

REDEEM project: Research and Development of fish and Eel Entrainment Mitigation at pumping stations

Jonathan Bolland

 @FishMigrationDr



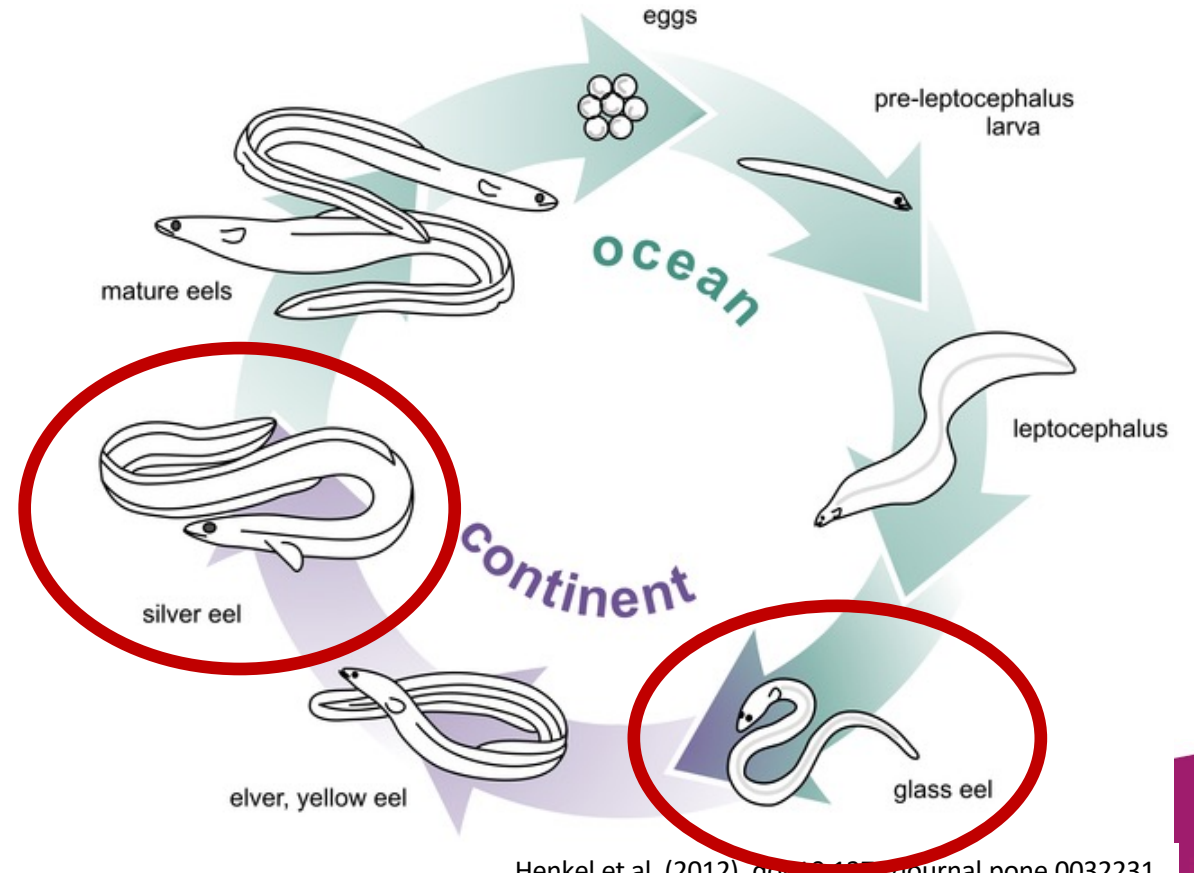
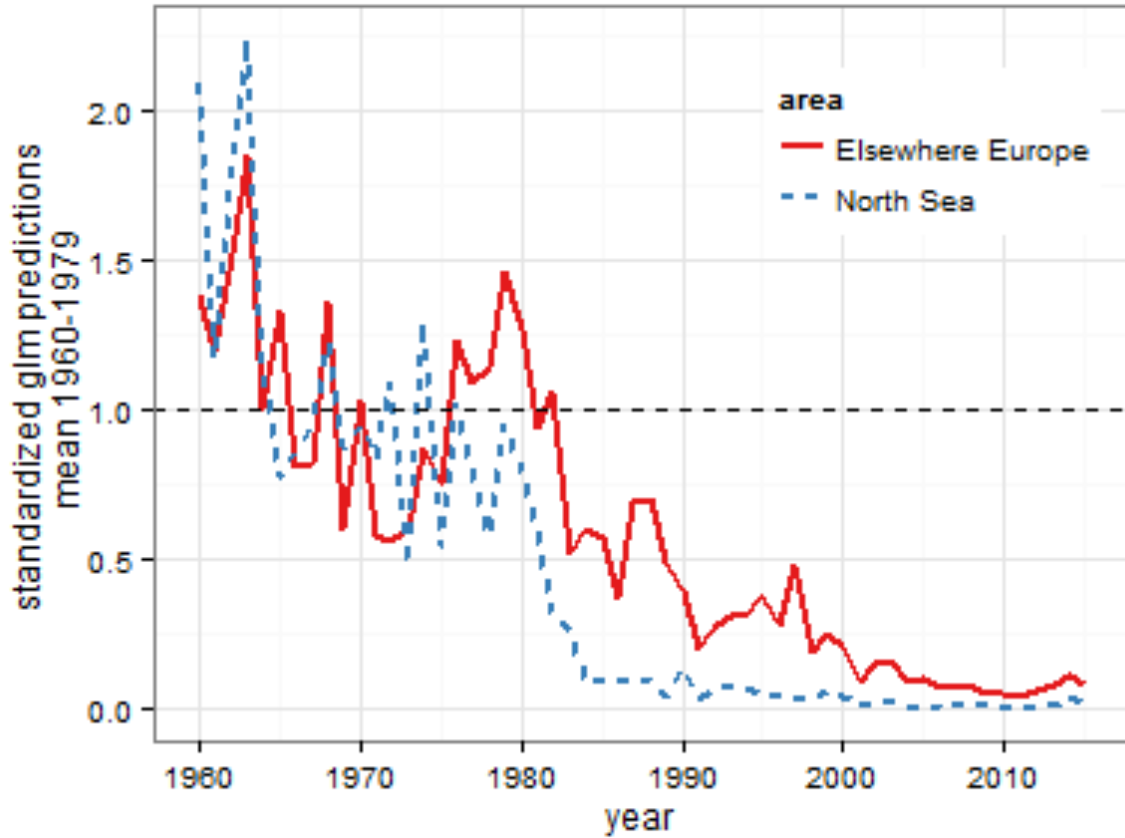
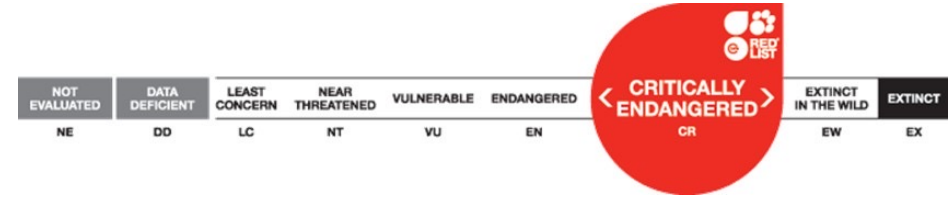


