Environment Agency

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Using video images for fisheries monitoring

A manual for using underwater cameras, lighting and image analysis

Science report SC050022/SR2

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- **Funding science**, by supporting programmes, projects and people in response to long-term strategic needs, medium-term policy priorities and shorter-term operational requirements;
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- **Carrying out science**, by undertaking research – either by contracting it out to research organisations and consultancies or by doing it ourselves;
- **Delivering information, advice, tools and techniques**, by making appropriate products available to our policy and operations staff.

Steve Killeen

Head of Science

Acknowledgements

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1 Introduction

This manual details the equipment and methods required to record underwater video images and to use them to monitor and count fish. It outlines the combination and arrangement of camera, lighting, image recording equipment, motion detection and image analysis software for a variety of applications related to monitoring fish. The technique can be used to validate existing fish counters (resistivity, infrared, acoustic) or as a stand-alone counting system.

The specifications given for system components can be found in commercially available off-the-shelf products, or can be met by manufacturers to a design appropriate for the technique.

This work was developed under Environment Agency project, *Development of a fish counting system for fish passes*. The full range of outcomes from this project, of which this manual is one component, is listed below.

- 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.

The methods outlined here use relatively cheap components, are easy to build, install and maintain and have demonstrated their ability to produce reliable results with modest use of staff time.

1.1 Use of video images

There is no universal tool for counting migratory fish in a river and there are situations for which a reliable technique does not exist. Video can be used in cases where other methods would be inappropriate or prohibitively expensive for the required purpose, such as:

- monitoring the effectiveness of newly constructed fish passes;
- obtaining data for the approval of existing fish passes;
- studying fish behaviour;
- whole river counting for returning stock estimates.

Absolute validation, that is, an accurate record of how many fish actually passed the counter and when, is very difficult to achieve. Cameras are used to obtain such a record, but under conditions of high turbidity and flow it can be impossible to be certain that all fish are visible and so it becomes more of a comparison. Video monitoring techniques, including image analysis and motion detection, can be used for these comparisons.

Any natural or manmade channel, fish pass, bypass, or water intake that is a maximum of two metres wide and two metres deep can use video counting. Sections of weir face may also be suitable.

2 Criteria for site appraisal

This section of the manual guides you through the process of choosing equipment and deciding how to deploy and orientate it on a specific site. The section does not compare alternative counting techniques; for more information on fish counting methods, please see the Contacts Section.

The equipment required to monitor any given site and its deployment configuration will depend entirely on the dimensions and characteristics of the monitoring location (depth, width, water clarity, security, power). The four most common types of pass, Denil, Larinier, pool and traverse and vertical slot, have common attributes which make it convenient to consider them together. The width and depth can vary widely even within fish passes of the same type, therefore it is not possible to specify one video counting array for each type of pass. Here, the Denil and Larinier passes have been broken down into size categories and different systems specified.

Take the time to plan:

You may have the tools, you may have the site, but do you have the time and resources to devote to them to obtain the results which the monitoring is being set up for? Fish counter projects that fail nearly always do so because the time required to routinely operate them is not planned for, or grossly underestimated.

For further advice, see the Contacts Section.

2.1 Purpose of monitoring

First, decide what your aims and objectives are for the site, as this will determine the type of information you need to obtain from your fish counter and therefore the type of kit needed. For example, at one site you may want to deploy a counter for a few weeks simply to see if any fish are using the fish pass, whereas at another site you may want to know the size and species of fish using a pass over a number of years.

2.1.1 Species ID

Detailed images may not be necessary to identify fish species at all sites. For example, only one species may be expected to use the pass, or the species in question may differ enough in size and form to be distinguished by their silhouette alone. The best camera and lighting array for species identification is a sideways camera looking across a light panel on the bed of the fish pass. However, this configuration will not work as well as a camera looking across to a light panel on the opposite wall in more turbid conditions; thus, the best configuration will depend on the characteristics and priorities for the site.

2.1.2 Sizing

A simple method of sizing by reference point has been integrated into both the image processing techniques outlined in this report (Fishtick and DVMD). The user clicks on two points within the view a known distance apart (at approximately the same distance from the camera as the fish) in order to calibrate, before measuring the fish. A simple calculation then determines fish length from the calibration. All that is needed for this method to work are a number of markers at known distances from the camera. This method can therefore work with all of the systems described in Table 2.1. However, under certain conditions, it may not be possible to place markers or to accurately estimate the distance of the fish from the camera, for example with upward-looking cameras with no structure in the view.

2.1.3 Fish behaviour

Avoid mounting equipment in areas where fish may hold. This may mean deploying on the downslope of a Denil or Larinier pass.

2.2 Logistics

2.2.1 Mains power

Some system configurations may not lend themselves to running on battery-powered systems, even with an on-site method of keeping the batteries charged. Wide fish passes which require lots of lighting are an example. Strategic or long-term monitoring sites would also benefit from mains power; it may be more cost-effective to install mains power where equipment is likely to be deployed for a number of years.

There are plenty of options for powering a system where mains power is not available (Section 3.2). Low-power charging options are not included in the system descriptions here, as they are very site-specific. Add whatever is chosen to the total cost of the system

2.2.2 Equipment maintenance

Don't forget to factor the time needed to clean cameras, light panels and white boards into your fish counter budget. During the summer months cameras will need to be cleaned at least every two weeks. Sites where debris is likely to accumulate will need regular checking and maintenance all year round.

2.2.3 Access to equipment

Equipment maintenance should be borne in mind when planning a fish pass counter site, as you will need to be able to access equipment over a range of river flows. You are likely to lose data if you have a fish pass in the middle of a river with only wading access. As soon as the flows increase, you will be unable to safely reach the equipment to clean cameras, remove debris or repair any damage.

2.2.4 Equipment housing

At some sites, you may be lucky enough to have a gauging station hut or similar in which to store recording hardware. On other sites there may be no sheltered storage and you will have to install your own cabinet or hut (for supplier information, see Section 3.1). Bear in mind the location of the site and the likelihood of vandalism, as this will affect the material you choose and where you decide to locate the housing.

2.3 River characteristics

Rivers vary widely in flow characteristics and turbidity, which affect the quality of the images you obtain and will influence how you design the video counting system. For example, a camera looking sideways with a light panel fixed to the opposite side of the fish pass will work better in turbid conditions than a camera looking over a light panel on the bed of the pass. However, the latter system will provide you with more information in the image to help with speciation.

Other site-specific features to watch out for are whether the area acts as a debris trap for all of the flotsam coming down the river, or whether the water is very turbulent. In both cases it is advisable to find another site or, if possible, to address the problem, for example by using debris booms or by removing the cause of the turbulence.

2.4 Cost

Video monitoring systems are the cheapest tools available for counting fish in passes and channels, but systems can range in price depending on the components selected. Costs increase as the width of the pass increases, mainly due to the cost of lighting the area. Infrared lamps or illuminators are a slightly cheaper, though less even method of illuminating the counting site than light panels; however, image quality may not be as good and may not work as well with the image processing tools.

The approximate cost bands in the selection matrix (Table 2.1) do not include provision for installing a mains power supply or a method of continually charging batteries on site.

2.5 Incorporating video counting into a fish pass

2.5.1 New passes

Appendix 1 provides the design specifications for the head of a fish pass. The features detailed in this can be included at the design stage of fish pass construction and the costs, which are a mere fraction of the total build costs, budgeted for at an early stage.
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2.5.2 Retrofitting

In many cases, it will be possible to retrofit video counting to an existing fish pass. For advice, please see the Contacts Section.

2.6 Validating an existing counter

Absolute validation, that is, an accurate record of how many fish actually passed the counter and when, is very difficult to achieve. Cameras are used to obtain such a record, but under conditions of high turbidity and flow it can be impossible to be certain that all fish are visible and so it becomes more of a comparison. Video monitoring techniques, including image analysis and motion detection, can be used for such comparisons.

Existing resistivity sites have used video counting techniques for comparison and to assist in validation. Based on actual validation data from these sites, the resistivity count and the video count, a method of estimating resistivity counter efficiency has been developed and is given in Appendix 2.

2.7 Equipment selection matrix

A selection matrix is provided in Table 2.1, although this is merely a guide. Use the criteria relevant to your site and requirements on the left of the matrix to read across and find the best system. Once you have found which system you require, refer to Table 2.2 for a list of components for that particular system. You can then refer to Section 3 for detailed information about the various components including supplier, price and power supply.

Example use of selection matrix in Table 2.1

Scenario:

- You have a 900 mm wide Larinier fish pass which you want to monitor.
- There is mains power at the site.
- You want to know whether fish use the pass and what species use it.
- You have a budget of £4,000.

Selection matrix:

- In the first selection criteria box, read along the row for a Larinier pass of up to 900 mm. There are three suitable systems, Systems 1, 3 and 5, but the rest of your requirements might narrow the options down.

- The next selection criteria box refers to the power supply. All systems can be operated from a mains power supply, so this doesn't reduce the options.

- From the options in 'information required' criteria box, choose the latter option (evidence that fish use the pass) and read across – again, all three systems are suitable.

- You want to identify which species use the pass, so choose the relevant row from 'level of ID' option and read across. Out of the original three options, only Systems 1 and 5 will provide this information.

- You have £4,000 to spend so buy the best! **System 1** is more expensive because the lighting is better so you will obtain better images. This is the one you want.

Table 2.1: Selection matrix for a video fish counting system

Criteria		System							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Type of fish pass/channel	**Denil ≤ 900 mm wide**	Y	-	Y	-	Y	-	-	-
	Denil > 900 mm wide	-	Y	-	-	-	Y	-	-
	Larinier ≤ 900 mm wide	Y	-	Y	-	Y	-	-	-
	Larinier > 900-1,800 mm wide	-	Y	-	-	-	Y	-	-
	Larinier > 1,800 mm wide	-	-	-	-	-	Y	-	-
	Vertical slot	-	-	-	Y	-	-	-	-
	Pool and weir	-	-	-	-	-	-	Y	-
	Crump weir	-	-	-	-	-	-	-	Y
Power supply	**Mains only**	-	-	-	Y	-	-	-	U
	Mains or 12 volt	Y	Y	Y	-	Y	Y	Y	U
Length of system deployment (all systems suitable for short-term deployment)	**Long term**	Y	Y	Y	Y	Y	Y	Y	-
	Strategic	Y	Y	Y	Y	-	-	Y	-
Information required	**Count**	Y	Y	Y	Y	Y	U	Y	Y
	Evidence that fish use pass	Y	Y	Y	Y	Y	Y	Y	Y
Level of ID	**Salmonids/non-salmonids**	Y	Y	Y	Y	Y	Y	y	Y
	Species level	Y	Y	U	U	Y	Y	U	U
Sizing of fish possible		Y	Y	Y	U	Y	Y	U	Y
Cost of system	**< £3,000**	-	-	-	-	Y	Y	-	-
	£3,000 - £4,000	Y	-	Y	-	-	-	Y	Y
	£4,000 - £5,000	-	Y	-	-	-	-	-	-
	> £5,000	-	-	-	Y	-	-	-	-

Y = Yes
U = Under certain conditions (for more details, see comments in Table 2.2)

Table 2.2: System details

System	Comments
System 1 • Single underwater sideways camera • Light panel on bed of pass/downslope • Desktop PC with DVR card (mains version) OR • Mini-ITX PC with DVR card (12v version) • Recommended software: Fishtick	
System 2 • Two underwater sideways cameras opposite each other • Light panel on bed of pass/downslope • Desktop PC with DVR card • Recommended software: Fishtick OR • Mini-ITX PC with DVR card (12v version) • Recommended software: Fishtick	
System 3 • Single underwater sideways camera • Light panel on side of pass opposite camera • Desktop PC with DVR card (mains version) OR • Mini-ITX PC with DVR card (12v version) • Recommended software: Fishtick or DVMD	• The silhouette image obtained from this lighting and camera arrangement may not provide enough information to identify fish to species level, depending on the species found in the area.
System 4 • Multiple (up to four) sideways cameras, one stacked on same side of pass • Light panels on side of pass opposite cameras • Desktop PC with DVR card • Recommended software: Fishtick	• The silhouette image obtained from this lighting and camera arrangement may not provide enough information to identify fish to species level, depending on the species found in the area. • Sizing only feasible if you are able to position markers within the camera field of view (Section 2.1.2)
System 5 • Single underwater sideways camera • White board on bed of pass • Overhead lamp (infrared or white light) • Desktop PC with DVR card (mains version) OR • Mini-ITX PC with DVR card (12v version) • Recommended software: Fishtick	

System	Comments
System 6 • Two underwater sideways cameras opposite each other • White board on bed of pass • Overhead lamp (infrared or white light) • Desktop PC with DVR card (mains version) OR • Mini-ITX PC with DVR card (12v version) • Recommended software: Fishtick	• For very wide passes, can include an extra downward-looking camera (add £100 to the system cost). • This system can be used to obtain a count if you have full coverage of the pass exit. • The system can be used to obtain evidence that fish are using the pass if two sideways cameras are used, but you do not have full coverage.
System 7 • Up to four cameras: underwater upward-looking cameras and/or a sideways camera next to notch • Overhead, angled lamp(s) either infrared or white light • Desktop PC with DVR card (mains version) OR • Mini-ITX PC with DVR card (12v system - possible if only one lamp) • Recommended software: Fishtick	• It may be possible to identify some species from a combination of the image and size information, but it will not be possible to identify all fish. • Sizing only feasible if you are able to position markers within the camera field of view (Section 2.1.2)
System 8 • Up to four overhead cameras • Overhead infrared/white lamp(s) • Desktop PC with DVR card (mains version) OR • Mini-ITX PC with DVR card – (12v system - possible if only one lamp) • Recommended software: DVMD (for one camera) or Fishtick	• It may be possible to identify some species from a combination of the image and size information, but it will not be possible to identify all fish.

DVR = Digital video recorder
DVMD = Digital video motion detector

3 Equipment

A video fish counting system has six major components:

- HOUSING
- POWER SUPPLY
- LIGHTING
- CAMERAS
- RECORDING HARDWARE
- IMAGE PROCESSING SOFTWARE

3.1 Housing

A dry and secure housing within close proximity of the site (cable runs greater than 250 metres should be avoided if possible) will be required for the recording equipment.

For sites with no suitable equipment housing present, it will be necessary to install a dry, secure cabinet to house the recording hardware, batteries (if used) and storage media. Envico Engineering provides a range of glass reinforced polyester (GRP) cabinets in all shapes and sizes suitable for this purpose (Figure 3.1). Contact details are provided in Table . Alternatively, metal boxes may be preferable for sites that are vulnerable to vandalism (Figure 3.1).

Figure 3.1: Examples of housing. The metal box houses a bank of three batteries powering lighting and recording equipment in the green wall mounted cabinet. In the second photograph is a GRP hut installed on a concrete base.

3.2 Power supply

- MAINS POWER SUPPLY
- BATTERY BANKS
  - Stand alone
  - Solar panels
  - Fuel cells
  - Micro-hydropower turbines

3.2.1 Mains power

If mains power can be installed at the site, this is the best option. If the site is at risk of flooding, the voltage will need to be dropped to 24 or 48 volts AC. This can be done at the power take-off point (above the flood prone area) and a cable run down to the site and terminated with an IP68 rated connector.

3.2.2 Battery banks

If mains power is not possible, do not despair. Short-term, and in some cases full-time, monitoring can be achieved using banks of 'leisure batteries' of 85 amp hours (Ah) or more. These can be used as a stand-alone power source (Figure 3.2) or connected to a solar panel, micro-hydropower turbine or fuel cell for recharging, which will extend the time between battery changes.

Solar panels and wind turbines may be appropriate for some sites, but at others environmental conditions may render them unsuitable. The likelihood of vandalism or theft should always be a consideration.

