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# Session B4: Fine-Scale 2D Acoustic Tracking of the Behaviour of Salmonids to Investigate Delays and Failures in Fish Passage; Implications for Assessing the Efficiency of Fish Passes

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# Fine-scale 2D acoustic tracking of the behaviour of salmonids to investigate delays and failures in fish passage; implications for assessing the efficiency of fish passes

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Environment Agency

# Ruswarp Weir – Yorkshire River Esk

# Ruswarp Weir – Co-located fish pass & Turbine

**Before**:

Pool-traverse pass

**After**:

Larinier pass
Low-head 50 kW HP
(max abstraction 4 cumecs)

# Changes in basic passage metrics for sea trout

(1) The ***Attraction Efficiency*** (proportion of tagged sea trout entering the array) **significantly higher** in post-commissioning dataset

**35% → 70%**

(2) The overall ***Passage Efficiency*** (proportion of tagged sea trout successfully ascending the weir) **significantly higher** in the post-commissioning dataset

**35% → 53%**

(3) The ***Fish Pass Efficiency*** (proportion of tagged sea trout detected in the array that ascended the weir via the primary [Larinier or Pool/Traverse] fish pass) **significantly lower** in the post-commissioning dataset

**100% → 68%**

# 2D tracking

# Fine-scale metrics

# Sea Trout

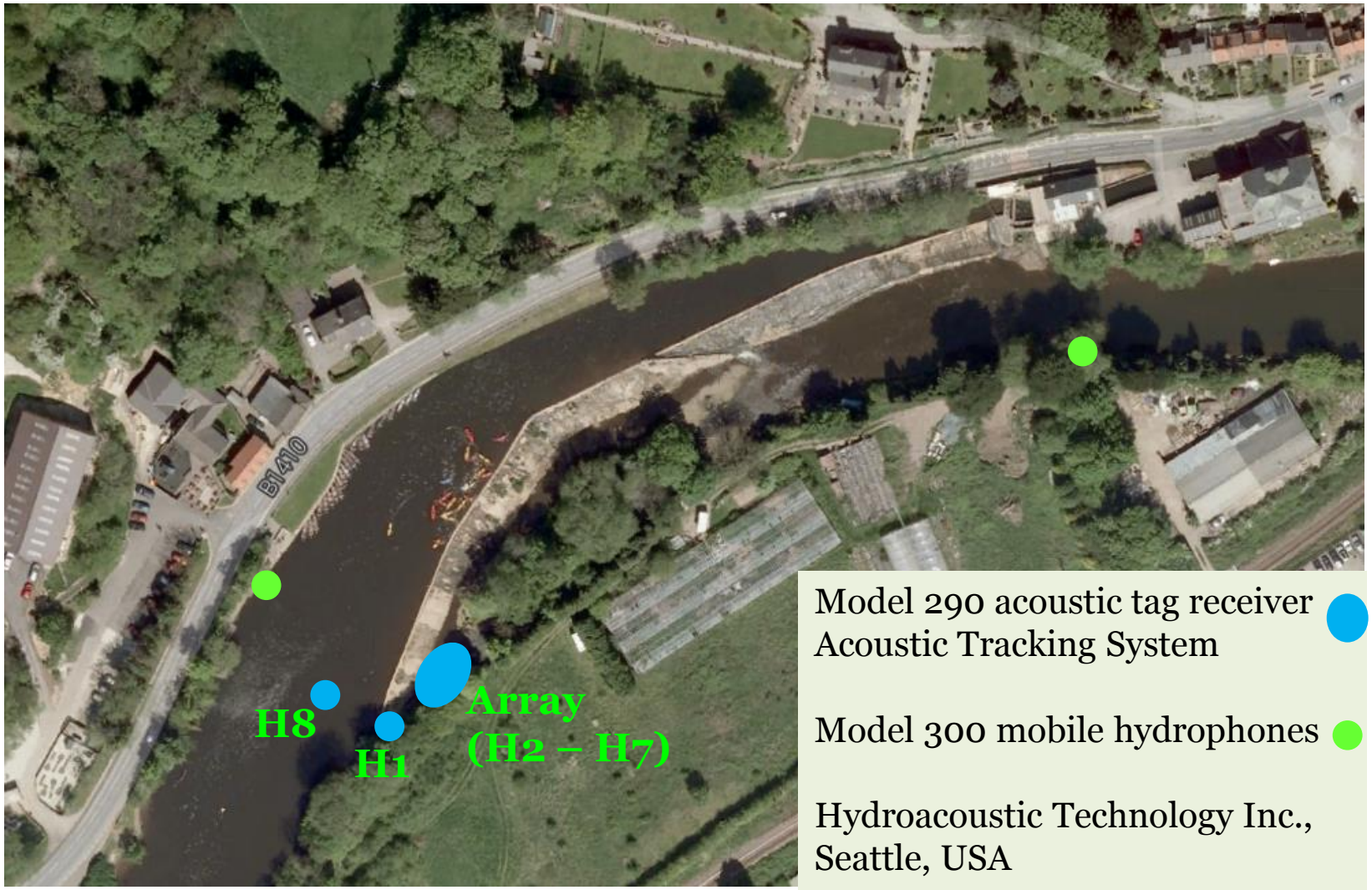
# Capture & Acoustic Tagging

| Year | Dataset | Sea Trout | | Tracks |
|---|---|---|---|---|
| | | Tagged | Tracked | |
| 2011 | Baseline | 38 | 14 | 37 |
| 2012 | Baseline | 10 | 3 | 48 |
| 2013 | Post | 46 | 31 | 491 |
| 2014 | Post | 44 | 31 | 464 |

Model 795LG acoustic tags
11-mm x 25 mm
4.6-g weight in air
expected life of 220 days
307 kHz
2-3 second unique ping interval
Hydroacoustic Technology Inc., Seattle, USA

