Hydropeaking (effektkjøring) in BKKs hydropower plants – Case Dale HPP

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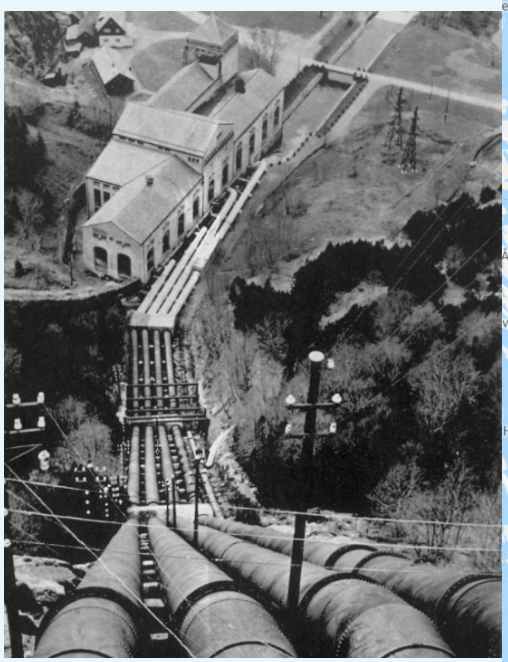
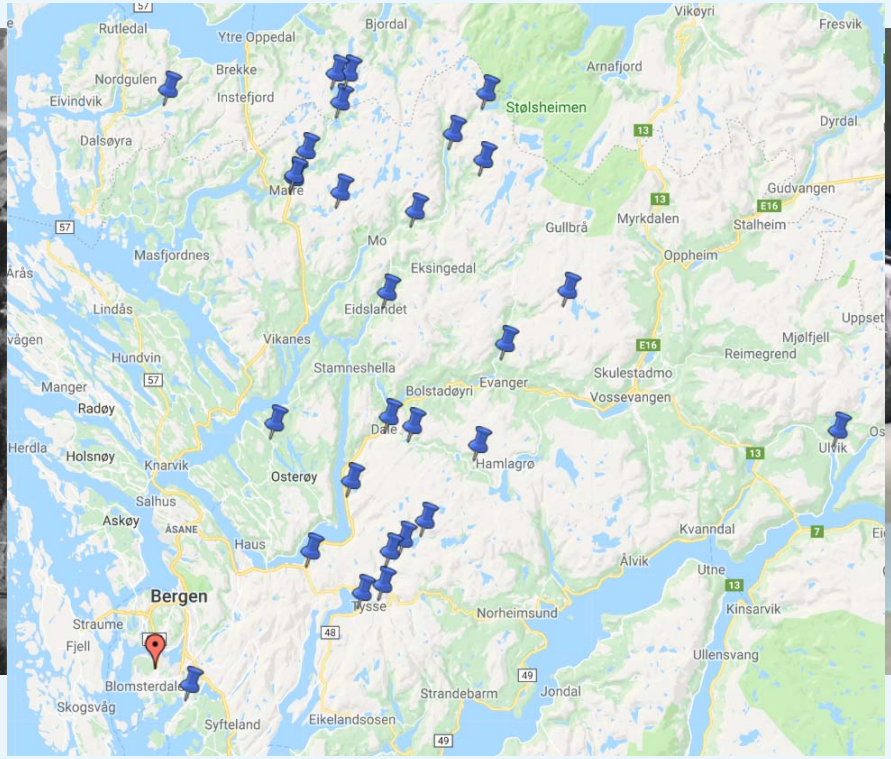
BKK Produksjon - the generation subsidiary
100 years of power development in Western Norway