At sites prone to vandalism, a methanol fuel cell can be used as this can be locked in a vandal-proof cabinet. A 30-litre fuel cell, at a cost of £1,810, is capable of providing 100 Ah of energy per day and can provide up to 2,000 Ah before requiring refuelling. Regular visits to top up the methanol will be necessary, but these will be far less frequent than for a stand-alone battery system. This may be the only method which produces enough power for a site with light panels or an infrared LED illuminator (Section 3.3).

For sites with a lower power requirement, a mini-hydropower turbine may be suitable although this was not used for this project. The turbine will only work in fast flowing streams, so will not be suitable for all sites. It can provide a maximum of eight amps continuously,

The limited power from one or more of the above will dominate the choice of equipment, with low-power options favoured over higher specification components. Basically, work out your power budget and remember to take account of power loss over long cable runs. If you have assumed the least power hungry components and need more amps than your power source can supply over an acceptable period, forget it! A summary of equipment power requirements is provided in Table 3.5.

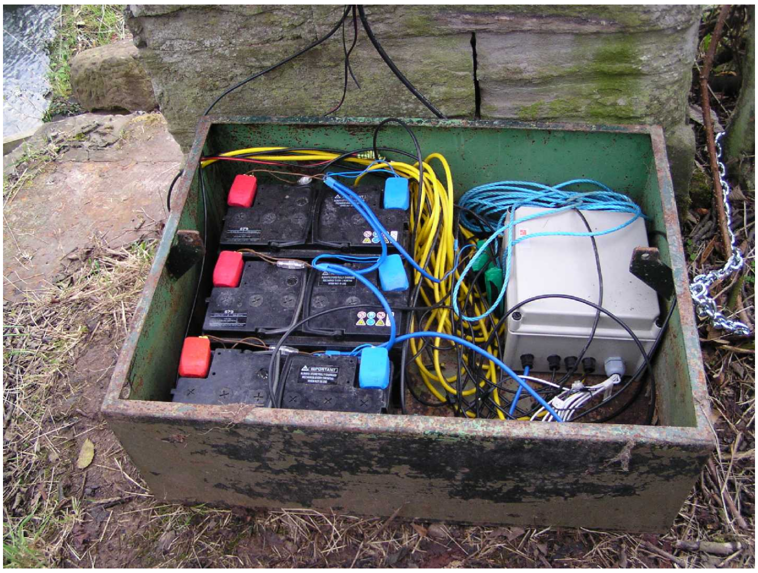

Figure 3.2: Bank of leisure batteries powering video fish counting system

3.3 Lighting

Four suggested lighting options are:

- LIGHT PANELS (LED or fluorescent tube panels)
- LED ILLUMINATORS AND LAMPS
- FLOODLIGHTS
- FLUORESCENT TUBE LIGHTING

The better the image, the more questions the data can answer (fish size, species identification). The right lighting will make all the difference to image quality, especially under turbid conditions, and will improve the performance of motion detection or analysis software.

The lighting and camera configuration will depend on the dimensions and type of pass, the information required from the counter (such as species, size), budget and the availability of mains power. For example, the best camera and lighting array for species identification is a sideways camera looking across a light panel on the bed of the fish pass. However, this configuration will not work as well in turbid conditions as a camera looking across to a light panel on the opposite wall. In all cases, it is important to ensure that the quality of the light is good, that there is sufficient light but not too much so as to cause the cameras to become over-saturated and that the lighting is unlikely to affect fish movements.

Fish sensitivity to light: References

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Munz FW and Beatty DD. 1965. A critical analysis of the visual pigments of salmon and trout. *Vision Research*, 5(1), 1-17.
Nicol JAC. 1989. *The eyes of fishes*. Clarendon Press, Oxford.
Schwanzara SA. 1967. The visual pigments of freshwater fishes. *Vision Research*, 7(3), 121-148.

3.3.1 Light panels – home-made and manufactured

LED light panels for underwater use were researched and developed in this project. The light panels consist of red LED strips mounted within a polypropylene box (Figure 3.3) and encapsulated in epoxy resin. The opaque polypropylene acts as a light diffuser resulting in an even, stable light (Figure 3.3). LED light strips were chosen because they operate from a 12 or 24-volt power supply and have relatively low power requirements (Table 3Table 3.1).

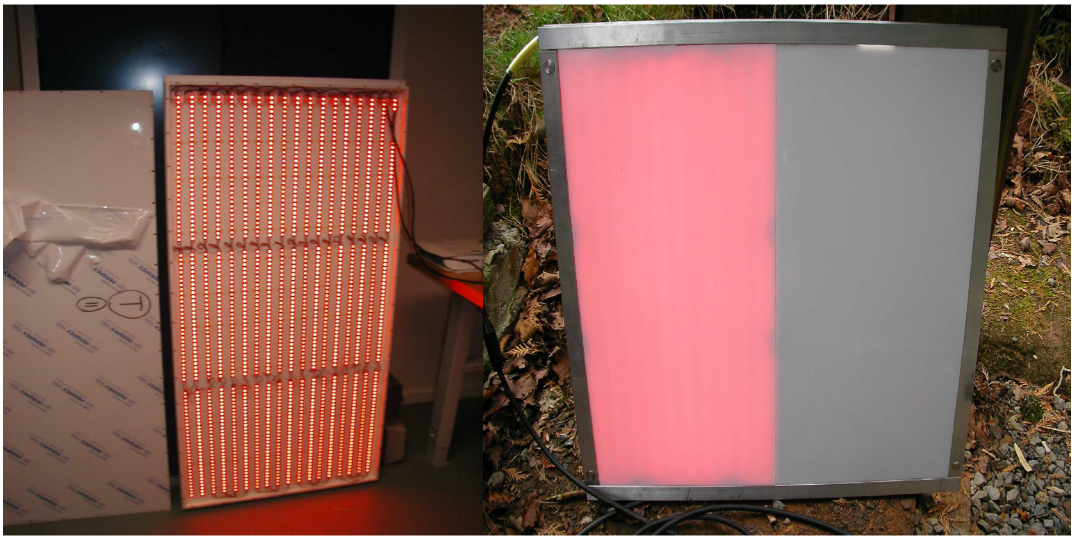

Figure 3.3: LED light panels under construction and complete

Light panels were initially manufactured in-house with the aid of Operations Delivery MEICA officers. It was, however, recognised that it would not be always be practicable for users to build their own light panels, so discussions were instigated with potential manufacturers. Two manufacturers were identified and their contact details and prices are given in Table 3.4.

Making your own light panel, however, is relatively straightforward, as shown in Appendix 9.
Light panels can be mounted either on the bed or the side of the fish pass. A specification for including light panels in a new fish pass was developed with the National Fish Pass Panel.

Deep red fluorescent tube light panels were used on Cardiff Bay fish pass. These large light panels require a mains power supply and would not be suitable for a 12-volt system. They are also expensive and require a lot of maintenance. Each tube is powered separately, entailing a large number of underwater connections, and problems were encountered with ensuring no water ingress at these connection points.

The fish sizing method incorporated into the image processing systems (Section 3.7) requires reference points within the camera field of view. These can be placed or drawn on the light panel before it is installed. It is important to measure and record the position of each marker.

3.3.2 Illuminators and LED lamps

If a light panel is not suitable or too expensive for the site, infrared lamps or illuminators are a good second choice, although the light won't be as even and the images might not work as well with image processing software. Cheap red, or infrared, underwater lighting is not an easy thing to find 'off-the-shelf'. Pro-Optocam has produced a prototype underwater 24-volt infrared LED illuminator (Figure 3.4 and Table 3.4) which was lent to this project for testing. It draws approximately two amps (Table 3.1) so would not be suitable for a stand-alone battery-powered site, but would be suitable where installation of a light box was not possible. Pointing a lamp or illuminator directly at a camera causes glare, so you need to reflect the light off a light background and point the camera at, or across, this. Alternatively, the light can be angled slightly away from the camera lens. Trial and error is usually necessary to optimise the lighting and camera configuration.

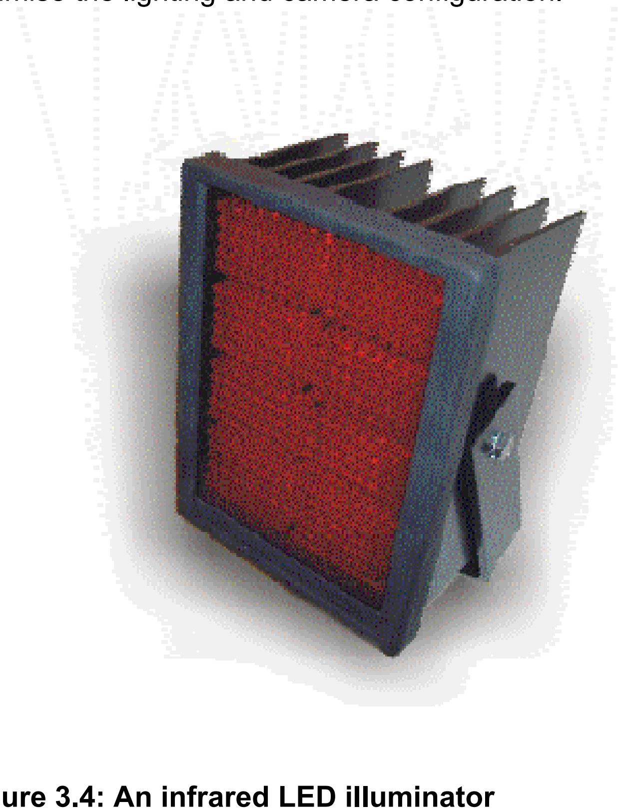

Figure 3.4: An infrared LED illuminator

For smaller sites, a less powerful LED lamp (Table 3.1) supplied by RF Concepts (Table 3.4) would provide sufficient light to enable fish counting. This lamp is waterproof but cannot be immersed. When positioning lighting, remember that a lot of light will be absorbed at the water surface and that infrared light is rapidly attenuated in water.

3.3.3 Floodlights

Security floodlights can be deployed in air to illuminate the area. Red filters can be attached to reduce any potential impact on fish movements. Floodlights will not be suitable for a stand-alone battery-powered site, due to the high power requirements.

3.3.4 Fluorescent tube lighting

Fluorescent tubes are used for overhead lighting above some resistivity weirs where suitable covering or housing exists. This is generally restricted to the non-spate rivers like the Test and Itchen, but is effective in providing good quality images for analysis and motion detection.

An underwater light box using fluorescent tubes as its light source was fitted to the bottom of a fish pass on the Cardiff Bay Barrage. The subsequent poor reliability, high maintenance and overall cost of this deployment, together with the recent technological advances of LED lighting, means that this method is not a viable option.

Figure 3.5: A covered resistively weir lit by fluorescent tubes, River Test

Table 3.1: Summary specification of the lighting equipment

	LED strip (449 mm)	*Infrared illuminator*	*Infrared LED lamp*
Voltage	12	24	12
Power requirement	260 mA per strip	2 amps	490 mA
Wavelength (nm)	625	850	850
Size (mm)	449 mm long	125 x 175 x 100	70 (D) x 90 (L)
Cost (£)	7	600	90

3.3.5 Suspended sediment

Suspended sediment attenuates light and reduces the visual range in a body of water. A measurement of the optical attributes of suspended matter (Nephelometric Turbidity Units or NTUs of a turbidity meter) is more useful than its mass concentration. But turbidity is only a relative measure of scattering set against an arbitrary standard. To assess the impact this will have on a visual fish counting system, a measurement of visual clarity (measured as Secchi or black disc visibility) is more useful. This will vary between sites and types of suspended sediment, making a table of turbidity measurements versus light penetration potentially misleading.

Visual clarity measurements are relatively non-subjective. It is recommended that a library of images gathered by each visual system is collated over a range of environmental conditions, together with the Secchi or black disc reading.

3.3.6 Algaecide and cleaning

Algae will build up on cameras and lighting placed in a river, reducing the effectiveness of the system. The rate at which this builds will depend on light levels, water velocity and site-specific conditions. If you know of a non-environmentally damaging algaecide that is transparent and can be sprayed or painted on the surface of equipment, please pass it on to the contacts listed in the Contacts Section.

Meanwhile, your camera lens and lighting source will need regular brushing to clean it (once every two to four weeks in the summer months).

3.4 Cameras

The type of underwater camera you go for will depend on your budget and the site. If you have a site where equipment is likely to be damaged by debris or vandals, it is best to go for cheap (£100) small underwater cameras (Figure 3.6) which can be easily replaced if the worst happens. When choosing a camera, make sure that the cable length is sufficient to reach your recording equipment. Cable extensions can be added but any cable joins will need to be kept out of the water. Some underwater cameras have integral LED lights which are supposed to be useful in low light conditions, but in reality the lights reflect off debris in the water close to the lens and aren't helpful. Try and avoid these. All of these cameras operate from a 12-volt supply and are fairly robust.

Most of the fish images in this manual have been gathered using cheap underwater cameras. For information on higher specification cameras, see the Contacts Section.

Figure 3.6: A low-budget underwater bullet camera with 30 m of cable

3.5 Recording hardware

- MAINS-POWERED RECORDING HARDWARE (PC + DVR card)
- 12-VOLT RECORDING HARDWARE
  - Low-power digital video recorders
  - Low-power computers

3.5.1 Mains-powered recording hardware

The best option for recording data is a computer-based recording system consisting of a digital video recorder (DVR) card installed in a PC. The files can be recorded onto an external or removable hard drive so that the data are portable and easy to take back to the office for analysis or transfer to another machine if necessary. Following analysis, the data can be copied in entirety onto an archive drive, short sections of the movie file can be selected and stored or if there is no reason to store the information, the data can be wiped off the hard drive.

A basic computer-based digital video system consists of a desktop PC with a DVR card, such as the SuperDVR card produced by Voltek (Table 3.4), installed. The DVR card may require a certain PC specification including a particular standard of graphics card or the equivalent onboard graphics facilities, so be sure to check what is required before you buy. These cards will record files in MPEG4 format, which is a widely used digital video standard, so that the data are compatible with image processing software. The DVR cards are supplied with easy-to-use software with which to program the required settings. The user can change the frame rate at which the file is recorded, set up a recording schedule, change the resolution and alter other settings as required.

A system such as this can be used to record video files which can then be bought back to the office and either watched (applicable for video validation of other counters) or played back through image capture and review software such as Fishtick (Section 3.7). A less labour-intensive method of collecting data involves installing image capture software on site and bringing data back for review only.

Standardised format: Is it compatible?

Digital recorders are reasonably cheap and some may be attractive low-power options. But beware of compatibility problems. Many will store data in a proprietary format that has to be converted to a standard format to be shared or analysed with software. For this reason, we have favoured standard PCs with digital video cards for collecting video files and sourced a suitable low-power PC.

The image processing and analysis packages described in Section 3.7 determine the specification of the computer.

3.5.2 Twelve-volt recording options

If it is not possible to access mains power at a site or for simple exploratory work, there are recording systems which will operate on a 12-volt power supply. What you choose will depend on your budget, the amount of data you wish to collect and how you plan to use it.

Low-power digital video recorders

Buyer beware: Many commercial digital video recorders store data in a proprietary data format. Image analysis or motion detection tools designed for data in a standard MPEG format will not work with proprietary data. Check that the product you are buying can save data to an MPEG format and not just provide a process to convert it later.

Low-power 12-volt digital video recorders such as Timespace Technology X200 DVR have been used by Environment Agency teams in Wales and in the South West. When choosing a DVR, things to look out for include whether the camera can take multiple video inputs, and what media the data are recorded onto (such as a removable hard disk cartridge).

Most DVRs will have a range of recording options including timer, schedule and alarm recording. It is useful if the DVR is supplied with a reviewer as this allows the user to program settings, watch the live feed in order to set the cameras up correctly and review recordings. Alternatively, a battery-powered video monitor, such as the CCTV test monitor supplied by System Q (Table 3.4), can be used. After the required data have been collected, the removable storage media can be taken away for review and the data downloaded to PC.

