

Four Steps to Fish-Friendly?

An Environmental Regulator's view of Fish Entrainment risk at Pump and Turbine Infrastructure.

First International Fish Impingement and Entrainment Conference
11 – 13 July 2023

Chris Bell

Andy Don

Chris Grzesiok

National Fisheries Service, Environment Agency.



Our Fisheries responsibilities

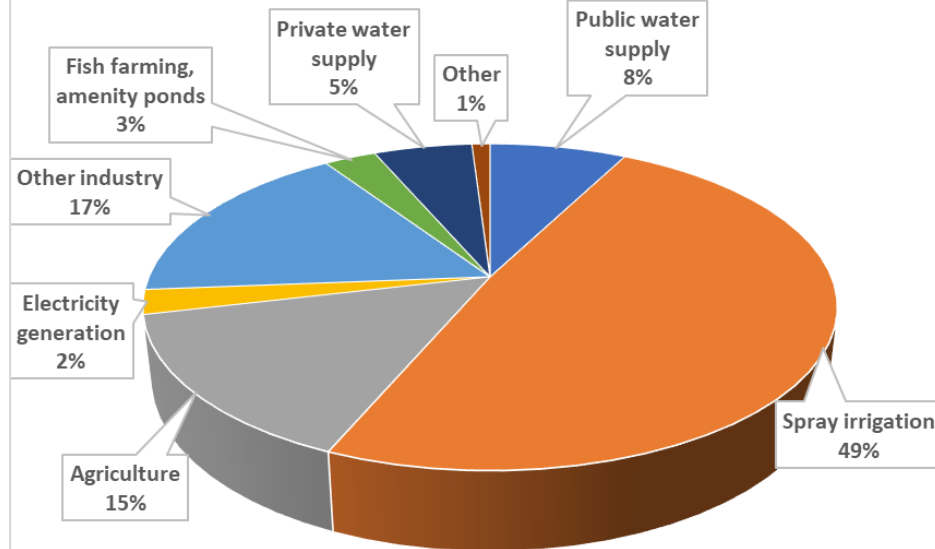
The Environment Agency has a specific duty to maintain, improve and develop fisheries, including both migratory and freshwater fish.



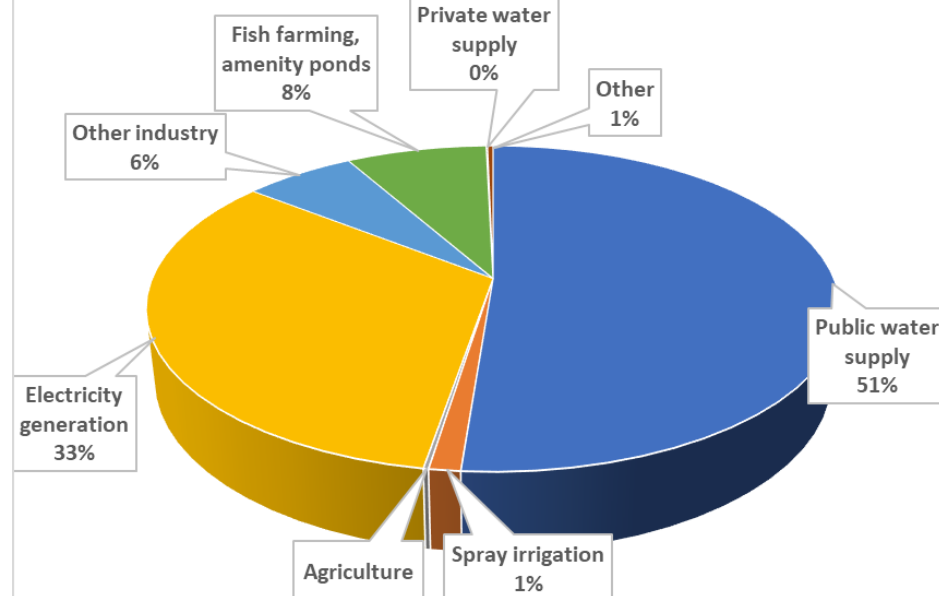
Environmental Risk vs. Societal Needs

c. 18,000 Abstraction Licences

Number of abstraction licences in force by purpose, England in 2018



Estimated abstraction volume by purpose, England in 2018



Our Approach to Evidence

EA Chief Scientist:

“...strong science and rigorous analysis are at the heart of the Environment Agency’s work to create a better place for people and wildlife and support sustainable development.”



