HydroCen

NORWEGIAN RESEARCH CENTRE FOR HYDROPOWER TECHNOLOGY

Løsninger for fiskevandring – funn fra forsøk

Ana T. Silva* & Bjørn Winter Solemslie **

***Senior Researcher at NINA**

**** Researcher Scientist at NINA**

NTNU SINTEF NINA Norsk institutt for naturforskning NVKS NORSK VANNKRAFTSENTER

Researchers

NINA: Torbjørn Forseth; Olivia Simmons, Kim M. Bærum, Finn Okland , Richard D. Hedger, Karl Ø. Gjelland, Bjørn Winter Solemslie, Benjamin Cretois

ETH: Ismail Albayrak, Robert Boes, David Vetsch, Kamal Pandey

Karlstad University : Olle Calles, Stefano Georganos

NTNU: Ole Gunnar Dahlhaug, Halvor Kjærås, Leif Lia

NORCE: Ulrich Pulg, Sebastian Franz Stranzl

Vattenfall R&D: David Aldvén, Patrik Andreasson, Eric Lillberg, Stephanie Müller

Ecole des Ponts: Remi Carmigniani

DTU: Henrik Baktoft

SINTEF: Igor Iliev, Marcell Szabo-Meszaros, Atle Harby

Michigan University : Aline Cotel

Industry Partners

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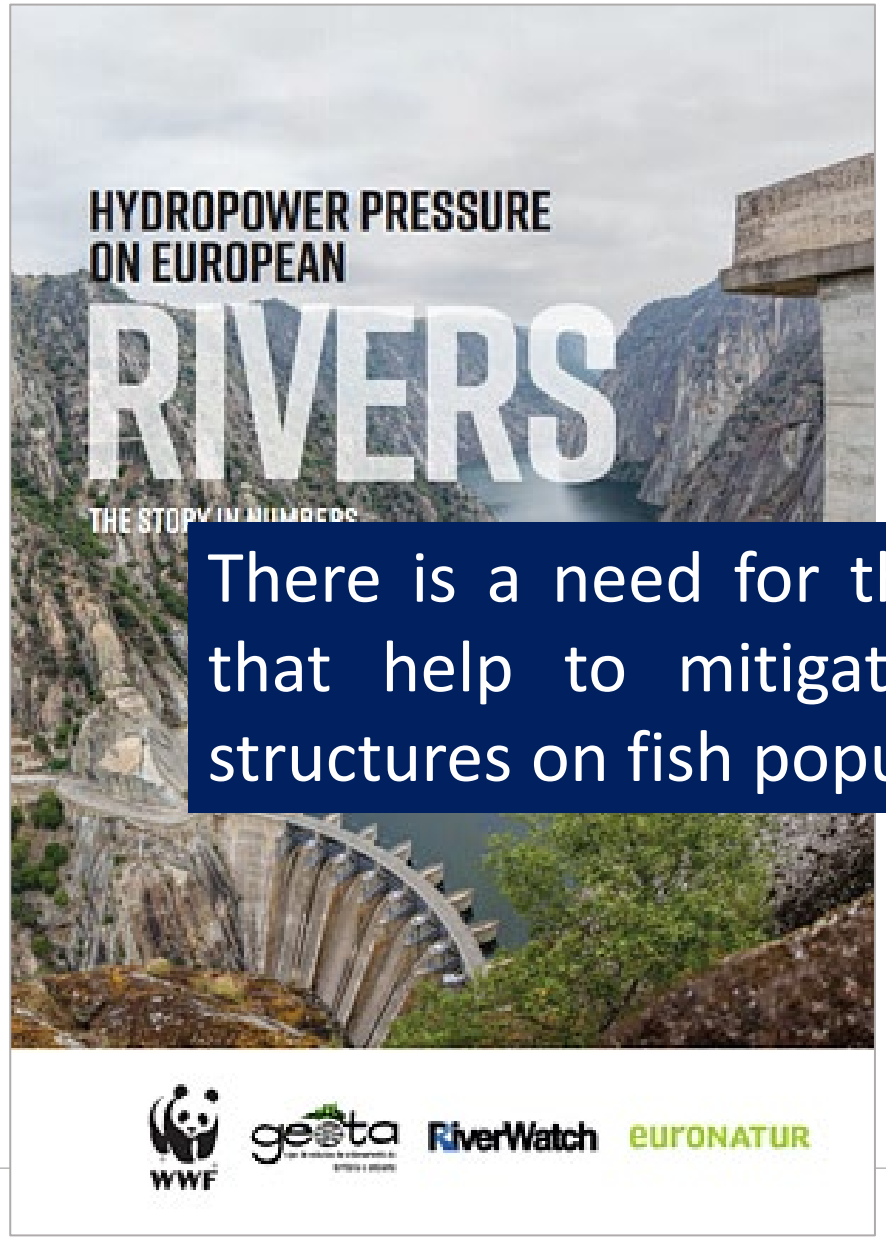
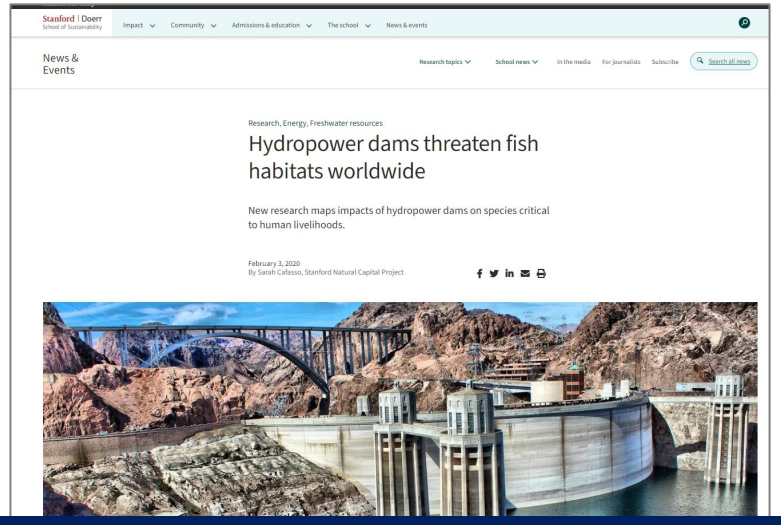
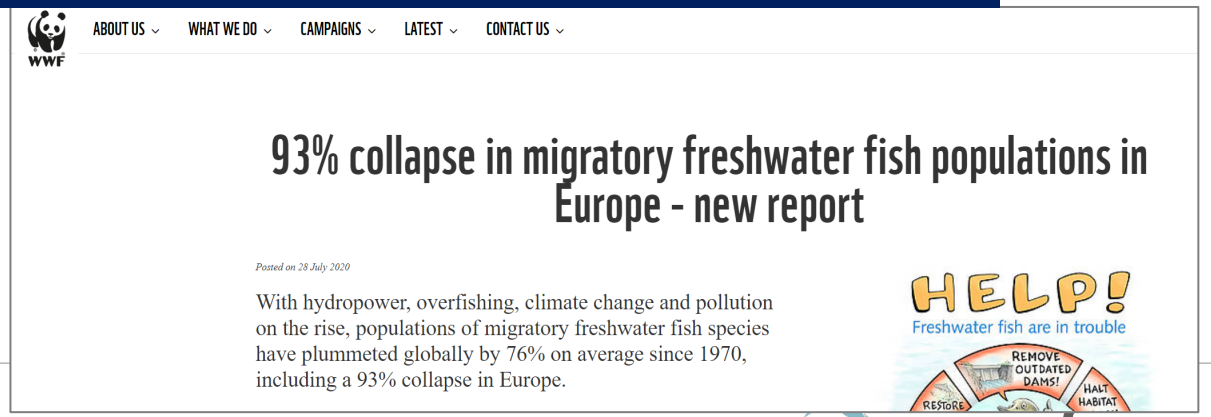




There is a need for the development of new solutions that help to mitigate the impact of anthropogenic structures on fish population.