The cost and functionality of digital video recorders can vary widely. For example, at £2,400 the Timespace X200 is the most expensive 12-volt recording option tested for this project (Table 3.2), being more comprehensive than the other two systems discussed here. It has a huge range of menu options, many of which are not applicable for the type of fish counting set-up required, which makes it more complex than necessary to configure.

At the other end of the scale are the 'MicroDVR' class of recorders. As the name suggests, these are small and very portable 12-volt recording options. They are also cheap, with prices starting at around £130 (Table 3.4). These units can often be powered by AA batteries or connected to a mains power supply. Data are recorded in MPEG4 format onto removable media such as 'Secure Digital' (SD) cards; these can be removed and files copied to a computer using an SD card reader. The MPEG4 format allows the data to be analysed using image processing software if necessary, although the software cannot be installed and used on site (Table 3.2). The relatively small capacity of SD cards at the moment limits the amount of data that can be recorded; for example, a two-gigabyte (GB) SD card can store 2.5 days of data. These types of DVRs are therefore more suited to exploratory, short-term deployment. Despite being small, some of the useful features available with the other two systems are retained, such as adjustable recording frame rate and schedule recording.

Low-power computers

There are a variety of small form factor PCs on the market which can operate on a 12-volt power supply, where the boards are assembled and powered differently to standard computers. The boards are stacked on top of each other and the whole system can be enclosed in a case 210 x 190 x 85 mm (Table 3.2). Before purchasing a low-power computer, check that it can run the Windows operating system and that it is compatible with DVR cards, such as those manufactured by Voltek or Swann (Table 3.4). If it is compatible with these cards, it will be possible to produce MPEG4 codec files (Table 3.2). Low-power external USB hard drives (Section 3.6) are available, which obtain power from the computer and do not need an additional power supply. Small 12-volt computer monitors can be bought to set the system up on site (Table 3.4).

As part of the project, discussions have been taking place with the suppliers of one type of low-power PC, the Mini-ITX system. The machines can be built to specification to ensure they are suitable for purpose and standard specifications for fish counting systems have been agreed. A specification for a machine suitable for use as a basic digital video recorder can be found in Appendix 4.

A system like this can provide all of the functionality of a standard computer-based recording system which means that, unlike the DVRs, image processing software can potentially be installed on the machine and operated on site. Testing of the suitability of the ITX machine to run Fishtick on site is underway and the results will be circulated when this is complete.

Table 3.2: A comparison of the low-power recording systems tested for this project

	Timespace	*Mini-ITX*	*MicroDVR*
Cost (£)	2,400	550	129
Power (watts)	7.2	2.5	
Size (mm)	220 x 116 x 52	210 x 190 x 85	90 x 65 x 30
Storage capacity (GB)*	250+	160	2
File format	Proprietary	MPEG4	MPEG4
Suitable for…?	Long-term use	Long-term use	Short-term use
Software	Not compatible	Can be installed	Used to playback files

*dependent on the maximum size of compatible storage media.

3.6 Data storage

EXTERNAL USB HARD DRIVES
- Mains-powered
- Low-power drives

External USB hard drives are a flexible and simple way to collect, transport and, if necessary, store data. A range of drives are available with up to two terabytes capacity. Some makes were tested for the purposes of the project but it was not possible to try everything, especially considering how quickly this area is expanding. A good place to find information is on www.dabs.com where you can read customer reviews of some products. Most external hard drives are 'plug and play', meaning that they can simply be connected to the USB port of the PC and will work without having to install any drivers or software.

The majority of the larger capacity (above 250 GB) external hard drives require a separate power supply, so are not suitable for sites with no mains power. There are, however, drives available which are powered from the USB port and do not need a separate power supply. These 2.5" hard drives, such as Freecom Toughdrive, are designed to be used with laptop computers and work with the Mini-ITX system. The maximum capacity of these low-power drives is currently 250 GB; however, this is likely to increase rapidly.

3.7 Introduction to image processing software

MOTION DETECTION VERSUS IMAGE TRACKING

- FISHTICK
- DIGITAL VIDEO MOTION DETECTOR (DVMD)

Image processing is an important component of a video counting system, as it can considerably reduce the amount of time taken to obtain a fish count from the raw video data. Using an image processing system to handle the data, rather than watching the video files, can make a video counting system viable where it may not have been before. It can also mean that far more data can be analysed from a site, increasing the amount of information that can be obtained.

3.7.1 Motion detection versus image analysis

A motion detection system produces a video clip of each event passing through a user-defined region of interest. The video clip can subsequently be viewed and interpreted by an operator. The criteria used to select which events to record can be user-configured (minimum and maximum size, direction of travel, intensity and so on). An image analysis system aims to produce a line of data for each event detected and provide sufficient information on each event for an operator to eliminate non-target species events. Each event is tracked as it passes through the region of interest and again, the criteria for a track being accepted as a fish event can be user-configured. In reality, an image analysis system requires at least a portion of the detected events to be verified visually by an operator.

3.7.2 Fishtick, the motion detection software system

Fishtick is an image processing software package developed by the Oregon-based company Salmonsoft. It consists of a capture programme, FishCap, and a review programme, FishRev. There are a number of different versions suitable for different purposes. Fishtick Gold was assessed in this project and this is the version referred to throughout this manual. FishCap captures images using motion detection or tripwire algorithms. The user is able to configure the programme for a particular site by setting regions of interest and then masking out areas within these regions (Figure 3.7) which may affect the capture process, such as weed waving in the current. The motion detection algorithm compares successive frames, looking for a large enough block of movement to be a fish. The user must set the size of the changed area which will generate a detection as well as the pixel threshold where, if a sufficiently large block of pixels shows enough change, a detection is triggered. Details of the parameters which can be set and instructions on how to use Fishtick are provided in *Fishtick Fish Passage Monitoring System User's Manual,* included in Appendix 8. This manual also gives the required PC specification for Fishtick.

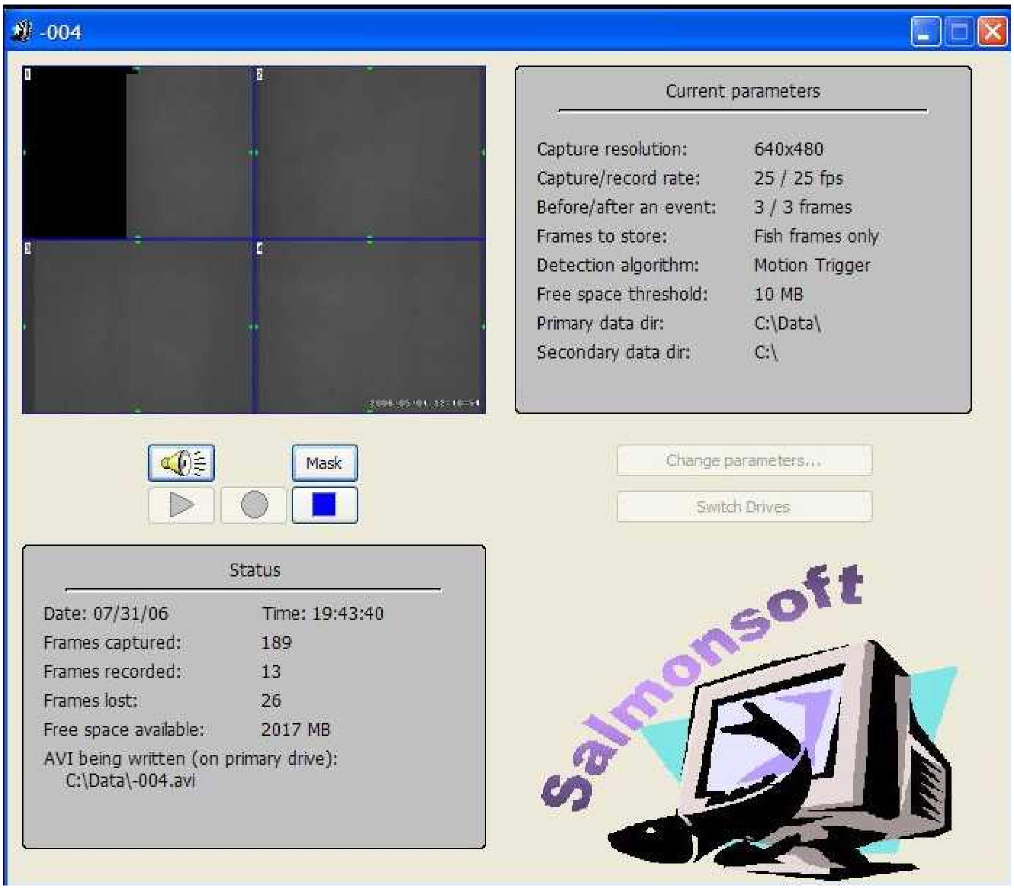

Figure 3.7: FishCap display screen showing how a quad input can be processed using four separate regions. An area of the top left image has been masked off.

The tripwire algorithm uses a series of up to 25 'tripwires' to detect fish; however, this method works best when turbulence is low, water clarity is good, and lighting is relatively uniform. In less optimal conditions, the motion detection algorithm will function better.

The captured images are stitched together and recorded to a new video file. FishRev allows the user to play this file back and add fish to an Excel spreadsheet using the fish up and down arrow keys at the bottom of the screen (Figure 3.8). The species and direction of movement are added at this stage and the user may also add size information if required (Figure 3.9). The Excel spreadsheet generated contains the date, time, species, direction of movement and size information for each fish added.

Fishtick can be used either on site with a live camera feed or on pre-recorded video data (digital or analogue). Pre-recorded files are played back at a much faster rate than that at which they were recorded without affecting the probability of detection. Exactly how much faster depends on the speed of the PC being used and the frame rate of the video files. It is also possible to analyse data collected using a quad or multiplexer with four cameras attached because Fishtick allows up to four regions of interest, each with their own configurable parameter settings, to be created.

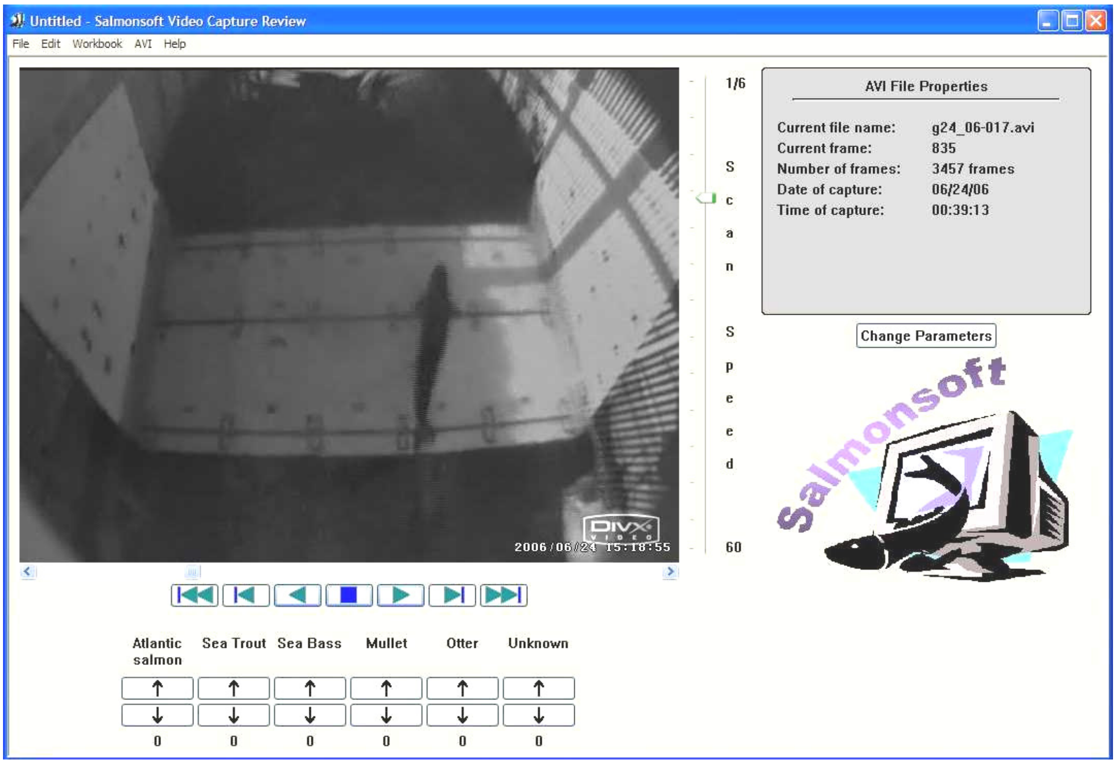

Figure 3.8: FishRev screen showing playback of a file collected from a resistivity counter site on the River Tamar at Gunnislake

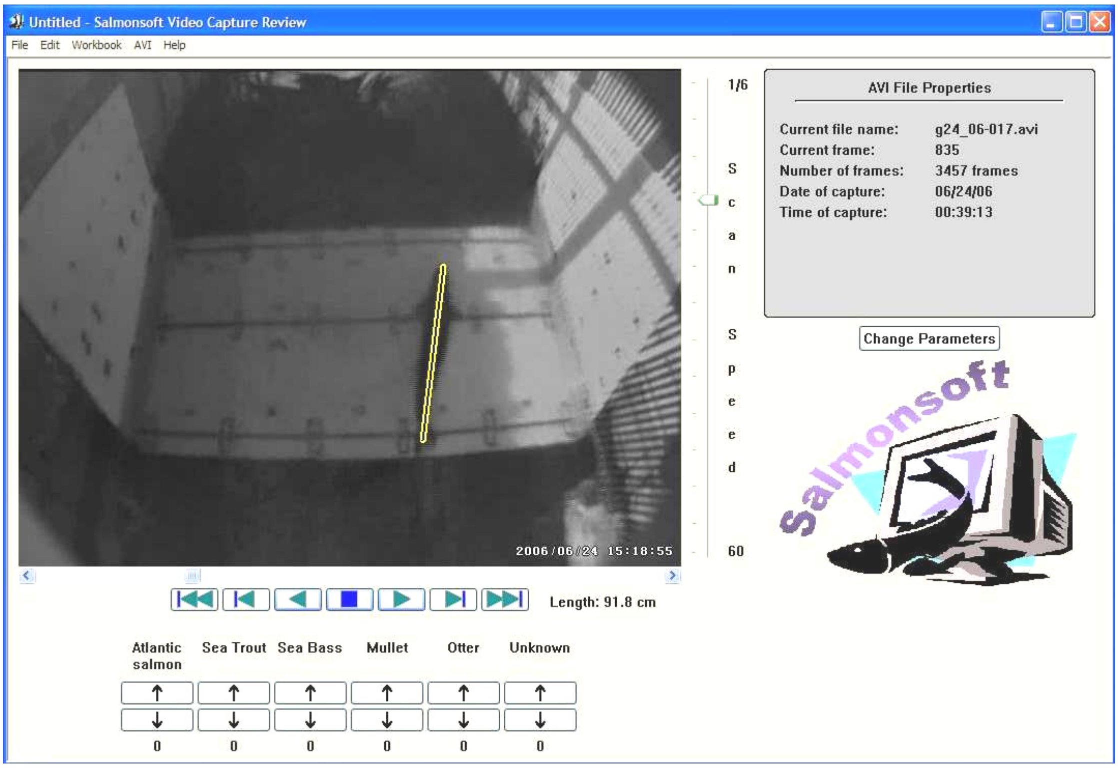

Figure 3.9: FishRev screen showing sizing of the fish from the previous figure. Size information is displayed below the bottom right of the video screen.

3.7.3 Digital video motion detector (DVMD1-X), the image analysis system

The DVMD is an image-tracking device produced and developed by Radiant, a company based in Colorado, USA. The DVMD1-X is a stand-alone product with its own built in digital signal processor. The DVMD operates as a switch, activating a recording device when an object is detected that meets user-defined conditions.