**Chief Scientist's
Annual Review 2022**

Chief Scientist's Group report

March 2023



What is Fish-Friendly?

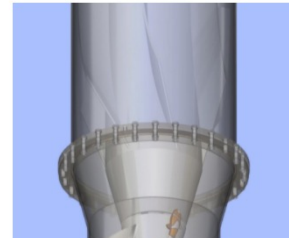
Fish Friendly hydroEngine®

a water-to-wire system for low head hydro applications



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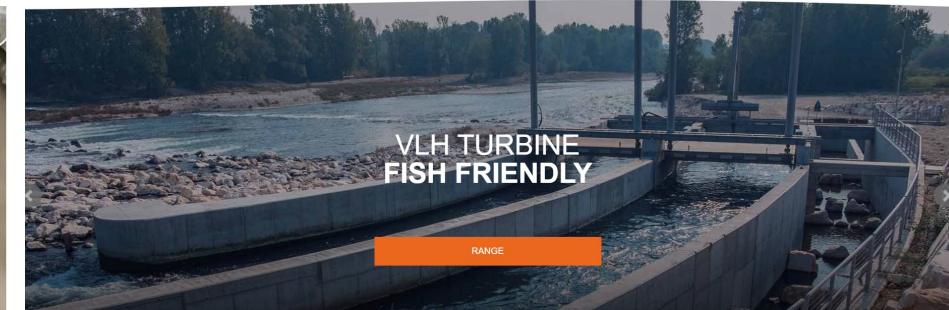
FISH FRIENDLY PUMP TECHNOLOGY



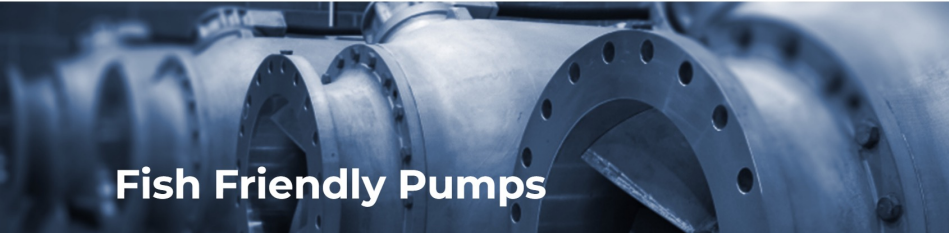
MJ2 technologies DESIGN AND MANUFACTURING OF TURBOGENERATOR GROUPS FOR HYDROELECTRICITY

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VLH TURBINE PMGA GENERATOR KAPLAN TURBINE TIDAL TURBINE



**FAIRBANKS
NIJHUIS
FISH FRIENDLY
PUMPS**



Hydropower generator
Innovation > Science > Whirlpool turbine creates fish-friendly hydropower

WHIRLPOOL TURBINE CREATES FISH-FRIENDLY HYDROPOWER



TURBULENT

Eco-friendly hydropower for anyone, anywhere.

Report on fish friendly design of the Turbulent vortex turbine.

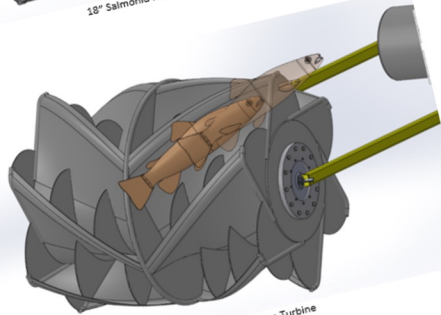


www.turbulent.be
wim.bevoert@turbulent.be | TEL: +32 499 64 65 20
Wigmaalsesteenweg 6, 3012 Willebe, Belgium

1



18° Salmonid Relative to Turbine



24° Salmonid Relative to Turbine

B | Page



PNL-32347

Behavior and Survival of Eels Passing through Natel Energy's Restoration Hydro Turbine

Progress Report

December 2021

Z. Daniel Deng
Robert P. Mueller
Brett D. Pflugrath
Katherine A. Deters

U.S. DEPARTMENT OF ENERGY Prepared for the U.S. Department of Energy under Contract DE-AC05-78RL01830