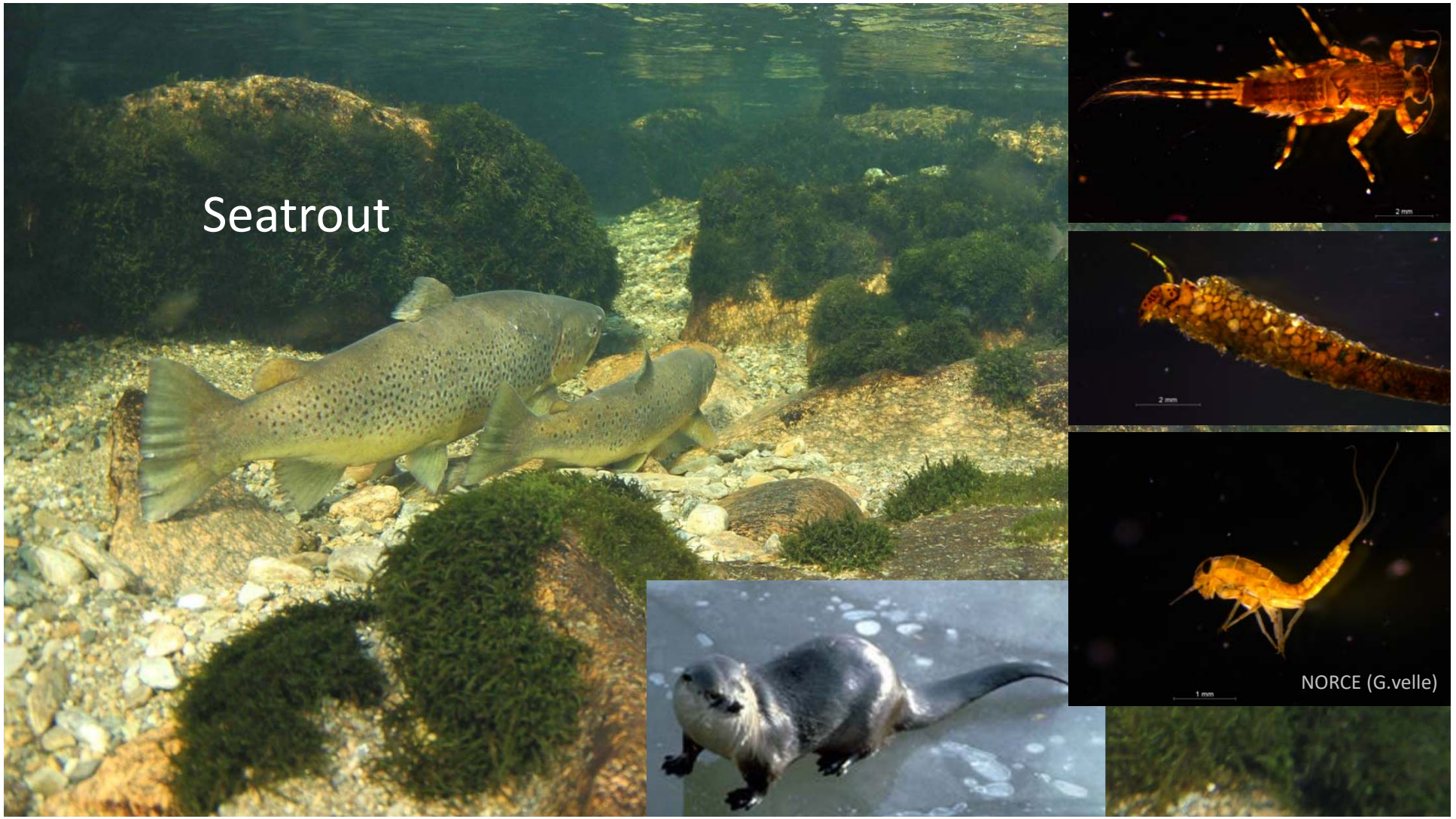
Frøland power plant 1912



Matre Haugsdal power plant 2016

Sustainable use of nature

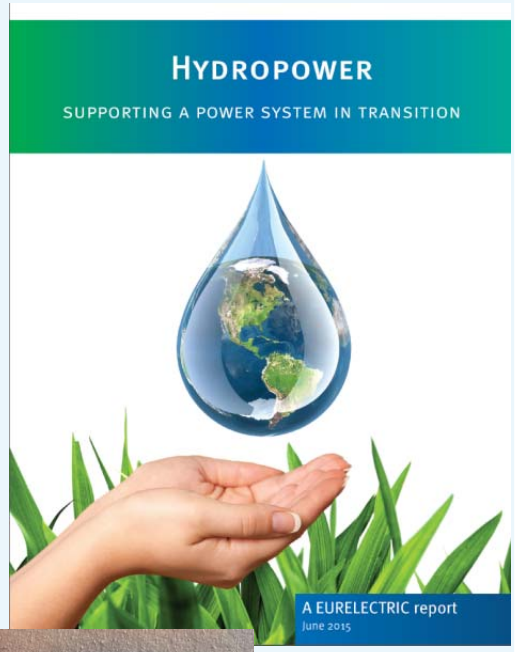

Atlantic
salmon


Seatrout
2 mm
2 mm
1 mm
NORCE (G.velle)

Hydropower – some important characteristics:

- Is reliable, efficient, climate-friendly - one of the lowest carbon footprints
- Is important for system stability and power supply
- Reduce flood risks
- Provides the most efficient energy storage technology, and is the only existing large-scale storage technology

- Capacity can easily be adjusted according to the demand, as electricity is produced in the moment its used.