All tagging done under Home Office Licence

# Remote and ATS hydrophones

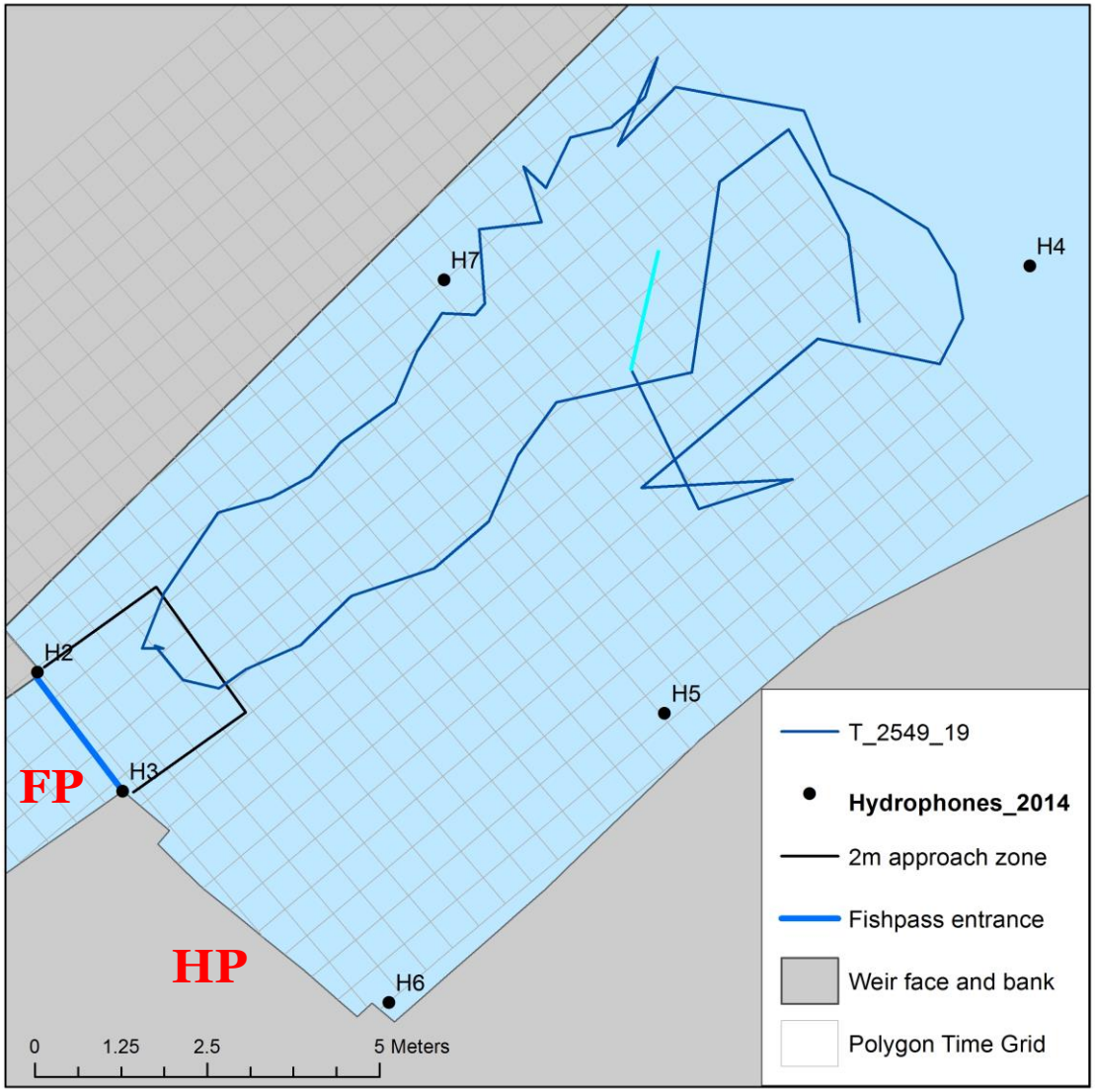



Model 290 acoustic tag receiver Acoustic Tracking System

Model 300 mobile hydrophones

Hydroacoustic Technology Inc., Seattle, USA

# 2D Tracking Analysis Methods & Metrics




Metrics:

