Reducing entrainment of river-resident fish at hazardous intakes through behavioural ecology

Understanding the temporal dynamics of a lowland river fish community at a hazardous intake and floodgate to inform safe operation

11/07/23 – IFM Impingement and Entrainment Conference

Josh Norman - Hull International Fisheries Institute

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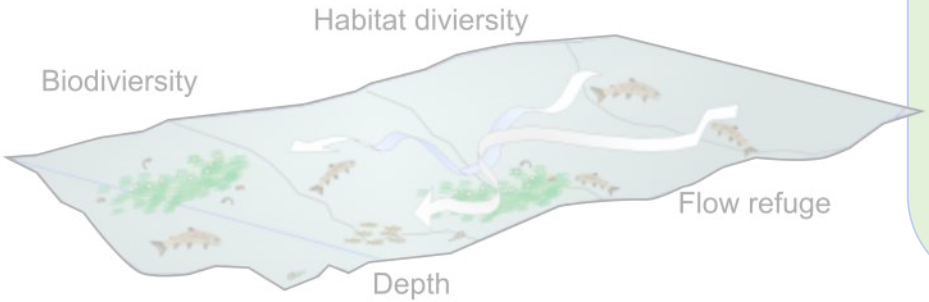
Background – Habitat and movement

All fish migrate or move between habitats



- Reproduction/spawning
- Daily ecological trade-offs:
  - Predation
  - Feeding
  - Light
  - Temperature
  - Hydrology

Diadromous fish

Potamodromous & River-resident fish

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Background – What is the problem?

Pumping stations

Pumping stations are everywhere…

- Water level maintenance
- Flood-relief

- Sevres longitudinal and lateral connectivity
- Reduces opportunities for natural ecological movement and modifies behaviour
- Major mortality hazard

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Background – Addressing resident fish

Bespoke legislation for European eels (IUCN red list) at hazardous intakes to provide protection under The Eels (England and Wales) Regulations 2009

Water Framework Directive initiatives also suggests intake managers should provide protection for river-resident fish

Ecological considerations for reducing entrainment are rare

- Existing protection at pumping stations = slow start-up & physical/behavioral screens. Could be enhanced by operation changes.
- Anecdotal knowledge of:
  - High entrainment rates
  - Huge aggregations over winter
  - Predator concentrations
  - Poor catches after flood-relief pump operations

Research lacking

Understand when and why fish are present: inform pump and infrastructure management to reduce entrainment risk

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Contents lists available at ScienceDirect

Journal of Environmental Management

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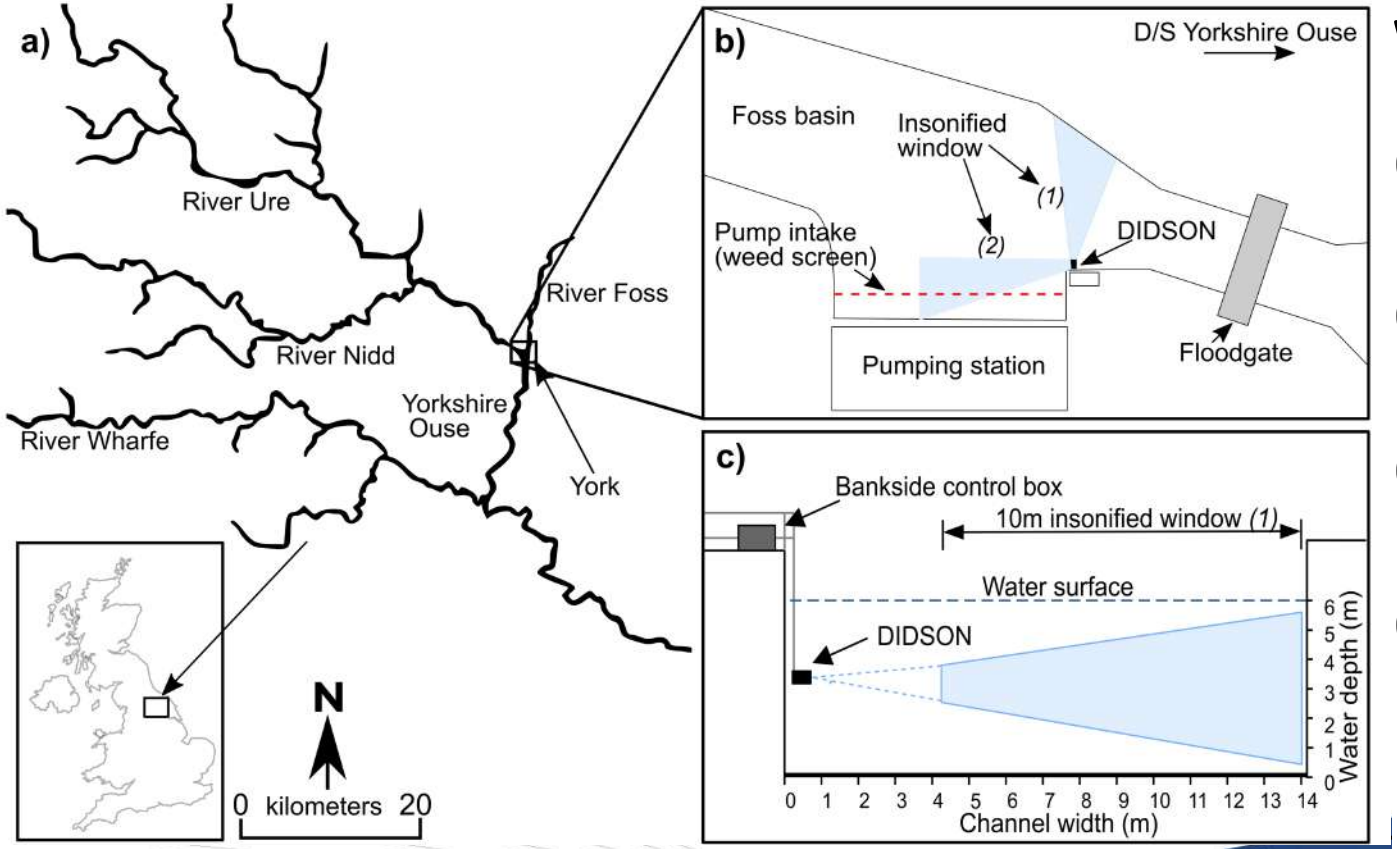
Research article

