ATLANTIC SALMON IN NORWEGIAN RIVERS- CHALLENGES AND OPPORTUNITIES

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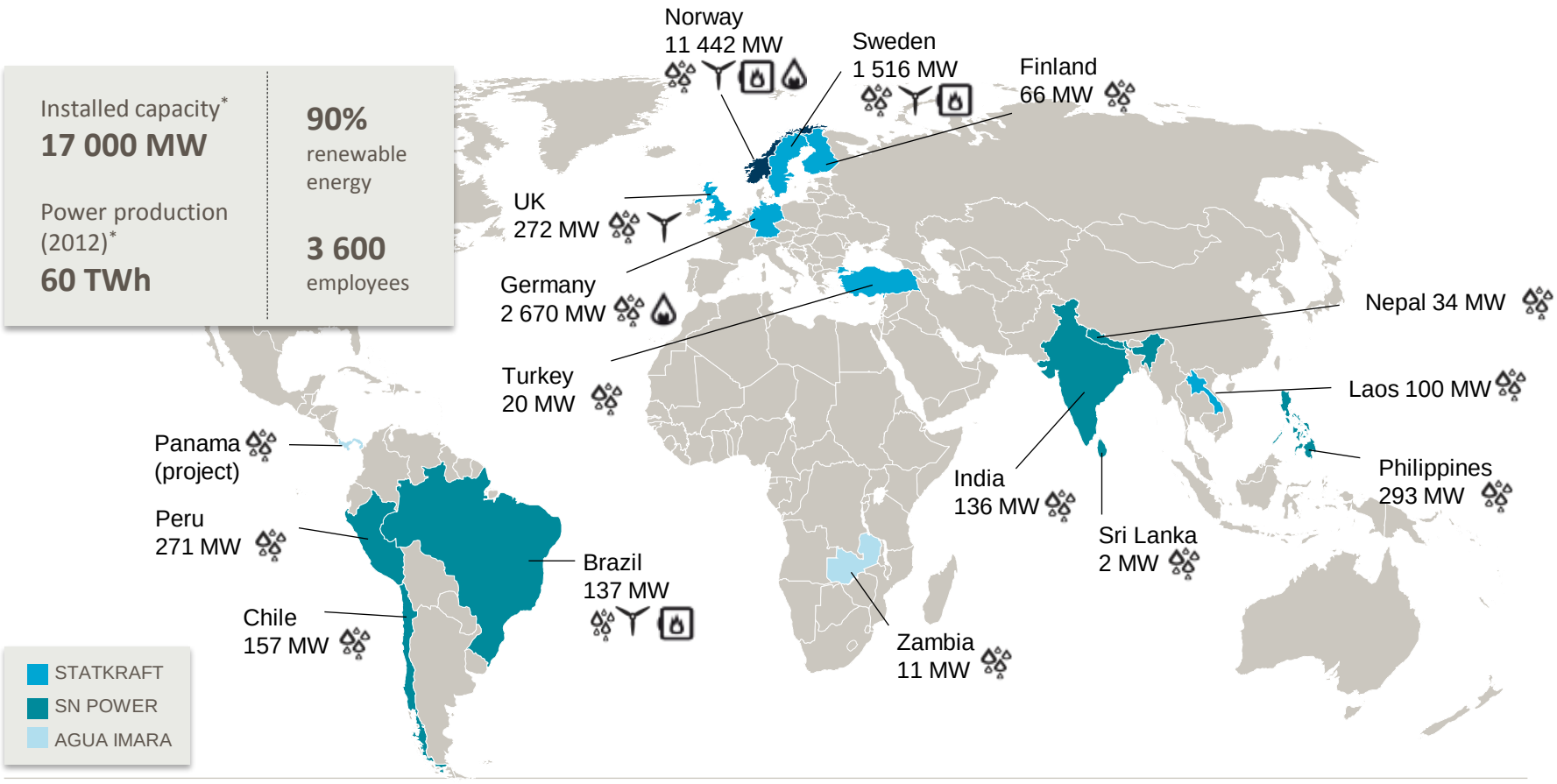
Statkraft at glance

Installed capacity*
17 000 MW

Power production (2012)*
60 TWh

90% renewable energy

3 600 employees



** Includes: Share in subsidiaries where Statkraft is majority owner 100 % of SN Power and Agua Imara's installed capacity*

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“You cannot step twice into the same stream…”
(Heraclitus, quoted by Platon in Cratylus)

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Status Norway: Atlantic salmon *Salmo salar* L.

- Increased numbers of multi sea winter salmon (3-7 kg and >7 kg) in 2011-2012 on the south-west coast of Norway probably due to improved marine conditions.
- Total return of salmon 50% compared to 1983 level- mostly due to low level of salmon <3kg.
- Increasing population in South-Norway and significant decrease in West-Norway.
- Industrial and recreational fishing not a significant threat, except in Tana.
- Two most important threats: Escape from fish farms and sea lice.

