Mitigating the effect of hydropower stations on fish migration in Norway

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Norwegian Institute for Nature Research

Research Interests:

- Ecohydraulics and anthropogenic changes to aquatic systems
- Fluid dynamics (Hydraulics)
- Effect of turbulence on fish behaviour, swimming performance and energetic costs
- Fish behaviour and ecology
- Biomechanics of aquatic locomotion
- Fish physiology
- Neurobiology: Hydrodynamic stimuli and fish behavioural response
- Ecology, fish conservation and restoration

- What's the aim of my PhD/Post-Doc?
- What is the context and the content of my work?
- How is my work innovative compared to existing methods/solutions?
- How can my work be implemented and used later on?

Mitigating the effect of hydropower plants on fish migration in Norway by understanding the impact of hydraulics on fish migratory behaviour

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Fish conservation and sustainability in rivers implies:

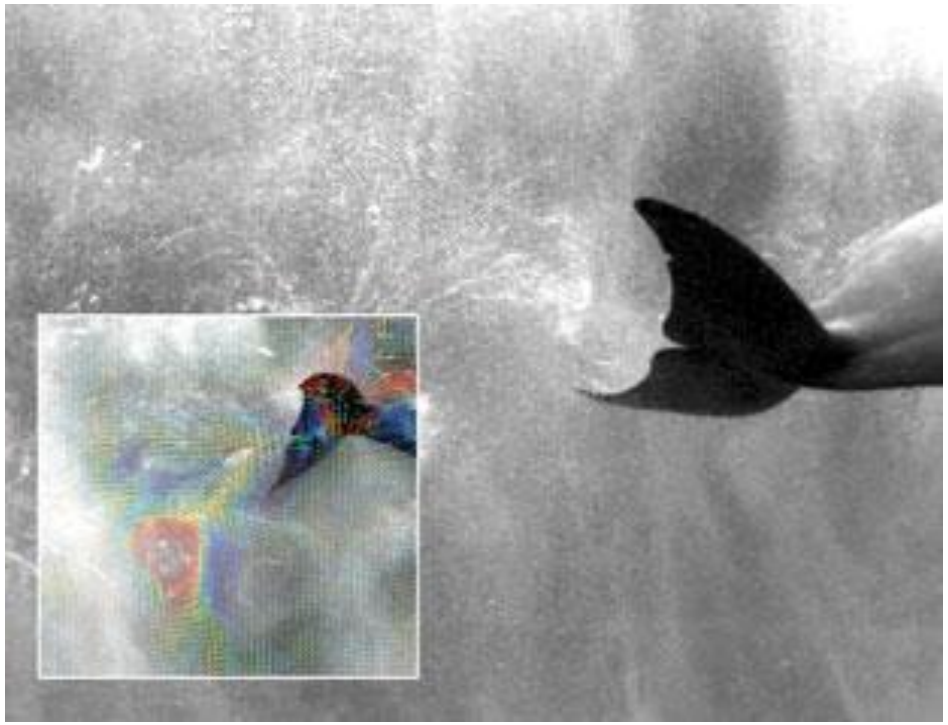
Interplay between fish (**endogenous factors:** motivation, physiology, fish life stage, species, size....) and the enviroment (**exogenous factors**: hydraulics, temperature, light, pH, oxygen, flow....)

Multidisciplinary approach :

Biology, Ecology, Physiology, Biomechanics, Fish behaviour, Hydraulics, Neurobiology

