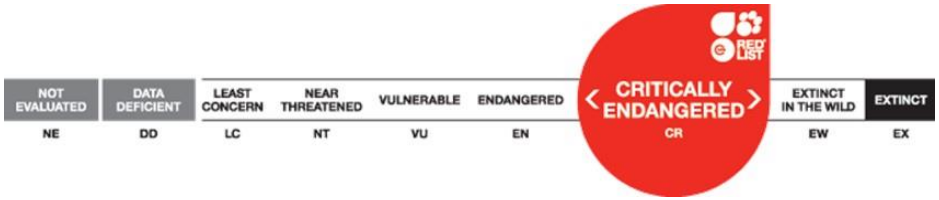
Eels II: Survival and Health of European Eels, Anguilla anguilla, Entrained in Water Pumps of Varying Size, Design and Specification AND Wider Considerations

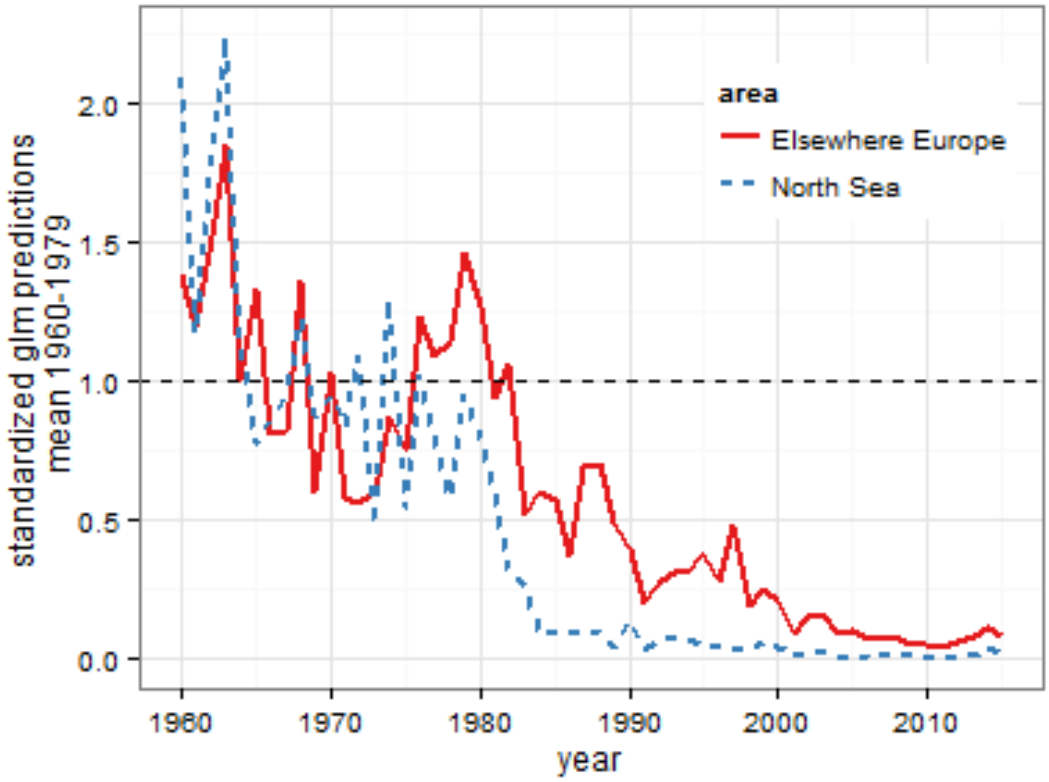
UNIVERSITY OF Hull

Survival and health of European eels, *Anguilla anguilla*, entrained in water pumps of varying size, design and specification AND wider considerations

Bolland, J.D., Stanford, R., Lewin, N.C., Williams, C.F., Angelopoulos, N.V., Baker, N.J., Murphy, L., Cowx, I.G., Reeds, J., Jerrom, K., Hooker, J. and Wright, R.M.

European eel decline

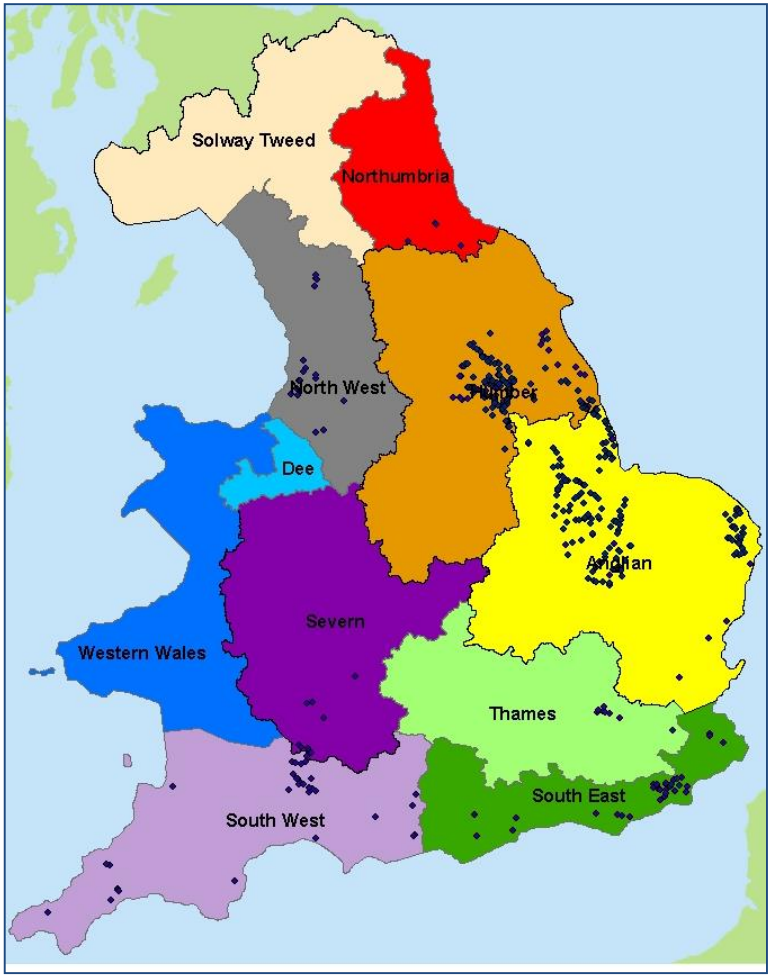




- The EC Eel Regulation (1100/2007) to protect them from human mediated activities.