*Approaches*

*Proximity*

***Duration***

***Time in cell***

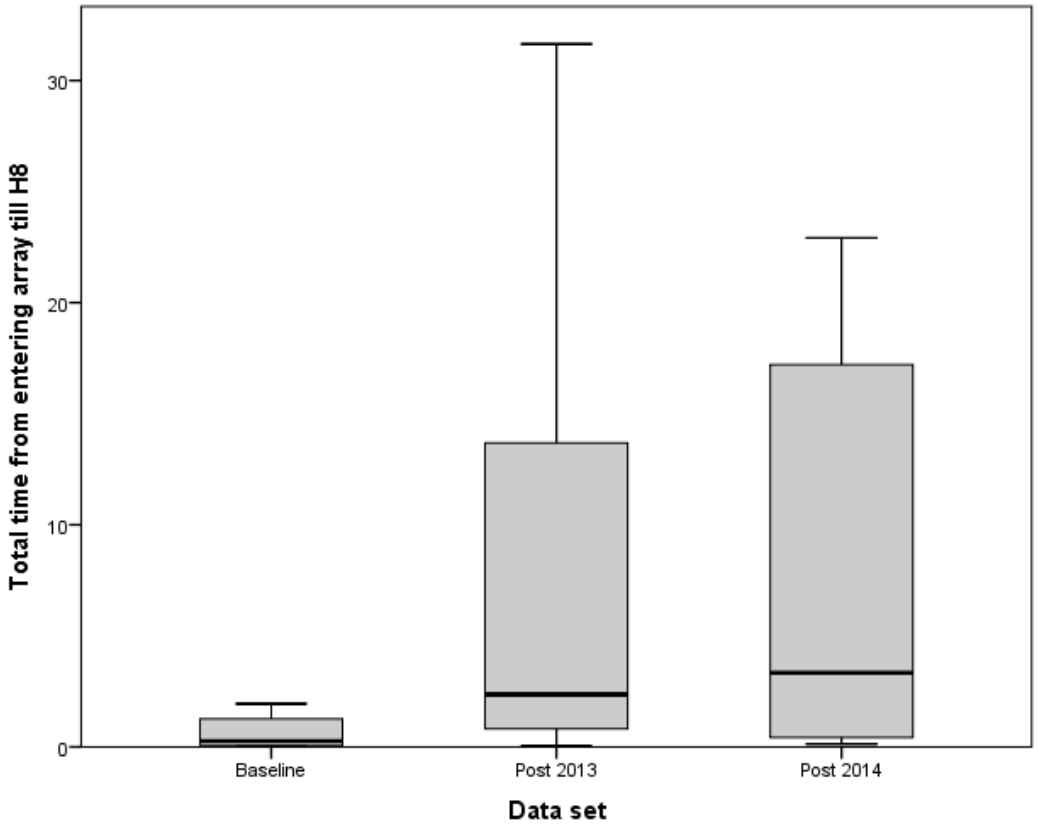
**FP = Fish pass entrance**

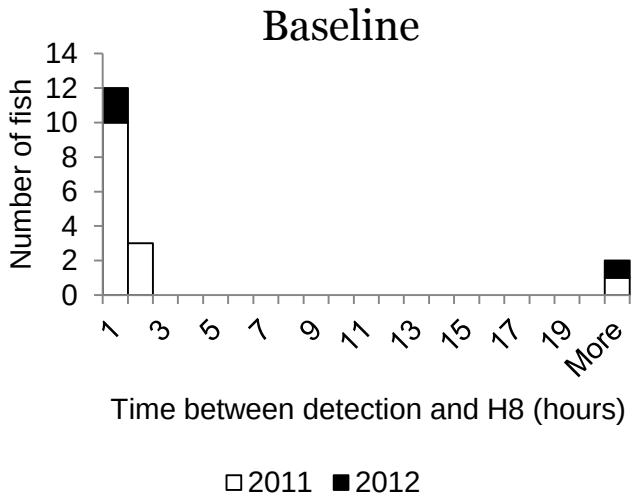
**HP = Hydropower outfall**

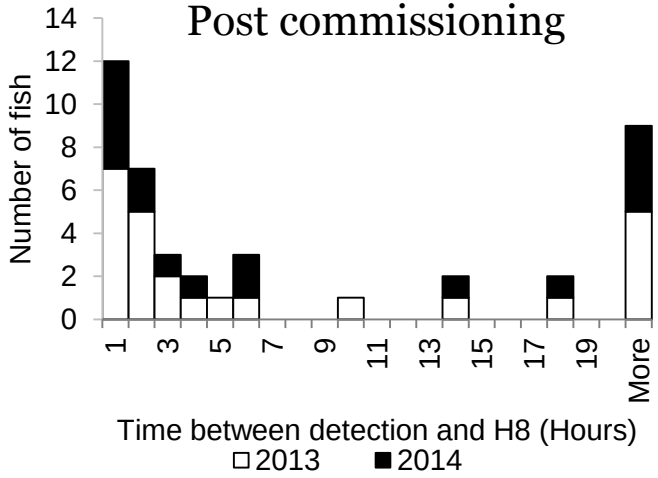
# Time from first detection in array to passage

Median total time from first detection (array) to passage

Significantly longer in post-commissioning dataset
Mann Whitney U-test: Z = 2.945, *n* = 60, P <0.01