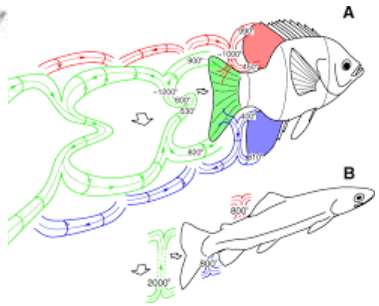
Hydrology, ... Economy, Sociology

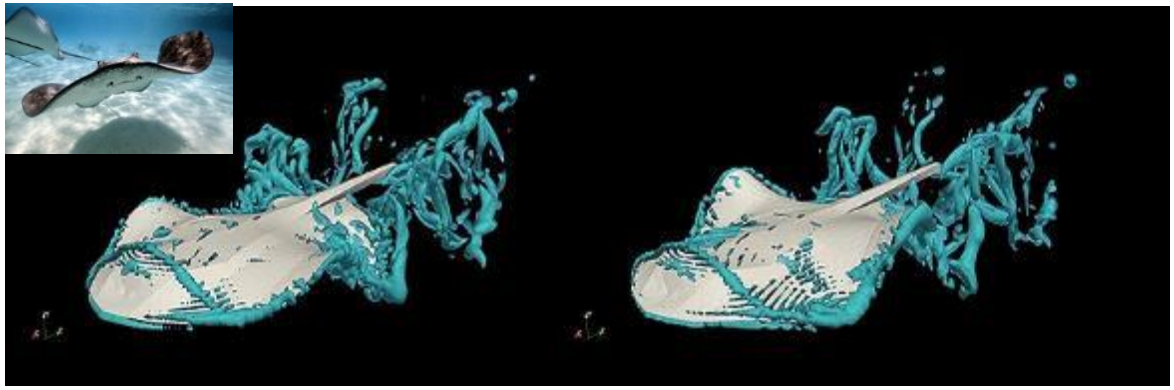
Fish in moving fluid

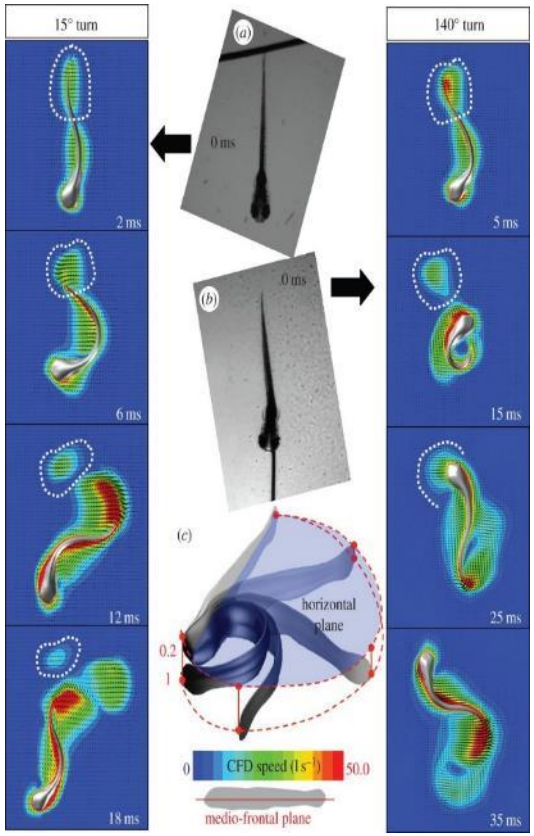


Fish et al. 2014. Measurement of hydrodynamic force generation by swimming dolphins using bubble DPIV. Journal of Experimental Biology 2014 217: 252-260

