Environmental design of hydropower: New developments and examples

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FME CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH
The Research Council of Norway

Hydropower summit 2020

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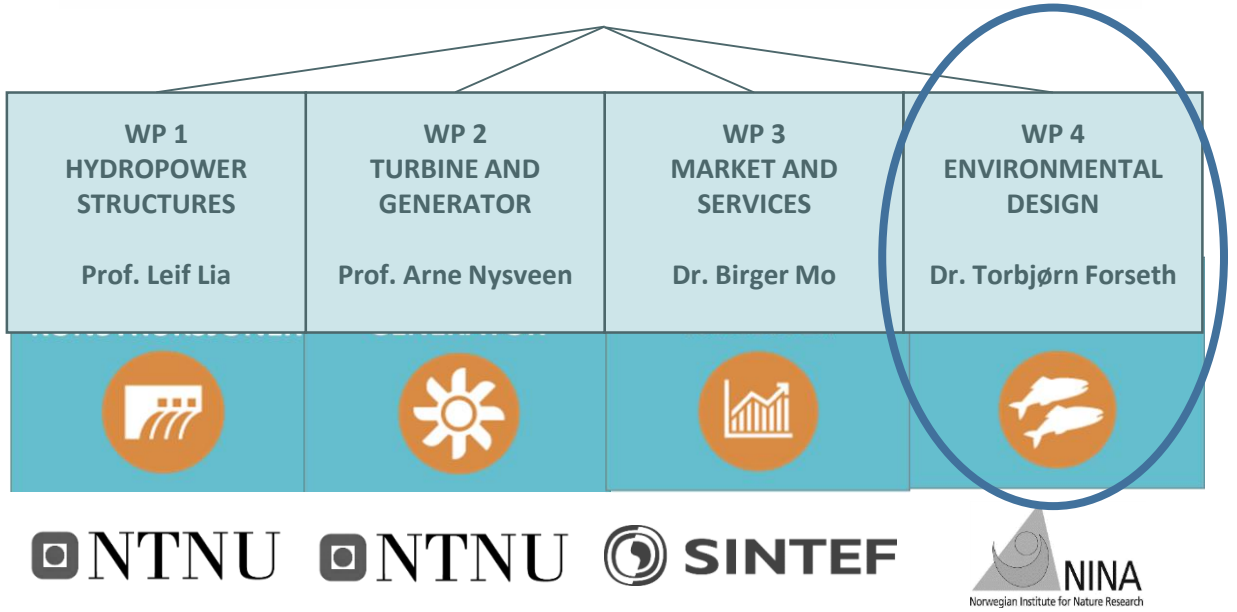

WP 4 ENVIRONMENTAL DESIGN

Main objective:

Expansion of the “environmental design in regulated salmon rivers” concept to new ecosystem components and multiple services and user interests

Tasks:

- T 4.1 Governance and social acceptance
- T 4.2 Ecological connectivity for fish in regulated rivers
- T **4.3 Environmental design for multiple interests under future flexible hydropower operation**