Understanding the temporal dynamics of a lowland river fish community at a hazardous intake and floodgate to inform safe operation

Josh Norman [a,*], Rosalind M. Wright [b], Andrew Don [c], Jonathan D. Bolland [a]



We will consider…

(1) Temporal dynamics of multi-species fish movements over 3 years
(2) Relationship with light, hydrology and temperature
(3) The impact of different pump operations
(4) How we use ecological knowledge to inform site operation and reduce entrainment

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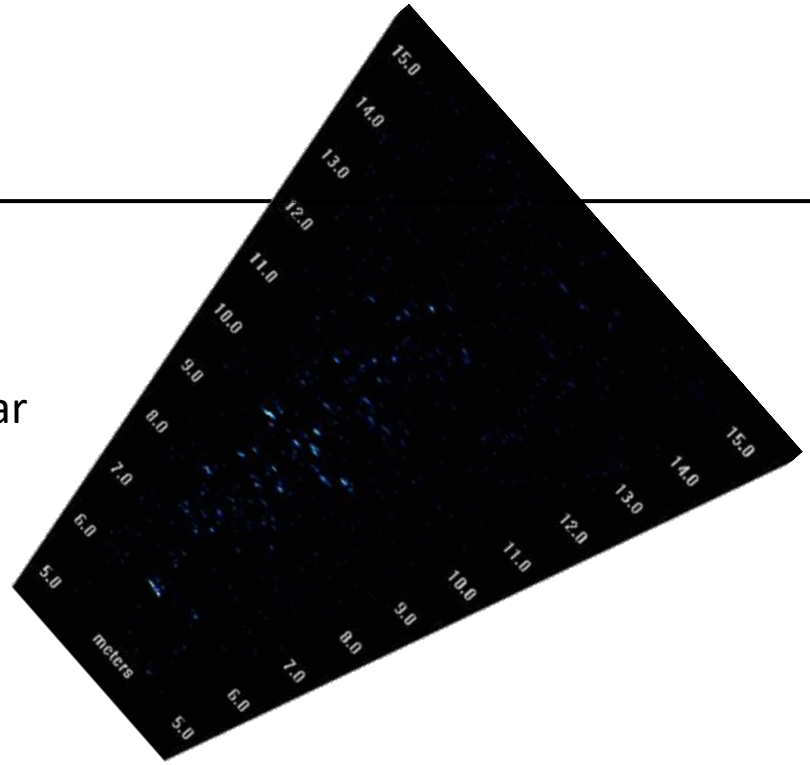
Fundamental findings

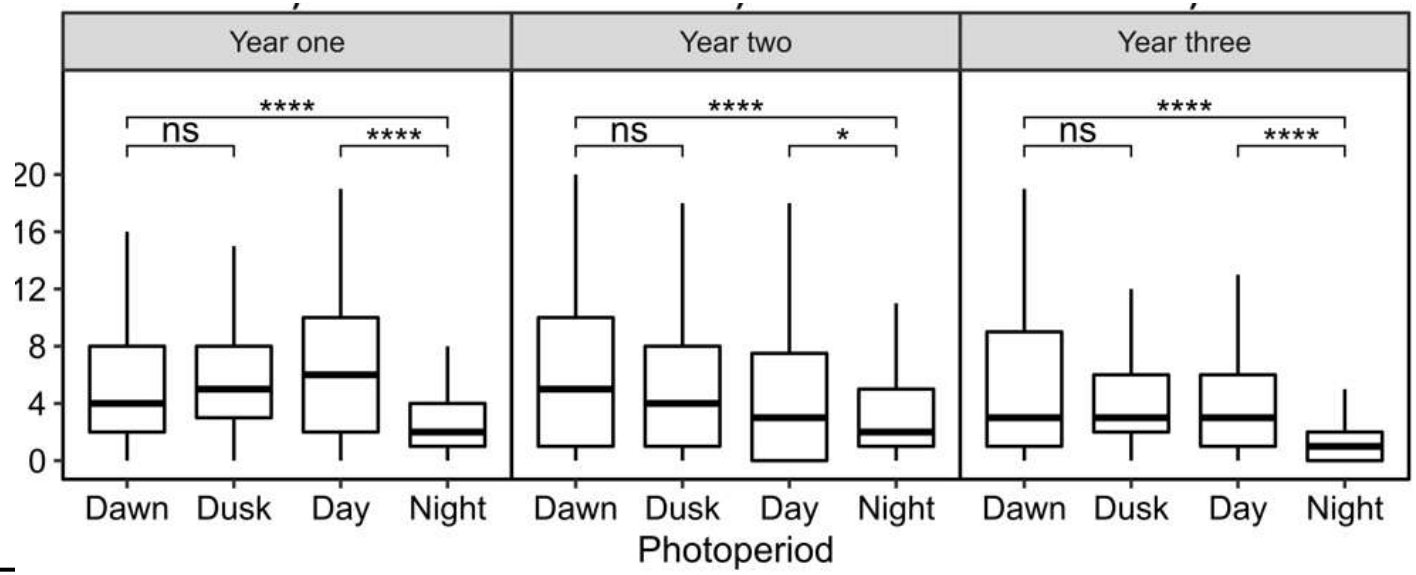
Multi-beam sonar (DIDSON) provides passive, non-invasive, pluriannual data collection

