



Using turbulent eddies to guide fish: The FishPath Project

Ana T. Silva

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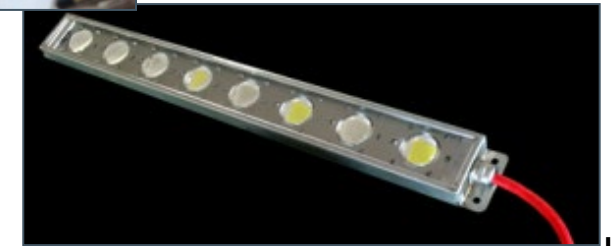
SUSHP 2023



FISH PASSAGE

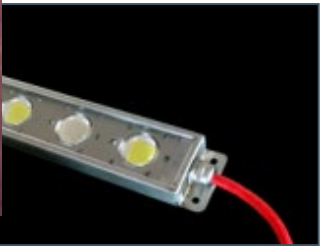


FISH GUIDANCE



FISH PASSAGE

FISH GUIDANCE

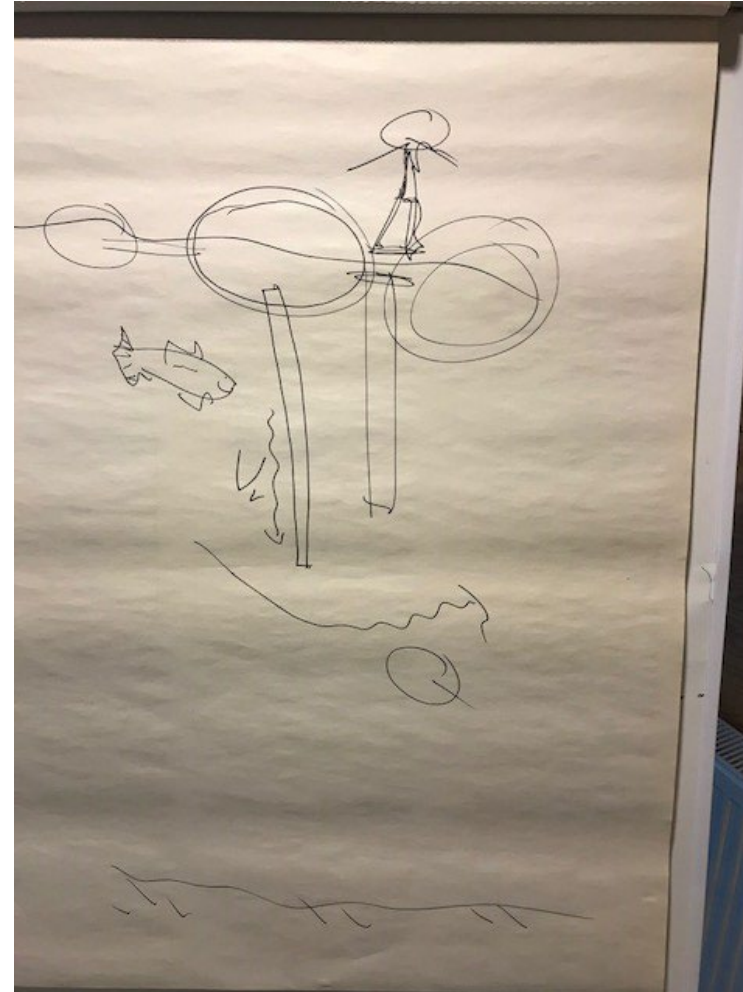
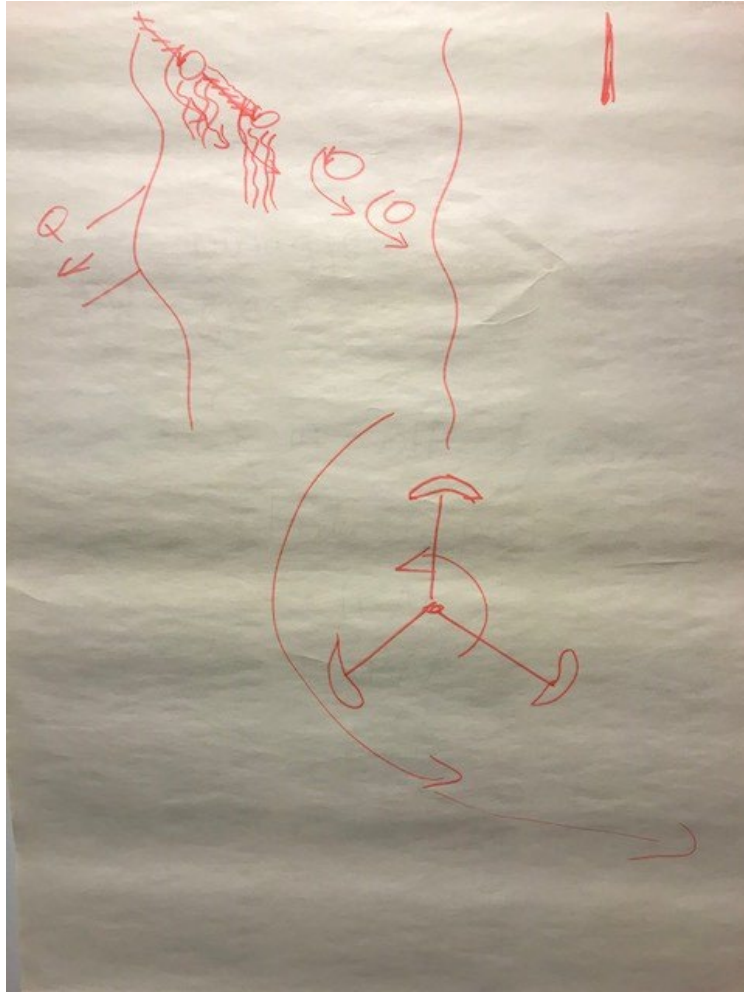


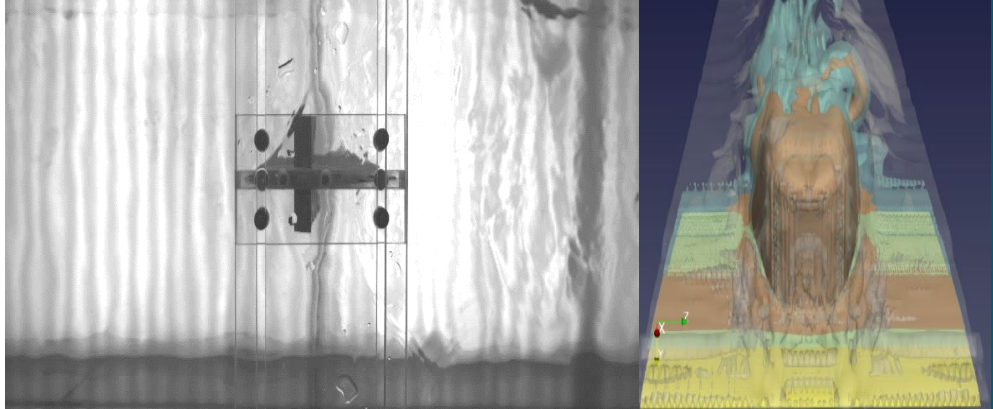
FishPath.. The origin

WORKSHOP OM LEDEGJERDER
19th June 2018, Trondheim, Norway



Drawings and Sketches





FishPath:

