Environment Agency

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Development of a fish counting system for fish passes

Science Report – SC050022/SR1

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Our work includes tackling flooding and pollution incidents, reducing industry's impacts on the environment, cleaning up rivers, coastal waters and contaminated land, and improving wildlife habitats.

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- **Delivering information, advice, tools and techniques**, by making appropriate products available to our policy and operations staff.

Steve Killeen

Head of Science

Executive summary

This report outlines a new method to monitor and count fish as they travel through a fish pass or channel. The method will be useful to owners and managers of fish passes, who must provide evidence that a pass is working effectively to be granted regulatory approval. To date, this has proved an expensive and technically challenging task. The Environment Agency issues approvals for fish passes under the Environment Act 1995, via a Fish Pass Panel through which all applications for new builds, alterations of existing passes and final approvals are dealt with. This report describes a simple and cost-effective monitoring method to gather data for the approval process, along with the equipment necessary to carry out such monitoring.

After developing the monitoring method, this project assessed its performance across a range of applications and drew up an instruction manual for its operation, *Using video images for fisheries monitoring*. Five sites representing a broad range of fish pass types were selected for trials. Camera, lighting and image recording equipment were deployed at each site, to identify the optimum combination and arrangement to produce the best fish images. The resulting video output was used to develop and evaluate three computer-based image analysis systems for detecting fish from video images. Two of these significantly out performed the third in terms of detection rate for fish and time taken for an analyst to obtain a fish count. One of these, Fishtick, is a commercially available motion detection system, where the analyst is presented with a stream of video clips which can be tagged individually to data. The other, DVMD, based on commercially available hardware used in the security industry, tracks targets and automatically counts objects as they pass through a camera field. These two different approaches were developed for counting fish at the trial sites.

Using Fishtick, 24 hours of data could be reviewed and analysed in 15 minutes with a detection rate of 90 per cent. The more automated approach of DVMD required an analyst to verify the automatic output. Though this had similar detection rates to Fishtick, the time taken to obtain a count could be four times as long. However, in applications with very few false counts, the time to produce a count of fish may be quicker than Fishtick.

The project generated the following results:

- A fish counting system costing less than £5,000 suitable for fish passes and narrow channels, along with an assessment of its performance.
- A guidance manual for using underwater cameras, lighting and image analysis techniques to monitor fish.
- Standard designs for the fish exit of a fish pass for the routine deployment of video monitoring equipment.
- An automated motion detection system for fish, developed to meet Environment Agency requirements.
- An automated image analysis system for counting fish based on an interface with commercially available hardware.
- Material for a workshop titled *Using video images for fisheries monitoring*.
- A statistical model for improving the accuracy and precision of fish counts using an automated motion detection or image analysis system.

The fish counting method outlined in this report is relatively cheap to build, install and maintain and has demonstrated its ability to produce reliable results with modest use of staff time. As a consequence, facilities for video monitoring are being installed on the River Mersey to monitor the return of salmon to the river, to help decide whether to

open up more of the river to salmon. Louds Mill weir on the River Frome is being refurbished to incorporate a video monitoring system, to assess the effectiveness of a gauging weir at passing fish. New fish passes on the River Yealm in Plymouth and River Ely in Cardiff are being installed with video fish counting systems. Video fish counters are being used on existing resistivity counters on the rivers Tamar and Fowey to assist in routine validation. The Department of Transport for the Isle of Man is installing a Fishtick system at a tidal barrage in Peel harbour.

Acknowledgements

The Project owes a big “thank you” to Jim Gregory, Emma Washburn and Peter Clabburn of Environment Agency Wales (EAW). The latter pair spent a year each on assignment, devising ingenious ways to combine lighting and camera arrays, deploying equipment and talking already overworked colleagues into helping out and analysing results. Thanks also goes to the Fisheries Assessment Team of EAW for the loan of their equipment and experience and to three of the aforementioned overworked colleagues, Adrian Fewings, Paul Elsmere and Mick Donkin of Environment Agency. The project also received the help and support of Pembrokeshire Anglers Association, Salmonsoft Inc., Radiant Inc., and Perceptive Solutions Ltd. We have tried to distil from all the above sources as much of the collective expertise as possible and reproduce it in this manual.

