REVIEW OF THE RIVER SPEY HYDROACOUSTIC COUNTER PROJECT 1996-2001

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SUMMARY

In 1995, the Spey Fishery Board, with a generous financial contribution from the late Martin Wills Trust, purchased a hydroacoustic counter from Hydroacoustic Technology Incorporated (HTI), Seattle, USA. Over the past six years, in conjunction with the National Hydroacoustics Collaborative Project, trials have been conducted to establish a suitable monitoring site, suitable methods of operation, an effective method of validation with underwater cameras, and provide data to enumerate fish passage.

This report details a brief history of the Spey acoustic counter and the advantages and disadvantages experienced so far at the present counter site. Only a small sample of results are included to provide an indication of the large amount of work involved and the importance of the data collected. The results so far indicate that the counter is detecting between 50% and 60% of upstream fish passage in its present location, Collie Pot, Delfur. Extensive data on fish passage have been collected. Timing of fish movement was affected by the rate of water discharge and water temperature. Trends in fish passage rates correlate closely with Catch Per Unit Effort (CPUE) data from the adjoining rod fishery.

Due to the vulnerability of the equipment whilst in the river and the passage of fish outwith the acoustic beam, the current counter location and set up has been reviewed. Although correction factors, which have been developed with the use of video validation, are applied to the detection rate of the counter, several further improvements are required.

Three options for the future location and deployment of the acoustic counter are suggested;

1. maintain the acoustic counter at Collie Pot with no additional engineering works or purchase of new equipment and continue site operation as in 2000,
2. reorganise the current equipment set up at Collie Pot to allow use of mains power and utilities available on the opposite bank and reduce the risk of flooding,
3. reorganise the current equipment set up at Collie Pot to allow use of mains power and utilities and reduce the flood risk, purchase and additional transducer for greater river coverage and carry out engineering works to further improve the site.

The River Spey acoustic counter provides an independent, real-time measure of fish passage and further development as detailed in Option 3 could be an invaluable asset to the Spey Fishery Board. With the imminent classification of the River Spey as a Special Area of Conservation (SAC) and the introduction of the Water Framework Directive in 2002, the provision of accurate information on the passage of adult salmonids is essential, providing funding support can be obtained. This further development of counter technology will allow the Board to maintain a leading role in the implementation of these European Directives.

1.0 History of the River Spey Hydroacoustic Counter

1.1 Purchase of the Counter

In 1994 the Spey Board tested a split-beam acoustic counting system (Model 243) developed by an American company, HTI, in the mainstem of the River Spey. Initial trials were successful and concluded that this type of system could be adapted to successfully count fish passage within the Spey (Johnston & Ransom, 1994; Steig, Ransom & Johnston, 1995).

Following this initial assessment the Board was enormously fortunate, via the Spey Research Trust, to be offered a very substantial donation by the Trustees of the late Martin Wills of Knockando. This not only enabled the Board to purchase an acoustic counter system, but also underwrote the funding for the first six years' development of the equipment. This remarkable endowment has enabled the Spey to take a leading national role in the development of hydroacoustic counting of salmon in fresh water as part of the National Hydroacoustics Collaborative Project. Organisations which have been involved in this project include the Environment Agency, Centre for Environment, Fisheries and Aquaculture (CEFAS, an Executive Agency for MAFF), Fisheries Research Services (FRS, an Agency of the Scottish Executive Environment and Rural Affairs Department, SEERAD) and the Spey Research Trust. An overview and guidelines on all aspects of fish counter operation are presented as a product of the R&D Project W2/037 (Gregory, Bray and Gough (2001[a]) and Gregory, Clabburn, Davies, Gough and Good (2001[b])).