Turbulent eddies to create paths for safe downstream migration for salmonids and eel past hydropower intakes

Project: NINA;
Project leader: Ana T. Silva & Torbjørn Forseth,
Duration: April 2021-2026;
Budget: 20 mill. Kroner (NFR) ~2million euros

FishPath Partners

MAIN PARTNERS



INTERNATIONAL PARTNERS



INDUSTRY PARTNERS



FISHCONSULTING
GmbH

Main goal

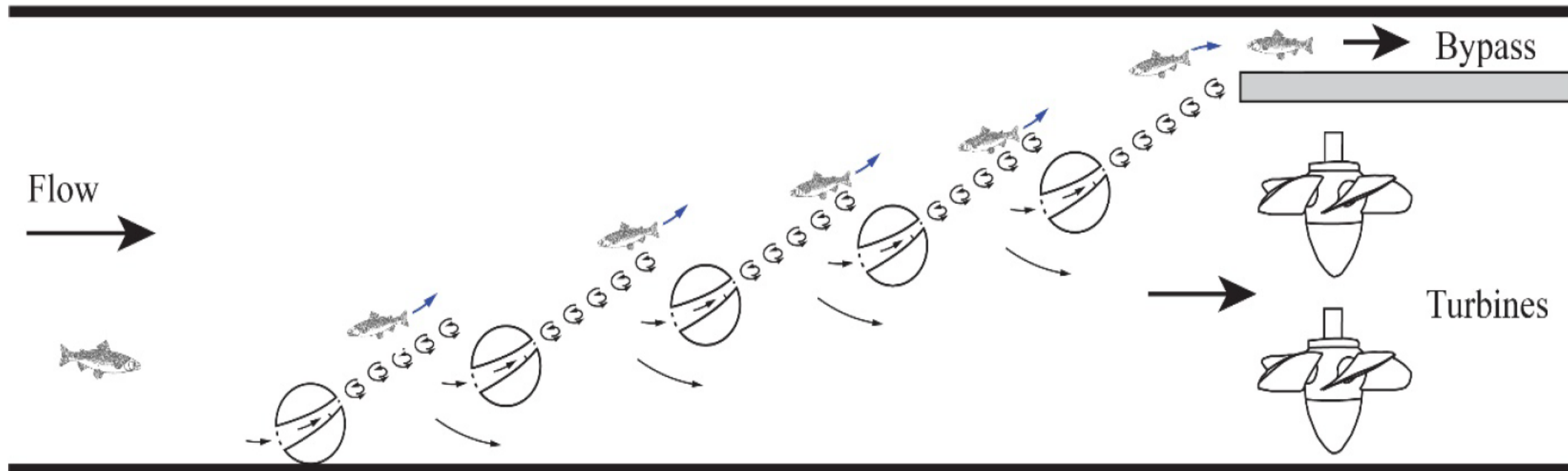
Guidance Systems



Source: Beck (2020)

Main goal

Eddies-based behavioural fish **Guidance Systems (EGS)**

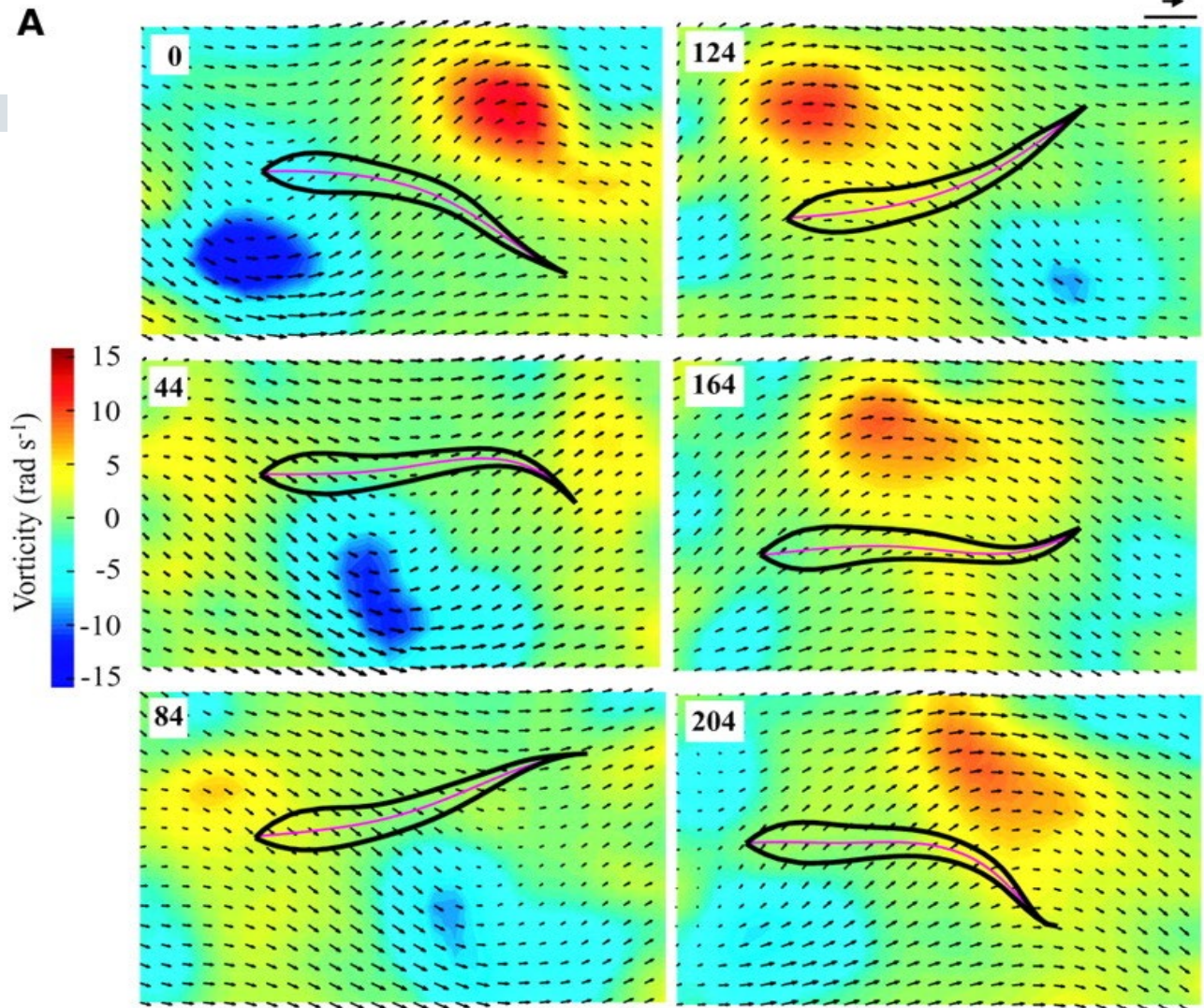


Project structure (4WP)

- WP1- Links between turbulent eddies and fish behaviour
- WP2- Innovative design of guidance structure
- WP3- Guidance efficiency
- WP4- Design guidelines for guidance structure

Why turbulent eddies?