Thorstad & Forset, May 2013

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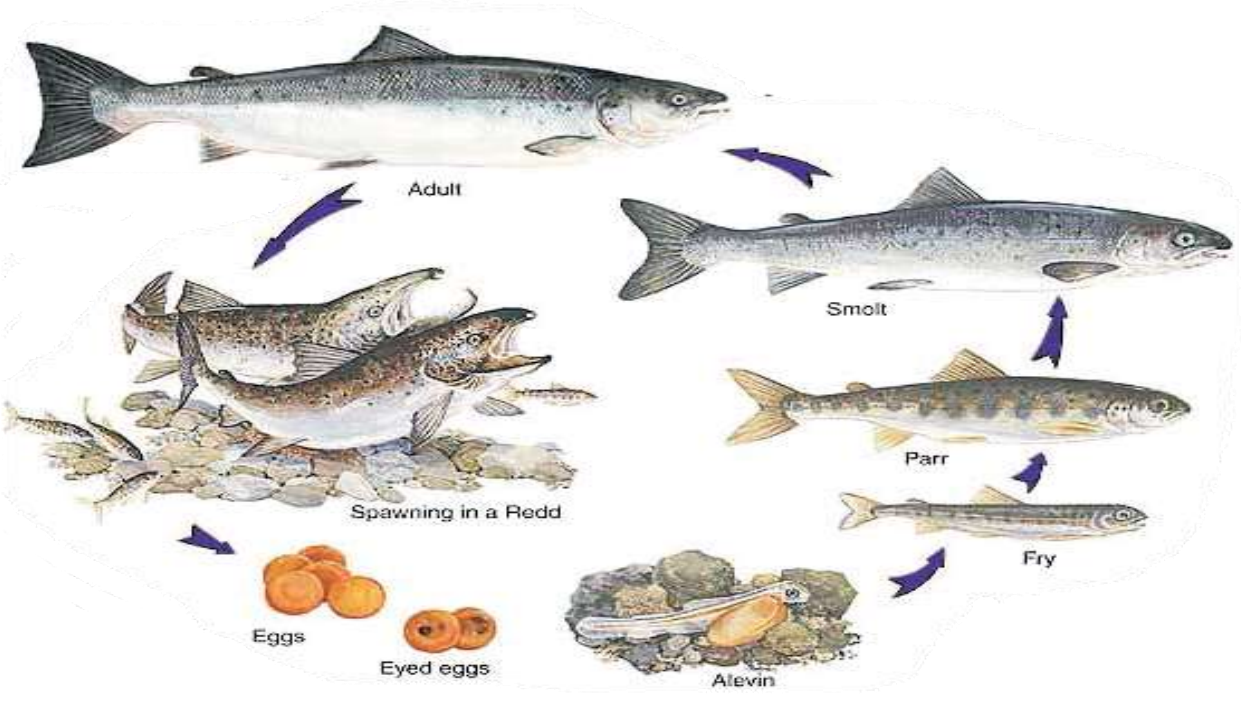
Holistic and adaptive management



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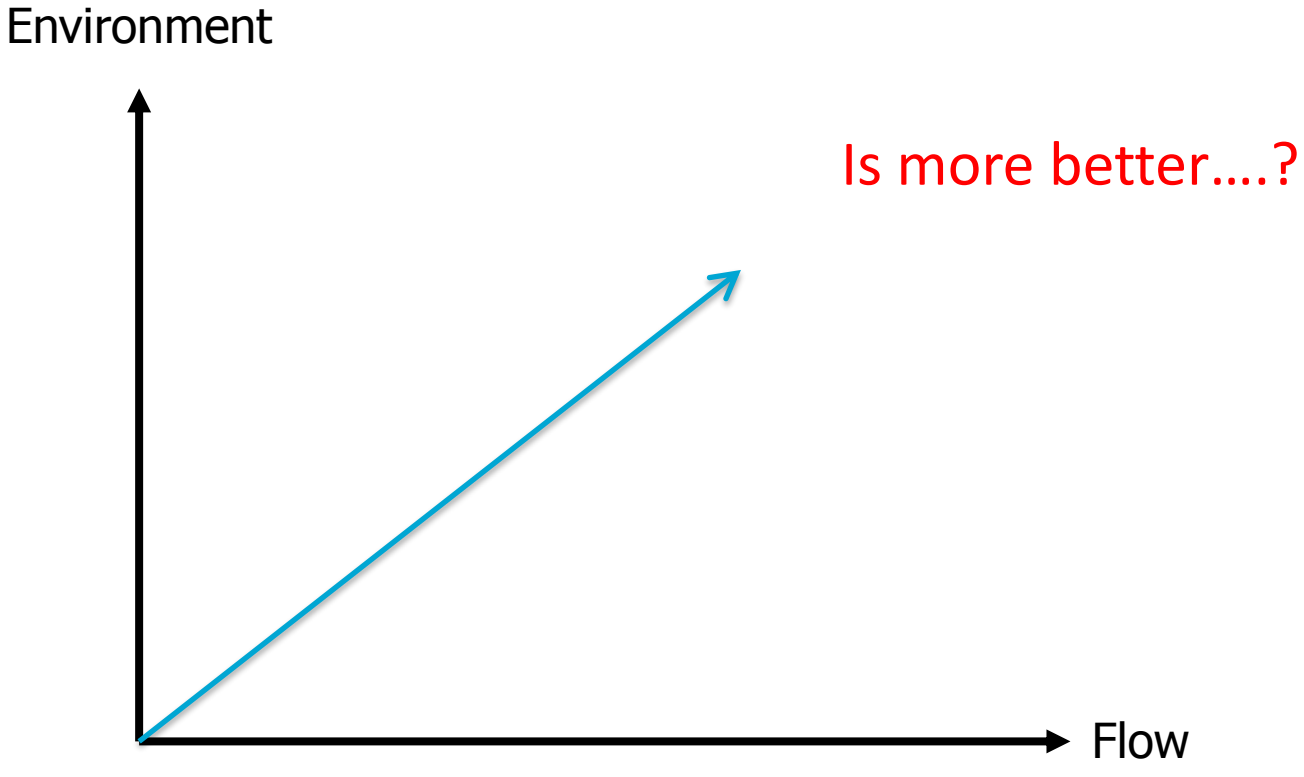
Targeting no restocking and focusing on sustainable populations of Atlantic salmon

- The national gene bank for salmon established by the Directorate for Nature Management in 1986 due to the difficult situation for Norwegian wild salmon in many rivers.
- Statkraft has 2 gene bank and 8 hatcheries (2 presmolt, 5 smolt, 1 for eggstocking).
- Genebanks: Preserve genes, e.g. after rotenon treatment of gyro infected rivers.
- Restocking of wild fish less successful due to low survival and low rate of returns (0.5-1%).
- Internal new (2014) R&D program to evaluate effect of restocking in rivers and reservoirs.