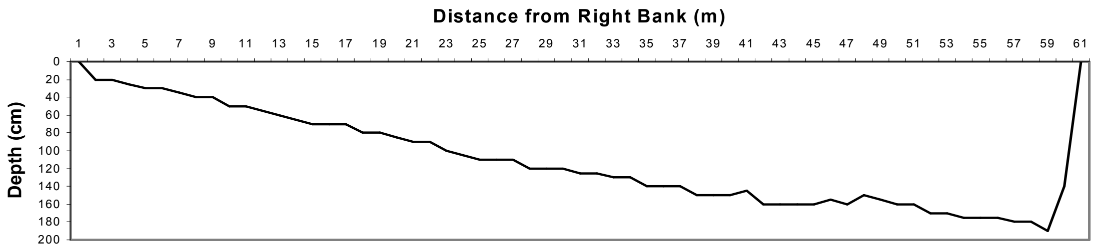
1.2 Site Selection

In 1996 a selection of sites were surveyed to find the most suitable location to install the acoustic counter (Locke, 1996). Seven sites on the lower waters of the River Spey were initially investigated, and the counter was then tested at the three most suitable; Otter Pool and Collie Pot (both Delfur) and Aultdearg (Brae Water). Signal to noise ratios at both Collie Pot and Aultdearg were found to provide the most suitable locations for further long-term deployment of the acoustic counter, and with the kind permission of the Delfur Fishings, the counter was finally deployed in Collie Pot, Delfur.

In Ransom, Johnstone and Steig, 1998, it is stated that an ideal site for riverine hydroacoustic counter deployment should have an acoustically 'soft' (silt to small cobble), gently sloping riverbed, with adequate water velocity but minimum turbulence and entrained air. The site should also have a triangular cross-section.

The Collie Pot site meets many of the criteria required for establishing an acoustic counter. The flow remains laminar through a range of conditions, the cross section of the river is triangular in profile (Figure 1) and at most times of the year fish do not appear to mill around at the site. However, the riverbed is rough, consisting of boulders and cobbles, and this reflects the acoustic signals. This results in a gap between the riverbed and the acoustic beam through which salmon can pass undetected.

Figure 1 - Depth profile of the river transect at Collie Pot, measured at 1m intervals during 2000.



1.3 Comparison with an Independent counting method (North Esk Trials)

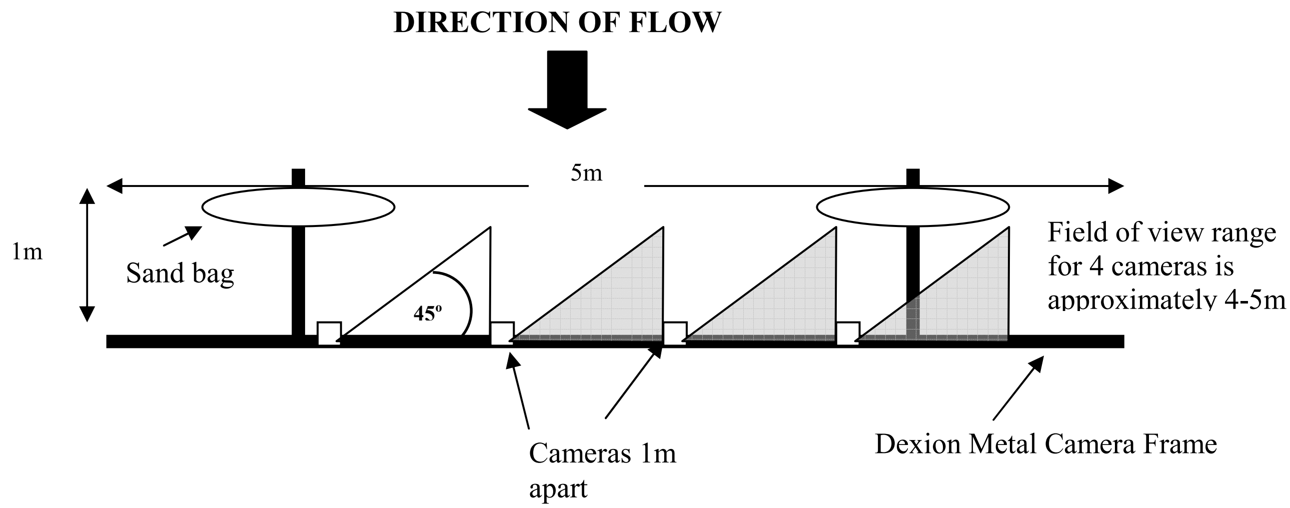
The River Spey acoustic counter was deployed in close proximity to an established resistivity counter at Logie, on the River North Esk, in July 1996, to assess how accurate the acoustic counter was at counting fish. A comparison of the fish counts detected using the acoustic counter, resistivity counter and closed-circuit television (CCTV) system revealed that the poor shape of the site and the high background noise levels substantially reduced the acoustic counter detection rate. The trial was unable to determine the accuracy of the acoustic counter; as fish were able to pass undetected through an area between the bottom of the acoustic beam and the riverbed. However, fish movement patterns were similar on all three systems (Bray, Laughton, Laburn & Simpson, 1996).