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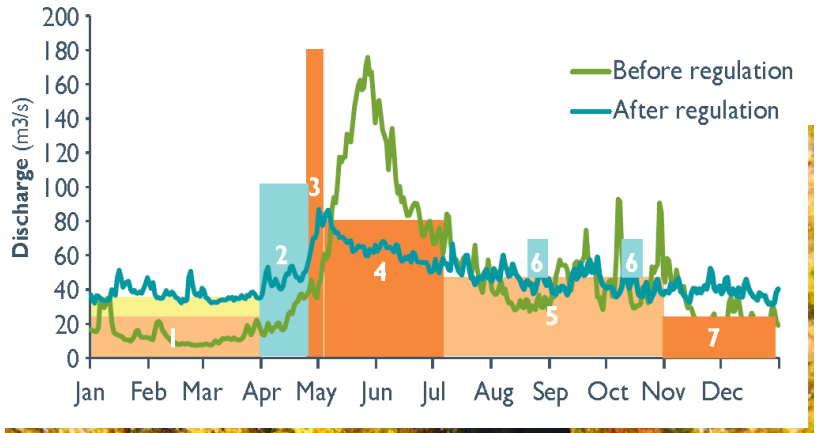
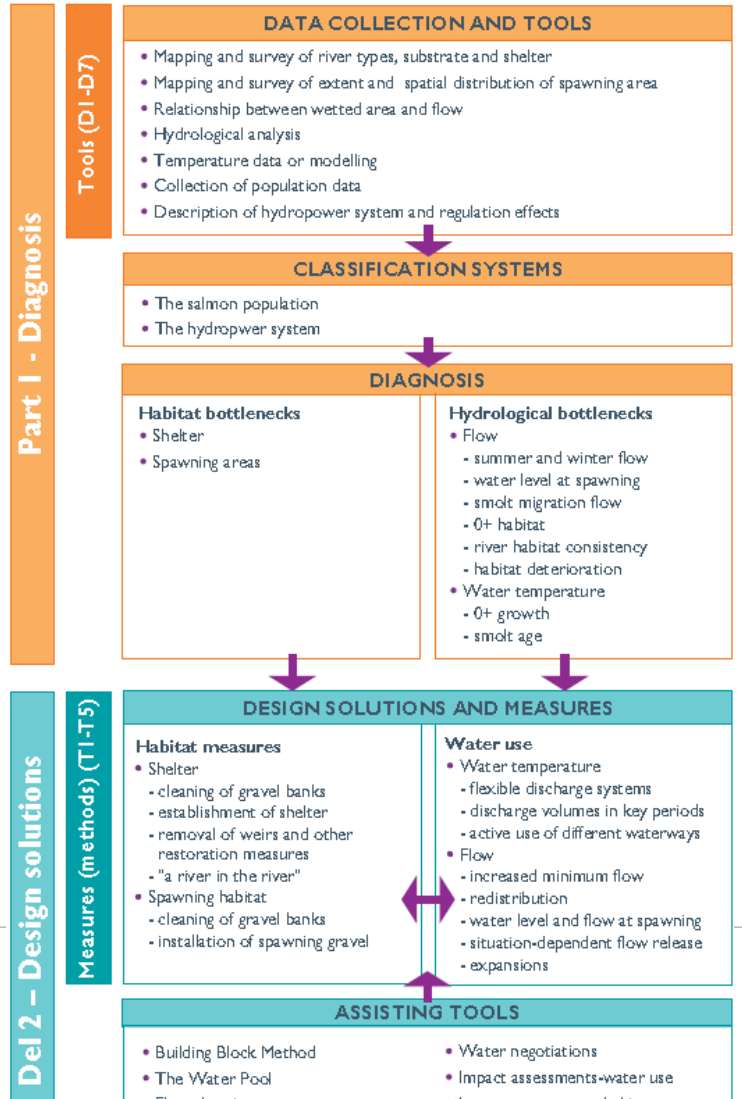
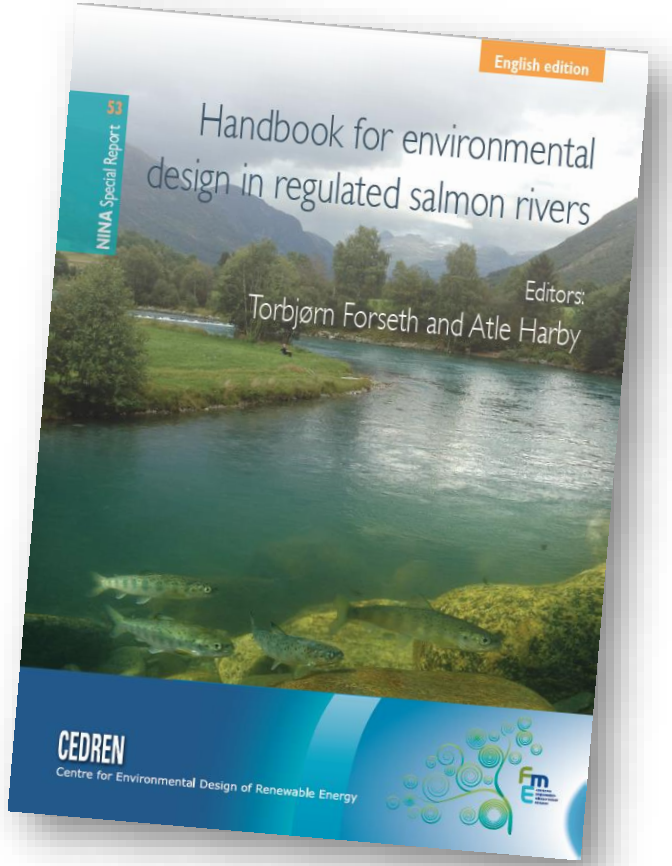
4.3 Broader environmental design

- Originally developed for “salmon vs. hydropower”







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4.3 Broader environmental design

- Expanding the concept to new river systems
  - Inland river systems; trout, grayling and other fish species
- Adding more ecological elements and people
  - biodiversity, recreational use, landscape perception
- Adding other hydropower services
  - Flexibility and balancing
  - Flood protection

Method Developments

Case studies




Method development

- Genetic kinship for comparing relative population sizes (for connectivity assessments)
- eDNA and barcoding for mapping and classification of invertebrate diversity
- Methods for mapping recreational use and interests
- Remote sensing for habitat mapping (satellites, drones, red and green lidar, optical sensors and other instruments) PhD work

Case: River Nea

Case: River Nea

- The 30 km long stretch up to the Heggset Dam (ca. 30 km)
- by far most important spawning river for brown trout in the lake Selbusjøen
- The lake holds piscivorous large bodied trout
- There are currently 32 weirs on the stretch

Case River

- Trout (pike & minnow)
- Green LiDAR (own mapping)
- Biodiversity
- Recreational use
- Weirs, aesthetics and landscape perception
- Measures

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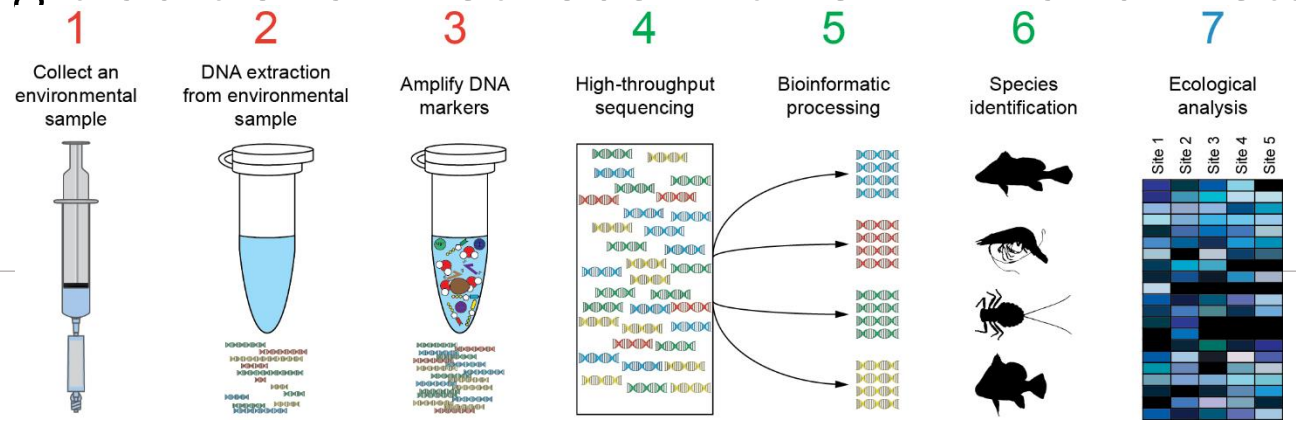
Biodiversity from a bottle of water