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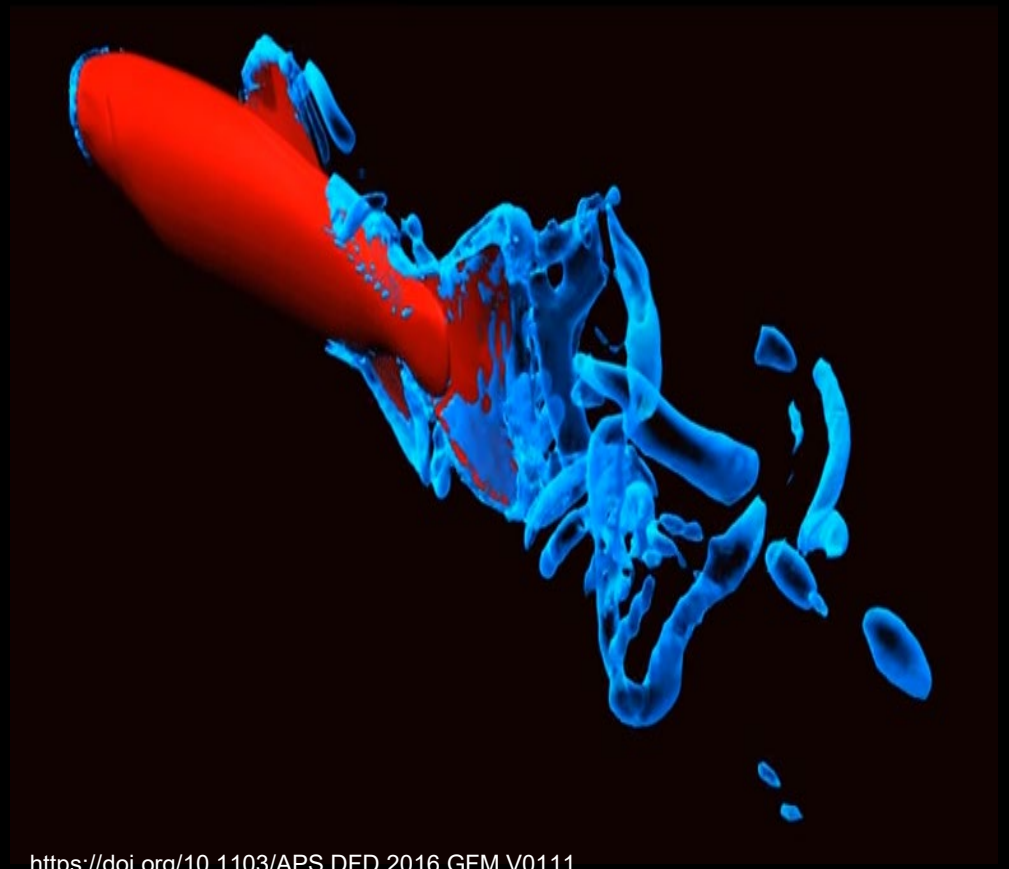

https://doi.org/10.1103/APS.DFD.2016.GFM.V0111

Understanding fish locomotion and their interplay with the hydrodynamics of the flow allows to the development of new designs of fish passage and fish guidance solutions

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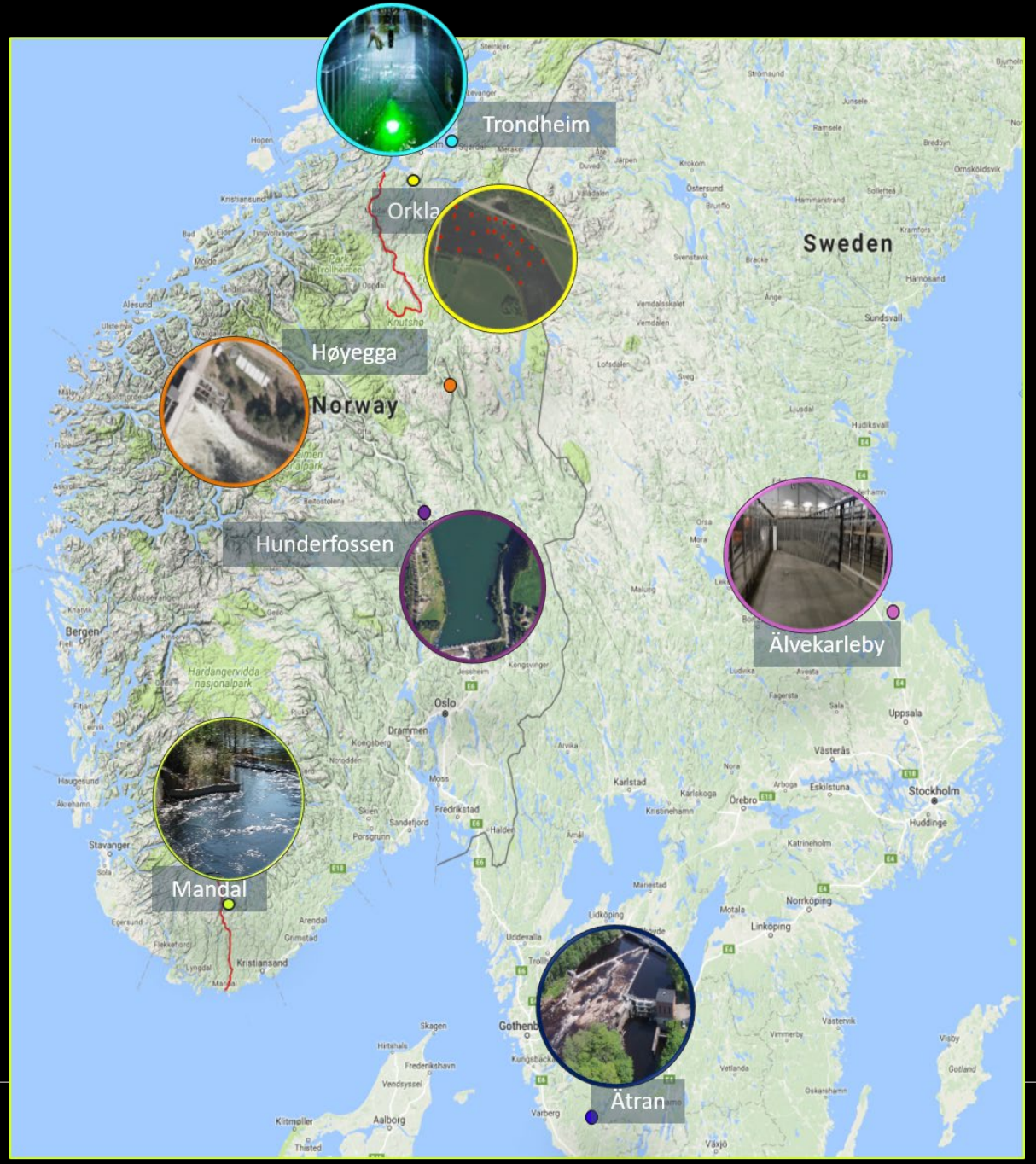
SAFEPASS - Safe and efficient two-way migration for salmonids and European eel past hydropower structures (2015-2019)