Contents

List of tables and figures

1 Introduction

Man-made modifications to river channels proliferated during and after the industrial revolution, with many obstructions resulting in localised extirpation of salmonid populations. There remains a legacy of inappropriate in-river constructions and Environment Agency Salmon Action Plans (SAPs) have identified approximately 2,000 man-made barriers to salmon and sea trout migration in England and Wales. To date, around 350 of these have a fish pass on them to aid migration, with many new passes currently in the planning or construction phase as a result of new funding opportunities such as EU Convergence Structural Funds.

We are involved in a programme of prioritising the construction of passes, with approximately 10 technical passes per year being built in England and Wales. There is little or no direct monitoring of these passes, which could help assess and/or improve fish pass design.

Fish counters are a vital tool in assessing fish stocks, but restrictions in the design and function of such devices prevents cost-effective monitoring at fish passes and artificial channels. Fish passes are designed to pass a regular and laminar flow of water down through a series of baffles or pools, to enable fish to cross obstructions. Current monitoring entails deploying equipment in the fish pass channel or severely modifying the channel or both. This can reduce the water flowing through the pass and can impede its function as a fish pass.

There is a real and present need nationally for a cost-effective counting system for salmon and sea trout that does not impede the through flow of water and is unobtrusive to fish movement.

Moreover, the present high costs of purchasing equipment, modifying channels, and deploying and operating counters frequently means that:

- New fish passes are being built with no method of monitoring their degree of success, in terms of how many fish use it. This is to the detriment of future fish pass designs and the operating regime of the individual fish pass.
- There is often no suitable inexpensive method for counting fish in existing fish passes.

Monitoring fish passes would normally involve short-term deployments to establish pass effectiveness for the range of flows expected. However, the location of many fish passes (in lower reaches) makes them ideal for longer term counting sites for national monitoring. Such systems would also help validate conventional fish counters already built into passes.

This project set out to address these issues and can be summarised in the following statement:

To research and use current lighting, camera and image analysis technology for a fish counting system fit for a range of fish passes and operational over a range of environmental conditions that is unobtrusive to fish and does not impede the design specifications and function of the pass, with lower purchase and operating costs than existing (inappropriate) counting methods.

2 Aims

Six objectives were identified for the project, as described below.

Objective 1: Identify and prepare five fish pass test sites
Examine range of flows, expected fish runs and types and details of fish passes to compile a shortlist of candidate deployment sites. Consider logistics of deployment at each and select five that represent a range of potential counting conditions.

Objective 2: Develop and trial unobtrusive camera array
Research latest low light level CCD camera technology, sensitive to 750-800 nm wavelengths. Design a multi-camera array using this technology that can be unobtrusively installed within the ubiquitous fish pass stop log notch. The image analysis system developed by the Environment Agency for the Cardiff Bay barrage fish pass is based on an earlier generation of camera systems and its configuration is unlikely to be suitable for other fish passes.

Objective 3: Develop and trial lighting arrangement
Research lighting systems currently used for underwater imaging in both fisheries and non-fisheries applications. Examine lighting arrangements currently used by the Environment Agency around the country for (manual) video validation of resistivity fish counters. These arrangements include light boxes, LED boards and lamps, both under and above water. Based on these findings, design and build a lighting arrangement best suited to obtaining images for capture and analysis that meets the deployment criteria outlined in Objective 1.

Objective 4: Deploy products of Objectives 2, 3 and 4 on test sites
Deployment of a camera, lighting and image capture/analysis system. During the course of the two-year project, the system will be deployed at four sites. Elevated flows with high debris and suspended solid loads are likely to provide the most challenging images for software development. An objective of deployment is therefore to collect data during these conditions at each site. At this stage it is not clear whether in achieving the objectives stated above, just one candidate system design will emerge for assessment or more than one. The project will actively seek to make other organisations and interested parties aware of the work and arrange for site visits and open days to explain the project and its likely outcomes.

Objective 5: Research and identify a software development platform
The image analysis software produced under R&D Project W2-037, a MAFF/Environment Agency collaboration, and that subsequently developed by the Environment Agency for the Cardiff Bay barrage, was done so with a much wider application in mind. This should therefore provide a suitable starting platform on which to develop fish counting software for fish passes. However, this assumption will be tested by researching current image analysis software and hardware developments to explore whether alternative, more effective solutions could be trialled. Research will be carried out on image tracking algorithms from other applications and their suitability for this project examined; if appropriate, the algorithms will be adapted.