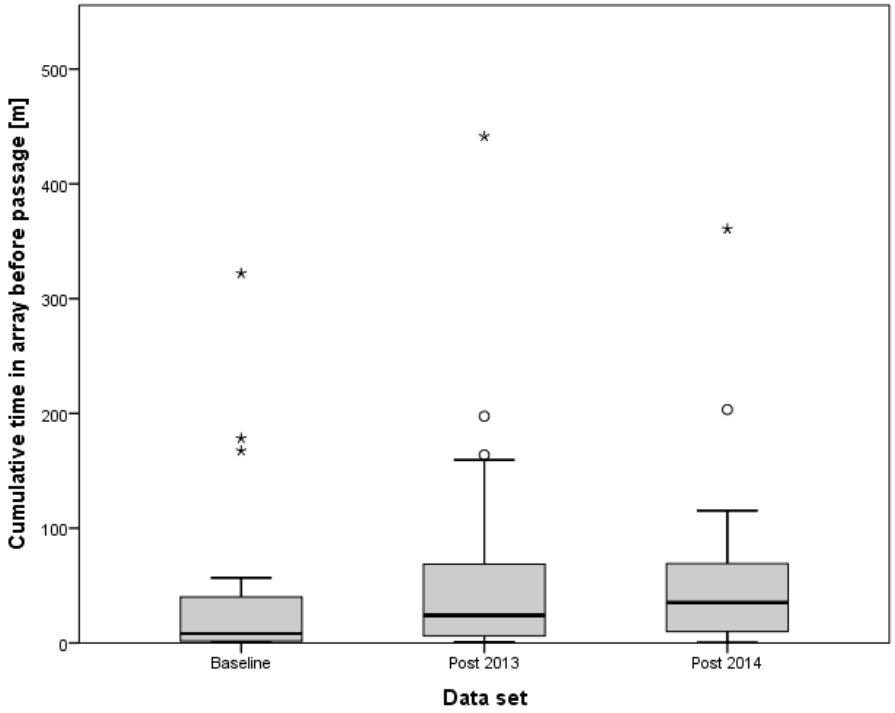



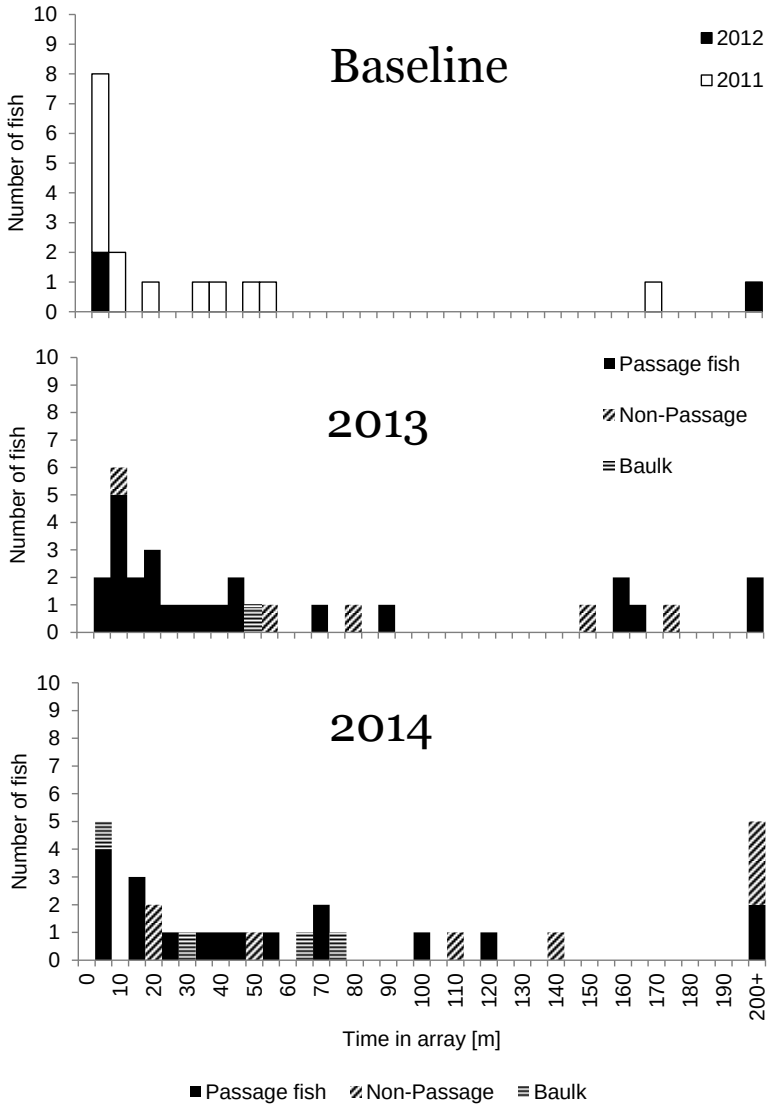
# Time spent in the array – sea trout

Median cumulative time spent in the array before passage:

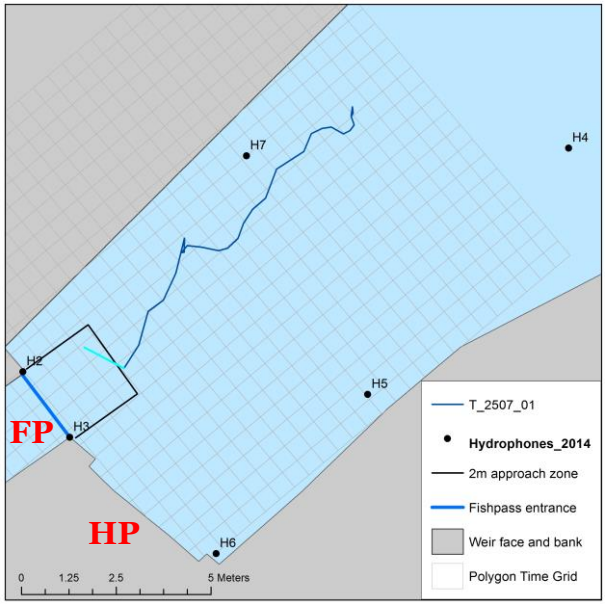
2014 - 26.36 (2.44 – 76.87) minutes (n = 18)
2013 - 24.18 (6.12 – 77.69) minutes (n = 25)
Baseline - 5.00 (1.61 – 29.81) minutes (n = 17)

