Acoustic Fish Tracking in a Tight Spot!

Environment Agency

Evidence Project SC120079

Assessing deflection, entrainment and impingement of smolts and silver eels in an artificial hydropower flume using an acoustic tracking system.

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Objectives

Principal Objective 1

Does the the screen size required by the regulatory authority in England protect migratory fish from hydropower intakes?

Principal Objective 2

Can the technical challenges of acoustic tracking in a small artificial channel be overcome to answer question 1?

Introduction

About 30 - 40 low-head hydropower developments are installed in England's rivers each year that usually require a level of screening to prevent fish entrainment.

Recommended screening includes aperture widths of 10 and 12.5 mm, however there is uncertainty regarding the level of protection these provide against entrainment and impingement for different life stages of migratory fish. In this study, a 2 m wide concrete channel connected to the River Test was modified to mimic a hydropower intake using removable vertical screens (Figures 1 & 2), and the behaviour of released wild Atlantic salmon smolts and silver eels recorded using a high resolution acoustic tracking system (HTI Hydroacoustic Technology Inc.).

FIGURE 1
Image of the screen installation and bypass (to right and downstream of the screen) with hydrophones in place (flow direction is going away from the camera). Note the channel has been de-watered; experimental water levels are indicated by the high water line on the bypass deflector behind the ladder. Hydrophone H3 is indicated by the white arrow.

Methods

Escape velocities in front of the screens were ~0.46 ms^{-1}, close to the maxima recommended for salmonids (0.6 ms^{-1}) and eel (0.5 ms^{-1}) in England (Figure 3).

Fish were released in batches above 10 mm, 12.5 mm or control screens and acoustic tracks analysed and scored for potential deflection, entrainment or impingement.

Static beacon tags were used to estimate positional uncertainty – 'jitter' - allowing criteria to be developed for potential passage through screens (> 10 cm beyond screen) and impingement (smolts stationary for >5 and eels >25 secs).

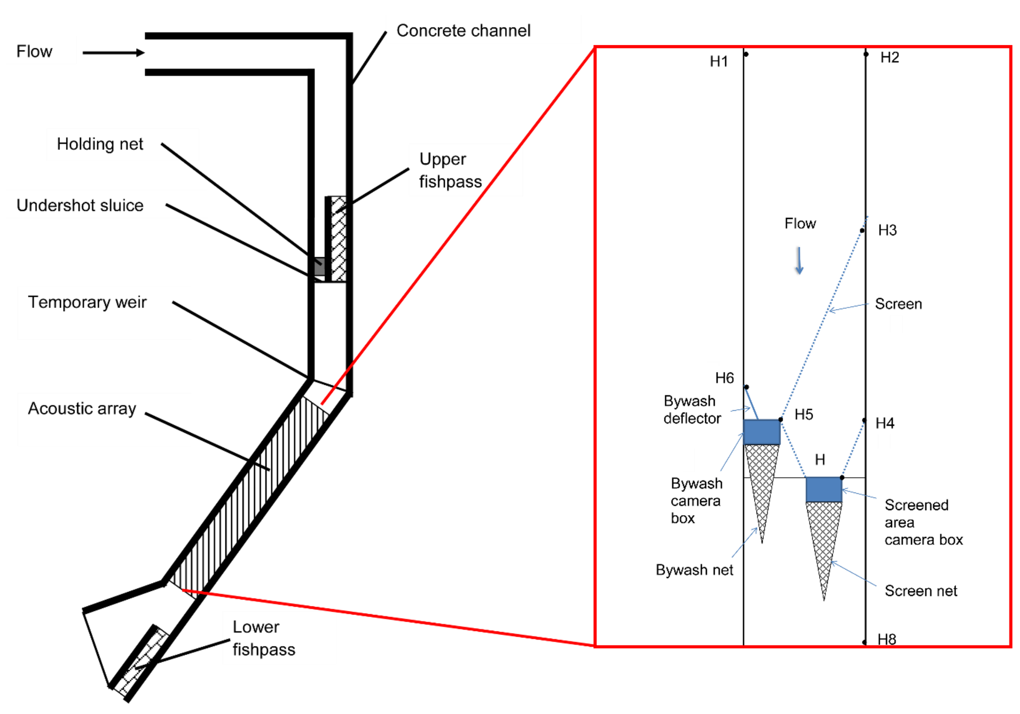

FIGURE 2
Schematic of the River Test experimental channel, illustrating the location and arrangement of the screen and bypass installation and the approximate position of the hydrophones for acoustic tracking (black dots).