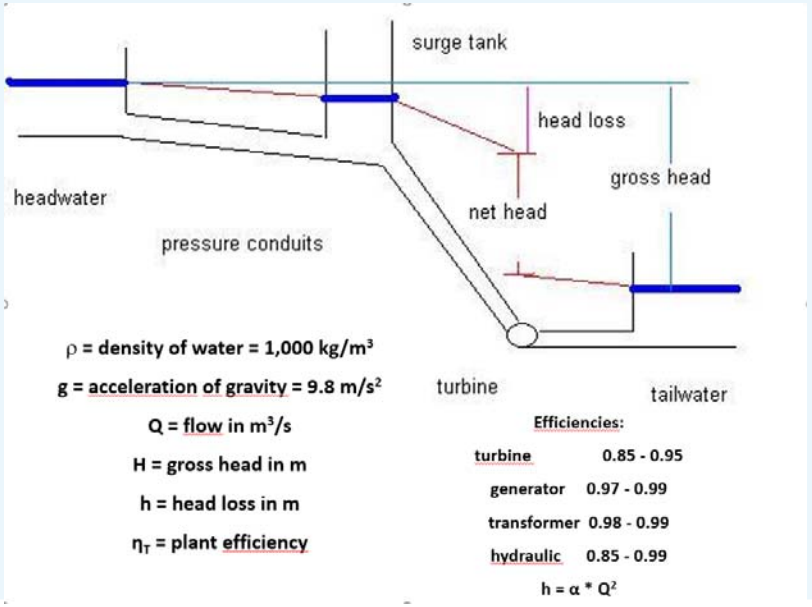
Electricity is generated in the moment its being used

- An example: - demonstrated by NRK in “Ut i Vår Hage”
  - Search for “Norsk Sluttstrøm”

Hydropower plants are transforming potential energy to kinetic energy

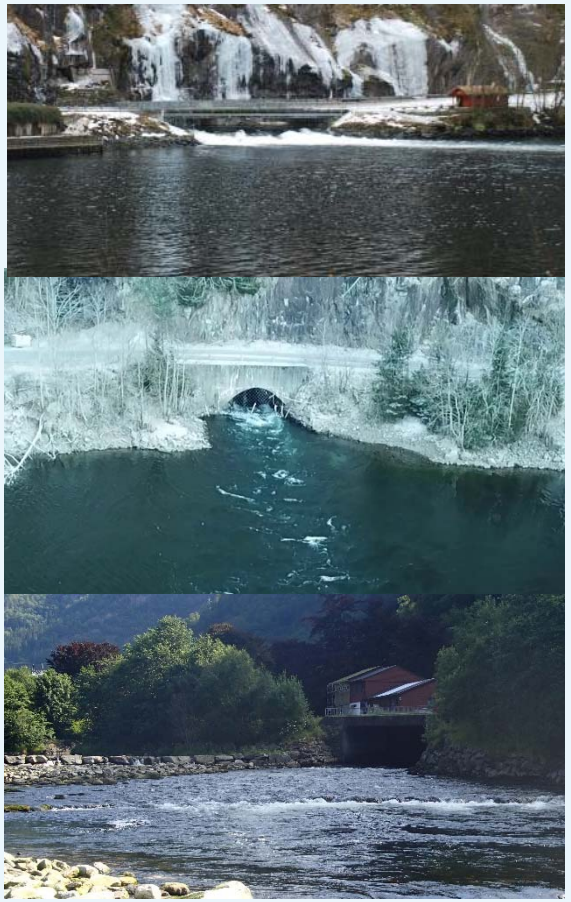
$$P = \rho * g * Q * (H - h) * \eta_T \qquad E = \int P * dt$$