- Environmental DNA (eDNA) is currently revolutionizing biodiversity assessment in lakes and rivers.
- To what extent can eDNA be used as a mapping tool
  - Red-listed species
  - Key species for ecological functioning
  - Biodiversity
- Comparing traditional methods with e-DNA and meta-barcoding



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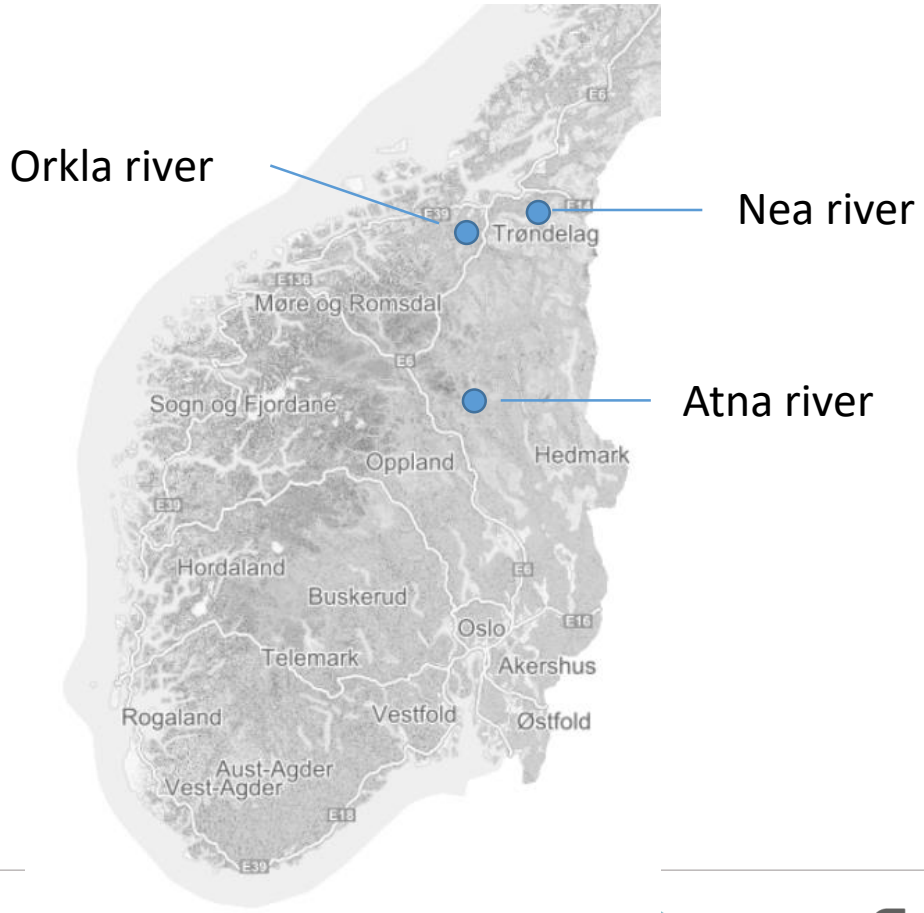
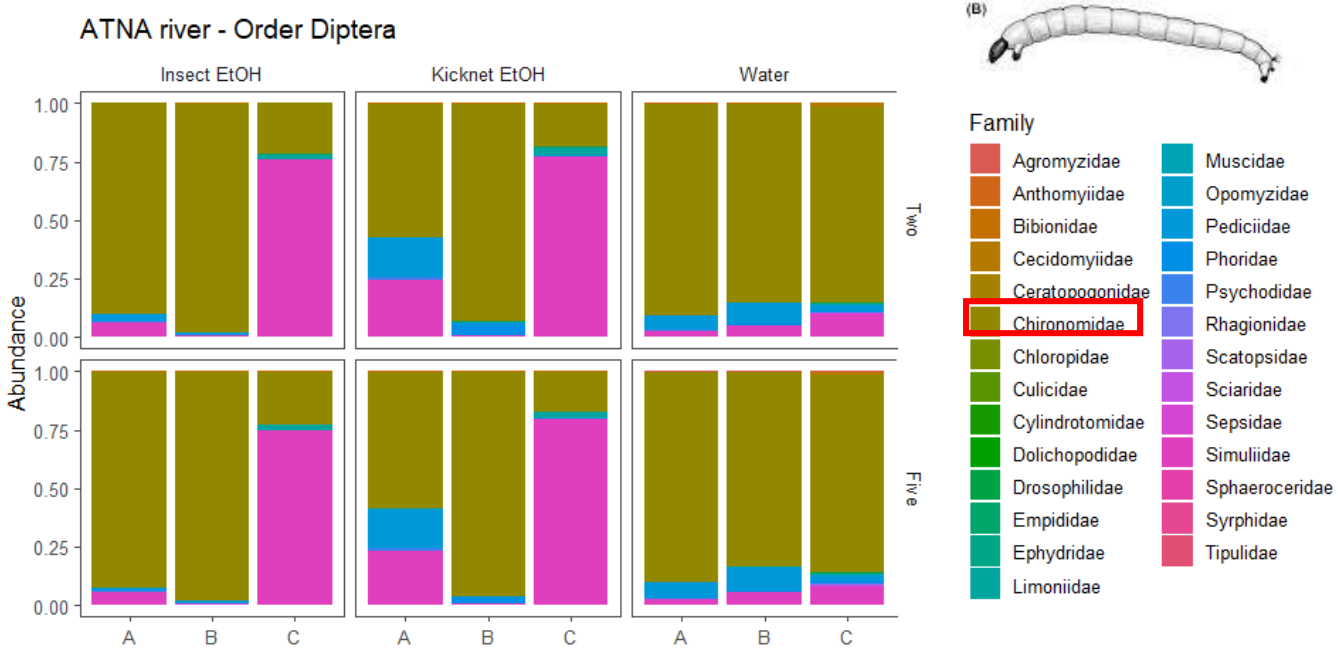
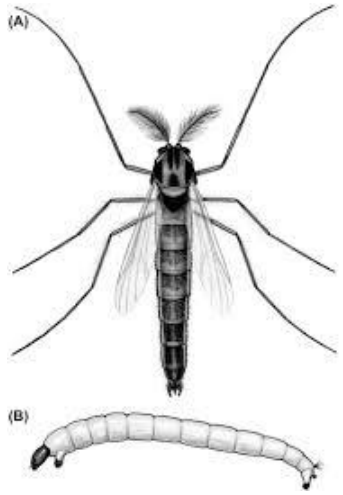
- Benthic diversity
  - Water Frame Directive
    - Ecological status
  - EPT-index (eutrophication)
    - Order Ephemeroptera
    - Order Plecoptera
    - Order Trichoptera
  - Kicknet-sampling and eDNA