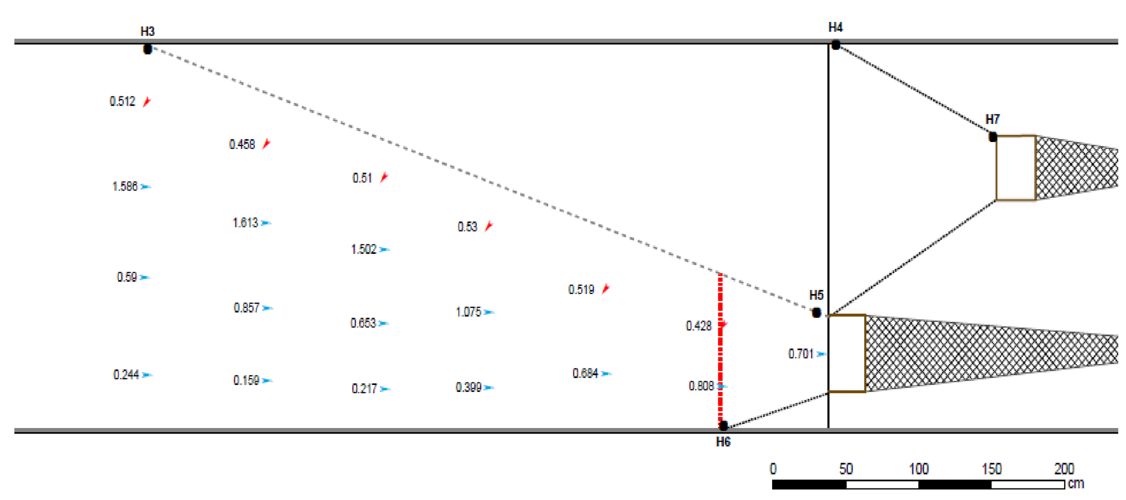

FIGURE 3
Mean channel velocities (ms^{-1}, blue arrows) and escape velocities (red arrows, measured 10 cm from screen face) recorded for the 12.5 mm screened eel trial. Red line = line of deflection; once tracks reached this fish were considered to have been deflected.

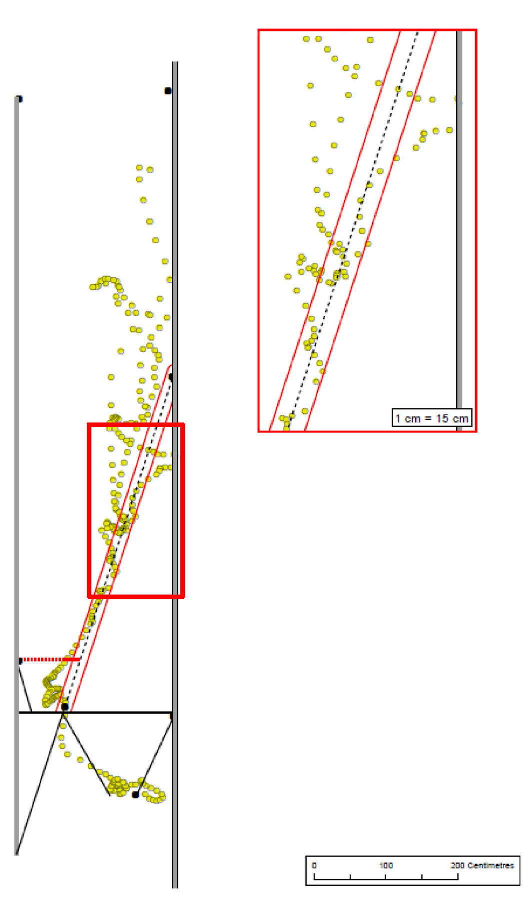

FIGURE 4
Track of smolt suggesting potential temporary entrainment through the 12.5 mm screen.