The DVMD parameters are more comprehensive than Fishtick parameters. The user is able to adjust the sensitivity of the DVMD, which is essentially motion detection. In addition, there are target elimination settings such as direction elimination and minimum/maximum speed. The DVMD unit may detect an object but will only track it – that is, trigger an alarm – if it fulfills these target settings. DVMD user manuals can be found in Appendix 9.

Each DVMD unit can only be used with one camera, although multiple DVMDs can be networked together. It is not suitable for a quad feed because, unlike Fishtick, the user is unable to set individual regions and configure each separately.

The development of a Windows module to interface with the DVMD was commissioned by the Environment Agency as part of this project, because the DVMD was of limited use without a record of events. A user guide for this interface is included in Appendix 7. When an event is detected by the DVMD, an alarm is triggered which outputs an analogue signal of the image and an “alarm file”. Based on this output, the interface populates a .csv file with track data, time, date, plus other relevant information from the alarm file and stores a linked video clip of the event.

The display contains an editable data table (in .csv file format) and a display window in which a video clip can be viewed (Figure 3.10). The table is a summary of all of the 'tracked events', providing a record of data for each of the events tracked by the DVMD. The user can scroll down through list and, as each event is selected, the video clip from the event is displayed in the window (Figure 3.10). The table is editable via this interface, allowing the user to alter the field values and add species, size and direction information. These changes can then be saved to the underlying file. Non-fish events can be marked within the interface display window and deleted in either Access or Excel.

A Falcon framegrabber card is required to record images using the DVMD interface. Details of how to install both the card and the interface are provided in Appendix 6.

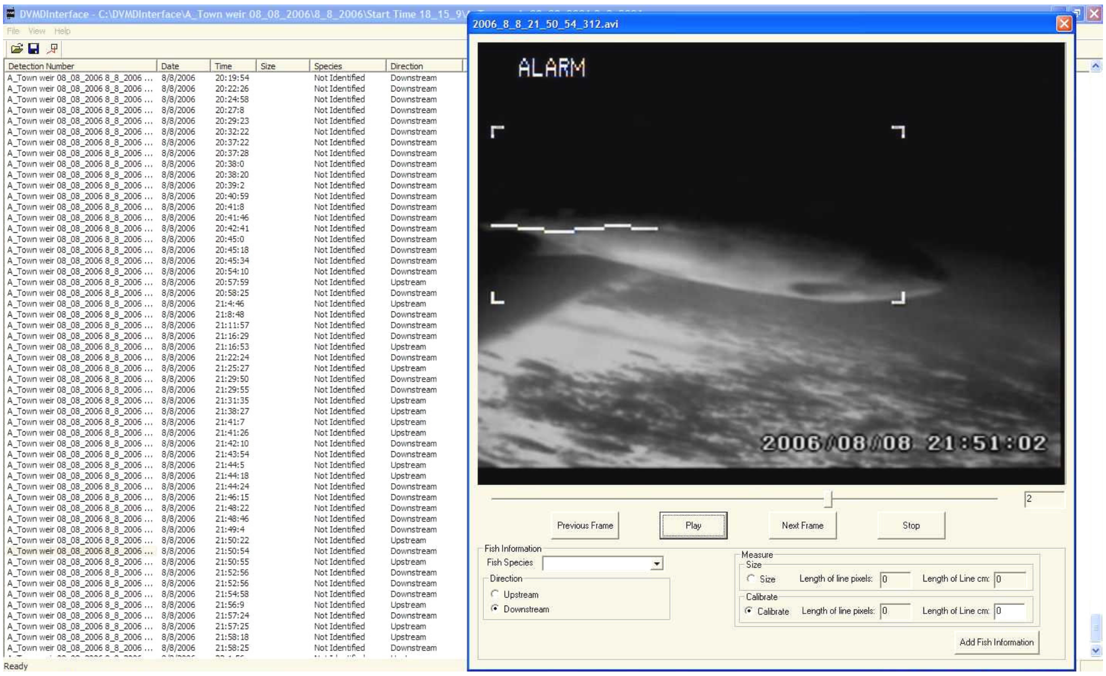

Figure 3.10: DVMD Interface program showing the data table and video clip of the selected event.

3.7.4 Which software platform to apply?

At present, we recommend the use of Fishtick. However, both platforms can be used to obtain a count of fish, with 90 per cent efficiency, faster than "blind" watching. Despite the high false detection rate, Fishtick can obtain a count faster than DVMD. There are certain situations where the DVMD will be suitable, such as for high image quality and/or downward-looking cameras. Ongoing developments may make it more widely applicable. For current advice, see the Contacts Section.

Table 3.3: A comparison of Fishtick and DVMD

Criteria	*Fishtick (motion detection)*	*DVMD (tracking)*
Ease of use	Easy	More difficult
Live feed	Yes	Yes
Pre-recorded feed	Yes	Only for calibration
Quad feed	Yes	No
Multiple cameras	Yes	No, not on one unit
Sizing	Yes	Yes
Directionality	No	Yes

Table 3.4: Equipment prices and supplier information

	Equipment	Cost	Supplier
Housing	GRP equipment housing (Roadside Range)	From £235	Envico Specialised Mouldings, Unit 8 Aberavon Road, Baglan Industrial Estate, Port Talbot, SA12 7BY. Tel: 01639 825740. Website: www.envicoengineering.com
	Steel cabinet and boxes		TechnoRail, Henfaes Lane, Welshpool, Powys, SY21 7BE. Tel: 01938 555511. Fax: 01938 555527. E-mail: techadvice@technorail.co.uk
	Metal security boxes		Scooter Store, Unit 11, Italstyle Buildings, Cambridge Road, Harlow, Essex, CM20 2HE. Tel: 01279 453565. E-mail: info@site-safe.co.uk
Power	Leisure batteries	From £80	Halfords or caravan equipment suppliers.
	Methanol fuel cell stack (SFC A50)	£1,810 (excl. VAT)	SiGEN Ltd, Mill of Craibstone, Bucksburn, Aberdeen, AB21 9TB. Tel: 01224 715568. Website: www.sigen.co.uk
	Micro-hydro turbine	£636 (excl. VAT)	Ampair, Park Farm, West End Lane, Warfield, Berkshire, RG42 5RH. Tel: 01344 303313. Website: www.ampair.com
Cameras	Underwater cameras	From £100	Website: www.2seeTV.co.uk
Lighting	Light panel (600 x 300 mm)		Encapsulation Technology, 147 Tadcaster Road, York, YO24 1QJ. Tel: 01904 705254.
		From £930	HydroSys, Swansea. Tel: 07773 359482.
		From £300	Your own honest toil.
	Infrared 24-volt LED illuminator	£600	Pro-Optocam, 7 Yarborough Court, Front Street, Ulceby, North Lincolnshire, DN39 6RZ. Tel: 01469 588855. Website: www.optocam.co.uk
	Infrared 12-volt LED lamps (IR-70)	£69	RF Concepts Ltd, C16 Dundonald Enterprise park, Carrowreagh Road, Dundonald, Belfast, BT16 1QT. Tel: +44 (0)28 9041 9388. Website: www.rfconcepts.co.uk
	Red LED strips	£7 each	Plus Opto Ltd, B13 Derwent Court, William Way, Moss Industrial Estate, Leigh, Lancsashire, WN7 3PT. Tel: 01942 671122. Website: www.plusopto.co.uk
	Red LEDs on a roll, very flexible with a self-adhesive backing.	£500 per six-metre roll	Ritelite (Systems) Ltd, Meadow Park, Bourne Road, Essendine, Stamford, Lincolnshire, PE9 4LT. Tel: 01780 765600. Fax: 01780 765700. E-mail: sales@ritelite.co.uk
	Lightbox tray	Variable	Westward Plastics, Unit 19, Cater Business Park, Bishopsworth, Bristol, BS13 7TW. Tel: 01179 358058. Website: www.westwardplastics.co.uk (Cardiff address details on website)
	Potting compound	£55 per kilo/litre	Farnell or RS
Recording	SuperDVR card, 4 Channel Digital Video PCI Card - DVC3004	£75	Voltek Automation Ltd, Unit 39C Churchill Way, Lomeshaye Industrial Estate, Nelson, Lancashire, BB9 6RT. Tel: 01282 695500. Website: www.voltek.co.uk

	Swann DVR card	£99	www.dabs.com
	X200 DVR	£2,400	Timespace Technology Ltd, Blackstone Road, Huntingdon, PE29 6TT. Tel: 01480 414147. Website: www.tspace.co.uk
	MicroDVR	£129	System Q Ltd, Turnoaks Business Park, Hasland, Chesterfield, S40 2WB. Tel: 01246 000000. Website: www.systemq.com
	Mini-ITX PC	£550	Industrial Computing Products, Unit 10 Colemeadow Rd, North Moons Moat Industrial Estate, Redditch, B98 9PB. Tel: 01527 406895. Website: www.icp-epia.co.uk
	CCTV test monitor	£249	System Q Ltd, Turnoaks Business Park, Hasland, Chesterfield, S40 2WB. Tel: 01246 000000. Website: www.systemq.com
	12-volt VGA PC monitors		Website: www.lilliputuk.com. Tel: 0845 0068868
		From £126	DogcamSport, 60 Boyd Avenue, Padstow, Cornwall, PL28 8HD. Tel: 01841 533079. Website: www.dogcamsport.co.uk
Processing	Fishtick	$6,995*	Salmonsoft, 5810 SW Idaho St, Portland, Oregon, 97221-1628, USA. Website: www.wecountfish.com
	DVMD	$875*	Radiant Inc, 2395 Kenwood Drive, Boulder, Colorado, 80305, USA. Website: www.dvmd.com

*Note prices are in US dollars

Table 3.5: Equipment power requirements

Equipment		**Power requirement (amps at 12 volts)**
Cameras	Underwater cameras	Approximately 0.200
Lighting	Light panel (600 x 300 mm)	
	Infrared 24-volt LED illuminator	2.000
	Infrared 12-volt LED lamps (IR-70)	0.490
	Red LED strips	0.260
Recording	X200 DVR	0.600
	Mini-ITX PC	2.000

4 Contacts

There is a wealth of knowledge and experience within the Environment Agency relating to fish counting and video monitoring. For information, advice or "pointing in the right direction", contact Jim Gregory or Emma Washburn in the first instance.

National Lead: Fish counting and using video images for fishery monitoring
Jim Gregory

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Southern
Adrian Fewings

South West
Jon Bilbrough, Paul Elsmere

Wales
Emma Washburn, Peter Clabburn

5 Case studies

5.1 Haverfordwest Town Weir, River Cleddau

Type of fish pass: Larinier 1,500 mm wide (Figure 115.1)
Power supply: Mains power available
System deployment: Trial deployment which, if successful, to become long term
Information required: Evidence of fish using the pass
Identification: Species level
Sizing: Not during trial, but possible
Cost of system hardware (not including image processing): below £3,000

System components
System 1 (Table 2) was used for the trial deployment (Figure 12). The pass is wider than the recommended 900 mm for one camera, but this was sufficient to obtain evidence that fish were using the pass and to run a trial deployment. A second camera will be installed following a successful trial period.

Camera: One sideways-looking camera
Lighting: an LED light panel (measuring 600 x 1,500 mm), made in-house, on the bed of the fish pass exit channel (Figure 12).
Recording hardware: Desktop PC (reconfigured machine from EA CIS team) with Voltek DVR card
Storage media: Two Freecom USB external hard drives (always one on site)
Image processing: The data collected were processed using both Fishtick and DVMD. For the proposed long-term deployment, Fishtick will be installed on a PC on site.

Figure 11: Installing equipment on Haverfordwest Town Weir fish pass (1,500 mm wide Larinier fish pass)

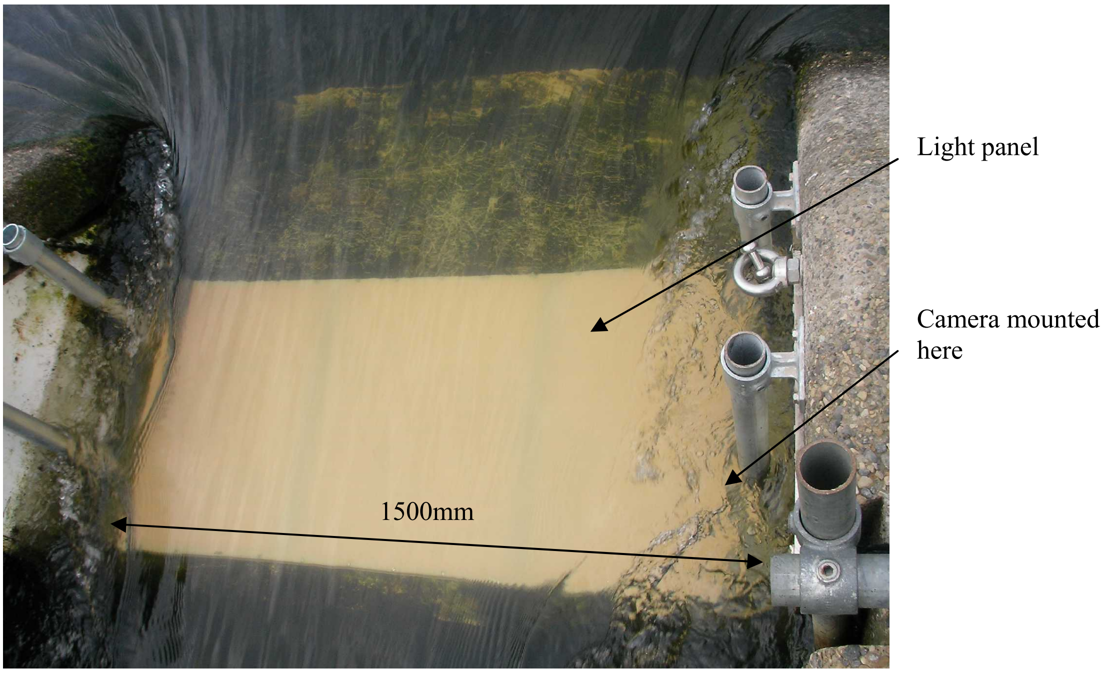


Figure 12: Fish pass exit showing light panel and scaffold poles, to which a camera was attached

Results

The data were recorded as MPEG4 video files (Figure 13) and played back through Fishtick and the DVMD. The parameters used are detailed in Table 5.1 and 5.2. The performance exhibited by Fishtick was good for this application, with 94 per cent of targets detected. DVMD assessment was disappointing in terms of efficiency (49 per cent) and was particularly poor in detecting fish in shoals. The DVMD system should be able to track multiple fish passing through, but struggled when there were multiple targets at various ranges from the camera against a relatively low contrast background. For full details of the results, see Washburn (2007).