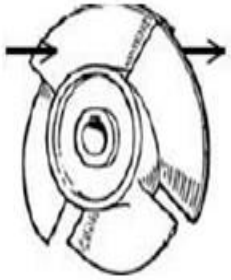
Pumping stations in England

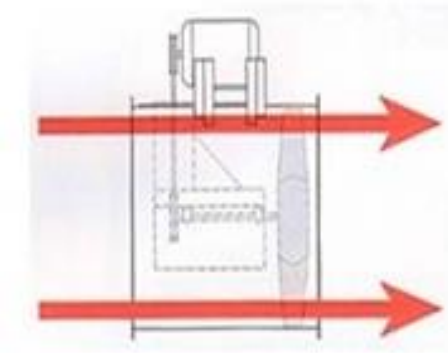
- In England, the European regulation is enacted through the Eels Regulations 2009 Statutory Instrument (the Eel SI), which includes powers to screen water intakes (including pumping stations) abstracting greater than 20 m^3 a day.
- Evidence of eel injury and mortality during pumping station operation is limited to anecdotal reports.
- Robust site specific assessments are required to confirm whether pumping stations are compliant under the Eels Regulations 2009 or require eel protection measures.

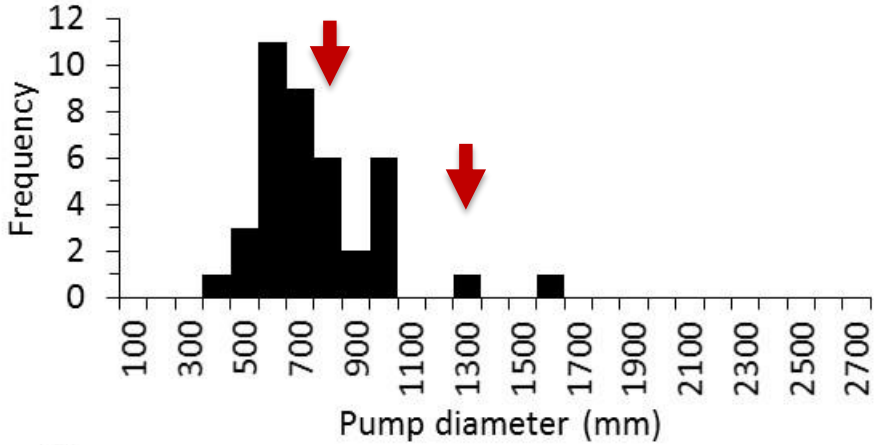


Review of high priority pumping stations, e.g. type of pump, size, rpm and number of blades

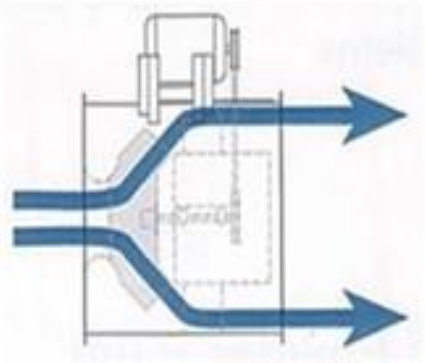
Axial, n = 49

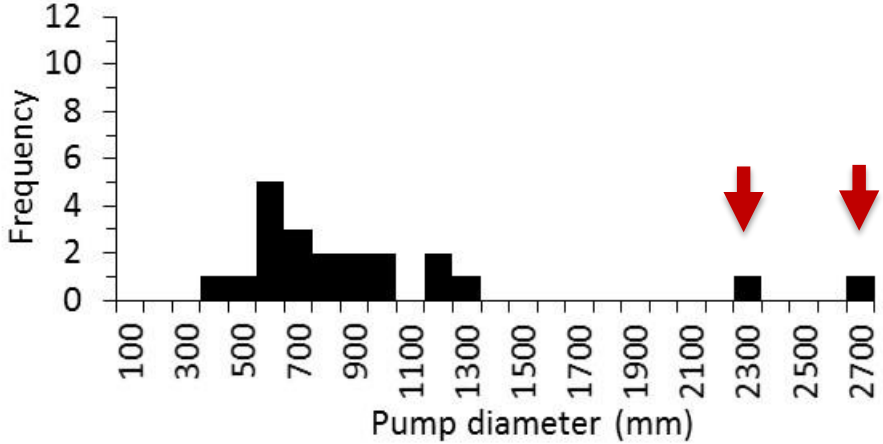






Mixed, n = 25





No information, n = 65

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Pumps studied in 2015

Pumping station	Type	Power supply	Diameter (metres)	Number of blades	Speed (rpm)	Capacity (cumecs)
MF-2.65	Mixed flow	Electric	2.65	3	125	20.0
MF-2.23	Mixed flow	Diesel	2.23	3	100	9.4
AF-1.3	Axial flow	Diesel	1.3	4	200	3.8
AF-0.8	Axial flow	Electric	0.8	4	400	1.9
FF-0.6	'Fish-friendly'	Electric	0.6	2	872	1.2

The entire site, not just the pump, was assessed!

- Eels captured, condition assessed, PIT tagged (under Home Office licence) and released upstream
- Recaptured downstream, scanned for PIT tag, external condition visually assessed and internal condition assessed at EA National Fish Lab
- Catchment and net controls

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Field methodology

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Mortality / survival

Pumping station	Mortality (%)	48-hr mortality (%)
MF-2.65	0/31 (0%)	0/31 (0%)
MF-2.23	0/57 (0%)	0/27 (0%)
AF-1.3	6/58 (10%)	1/39 (3%)
AF-0.8	10/17 (58%)	-
FF-0.6	1/60 (2%)	3/30 (10%)

- The greatest level of mortality was found for the smallest axial flow pump with the most blades on the impeller and the highest rotation speed.
- Larger mixed flow pumps with fewer blades and slower rotation speed did not kill eels.
- Three eels entrained in a pump marketed as ‘fish friendly’ (the first of its kind in the UK but with original pipework) died after 48-hours.