NINA project, led by Torbjørn Forseth

Funded by the Norwegian Research council, 12 HP-companies and management; 25 mill NOK (2,5 mill EUR)



Atlantic salmon (*Salmo salar*)

European eel (*Anguilla anguilla*)

Brown trout (*Salmo trutta*)

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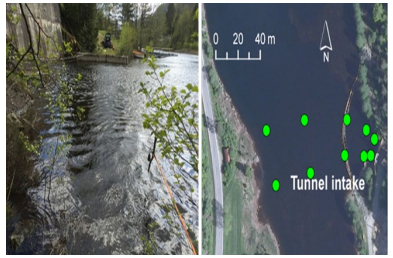

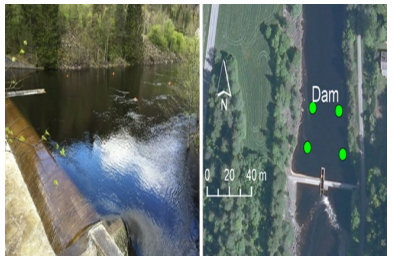

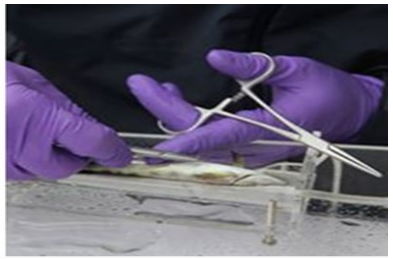

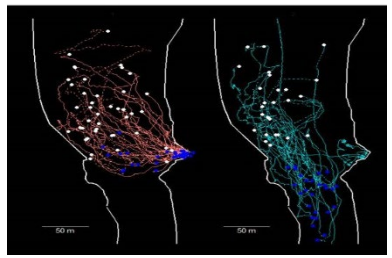

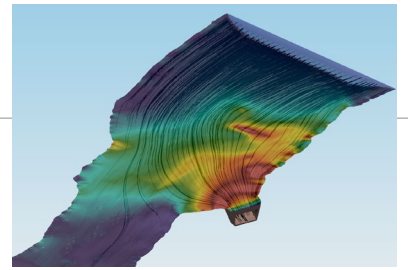

MANDAL RIVER (salmon smolts)

What determines smolts downstream migration?

Model for swimming direction and swimming speed as function of hydraulics

ELSEVIER

Science of The Total Environment
Volume 705, 25 February 2020, 135773

The effects of hydrodynamics on the three-dimensional downstream migratory movement of Atlantic salmon

Ana T. Silva [a], Kim M. Bærum [b], Richard D. Hedger [a], Henrik Baktoft [c], Hans-Petter Fjeldstad [d], Karl Ø. Gjelland [e], Finn Økland [a], Torbjørn Forseth [a]

https://doi.org/10.1016/j.scitotenv.2019.135773
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- Fish swimming speed and direction depend on the magnitude and direction of velocity and turbulence and are related with fish swimming capacity/mode
- Fish diverge from the flow at speeds higher than their sustained swimming speed (>0.38 m s^{-1})
- Fish “go with the flow” when water velocities are above 0.5m/s
- Direction of the flow strongly influences fish swimming behaviour

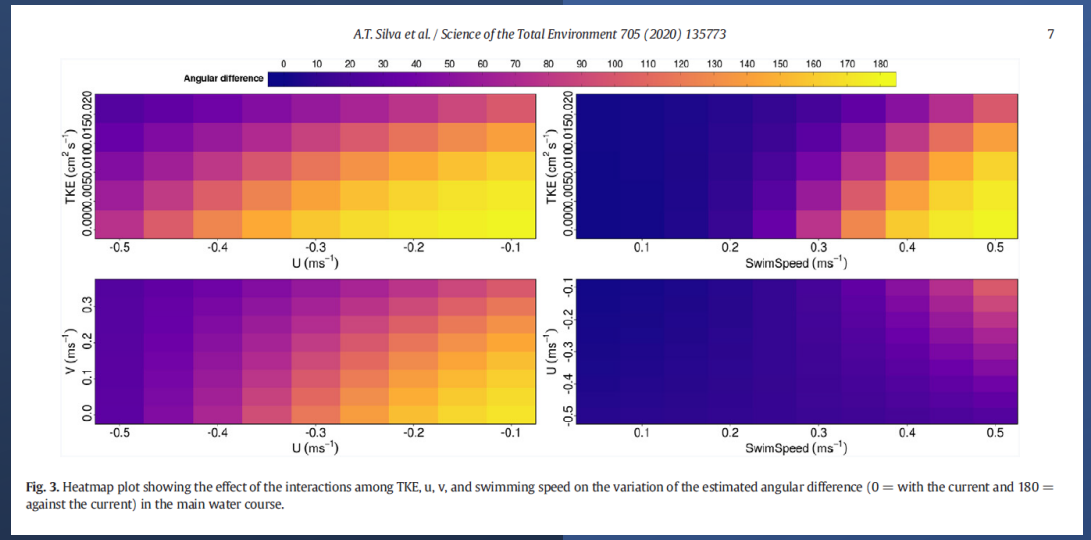


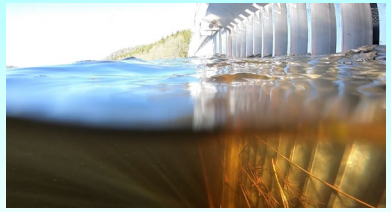
Fig. 3. Heatmap plot showing the effect of the interactions among TKE, u, v, and swimming speed on the variation of the estimated angular difference (0 = with the current and 180 = against the current) in the main water course.

Silva, et al. 2020, *Science of The Total Environment*

- ~85m long (several panels 10m)
- 1.5m deep
- Bar space: 50 mm
- Bar thickness: 10mm
- Bar length : 100 mm
- Bar type : modified angled bar rack

(90 to the structure + >90 last 15m)

- Cost ¨800 TEUR



Guidance efficiency of the fish that had contact with the structure : 88 %

ETH zürich

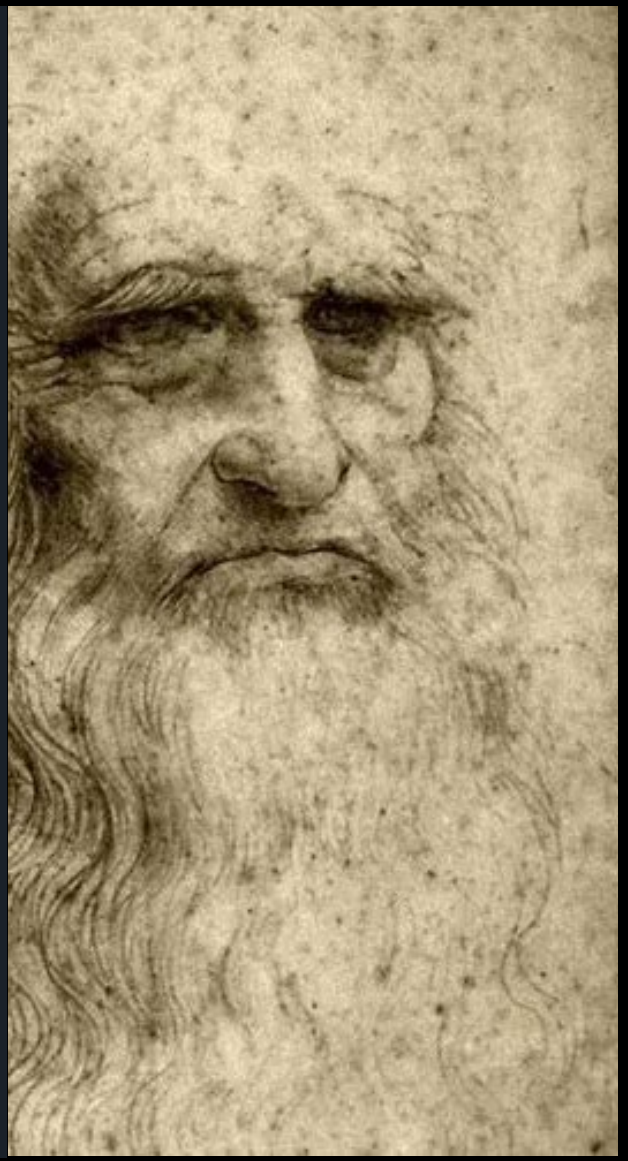
Steis Mek. Verksted AS

Foto: Steis Mek. Verksted As

NEW IDEA !