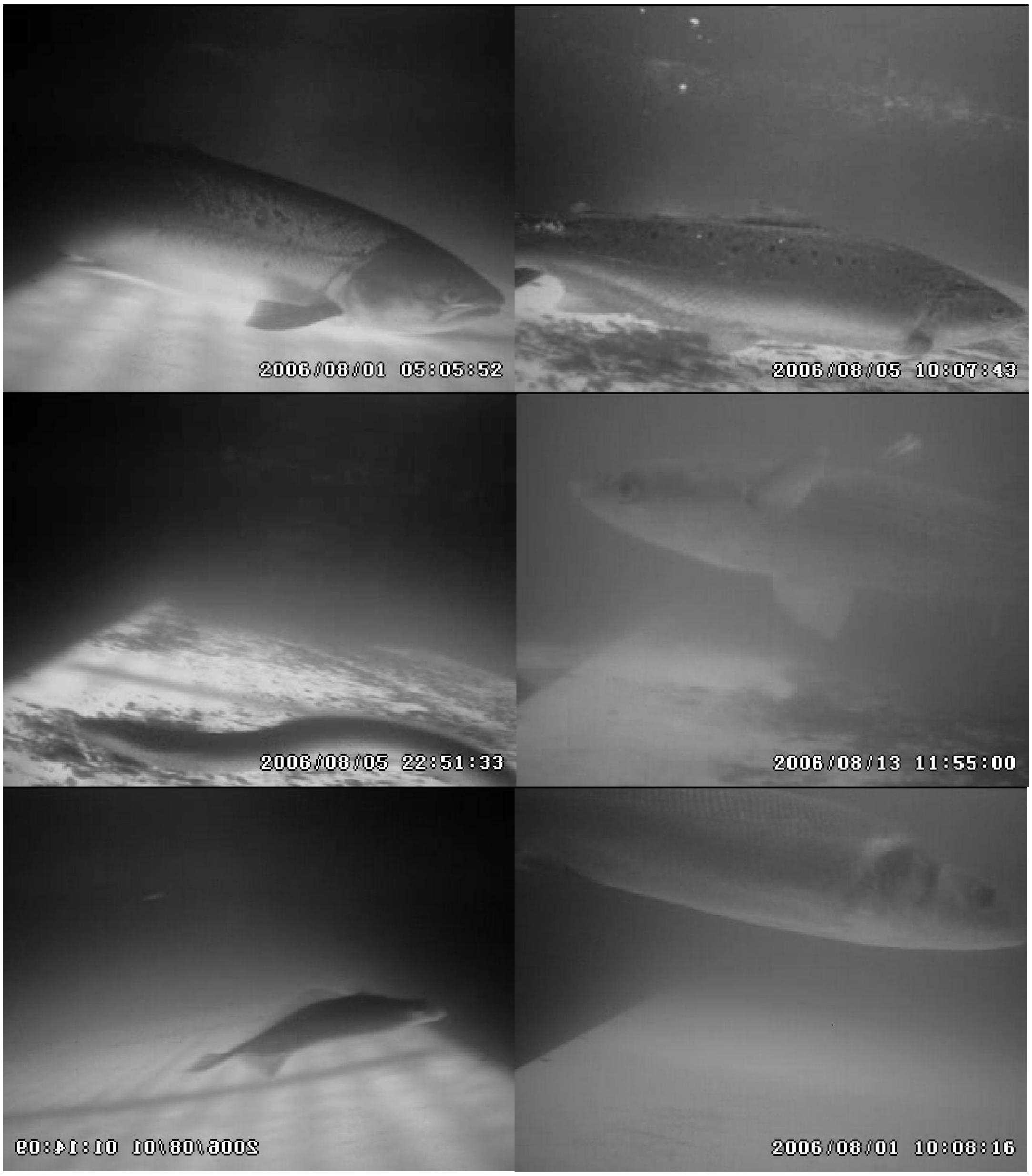


Figure 13: Some examples of the images collected at Town Weir fish pass using a sideways camera and light panel on the bed of the fish pass

5.2 Warkworth, River Coquet

Type of fish pass: Pool and traverse and Denil (Figure 14)
Power supply: Mains power available
System deployment: Trial deployment
Information required: Evidence of fish using the pass
Identification: Species level
Sizing: Not during trial
Cost of system hardware (not including image processing): below £1,000

System components

System 1 (Table 2) was used for the trial deployment. This was sufficient for the purposes of the trial deployment and to obtain evidence that fish were using the pass.

Camera: One sideways-looking camera
Lighting: None.
Recording hardware: Desktop PC (reconfigured machine from EA CIS team) with Voltek DVR card
Storage media: Two Freecom USB external hard drives (always one on site)
Image processing: The data collected were processed using both Fishtick and DVMD.

Figure 14: The North Warkworth pass. Cameras were deployed at the top of the pass

Results

Approximately 60 fish were used as a subsample with which to assess the software. Fishtick detected 75 per cent of targets and the DVMD detected 73 per cent of targets.

5.3 Manley Hall, River Dee

Type of fish pass: Resistivity weir (Figure 15)
Power supply: Mains power available
System deployment: Validation of resistivity counter and trial deployment
Information required: Evidence of fish for comparison with resistivity data
Identification: Species level
Sizing: Possible using data collected
Cost of system hardware (not inluding image processing): below £1,000

System components

System 8 (Table 2) was used for this deployment.

Camera: One downwards-looking camera (Figure 15)
Lighting: Infrared floodlight
Recording hardware: Desktop PC with Voltek DVR card
Storage media: Two Freecom USB external hard drives (always one on site)
Image processing: Manual. No image processing software was used for the validation of the resistivity counter. The data were also processed using Fishtick.

Results

Data were collected and used for video validation of the weir section over a number of weeks. A subsample of five days, during which 64 fish were observed, was used as part of the software assessment for this project. Fishtick detected 78 per cent of the fish.

Figure 15: Manley Hall resistivity counter site showing the camera and lighting gantry

Figure 16: Example image collected at Manley Hall using the camera and lighting gantry

5.4 Hampton Court, River Lugg

Type of fish pass: Larinier (Figure 17)
Power supply: Battery bank
System deployment: Validation of Vaki counter and trial deployment
Information required: Evidence of fish for comparison with Vaki data
Identification: Species level
Sizing: Not possible during this deployment

System components

System 7 (Table 2) was used for this deployment.

Camera: One upwards-looking camera
Lighting: Infrared LED lamp reflected off a white background (Figure 18)
Recording hardware: 12-volt VCR replaced by Timespace DVR
Storage media: N/A
Image processing: Data were processed using Fishtick

Figure 17: Larinier fish pass at Hampton Court on the River Lugg

Figure 18: Infrared light was reflected off a white polypropylene sheet positioned above the fish pass exit

Table 5.1: Fishtick parameter settings used for data collected from the case studies

Parameters		Haverfordwest Town Weir		Warkworth	Manley Hall	Hampton Court
Detection		Region 1	Region 2			
	Motion threshold	18	30	18	3	18
	Auto masking	OFF	OFF	OFF	OFF	ON
	Auto mask threshold	2	2	2	4	2
	Auto mask frequency	75	75	75	99	75
	Pixel threshold	12	80	8	25	8
	Smallest object	8	120	8	4	8
	LoRes detection	OFF	OFF	OFF	OFF	OFF
Detection filters	Frames recorded before	3	3	3	3	3
	Frames recorded after	3	3	3	3	3

Table 5.2: DVMD parameter settings used for data collected for the case studies

Parameters		Haverfordwest Town Weir	Warkworth
Sensitivity	Contrast	6	9
	Filter rates	4	4
	Background	10	20
	Alarm duration	4	1
	Minimum age	1	2
	Minimum move	2	5
Target	Maximum velocity	40	40
	Minimum velocity	2	1
	Luma	0, 255	0, 255
	Direction elimination	NONE	NONE
Target size	Far width maximum	70	50
	Far width minimum	10	1
	Far height maximum	50	40
	Far height minimum	4	1
	Near width maximum	70	50
	Near width minimum	10	1
	Near height maximum	50	40
	Near height minimum	4	1

6 References

Washburn, E. 2007. *Haverfordwest Town Weir Fish Pass: Development of a fish counting system to assess pass effectiveness*. Environment Agency Internal Report.

Appendix 1: Provision for video monitoring of fish passes: outline specification for head of passes

Simple modifications to the design of the head of a fish pass will permit monitoring of fish passage by video. This can be achieved by illuminating the counting area, increasing the distance of cameras from the fish and allowing for isolation of the area in order for adjustments to the system to be carried out.

Incorporating the following points should facilitate video monitoring in most circumstances, except for passes with very short exit channels. A general specification that applies to most passes with an exit channel is described first. Overviews of the head design for each type of fish pass are provided in subsequent sections and details are provided where the design differs from the general specification.

A1.1 General specification

Side recess

- Galvanised steel runner mounted in side of pass to accommodate lighting panel or polypropylene board, so that the board/panel is flush with the wall of the pass when in place (Figure A1.1).
- The runner to have an inside depth of 35 to 40 mm, width of 620 mm and to extend to the top of the fish pass wall so that the board/panel can be slotted in and lowered into position (Figure A1.1).
- The two front retaining flanges to be 30 mm long.
- If a light panel is required, it should be 30 mm x 600 mm x height equivalent to Q10.

Bed recess

- Recess 30 mm deep in base of pass, on downslope if present to accommodate lighting panels or polypropylene boards.
- Recess to extend 620 mm in an upstream-downstream direction.
- The width of the recess will be dependent on the width of the pass and should span the entire pass width.
- If a light panel is required, the dimensions of the panel should be 30 mm x 600 mm x (width of pass – 20 mm).

Camera channel

- Camera channel to be installed central to the bed recess and/or centrally opposite the side recess.
- Channel to be made from galvanised steel and mounted within the concrete structure (Figure A1.19A1.2).
- Dimensions: 300 mm x 300 mm.
- Slots (Figure A1.19A1.2) either side of front of channel to allow an 8 mm thick perspex sheet (with optical refraction index similar to glass) to be slotted in front of the camera. Designed so that the Perspex sheet is keeping the light panel in place (see below) and when in place, the front of the channel is more or less smooth and continuous with the fish pass wall.

- Channel to extend to the top of the fish pass wall.
- Removable flanges (100 mm long and 20 mm wide) to be bolted to either side of camera channel at the bottom, to fix light panel or polypropylene board in position (Figure A1.19A1.2).

Perspex sheet design to fix the light panel

Light panels to be fixed down by attaching counter-sunk (at bottom edge) flanges to the Perspex sheets. Using coach bolts with the head on the river side will mean that no turbulence will ensue from the bolts. Some form of fixing will be needed over the Perspex sheet slots to ensure that they cannot ride up, and this could be something that covers the top of the camera slot. This means that the light board shape remains standard and simple, and it is a simple approach easily fabricated.

Camera mount

- It is recommended that the camera mount is constructed from Kee Systems (www.keesystems.com) Kee Klamp range of products.
- A vertical pole (size 6) to be bolted to a plate on the side wall of the camera channel using a Type 70 “rail support” (size 6) clamp. This must be easy to remove and attach as necessary whilst setting up cameras (Figure 20.3).
- The vertical pole to slot over a spike in the bottom of the camera channel, to hold it in place (Figure 20.3).
- Camera contained within a Type 16 “clamp-on tee” (size 6) clamp (Figure 21A1.4). Depending on what make of camera is being used, it may be necessary to pad camera out with rubber to ensure good fit within the clamp. Check camera fits before installation.
- The clamp containing the camera to be attached to the vertical scaffold pole using a Type 114 swivel tee (Figure 21). This will allow the camera to be aimed up and down.
- Measurements provided in Figure 22 must be checked to ensure that, once in place, the camera is in the centre of the channel and that the channel walls are not within the field of view. If different clamps and poles other than those recommended are used, then the measurements in Figure 225 will change.

Stop log grooves

Stop log grooves (100 mm x 100 mm) situated on either side of the lighting/polypropylene board to allow isolation of the panels and camera chamber for work and maintenance.

Water velocity in upstream exit channel

Maintain water velocity of 0.5 ms^{-1} (coarse fish) to 1.0 ms^{-1} (salmonids) to deter fish holding in the upstream exit channel.

