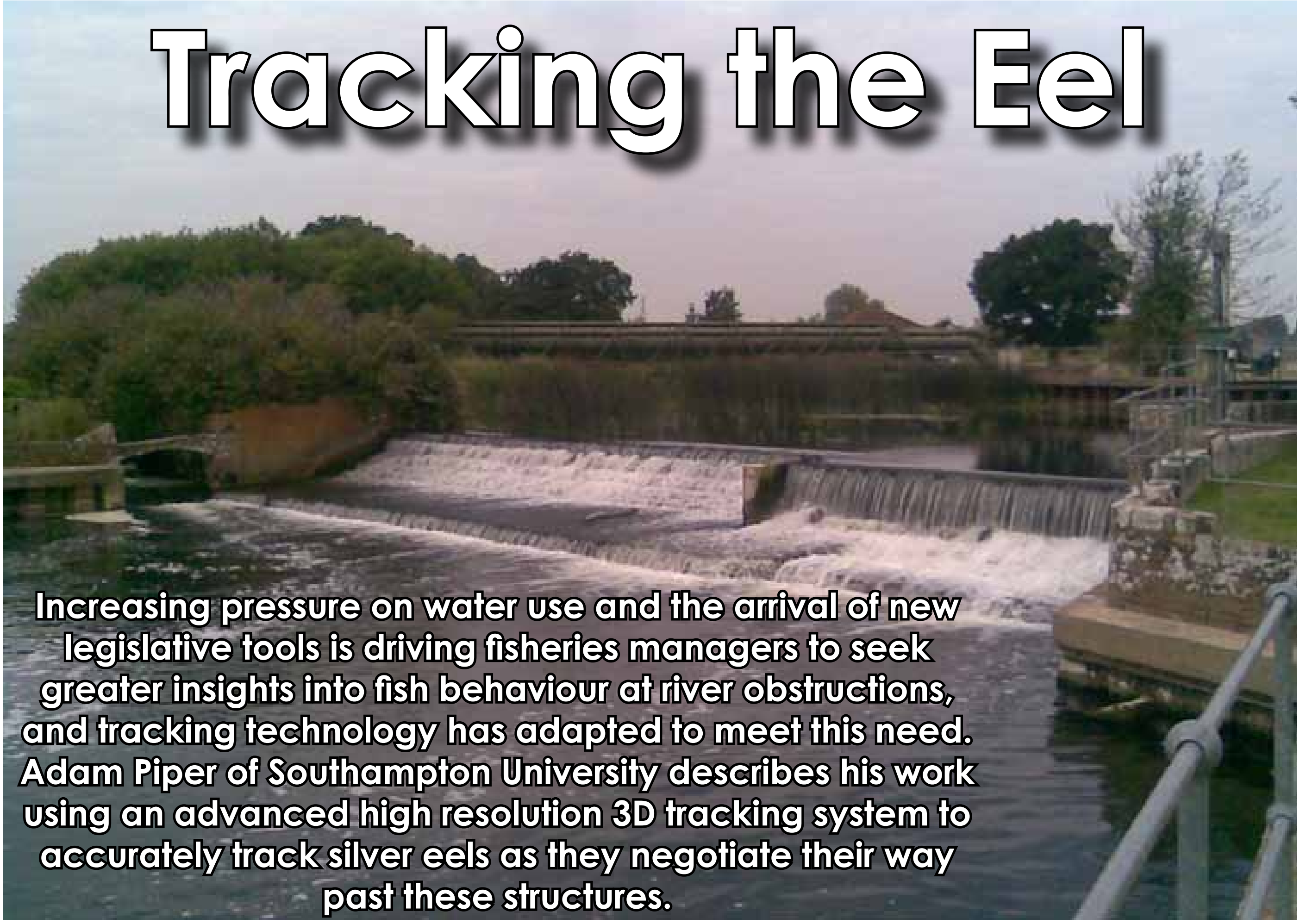
Tracking the Eel



Increasing pressure on water use and the arrival of new legislative tools is driving fisheries managers to seek greater insights into fish behaviour at river obstructions, and tracking technology has adapted to meet this need. Adam Piper of Southampton University describes his work using an advanced high resolution 3D tracking system to accurately track silver eels as they negotiate their way past these structures.

There is ever increasing recognition of the potential negative impacts of riverine barriers on fish populations. Although there is still debate surrounding the decline of our European eel stock, barriers are suggested as one possible cause, due to the disruption or cessation they may cause to migration of all freshwater life-stages. In England and Wales, it is estimated that 2,500 obstructions prevent or reduce fish migrations, and on a European scale, 32% of inland waters are considered inaccessible to eels because of man-made barriers. Furthermore, with the recent push for hydropower under the EU Renewable Electricity Directive 2001, the number of structures posing a migratory barrier to fish is only likely to increase, with eels experiencing considerably higher mortality in these turbines than other fish, and a reported injury rate of 16-38%.