Objective 6: Develop software for event detection and analysis based on images collected
Two areas will require substantial development: event detection and event analysis. Event detection capabilities will be developed to reduce the number of non-fish events detected and optimise the image collected for analysis. Development of the automatic event analysis component will focus on automated tracking of each event through the

camera array field-of-view, calculating the speed and direction of travel for each event together with absolute size. Development will be carried out in-house during the first two years. A contracted system developer will produce the user interface in the second year.

2.1 Project outcomes

- A fish counting system costing less than £5,000 suitable for fish passes and narrow channels, and an assessment of its performance.
- A guidance manual for using underwater cameras, lighting and image analysis techniques to monitor fish.
- Standard designs for the fish exit of a fish pass for the routine deployment of video monitoring equipment.
- An automated motion detection system for fish, developed to meet Environment Agency requirements.
- An automated image analysis system for counting fish based on an interface with commercially available hardware.
- Material for a workshop titled *Using video images for fisheries monitoring*.
- A statistical model for improving the accuracy and precision of fish counts using an automated motion detection or image analysis system.

2.2 Benefits

Measuring the effectiveness of fish passes

The Environment Agency has a statutory duty to issue final approval for all fish passes in England and Wales. To do this, the Environment Agency must be assured that “the pass is functioning to its satisfaction”. This report offers a tool to assess fish passes prior to approval by the National Fish Pass Panel.

Obtaining a returning stock estimate for salmon

The system outlined here could be used as a primary fish counting tool to estimate returning stock in situations and rivers where alternative methods would be too costly or impractical.

Validating conventional fish counters

The Environment Agency has 26 fish counters that use video to sub-sample and validate the counter data collected. This is time-consuming and resource-intensive. The tool developed here offers a more efficient process and increases the precision and accuracy of existing counters.

3 Progress against objectives

3.1 Objective 1: Identify and prepare five fish pass test sites

Seven trial sites were selected during the first year of the project (Table 3.1), encompassing a range of fish pass types and dimensions. This exceeded the number of sites set out in the objective. A number of extra passes were examined as potential trial sites during Year 2 of the project; however, as the majority of these sites would have required considerable amounts of time and resources from the project, it was decided to concentrate on fulfilling the remaining objectives. For full details of the work carried out in Year 1 of the project, please refer to Science Project Annual Report: SF0247/ASR.

Recording and lighting equipment supplied by the project was deployed on a second site at Gunnislake on the River Tamar by staff from South West region, but weather conditions deteriorated before the equipment was fully installed and therefore no data were collected.

Video data were collected from a resistivity counter site at Manley Hall on the River Dee, North Wales during the second year of the project. Equipment was installed here with the main aim of validating the existing counter, but the data collected provided a further source of assessment data for the image analysis and review software, therefore it was included in the list of trial sites.

Table 3.1: Details and locations of the trial sites

Fish pass type	*Site*	*River*	*EA Region*
Baffle	Warkworth	Coquet	North East
Denil	Cardiff Bay	Taff	Wales
Denil	Cardiff Bay Auxillary	Taff	Wales
Larinier	Hampton Court	Lugg	Wales
Larinier	Town Weir	Cleddau	Wales
Crump weir	Nursling	Test	Southern
Crump weir	Gunnislake	Tamar	South West
Crump weir	Manley Hall	Dee	Wales

3.2 Objectives 2 and 3: Develop and trial camera arrays, lighting and recording media

3.2.1 Lighting

During Year 1 of the project, diffused LED light panels were designed and a prototype was built in-house before being deployed on Cardiff Bay auxillary fish pass. It was, however, recognised that it would not be practicable for all users to produce their own light panels, so discussions were instigated with potential manufacturers. These discussions were extended during Year 2 to include a design for a frame to hold the light panels and cables in place. Two prototype light panels and a frame (Figure 3.1) were produced by a commercial manufacturer and were assessed in fish hatchery tanks.