A striking pattern





Order Diptera and Family Chironomidae dominates the DNA-data!

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Still some work to find optimal markers

BIN	Insects	EtOH	Water
Amphinemura borealis	0.01944585	0.00381064	0.00685842
Amphinemura sulcicollis	0.00687052	0.00054895	0.00223878
Amphinemura sulcicollis, Amphinemura standfussi	0.00052764	8.49E-05	0.0003551
Capnia atra	0.00380944	0.00222303	0.00083175
Capnopsis schilleri, Capnopsis chilleri	1.25E-06	0.00644745	0.0007819
Dinocras cephalotes	0.0281271	0.00060119	0.00187673
Diura nanseni, Diura bicaudata	0.06750801	0.00566673	0.00810901
Isogenus nubecula	0.00799243	3.89E-05	0.00106428
Isoperla difformis			0.00023779
Isoperla grammatica	0.0010975	5.98E-06	0.00014317
Isoperla obscura			0.000112
Isoperla obscura, Isoperla grammatica	0.00689313	6.28E-05	0.00108021
Leuctra digitata	0.00025991	0.00013787	0.00080087
Leuctra fusca, Leuctra digitata	0.00641626	0.01030072	0.00346327
Leuctra hippopus	0.02326122	0.00047056	0.00292855
Leuctra hippopus, Leuctra digitata	0.00214501	1.18E-05	6.84E-05
Leuctra nigra	7.20E-06	0.00142146	0.00088116
Leuctra sp. MAA	9.05E-06	4.13E-05	
Nemoura avicularis, Nemoura cinerea			0.00033385
Nemoura flexuosa		5.28E-06	0.00056475
Nemoura flexuosa, Nemoura cinerea, Nemoura dubitans			0.00035513
Nemoura sp. G_BB3			9.99E-05
Protonemura meyeri	0.00203654	7.88E-05	0.00038325
Siphonoperla burmeisteri		1.64E-05	0.00106702
Siphonoperla burmeisteri, Xanthoperla apicalis	0.00781966	1.84E-05	0.00227956
Taeniopteryx nebulosa	0.01896452	0.0010401	0.00116463

Kicknet-sampling
Amphinemura borealis
Capnia atra
Dinocras cephalotes
Diura nanseni
Isoperla grammatica
Isoperla obscura
Leuctra fusca
Leuctra hippopus
Leuctra sp.
Perlodidae spp.
Protonemura meyeri
Siphonoperla burmeisteri
Taeniopteryx nebulosa