Background



Liao et al . 2003

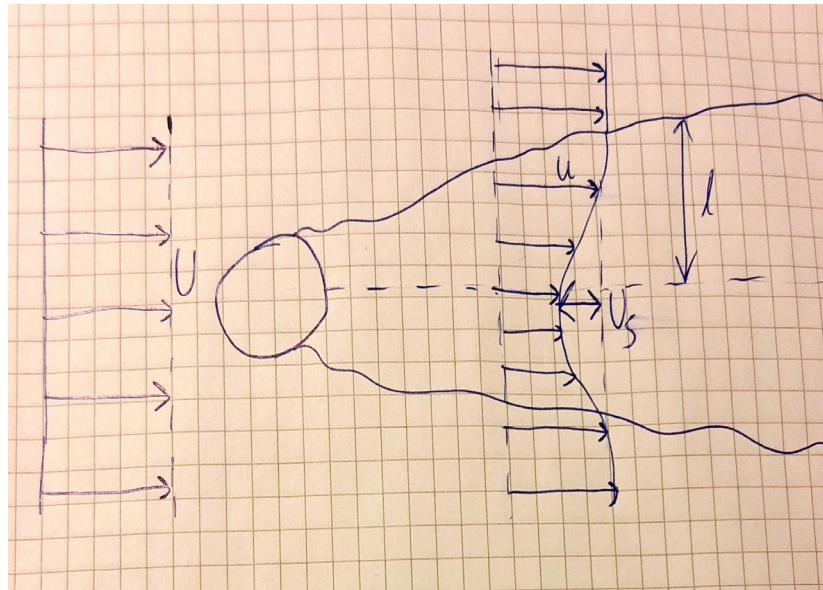
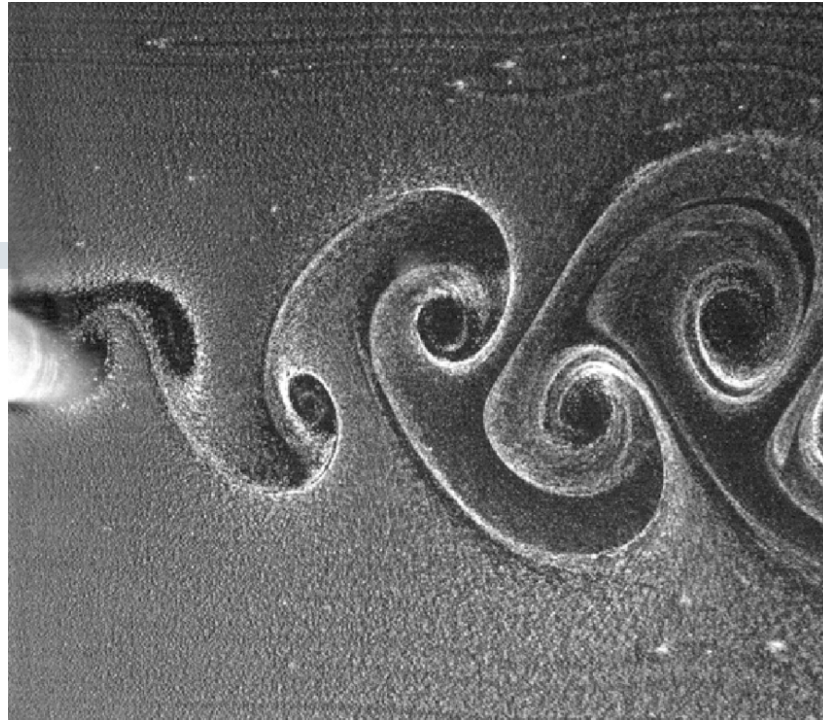
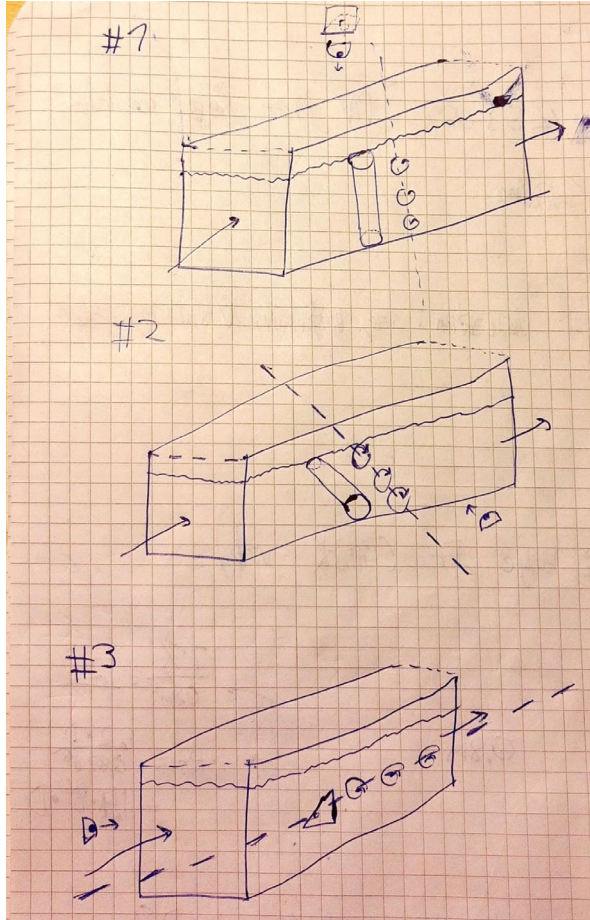
Research on turbulent eddies and fish



Turbulence affects fish swimming behaviour

+significantly increased knowledge of turbulence vortices as a hydraulic phenomenon and model tools to describe them