Multi-beam sonar



17,630 fish counted (Real-world estimate will exceed 100's of thousands ~44m2)
- Year one 5500 (impact)
- Year two 7892 (baseline, no pump)
- Year three 4238 (impact)

Captured **predictable** and **stochastic** ecological behavior of river-resident fish during non-operational river levels and during pump and floodgate operation



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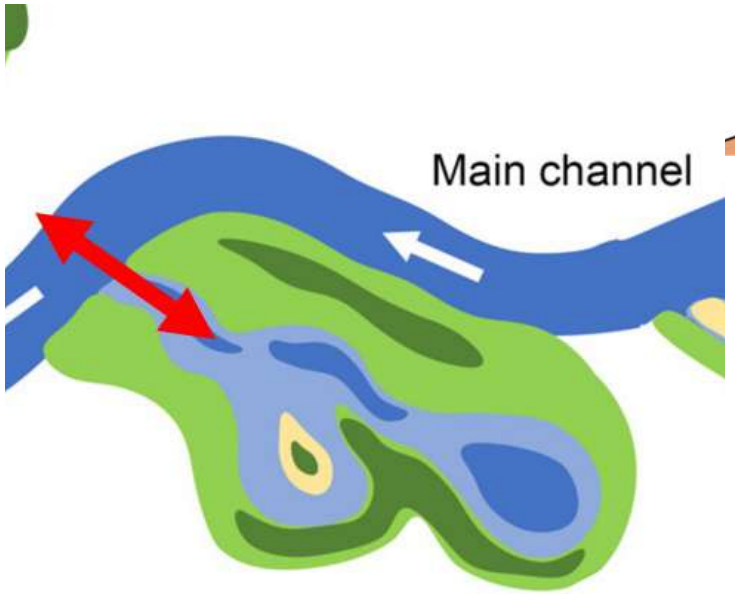
Temporal fish presence – lateral movement

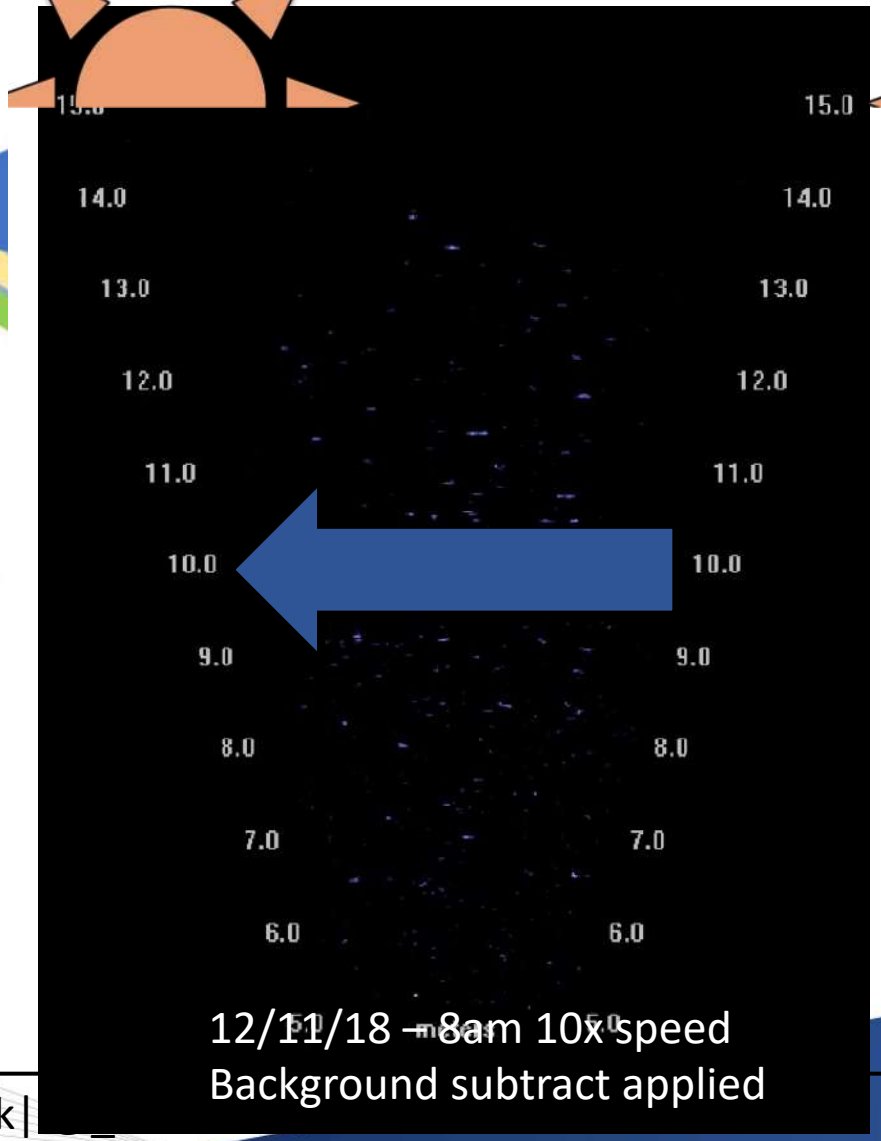
What are the prevailing temporal dynamics in the frequency and magnitude of fish counts around a hazardous intake?