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Background

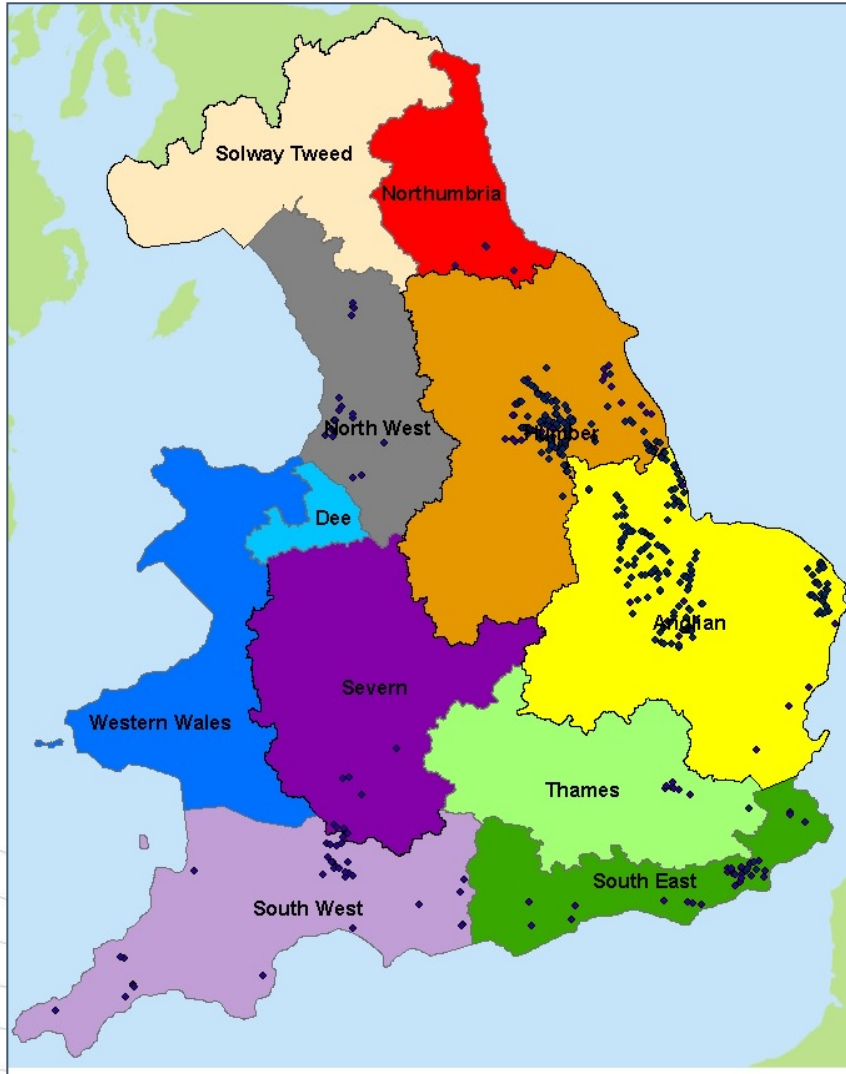
Eels and pumping stations

European eel decline



Henkel et al. (2012). doi:10.1371/journal.pone.0032231

Pumping stations in England



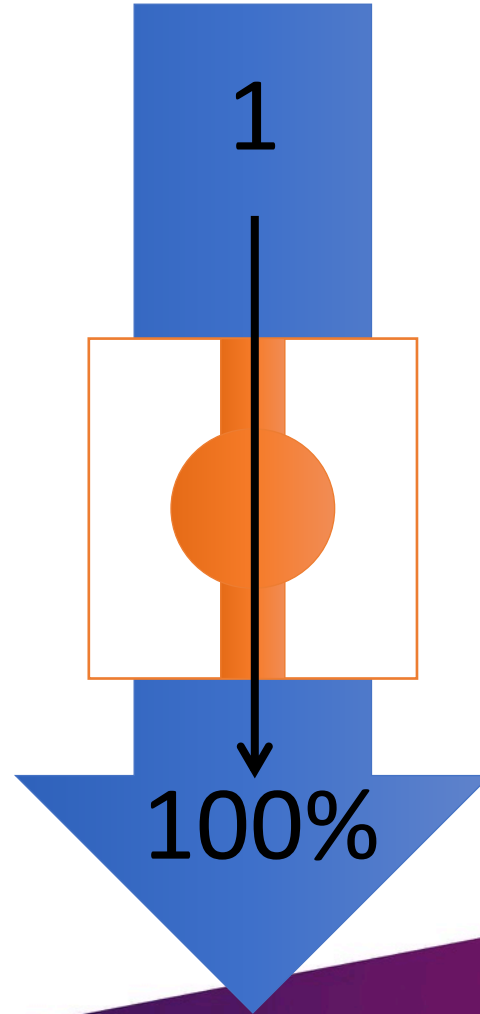
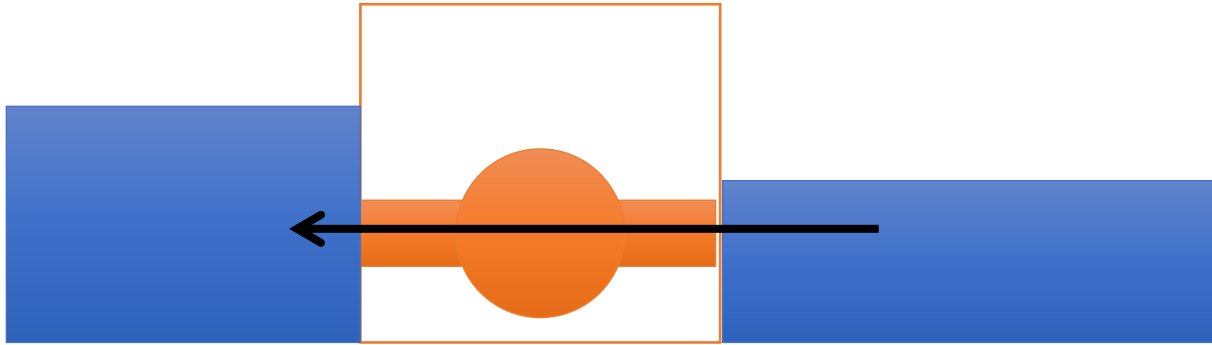
COUNCIL REGULATION (EC) No 1100/2007
of 18 September 2007
establishing measures for the recovery of the stock of European eel

2009 No. 3344
**FISHERIES, ENGLAND AND WALES
RIVER, ENGLAND AND WALES**
The Eels (England and Wales) Regulations 2009



- In England, water intakes (including pumping stations) abstracting greater than 20 m³ a day must be screened.
- Over 900 pumping stations in England
- It is assumed that eels are everywhere, and all sites must comply

What is a pumping station?



Key details:

- Pumping stations are a barrier to upstream passage
- Providing downstream passage is challenging and expensive

Pumped catchments = long lakes





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REDEEM

2018-2023

REDEEM project: **R**esearch and **D**evelopment of fish and **E**el **E**ntrainment **M**itigation at pumping stations

- Understand fish and eel distribution and behavior
- Assess the effectiveness of existing and new technologies to minimise entrainment / maximise safe passage
- Develop innovative measures to provide applied outcomes