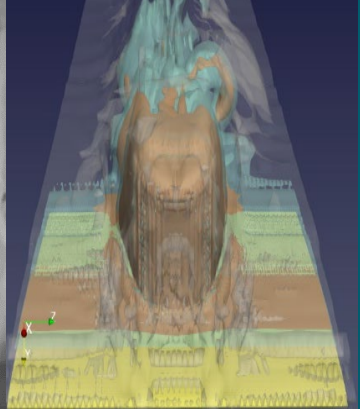
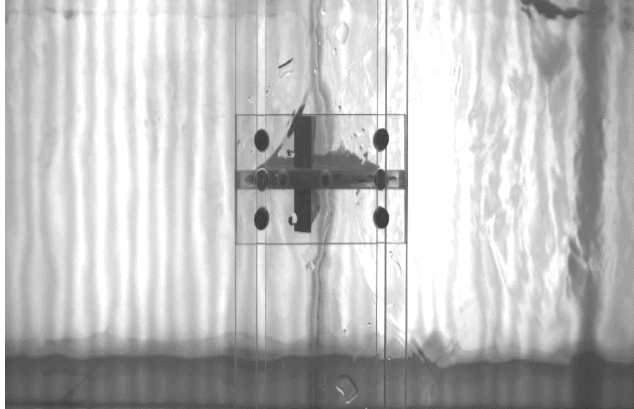




<p>Intensity</p> <ul style="list-style-type: none"> ➤ Turbulence intensity (both dimensional and non-dimensional) ➤ Turbulent kinetic energy ➤ Reynolds shear stress ➤ Vorticity
<p>Periodicity</p> <ul style="list-style-type: none"> ➤ Predictability ➤ Energy spectra
<p>Orientation</p> <ul style="list-style-type: none"> ➤ Axis of eddy rotation ➤ Direction of dominant fluctuation
<p>Scale</p> <ul style="list-style-type: none"> ➤ Eddy length scale ➤ Eddy diameter ➤ Reynolds number

Eddies characteristics

IPOS. A method for organizing and discussing the various (Lacey et al 2012)



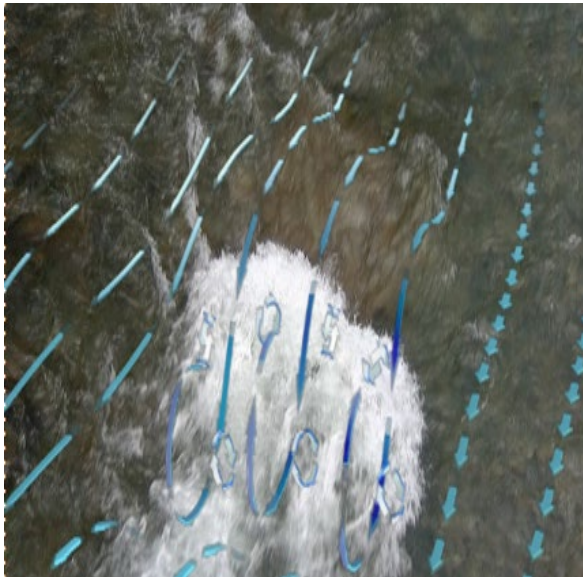
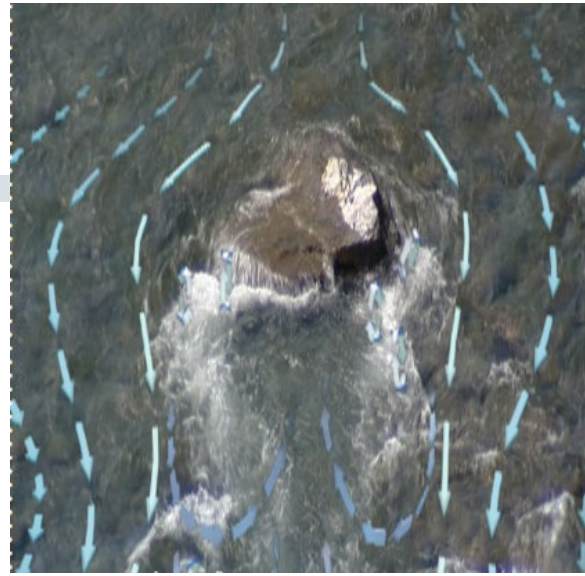
FishPath:

Turbulent eddies to create paths for safe downstream migration for salmonids and eel past hydropower intakes

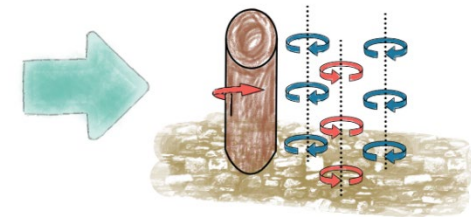
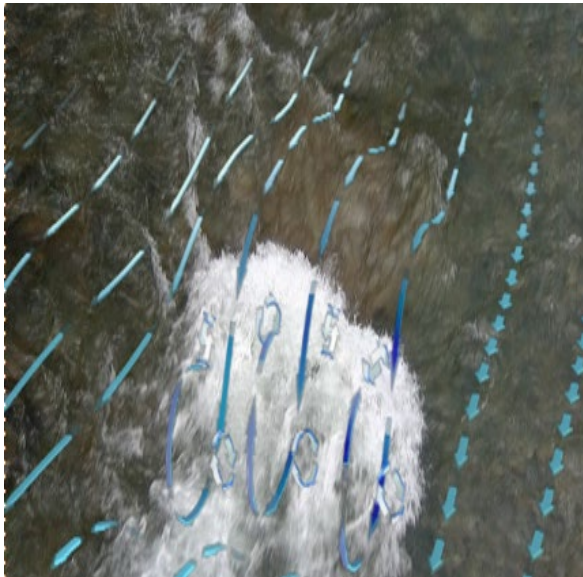
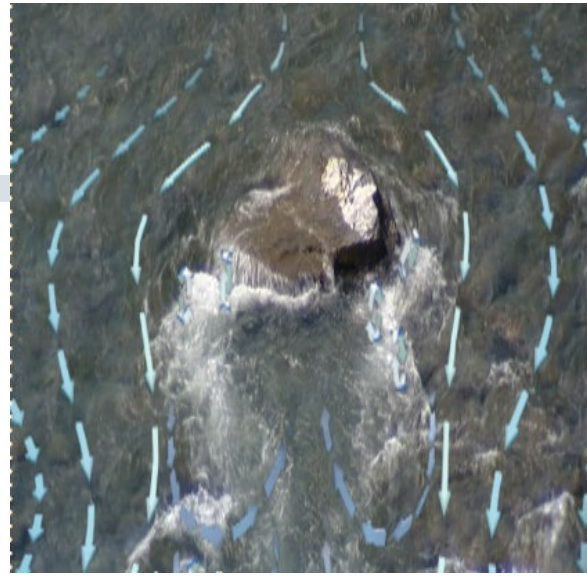
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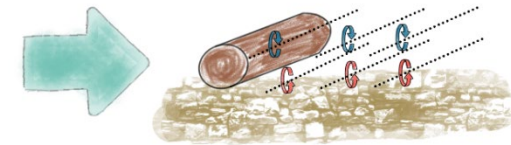
EDDIES – single elements :