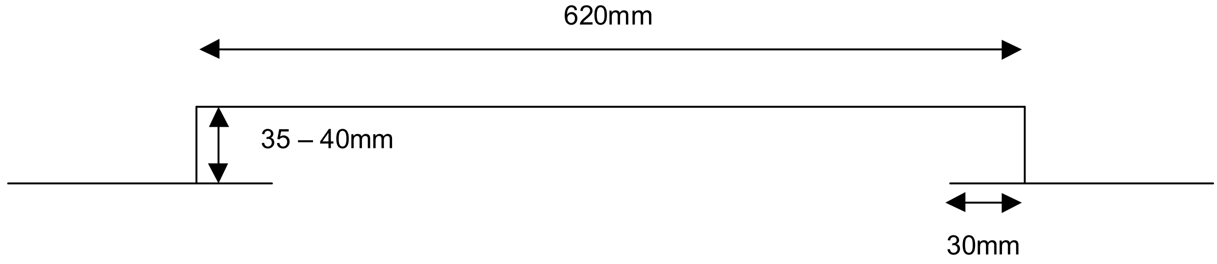


Figure A1.1: Side runner detail and dimensions

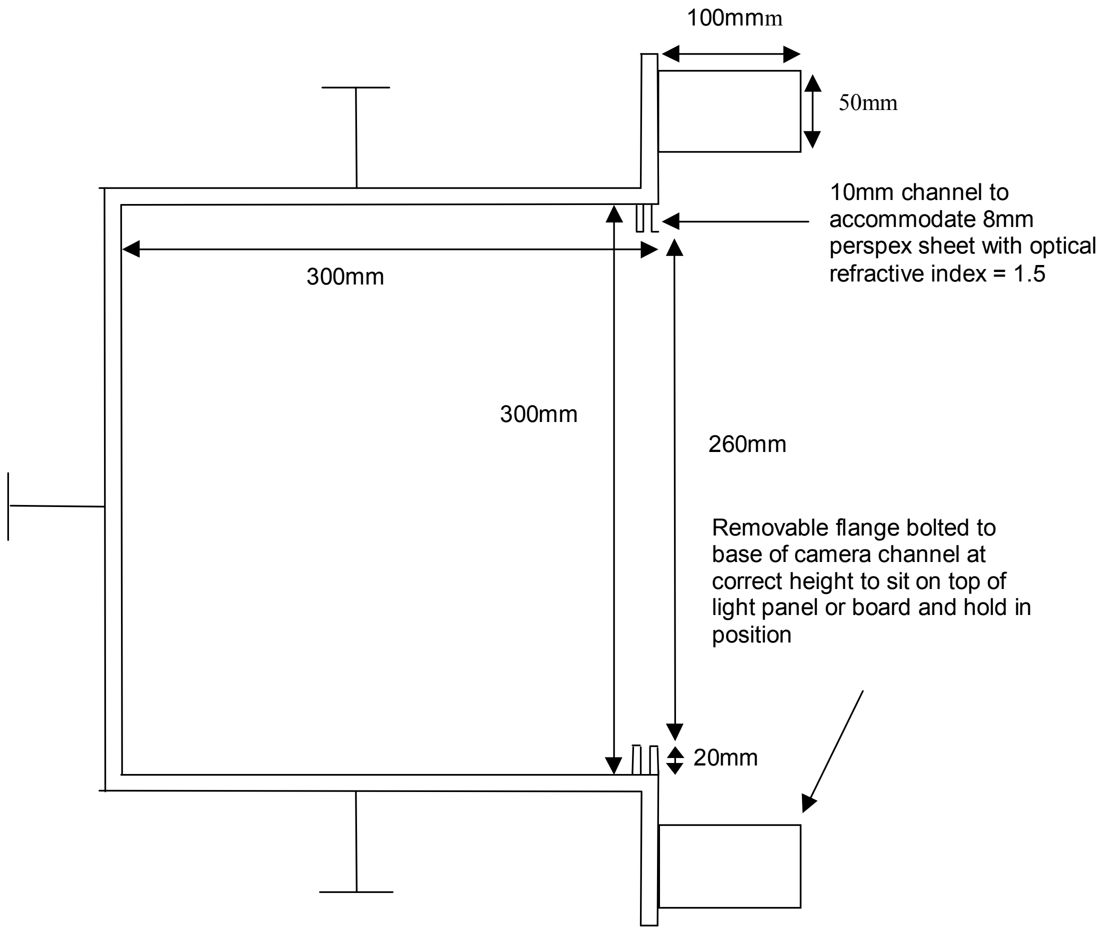


Figure A1.19: Plan view of camera channel

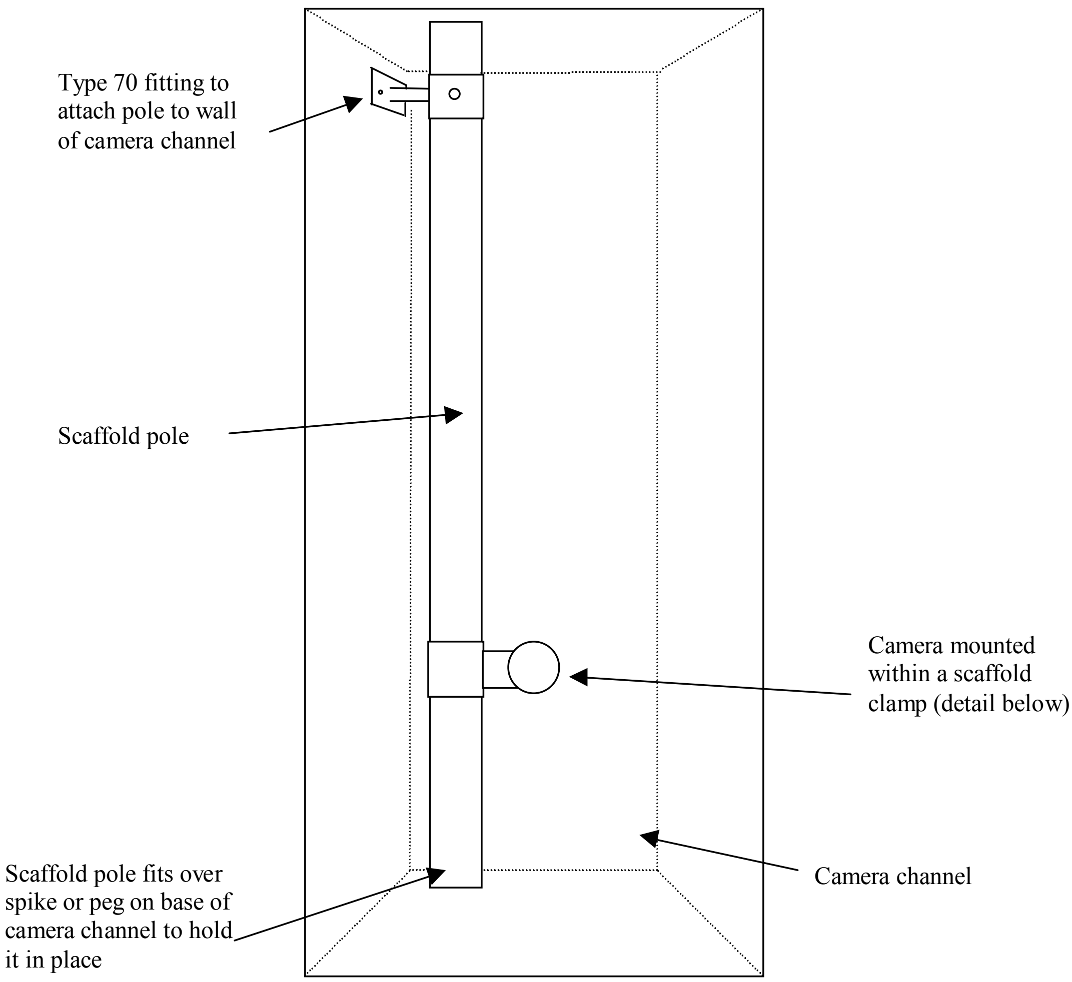


Figure 20.3: Overview of camera mounting arrangement from front of camera channel

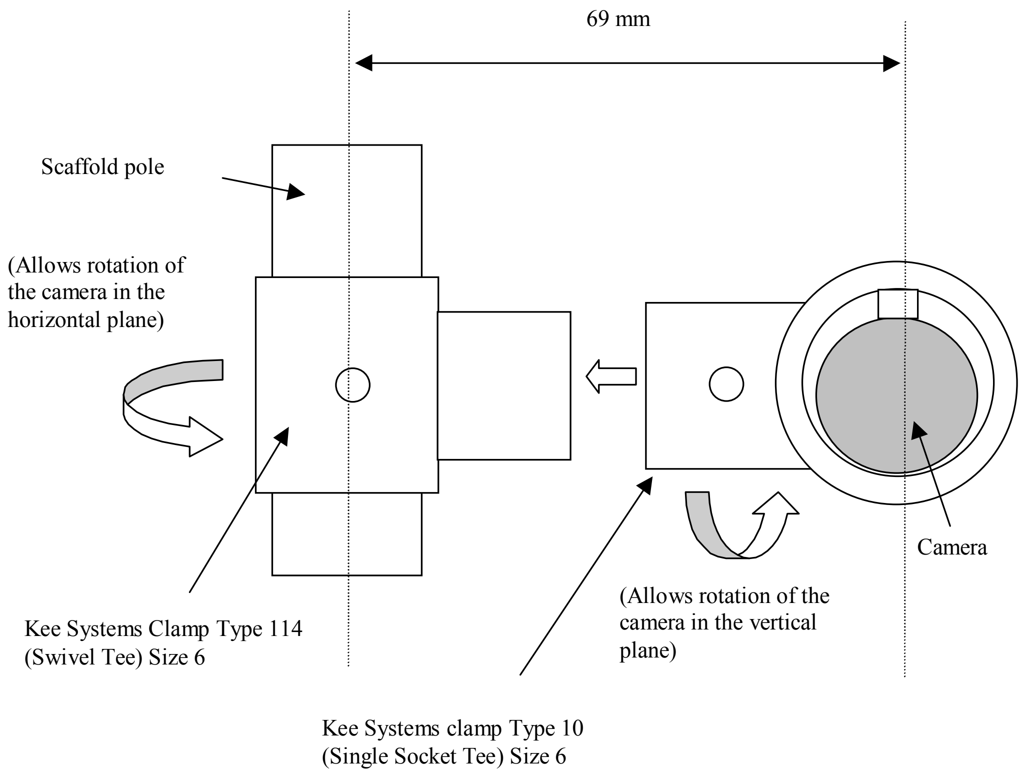


Figure 21: Front view and details of the camera mount arrangement

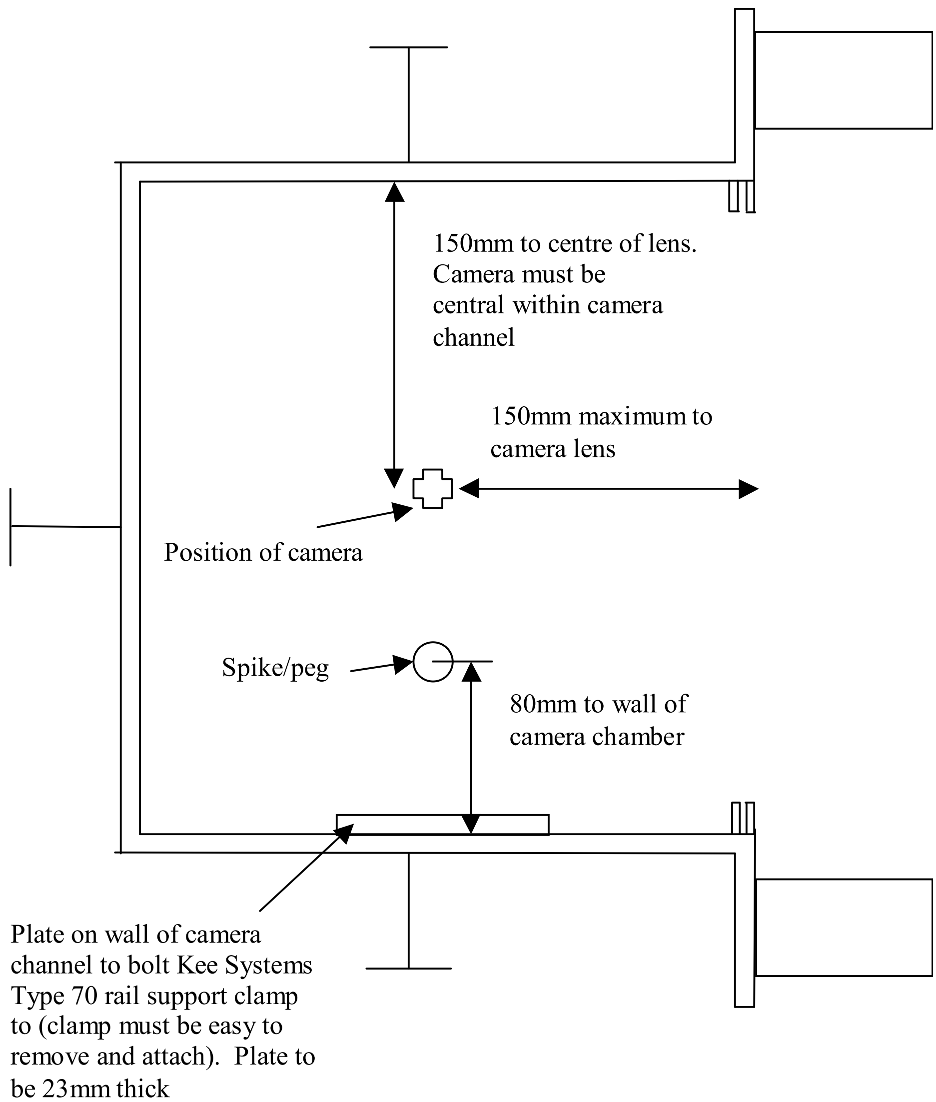


Figure 22: Plan view of camera mount arrangement including position of camera and spike/peg to hold scaffold pole in position

A1.2 Larinier pass

A) If the pass is equal to or less than 900 mm wide, one camera chamber is required (Figure 23). The light panel can be mounted in either a bed or side recess and a polypropylene board mounted in the other recess:

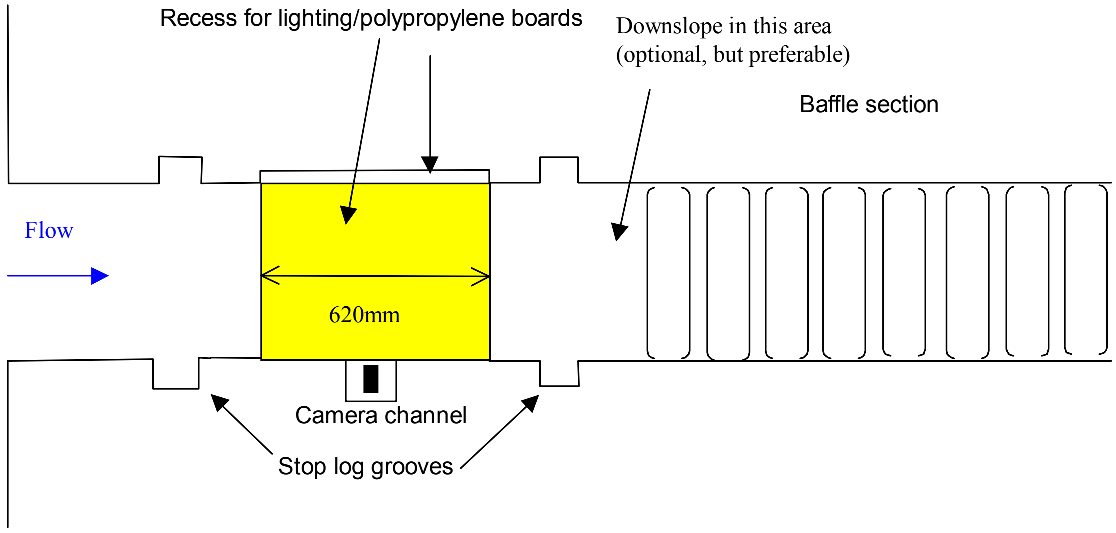


Figure 23: Plan view of counting arrangement on Larinier pass up to 900 mm

Side recess
See general specification (Figure). If to be fitted on a slope, a 30 mm deep recess running the length of the slope and extending to a height at least equivalent to Q10, with a white polypropylene sheet cut to fit and bolted in place, is ideal.

Fixing the light panel
Light panels to be fixed down by attaching counter-sunk (at bottom edge) flanges to the Perspex sheets. Using coach bolts with the head on the river side will mean that no turbulence will ensue from the bolts. Some form of fixing will be needed over the Perspex sheet slots to ensure that they cannot ride up, and this could be something that covers the top of the camera slot. This means that the light board shape remains standard and simple, and it is a simple approach easily fabricated.

Bed recess location
Down slope. Fish behaviour is likely to be more predictable on the down slope of a pass than on the level with slower water. But logistically, it can be more difficult to locate a light panel on a down slope and the dimensions can be restrictive. The lighting panel can be an adjustable length, perhaps down to 300 mm where the head of the pass is severely restrained.

Camera channel
Camera channel to be installed central to the bed recess and centrally opposite the side recess (Figure 23). See general specification for details.

Camera mount
See general specification.

Stop log grooves
Stop log grooves (100 mm x 100 mm) situated on either side of the lighting to allow isolation of lighting panels and camera chamber for work and maintenance (Figure 23).

Water velocity
Maintain water velocity of 0.5 ms^{-1} (coarse fish) to 1.0 ms^{-1} (salmonids) to deter fish holding in the upstream exit channel.

B) If the pass is greater than 900 mm wide, it is necessary to have a camera channel on each side of the fish pass exit. The light panel can be mounted in a bed recess. No side recess is required (Figure 24):

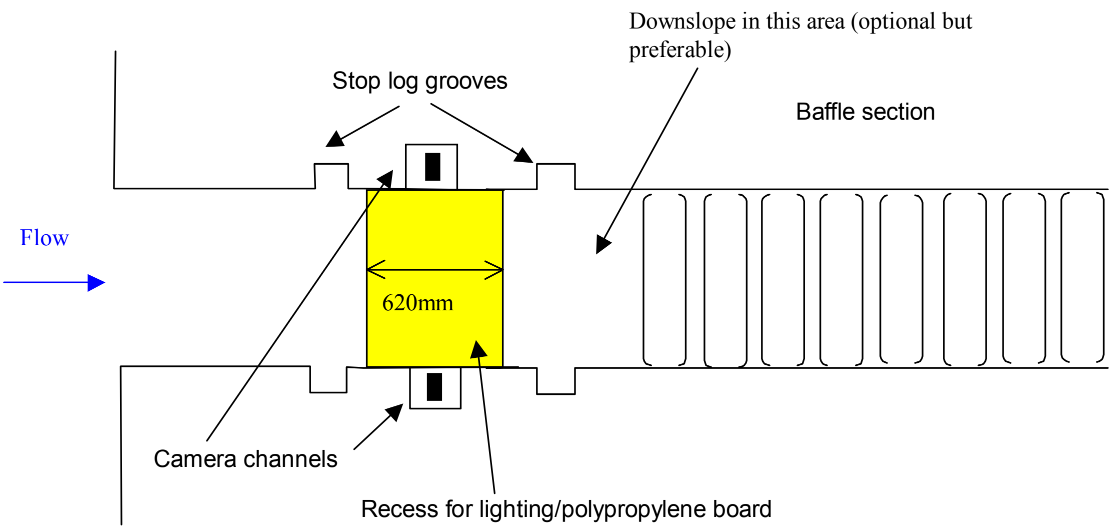


Figure 24: Plan view of a video counting arrangement on a Larinier pass more than 900 mm wide

Side recess
Not required.

Bed recess
See general specification.

Camera channel
Camera channels to be installed central to the bed recess and directly opposite each other (Figure 247). See general specification for details.

Camera mount
See general specification.

Stop log grooves
Stop log grooves (100 mm x 100 mm) situated on either side of the lighting to allow isolation of lighting panels and camera chamber for work and maintenance (Figure 24.7).

Water velocity
Maintain water velocity of 0.5 ms^{-1} (coarse fish) to 1.0 ms^{-1} (salmonids) to deter fish holding in the upstream exit channel.

A1.3 Denil pass

Where exit channel is present, use specification for a Larinier pass less than or equal to 900 mm wide (Figure 23).

A1.4 Vertical slot

A camera chamber to contain up to four sideways cameras opposite a light panel or panels mounted in a side recess.