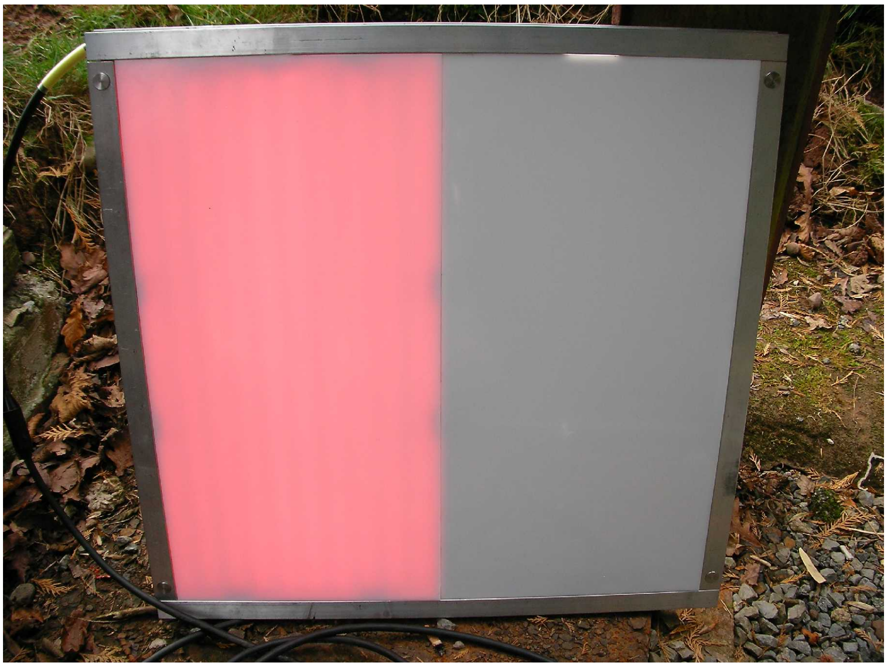

Figure 3.1: Two prototype light panels. The left hand panel is powered up.

Figure 3.2: Example data collected during light panel trials at Cynrig Hatchery

Infrared illuminators and lamps were tested during Year 1 and deployed on sites to either illuminate the target from above or to provide background illumination. The latter was achieved by bouncing the light off a white polypropylene sheet positioned in the camera field of view. The drawback with these lamps is that they have to be positioned out of the water and shone through the water surface, as they are not submersible. A prototype of an IP68 rated (fully submersible) infrared LED illuminator, developed by British company Pro-Optocam, was acquired and was also tested at fish hatchery tanks (Figure 3.3).

Figure 3.3: Example data collected using infrared illuminator in trials at Cynrig Hatchery

3.2.2 Recording media

Reconfigured desktop PCs fitted with four channel digital video recorder (DVR) cards were used during both years at sites where mains power was available. The output file codec is MPEG4, a format that is compatible with most media players. The DVR card requires an additional graphics card and will work with Windows 2000 or XP machines. The rebuilt machines from CIS are relatively low specification.

A 12-volt low-power digital video recorder (X200) produced by Timespace Technology was deployed at Hampton Court on the River Lugg. Besides the low power requirements of these DVRs (an X200 DVR and a camera will draw around 0.7 amps), the other advantages were a removable hard drive and a handheld reviewer which could be plugged into the DVR without the need for an extra power source. Unfortunately, the DVR encrypted the recorded files so that they could only be played back through a particular piece of software provided by the manufacturer. It was possible to decrypt the files into ***avi*** format using the software, but this was time-consuming. The encryption meant that the files collected could not easily be played back through motion detection and image analysis software packages.

Other 12-volt solutions were sought and small form factor PCs were identified as an alternative solution. Mini-ITX processor systems were found to offer the best all-round option. Drawing nearly two amps of current, they were a quarter of the price of low-power DVRs and allowed data to be stored in a standard format. A custom-made machine was acquired from Industrial Computer Products.

The boards in these types of PC are assembled and powered differently to standard computers and, because of this, the systems can operate on a 12-volt power supply and consume less than 25 watts when working under load. The boards are stacked on top of each other, enabling the whole system to be enclosed in a case roughly 210 x 190 mm. The system uses Windows and is compatible with a range of graphics cards, so can produce MPEG4 codec files.

3.2.3 Power supplies

Equipment that can run on a 12-volt supply was preferentially selected; the options for providing power from solar, mini-hydro power and a methanol fuel cell are detailed in the manual.

3.2.4 Fish pass design

Discussions with members of the National Fish Pass Panel led to the derivation of standard designs for the exit of fish passes and these are described in the accompanying manual.

3.2.5 Video workshop

Material for a workshop entitled *Using video images for fisheries monitoring* was compiled for this project. The primary aims of the workshop were to share ideas, technologies and best practice, ensuring that new technology and information on video monitoring would be shared with practitioners.