Crepuscular **lateral movement** between main-river and off-channel pumping station

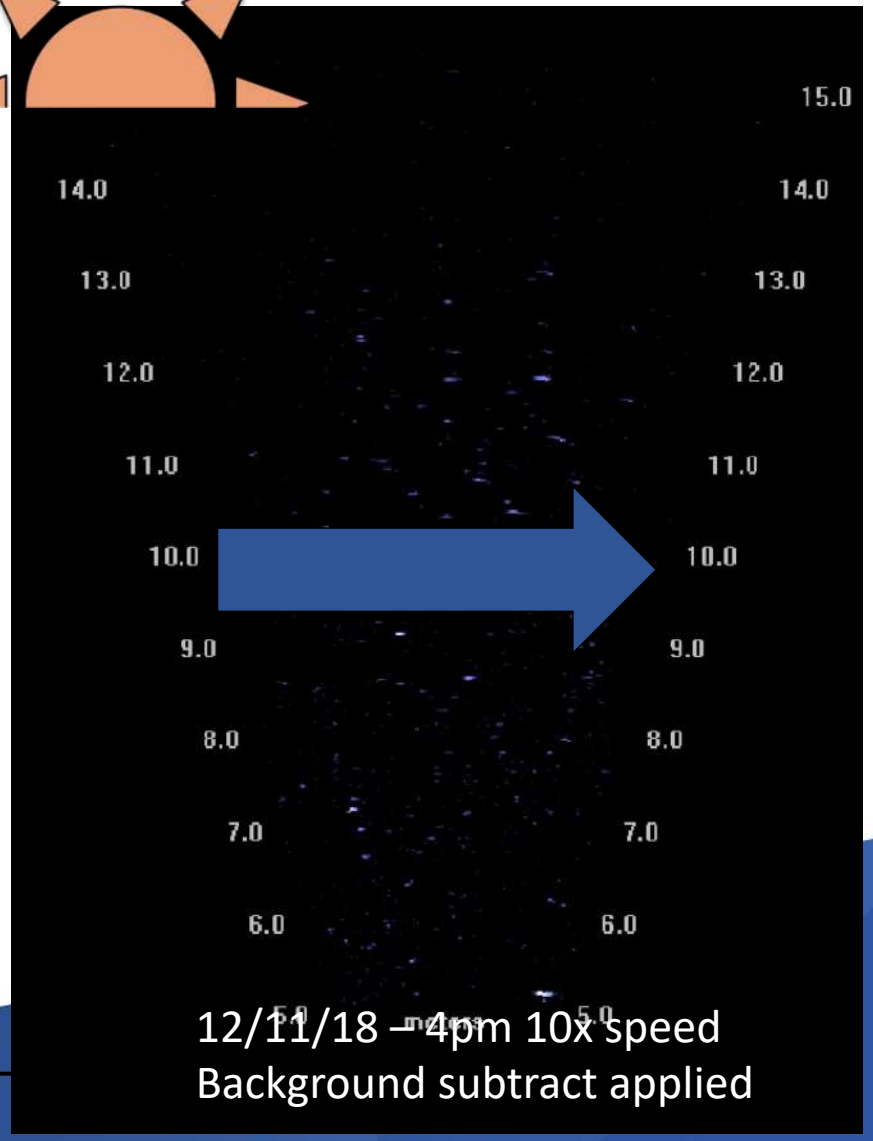
- Temporal entrainment risk?