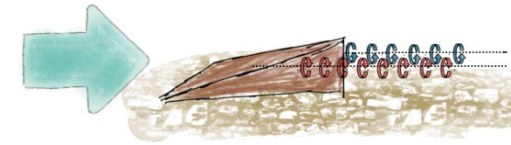
EDDIES – single elements :



Vertical Eddies

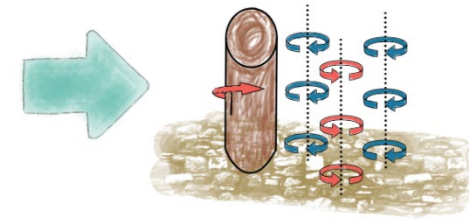
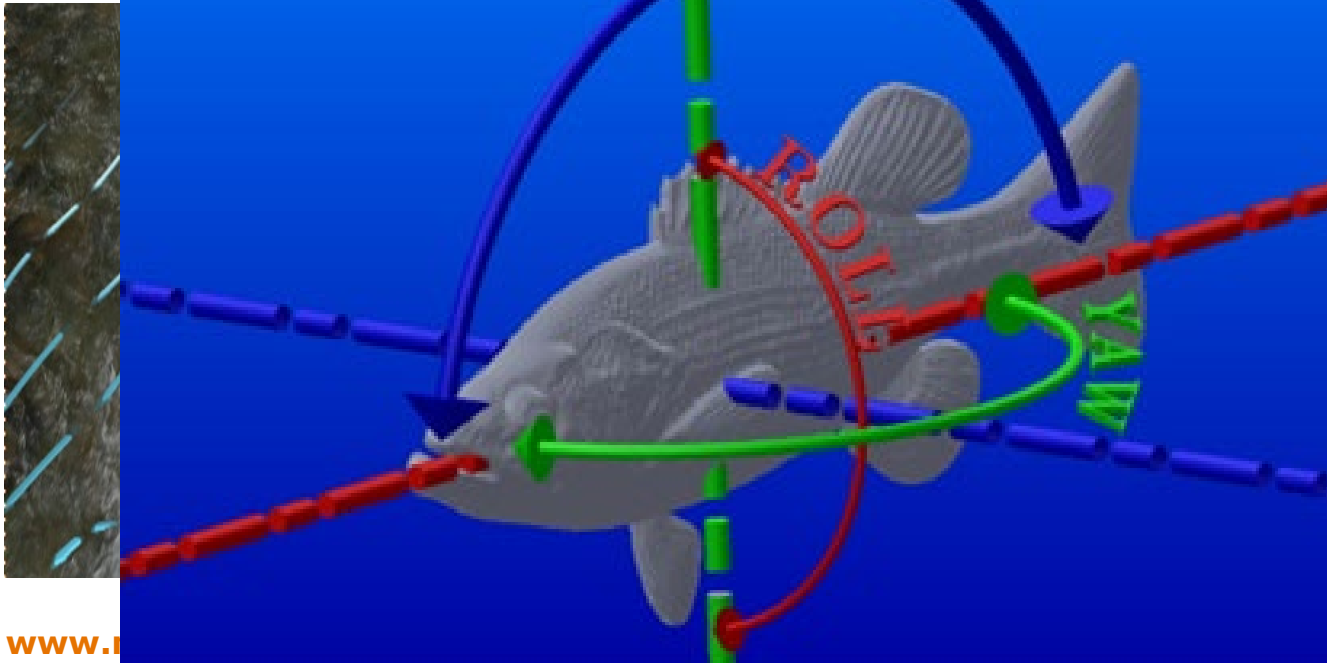
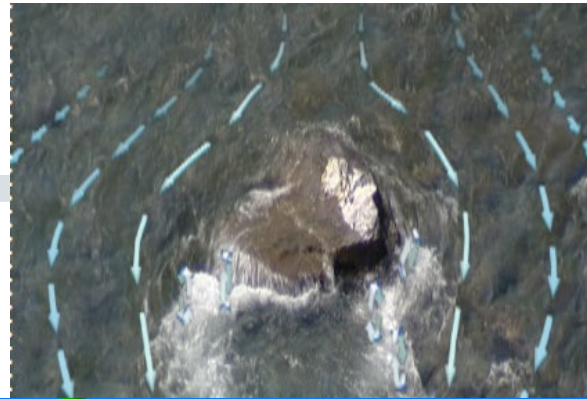


Horizontal Eddies

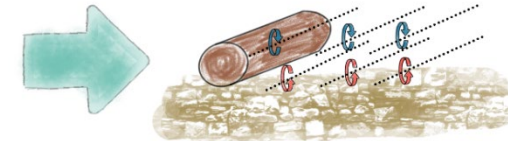


Streamwise Eddies

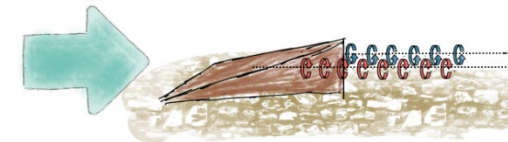
EDDIES – single elements :