Report 2011-096

J.H. Wanink
R. Bijkerk
G.H. Bonhof
N. Bouton
H. Slabbeboom



Universiteit Leiden

Koeman and Bijkerk

Ecological research and consultancy
Visiting address Oosterweg 127 Haren
Postal address P.O. Box 111 9750 AC Haren
Telephone 050 8200018
Telefax 050 8200013
E-mail info@koemanenbijkerk.nl
Website www.koemanenbijkerk.nl

This is a summary of the complete final report (215 pages). The content is based on pumping station "Kralingse Plas" which is executed with a Pentair Fairbanks Nijhuis / FishFlow Innovations fish-friendly pump.

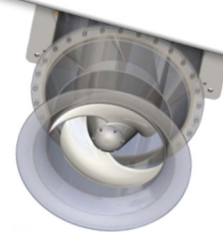
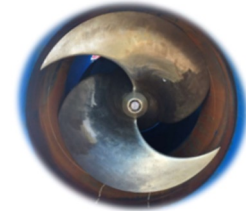
English translation on behalf of Pentair Fairbanks Nijhuis.

1



Eel passage at the Orchard Rd Pump Station – Stage 2 (2018)

Prepared for the Waikato Regional Council
November 2018



Report: VA2009_19
On behalf of:
FishFlow Innovations
August 2009

by:
Author(s):
F.T. Vriese (VisAdvies).

English translation of Axial pump sections on behalf of Nijhuis Pompen BV

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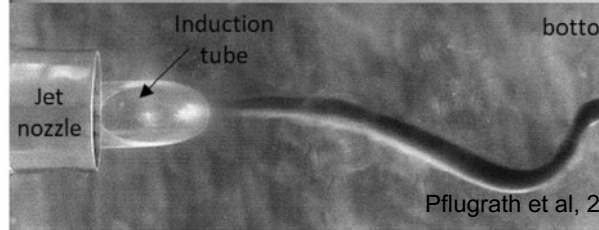
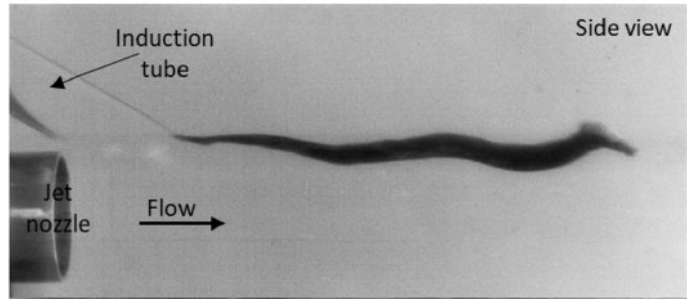
Quality of Evidence

- Some good, has led to acceptance.
- But a lack of standardisation.
 - Varying approaches – often by territory?
 - Statistical design – sample size, power, controls.
 - Desk vs. lab vs. field studies
 - Species
 - Mortality vs. damage.
 - Post-exposure mortality.
 - Post-mortem study.