The fish-passage literature is extensive, and fish passage design is advanced, though much of this work has proven largely redundant for eel, principally owing to its salmo-centric and site specific biases. One emerging pattern we see across all species, however, is the strong influence that hydraulics may have on fish behaviour and passage ability. There is a dearth of this kind of work for the eel, so it is hoped that gaining a better understanding of how eel respond to the hydraulic conditions created by barriers could prove a crucial step towards the development and provision of effective passage solutions.

The need to understand how structures affect both upstream and downstream migration of the catadromous eel gave rise to collaboration between the Environment Agency and the International Center for Ecohydraulics Research (ICER www.icer.soton.ac.uk) group at Southampton University. I was fortunate to be offered a PhD position within this group and since October 2008 have developed the project. The research will address both the juvenile and adult migrating life stages of eel, investigating behavioural responses to barriers in terms of the hydraulic conditions they experience. In particular I am looking at attractants and deterrents, and the porosity of structural barriers and eel passes.

Silver Eel Behaviour at barriers

There is much evidence that barriers slow the rate of migration in silver eels, with some work suggesting they may delay it by several months, possibly causing silver eels to revert to yellow eel stage. Whilst delayed behind barriers, eels often display 'recurrent behaviour' whereby individuals approaching turbines, trash-racks or structures are repelled, turn, and swim away, with up to ten approaches made before finally passing.

Interestingly, such behaviour has hypothetically been attributed to a reaction to hydraulic variation because rejection often begins at points where water velocity changes suddenly, and before the eel actually encounters the physical structure.

Autumn silver eel telemetry study

Fish trials carried out in flumes have historically been the mainstay of fish behaviour work at the fine-scale that I hoped to achieve, though with the obvious drawbacks of not being able to recreate natural conditions in a laboratory. In the field, however, we are faced with a number of difficulties, not least the highly turbid flood waters typically associated with silver eel migration.

Within my study I was hoping to record fine-scale behaviour in the field and for this I would need accurate positioning of actively migrating silver eels on a virtually continuous (one second interval) basis. The primary methods considered were: underwater filming, which was not an option due to high turbidity; or high definition sonar e.g. Didson, however this only gives a 'cake slice' view for a set point. I needed to record the trajectory of movement throughout the study site, leaving telemetry as my most feasible option.

Conventional radio and acoustic telemetry are invaluable for detection passage past a fixed point (gating method) or locating a transmitter to a general area; however, the sub-meter accuracy I was looking for has only been made possible since the advent of a new generation of acoustic positioning systems. These are capable of calculating 2 or 3D positions of a

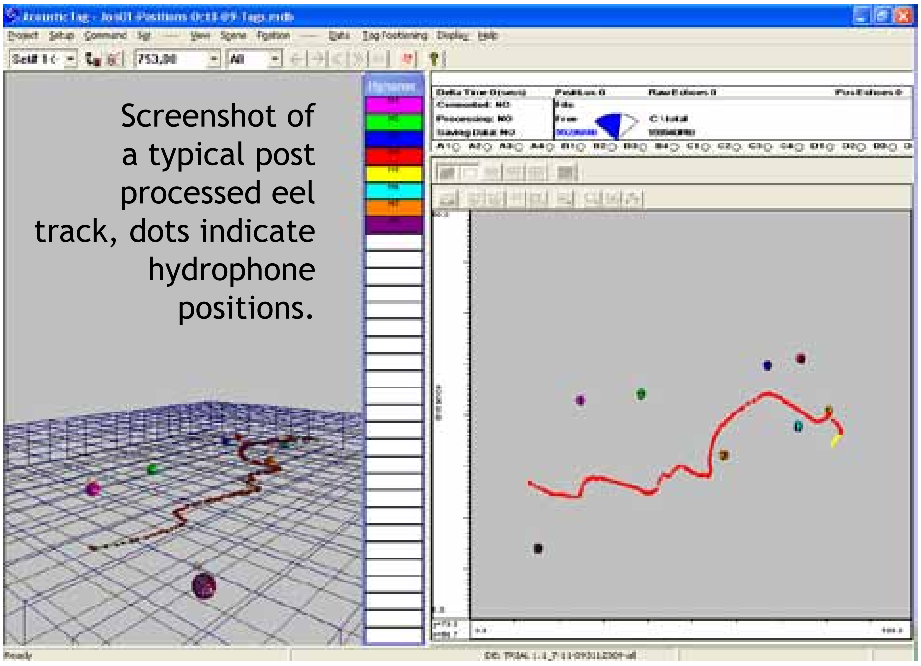
tagged fish based on the difference in arrival times of tag signals at multiple hydrophones, typically positioned around the perimeter of a site of interest. After much research, I decided that the Model 290 receiver system produced by Hydroacoustic Technology Incorporated (HTI) offered the best capability for my study.