Using tubulence to guide fish _ EDDIES


Science



FishPath: Turbulent eddies to create paths

for safe downstream migration for salmonids and eel past hydropower intakes

Affiliated to HydroCen (WP 4.4)
Project: NINA; **Project leader:** Ana T. Silva & Torbjørn Forseth,
Duration: April 2021-2026;
Budget: 20 mill. Kroner (NFR)

MAIN PARTNERS

NINA
ETH zürich
NTNU
NORCE
SINTEF

INTERNATIONAL PARTNERS

KARLSTAD UNIVERSITY
UNIVERSITY OF MICHIGAN
DTU

INDUSTRY PARTNERS

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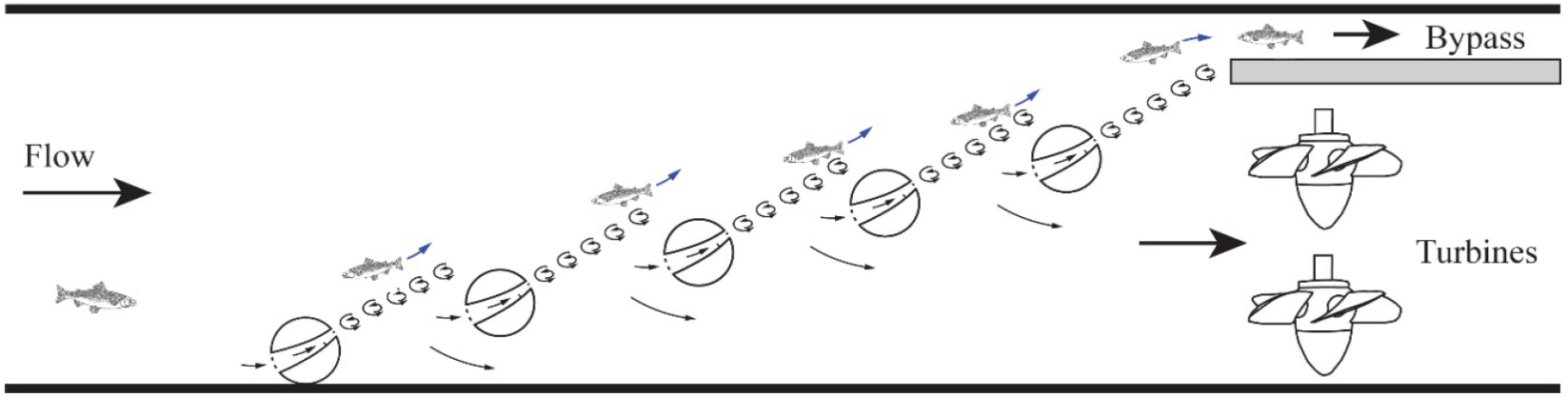
TrønderEnergi
VATTENFALL
Å ENERGI
MILJØ-DIREKTORATET
NVE
FISHCONSULTING GmbH

Kamal Pandley
PhD Student, ETH

Goal :

Eddies-based behavioural fish **G**uidance **S**ystems (**EGS**)



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Solutions for different Life stages

Smolts

Kelts

KELT2SEA :

Towards new downstream passage solutions for repeated spawners (kelts)

Olivia Simmons
NINA, Postdoc

KELT2SEA is an HydroCen funded project

Project Owner: NINA
Project leader: Ana T. Silva
Project period: June 2022-2024
Project Budget: 3 mill. kroner

PARTNERS

NINA

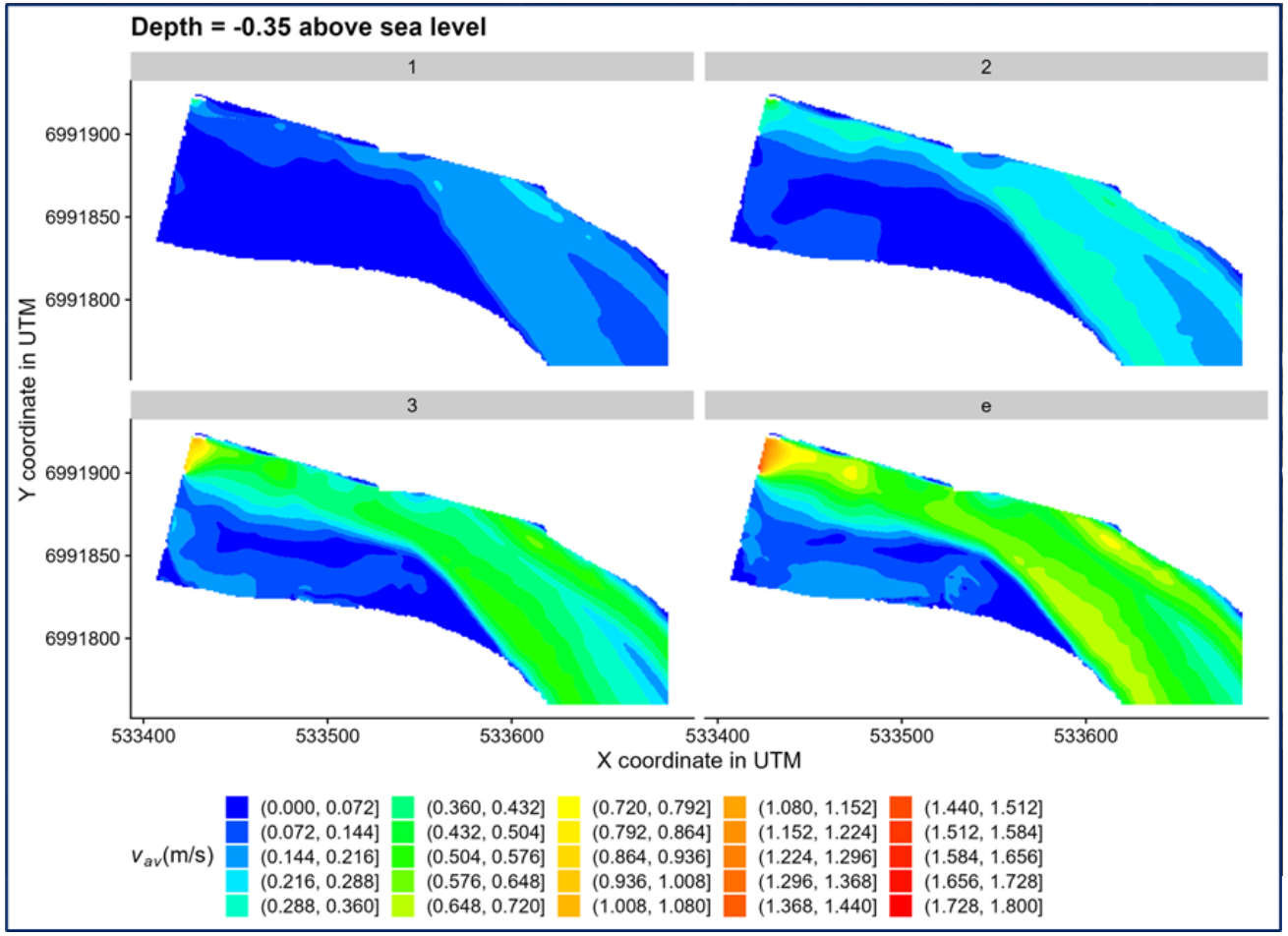
KARLSTAD UNIVERSITY

VATTENFALL

GOALS:

- Understand impact of hydraulics on kelt`s behaviour
- Study of kelt behaviour at vicinity of trash-racks and bypass entrance
- Develop a predictive model for downstream migratory behaviour of kelts

Field work: Orkla case



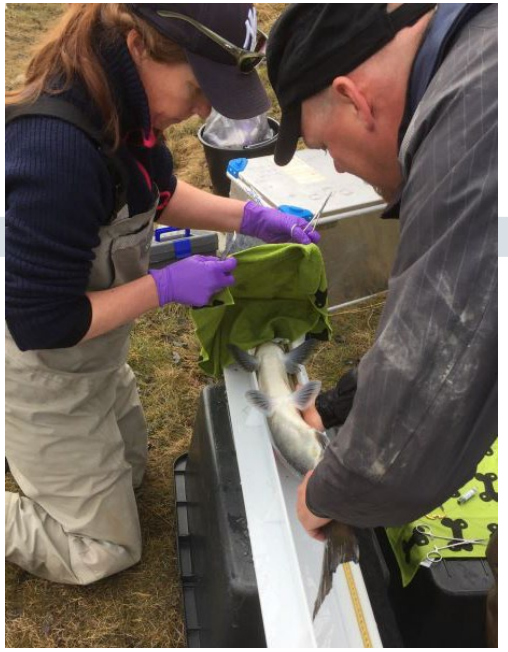
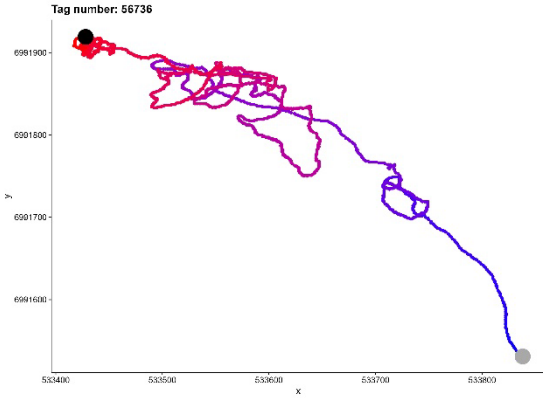
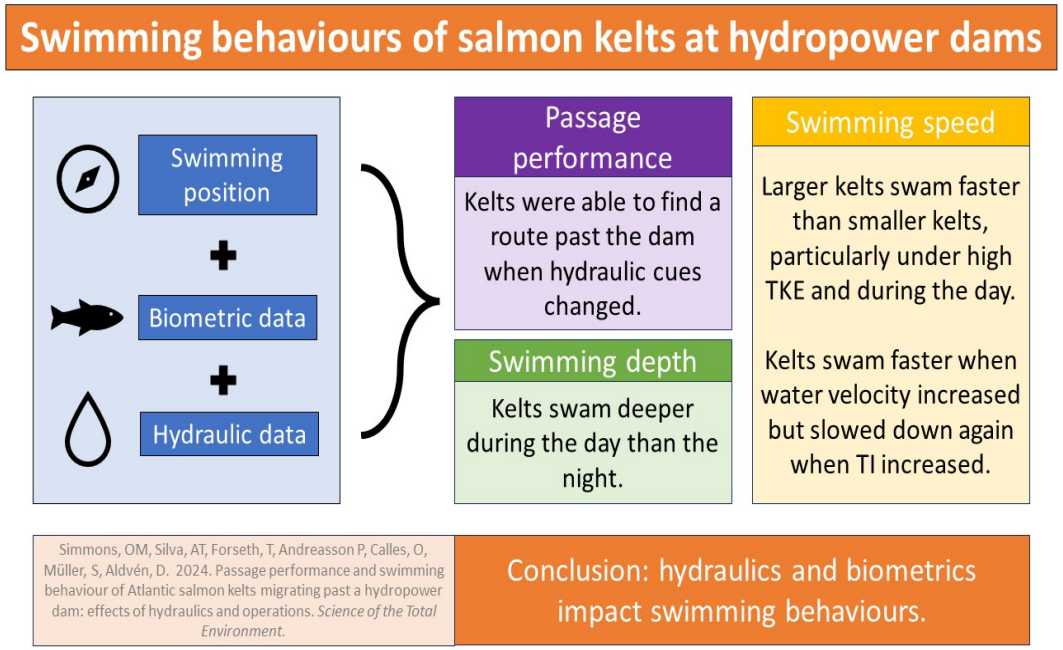


Photo: K. Ø. Gjelland

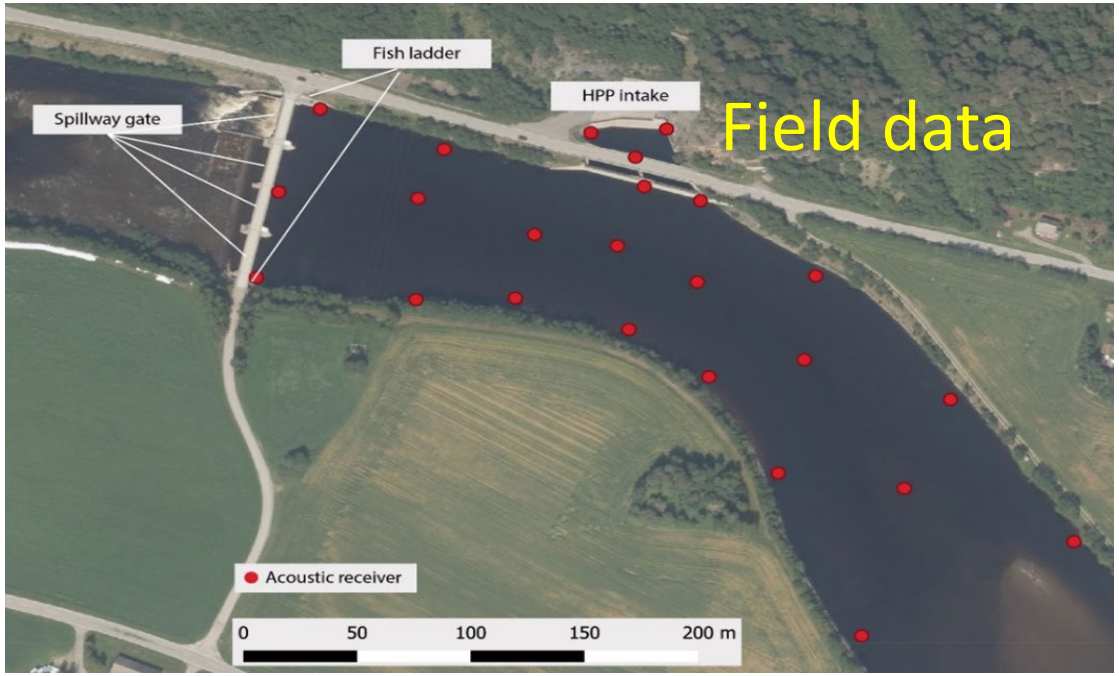


Scenario	% Open	% Discharge via dam
1	2.26	0.00
2	41.91	19.67
3	60.41	34.32
4	70.51	45.55