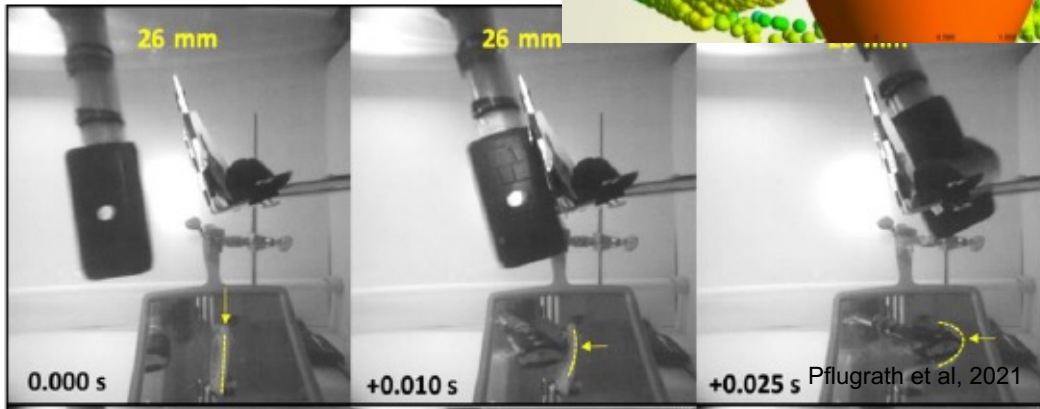
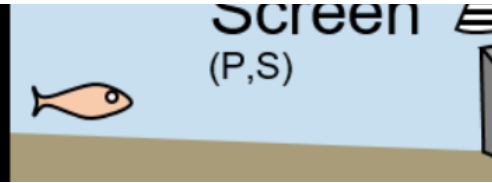
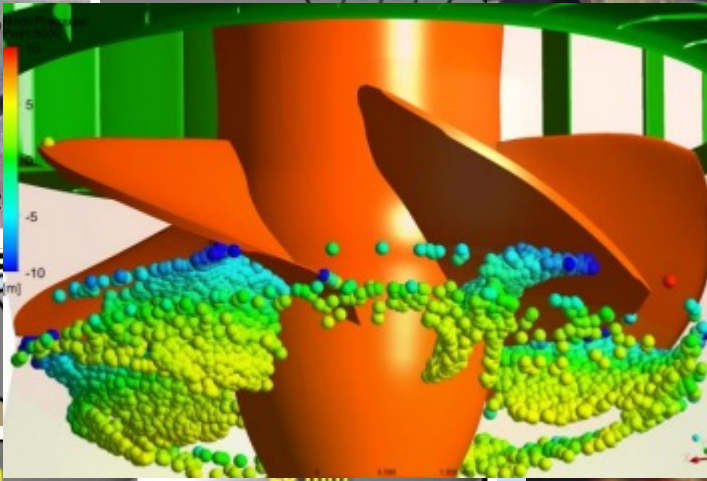
Recent Advances