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Behavioural assessment

- **Motor capacity** – Is the eel moving and lively?
- **Response** – Does the eel respond to stimuli?
- **Bodyform** – Does the eel conform to a anguilliform shape?
- **Buoyancy** – Is the eel neutrally buoyant position?

If the answer to **all** questions was **yes** the eel was assigned a behaviour category of "**Normal**"

If the answer to **any** question was **no** the eel was assigned a behaviour category of "**Abnormal**"

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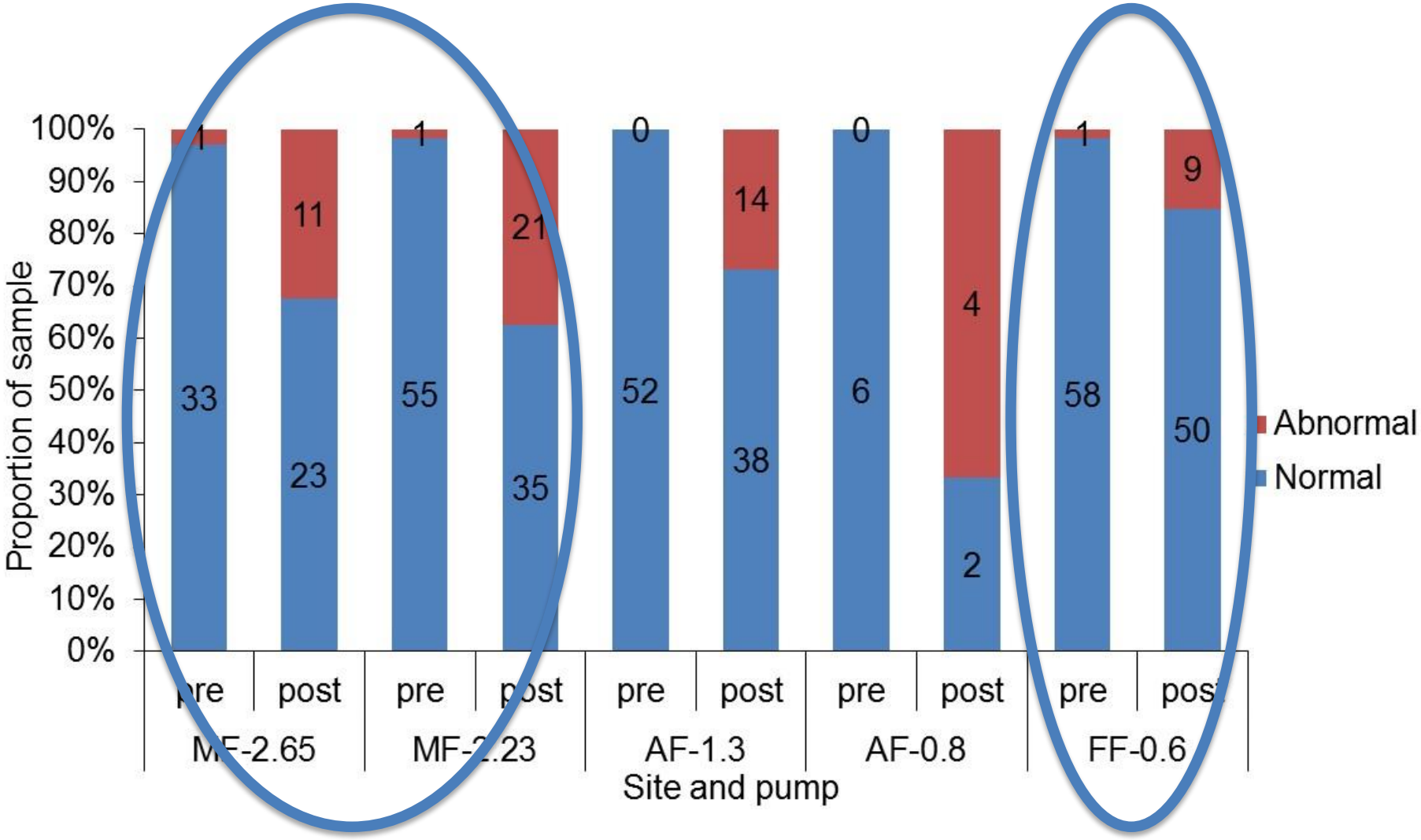
Change in behaviour