Vertical Eddies

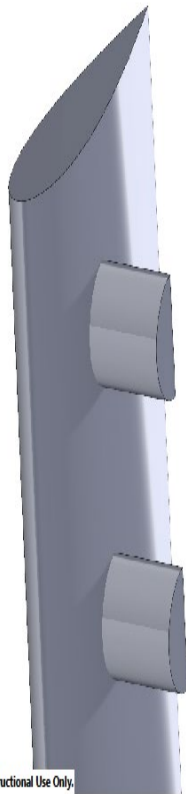


Horizontal Eddies



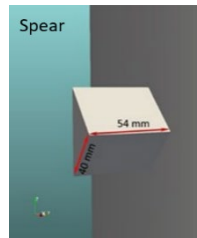
Streamwise Eddies

Single elements

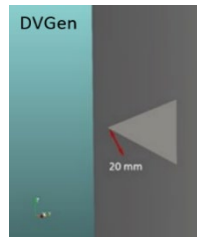


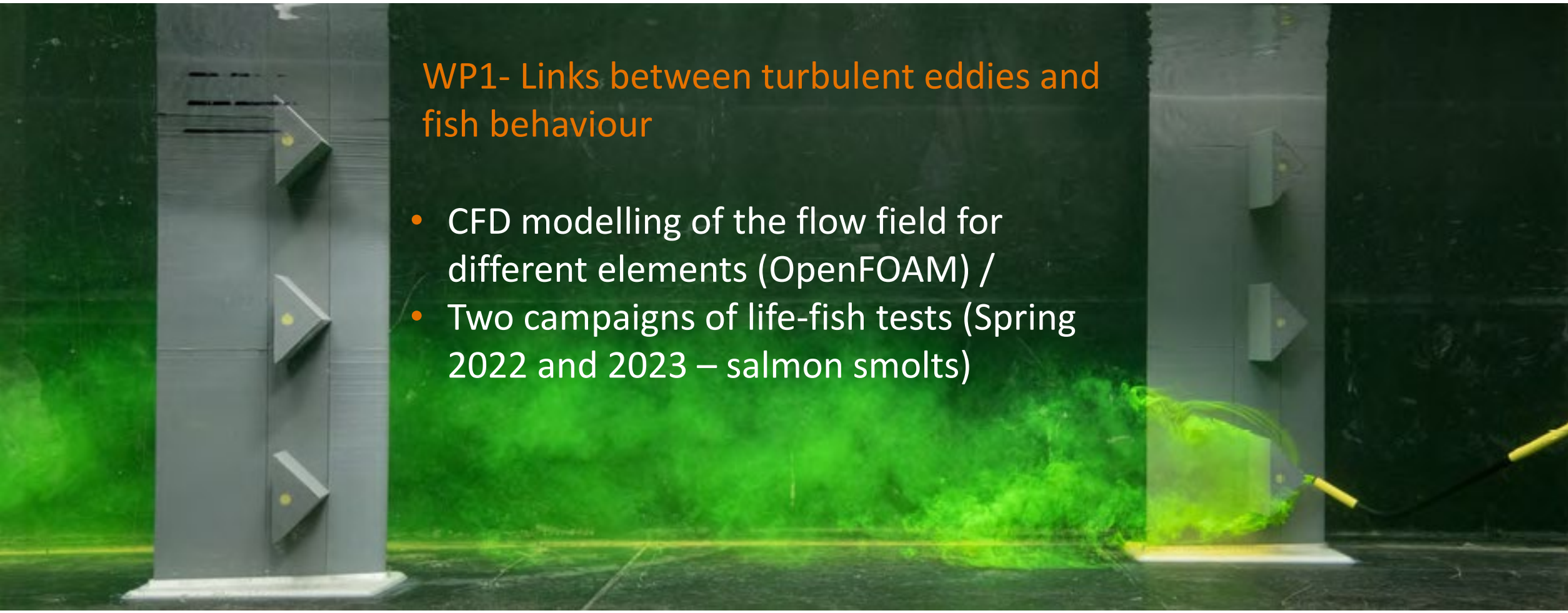
SOLIDWORKS Educational Product. For Instructional Use Only.

Spear



Delta wing



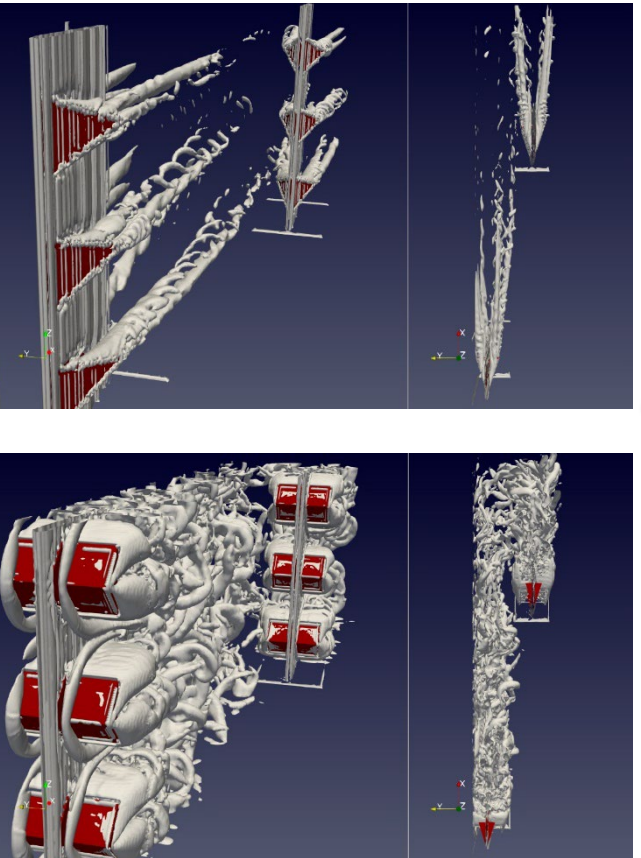


WP1- Links between turbulent eddies and fish behaviour

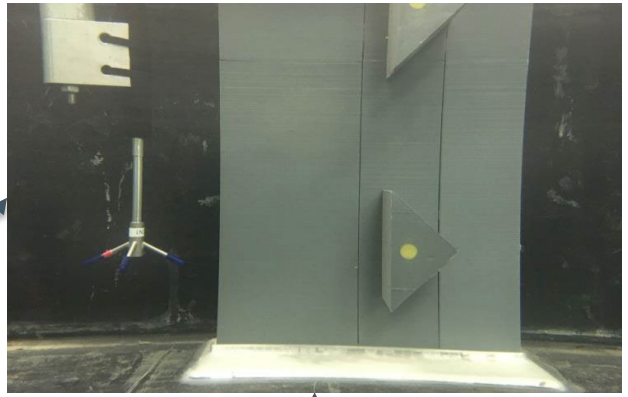
- CFD modelling of the flow field for different elements (OpenFOAM) /
- Two campaigns of life-fish tests (Spring 2022 and 2023 – salmon smolts)

CFD Modelling and validation

CFD



ADV



Literature

J. Fluid Mech. (2006), vol. 559, pp. 185–207. © 2006 Cambridge University Press
doi:10.1017/S0022219X06006006 Printed in the United Kingdom

A combined direct numerical simulation–particle image velocimetry study of the turbulent near wake

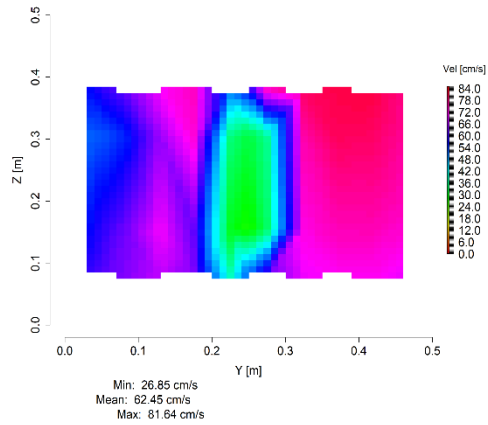
By S. DONG¹, G. E. KARNIADAKIS¹, A. EKMEKCI² AND D. ROCKWELL¹

