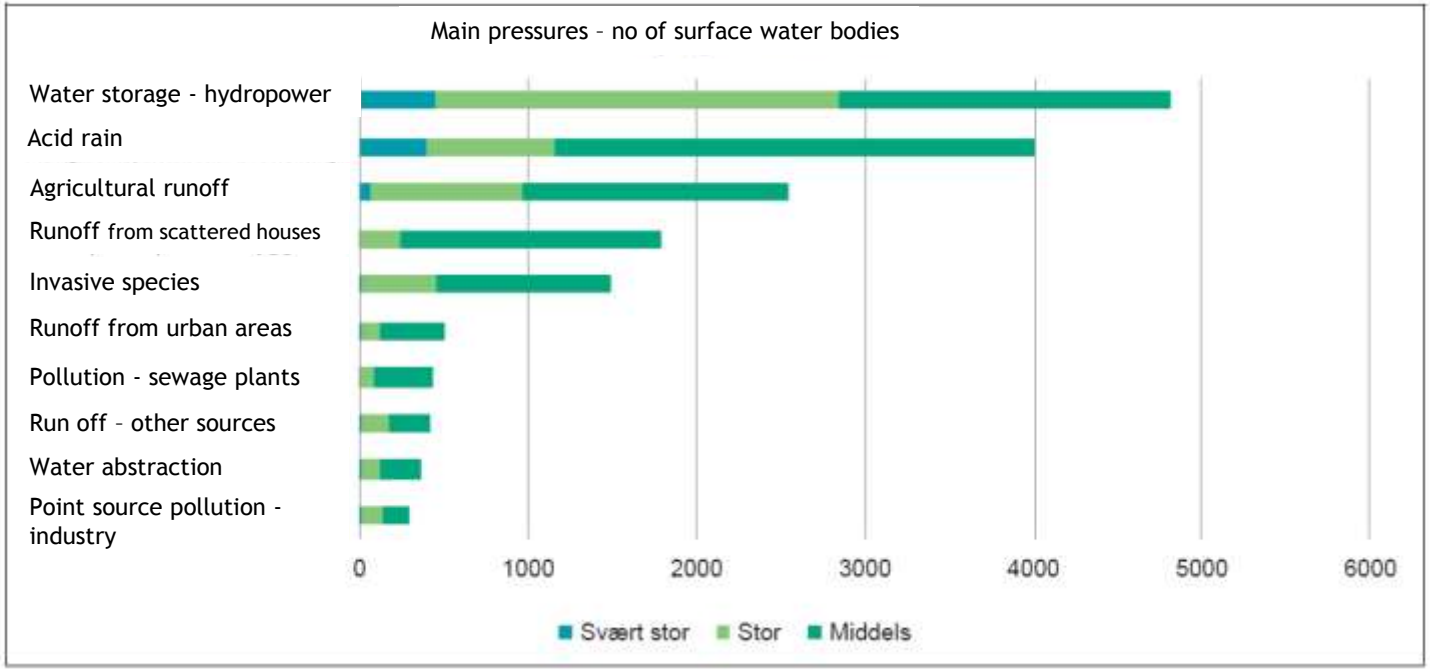
The implementation of the WFD in Norway

- Mitigating hydropower effects on fish stocks

Roy M. Langåker, Norwegian Environment Agency

Main pressures in Norway - from regional plans



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Main issues in Norway

Photo: NVE, Eilif Brodtkorb

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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)

River basin districts	Flow measures	Other measures	Total
Glomma/Västerhavet	35	**33**	68
Vest-Viken	35	**56**	91
Agder	17	**8**	25
Rogaland	2	**1**	3
Hordaland	10	**13**	23
Sogn/Fjordane	13	**48**	61
Møre/Romsdal	12	**10**	22
Trøndelag	8	**10**	18
Nordland	16	**23**	39
Troms	8	**21**	29
Finnmark	4	**4**	8
Norway	**160**	**227**	**387**

Mitigating impacts from Hydropower
– Flow mesures to modernise environmental requirements