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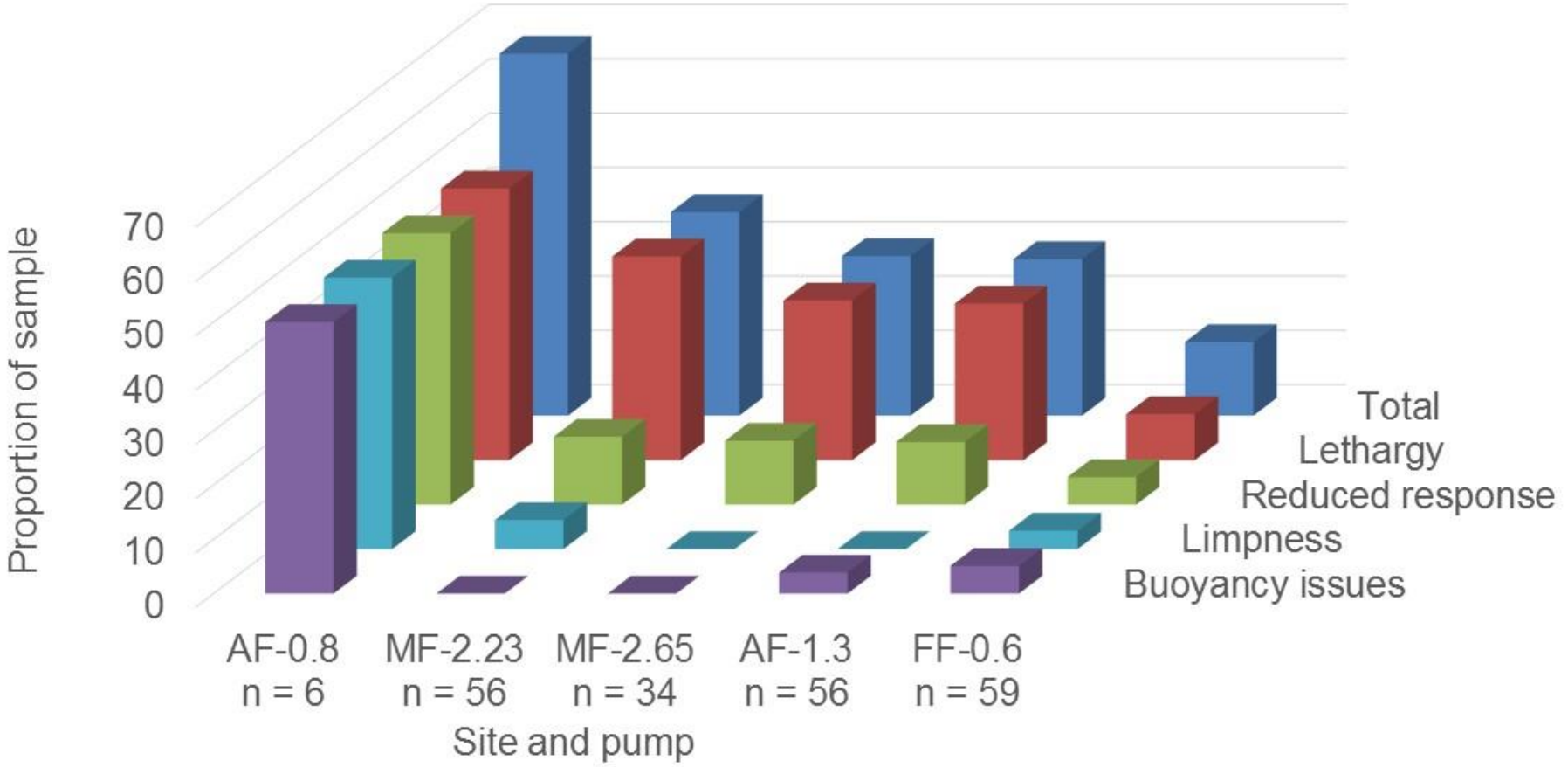
How behaviour changed



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Eel condition assessment

1. No visible damage to the fish exterior, the fish should be alive and appear healthy.
2. Minor injury; mainly superficial – unlikely to affect function or survival.
3. Moderate injury; more substantial injury – likely to affect function.
4. Major injury; severe injury – likely to affect both function and survival.
5. Mortality, the fish is no longer alive

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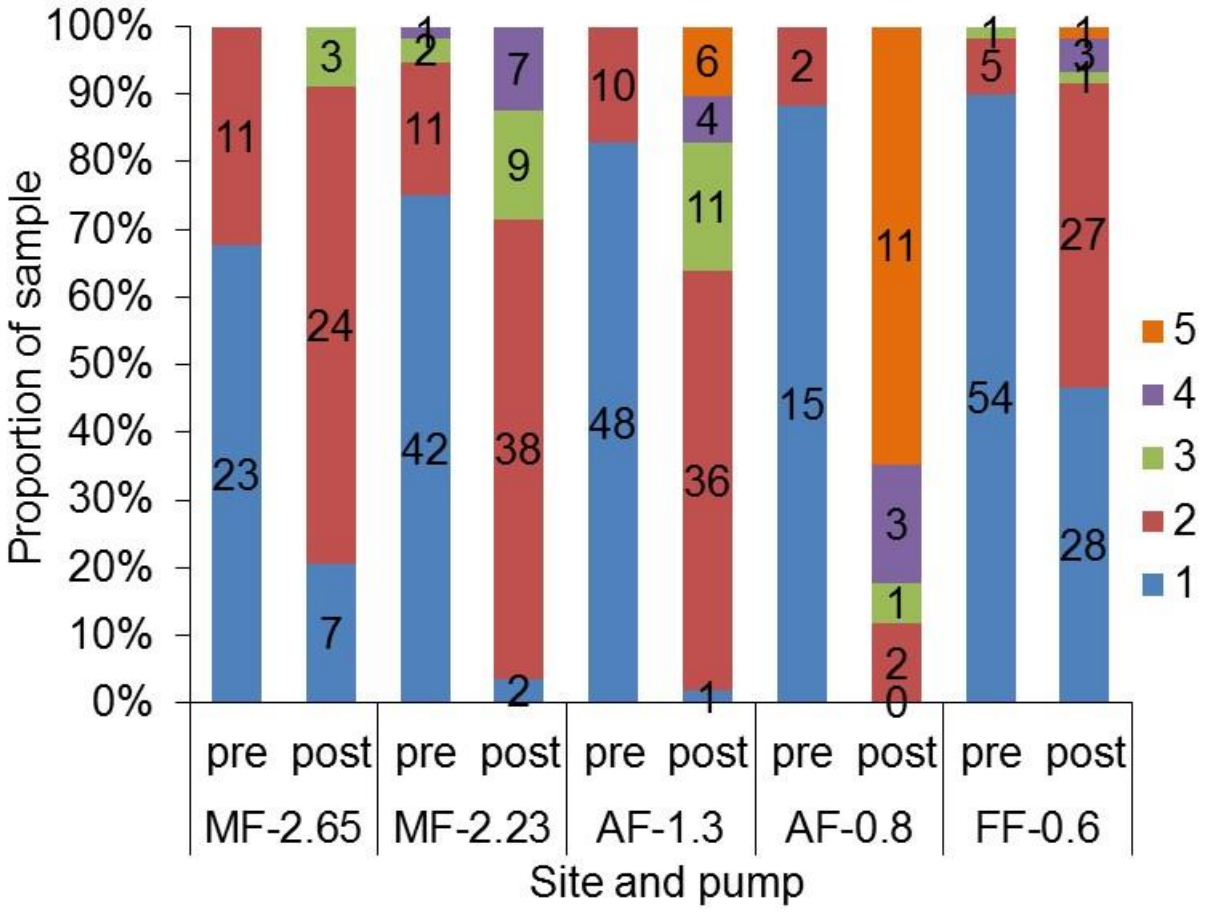
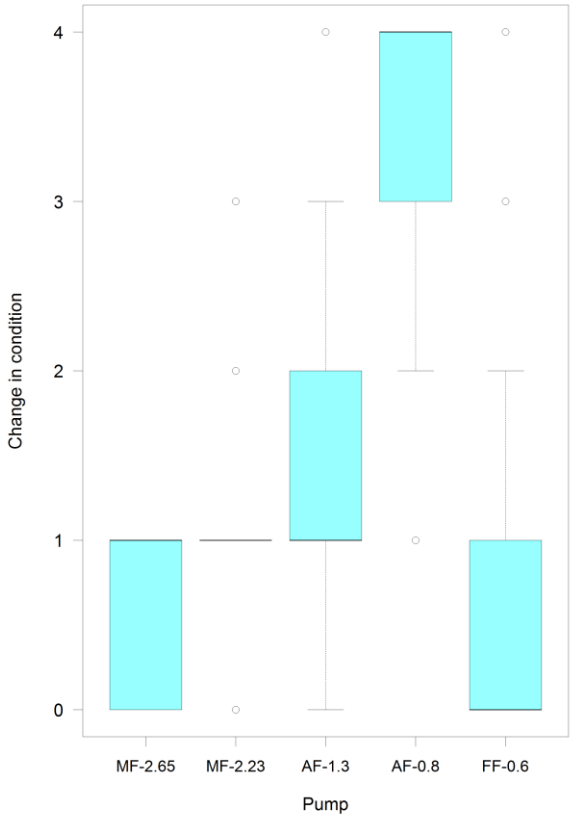
Change in condition