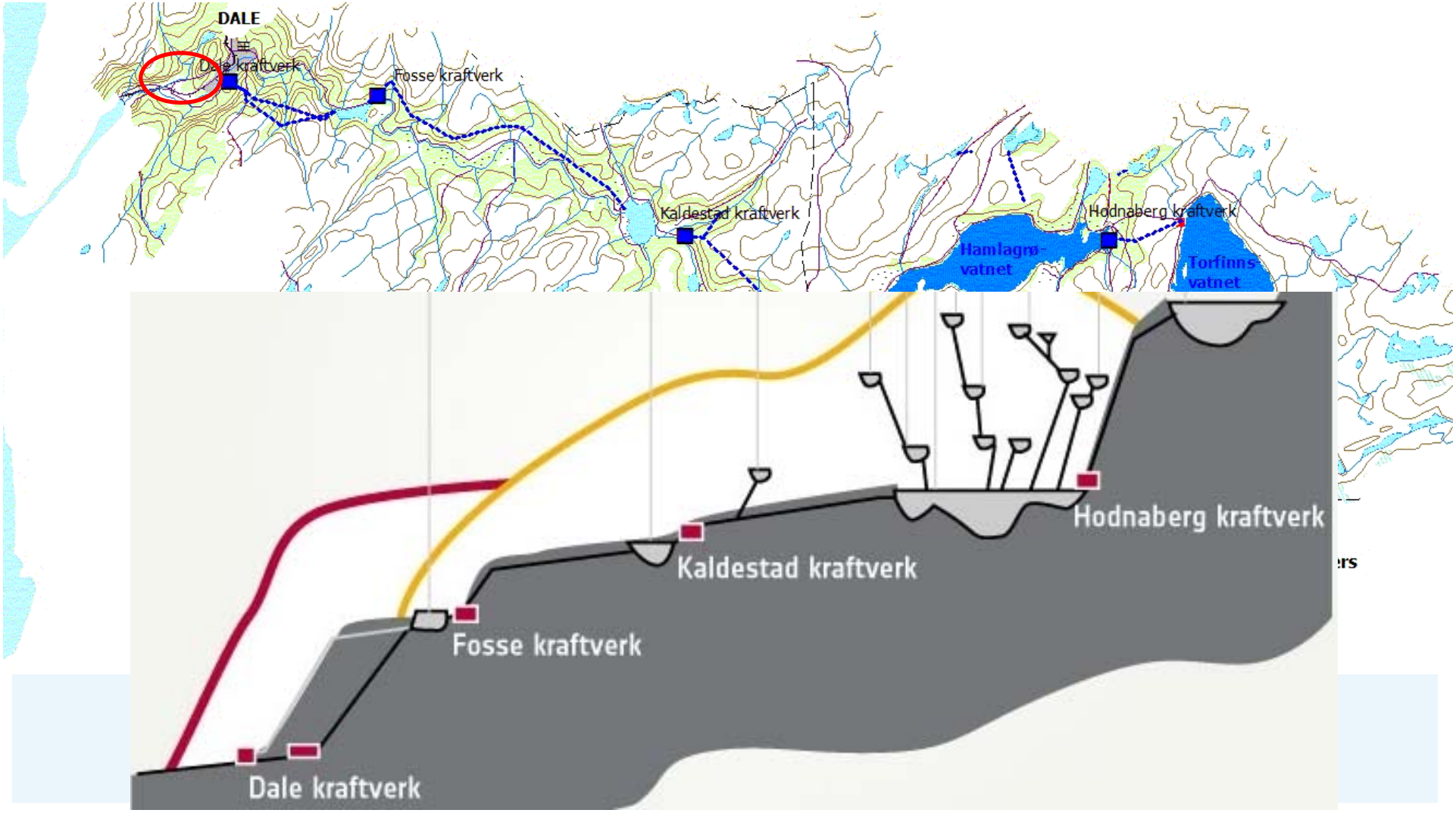
- Typical Efficiencies (η):
  - Hydropower plants: 0,85
  - Gas turbines: 0,30-0,40
  - Combined cycle: 0.58
  - Electro engines: 0,60
  - Car Engine: 0,25



Impacts of hydropeaking depends on topographical and local conditions…

- As a guideline environmental impact caused by hydropeaking are:
  - None or minor impacts when outlet goes to the sea
  - Minor or small when outlet goes into lakes
  - Medium to severe when outlet goes into rivers with no mitigation measures
- This presentation will focus on rivers!



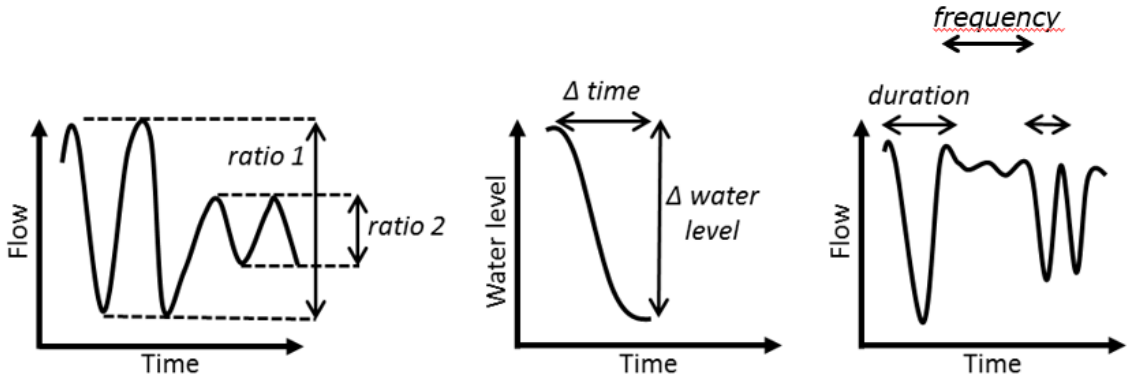

DALE
Dale kraftverk
Fosse kraftverk
Kaldestad kraftverk
Hodnaberg kraftverk
Hamlagrø-
vatnet
Torfinns
vatnet
Hodnaberg kraftverk
Kaldestad kraftverk
Fosse kraftverk
Dale kraftverk