The system, which is the only one of its kind in the UK, arrived from Seattle in October 2009. After unpacking and checking the rather daunting shipment, a series of lab tests were conducted to iron out any problems before deployment in the field. After considering numerous barrier sites I settled on a set of structures on the River Stour in Dorset which formed in effect a single barrier across the river, but consisted of a concrete stepped weir, a weir and pool fish pass, undershot penstock gates and a rolling drop weir.

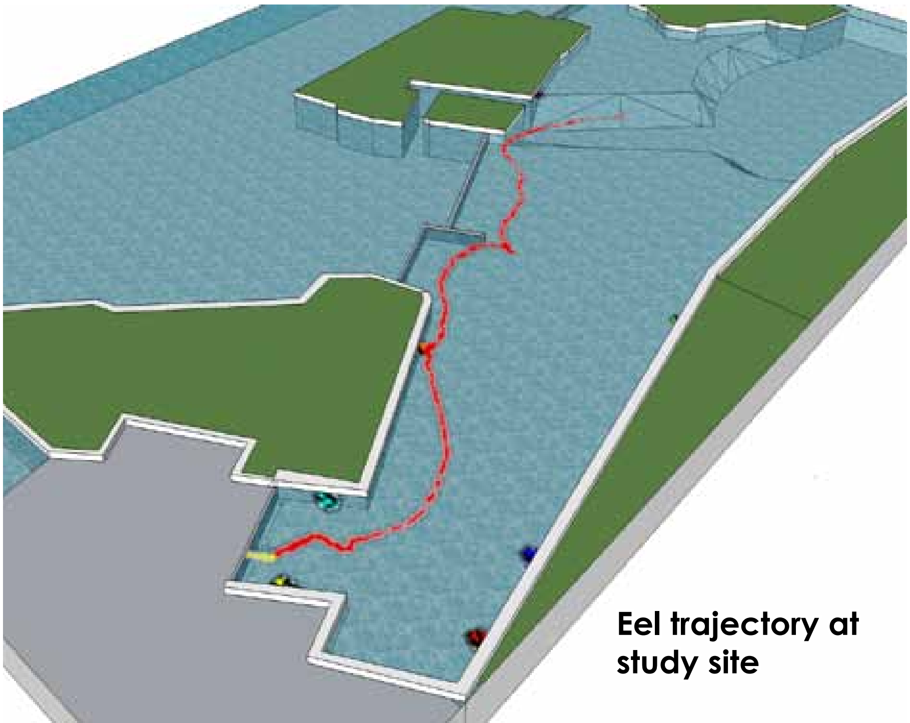
The 8 hydrophones were mounted to simple pole frames installed at strategic positions around the perimeter of the upstream forebay to the barriers. Up to 150m of cable were run from the hydrophones back to the central receiver unit, linked to a laptop in a nearby building. The system was initialized and a series of checks and calibrations carried out. Much of this involves determining accurate hydrophone positions and functioning. The next stage involves a series of detection tests (tag drags) to establish the best setting to use within the system, and with the transmitters themselves which are user programmable. This process also enables you to establish the positioning accuracy and detection area of your setup. After the typical trial and error stage you would expect from a first time user of a complex system, and several relocations of hydrophones to ensure optimum detections, the system was finally ready.

Actively migrating silver eels were captured in a wolf trap on the river. Five fish (size range 635 -765 mm FL) were anaesthetised and abdominally implanted with HTI transmitters (model: 795G, 11mm diameter, 25mm length, weighing 3.1g in air). After surgery, fish recovered and re-acclimatiseed in an in-river holding cage upstream of the structures for 12 hours before being released at approximately 10pm. This was repeated on consecutive nights for three more groups of five fish, and alternating hydraulic conditions were set each night by varying discharge through seven penstock gates. The movements of the telemetrised eels and their passage over the barriers were recorded from time of release until two months afterwards, in

Mounting frame with wire going to hydrophone



Screenshot of a typical post processed eel track, dots indicate hydrophone positions.



Eel trajectory at study site

Adam surgically implanting a transmitter

case of significant delay.

For the hydraulics component of the study a mobile Acoustic Doppler Profiler (ADP) was employed to map the hydraulic environment. This device was pulled across the study site in transects, recording water velocities and standard deviations, from which a number of parameters such as turbulence intensity, strain and shear can be calculated.

This data will be integrated to individual fish trajectories looking for possible relationships between active selection or avoidance behaviour, and specific hydraulic conditions. It is hoped that this work will aid the development of widely applicable, rule-based criteria, for the survival and migration of eels past a wide range of structural impediments.

This year has been a steep learning curve with all the challenges of learning a new technology, in combination with the inevitable uncertainties of fieldwork. High resolution acoustic telemetry is not exactly cheap, and requires a significant time investment in deployment, testing and data processing. However, I think acoustic positioning telemetry has huge potential in the UK, and is currently one of the most appropriate methods for field-based fine resolution behavioural studies over relatively large areas.

I hope to be able to carry out similar behavioural studies next autumn with the benefit of this year's data to inform my direction.