The workshop was divided into three sessions and the delegates assigned to small groups. The first session, ‘Gathering images of fish for monitoring’, was a discussion and ideas-sharing session covering lighting, recording equipment and cameras. Following this, each group was provided with plans for proposed fish pass sites and asked how they would design a video monitoring system and what changes they would make to the fish pass design to accommodate this system. The final session, ‘Tools and techniques – processing, reviewing, storing and applying results’ was an informal demonstration of some of the computer programmes and hardware used to analyse and store the data collected.

A CD of workshop materials and proceedings from the workshops is available from this project.

3.3 Objective 4: Deploy products of Objectives 2, 3 and 4 on test sites

A range of equipment was deployed on the selected test sites and various configurations of lighting and cameras were used (Table 3.2). Details of sites and equipment installed during Year 1 can be found in Environment Agency Science Project Annual Report: SF0247/ASR. Further information is provided below where work was carried out during Year 2.

Table 3.2: Lighting and camera configurations used on the eight trial sites

Lighting		***Cameras***		***Site***
Orientation	*Type*	*Orientation*	*Type*	
Overhead	Fluorescent tube	Downward	In air	Nursling, River Test
Overhead	Infrared illuminator	Downward	In air	Gunnislake, River Tamar
Overhead	Floodlight	Downward	In air	Manley Hall, River Dee
Overhead reflected	Infrared illuminator	Upward	Underwater	Hampton Court, River Lugg
On bottom	Red fluorescent tube lightbox	Downward	In air	Cardiff Bay
Sideways	Red LED lightbox	Sideways opposite	Underwater	Cardiff Bay Auxiliary Pass
On bottom	Red LED lightbox	Sideways	Underwater	Haverfordwest, River Cleddau
NONE	NONE	Sideways	Underwater	Warkworth, River Coquet

3.3.1 Town Weir, River Cleddau

A single underwater camera and cables were installed at the top end (exit) of the fish pass in 2005 (Figure 3.4) and data recorded during daylight hours via a digital video recorder (DVR) card within a PC onto an external hard drive.

Figure 3.4: Installing equipment at Haverfordwest Town Weir fish pass

In May 2006, this was supplemented by a light panel, emitting a low level deep red and measuring 1,500 mm by 600 mm, which was fitted to the bed of the fish pass and the camera aimed horizontally across it to the far side of the pass. This enabled 24-hour monitoring of the site. Some examples of the images collected are shown in Figure 3.6.

Figure 3.5: Fish pass exit showing light panel and scaffold to which camera was attached