Dale river

- Section downstream Dale HPP

What is hydropeaking?

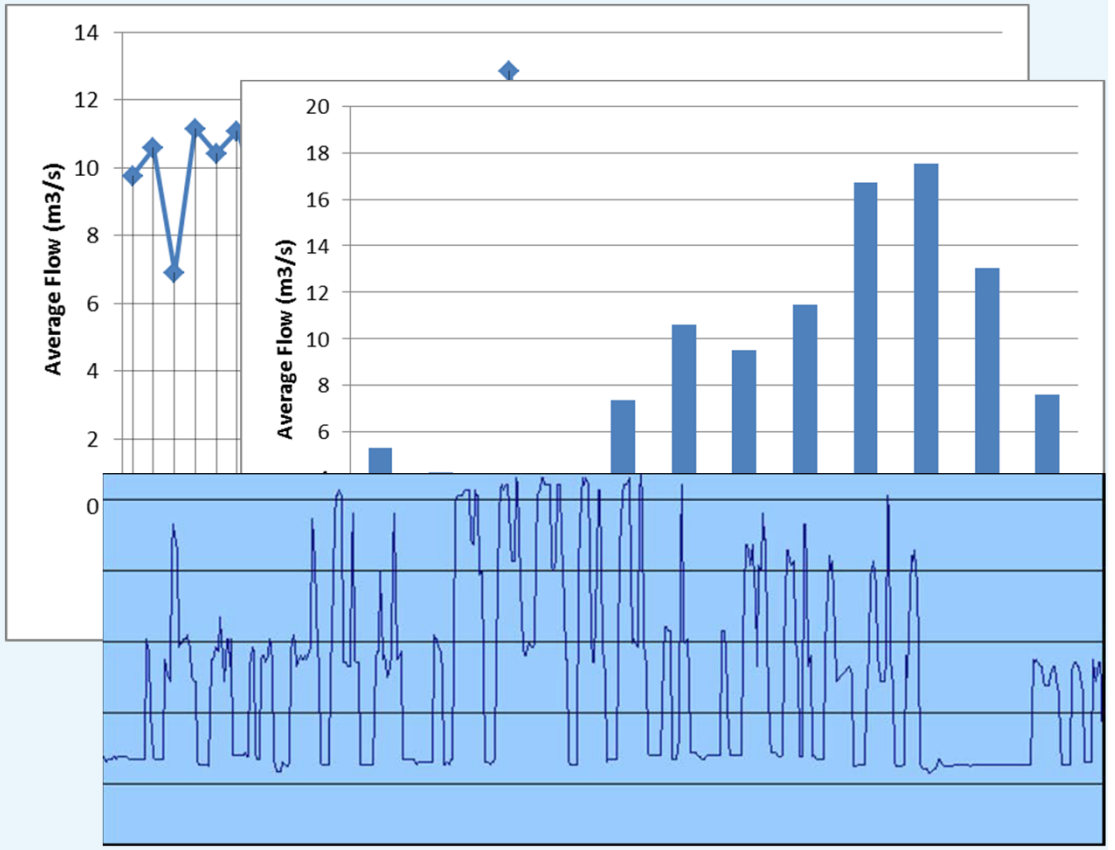
- Refers to hydropower operations that are characterised by more rapid and frequent changes in power production than typical base-load hydropower production.
- Rapid fluctuations in discharge, water level and temperature may cause negative impacts to the riverine ecosystem