Five (outgoing) PhD students

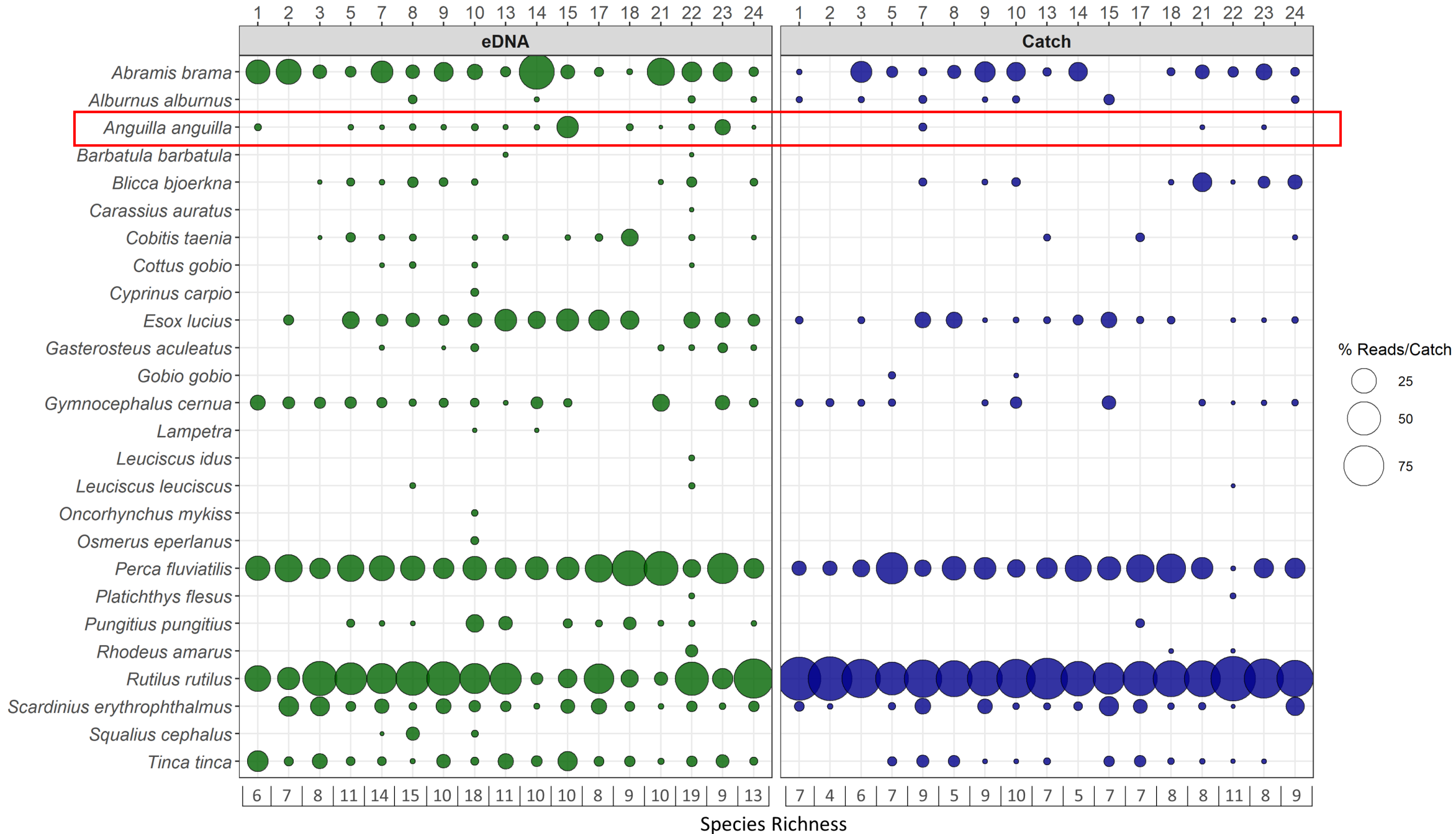
- Developments in environmental DNA (eDNA) based decision-making in modified river catchments (Dr Nathan Griffiths)
- Understanding behavioural ecology of river-resident fish in winter to improve protection at water pumping stations (Dr Josh Norman)
- The effectiveness of fish-friendly pumping stations for downstream migrating silver European eel (*Anguilla anguilla* (L.)) (Dr Oliver Evans)
- Enhancing critically endangered European eel (*Anguilla anguilla*) protection at hazardous intakes (Dr Liam Carter)
- Improving hydrodynamic understanding of migrating European eels at lowland pumping stations (Stephen Collier)

Q: Why eDNA?

A: Eels aren't as widespread as they used to be!

- Eels are rare:
 - Not in all pumped catchments (i.e. low site occupancy)
 - Low abundance when present (i.e. low detection probability)
- Manage / prioritise pumping stations using eel presence / absence
- It's hard to confirm absence / avoid a false negative!
- eDNA recognised as highly sensitive and cost-effective
- Main objective = wide-scale understanding of eel (and entire fish community) distribution to ensure the largest populations are (quickly) protected and (limited) money is spent wisely

Site Number



Q: Why study coarse fish?

A: Underwater caves are not as safe as fish think!

- Fish occupy pumping stations that operate infrequently
- Further our understanding of the processes that influence occupation
- Need to identify measures to minimise fish entrainment
- Alternative habitats – if we build it, will they come?