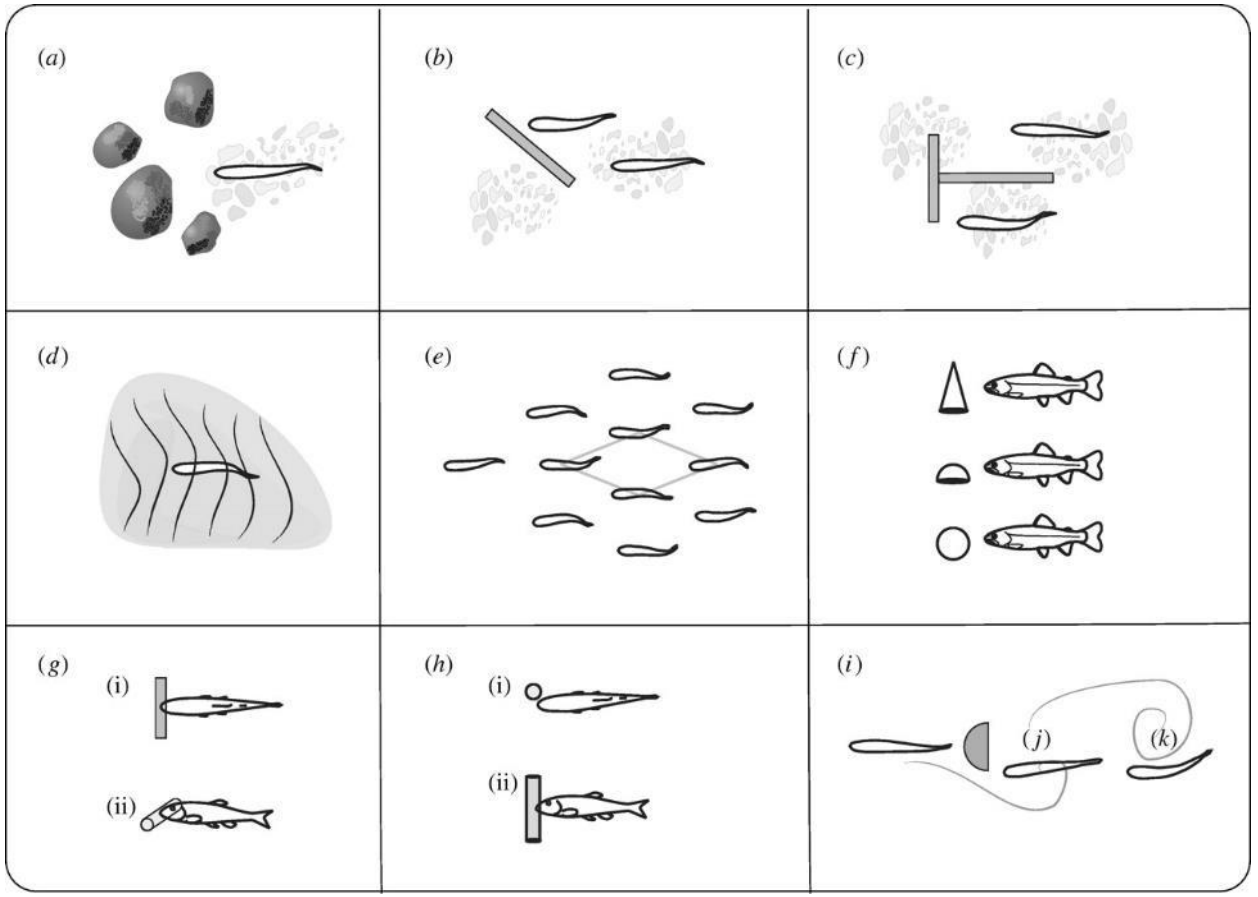
Fish swimming v.s Flow dynamics



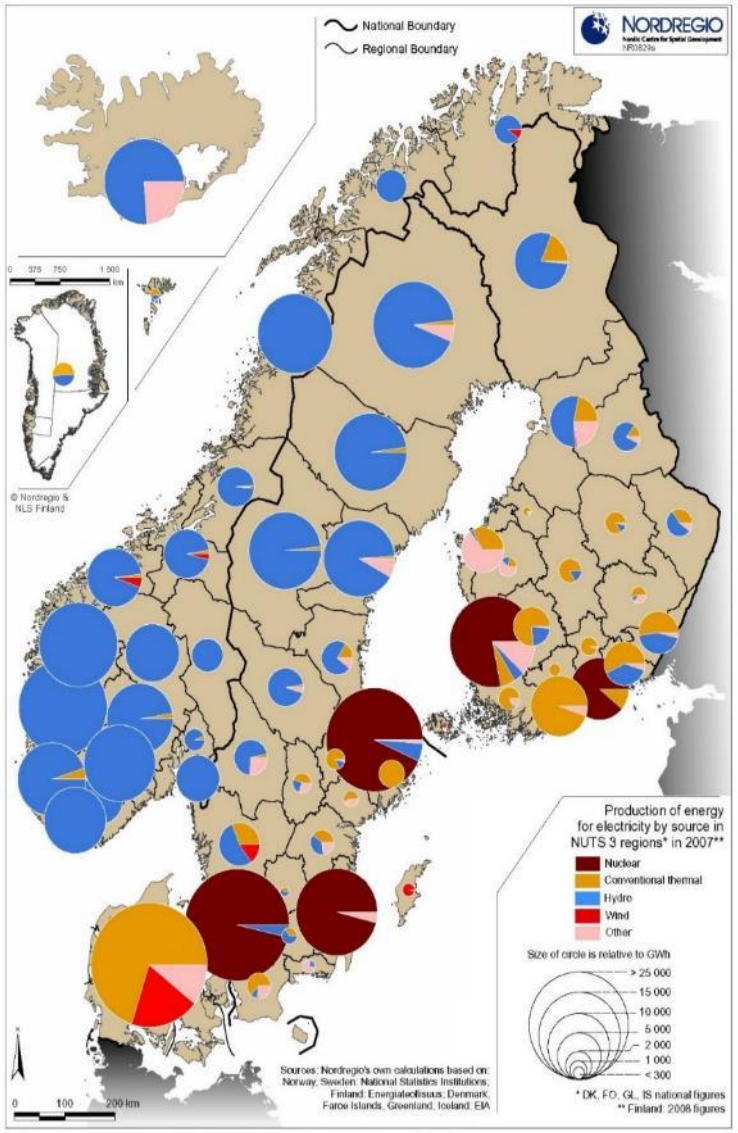




Interaction with fluid dynamics in Nature




Energy expenditure



Map shows production of energy for electricity by source in Nordic NUTS 3 regions in 2007

Hydropower v.s Fish Conservation

96% of all electric power production in Norway comes from hydropower.

Hydropower developments have led to a drop in wild salmon production in Norway's salmon rivers, and are a critical pressure on salmon stocks in 110 of a total of 481 salmon rivers.