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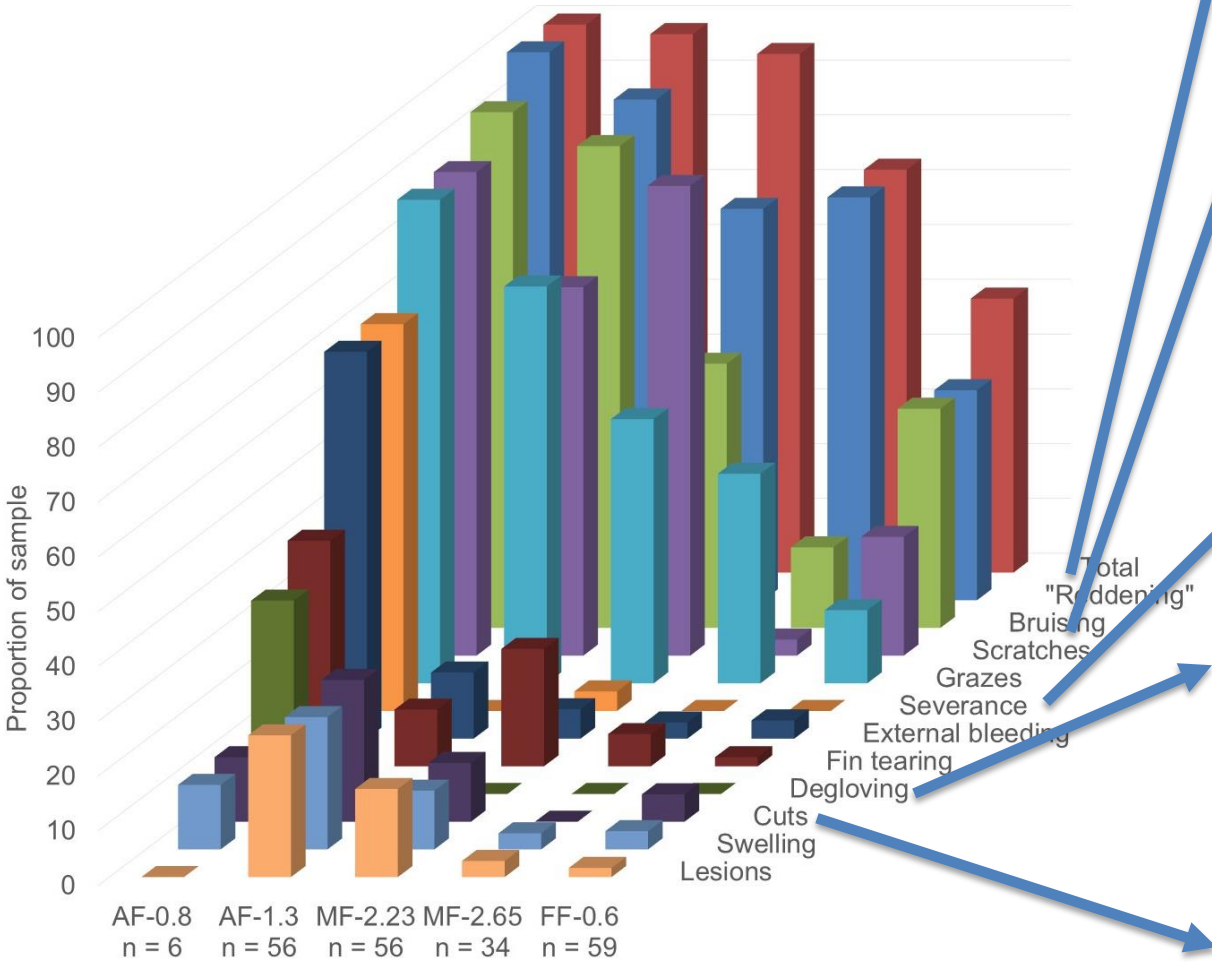
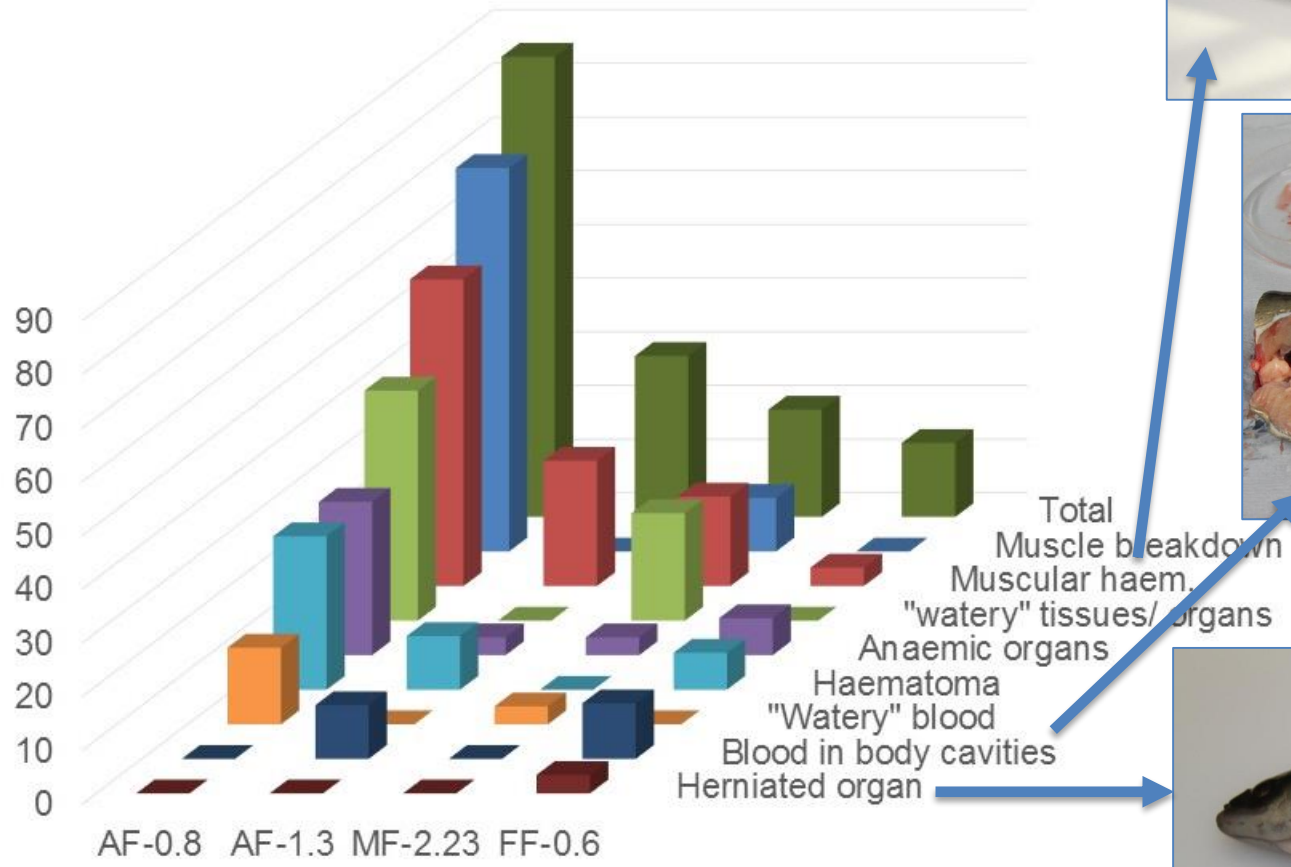
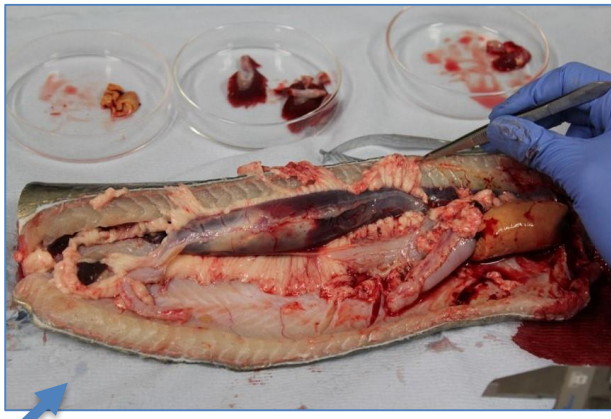
External injuries