Sunrise Peak activity & **basin entry**



12/11/18 – 8am 10x speed
Background subtract applied

Sunset Peak activity & **basin exit**



12/11/18 – 4pm 10x speed
Background subtract applied

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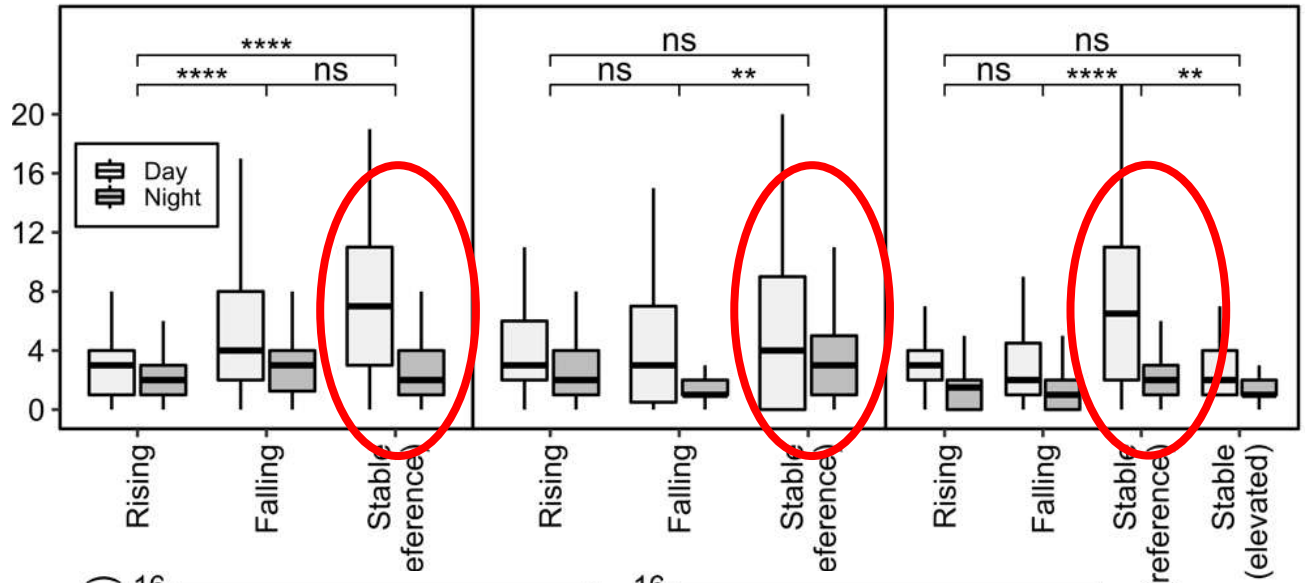
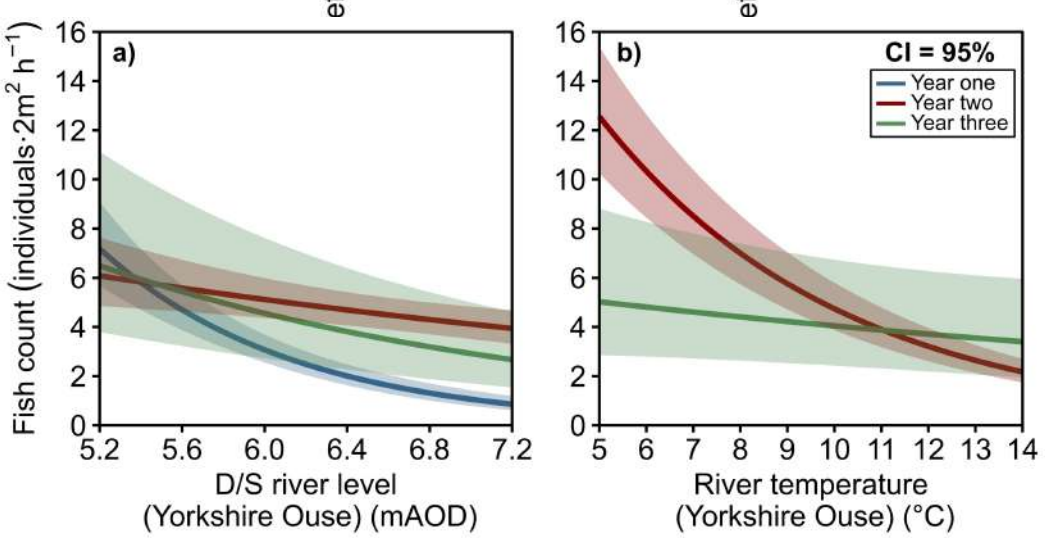
Hydrology & temperature influence





River level and temperature impact on fish counts modelled with GLMM

Unexpected result: **Fish move into Foss basin during stable levels** but not rising levels

In the absence of pumping **fish count increases during winter (overwintering activity)**

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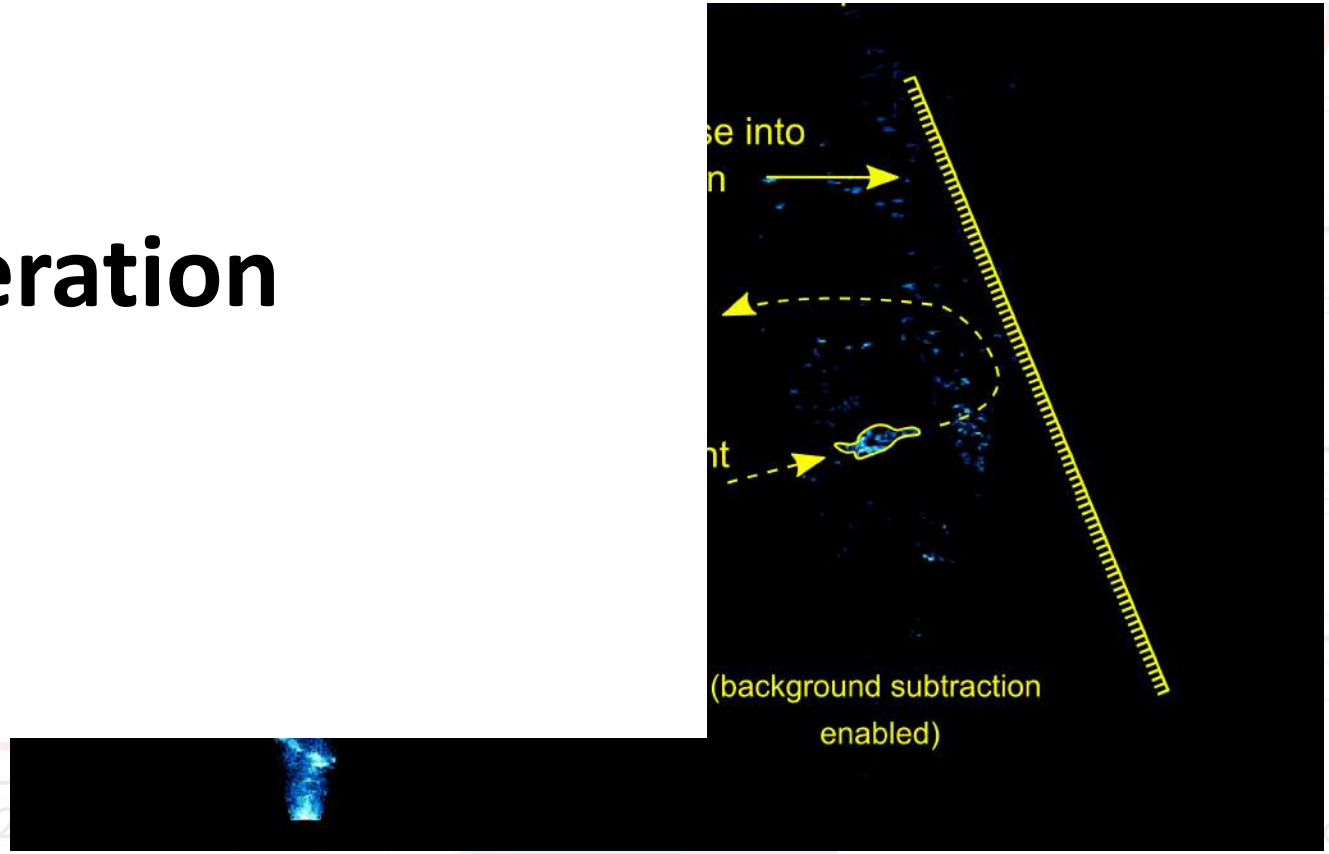
ARTICLE (under final review)