FIGURE 2. Contours of normalized mean spanwise vorticity at $Re=10000$: (a) PIV;

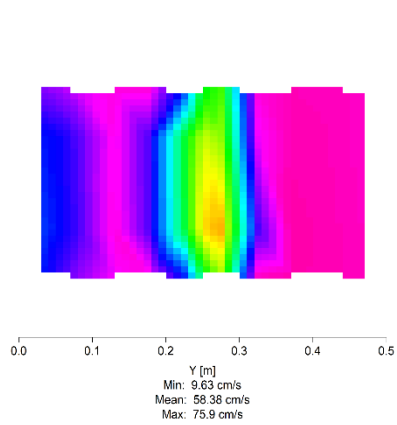
Validation

Spear

Velocity from ADV at X= 4.497



Velocity from CFD at X= 4.497



Life-fish experiments



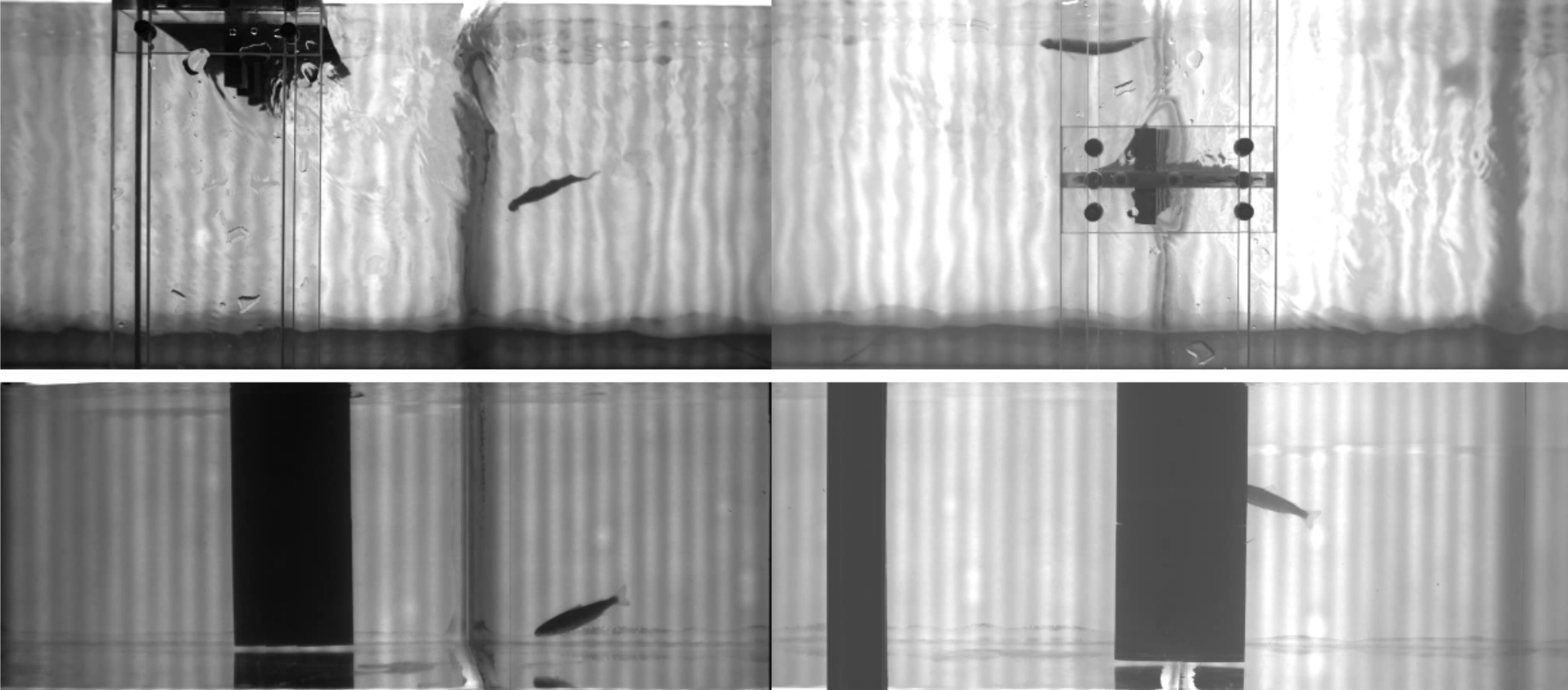
Live-fish test experiments:


Laboratory of Hydraulics
Hydrology and Glaciology

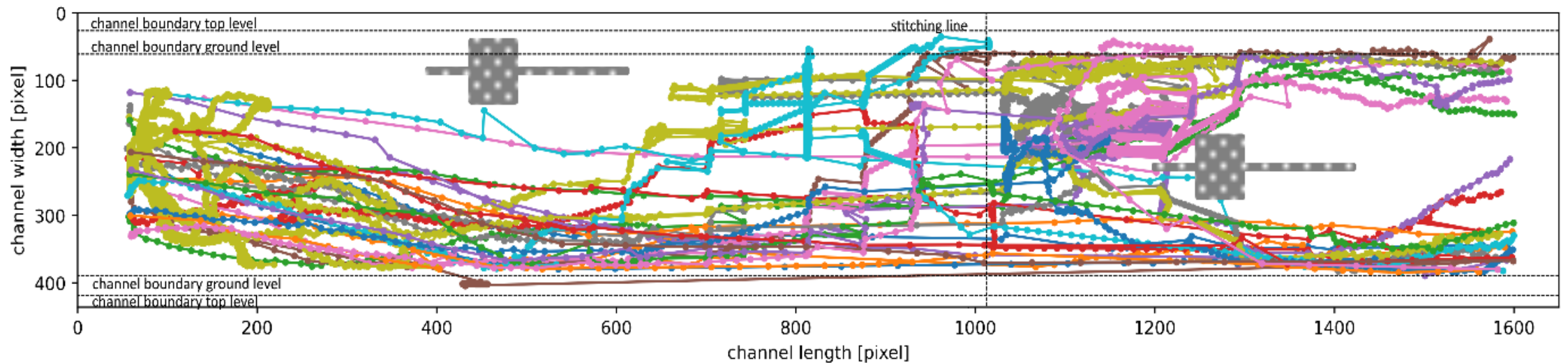
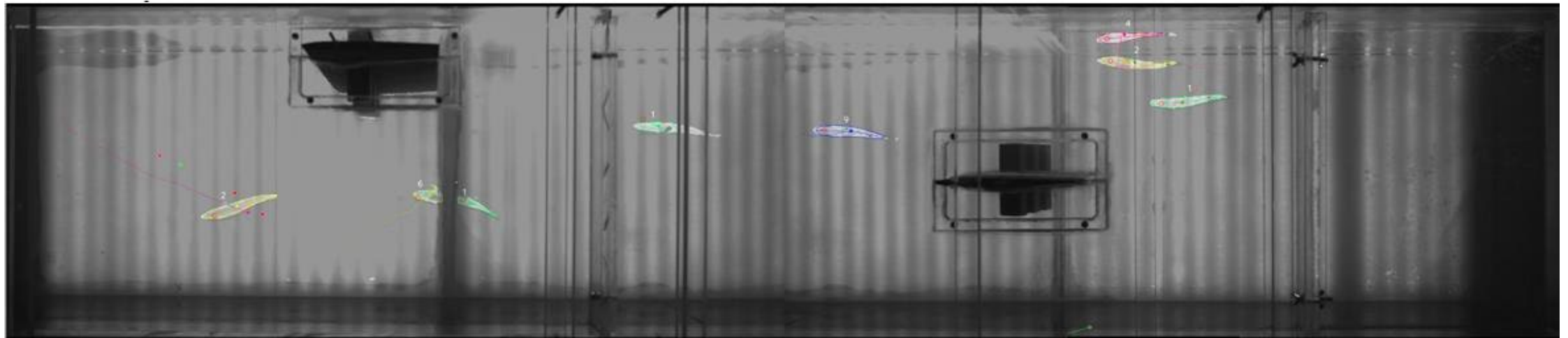
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Atlantic salmon (*Salmo salar*)