Mann Whitney U-test: Z = 2.026, *n* = 60, P <0.05

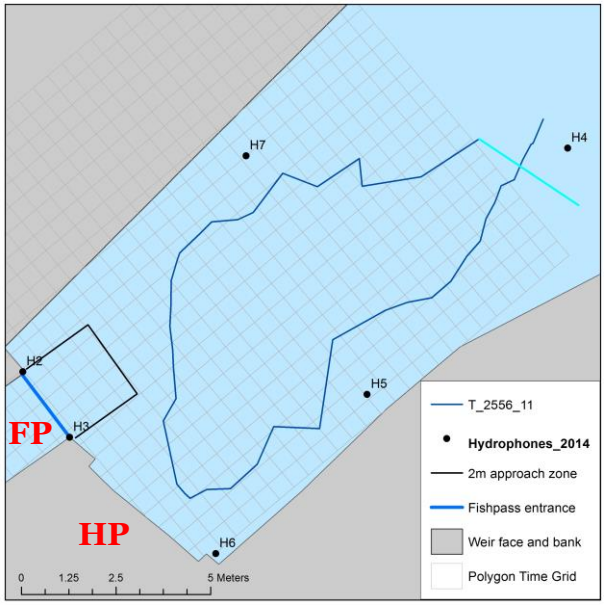


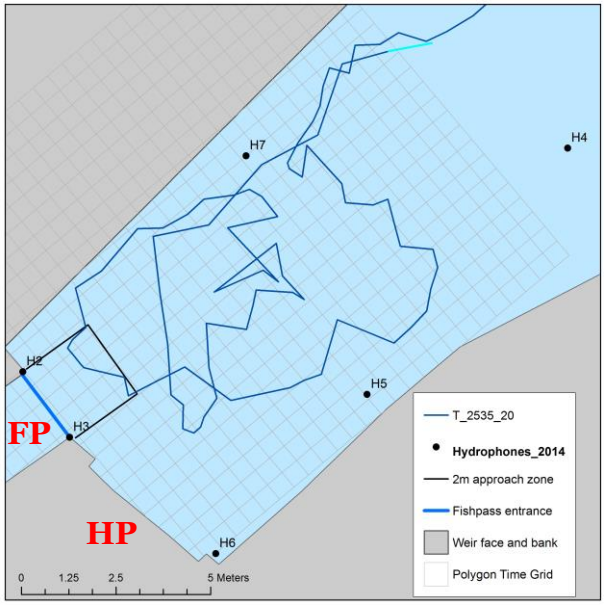
# 2D Tracking Analysis




Simple - Passage

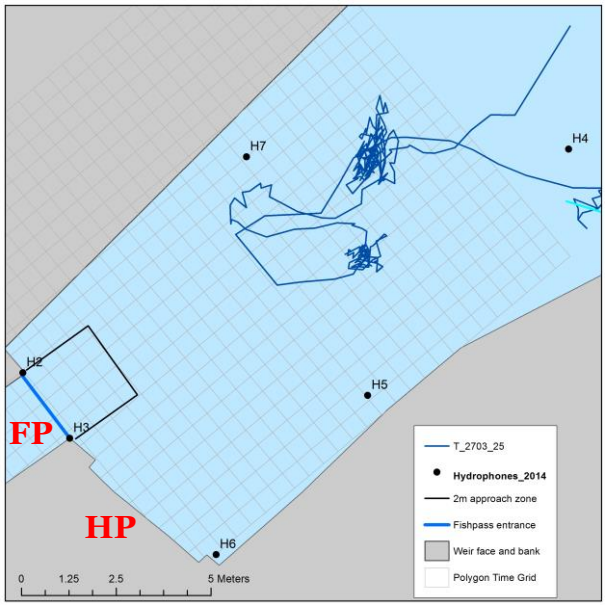


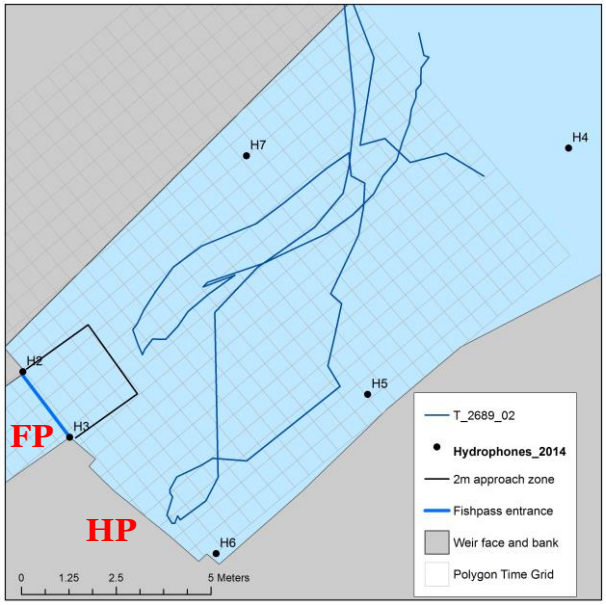

Simple – Non-Passage

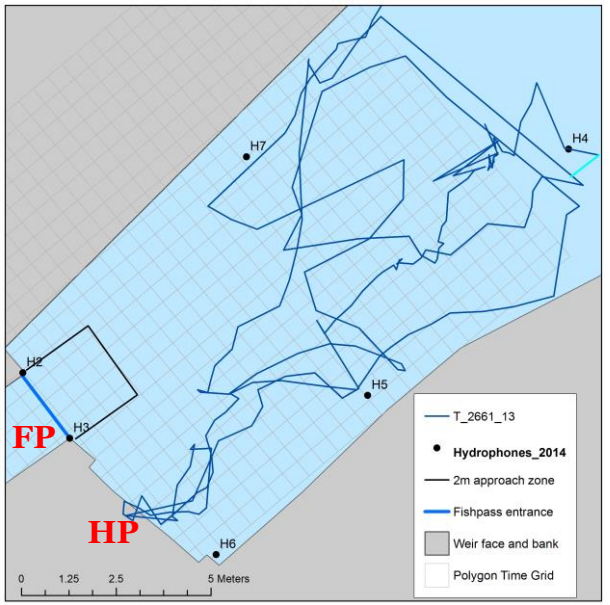



One or more approaches?

# 2D Tracking Analysis



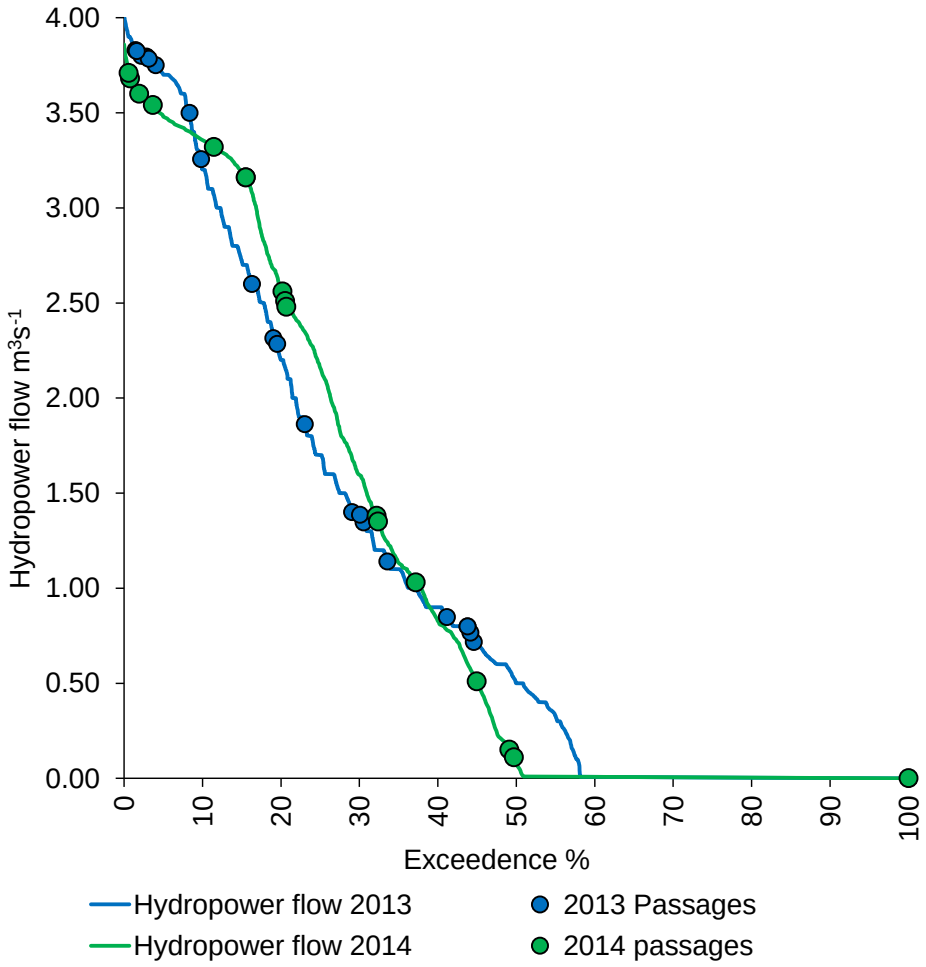




Resting – no approaches?

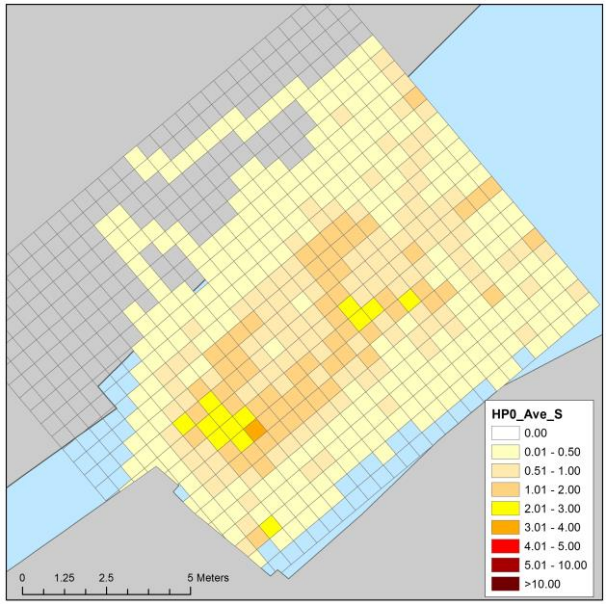
Non-passage: Evidence of attraction to HP outflow / deeper water (distraction)?