Swimming behaviour og Atlantic salmon kelts affected by hydraulics and dam operations

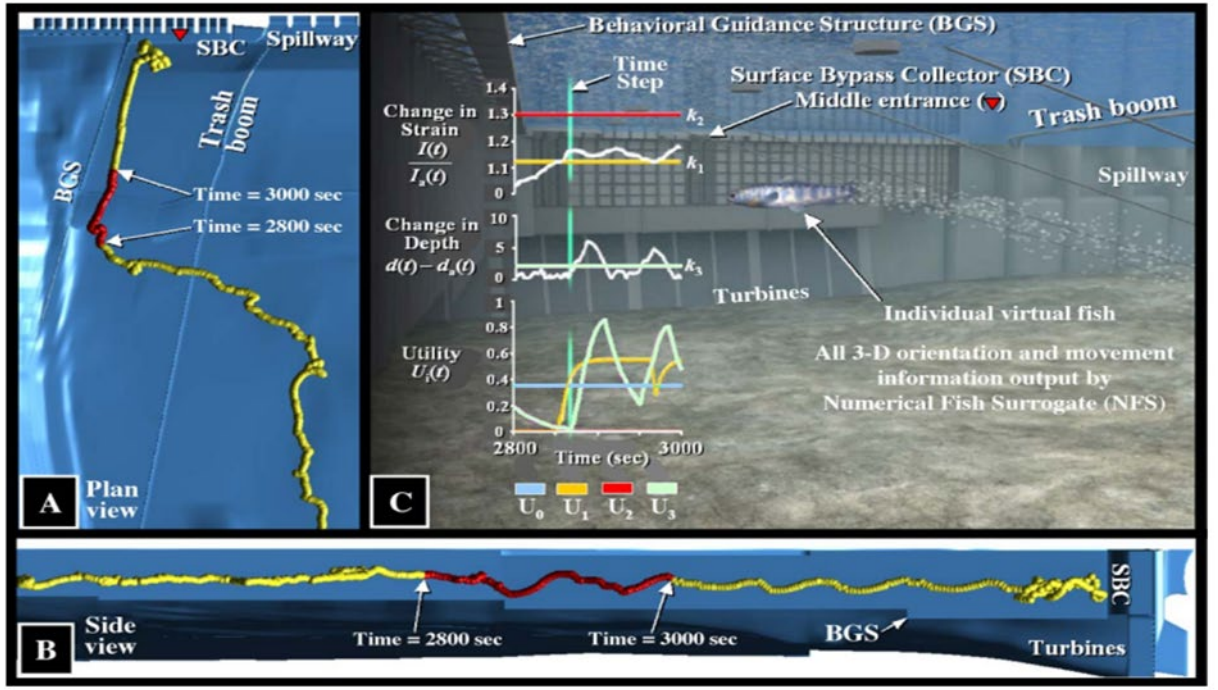


Simmons et al. 2024, Science of the total Environment



Field data

Lab data



Information on effect of hydraulics on kelts will allow for the development of predictive models and to design new downstream passage solutions for kelts

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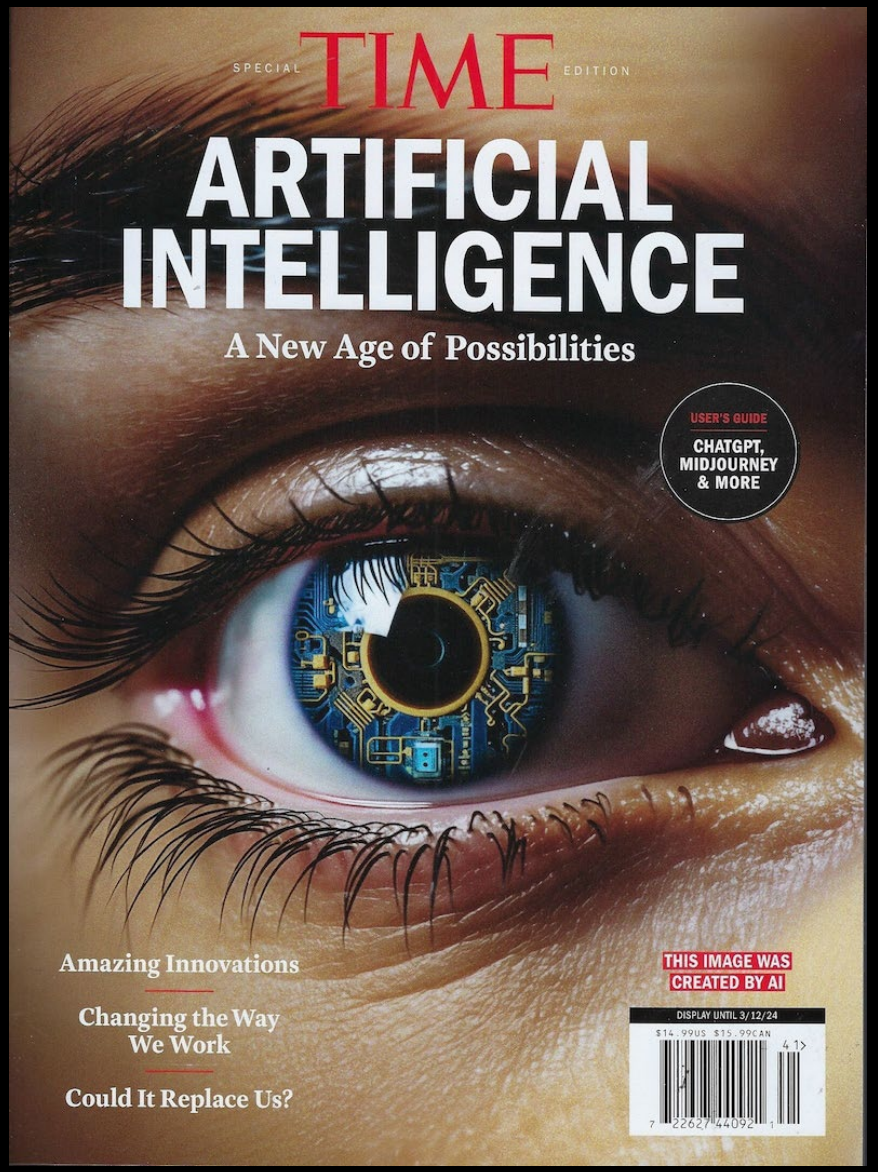

TIME Magazine Special (Artificial Intelligence A.I.) 2024

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USING MACHINE LEARNING FOR IMPROVED EEL DOWNSTREAM PASSAGE DESIGN

PROJECT LEADERS:

Ana T . Silva (NINA) & Olle Calles (Karlstads University)

Project period: 2023-2026

Joschka Wiegleb
Karlstad University, Postdoc

FUNDING :

6 694 kSEK

SVENSKT VATTENKRAFTCENTRUM

Energiforsk

VATTENFALL

PARTNERS

NINA
Norwegian Institute for Nature Research

KARLSTADS UNIVERSITET

VATTENFALL

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THEORY
BRIDGE
THE
GAP
PRACTICE