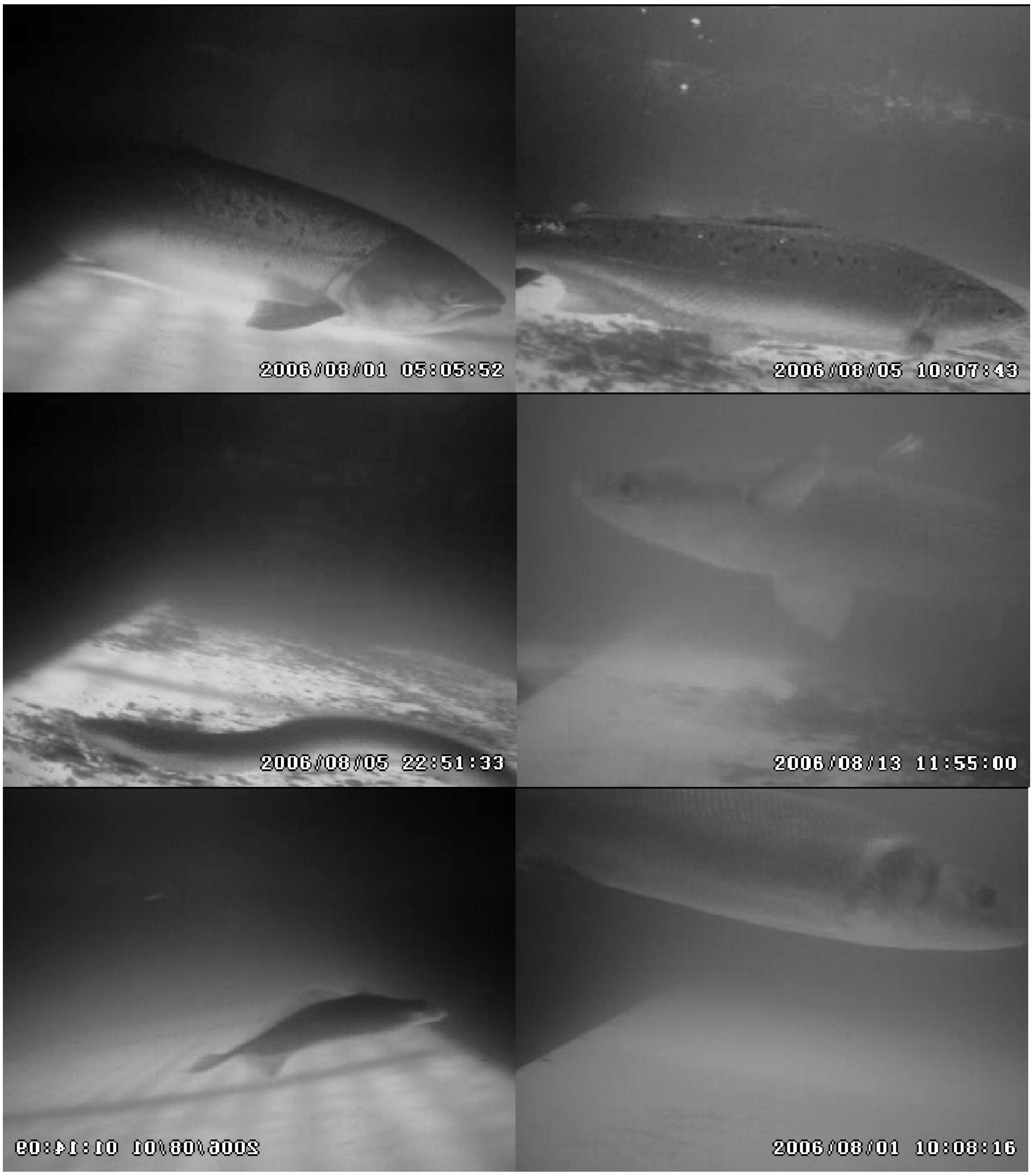

Figure 3.6: Example still images from video data collected at Haverfordwest Town Weir

3.3.2 Manley Hall, River Dee

A camera and floodlight were deployed on a scaffolding tower looking down onto a section of the weir face (Figures 3.7 and 3.8), with data collected onto an external hard drive via a DVR card in a reconfigured PC. The primary aim of the deployment was to validate the existing resistivity counter.

Figure 3.7: Manley Hall resistivity counter site showing the camera and lighting gantry

Figure 3.8: Example image collected at Manley Hall using the camera and lighting gantry

3.3.3 Hampton Court, River Lugg

An X200 DVR was deployed at Hampton Court on the River Lugg (Figure 3.9). An upwards-looking underwater camera was mounted beneath the fish pass exit and infrared light reflected off a white board positioned out of the water above the camera (Figure 3.10). Data were collected from this site during the first year of the project using an analogue video recorder, but the quality of these images was relatively poor compared to those obtained from the X200. The DVR was reliable and drew very little power; however, processing the data was time-consuming as the files had to be decrypted. Unfortunately, few fish were observed during the period of deployment.

Figure 3.9: Larinier fish pass at Hampton Court on the River Lugg

Figure 3.10: Infrared light reflected off white polypropylene sheet above fish pass exit

3.4 Objective 5: Research and identify a software development platform

3.4.1 Initial software assessment

Three image capture and analysis platforms were identified at the outset of the project. Two of these can be categorised as image analysis systems where the resultant output for each event detected is a line of data. The third is a motion detection system where the output is a video clip of each event, which is then viewed and interpreted by an operator. All three systems have various levels of user-configurable parameters to define an event and trigger the detection of an image or motion.

3.4.2 Image analysis systems

Fish Analysis3: An in-house Environment Agency programme developed specifically to monitor fish in the controlled environment of the Cardiff Bay barrage.

Video Motion Detector (DVMD): Based on a commercially available security system produced by US company Radiant to detect and track intruders, but had been used to detect smolts in a Norwegian river.

3.4.3 Motion detection system

Fishtick: Developed by two fisheries enthusiasts to provide a video alternative to manned tower counts or counting windows in fish passes prevalent in North America, and sold through a company the two ex-Microsoft employees have called Salmonsoft.