How much water is needed….?



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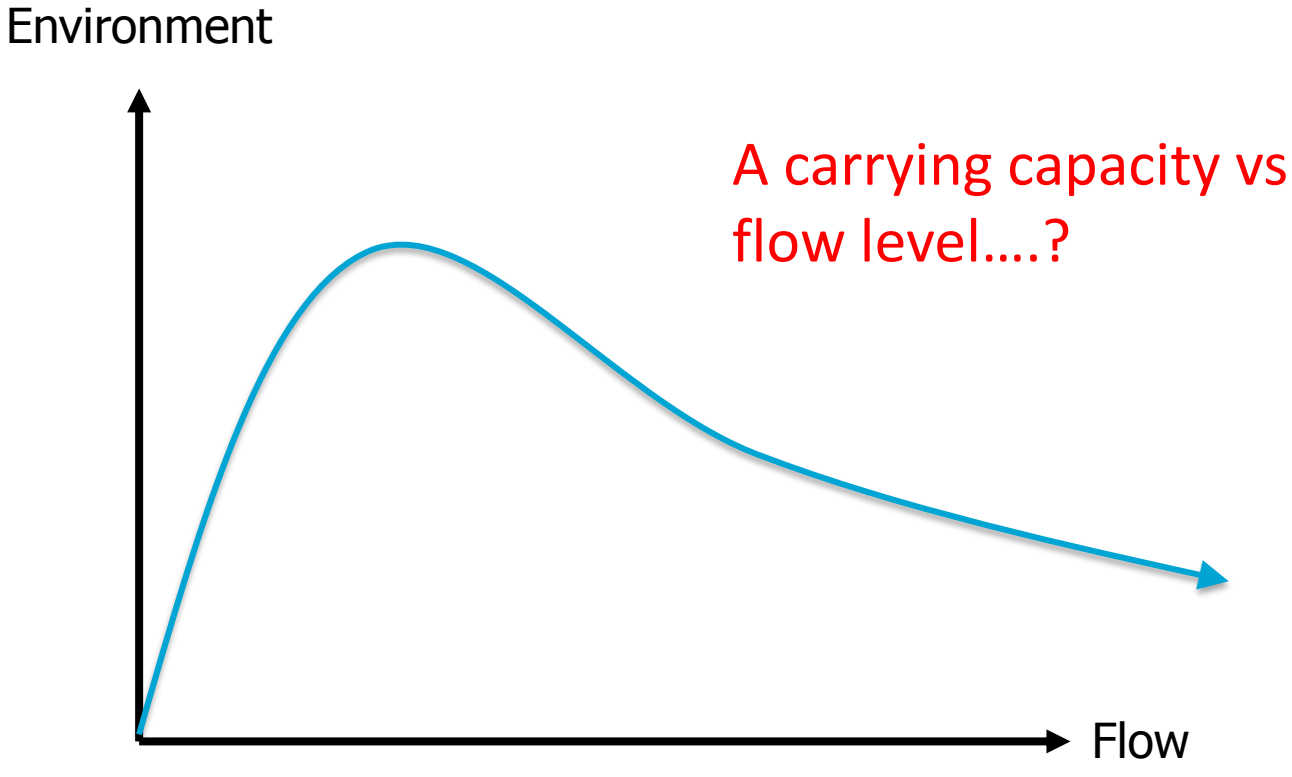

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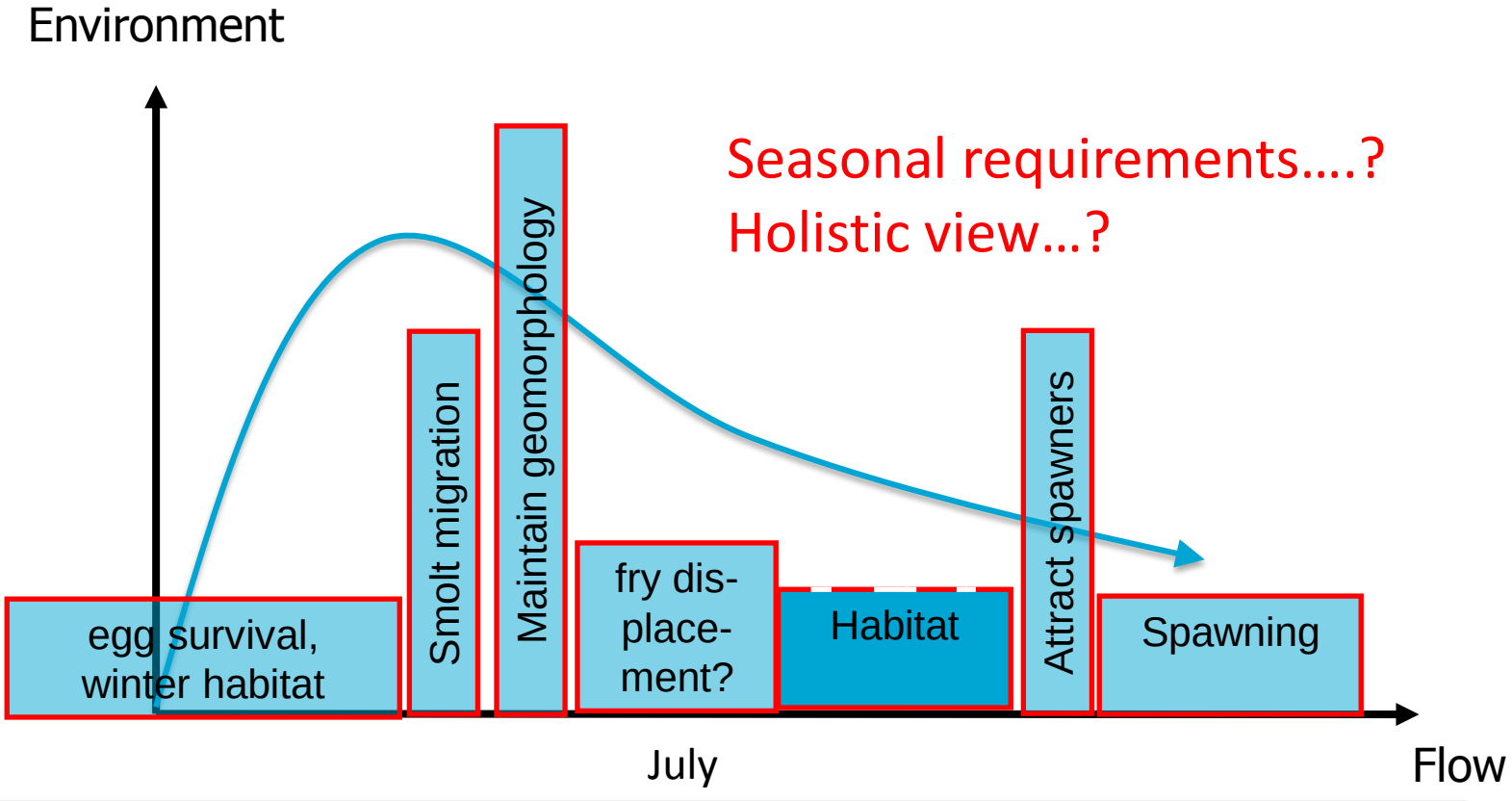