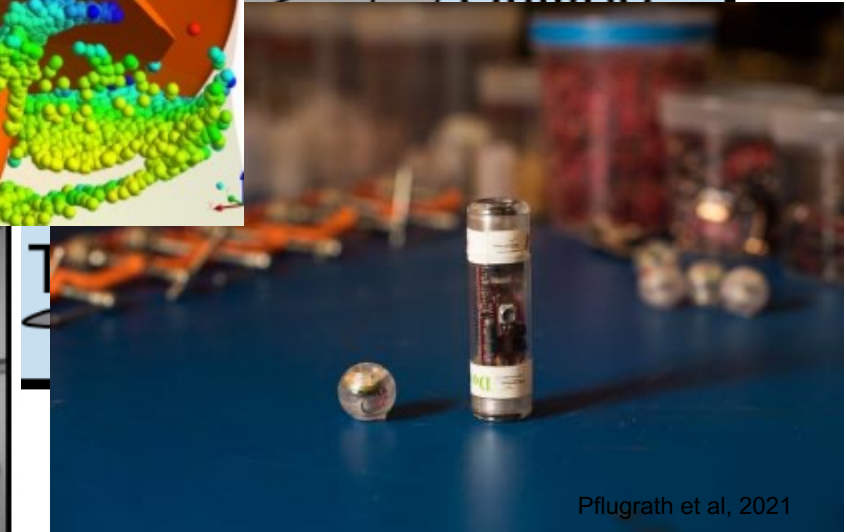
Pflugrath et al, 2021



Pflugrath et al, 2021



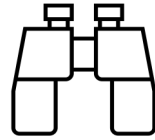
Pflugrath et al, 2021



Pflugrath et al, 2021

How EA has responded

Kept up to date



Research



Implementation



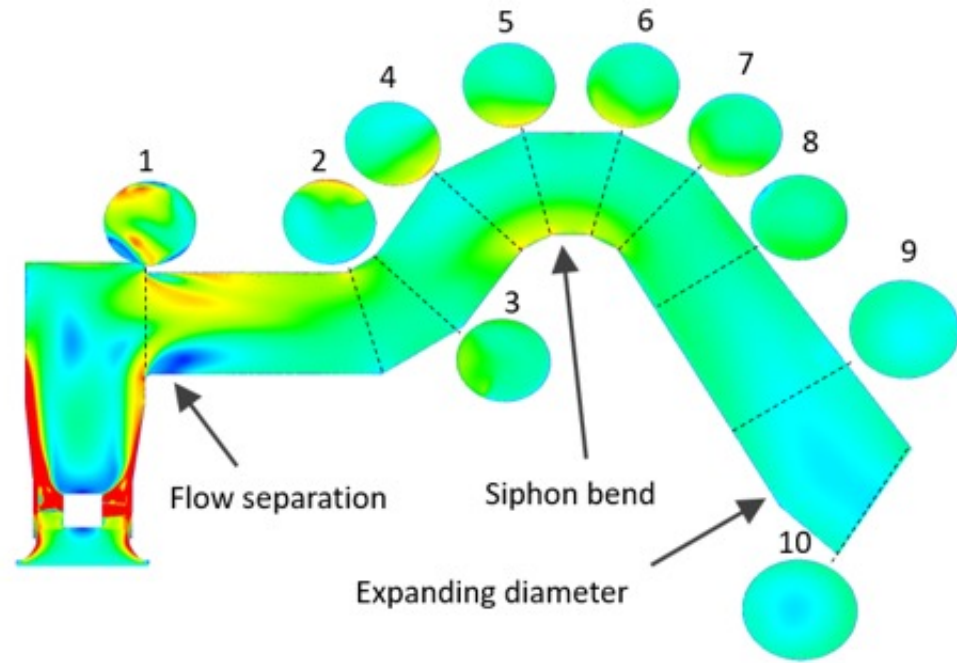
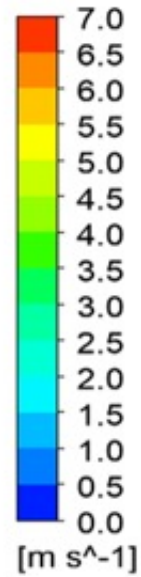
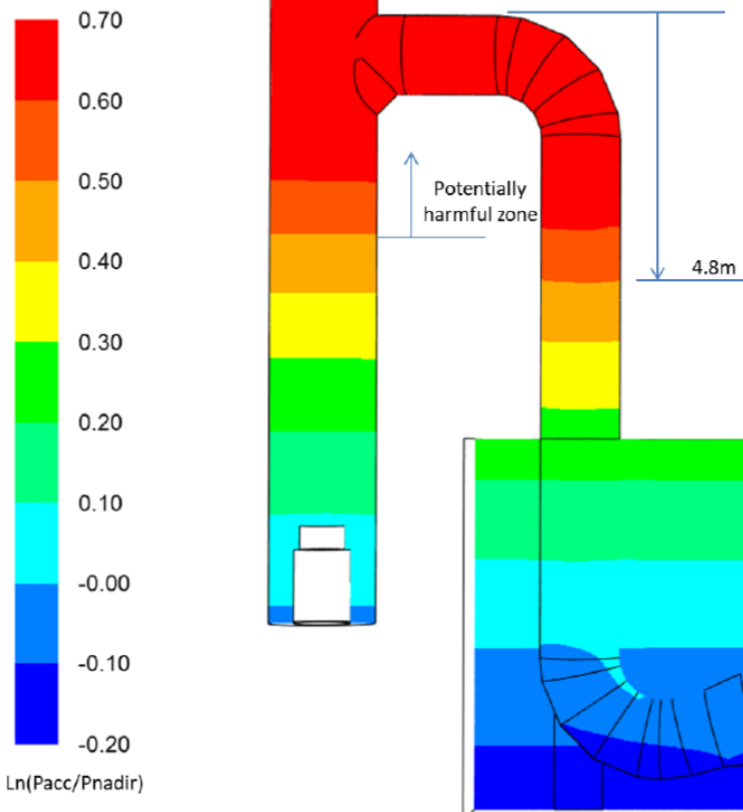
Requested evidence



Updated guidance



Step 1 - CFD



Step 2 – NEN 8775 Standard

Dutch standard

NEN 8775

(en)

Fish safety - Method for the determination of the fish safety of pumps, Archimedean screws and confined water turbines used in pumping stations and hydroelectric plants

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NEN 8775 App. for Pumps

Environmental Agency: Estimating Fish Injury

Pump Specifications

Pump type

Pump size (m)

Target shaft speed (rpm)