Table 3.3: Summary of the functionality of each software platform

Criteria		Fishtick	DVMD	Fish Analysis3
Suitable for on-site data processing of a live video feed		Y	Y	N
Suitable for processing avi clips	*Short term (e.g. for calibration)*	Y	Y	Y
	Long term (e.g. for data collection)	Y	N	N
Adjustable motion detection parameters		Y	Y	Y
Adjustable target tracking parameters		N	Y	Y
Manual counting		Y	Y	Y
Automatic counting		N	N	N
Suitable for use with multiple cameras		Y	N	N
Date/time event summary		Y	N	Y
Fish sizing		N	N	N
Swimming speed summary		N	N	N
Manual species definition		Y	N	Y

All three systems were in need of software development to adapt them to the aims of this project. To assess which platform had the most potential, a series of trials were conducted.

3.4.4 Software trials

A set of reference data was created from some of the trial sites by selecting a time period, visually inspecting every frame and recording the time and description of every fish event. This reference dataset for each site was used to assess all three systems. The results were partially reported in the Year 1 annual report but are also included here, as Fish Analysis3 was assessed after the report was completed. When Fish Analysis3 was included in the assessment, the reference dataset was altered slightly to enable a fair assessment of performance. This made a small difference to the Fishtick/DVMD results reported in the Year 1 annual report and hence leads to an unavoidable discrepancy between these two reports.

The assessment process was carried out as follows:

- Reference dataset was obtained from a visual inspection of collected avi files.
- Subset of data was played through each system and the parameters optimised.
- Full dataset was processed using each system's optimised parameters.
- Results were reviewed and the number of events tracked or detected that corresponded to fish in the reference data were recorded to give detection efficiency.
- The number of tracked or detected events that did not correspond to fish in the reference data were recorded to give a false detection rate (false positives).
- The time taken to obtain a verified count of fish from the output of each system was recorded to obtain a comparison of usability.

3.4.5 Reference dataset

The initial software assessment was carried out using data from two sites, one with a camera in air looking down at a weir face and the other with an underwater camera looking sideways across a concrete channel at the top of a fish pass. The datasets are summarised in Table 3.4.

Table 3.4: Standard dataset from two trial sites used to assess image capture and analysis systems

Site name	*Configuration*		*Hours of data*	*Number of targets included in assessment*	
	Camera	*Lighting*		*DVMD*	*Fishtick and Fish Analysis3*
Nursling	Downward	None	6	54	33
Warkworth	Underwater Sideways	None	5	61	66

Differences between the way the three systems restricted the number of fish events were compared. DVMD could show clearly what it had tracked, but the other two could not. So it was only valid to compare fish events where nothing else was in the frame, such as weed, that could have mistakenly triggered the system.

The results are displayed graphically in the interim report and summarised in Tables 3.5 and 3.6. The DVMD system would need development to make provision for a review procedure and therefore the time taken to analyse data for the DVMD system was not comparable in this trial.

Table 3.5: Results of assessment of three software options for processing data collected using a sideways-looking underwater camera (Warkworth)

Measure	*Fishtick*	*DVMD*	*FishAnalysis3*
Mean efficiency	75%	73%	46%
Number of false detection	2	73	7
Time taken to analyse one hour of real time data (minutes)	6	n/a	14

Table 3.6: Results of assessment of three software options for processing data collected using a camera in air looking down at a Weir face (Nursling)

Measure	*Fishtick*	*DVMD*	*FishAnalysis3*
Mean efficiency	91%	89%	74%
Number of false detection	1,147	238	55
Time taken to analyse one hour of data (minutes)	15	n/a	29

3.4.6 Trial conclusions

DVMD and Fishtick efficiencies were found to be similar, while the efficiency of Fish Analysis3 was lower. Fishtick and DVMD produced a high number of false detections for the downward-looking camera orientation, but very few for a sideways underwater set-up. Fish Analysis produced few false detections for either orientation. Despite the high number of false targets detected by Fishtick, it took less than half the time for an operator to verify the data and produce a count. Fish Analysis3 was not capable of running on site in real time as Fishtick and DVMD were. With this factored in, Fish Analysis3 would take four times as long to verify collected data into a count.