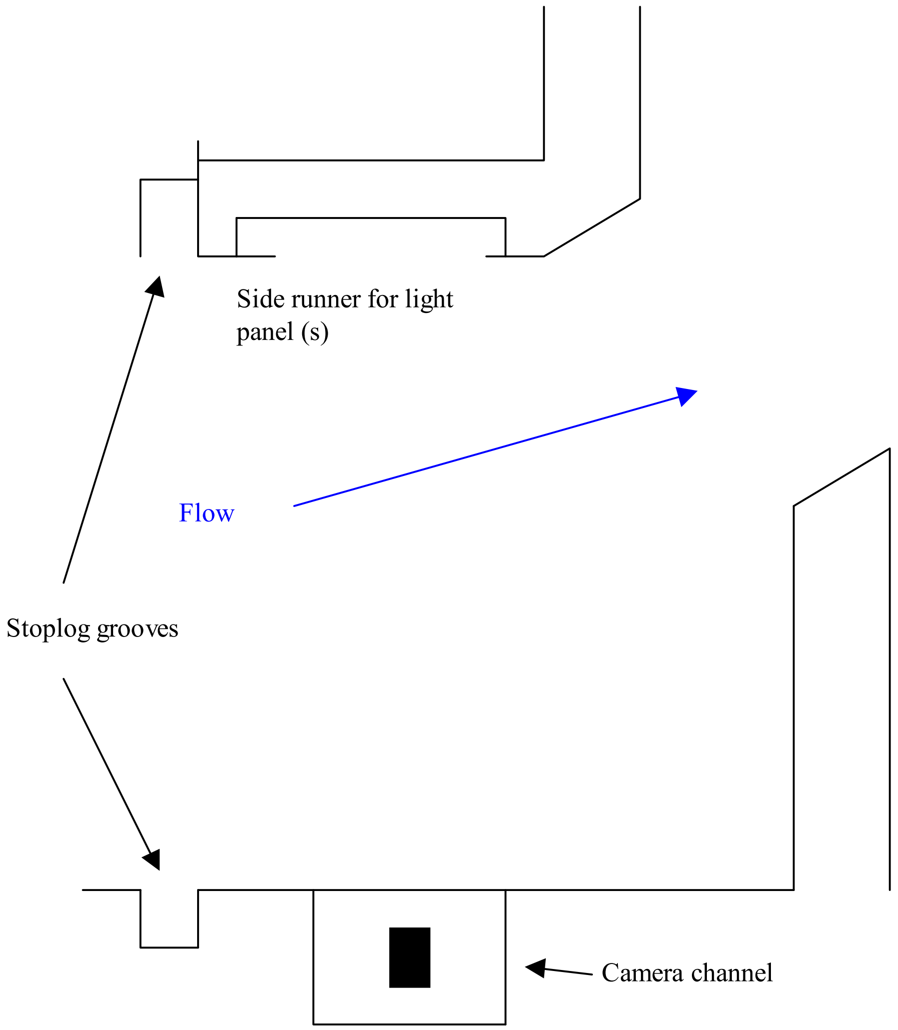


Figure 25: A video counting arrangement for a vertical slot fish pass

<u>Side recess</u>

- If light panels are to be mounted in a frame, the increased dimensions need to be accounted for.
- Galvanised steel runner mounted in side of pass to accommodate lighting panel or polypropylene board, so that the board/panel is flush with the wall of the pass when in place (Figure and Figure 25).

- The runner to have an inside depth of 35 to 40 mm, width of 620 mm and to extend to the top of the fish pass wall so that the board/panel can be slotted in and lowered into position.
- The two front retaining flanges to be 30 mm long.
- If a light panel is required, this should be 30 mm x 600 mm x height equivalent to Q10.

Bed recess
Not required.

Camera channel
See general specification.

Camera mount
- It is recommended that the camera mount is constructed from Kee Systems (www.keesystems.com) Kee Klamp range of products.
- A vertical pole (size 6) to be bolted to a plate on the side wall of the camera channel using a Type 70 "rail support" (size 6) clamp. This must be easy to remove and attach as necessary whilst setting up cameras (Figure 20.3).
- The vertical pole to slot over a spike in the bottom of the camera channel, to hold it in place (Figure 20.3).
- Cameras contained within Type 16 "clamp-on tee" (size 6) clamps (Figure 21.4). Depending on what make of camera is being used, it may be necessary to pad cameras out with rubber to ensure a good fit within the clamps. Check cameras fit before installation.
- The clamps containing the cameras to be attached to the vertical scaffold pole using Type 114 swivel tees (Figure 21). This will allow the cameras to be aimed up and down.
- Cameras to be mounted above each other on the scaffold pole. It is recommended that no more than four cameras are used at once, because data processing with large numbers of cameras can be time-consuming. In addition, some of the data processing software available for fish pass camera data is designed to collect and process data from a maximum of four cameras.
- Measurements provided in Figure 22 must be checked to ensure that, once in place, the cameras are in the centre of the channel and that the channel walls are not within the fields of view. If different clamps and poles other than those recommended are used, then the measurements in Figure 22 will change.

Stop log grooves
Stop log groove (100 mm x 100 mm) situated at the very end of the exit flow straightener upstream of the lighting, to allow isolation of lighting panels and camera chamber for work and maintenance (Figure 25).

Water velocity
Maintain water velocity of 0.5 ms^{-1} (coarse fish) to 1.0 ms^{-1} (salmonids) to deter fish holding in the upstream exit channel.

A1.5 Pool and traverse

Users: Please fill this section in yourselves.

Appendix 2: Model for calculating uncertainty

Estimation of numbers of fish from a resistivity counter, image counting system (IC) and ground-truthing (GT)

Counts from the Manley Hall counter (Dee) over four days are as follows:

Counter	IC	GT	Day 1	Day 2	Day 3	Day 4	Total
Yes	No	No	4	6	1	1	12
Yes	No	Yes	3	7	2	1	13
Yes	Yes	Yes	11	10	12	5	38
No	No	Yes	0	0	0	0	0
No	Yes	Yes	1	0	1	1	3

It was assumed that the GT was 100 per cent efficient, that the counter and IC operated with a constant underlying efficiency over the four days, and that the counter generated false positives at a constant underlying rate. A simple probabilistic model for the data is:

Observed count = True count + False positives
True count ~ Binomial(***Counter-efficiency***, GT)
False positives ~ Poisson(***False-positive rate***)
IC ~ Binomial(***IC-efficiency***, GT)

Fitting this model to the above data provides estimates of the three unknown parameters.

Parameter	Estimate	Standard error	Lower 95%CL	Upper 95% CL
Counter-efficiency (proportion)	0.93	0.03	0.85	0.98
IC-efficiency (proportion)	0.75	0.06	0.63	0.85
False-positive rate (counts/day)	3.00	0.87	1.55	4.92

The counter is 93 per cent efficient (85-98 per cent), the IC is 75 per cent efficient (63-85 per cent), and the counter generates false positives at an average rate of three per day (1.55 to 4.92). Had the initial calibration been undertaken using IC but not GT, it would not have been possible to estimate the three parameters separately. Having calibrated the model on counter + IC + GT data, it can then be applied to days when just the counter is running:

Day	Count	Truth	Estimate	Standard error	Lower 95%CL	Upper 95% CL
5	18	15	16.15	2.45	11.52	21.20
6	23	17	21.20	2.58	16.41	26.62
7	15	15	13.12	2.38	8.55	18.02
8	7	7	5.06	2.17	0.98	9.56

Or days when both the counter and IC are running:

Day	Count	IC	Truth	Estimate	Standard error	Lower 95%CL	Upper 95% CL
9	18	12	15	16.23	1.78	13.11	20.05
10	23	10	17	19.08	2.09	14.92	23.22
11	15	13	15	15.63	1.50	13.29	19.03
12	7	6	7	7.52	1.09	6.08	10.15

The addition of the IC improves the accuracy and precision of the estimates, but the degree to which this happens will depend on the relative magnitudes of the three parameters estimated. This model could be greatly improved by calibrating on a longer time period, and including river flow as an explanatory variable for counter and IC efficiency.

Robin Wyatt, 26 Mar 2007

The key part of the model in WinBUGS language is:

```
model{
		fp.rate~dgamma(0.001,0.001)
		counter.eff~dbeta(1,1)
		vid.eff~dbeta(1,1)
		#c.fp.rate <- cut(fp.rate)
		#c.counter.eff <- cut(counter.eff)
		#c.vid.eff <- cut(vid.eff)
		c.fp.rate <- fp.rate
		c.counter.eff <- counter.eff
		c.vid.eff <- vid.eff

		for (i in 1:4){
				false.positive[i] ~ dpois(fp.rate)
				count.fish[i] ~ dbin(counter.eff, fish[i])
				vid[i] ~ dbin(vid.eff, fish[i])
		}

		#mu.p ~dnorm(0.0, 1.0E-5)
		#sd.p ~ dunif(0,50)
		#tau.p <- 1/(sd.p*sd.p)

		#for (j in 1:4){
				#Counter only
				#p.fish[j] ~ dnorm(mu.p, tau.p)I(0,100)
				#np[j] <- p.fish[j]*c.counter.eff+c.fp.rate
				#npq[j] <- p.fish[j]*c.counter.eff*(1-c.counter.eff)+c.fp.rate
				#p[j] <- 1-npq[j]/np[j]
				#n[j] <- np[j]/p[j]
				#counter[j] ~ dbin(p[j],n[j])

				#Counter + IC
				#p.fish[j] ~ dnorm(mu.p, tau.p)I(0,100)
				#np[j] <- p.fish[j]*c.counter.eff+c.fp.rate
				#npq[j] <- p.fish[j]*c.counter.eff*(1-c.counter.eff)+c.fp.rate
				#p[j] <- 1-npq[j]/np[j]
				#n[j] <- np[j]/p[j]
				#counter[j] ~ dbin(p[j],n[j])
				#vid2[j] ~ dbin(c.vid.eff, p.fish[j])
		#}
}

#Data
list(
		fish=c(15, 17, 15, 7),
```

```
            count.fish=c(14,17,14,6),
            false.positive=c(4,6,1,1),
            vid=c(12,10,13,6),
            #vid2=c(12,10,13,6),
            #counter=c(18,23,15,7)
)
#Initial values to get model going
list(fp.rate=3,
#sd.p = 1, p.fish=c(15, 17, 15, 7)
)
```

Appendix 3: Fuel cell details

siGEN: Product Catalogue

Supplier Name: **Smart Fuel Cell Gmbh**

SiGEN
FUEL CELL POWER SOLUTIONS

Product name:	Description:

siGEN Product Range Fuel Cell

Product Group: Fuel Cell Accessories

M28 28Litre methanol Tank for EFOY

Product Code:	00284
Product Price Excl VAT:	£57.00
Product Price Incl VAT:	£66.98

Methoanl fuel for EFOY product range. Contains tested and approved methanol for EFOY fuel cells. Contents:
* 28 liter (Capacity: 25.200 Wh oder 2128 Ah).
* TÜV SÜD safety tested; GS mark for eprüfte Sicherheit (tested safety)".
* Delivery size: Packaging unit with 1 cartridges
* Dimensions M28 (L x W x H): 37,0 x 28,5 x 39,4 cm

M10 10Litre methanol Tank for EFOY

Product Code:	00283
Product Price Excl VAT:	£22.00
Product Price Incl VAT:	£25.85

Methoanl fuel for EFOY product range. Contains tested and approved methanol for EFOY fuel cells. Contents:
* 10 liter (Capacity: 9000 Wh or 760 Ah).
* TÜV SÜD safety tested; GS mark for eprüfte Sicherheit (tested safety)".
* Delivery size: Packaging unit with 1 cartridges
* Dimensions M10 (L x W x H): 23.0 x 19.3 x 31.8 cm

M5 5 Litre methanol Tank for EFOY

Product Code:	00282
Product Price Excl VAT:	£25.00
Product Price Incl VAT:	£32.31

Methoanl fuel for EFOY product range. Contains tested and approved methanol for EFOY fuel cells. Contents:
* 5 liter (Capacity: 4500 Wh or 380 Ah).
* TÜV SÜD safety tested; GS mark for eprüfte Sicherheit (tested safety)".
* Delivery size: Packaging unit with 2 cartridges

Set of 2 x M5 Fuel Cartridges (5 l each)

Product Code:	00131
Product Price Excl VAT:	£30.00
Product Price Incl VAT:	£35.25

M5 5 -litre cartridge for the suply of methaonl to the SFC A50 .

Simply screw it onto the SFC fuel cell and throw the switch; that's all there is to it. The built-in safety valve prevents methanol from escaping, making the approved fuel cartridges safe and easy to use. It's even possible to change fuel cartridges during operation within seconds.

Light and Easy to Handle - An M5 fuel cartridge weighs only 4.2 Kg when full providing more than 3,600 watt-hours of electricity. A comparable lead battery would weigh about 100 Kg.

This unit is shipped EMPTY

Monitoring Software SFC A50

Product Code:	00130
Product Price Excl VAT:	£200.00
Product Price Incl VAT:	£235.00

siGEN: Product Catalogue

Supplier Name: **Smart Fuel Cell Gmbh**

FUEL CELL POWER SOLUTIONS

Product name:	Description:	
EFOY 600Wh DMFC (25W) Portable Fuel Cell System **Product Code:** 00281 **Product Price Excl VAT:** £1,215.00 **Product Price Incl VAT:** £1,427.63	The EFOY 600 is a complete autonomus portable DMFC fuel cell system. It designed t provide battery support in remote locations. It will cut in when the battery charge drops to a user defined theshold and switchoff again whenthe charge rises to a user defined level. It can be monitored via RS232 I/F via PC and can be monitiered remotely via landline or cell phone EFOY 600 Specification Nominal Voltage 12V Nominal Current 2.1A Power rating 50W charging capacity 600 Wh/day 50 Ah/day Fuel Consumption 1.1l/kWh Dimensions (L x W x H): 43.5 x 20.0 x 27.6 cm Incl. accessories/installation kit	
EFOY 1200Wh DMFC (50W) Portable Fuel Cell System **Product Code:** 00280 **Product Price Excl VAT:** £1,785.00 **Product Price Incl VAT:** £2,097.38	The EFOY 1200 is a complete autonomus portable DMFC fuel cell system. It designed to provide battery support in remote locations. It will cut in when the battery charge drops to a user defined theshold and switchoff again whenthe charge rises to a user defined level. It can be monitored via RS232 I/F via PC and can be monitiered remotely via landline or cell phone EFOY 1200 Specification Nominal Voltage 12V Nominal Current 4.2A Power rating 50W charging capacity 1200 Wh/day 1000 Ah/day Fuel Consumption 1.1l/h Dimensions (L x W x H): 43.5 x 20.0 x 27.6 cm Incl. accessories/installation kit	
EFOY 1600Wh DMFC (65W) Portable Fuel Cell System **Product Code:** 00279 **Product Price Excl VAT:** £2,070.00 **Product Price Incl VAT:** £2,432.25	The EFOY 1600 is a complete autonomus portable DMFC fuel cell system. It designed t provide battery support in remote locations. It will cut in when the battery charge drops to a user defined theshold and switchoff again whenthe charge rises to a user defined level. It can be monitored via RS232 I/F via PC and can be monitiered remotely via landline or cell phone EFOY 1600 Specification Nominal Voltage 12V Nominal Current 5.4A Power rating 65W charging capacity 1600 Wh/day 130 Ah/day Fuel Consumption 1.1l/kWh Dimensions (L x W x H): 43.5 x 20.0 x 27.6 cm Incl. accessories/installation kit	

siGEN Ltd | Mill of Craibstone | Bucksburn | Aberdeen | AB21 9TB | Scotland
Tel +44 (0)1224 715568/716254 I Fax +44 (0)1224 714818 I Web www.sigen.co.uk I Email

Appendix 4: Quote for ITX system

Industrial Computing Products
Unit 10 Colemeadow Road
North Moons Moat Industrial Estate
Redditch
Worcestershire, B98 9PB
UNITED KINGDOM

A SOLID STATE COMPANY

Phone: +44 1527 406895
Fax: +44 1527 406899
E-mail: Sales@ICP-epia.co.uk
Web: www.ICP-epia.co.uk

Quote Number: 12056

Quotation

Page: 1 of 1

Quote To:

Environment Agency Wales -
Environment Agency, Accounts Payable
Aqua House, Dept 444, PO box 263
London Road
Peterborough
PE2 8AG

emma.washburn@environment-agency.wales.gov.uk

Date: 07/03/2007
Expires: 06/04/2007

Sales Person: Daniel Adams

Daniela@wordsworth.co.uk

Please supply longer leads for m1-atx 70cm plus.
Fashion a wiring loom to connect ignition to positive rail.