Target flow rate (m^3/s)

Flow rate range (x axis)



Head range (y axis)



QH curve range



Fish Specifications

Fish type

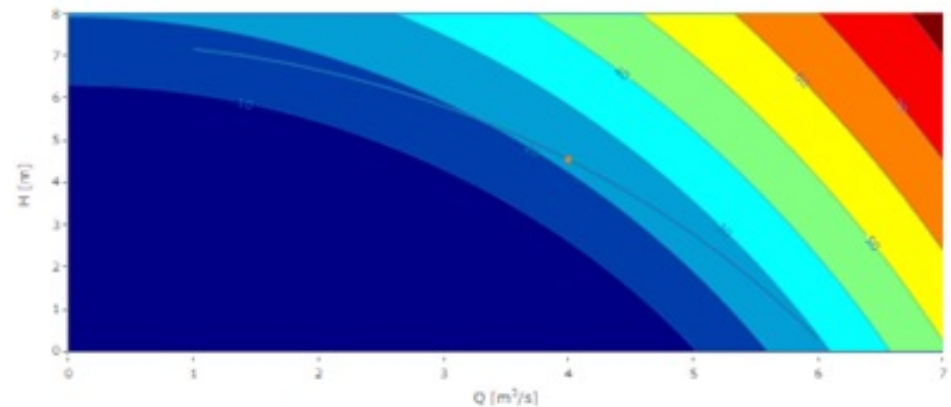
- Scaly Fish
- Eel

Length of fish (m)

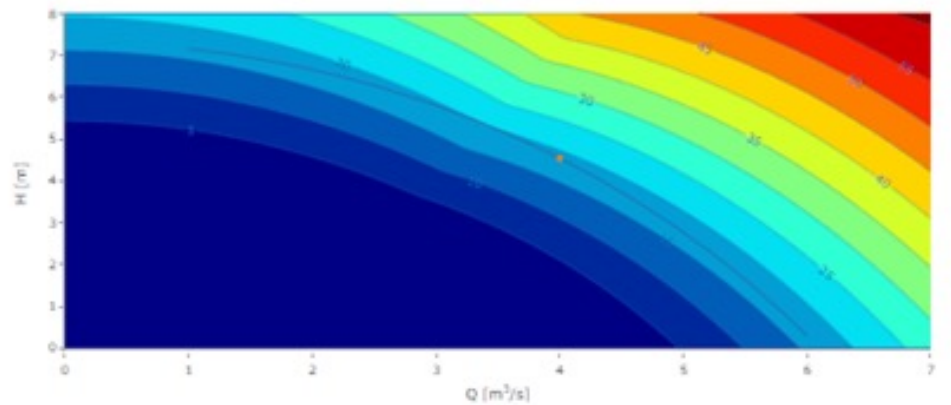
Width of fish (m)