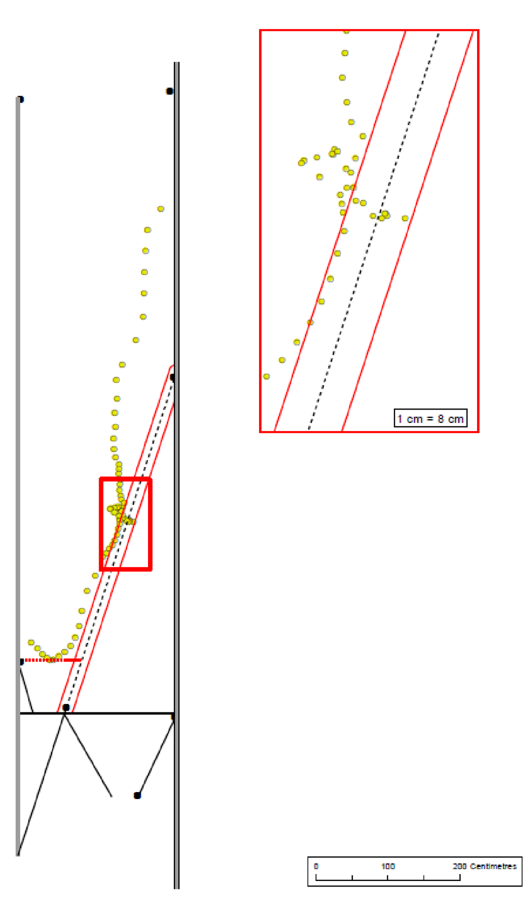

FIGURE 5
Track of smolt suggesting potential temporary impingement on the 12.5 mm screen.

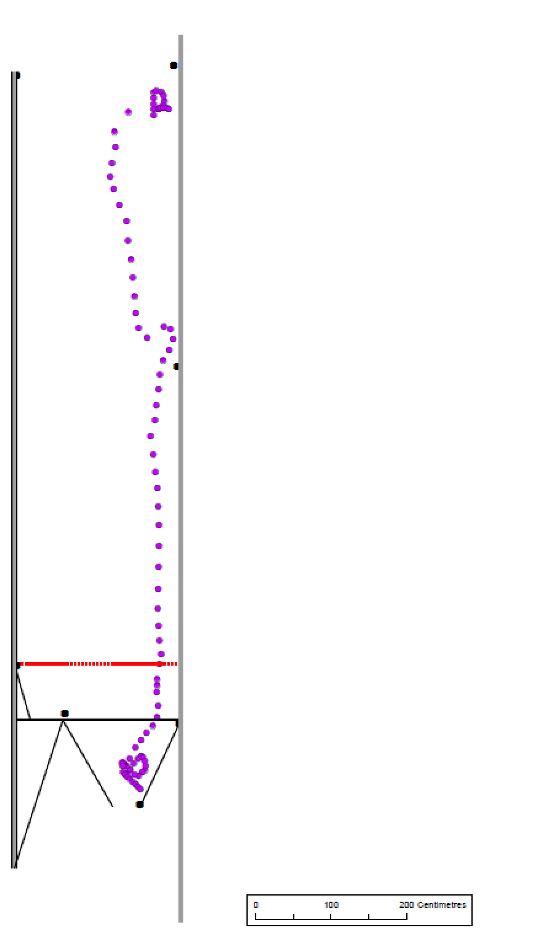

FIGURE 6
Track of control smolt showing rapid transit of study area into net behind the removed screen.