Focus on downstream impacts

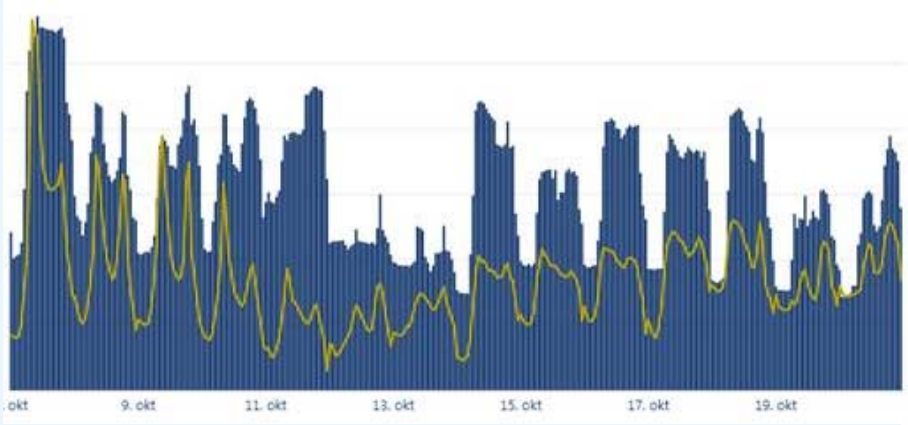
Fluctuations in flow – natural or artificial

- Natural variations from year to year and throughout the year, and within a day
- Artificial flow fluctuations should be defined as flow fluctuations induced by hydro operations, and they can simply be identified as situations where one or several of the factors mentioned (flow ratio, rate of change, frequency, duration and time) exceeds natural limits



What is hydropeaking in more details?

- Some characteristics:
  - More frequent changes than natural conditions would give, or faster start/stop than the actual hydrological situation
  - Element of periodicity
  - Maximum value significant lower than flooding



- Typical drivers:
  - Marked, selling at peak
  - Balancing of grid
  - Balancing of non-adjustable power production (coal, nuclear)
  - Balancing of variable renewable energy (wind and solar)