(*Norwegian Environment Agency*)

Hydropower infrastructure and discharge schemes have caused the reduction and even extinction of numerous Atlantic salmon populations in Europe.

(Fjeldstad et al. 2012, *Journal of Fish Biology*)

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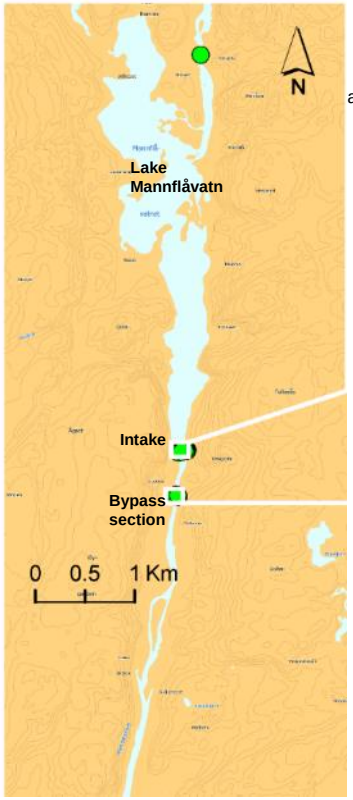
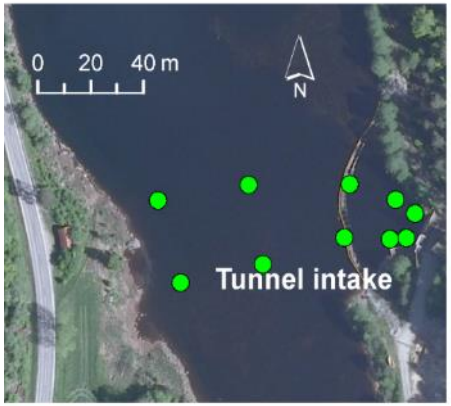
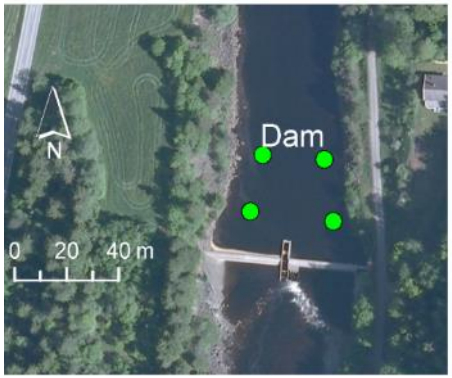
2D and 3D Telemetry







-200 kHz acoustic telemetry hydrophones (Lotek).
- Small tags (15x6.5 mm), burst interval of 5 s last for 45 days.
- 99 tagged smolts