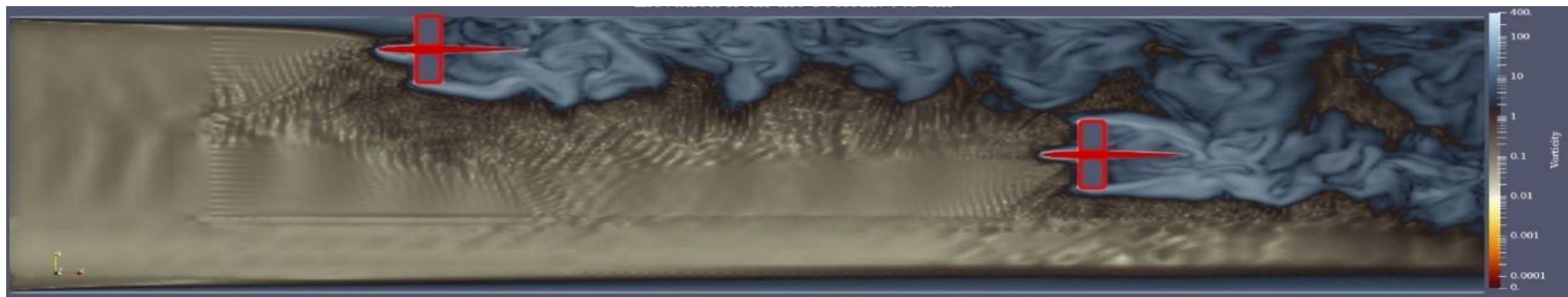
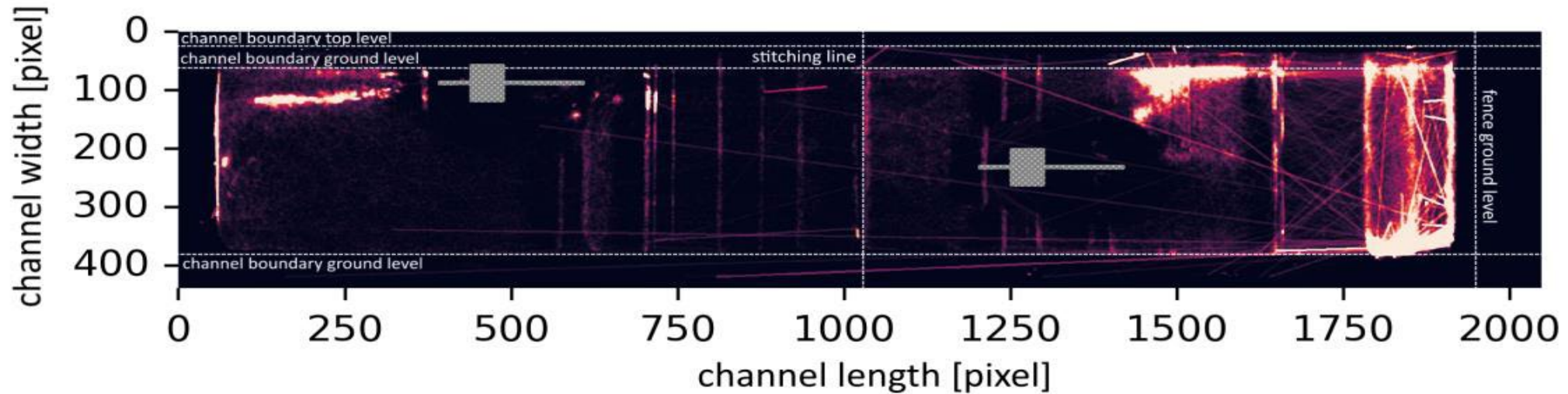


Fish tracking (Trex)



Fish seem to be guided by eddies!

Configuration	Guiding efficiency
SLV2	74 % (20)
DWLV2	41 % (11)




Live-fish tests with single elements

Salmon smolt (March 2023)



MORE INFORMATION ON THE PROJECT:

Webpage: [FishPath \(nina.no\)](https://nina.no)



NINA VÅRE FAGOMRÅDER NATURMANGFOLD NATUR OG KLIMA BÆREKRAFTIG SAMFUNN



Researchers seek to use turbulent eddies in the river to safely guide salmon and eels past hydropower plants.

FishPath

Turbulent eddies to create paths for safe downstream migration for salmonids and eel past hydropower intakes

Fish on their downstream migration in rivers often encounter hydropower dams and intakes and tend to follow the main flow into the turbines where they may be injured or killed. While some alternative guiding rack systems have shown promising results, there is a need to develop next generation systems that are cost-effective and easier to operate. In FishPath we aim to find a completely new way of guiding fish past the water intake of power plants.

Contact

- Ana Silva, project leader, NINA
- Torbjørn Forseth, co-manager, NINA

About FishPath

FishPath is a research project lead by the Norwegian Institute for Nature research. The main partners in the project are ETH Zürich, NTNU, NORCE and SINTEF Energy. It is funded by the Norwegian Research Council, with support from hydropower industry and the Norwegian Environment Agency.

Research period: 2021-2026

Partners

Main partners:

- NINA
- ETH Zürich
- NTNU
- NORCE
- SINTEF Energy

International partners:

- University of Michigan
- Technical University of Denmark

Thank you for your attention!