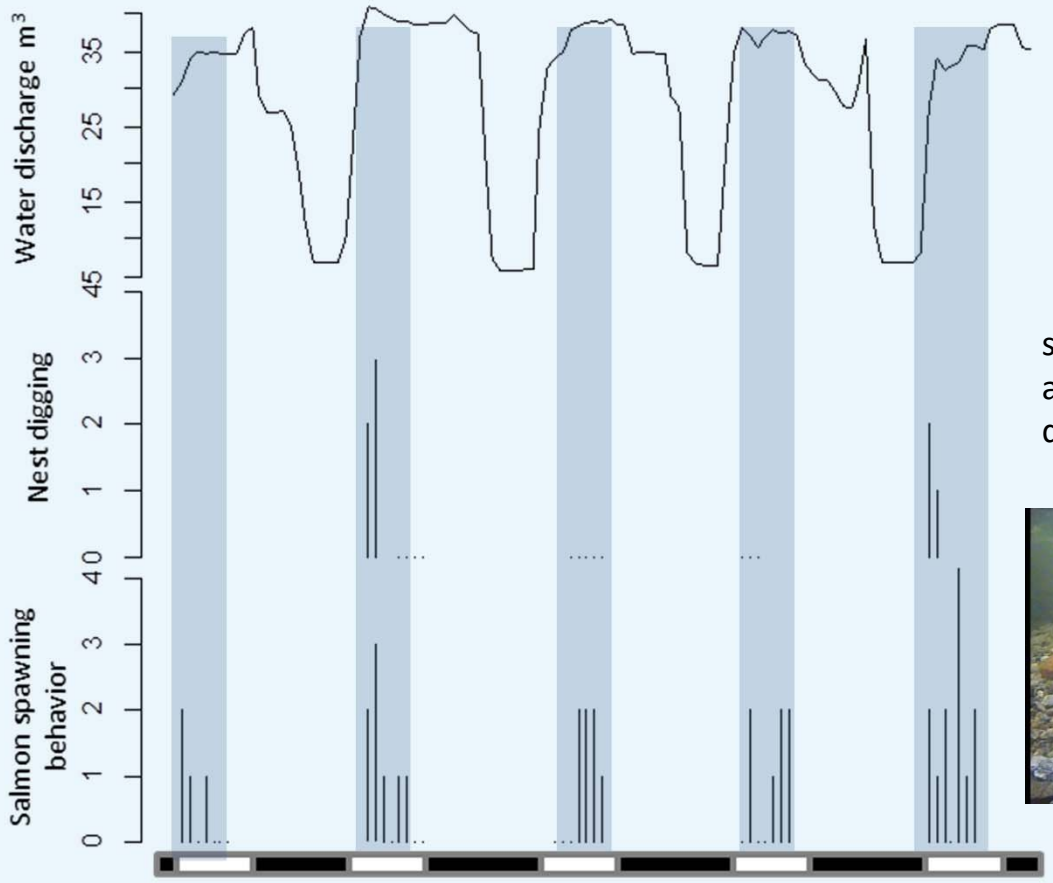
Spawners

Juveniles

Redds

Eggs

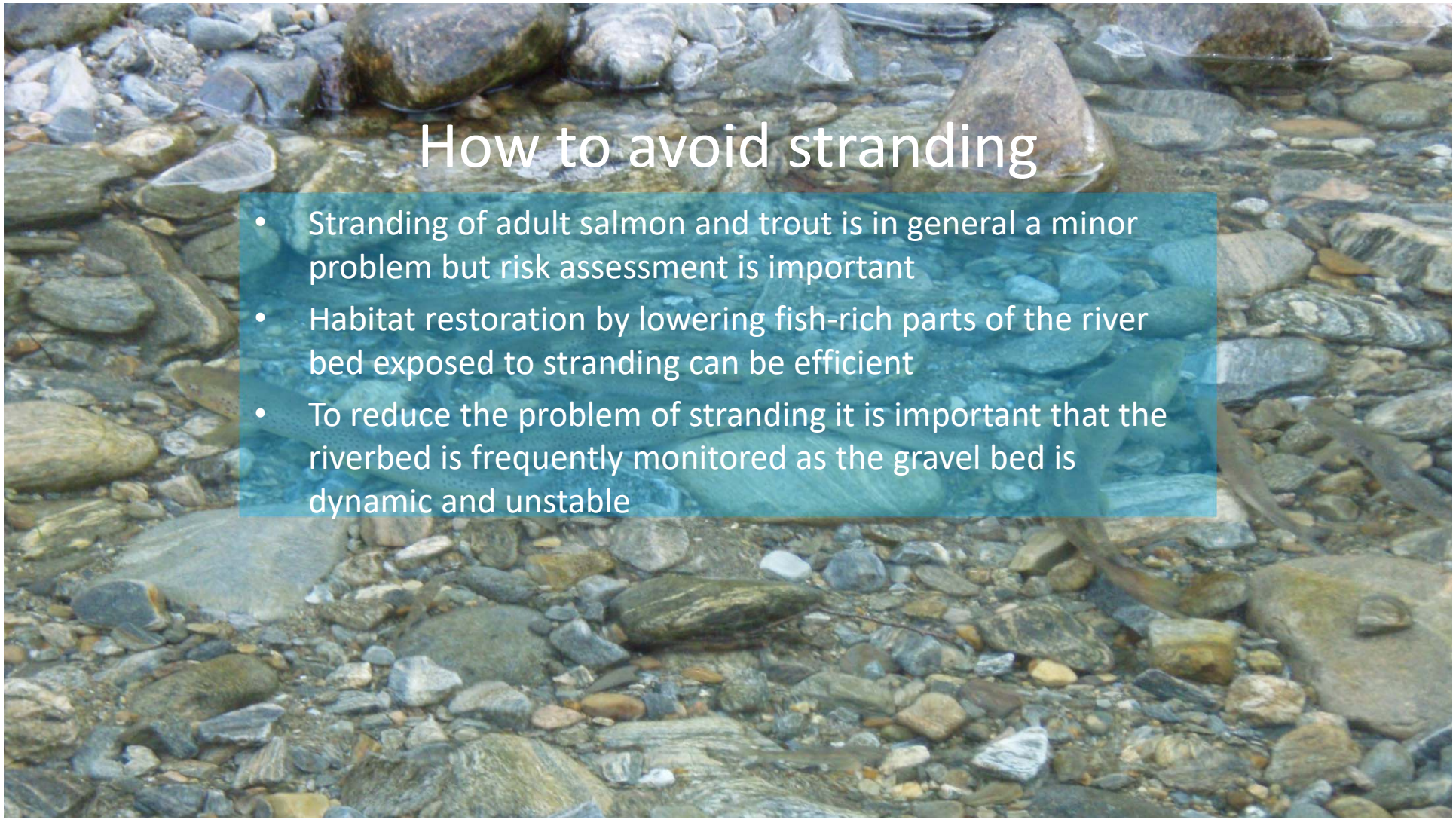
Film illustrating rapid changes in water discharge and salmon spawning behaviour



salmon typically spawn after rise in water discharge

What do we know about spawning and hydropeaking?

- Sudden changes in water discharge may interupt the spawning of seatrout and Atlantic salmon.
- **But** the fish is strongly motivated to continue the spawning when the discharge increases again
- These results have also been found in studies using pacific salmon species (Chapman et al. 1986, Tiffan et al. 2010).