Freshwater Biology WILEY

Impact of anthropogenic infrastructure on aquatic and avian predator-prey interactions in a modified lowland river

Wright[3] | Jonathan D. Bolland[1]

Pump operation



Temp

September
October
November
December
January
February

decrease
decrease
decrease

13:00
17:00
21:00

Josh Norman: J.Norman2

day (24-hour)

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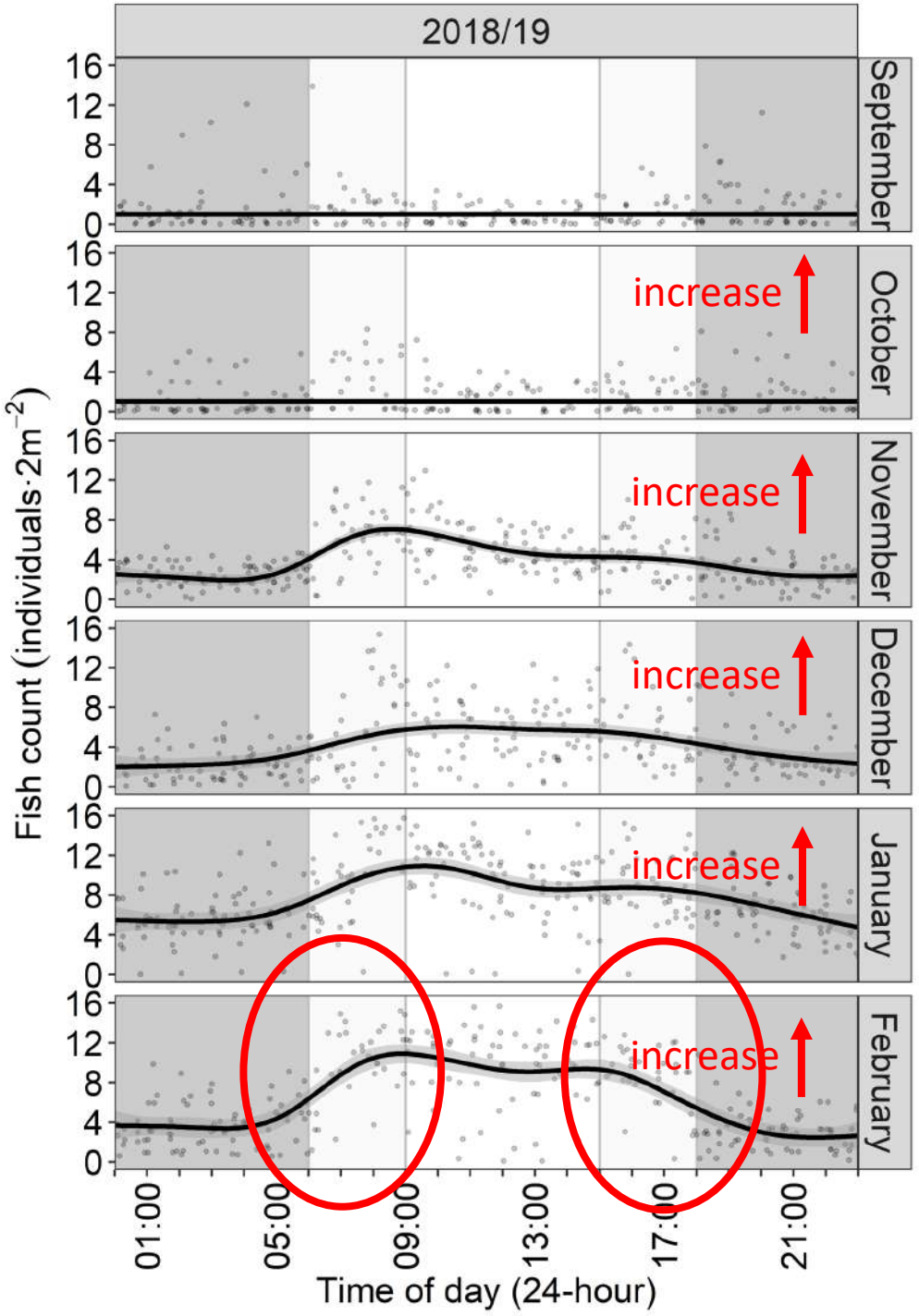
Temporal fish counts (Y2)

- Fish count **increases** through the season

November: **1299**
February: **2014**

Effectively recorded baseline data

- No pump operation
- Fish perform **overwintering** activities in backwater habitat
  - Strong temperature influence