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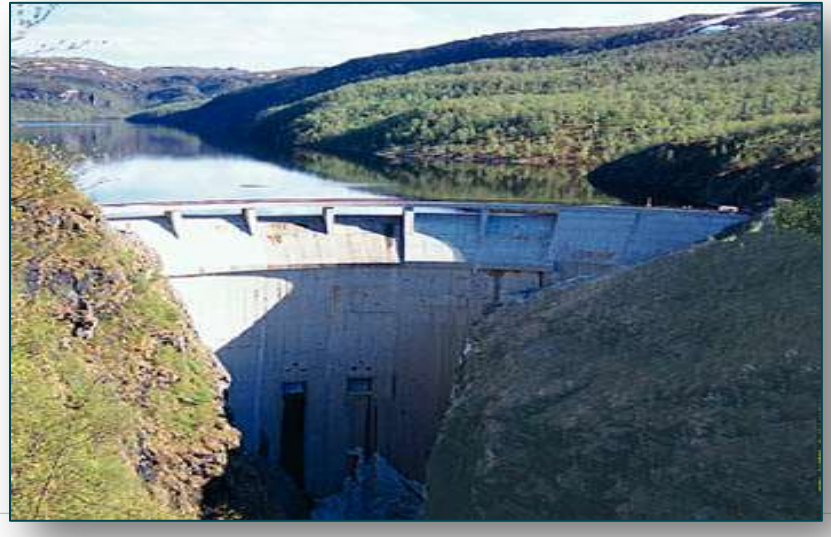
Our key challenges hydropower and salmon in Norway

1. Migration barrier and loss of connectivity
2. Spawning success and growth of juveniles



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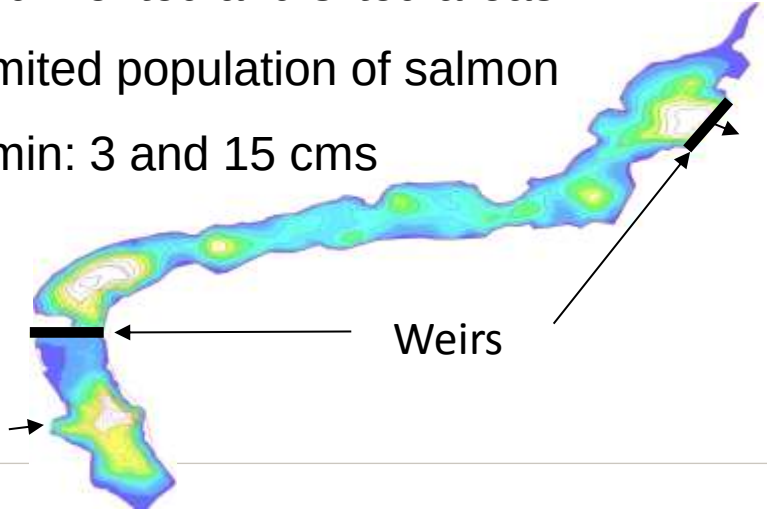
1. Migration barrier and loss of connectivity:

Case Nidelva, South-East Norway

Challenges:

- Weirs from 70’s build for estethic and recreational reasons
- Still water/low flow velocity, pike
- Sedimented and silted areas
- Limited population of salmon
- Qmin: 3 and 15 cms



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Migration barrier and loss of connectivity:

Case Nidelva, south-East Norway

Solutions:

- Hydraulic modeling to analyze removal of weirs testing different scenarios and outcomes
- Removal of weirs
- Biological monitoring of spawning and juvenile densities of Atlantic salmon before (since 2002) and after (2007) to evaluate results