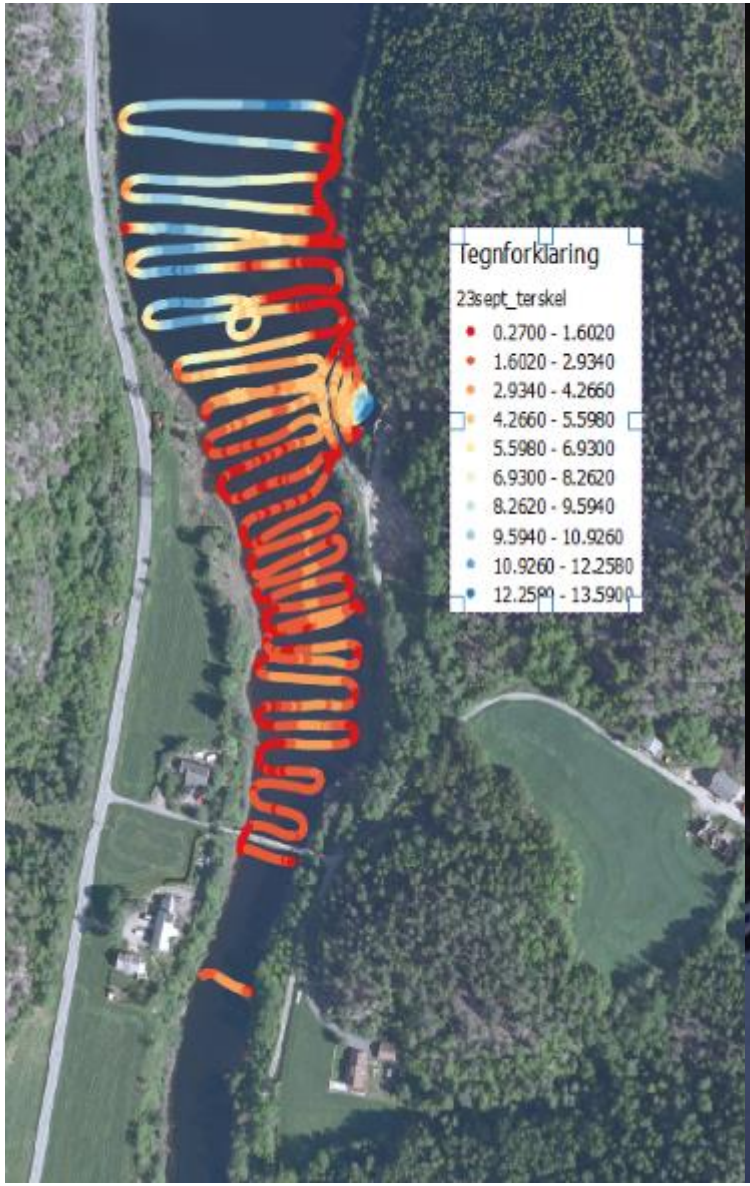
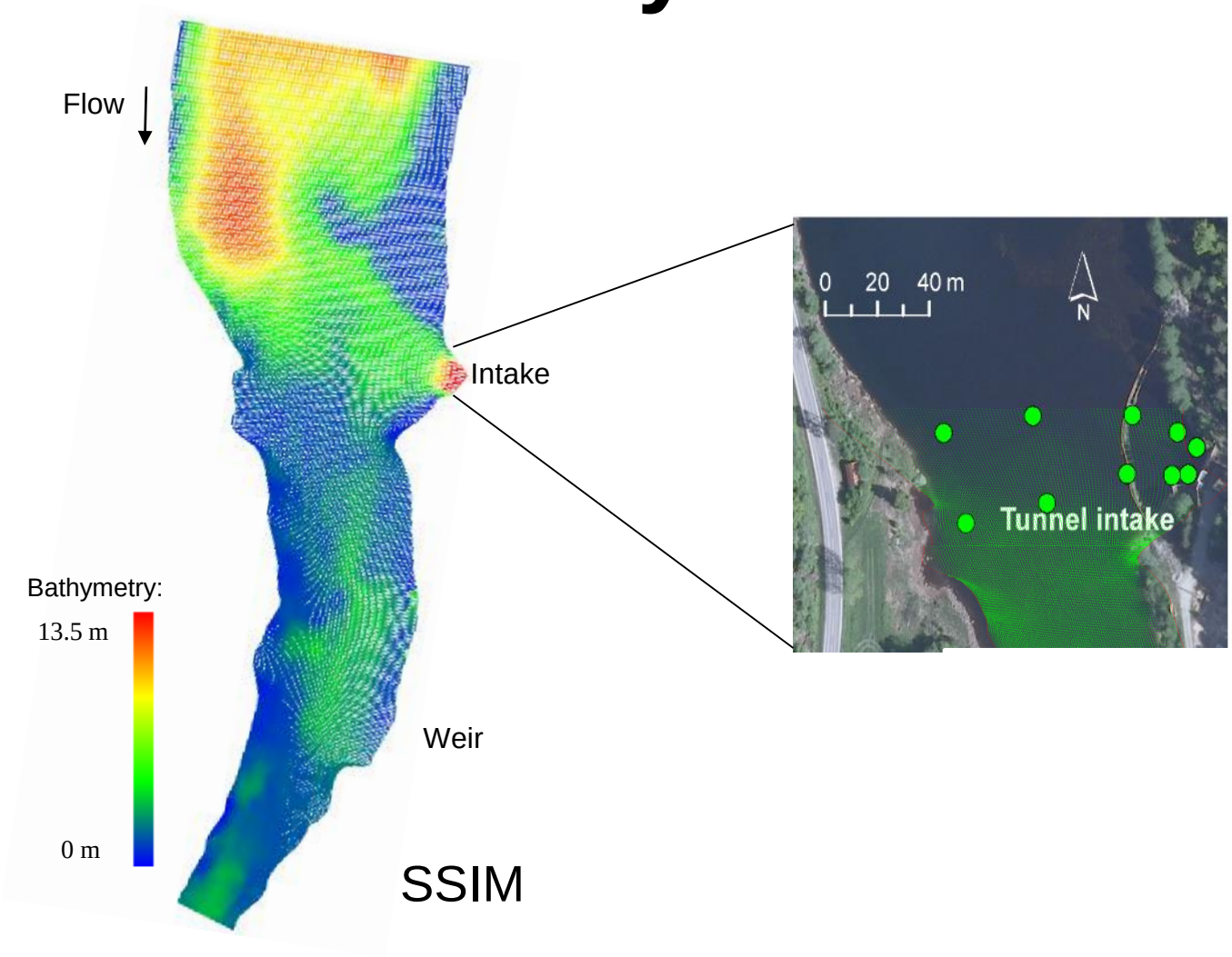