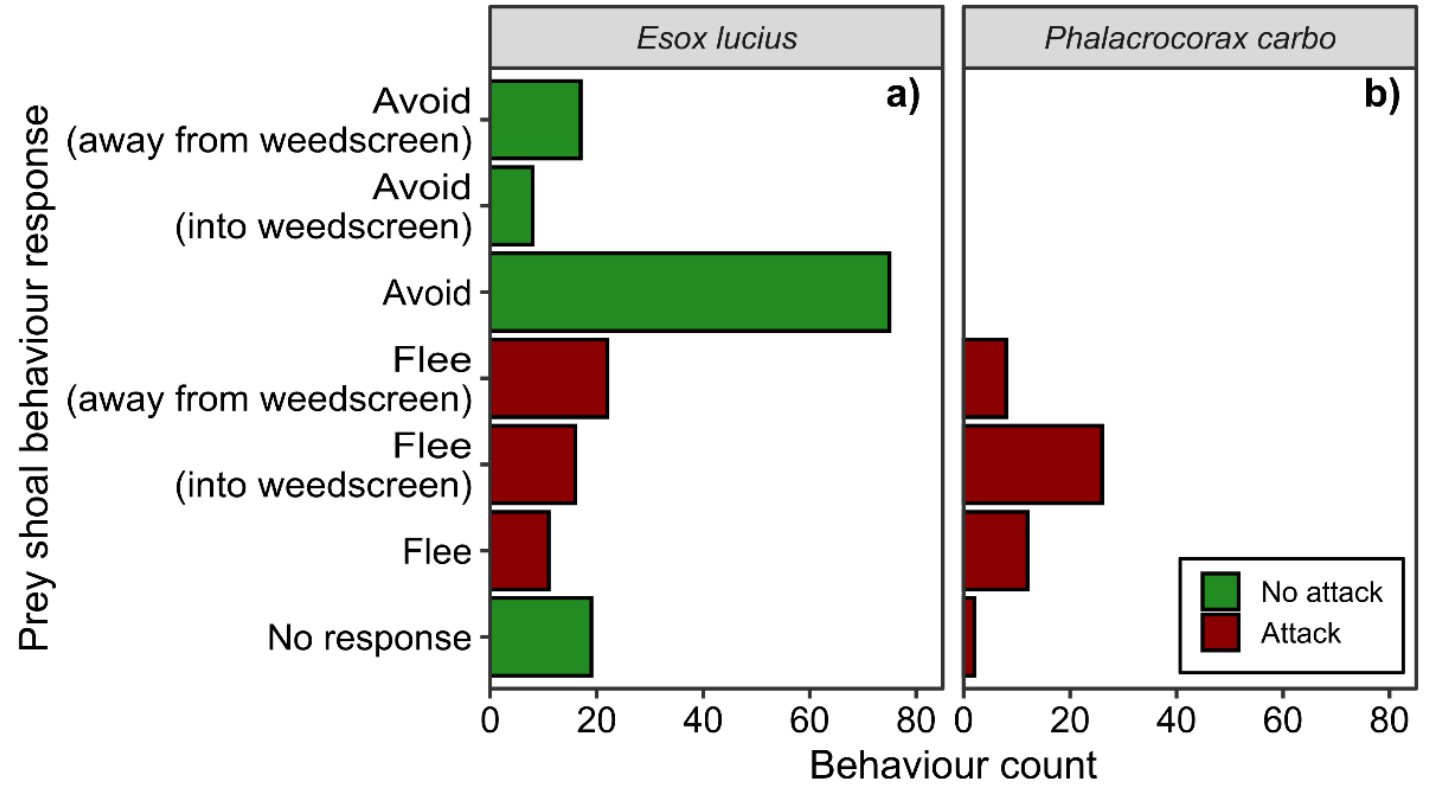
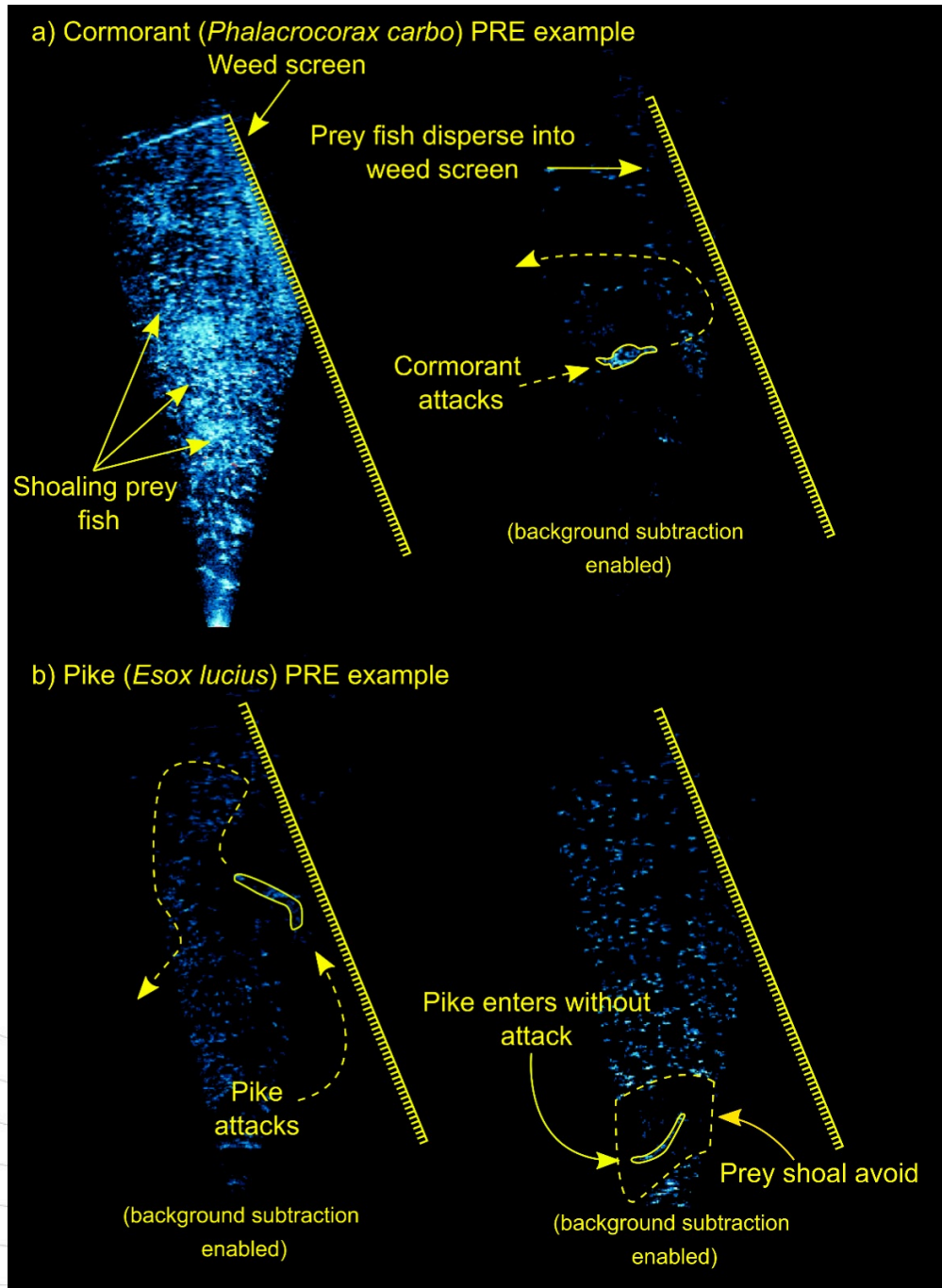
➤ Main objective = real-world solutions that provide predator and flow refuge without compromising pump operation