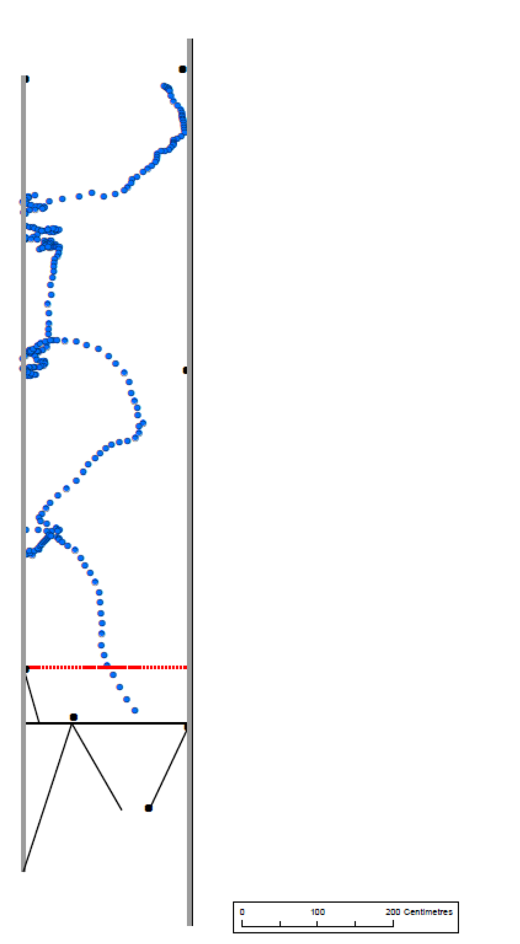

FIGURE 7
Track of control eel showing holding behaviour and passage into the net behind the removed screen.

Results

229 smolts were released ranging in length from 105 – 170 mm. 215 tracks were analysed, resulting in;

10 mm screen: **97% deflection**, 2% potential entrainment and 1% potential impingement rates.

12.5 mm screen: **93% deflection**, 1.8% potential entrainment and 0.9% potential impingement rates (4.3% failed to reach the line of deflection).

Sufficient eels were only available for one screening and one control trial. 68 tracks from 47 eels ranging from 335 – 555 mm were analysed, resulting in **100% deflection** by the 12.5 mm screen and 0% impingement.

Aperture Size & Species	Number of Fish Interacting with (*Challenging*[a]) Screen	Number of Fish Tracked to Deflection Line (*Recaptured in Bywash Net*)	95% Confidence in Deflection Efficiency[b]
10 mm Smolts	100 (*109*)	97 (*68*)	92.4% (*54.1%*)
12.5 mm Smolts	114 (*120*)	106 (*81*)	87.7% (*59.8%*)
12.5 mm Eel	27 (*38*)	27 (*20*)	89.5% (*38.2%*)

FIGURE 8
Confidence in in deflection efficiency estimates for acoustic tracking and recapture data (in *italics*).

[a] It is assumed the number of fish challenging the screen is equivalent to the number of fish released.
[b] Determined from binomial probability calculations.

Discussion

Significant challenges to the acoustic tracking approach included the very small study area (approximately 10 x 2 m) and highly reflective boundaries resulting in competing multipath signals. Nevertheless, tracking of fish was rapid, practical and greatly enhanced the study.

Recapture data alone would have produced considerably lower confidence in deflection efficiencies for all screen and species combinations (Figure 8), and would have provided no information on impingement rates.

High debris and sediment loads at the site during the eel run would have seriously limited the value of purely recapture and video methodologies for assessing eel deflection and impingement.

Conclusion

Current good practice guidelines in England of 10 mm and 12.5 mm screening for water intakes at hydropower sites appear appropriate.

Using a hydropower site mimic enabled greater control over flow and screening conditions and permitted tag recycling. This reduced the overall cost of the study and allowed greater flexibility for transferring findings to low head hydropower installations and other water intakes.

This high resolution tracking study supports our current guidance to hydropower developers.

Thanks to

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