Internal injuries





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Direct impact of entrainment summary

Site	Mortality	48-hr mortality	Abnormal behaviour	External condition
MF-2.65	0%	0%	32%	0.56
MF-2.23	0%	0%	38%	1.05
AF-1.3	10%	3%	27%	1.45
AF-0.8	58%	-	67%	3.24
FF-0.6	2%	10%	15%	0.58

- BUT… what about the indirect impacts:
  - Migration through catchment (acoustic telemetry)
  - Behaviour immediately upstream (ARIS)

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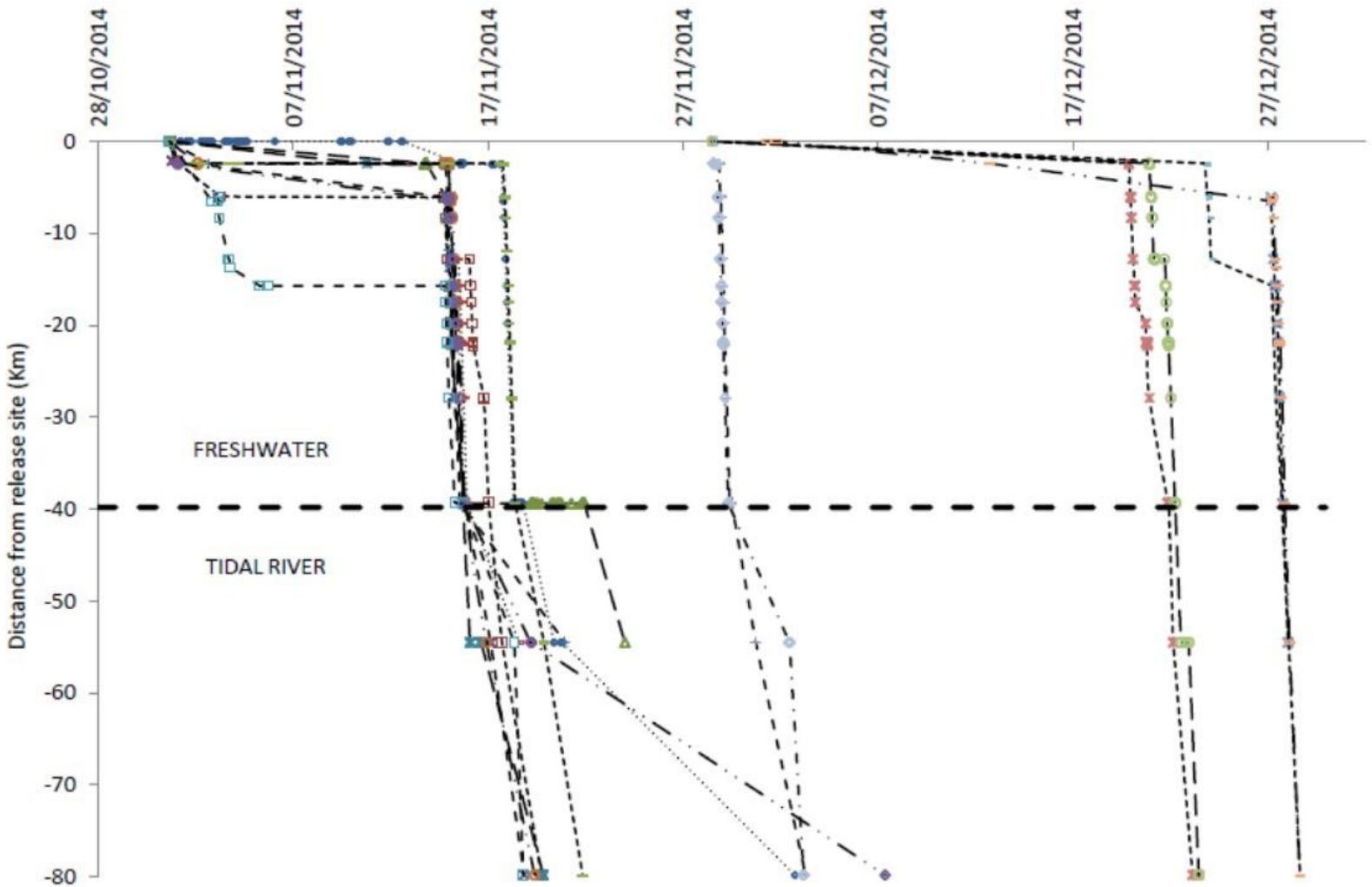
1. Catchment-wide migration; unregulated river