Flow measures by revision of terms in priority water bodies by 2021 - 2033			
	2021	2027	2033
Catchment areas*	18	30	31
Started by 2017	17	17	5

* May include many water bodies and 1 to 7 licenses

Authority: Norwegian Water Resources and Energy Directorate (NVE)

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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 Enviroment Agency

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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 prosseses
  - 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

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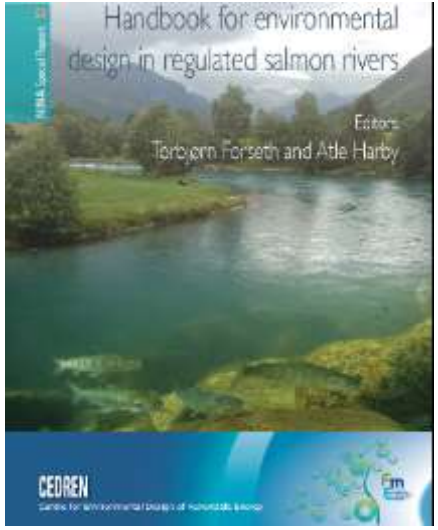
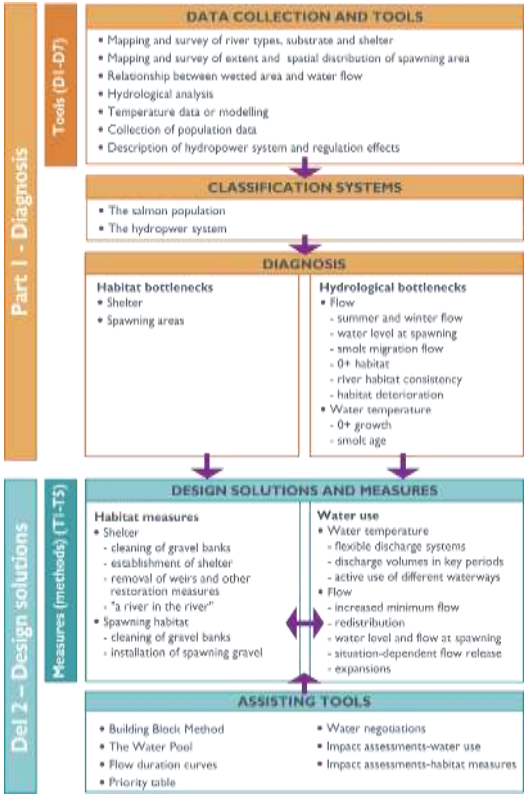
Habitat measures and Environmental Flow - tools



Handbook:

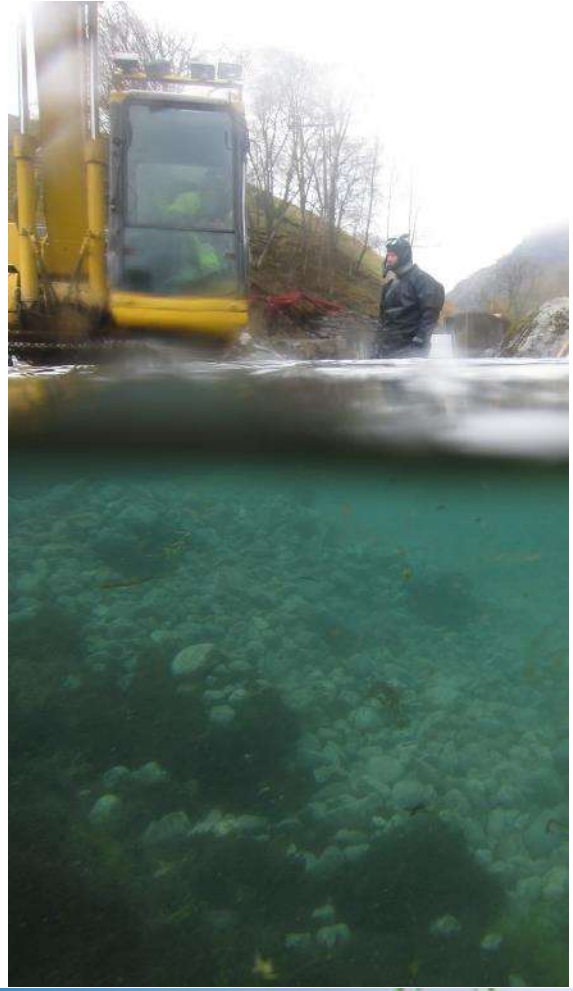
- *…how to explore, develop and implement measures*
- *that improves conditions for Atlantic salmon in regulated rivers*
- *in optimal trade-offs with hydropower production*