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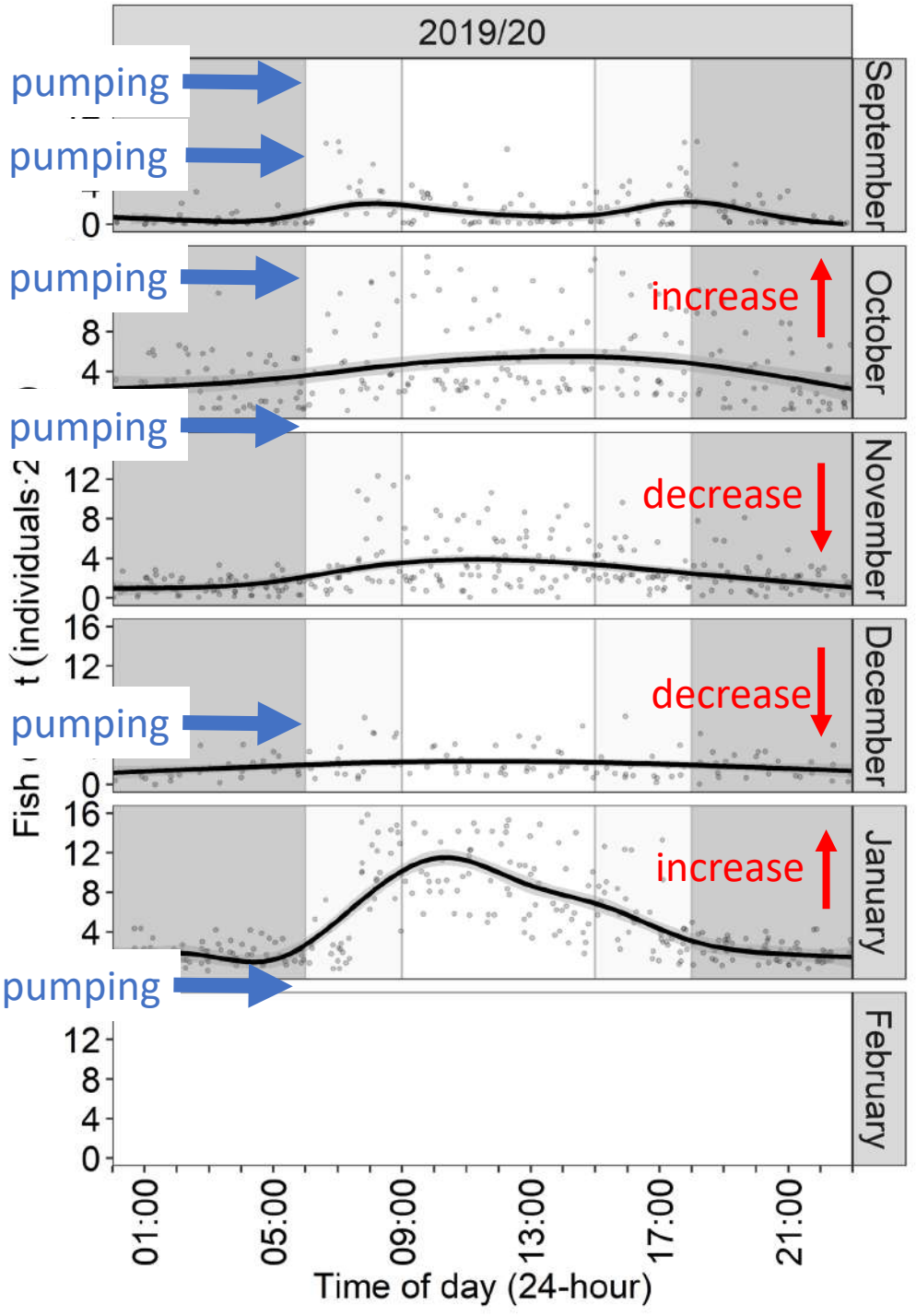
Temporal fish counts (Y3)

- Fish count is **stochastic** through the season

November: **799**
January: **1670**

- **Crepuscular activity at dawn and dusk**
- Frequent pump operation throughout study period disrupted ecological movements of fish



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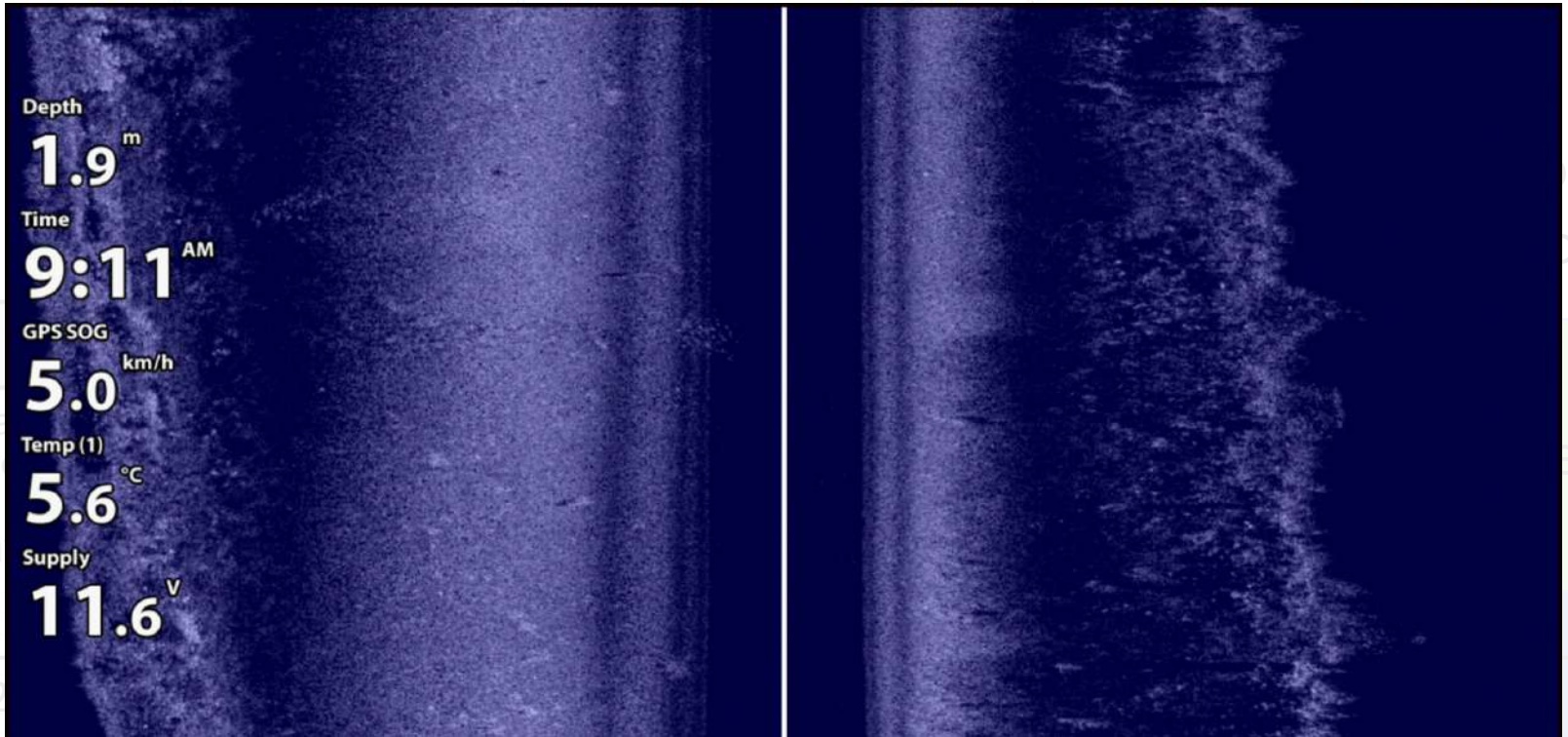
ARTICLE