Guiding fence at the Bjørset dam

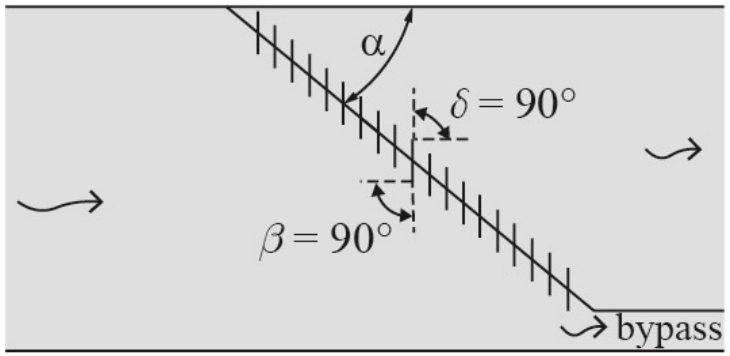
- Inlet of Svorkmo power plant
  Project Owner: Aneo/TrønderEnergi
- Challenges with both smolt entering the powerplant and kelts being stuck in the intake basin.
- Old structure includes a smolt curtain with inlet to the intake basin submerged by 2-2.5m.

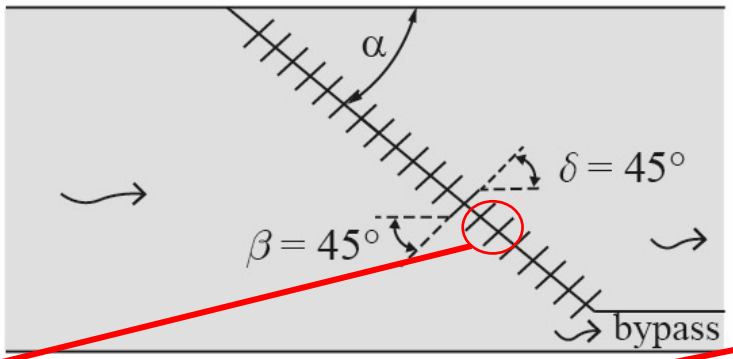
Technical concept

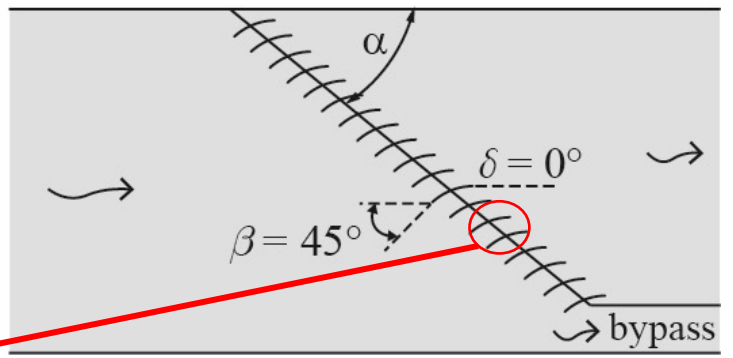
- Utilizing same technology as guiding fence in the Mandal river
- Possibly newer generation with lower danger of clogging
- Concept allows for larger than usual light gap between bars, lower head-loss and greater fish guiding efficiency

- Strong collaboration with ETH Zürich for the technology and Steis Mekaniske and Lister Engineering for mechanical design and implementation

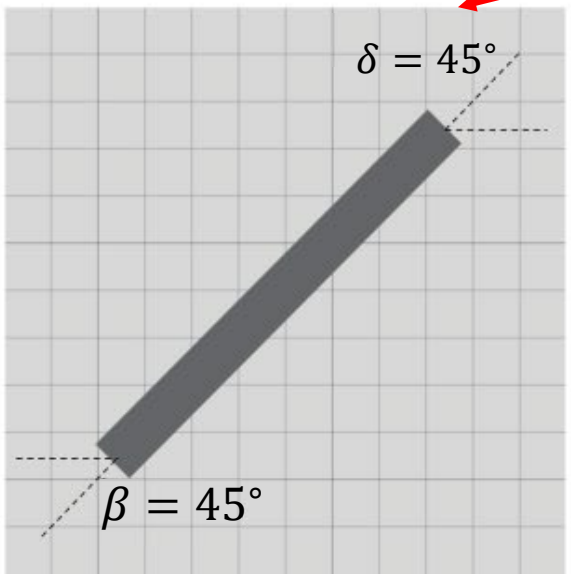
Technical concept



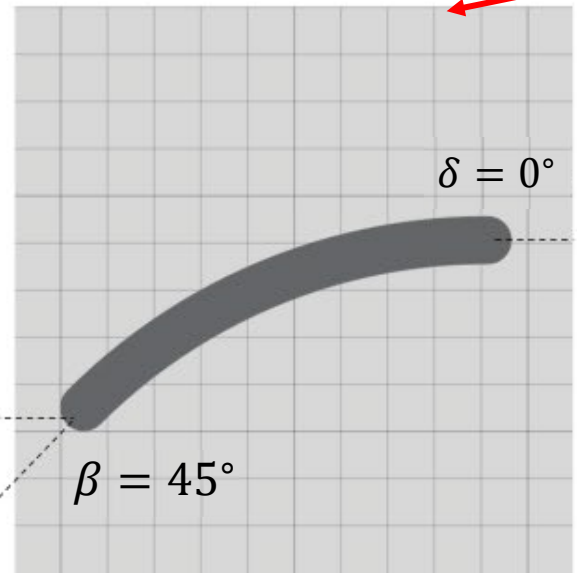




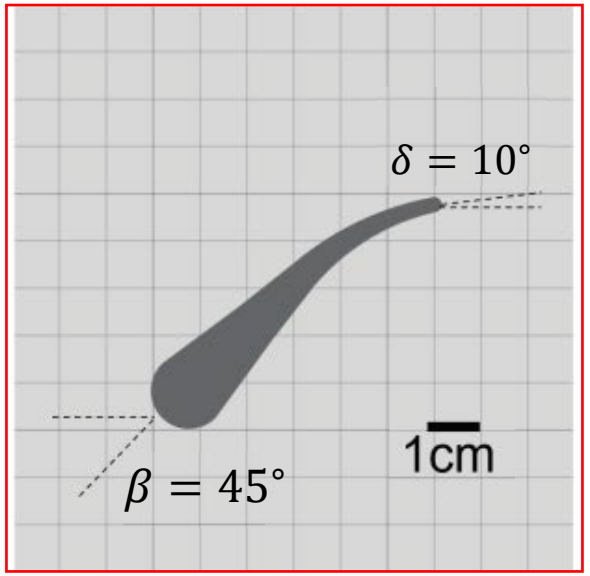
[1]



Modified Bar Rack



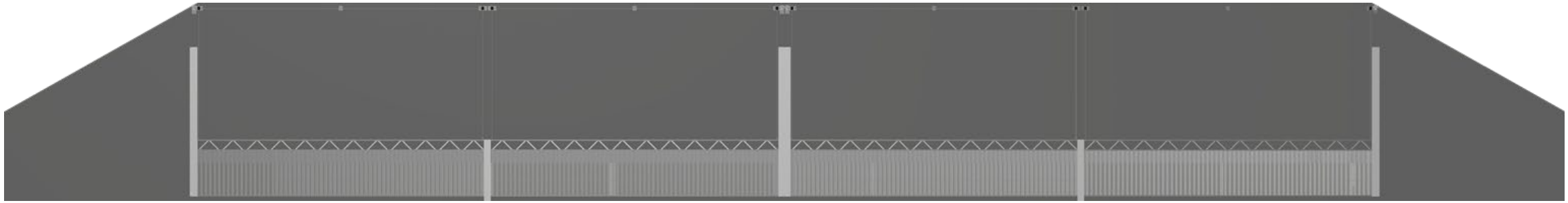
Curved Bar Rack



[2]