# Timing of passage in relation to generation




- hydropower turbine active for 51% of the time (1/9/2014 to 31/12/2014) (58% in 2013)
- operating at near capacity (abstraction > 3.7 $m^3s^{-1}$) for <1% of the time
- Sea trout were observed to ascend through the fish pass under most conditions

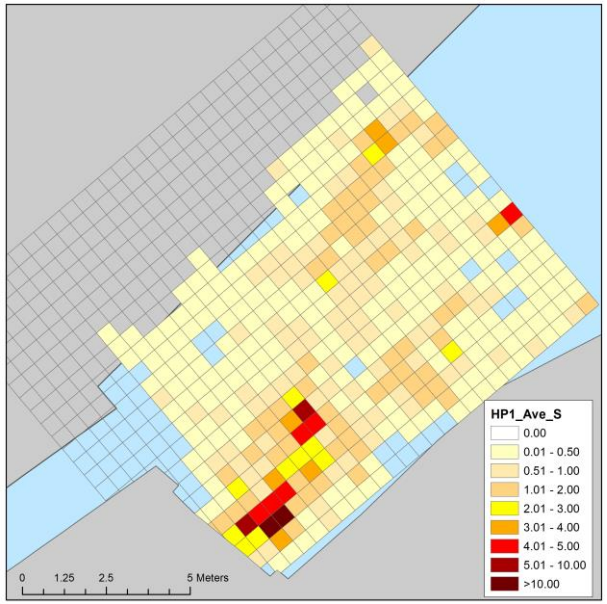
# Pool use in relation to turbine discharge