How to avoid stranding

- Stranding of adult salmon and trout is in general a minor problem but risk assessment is important
- Habitat restoration by lowering fish-rich parts of the river bed exposed to stranding can be efficient
- To reduce the problem of stranding it is important that the riverbed is frequently monitored as the gravel bed is dynamic and unstable

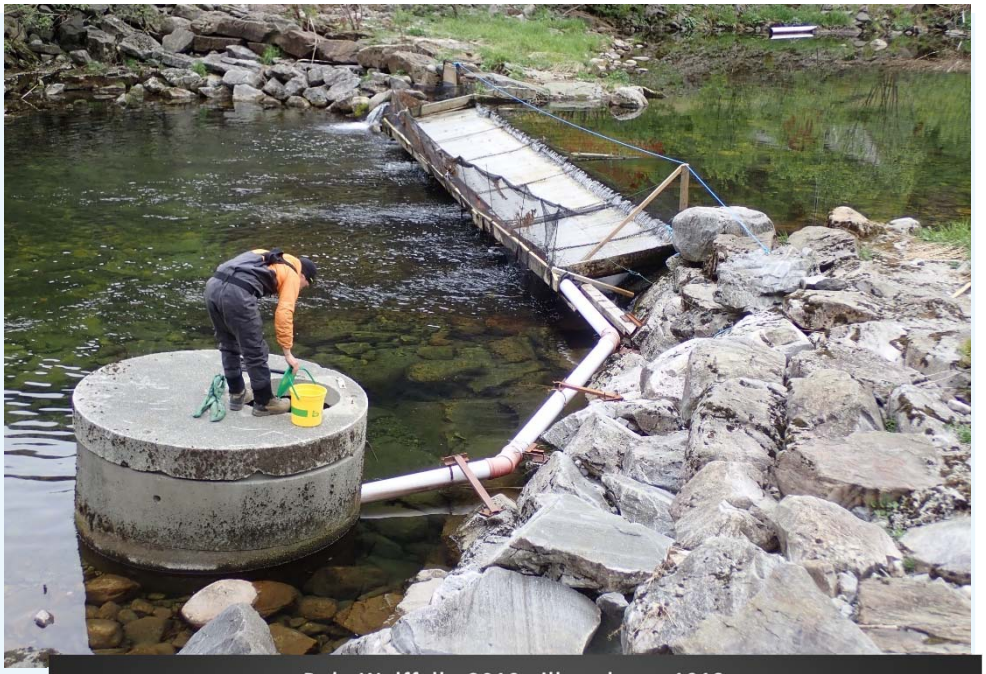
Summing up

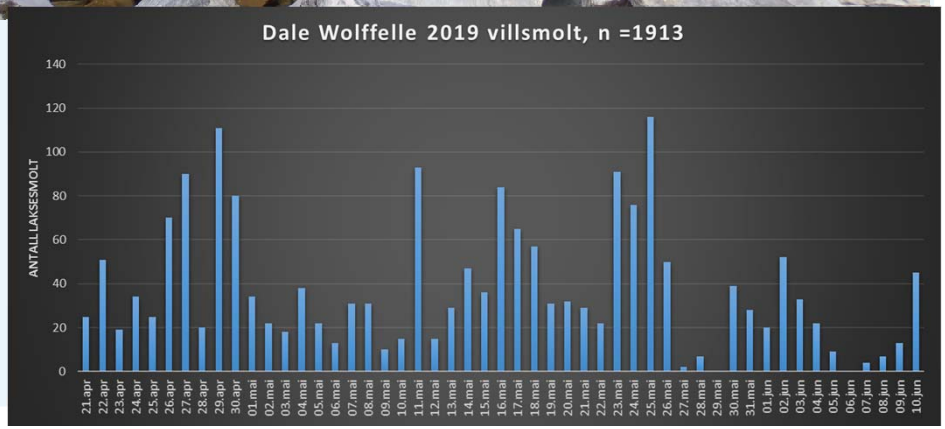
- Hydropeaking is highly pending local conditions
- Avoiding stranding is important and mitigation measures is a combination of:
  - Physical measures
    - Habitat restoration and weir construction
  - Plant discharge water, like Dale HPP
  - Monitoring of both fish, fish habitat and physical conditions

- All based on up to date field data and best scientific knowledge

Conclusions

- Hydropeaking is complex, pending hydrological condition, need for storage, marked conditions and demand
- Despite almost 100 year of hydro generation, the Dale river has satisfactory population of both atlantic salmon and seatrout
  - This years catch of smolt in the smolt trap indicates compatibility between power generation, hydropeaking and fish ….





Further reading:

- Cedren.no - Centre for environmental design of renewable energy - CEDREN
  - 8 years (2009 – 2016)
  - E.g.: EnviPEAK – handbook
- HydroCen.no
  - Ongoing research programme

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