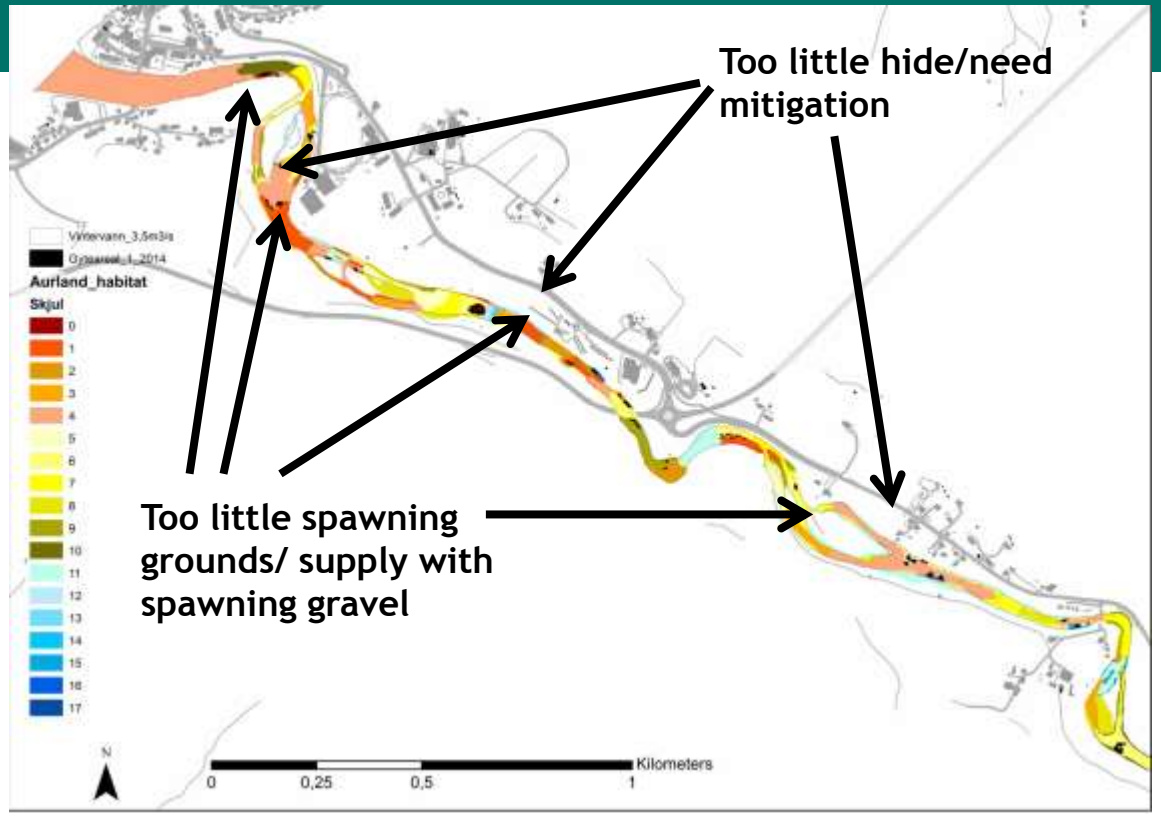
Design solutions

Water use or habitat measures

– often in combinations



Case River Aurlandselva – Identify bottlenecks and mitigation measures



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Measures in River Aurlandselva