Orkla river - Plecoptera

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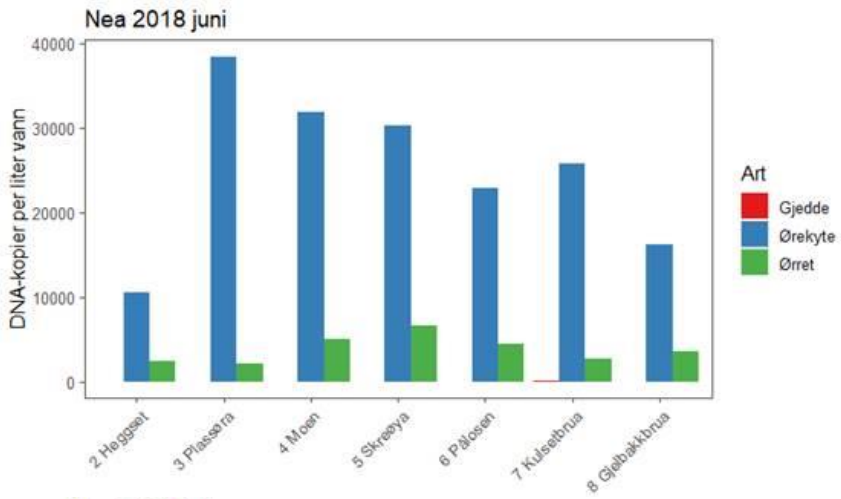
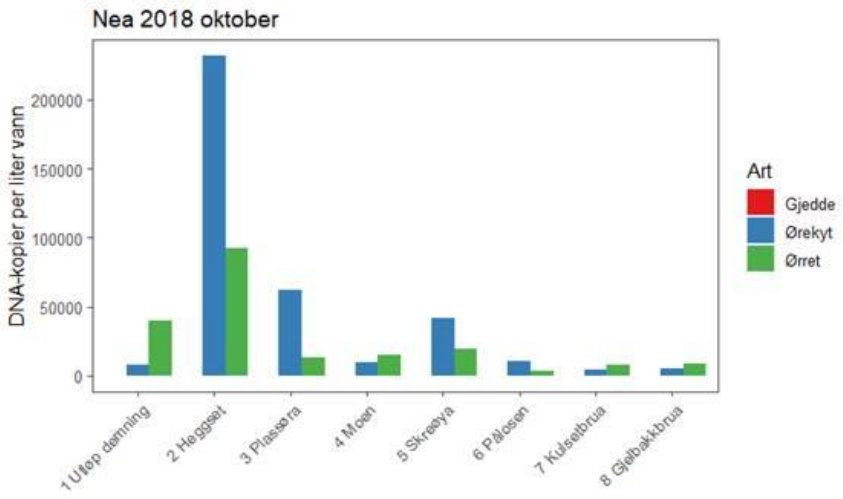
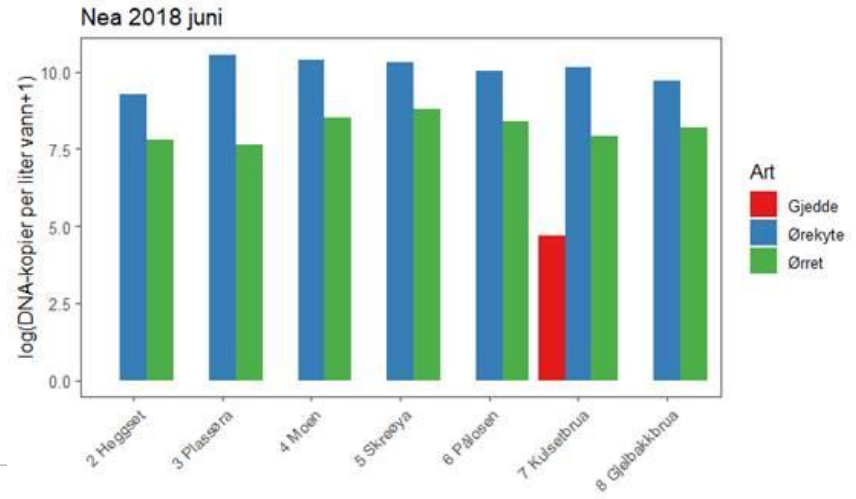
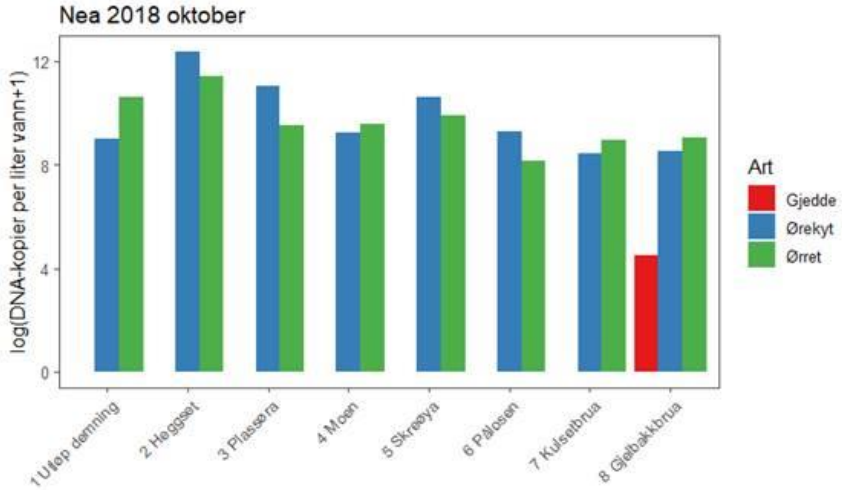
Nea river – fish eDNA density