Submit

Estimated mutilation ratio for 50 cm Scaly Fish



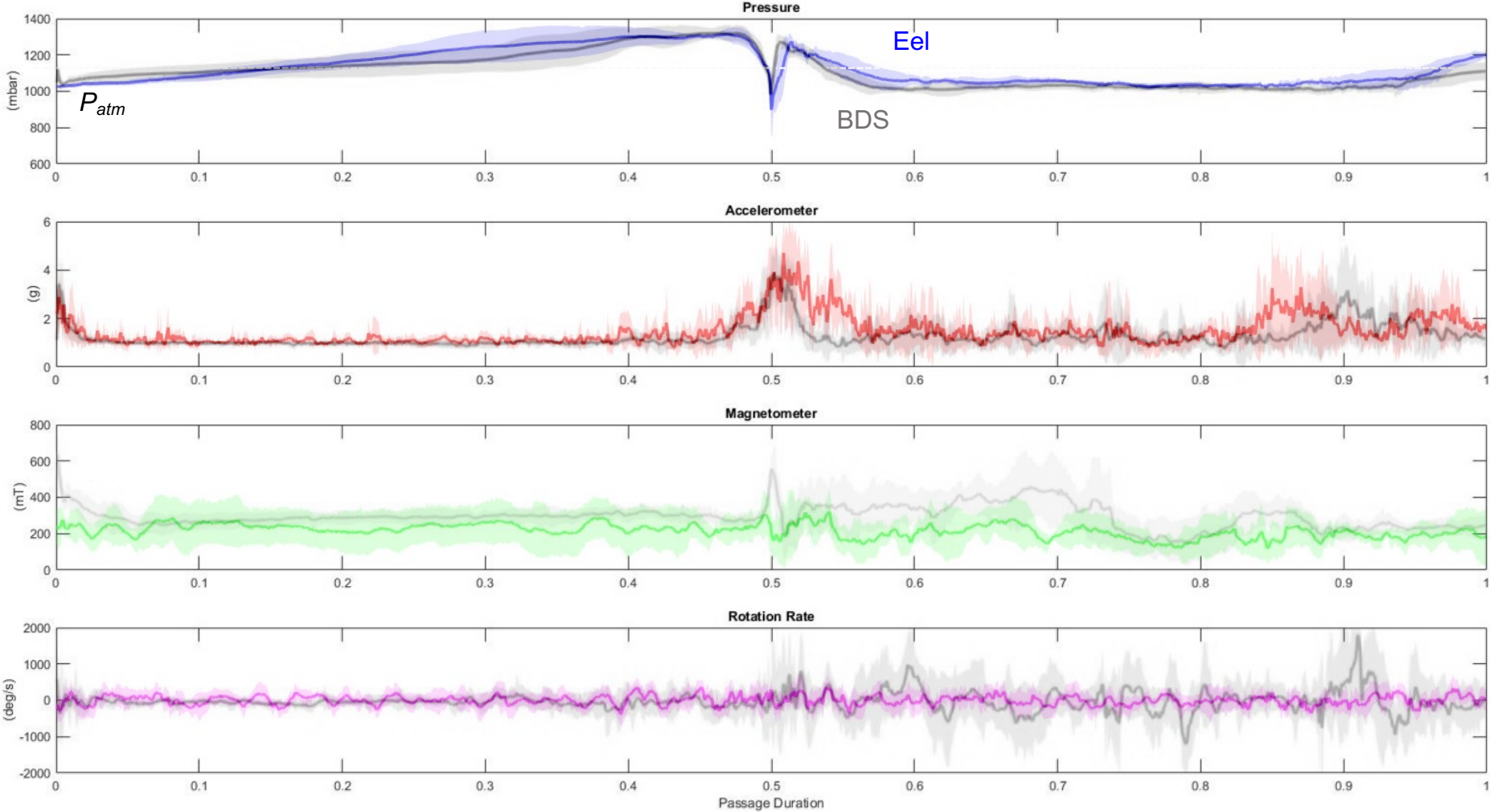
Estimated mortality rate for 50 cm Scaly Fish [%]