- 500 m2 of new spawning gravel

Before

After

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Measures to improve habitat for juvenile fish

before

after

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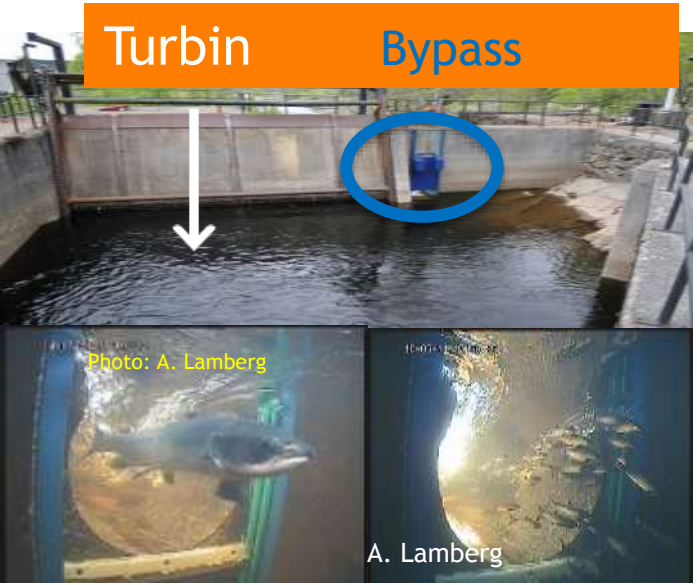
Connectivity – downstream migration

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

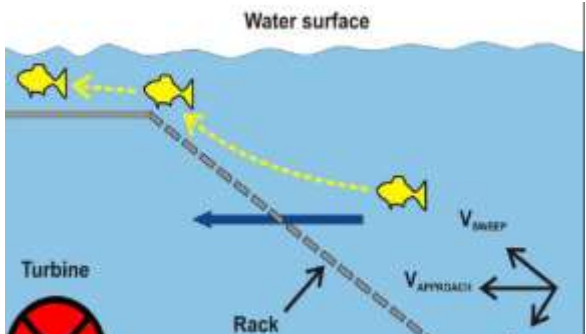


SafePass: ongoing reserch program

Fish: Safe up and down migration trough 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 volunteerily 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

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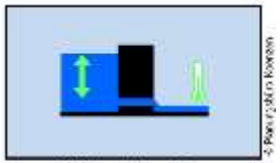
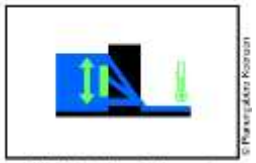
Water temperarture and supersaturation

- example on impacts we need more experience and testing

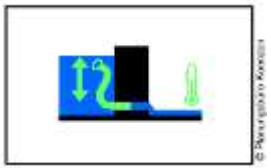
Typical hymo impacts	Alteration of physico-chemical conditions downstream of reservoir Deep water intake E.g. altered water temperature or quality in rivers
Typical ecological impacts	Altered composition or growth of biological quality elements Reduced survival/growth rate of fish in particular
Success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



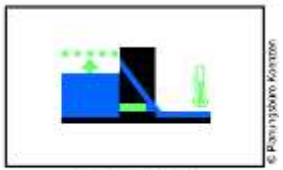
Mitigation for physico-chemical alteration