Pike

Minnow

Brown trout

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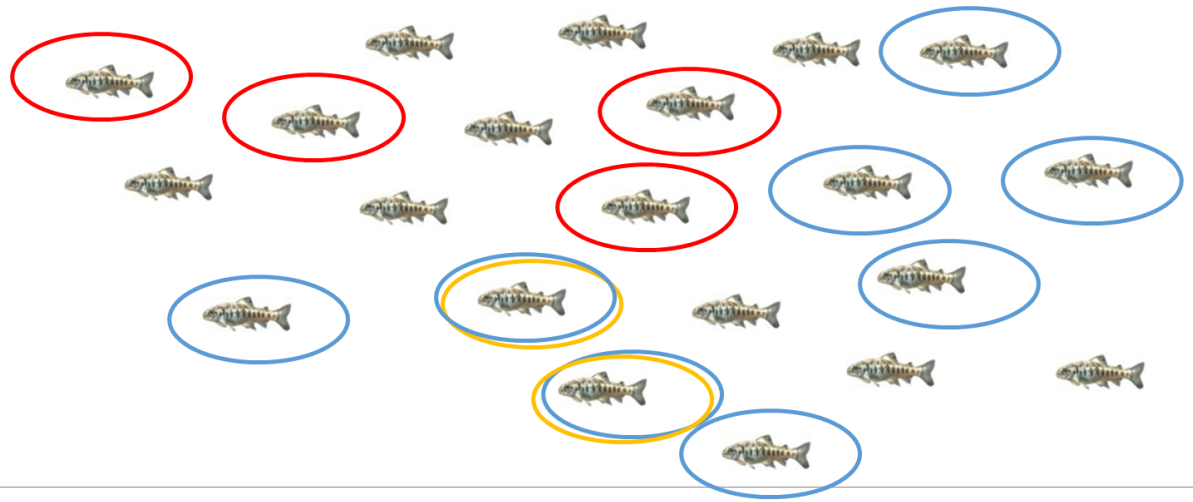
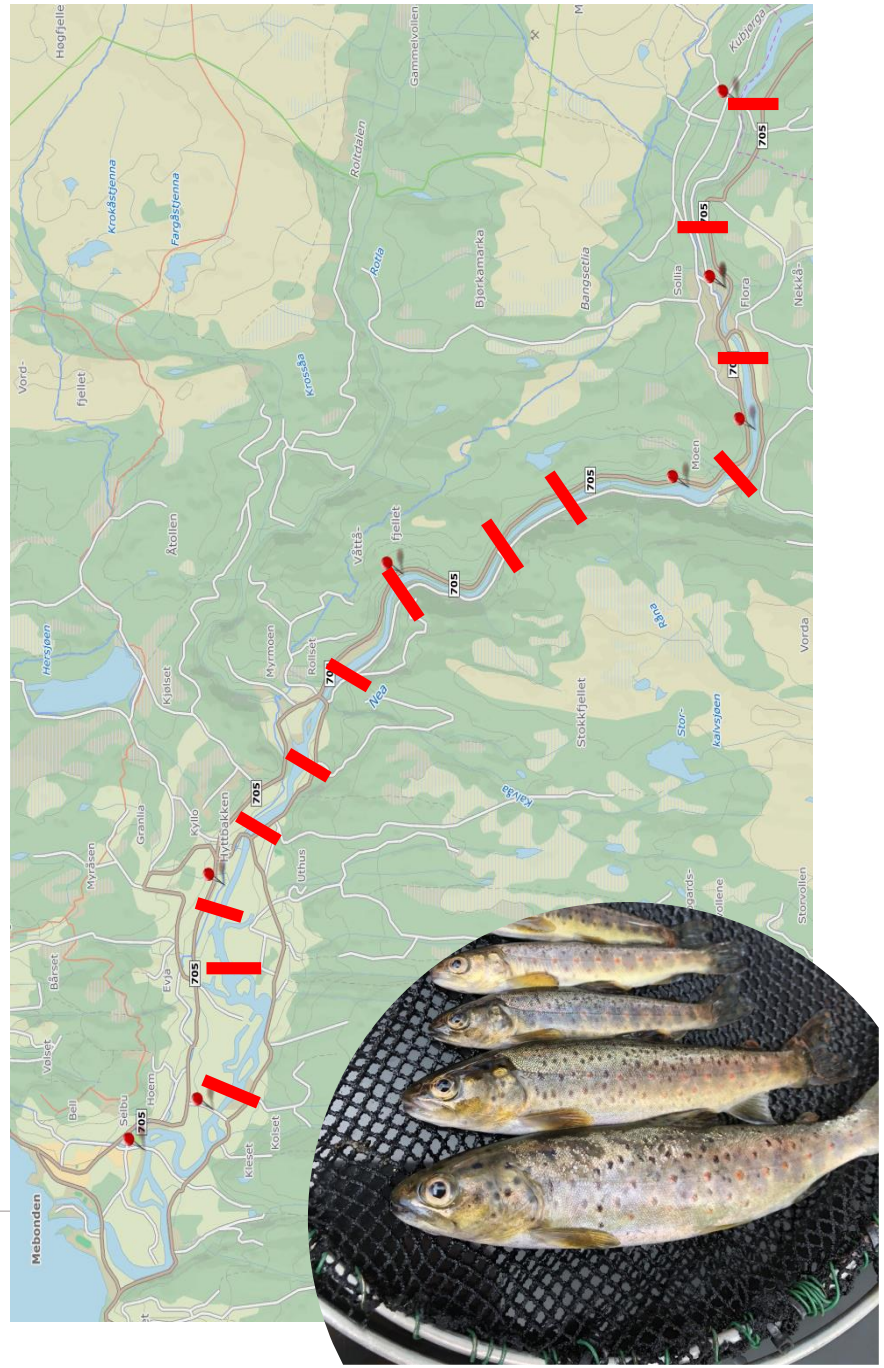
Genetic kinship