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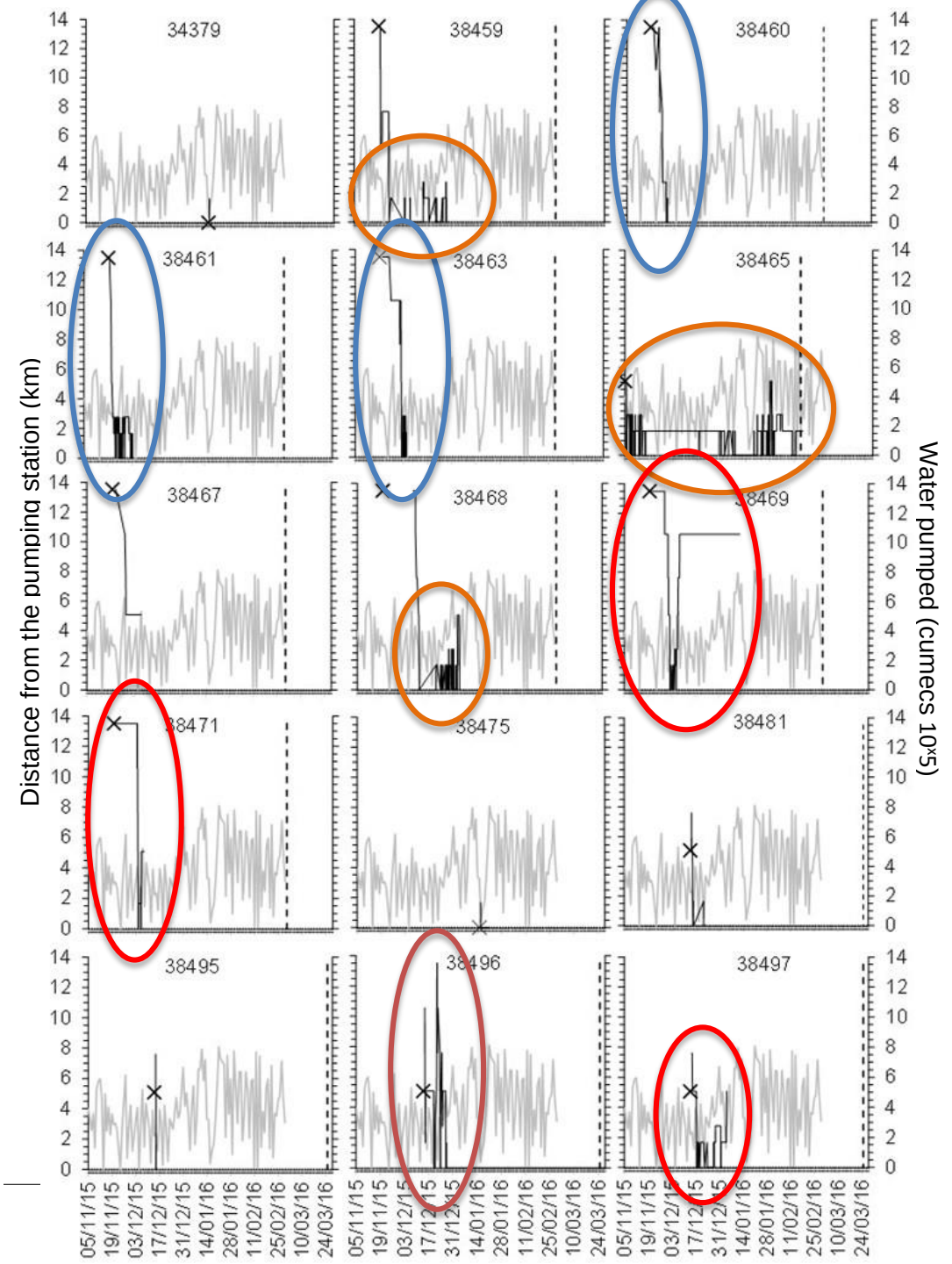
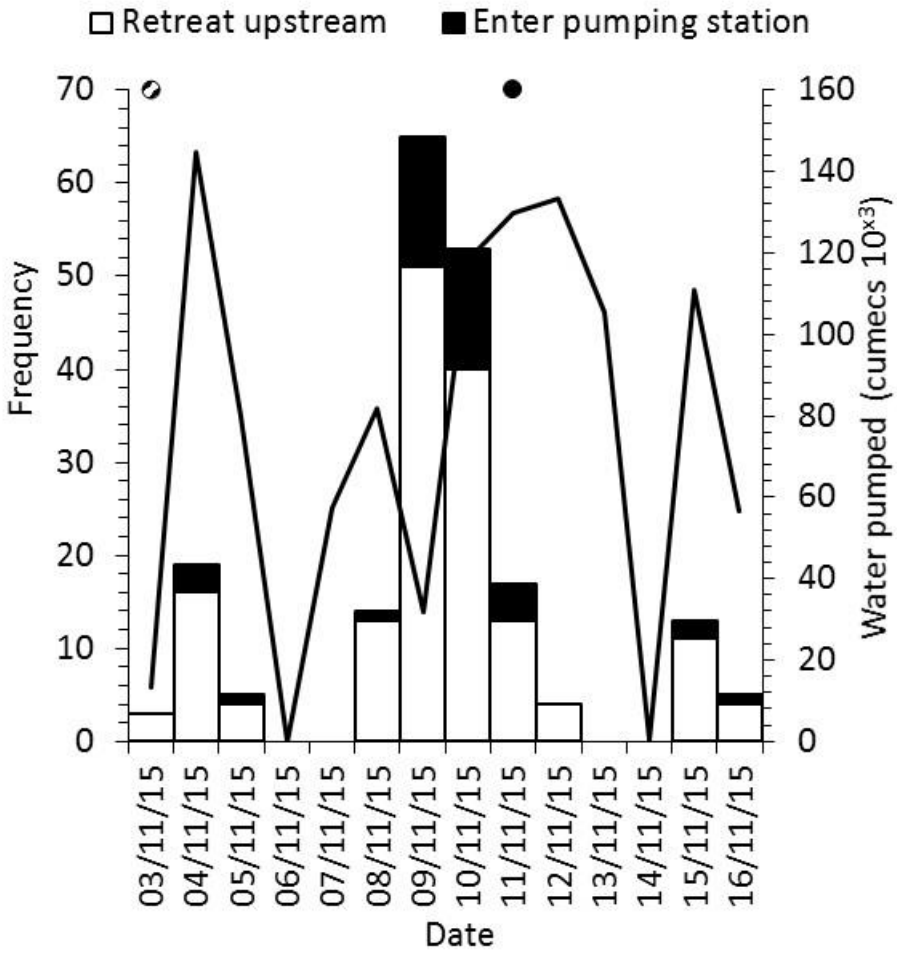
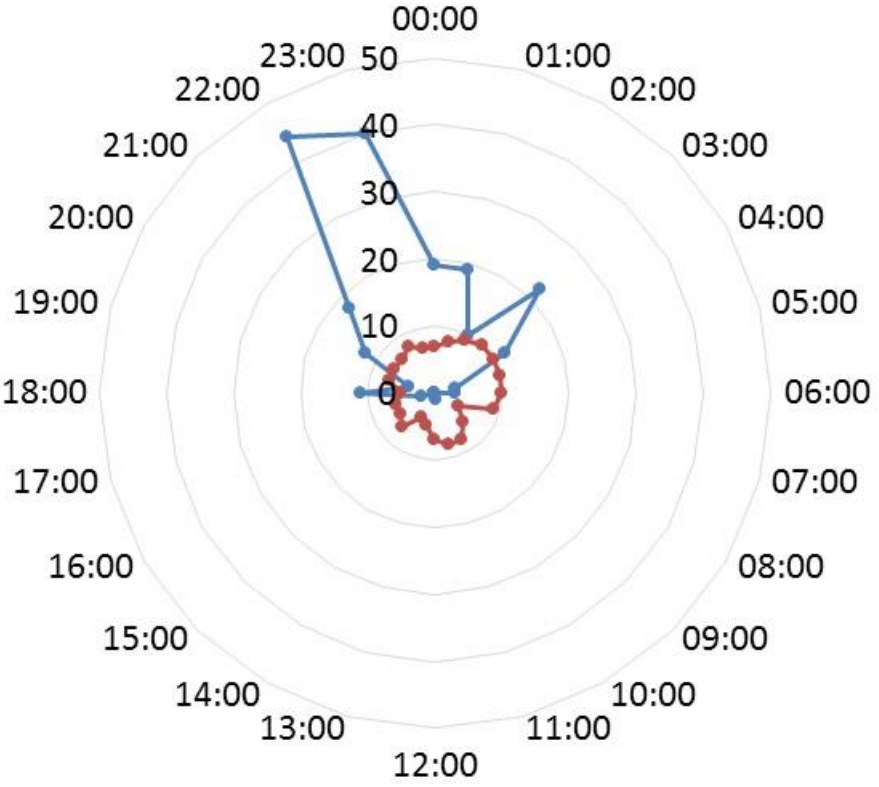
1. Catchment-wide migration; regulated by a pumping station

- Moved quickly through the catchment
- Delay:
  - Average = 10 days
  - Max = 33 days
- 14/15 (93%) retreated upstream:
  - Average distance = 4.2 km
  - Max distance = 13.5 km
- 6 eels last detected in middle of the catchment



2. Behaviour immediately upstream (ARIS footage)





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Conclusions

- Mortality increased as pump size decreased and operational speed increased.
- The pumping station with a fish-friendly pump but original pipework killed four eels but there was the lowest overall impact on behaviour and external condition.
- Types of injuries observed being used to identify likely cause.
- Impact on downstream migration may be more detrimental than entrainment?
- Eels are reluctant to pass through weed screen, possibly leading to trails of alternative passage routes.
- Eels almost exclusively approach pumping stations at night, possibly leading to operational changes.

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Thanks for listening

Thank you to the Environment Agency, especially the team at the National Fish Lab, Internal Drainage Boards, Reuben Page and the commercial eel fishermen!

- Please see posters by Leona Murphy (#24) and Nicola Baker (#1) for more information about catchment-wide migration and behaviour immediately upstream of pumping stations

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