Removal of weirs, before - after

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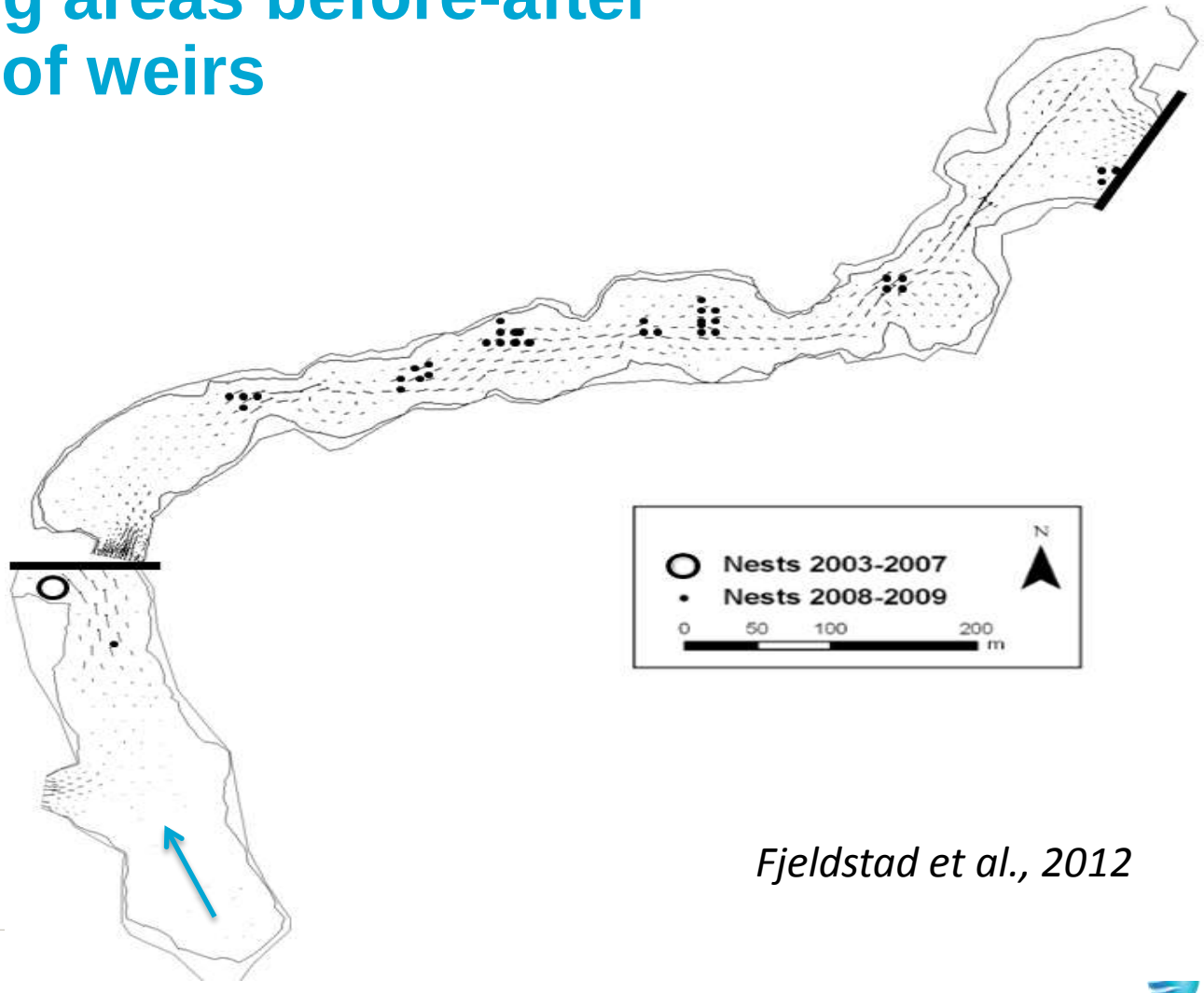
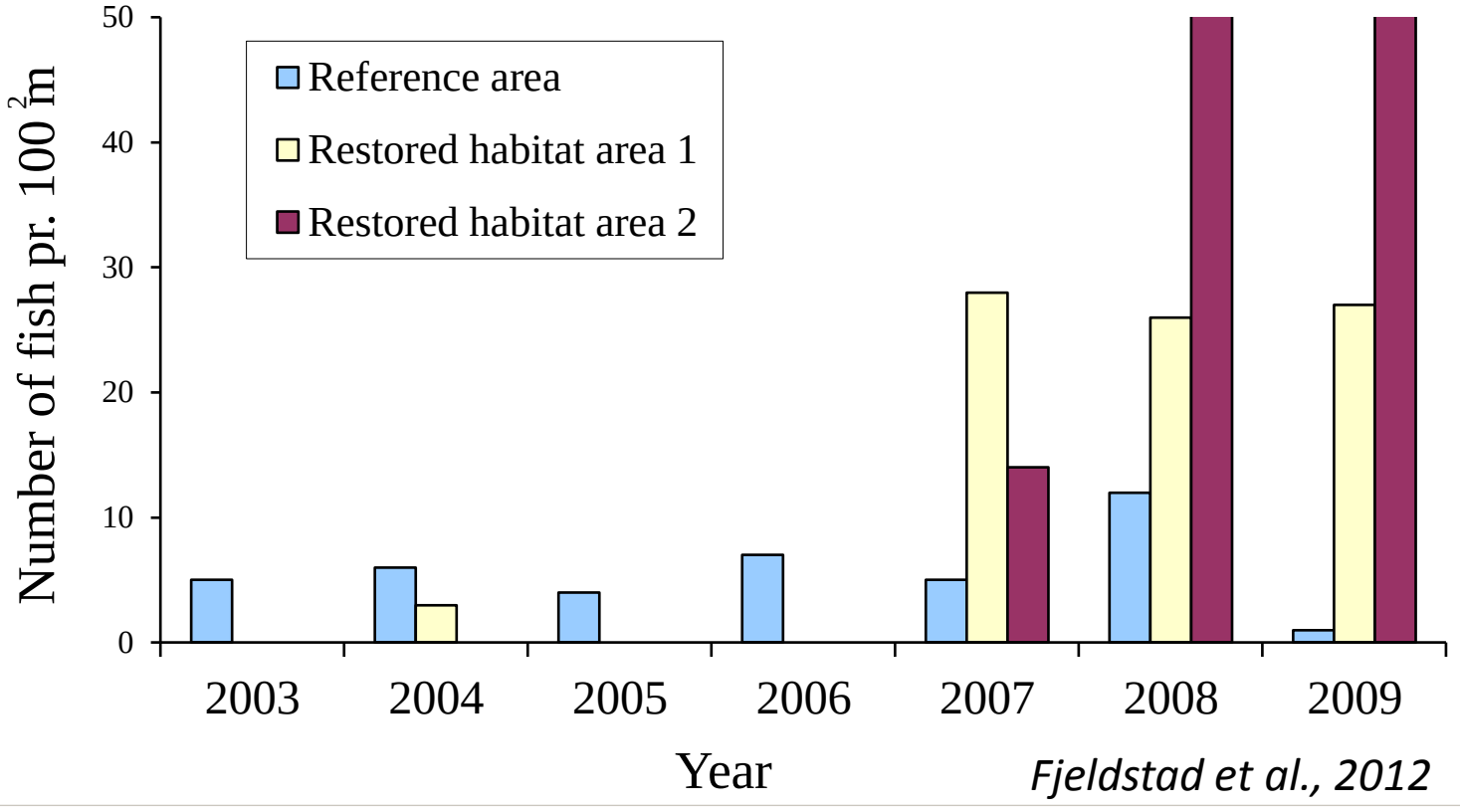
Spawning areas before-after removal of weirs