Use genetic kinship to test the effect of weirs on the brown trout population



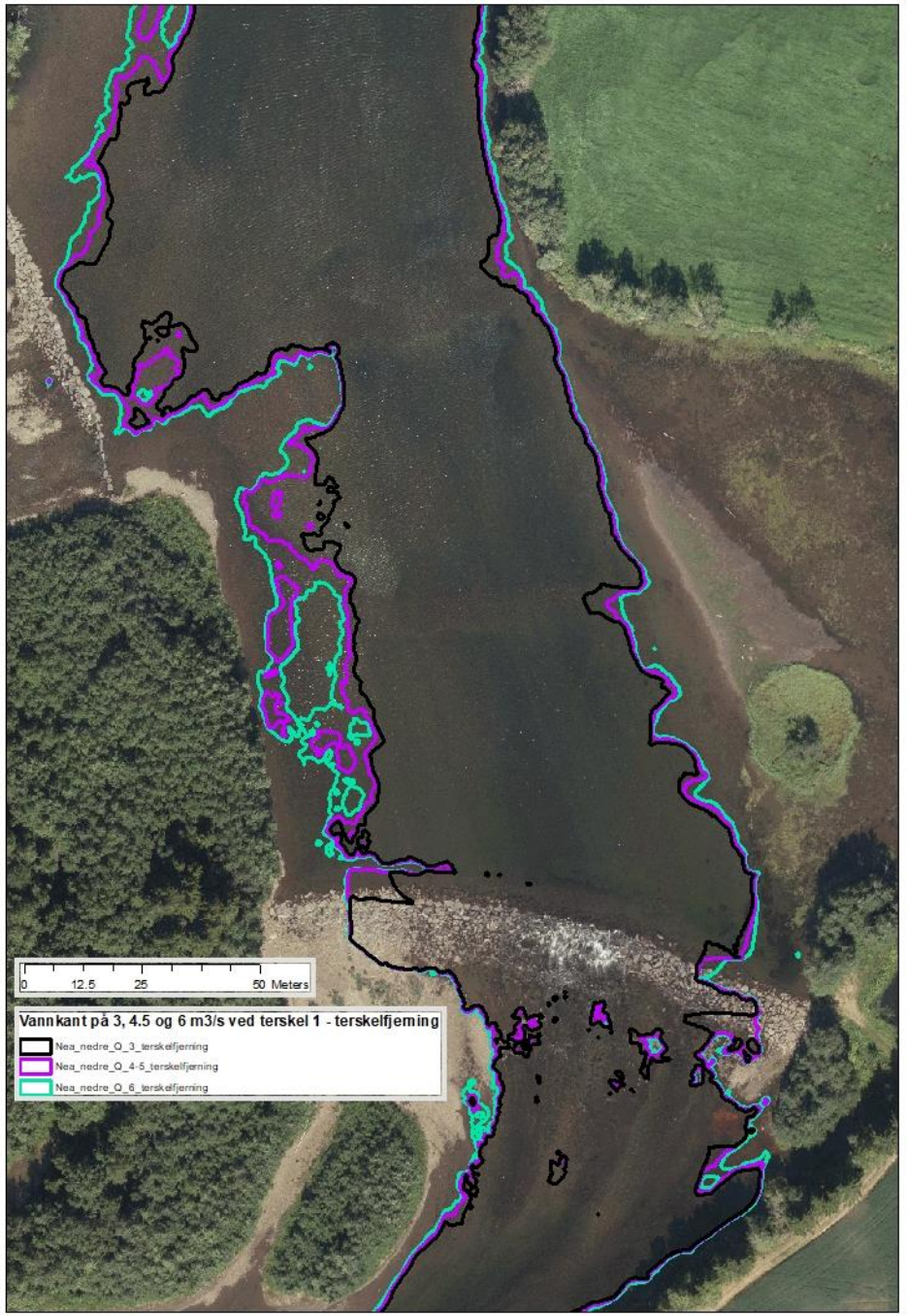


Using remote sensing for hydrodynamic modeling of weir adjustments or removals

- Green laser data
- Hydrodynamics
- Flow alteration
- Photo scenarios
- Tourism / local communities

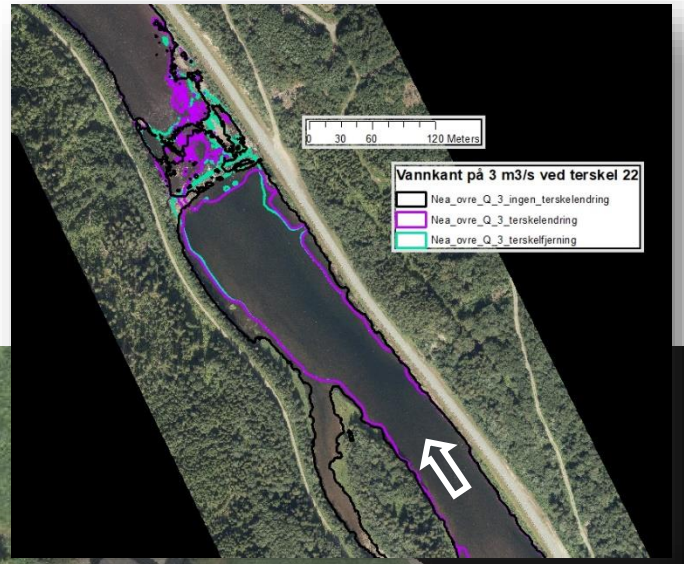
-> How does tourists and locals react to possible changes of flow and water covered area in their rivers;