Multiple intakes at different heights in reservoir dam

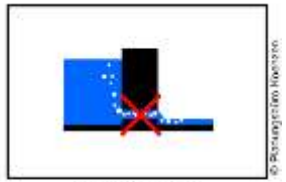


Installing flexible intake



Managing reservoir level

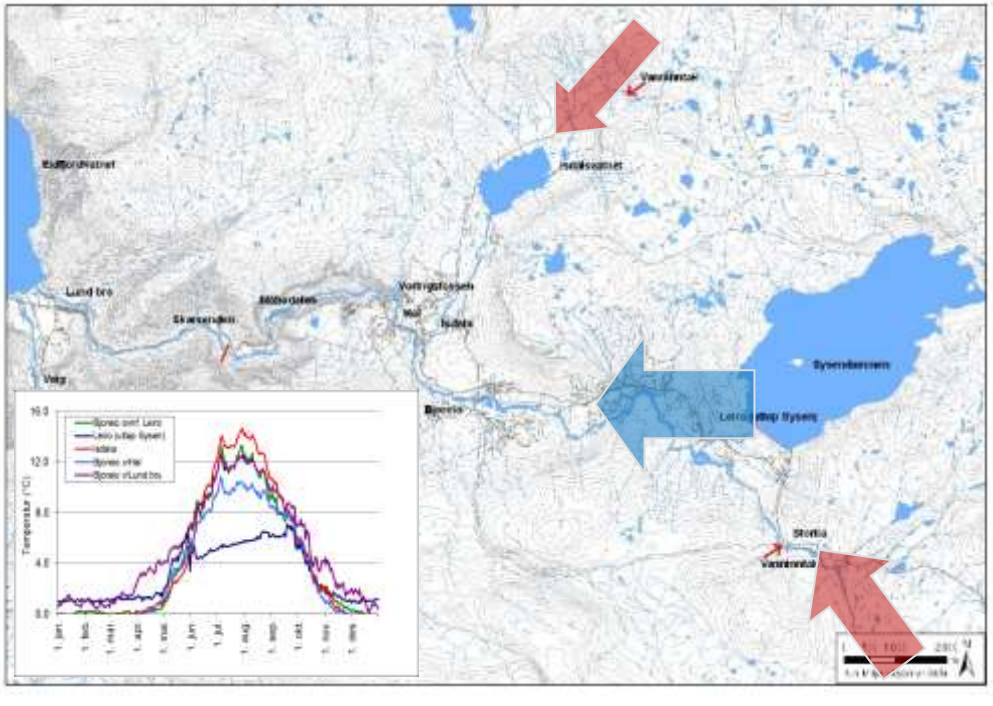
and



Mitigating oversaturation

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 collcted by tunnels to the main reservoir (Sysen)**
- **Environmental flow: Reservoir; bottom water**

Last 10 years:

- **Experimnents to let (some of) the water go directly to the main river from the two tributaries**

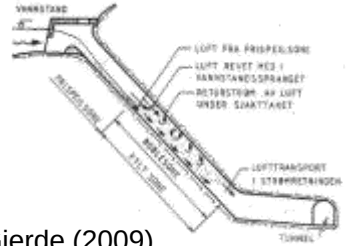
Effects:

- **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 desease
  - In rivers fish will be killed at 110 - 140%
  - Effects on behaviour and
    immune system under 110%
- Hydropower induced:
  - **Creek intakes**, tight intake grids,
    areation at the outlet channel +



Gjerde (2009)

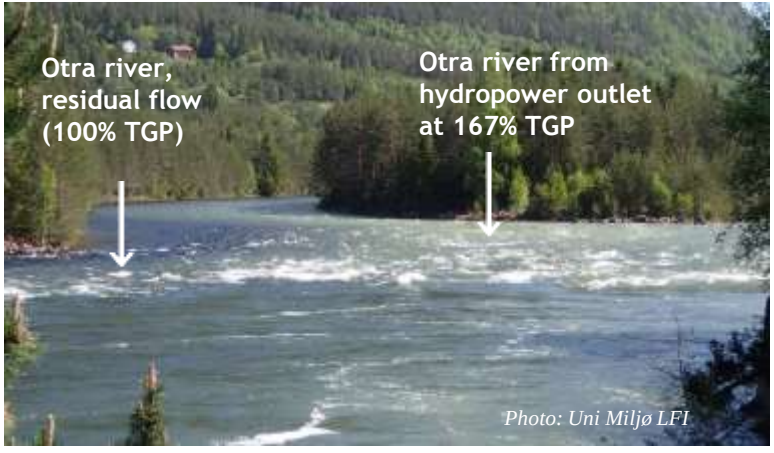
More info: ulrich.pulg@uni.no

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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