The low false detection rate for Fish Analysis3 and relatively low efficiencies indicated that the parameters could be widened to capture more fish targets at the expense of an increase in false detection rate. However, the user-changeable parameters were limited and a small change in one would lead to a huge increase in false detection.

Based on these results, it was concluded that Fish Analysis3 would require the greatest amount of development work, but there were sufficient doubts over its performance to decide not to spend further time and money on it. Development therefore focussed on the motion detection system, Fishtick, and the image analysis system, DVMD. This decision was taken in consultation with the Project Board.

3.5 Objective 6: Develop software for event detection and analysis based on images collected

3.5.1 Assessment of Fishtick and DVMD, post-software developments

The Fishtick developments were carried out by Salmonsoft. The development of a review interface for DVMD was put to tender and awarded to Perceptive Solutions in Guildford. The reference dataset used for this second round of assessment came from the River Cleddau at Townweir and was gathered from the top of a 1.8-metre wide Larinier fish pass with a light panel fitted to the bed and a sideways-looking camera.

Five days of continuous data collection provided a total of 547 fish targets for a range of species.

Table 3.7: Standard dataset from Haverfordwest Town Weir fish pass for further assessment of Fishtick and DVMD

Date	*Individual fish*	*Fish in shoals*	*Total number of fish*	*Average daily flow (ADF)*
02/08/06	33	2	35	1.71
04/08/06	6	6	12	1.62
06/08/06	19	23	42	1.61
08/08/06	57	266	323	1.53
10/08/06	38	97	135	1.49
Total	**153**	**394**	**547**	

Table 3.8: Fishtick results

Date	*Individual fish*		*Shoaling fish*		*Total fish*		*Efficiency (%)*
	Actual	**Detected**	**Actual**	**Detected**	**Actual**	**Detected**	
02/08/06	33	31	2	2	35	33	94
04/08/06	6	3	6	6	12	9	75
06/08/06	19	19	23	23	42	42	100
08/08/06	57	50	266	260	323	310	96
10/08/06	38	30	97	89	135	119	88
Total	**153**	**133**	**394**	**380**	**547**	**513**	**94**

The bulk of the Fishtick development work was to adapt and refine the image capture component of the software. This in turn improved the review performance. For an operator to review and analyse the output from the Fishtick fish capture programme and verify a count of fish by species took approximately 15 minutes per 24 hours of data collected. Extrapolated for a whole year, this indicates that a verified fish count could be obtained from 13 days of staff time, a shorter time period than even the best operated resistivity counter.

Table 3.9: DVMD results

Date	*Individual fish*		*Shoaling fish*		*Total fish*		*Efficiency (%)*
	Actual	**Tracked**	**Actual**	**Tracked**	**Actual**	**Tracked**	
02/08/06	33	28	2	2	35	30	86
04/08/06	6	4	6	3	12	7	58
06/08/06	19	16	23	12	42	28	67
08/08/06	57	42	266	103	323	145	45
10/08/06	38	25	97	34	135	59	44
Total	**153**	**115**	**394**	**154**	**547**	**269**	**49**

Twenty-four hours worth of data took approximately one hour to verify and review to produce a count using the DVMD approach.

4 Conclusions

The performance of Fishtick was found to be satisfactory in this project. DVMD was disappointing in terms of counting efficiency and was particularly poor in detecting fish in shoals. The DVMD system has the ability to track multiple fish passing through, but struggled with multiple targets at various ranges from the camera against a relatively low contrast background.

Fishtick has demonstrated the flexibility to be used on site in real time or offline to process data later in the office. The parameters are intuitive and easy to set up. The software can be used with up to four cameras and when used offline, the processing speed can be 10 times faster than the frame rate at which data was collected.

In its current form, the DVMD system is optimised for processing at 25 frames a second and this makes it less suitable for using offline. The parameters are more difficult to optimise and the inter dependency of them more complex than Fishtick. It took longer than Fishtick to set up for our reference dataset, despite the fact that parameters for a similar site had already been established. For the software to process data from four cameras, four systems would be required, although the cost of each would be about a third to a quarter of the cost of Fishtick. However, in applications where the target events are viewed in high contrast and at a similar range such as a weir face, DVMD may offer advantages over Fishtick.

In terms of future work, implementation of the video monitoring system on the River Mersey, Frome, Cleddeau and Yealm is ongoing for 2007. Turbidity measurements will be taken to establish the limits of system operation.

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