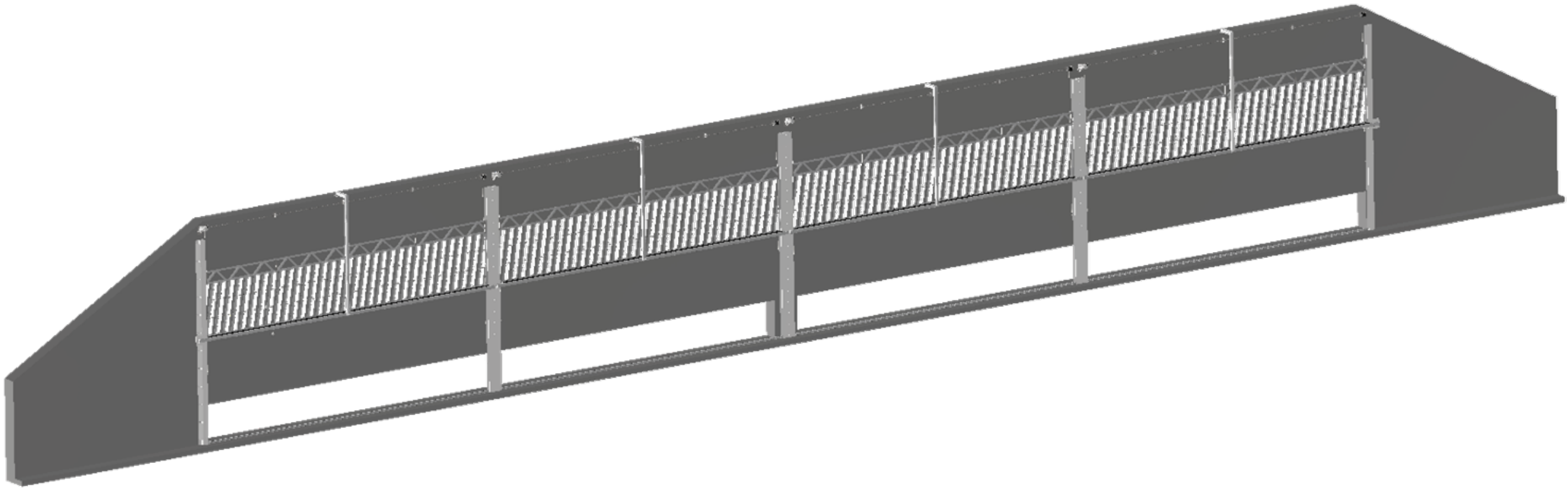
Foil shaped curved Bar Rack

Technical Concept



By Lister Engineering

Technical Concept



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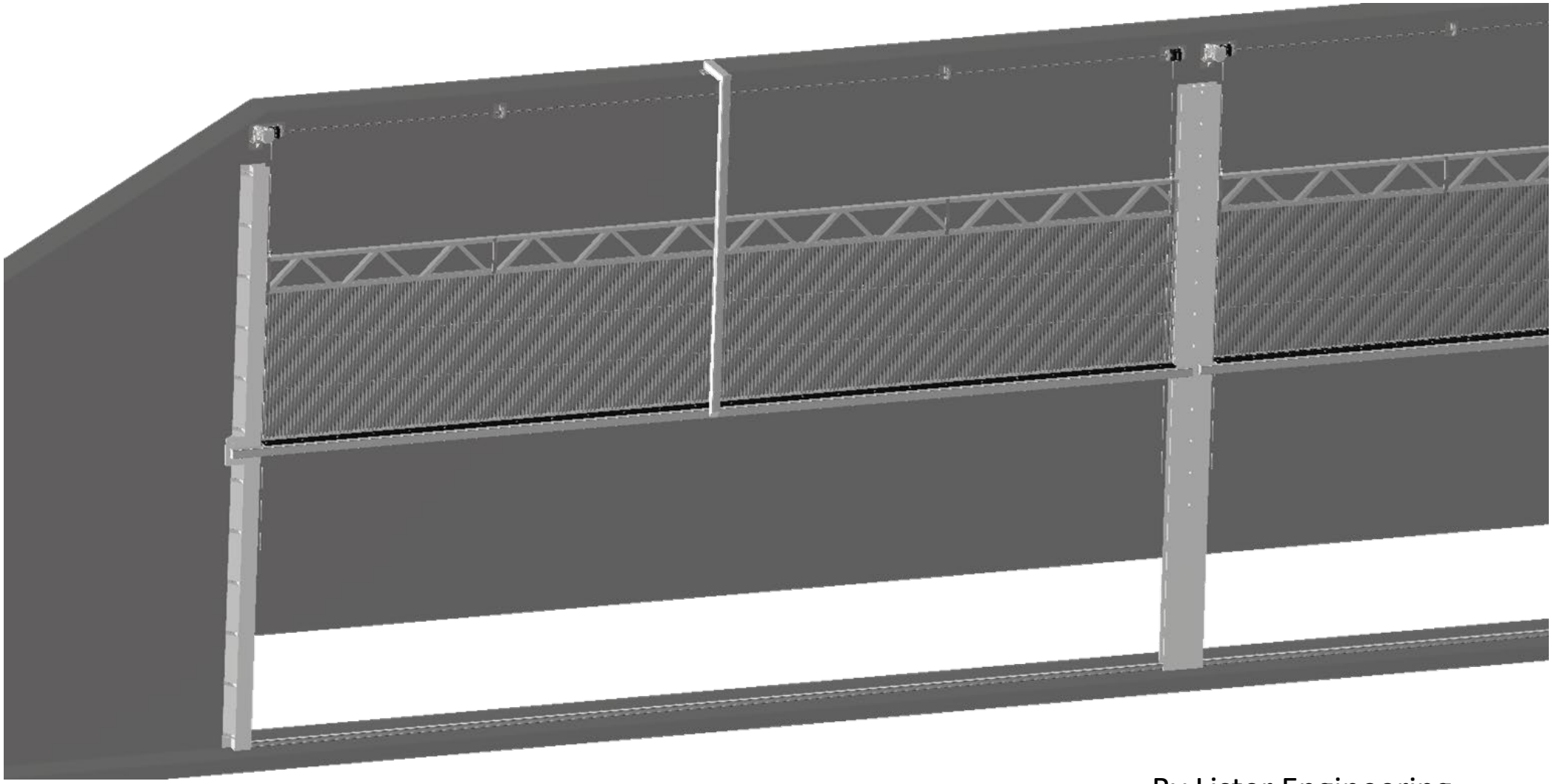

By Lister Engineering

Current status

- Work on design of bars for the fence
- TrønderEnegi Kraft plans dredging work in the river outside inlet basin in 2024/25
- Planned installation of guiding fence in spring of 2025


Thank you
Questions?

References

1. Beck C, Albayrak I, Meister J, Peter A, Selz OM, Leuch C, et al. Swimming Behavior of Downstream Moving Fish at Innovative Curved-Bar Rack Bypass Systems for Fish Protection at Water Intakes. Water. 2020 Nov 19;12(11):3244.

2. Leuch C, Beck C, Albayrak I, Vetsch DF, Boes RM. Analysis And Optimization of Hydraulic Characteristics at Fish Guidance Structures Using CFD. 2022;