Fjeldstad et al., 2012

Densities of juvenile Atlantic salmon before-after



Fjeldstad et al., 2012

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Our key challenges hydropower and salmon in Norway

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2. Successful spawning and survival of eggs and juveniles

Case Bjoreio and spawning- North-West Norway

Challenges:

- Critical low level of Atlantic salmon population.
- High level (>20%) of escaped farmed salmon
- New action plan and investigations replaced mandatory restocking in the river.
- Hydro-regulation and low winter flow causing drying and freezing of spawning areas and eggs of Atlantic salmon
- Lower water temperature during the first feeding period (June/July) reduce fish growth and increase mortality the following winter

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Winter flow and stranding of spawning areas

Spawning in Atumn

Winter time conditions

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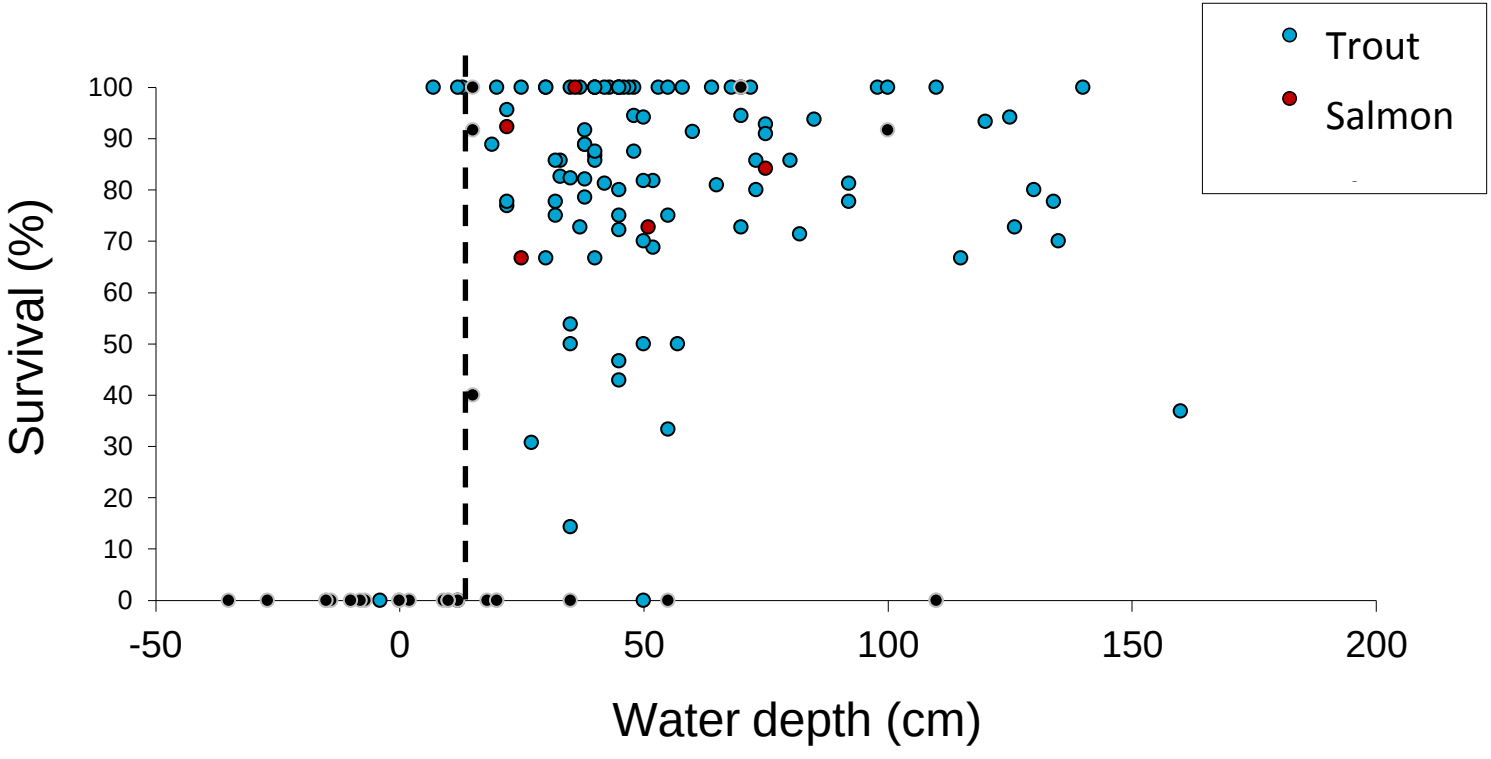
How much water to have 100% egg survival?