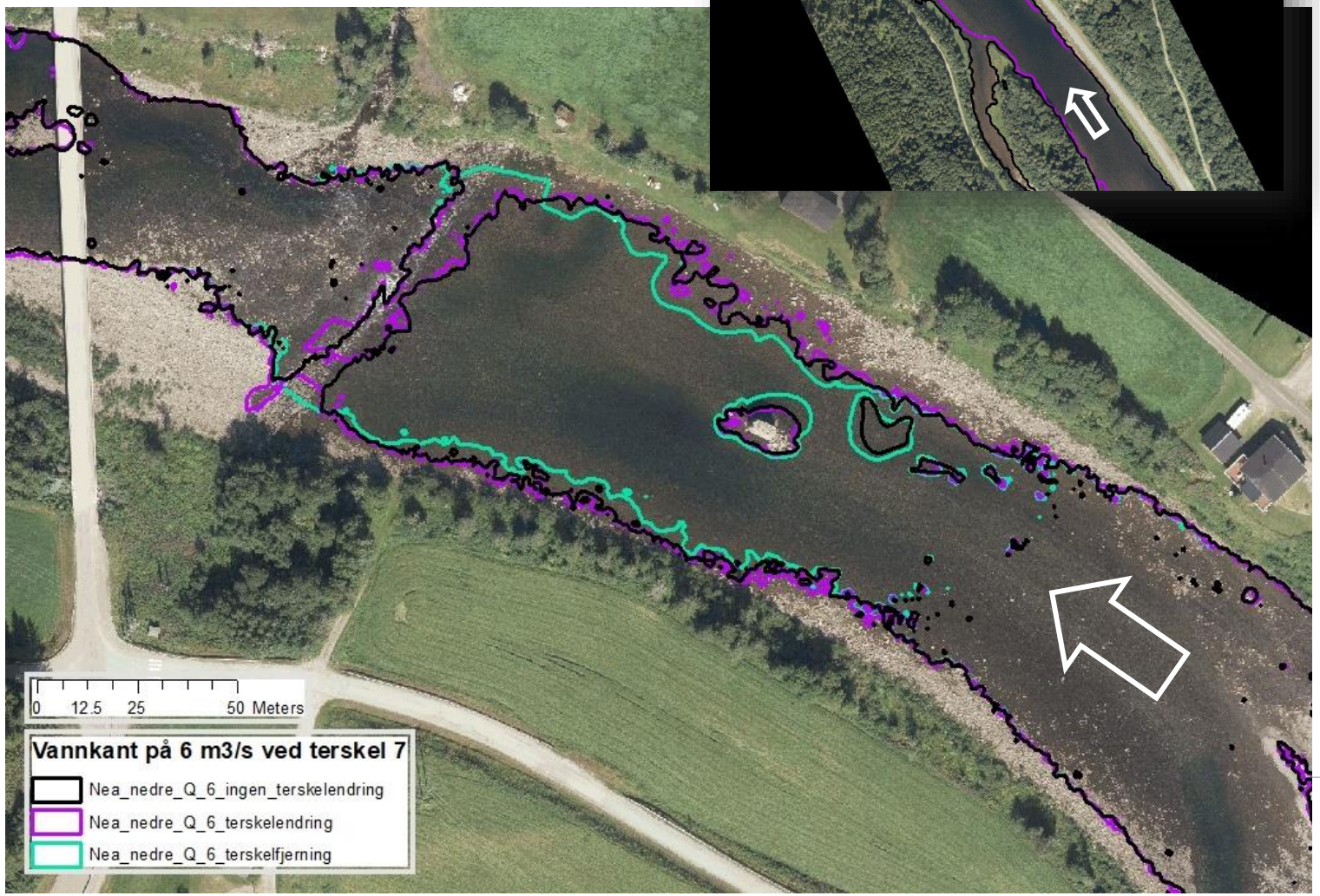
Visual preference assessment

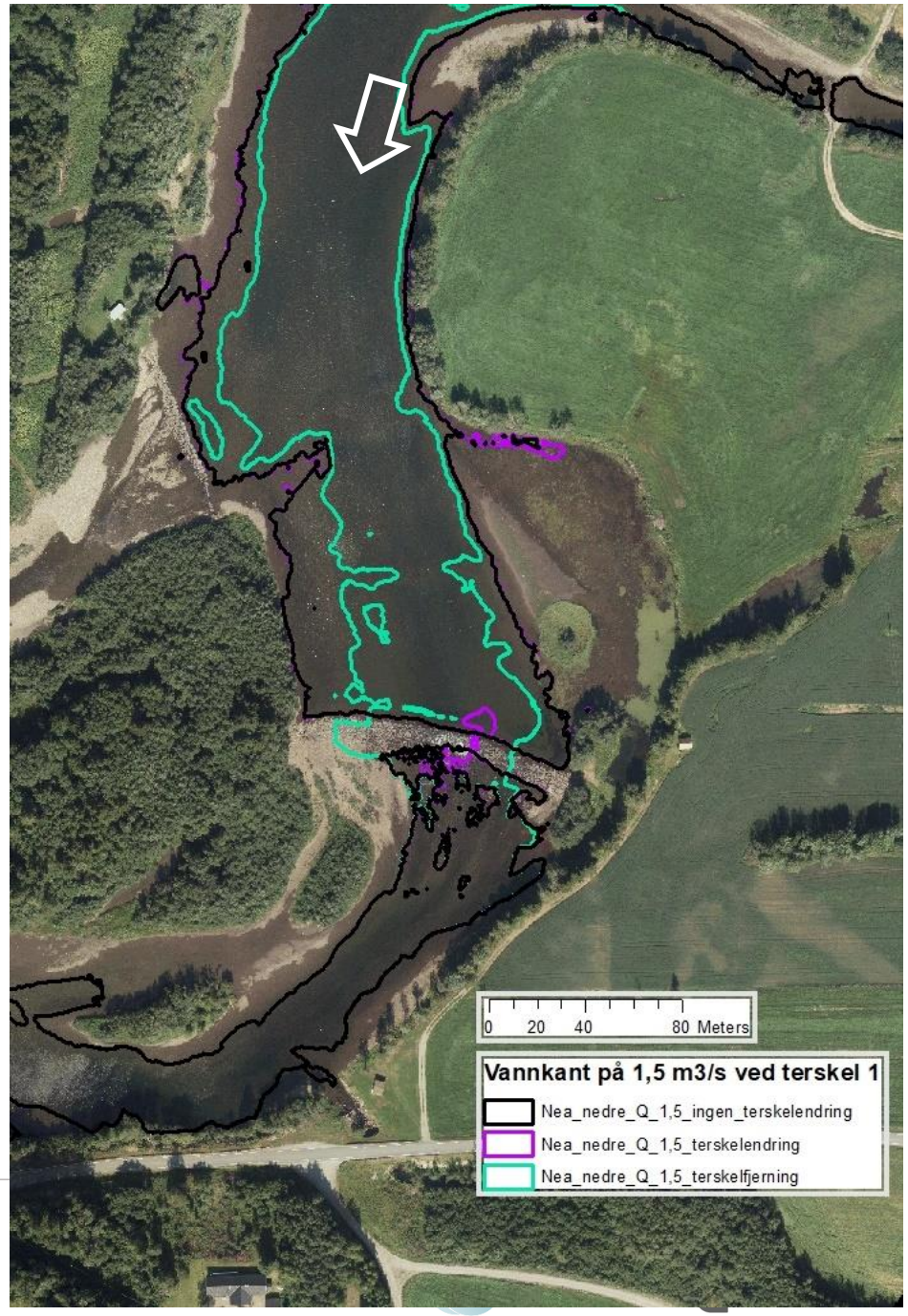


Examples from HydroCen

From model to photo-manipulations







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Thank you!

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The role of reservoirs in flood protection

Energy services - flexibility

The HP systems ability to provide energy supplies on a short, medium-long and long time horizon by changing production – with consequences up- and downstream