Turbine discharge

0 Cumecs (Off)

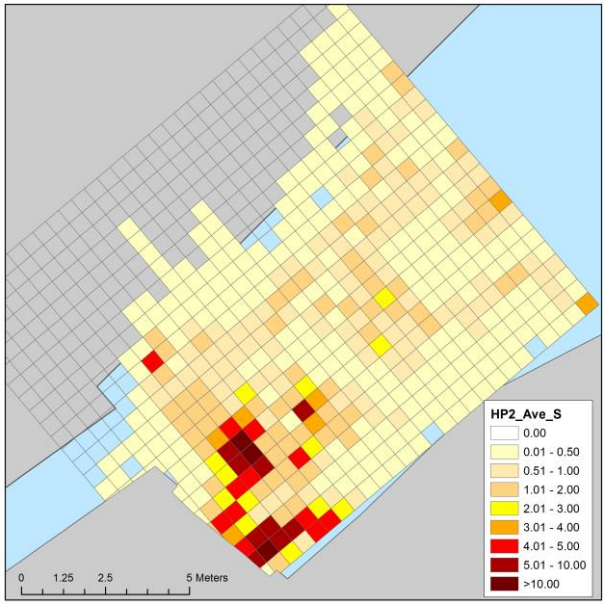
*n* tracks = 26




Turbine discharge

0.01 to 1.00 Cumecs

*n* tracks = 13

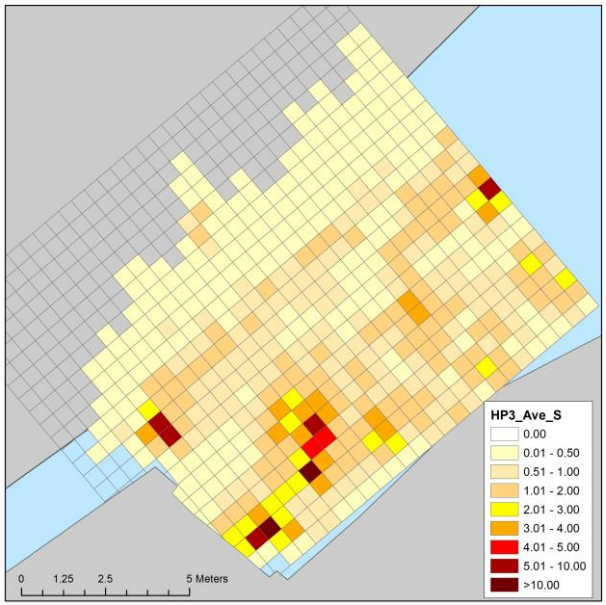


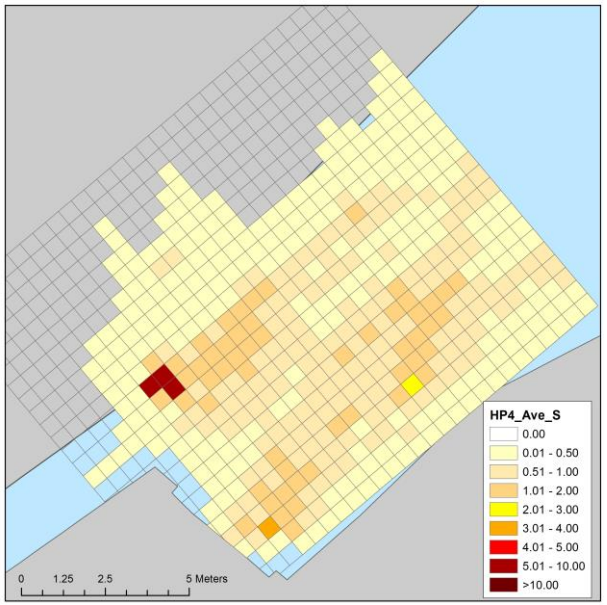

Turbine discharge

1.01 to 2.00 Cumecs

*n* tracks = 30

# Pool use in relation to turbine discharge




Turbine discharge

2.01 to 3.00 Cumecs

*n* tracks = 89

Turbine discharge

>3.01 Cumecs

*n* tracks = 228

# Hot spots – unusual individuals or common trend?

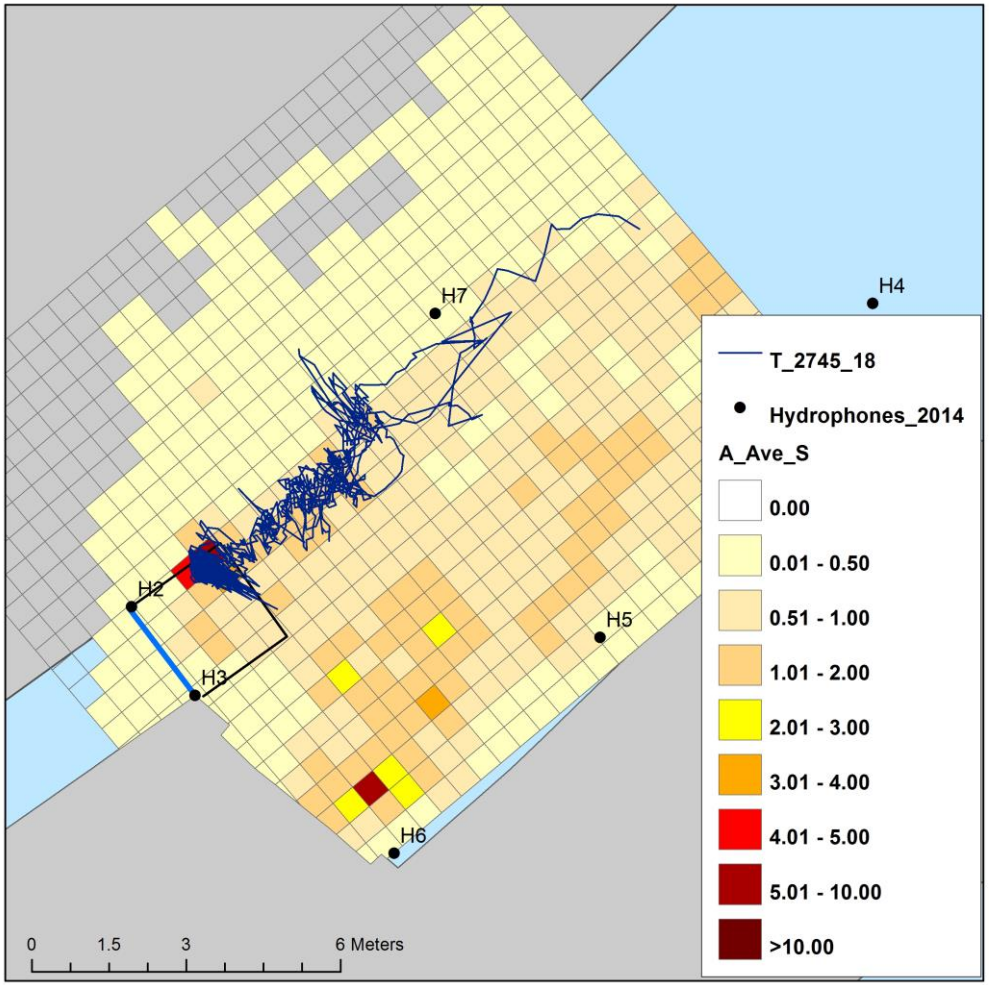
**Fish 2745**

Track 18

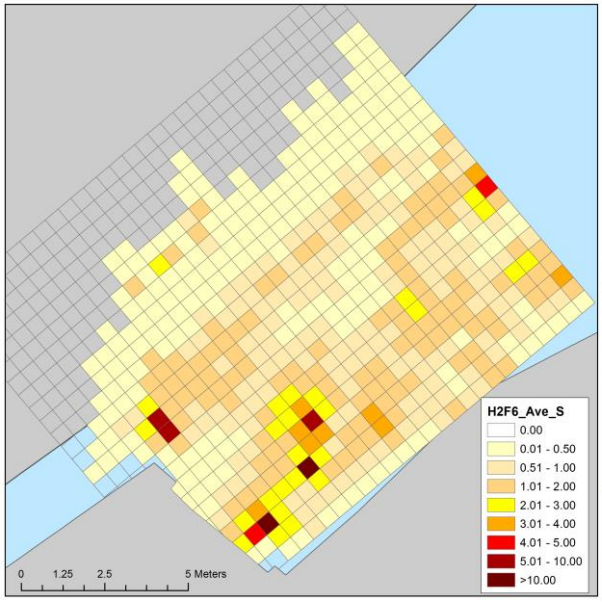
Duration = 2.5 hours

Conditions:

Ebbing spring tide (5.3m)
Non passage
Early hours of the morning (3am)
Abstraction = 3.33 cumecs
Discharge = 6.31 cumecs



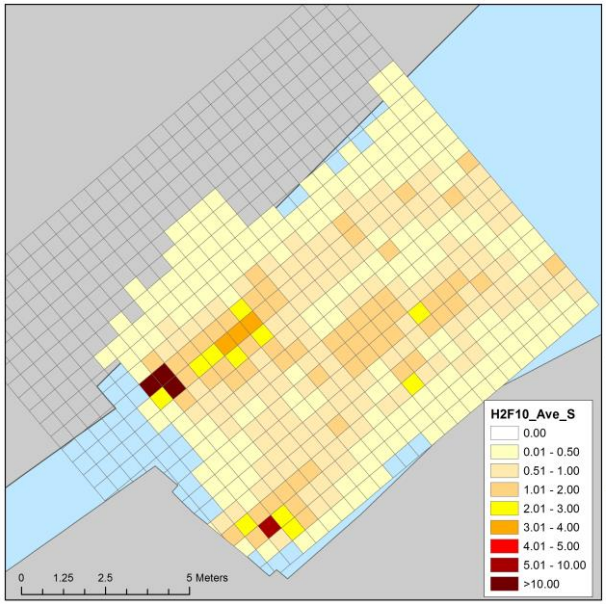
# Pool use in relation to turbine and river discharge