Josh Norman PhD

- Understanding river-reservoir systems to inform safe operation (<https://doi.org/10.1016/j.jenvman.2023.117716>)
 - Modifying when the flow is high to promising non-engineered management options
- Simultaneous qualitative and quantitative analysis at a pumping station

Talk today @ 11:40



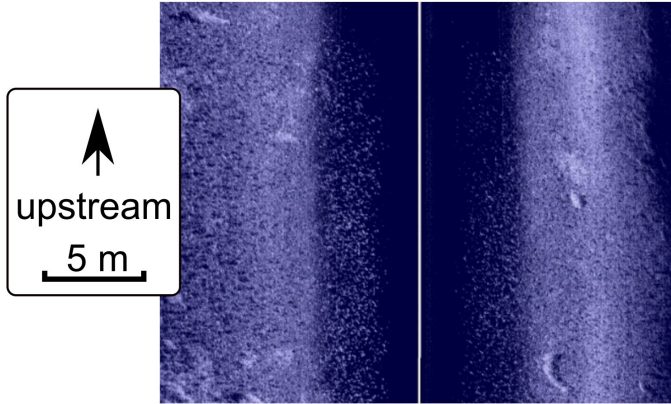


Josh Norman PhD

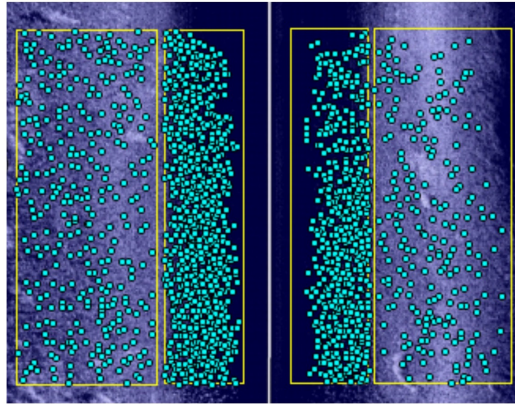
- Understanding river-resident fish movements to inform safe operation (<https://doi.org/10.1016/j.fme.2022.117716>)
 - Modifying water management
- Simultaneous
 - Predation and schooling (at pumping station)
- The response
 - 50% of fish did not respond and was influenced by overhead shelter. Roach preferred artificial habitat after exclusion from the pumping station.
- The impact of extreme flood-relief pump operations on resident fish and the potential for artificial habitat introduction (<https://doi.org/10.1111/fme.12636>)



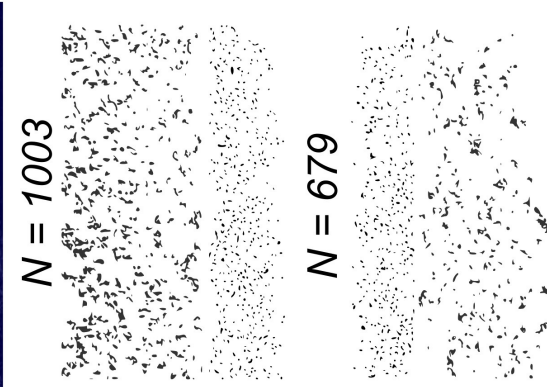
(a) November 2017 S1 side-scan output



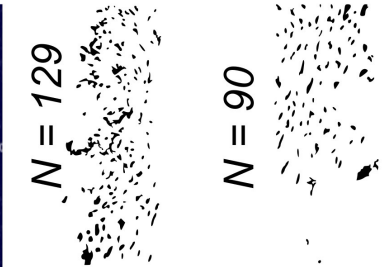
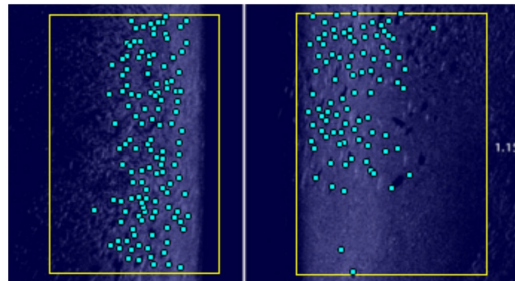
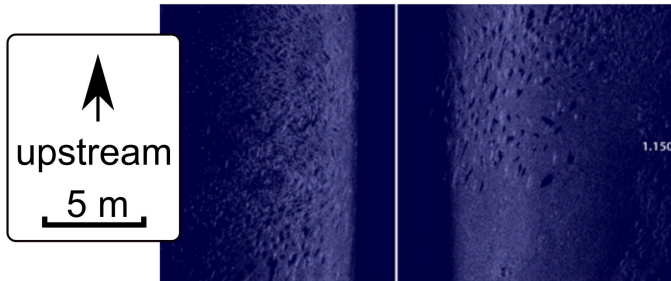
individual point counts applied to fish targets



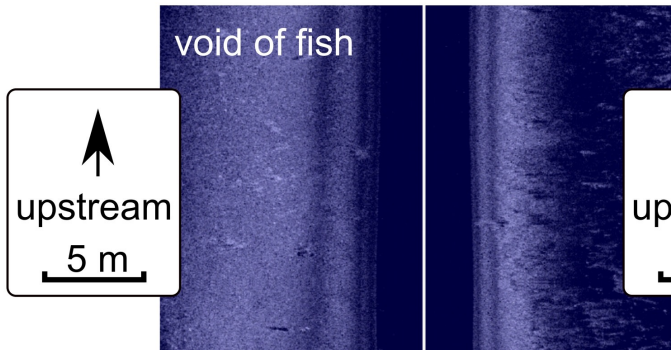
findMaxima outputs



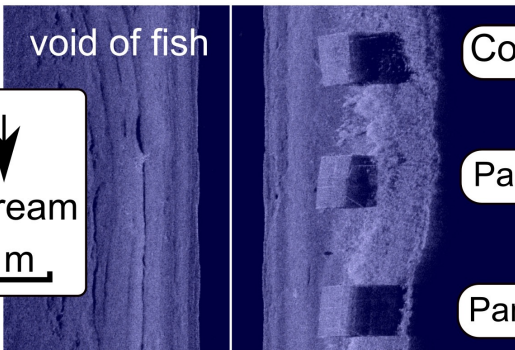
(b) December 2019 S1



(c) December 2021 S1



(d) December 2021 artificial habitat



Complete refuge (C)