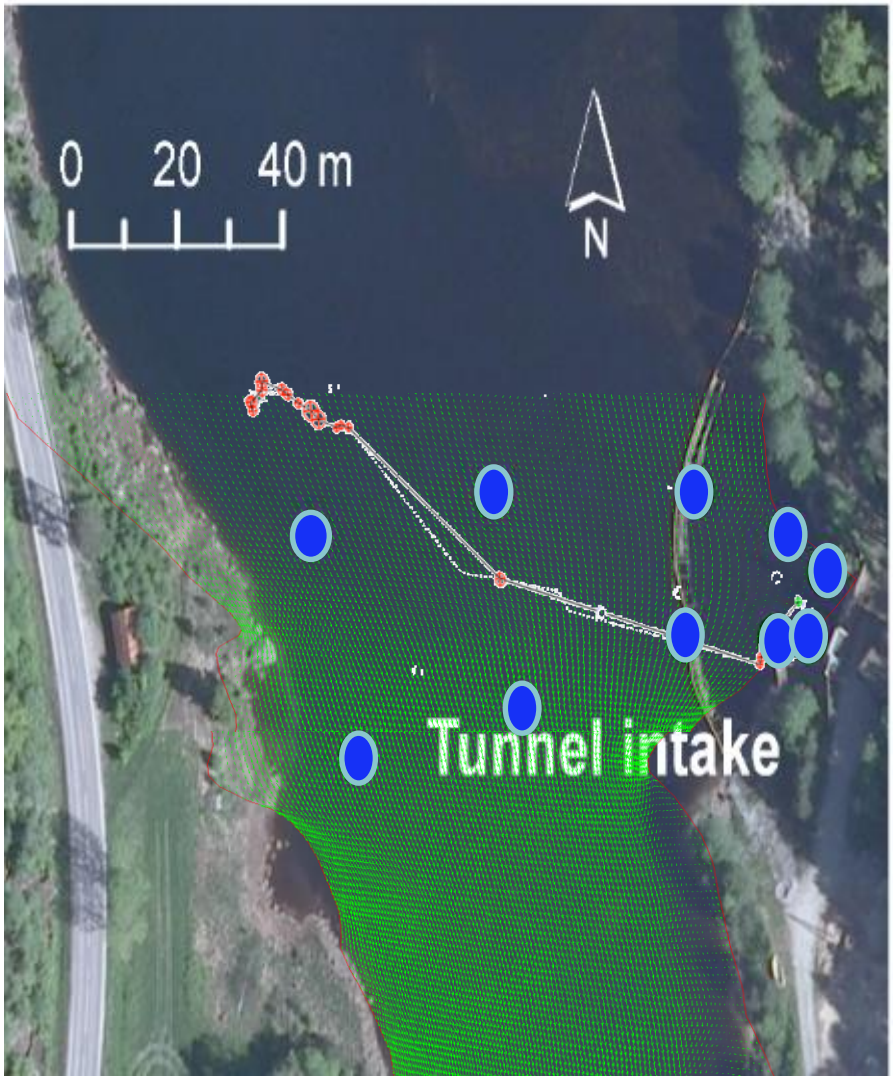