Line	Part Number	Description	£ STERLING (GBP)
1	FISH-SYSTEM-MARK2	Pack-Box, EN12000, M1-ATX.	

Fit M1-ATX to lid of PACK-BOX.

Comprising of;

Qty	Part	Description
1	PACK-BOX	WALL MOUNT ENCLOSURE FOR MINI-ITX BOARDS.
1	EPIA-EN12000E	EN12000EG NEW MINI-ITX BOARD WITH 1.2GHZ C7 FANLESS
1	DIMM-512MB-533-DDR2	MEMORY MODULE
1	HD80GB-2.5	EIDE 2.5" HARD DISK DRIVE
1	CABLE-2.5-3.5-RS	2.5" IDE HD ADAPTER
1	M1-ATX-RS	AUTOMOTIVE 90W DC CONVERTER PSU 12V I/P , ATX O/P
1	PCI-01HR-G	ROHS COMPLIANT PCI RISER FOR USE WITH PACK-BOX
1	INSULATION-HDD-2.5	INSULATION SHEET FOR 2.5" HARD DISK DRIVE
1	WINXP-PRO	MICROSOFT WINDOWS XP PROFESSIONAL OEM
1	VOLTEK-DVR-CARD	4 CHANNEL DIGITAL VIDEO PCI CARD
	Build and Test	

Quantity	Unit Price	Net Price
1.00	550.00	550.00 GBP

Appendix 5: Fishtick price list

FishTick pricing:

Hardware prices:

Desktop system: Includes two computers, one for capture and one for review, with a 2.8 GHZ processor, 1 GB RAM, 80 GB Drive, DVD-RW, 1 year warranty, and 17" flat panel monitors or equivalent. The capture machine includes a video capture device (Plextor PX-AV200U or equivalent) while the review computer includes Excel. $2200

Notebook system: Includes notebook computer for capture, desktop for review. Price depends on notebook specifications, minimum price $2700

Hard Drives: 4 GB flash drive to transfer files-per drive $80

Camera: Arm Electronics CDN 600 camera plus lens (or equivalent) $400

Miscellaneous: Cables, fittings, universal power supply, tripod $300

Software prices:

FishTick Lite: Designed for applications with low turbulence and uniform lighting, including fish wheel applications. Tripwire and switch detection algorithms only, no subsampling or AVI file input. Standard template (Fish count by hour and date). Unlimited technical support.

First capture and review system: $2495

Additional capture site..$1995

FishTick Standard: Designed for applications with less ideal lighting or high turbulence. Allows for editing of AVI files, subsampling, choice of spreadsheet templates, unlimited technical support.

First capture and review system: $4995

Additional capture site..$3495

Plus Package: A collection of enhancements that can be added to either the Lite or Standard version. Includes high resolution, saving configuration files, recording comments and notes, subsampling, and more. Prices are per site.

Upgrade from FishTick Standard..$995

Upgrade from FishTick Lite $1495

Templates: New template $495

FishTick Gold. FishTick Standard, the plus package, one custom spreadsheet template included, one year free upgrades and 10 hours developer-level support.

First capture and review system: $6995

Additional capture site, no review system $2995

Version Upgrades:
FishTick Lite—$995, with Plus Package—$1795
FishTick Standard—$1495, with Plus Package—$1995

Site Visit and Leasing: Contact us for the cost of a site visit or leasing.

August 2007

Appendix 6: Guide to the DVMD interface

Installation

- It is recommended that the DVMD and DVMD interface are installed on a PC deployed on site and the data files are bought back to the office for review. It is therefore necessary to install the interface on an additional PC so that the user is able to review the collected files. A framegrabber card is not required to review the files.
- To install the interface with a Falcon framegrabber card, install the card before installing the DVMD interface. Create a new folder called DVMDInterface on your C-drive and copy the executable program from the CD to this folder. Double click to open. There is no installation process as such and the program should run first time.
- To install the interface without a framegrabber card, certain files need to be copied to specific places on the PC (for details of how to obtain these files, contact Emma Washburn or Jim Gregory):

    1. Falcon (system file) needs to go in C/Windows/System32/Drivers
    2. The other four (falcavi.dll, falcon.dll, idshok.dll, ijl15.dll) in C/Windows/System32

  Create a file called DVMDInterface and copy the interface program into it. You can then open the DVMD interface. You'll get an error message saying something about hardware not installed. Just OK this. The user will only be able to review previously collected .csv files.

Menu options

- The Settings tab (under View) has a link to ManagerNET, the program used to communicate with the DVMD and set the tracking parameters. The user can also set the folder in which they wish the results to be stored. There is an option to set the avi codec (MPEG4 Codec V2 is recommended) and the playback speed for review. New species can be added to the list, which is available to the user when reviewing files.

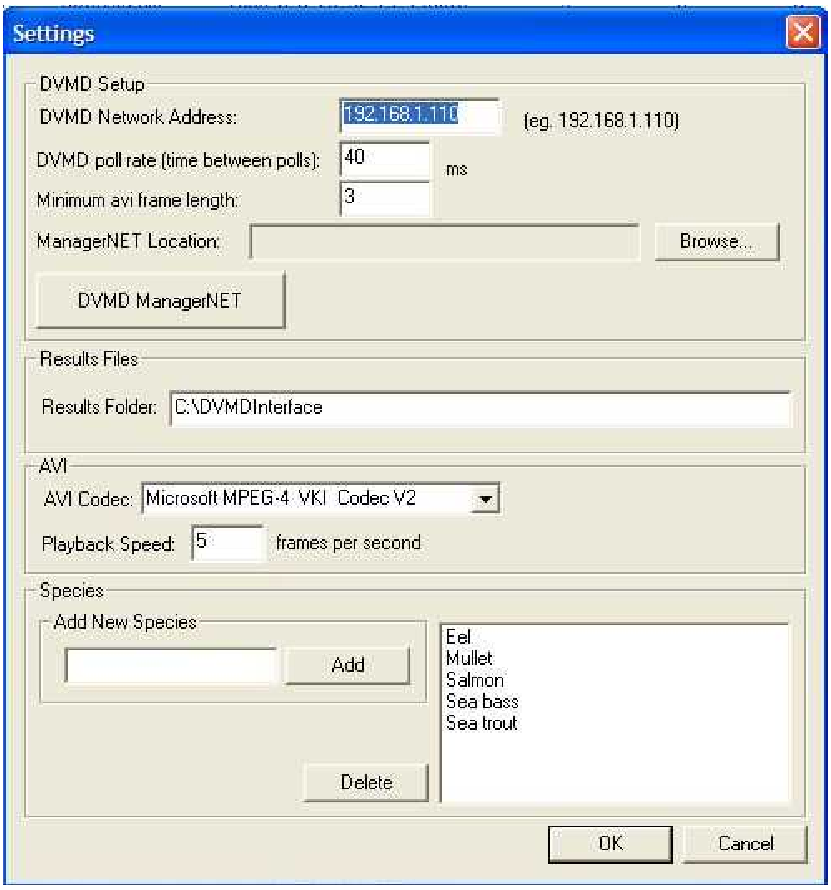


Figure 26: Settings menu in DVMD interface

- The Track tab (under File or shortcut button on toolbar) allows the user to appoint an upstream direction for the fish and enter a site identification number (Figure). There is then an option of using the PC clock or entering an avi start time to determine the fish time. The PC clock would be used if the PC and DVMD were deployed on site and collecting in 'real time', which would be the usual way of using the DVMD. However, some initial calibration of the DVMD parameters would be required and this would be carried out using another PC to play back a video file from the site through the DVMD. There is an option to enter a start date and time for the video file and a playback speed. Normal speed is 25 frames per second. This information is then used to determine the time of any fish tracked.
- The video display screen can be turned on and off by clicking Video Display in the View menu.

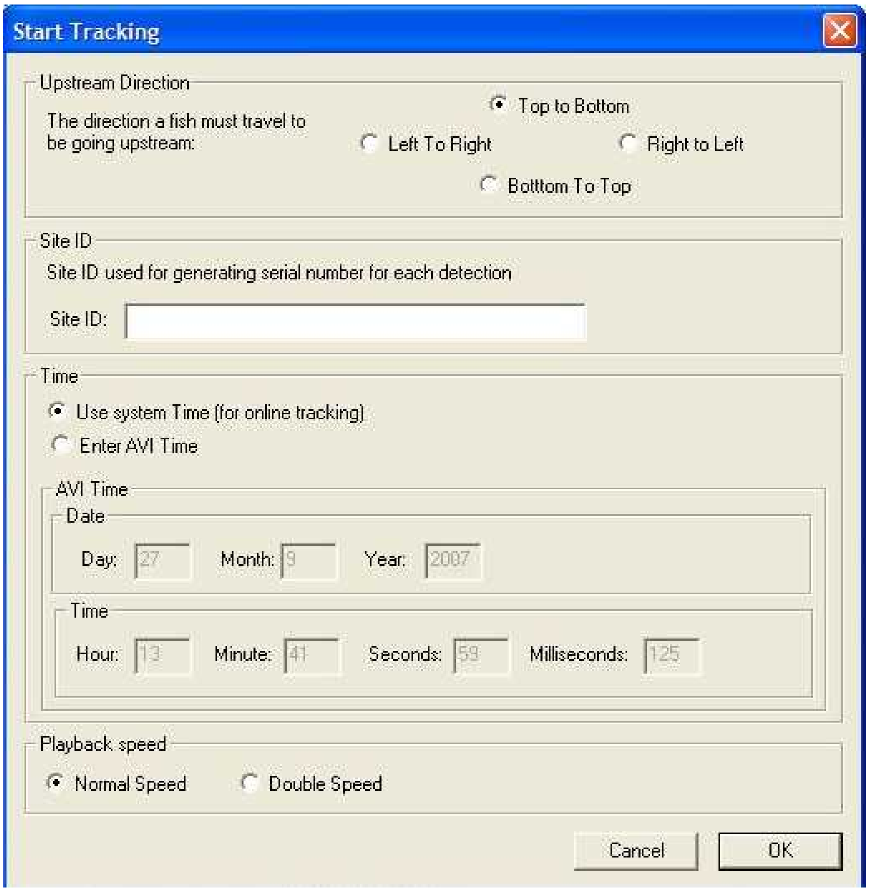


Figure A6.2: Track menu in DVMD interface

To review files collected by the DVMD:

- Open the relevant .csv file.
- Ensure everything is set up as required in the Settings tab.
- Scroll down through the list in the table using the arrow keys.
- Use the buttons in the video display box below the video screen to play the clip (Figure 27).
- When a fish is seen, the species information can be selected from the drop down menu in the video display box (species can be added in the Settings tab).
- The direction of movement can be altered if necessary using the Direction selection buttons below the fish information box (Figure 27).
- The fish can be sized by first highlighting the calibrate section. Hold down the left mouse button and draw a line on the video screen between points a known distance apart, preferably in roughly the same area as the fish. Enter the length of the line. Then click in the Size section and draw a line along the fish. The fish length will be displayed in the ‘length of line cm’ box.
- When all of the fish information has been input, click ‘add fish information’ in the bottom right hand corner of the video display box (Figure 27). The information will be added to the table.
- When the file has been reviewed, make sure it is saved before closing or all of the changes will be lost.

Figure 27: DVMD interface video display

Appendix 7: Fishtick user manual

Appendix 8: DVMD user manual

Appendix 9: How to make your own underwater light panel

By: Mike Haley, MEICA Team, Crosshands, Wales.

Components (supplier)

Perspex case (Westward Plastics)
PX449 12-volt red LED strips (Plus Opto)
Potting compound such as Ambersil Q-SIL 215 (Farnell, RS)
Stainless steel screws
Silicone sealant – marine grade
Waterproof glands
Rubber matting

The light panel illustrated here has the following dimensions:
Outside = 661 x 1501 x 30 mm
Inside = 640 x 1484 x 20 mm
This gives an internal volume of 0.19 cubic metres, requiring almost 19 kilograms of potting compound.

Warning: The polymers used here will absorb water over time. This may cause water ingress to the electronics, eventually leading to failure. The mean time before failure has not been estimated but if a light panel is required for several years, consideration should be made for making the tray out of metal and for provision for the diffuser lid to be changed annually.

Preparation

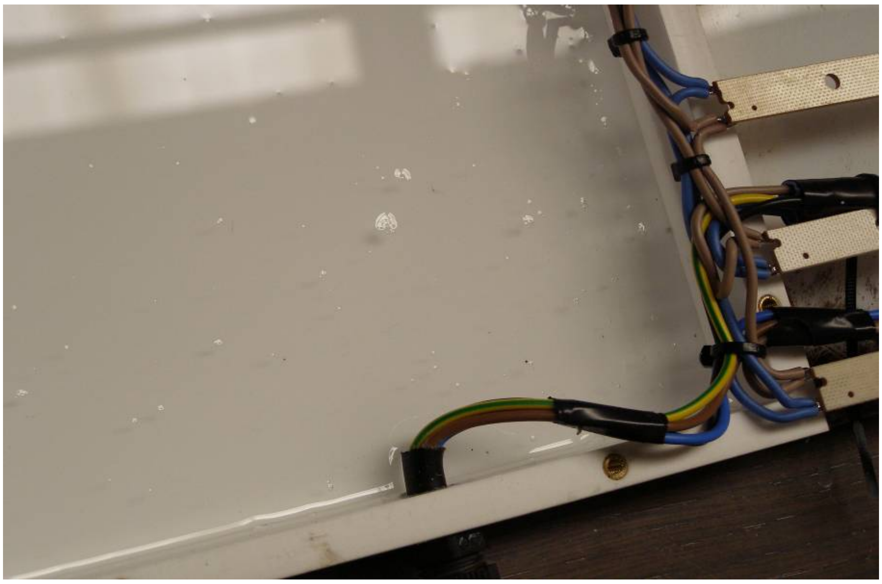
1. Send drawing with required light panel dimensions to Westward plastics: Contact Mark Britton (0117 935 8058). Opaque diffuser and solid white tray.
2. Attach rubber matting to the outside of the base of the light panel.
3. Contact MEICA electrician to attach red LED strips (from Plus Opto, 01942 671122) to the base of the tray, wire them up and seal gland in place.
4. Put box on level surface, pour in well mixed and vented potting compound. Replace diffuser, refasten all bar three screws to allow expansion of compound (see datasheets for use and health and safety).

1. Connect LED strips together in required configuration. Space the strips about 35 mm apart and ensure as large a free gap as possible between LEDs and lid of box. Glue plastic strips to the LED strips to form a semi-rigid frame which will aid in placing the LEDs into the base compound.

2. Clean and degrease base and lid.

3. Mix six litres of compound steadily for 3-5 minutes, in a clean suitable container.

4. Pour mixed compound into light box base; this amount will give an approximate 5 mm covering.



5. Curing time is 20 hours at 25°C and one hour at 100°C. Thus, the compound curing time is heat-accelerated. A heat gun was used set at 500°C to achieve an approximate surface temper of 80-100°C. Using the heat gun also had the effect of dispersing the trapped air bubbles. This was done for approximately one hour, holding the heat gun six to eight inches above the compound.

6. Offer the LED strips onto the semi-cured compound.

7. Mix a further 11 litres of compound and pour into the box. This should fill the box completely. Allow to set naturally or accelerate.

8. Fit light box lid using stainless steel screws. Transport light box to site. Before installing into position, fit 6-8 mm rubber matting to underside of light box to take up any unevenness that may penetrate the light box case.

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