Partial refuge (A)

Partial refuge (B)

Q: Why study fish-friendly pumping stations?

A: Maybe they aren't rotating fish passes!

- Prevent mortality and deteriorations in health – must be able to complete life-cycle; a prerequisite but requires independent real-world validation
 - Fish passage solution: any device, structure or mechanism which is designed or operated to facilitate the safe movement of fish in an upstream and/or downstream direction past one or several impediments (CEN standard 2021).
 - High passage rate, relative to those attempting
 - Minimise passage-related delay
 - The entire pumping station must be fish-friendly!
- Main objective = understand eel movements, behaviour and health at fish-friendly pumping stations to maximize safe escapement

Oliver Evans PhD

- Passage of acoustic-tagged



Talk on Wednesday @ 15:00

ed ASP
reluctanc



Q: Why study downstream passage solutions?
A: Where and when FFPs cannot be installed

- Gravity sluice at a pumping station does NOT provide a safe downstream passage route (<https://doi.org/10.1016/j.ecoleng.2020.106069>)

- Flume evidence (<https://doi.org/>

- No widely applied solutions at pumping stations

➤ **Main objective: passage solutions for pumping stations**



Ecological Engineering
Volume 159, 15 January 2021, 106069

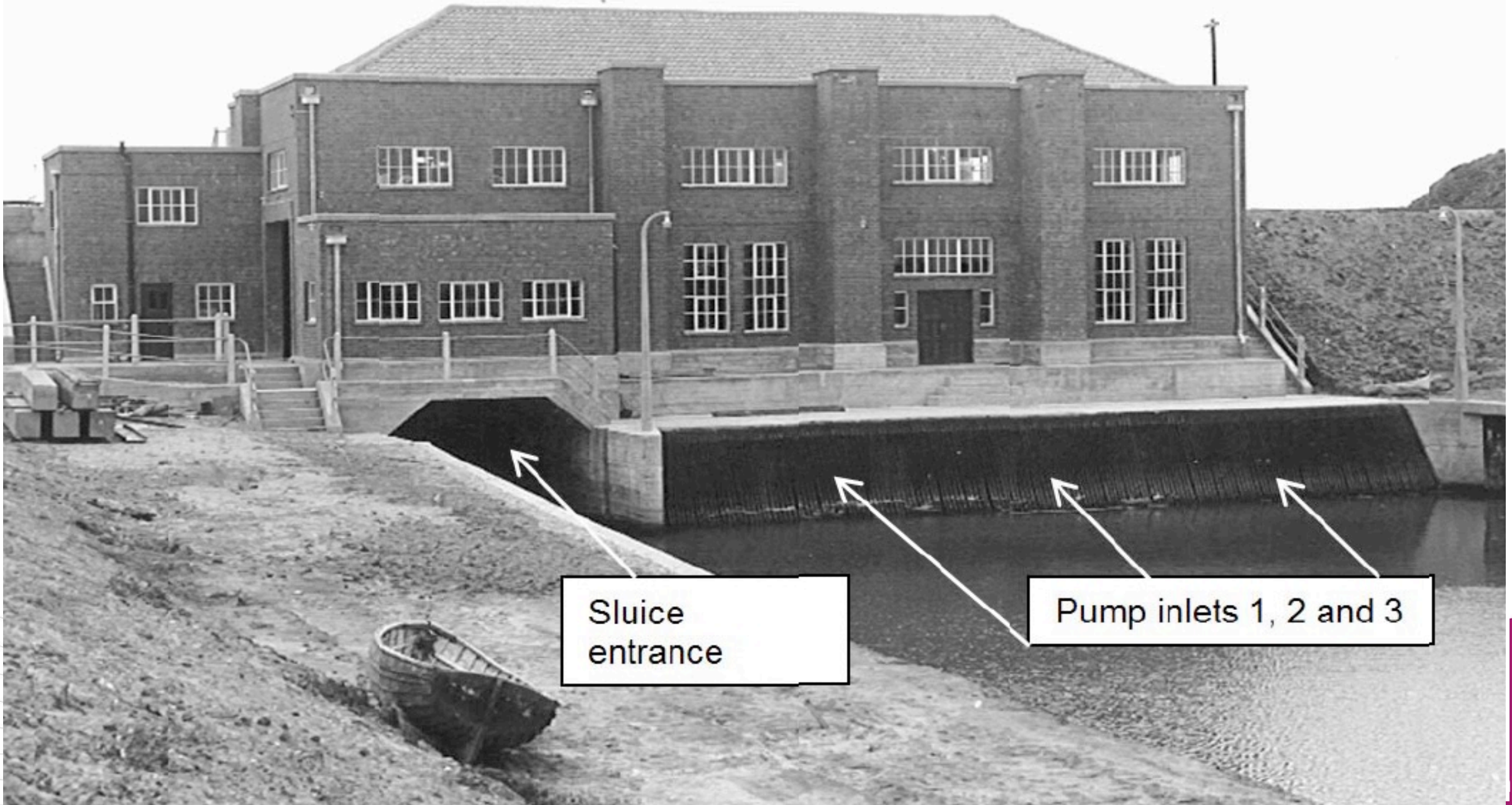
Ecological Engineering
Volume 126, January 2019, Pages 74-82