Turbine > 2 cumecs

River < 6.0 cumecs

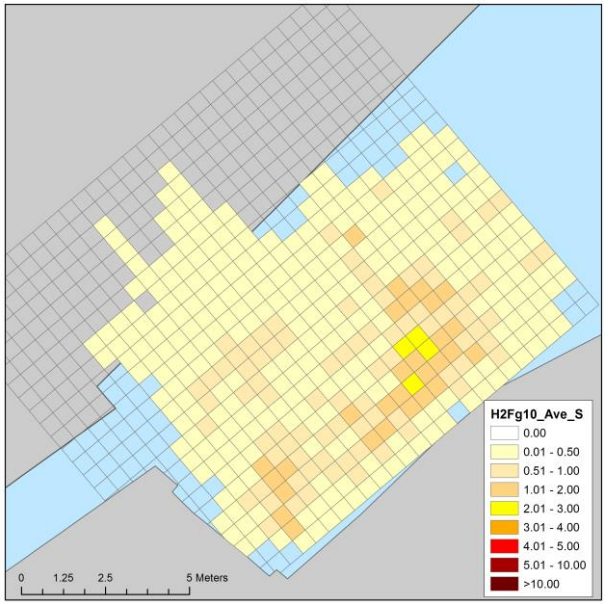
*n* tracks = 110




Turbine > 2 cumecs

River 6.0 - 10.0 cumecs

*n* tracks = 111




Turbine > 2 cumecs

River > 10.0 cumecs

*n* tracks = 96

# Ruswarp Weir – changes to the approach pool

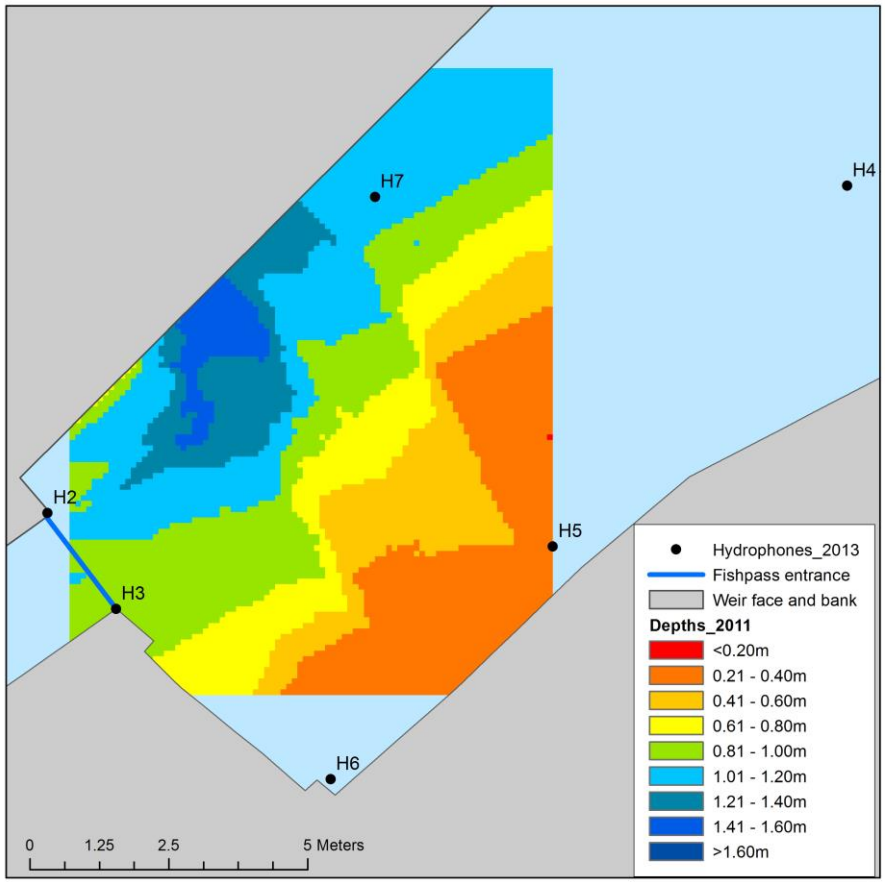
**Before**:

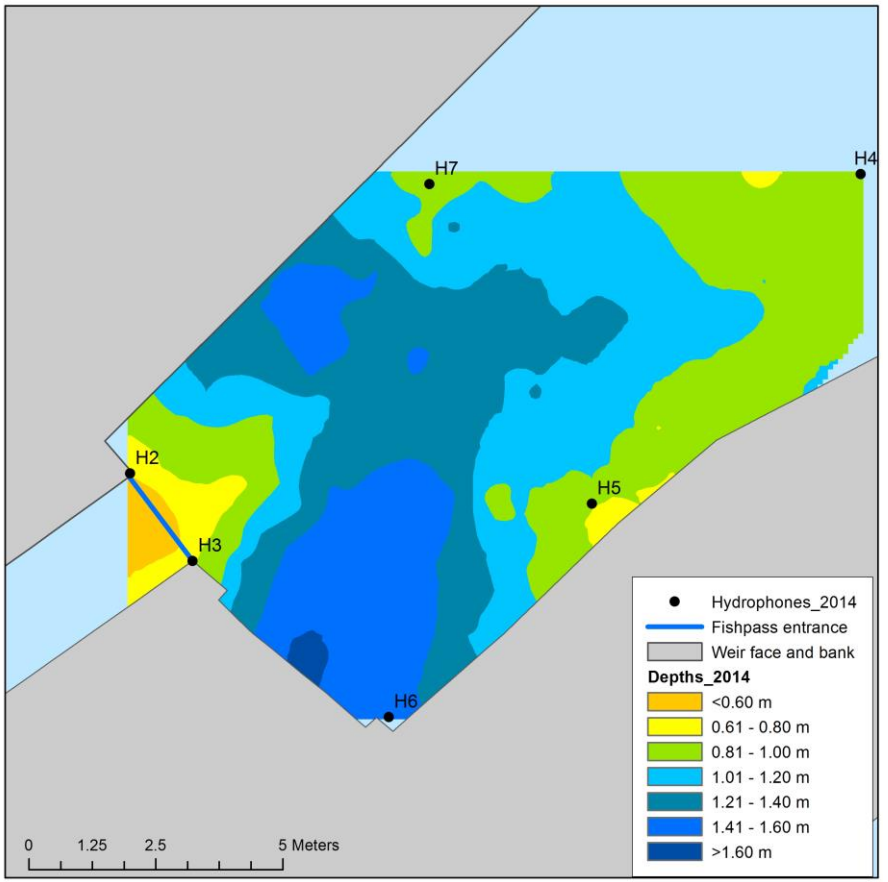
Pool-traverse pass
Shallow margins on RH bank

**After**:

Larinier pass
Deepest on RH bank

# Pool Bathymetry (GIS kriging)




2011
Determined by ADCP

2014
Determined manually

# Conclusions

(1) There is some evidence of attraction of fish to the area in front of the hydropower outfall screens

- most apparent when the turbine was active at river flows <6$m^3s^{-1}$
- this area is also the deepest part of the pool
- refuge in deep water or distraction from fish pass flow?
- Further interrogation of behaviours required

(2) The delay between arrival in the pool and eventual passage was statistically significantly greater in 2013 and 2014 than in the baseline

- probably of little energetic consequence given the overall scale and duration of the sea trout migration
- possible consequences for increased predation risk
- predation is confirmed to occur within the vicinity of the pool

# Thank you