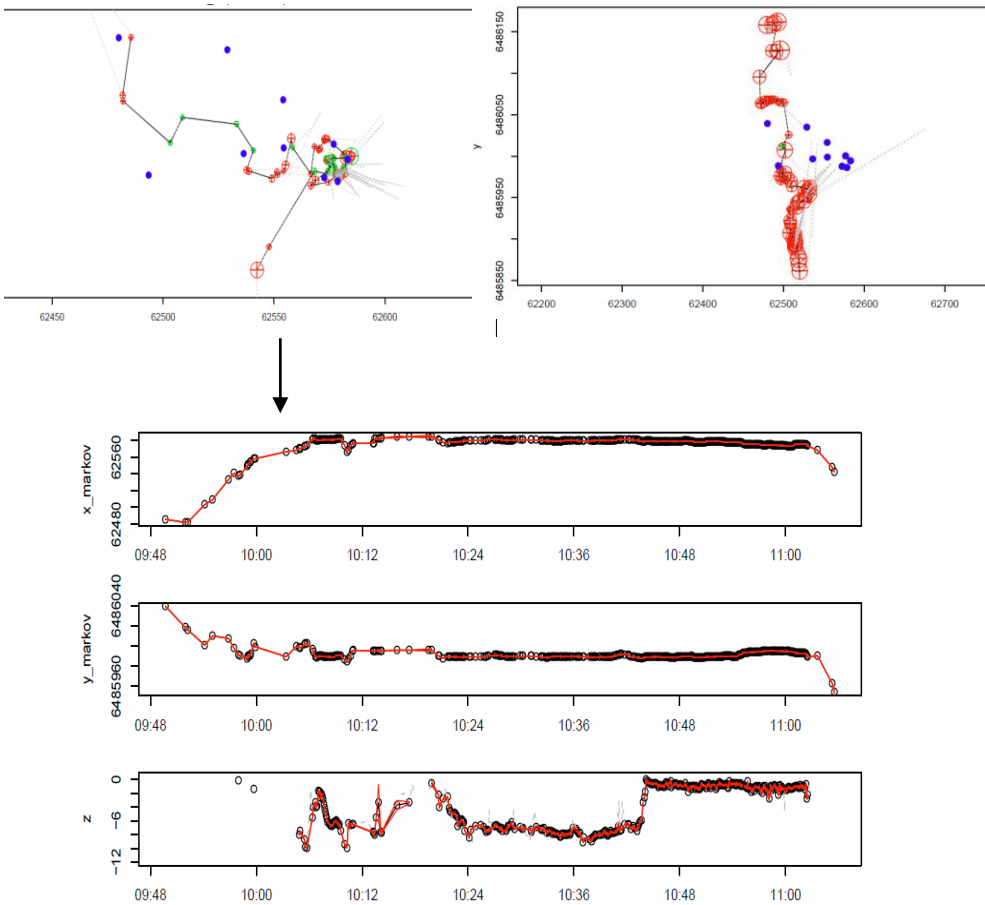
Photo: Hans-Petter F.