Comparison of attraction, entrance and passage of downstream migrant American eels (*Anguilla rostrata*) through airlift and siphon deep entrance bypass systems

Nicola Baker ^a, Alex Haro ^b  , Barnaby Watten ^b, John Noreika ^b, Jonathan D. Bolland ^a

eels at pumping

passage solutions for



Sluice
entrance

Pump inlets 1, 2 and 3

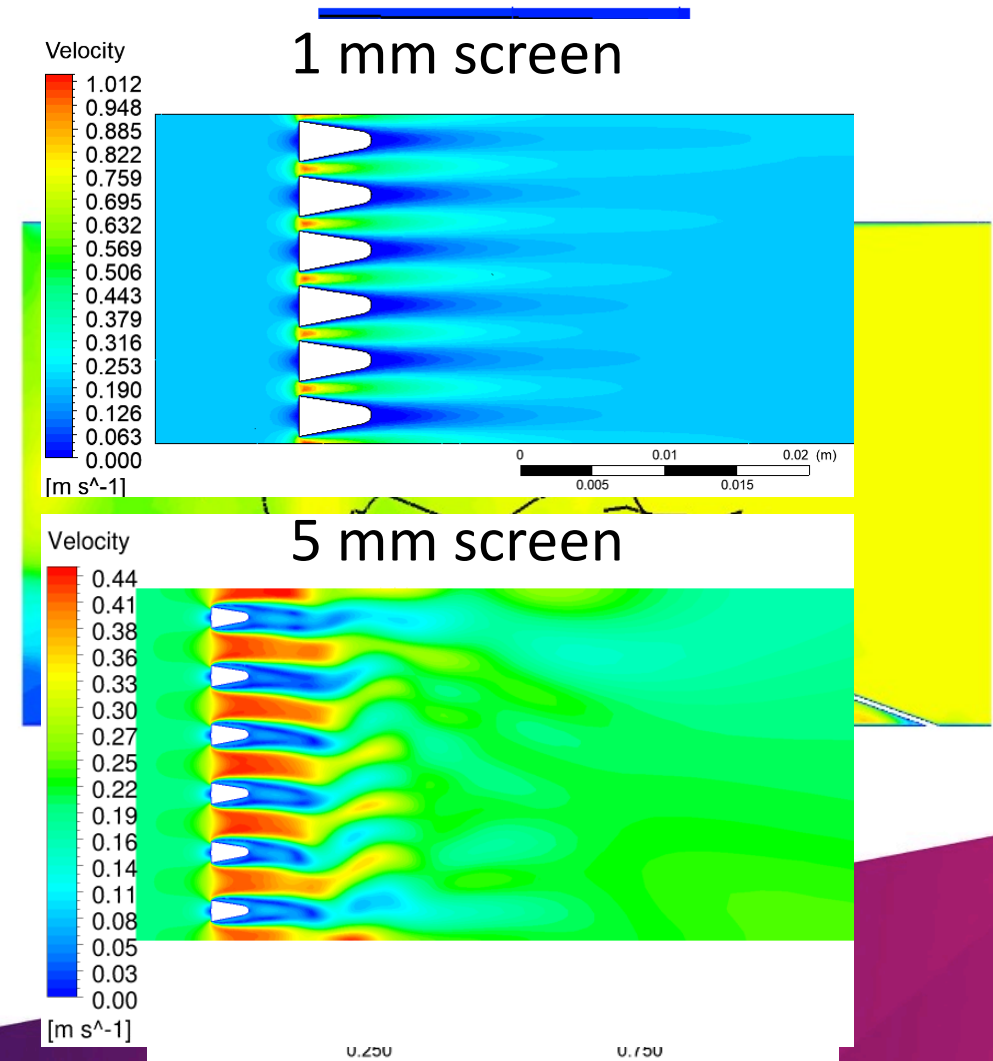
Q: Why study flows (and eels)?

A: We need to think and **feel** like an eel!

- We now know loads about eel ecology and how they respond / behave, but not necessarily why
 - Eels typically move in the middle of the night during floods – vision will be heavily impaired – and thus **flow is king**
 - Measuring hydraulics and visualising flows enables us to better understand why eels move / behave in certain ways, especially at man-made infrastructure
- **Main objective = improve the performance of downstream passage solutions and physical exclusion screens for eels at hazardous intakes**

Stephen Collier PhD (primary supervisor = Dr Rob Thomas)

- Hydraulic attraction at a downstream bypass for European eels
- Eel response to altered flow conditions at guidance structures
- Screen hydrodynamics and influence on juvenile eel behaviour





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REDEEM 2.0



Four new PhD students, and a couple of PDRAs

- eDNA to assess fish and eel distribution to inform prioritisation (Angus Monaghan)
 - Post-doc support from Dr Graham Sellers (EvoHull)
- Screening intakes for European eels (Jack Wootton)
- Fish-friendly pumping stations and hydropower (Katharina Reimann)
- Downstream passage solutions in pumped catchments (Islam Hashem)
- Coarse fish distribution using sonar techniques (Dr Josh Norman, PDRA)

➤ **Please contact us with sites or technology to investigate**



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Thank you

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