Fisheries Management and Ecology | WILEY

The impact of extreme flood-relief pump operations on resident fish in an artificial drain and the potential for artificial habitat introduction

Josh Norman[1] | Jake Reeds[2] | Rosalind M. Wright[3] | Jonathan D. Bolland[1]



Evidence-based protection: remedial measures

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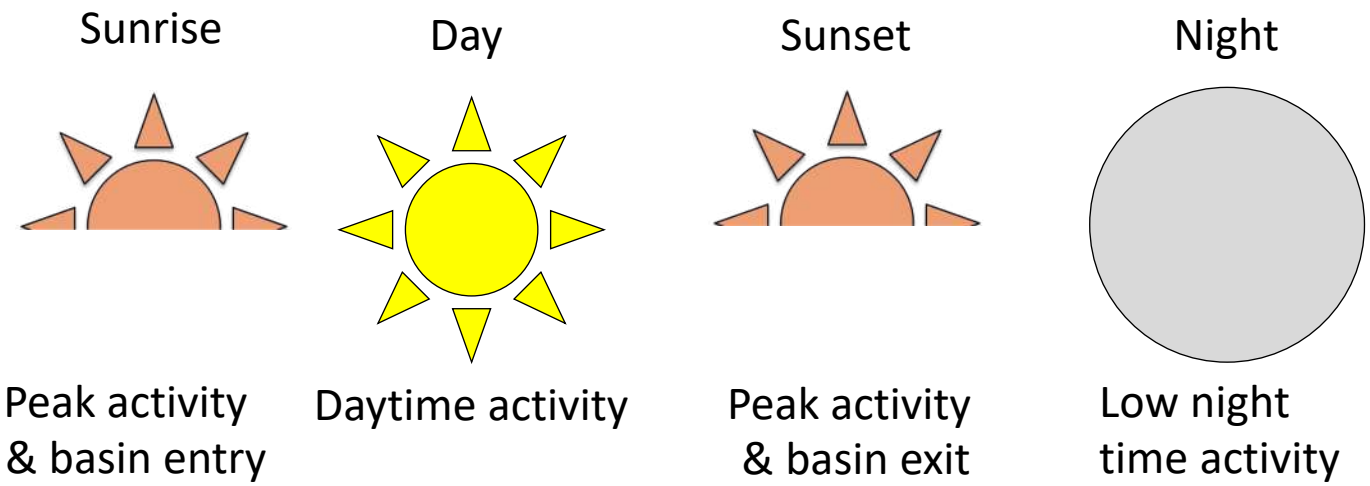
How might the knowledge of temporal fish movements be incorporated into management of hazardous intakes and associated river infrastructure?



Two methods: (1) Adjust when pumps operate (2) Prevent entry ahead of pump operation

(1) Fish-friendly operational regime - Overall fish abundance was highest during daylight and lowest at night; pumps should not be started during the day to protect the most fish

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Modified floodgate operation

- Lowering floodgate ahead of dawn significantly reduced lateral movements of fish from main-river into off-channel pumping station forebay
- Fish returned to normal temporal movement pattern immediately following trial
- Fish counts also reduced when compared to hydrologically similar period

(2) Prevent entry ahead of pump operation - Given fish tended to immigrate into Foss Basin at dawn and lowering the floodgate during a trial temporarily interrupted this movement, the floodgate should be lowered prior to dawn ahead of predicted pump operation due to elevated river levels.

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First published research using temporal information on river-resident fish movements to inform pumping station and floodgate operation

Refuge use at pumping stations

Multi-species river-resident fish community perform ecological movements between pumping station and main river

Pumping station impacts on river-resident fish

Pump operation can negatively impact ecological functioning of river-resident fish communities

Fish Paradoxically occupy pumping stations in absence of natural habitat

100's of thousands of fish at risk during normal operation

Take home message

Understanding behavioural ecology of prevailing fish communities = **reduced entrainment risk**

Temporal management of pumps and infrastructure required


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