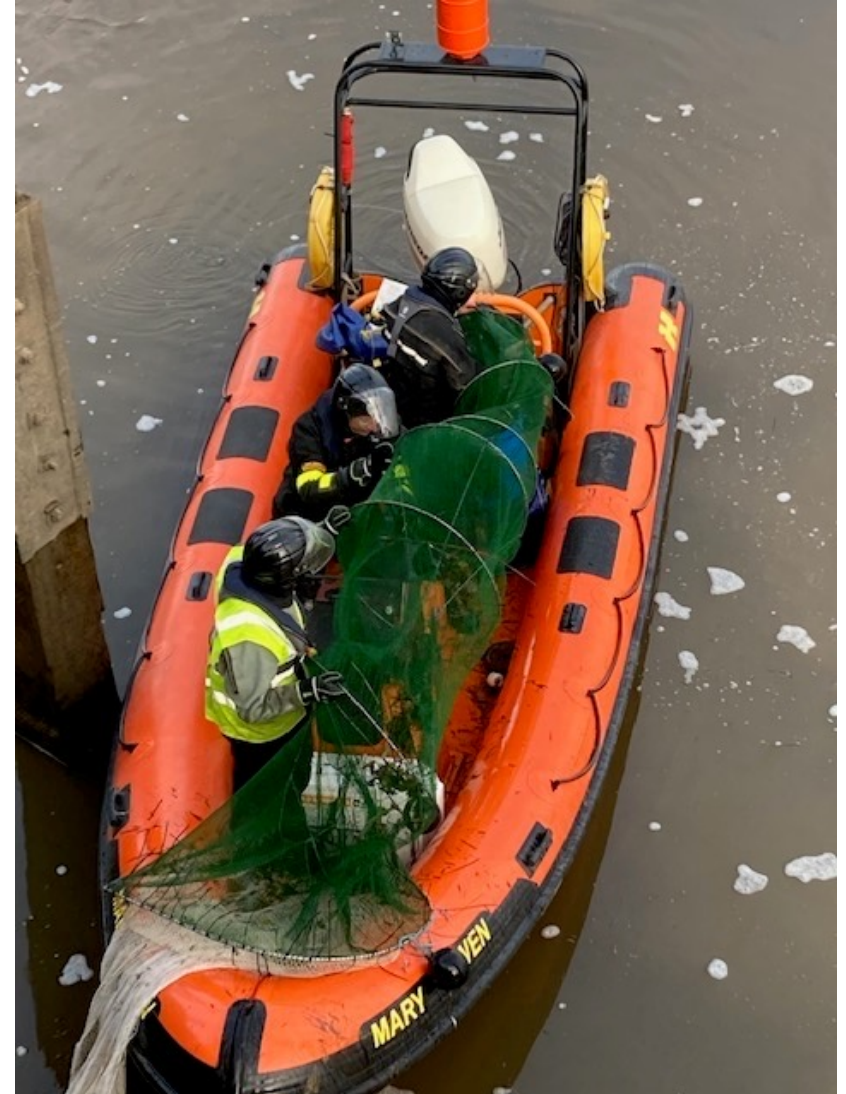
Step 3 – Fish Sensors



Eel/Backpack and BDS Passage Summary



Step 4 – Live Fish Trials



In Summary:

“Fish-friendliness” is not defined in terms of execution or outputs, although some concepts – slower moving, fewer blades, blunt and swept leading edges, minimal pinch-points are all good starting points.

The main potential causes of damage/mortality are collision, barotrauma and fluid shear. But we shouldn't ignore delay, turbulence, cavitation and predation.

We have used available evidence from the literature to form useable and measurable damage thresholds for some common species.

We can use CFD and our NEN 8775 to make pre-assessments of a proposed pump/turbine and its whole system.

We can then use sensors and live fish trials to test an installation. This can validate the modelling and calibrate the sensors and help us phase out live fish trials.

There are gaps in the UK evidence – working on these and watching carefully elsewhere.

Keen to work towards a BS or CEN Standard.



Thank you

6.0 Water Pumps

Summary Box 6.0 - Pumping Stations

Although often described as 'Fish Friendly' (FF), pumps that are less damaging than traditional designs do not eliminate the risk to eel and fish and can still cause physical damage or mortality. Therefore, it is important that any FF pump operates below damaging thresholds set in the guidance and that the **entire pumped system** is taken into account to provide the best option possible. The system should include:

- Intake / sump arrangement
- 'Fish friendly' pump
- Pipework (i.e. bends, joints, elevation changes etc.)
- Siphon-breakers, valves / other control structures (e.g. non-return flaps)
- Discharge or outfall arrangement
- Separate upstream / downstream eel and or fish passage structure where applicable

! Important Simply installing a FF pump does not mean the site is considered BAEP. Each one of the above-identified pump system components needs to be addressed.

Need to know values for FF pump systems:

- Blade strike – L/t ratio and strike speed (Figure 30)
- Decompression – Log ratio pressure (LRP) of less than 1.0 for eel
- Shear strain – Less than 800 cm/s/cm
- Shear stress – Less than 774 n/m²
- Turbulence – Less than 0.2 m²/s²
- Velocity internal pipework – Less than 12 m/s
- Velocity discharge impact velocity – Less than 8 m/s

! Important The way in which the pumping station is operated will influence the above criteria. See Section 6.3.2 on variable speed pumps / slow pump start-up

Mobile Pump Options

Mobile pump screens should consider:

- Approach velocity – (See Table 3.3)
- Screen size mesh (2, 3, 9 or 12mm – refer to Table 3.3)
- Location – Off the bed preferably with good water flow mid-water column
- Material – Solid construction to avoid deformation when under pressure
- Blinding - Allow for 50% for passive screens and 10% of active screens
- Maintenance – Easily accessible and frequently checked