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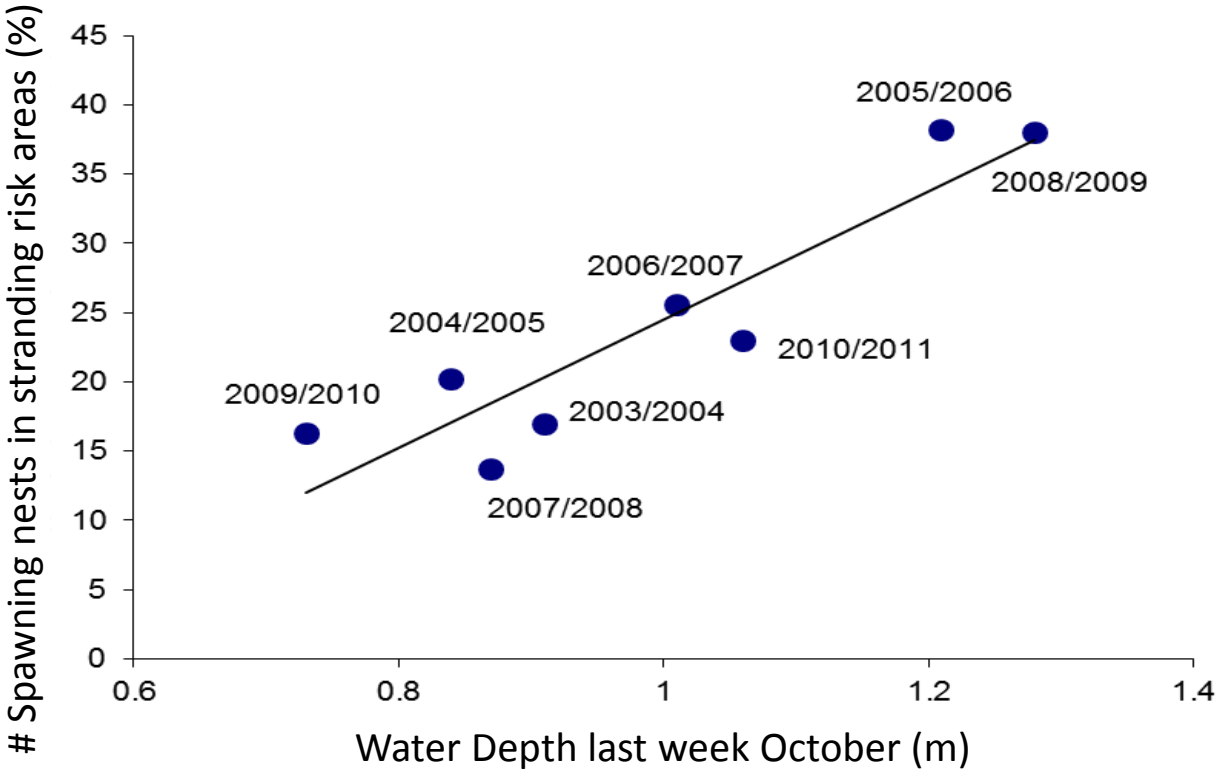
Correlation between water level during spawning period and proportion stranded redds



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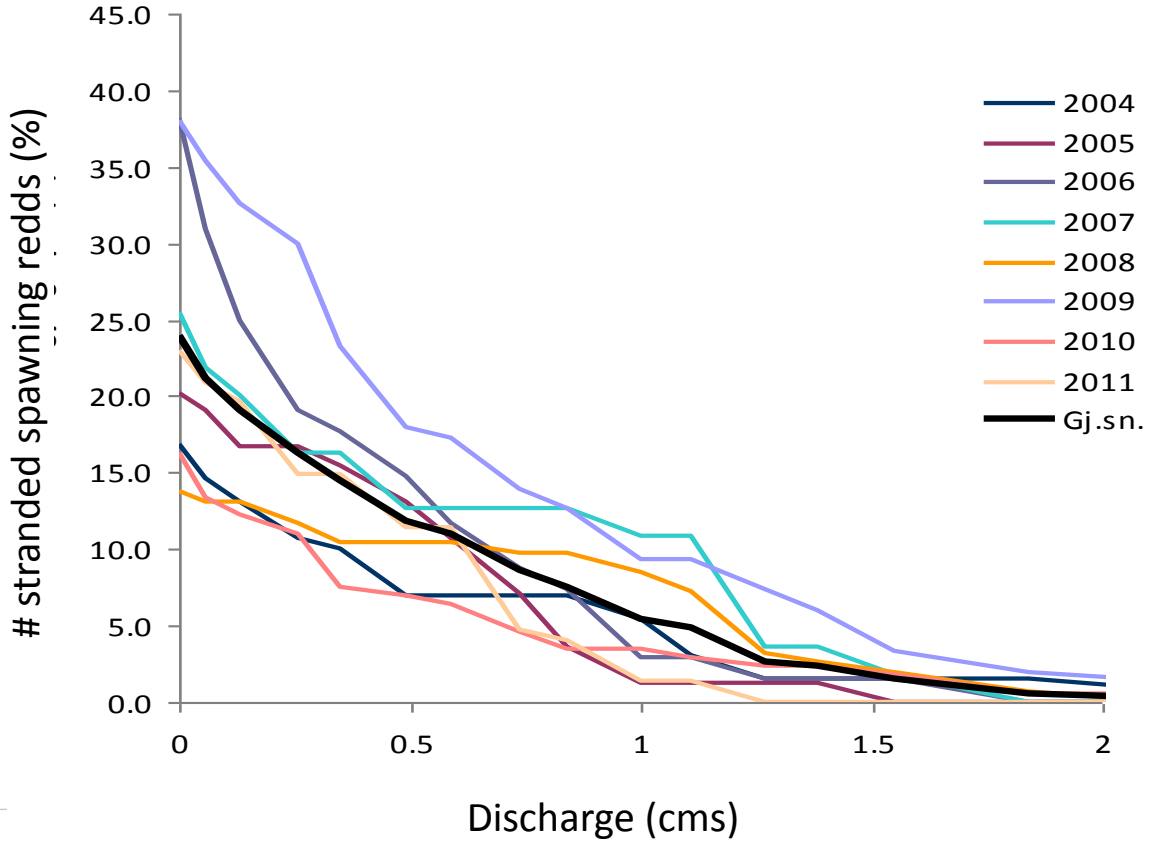
Mapped needed discharge to obtain zero stranding of spawning redds.