Hydraulics :


Flow
Intake
Bathymetry:
13.5 m
0 m
Weir
SSIM
0 20 40 m
N
Tunnel intake

Migratory route of fish





Which route? What to follow?

Hydraulic cues ?

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- Integrates a multidisciplinary approach to study the impact of antrophogenic activity on fish populations aiming to improve fish sustainability

- Uses new technology to reveal relationships between hydraulics and fish behaviour in 3D.

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My work can be implemented in new hydropower constructions, or it can be used to improve existent hydropower facilities, improving fish conservation status and sustainability in regulated rivers with minimum loss of energy production and financial expenditures

Ultimately, my work will help to ensure the sustainability of different fish species of high economical and recreational value

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PhD Forestry Engineering

Study of the effects of hydraulics **(turbulence)** on fish behaviour and swimming performance during fishway passage

(Ecohydraulics, Hydraulics , Fish swimming performance)

Teresa Ferreira, Antonio Pinheiro

Post-doc:

(Fluid mechanics, Biomechanics and Fish behaviour)

Christos Katopodis , Mark F. Tachie

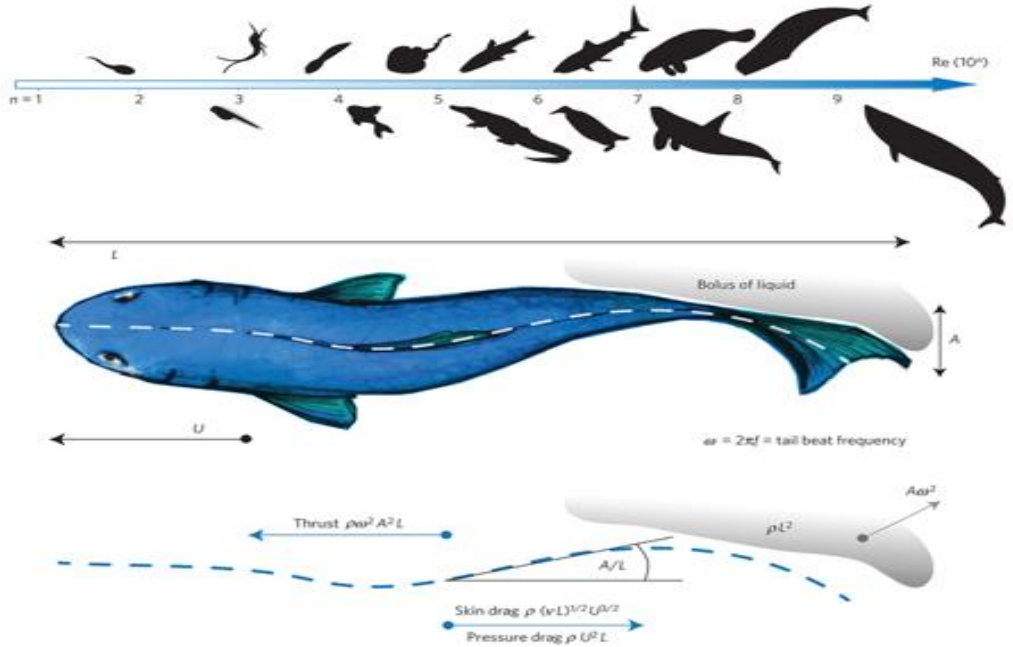
(*Fish physiology, Fish behaviour and Biomechanics*)

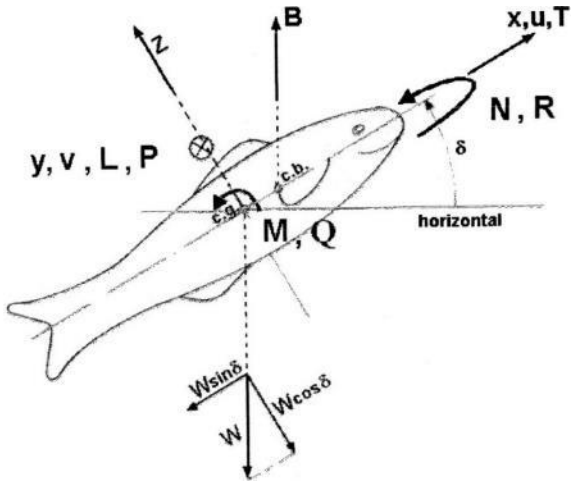
Steven Cooke

(Fish migration, Biomechanics and Fish behaviour)

Torbjørn Forseth

Fish swimming v.s flow dynamics





Energy expenditure associated to control of posture, stability and swimming performance (energy associated to biomechanics and hydraulics)

+

Energy expenditure associated to migration and physiological mechanisms

Negative implications for fish swimming performance and sustainability (survival)

Heading for normal slides

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