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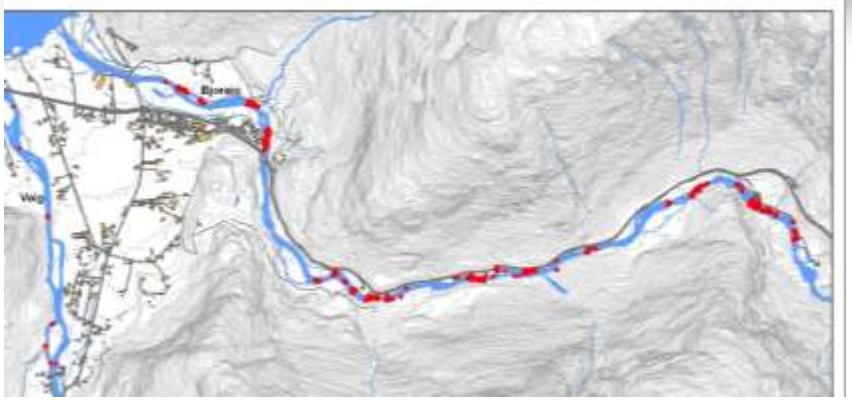
Spatial distribution of spawning areas is vital to increase total production of salmon.

1069 spawning areas registered and analyzed 2004-2012.

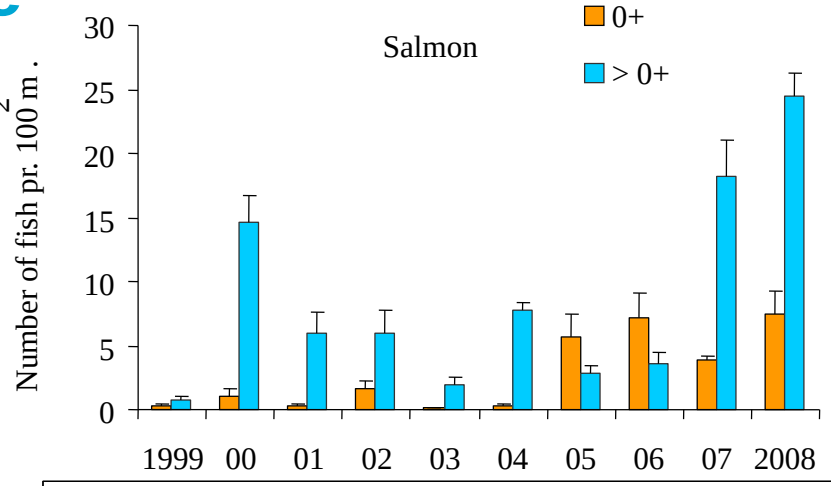
Strong correlations between river scale juvenile density

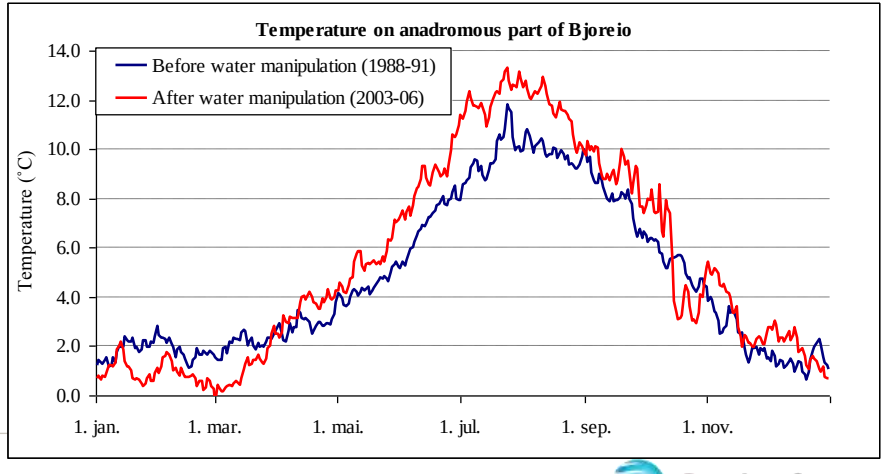
- and the percentage river area suitable for spawning
- and the spatial distribution of spawning areas.



Increased juvenile growth and density by altered water temperature

- Modelled growth of juvenile salmon vs water temperature
- Replaced 40% of the cold water with 2-4 degrees warmer water by releasing water from two other intakes during summer.
- Measured growth and densities of 0+, 1+ and 2+
- Increased growth and densities as a direct result of altered temperature in the minimum release





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Overall positive outcomes

Foto: LFI-Unifob v/B. Barlaup

- By small modifications of the flow regime a win-win situation is created by improved environmental conditions for salmon with limited level of production loss
- But it takes time, and data before-after is critical, i.e. holistic and adaptive management and crossdisciplinary planning is crucial

Future..?

Handbook on hydropower and environmental design finalized Sept-2013

- Focus species: Atlantic salmon (*S.salar* L.)
- Up to date knowledge on hydropower and Atlantic salmon- Environmental Design
- Two main parts
  1. Diagnosis
  2. Solutions
- Multidisciplinary linking biology and hydrology

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