1.4 Video Validation

As with all fish counters it was recognised early on in the project that an independent monitoring system to assess the problem of fish passage outwith the beam would be required to validate the acoustic counter. Validation is the process by which the detection rate of a fish counter (how many of the targets it counts are actually fish targets and how many fish targets it did not count) is quantified and the counter errors assessed spatially, temporally and over a range of flow conditions (Gregory *et al*., 2001[b]).

In 1997, three different underwater camera systems were tested within the area of the acoustic beam to monitor fish (Paterson, 1997). The most useful set up was found to be an arrangement of four small cameras mounted in a row and tilted at 45^{o}, as shown in Figure 2.

Figure 2 – A plan view of the dexion metal camera frame with 4 side view cameras.



A protocol was designed to ensure that the video footage represented the day-to-day variation within the river. This validation protocol has been constantly modified and updated throughout the entire acoustic counter project and currently one hour of video is selected at random throughout the hours of daylight. An attempt to monitor fish passage during darkness using infra-red was also attempted but further work to improve this technique is required.

1.5 Long-term data sets

After the establishment of a suitable site and the development of a video validation methodology the main focus during 1998 was to collect a continuous run of data on fish passage (Good, unpub.). This more closely resembles the operating procedure and the type and quality of data generated if the counter is to be used in the routine management of the River Spey salmonid stocks.

Regular testing of the equipment using a standard target indicated the counter was operating within required parameters and regular monitoring of the relative positions of cameras and transducers were carried out. Criteria for processing the raw data collected were established. This period indicated that the operation of the counter required two fully trained operators to effectively manage data collection and processing.

1.6 Flat bed resistivity counter

In 1999, a flat bed resistivity counter was installed beneath the acoustic beam, to determine whether an additional counting device could improve the counter detection rates (Brotherston, 2000). The swimming height of these fish was also investigated to determine whether many fish were swimming below the beam and therefore were not being detected. A comparison of upstream fish counts detected by the acoustic counter, resistivity counter and video footage revealed that on occasion fish were detected by all three systems simultaneously. However, the resistivity counter detected the passage of upstream fish not detected by the acoustic counter because they passed between the acoustic beam and the riverbed. The small increase in detection rate using the two counters, however, did not justify the extra time and effort required to install and maintain the flat bed resistivity counter within the main stem.

Information gained from the project indicated that the mainstem of the River Spey was not an ideal location for this trial because the riverbed was too wide and deep to ensure all fish were detected by at least one counter. However, it is recommended that using these three detection methods in a smaller riverine location such as one of the River Spey tributaries may be more successful.

1.7 River bed modification

Information gained from the acoustic counter, video footage and in-river works indicated that there was an area between the river bed and the acoustic beam through which fish could pass undetected. Following the success of a sandbag installation on the river bed of the Fraser River, Canada (Enzenhofer and Olsen, 1996), a sandbag mat was installed in July 2000 to ensure that the bottom edge of the acoustic beam was a close fit to the river bed and to reduce the amount of reflective noise generated by the substrate. Initial installation was successful and an area 5m by 10m was covered in a condensed mat of sandbags. Cameras were embedded between the sandbags to validate the acoustic counter and monitor the success of the sandbag installation.

The sandbag mat was successful in reducing the area through which fish can pass undetected and would be useful in future acoustic sites. For future installations a sandbag mat which covered the entire width of the riverbed is recommended.

1.8 2001 Review

The volume of raw data collected during the operation of the acoustic counter requires a substantial amount of time to process and further analysis of the data is necessary to produce information on overall fish passage. To collate and assess the large quantity of acoustic data whilst running the counter would have been difficult due to time demands. It was therefore decided not to install the acoustic counter in the River Spey during 2001 to allow time for a fuller, detailed analysis of the past six years' counter data.

An initial review of the data revealed that the most useful long-term data sets were those collected in 1998, 1999 and 2000. Prior to this, the counter was very much in a trial phase and any data collected should be treated with extreme caution. A large amount of time was required to accumulate the different categories of data and transform them into a more manageable format. Additional environmental data was obtained from the Scottish Environmental Protection Agency (SEPA) (*pers. comm.* Ron Murdoch, 2001).

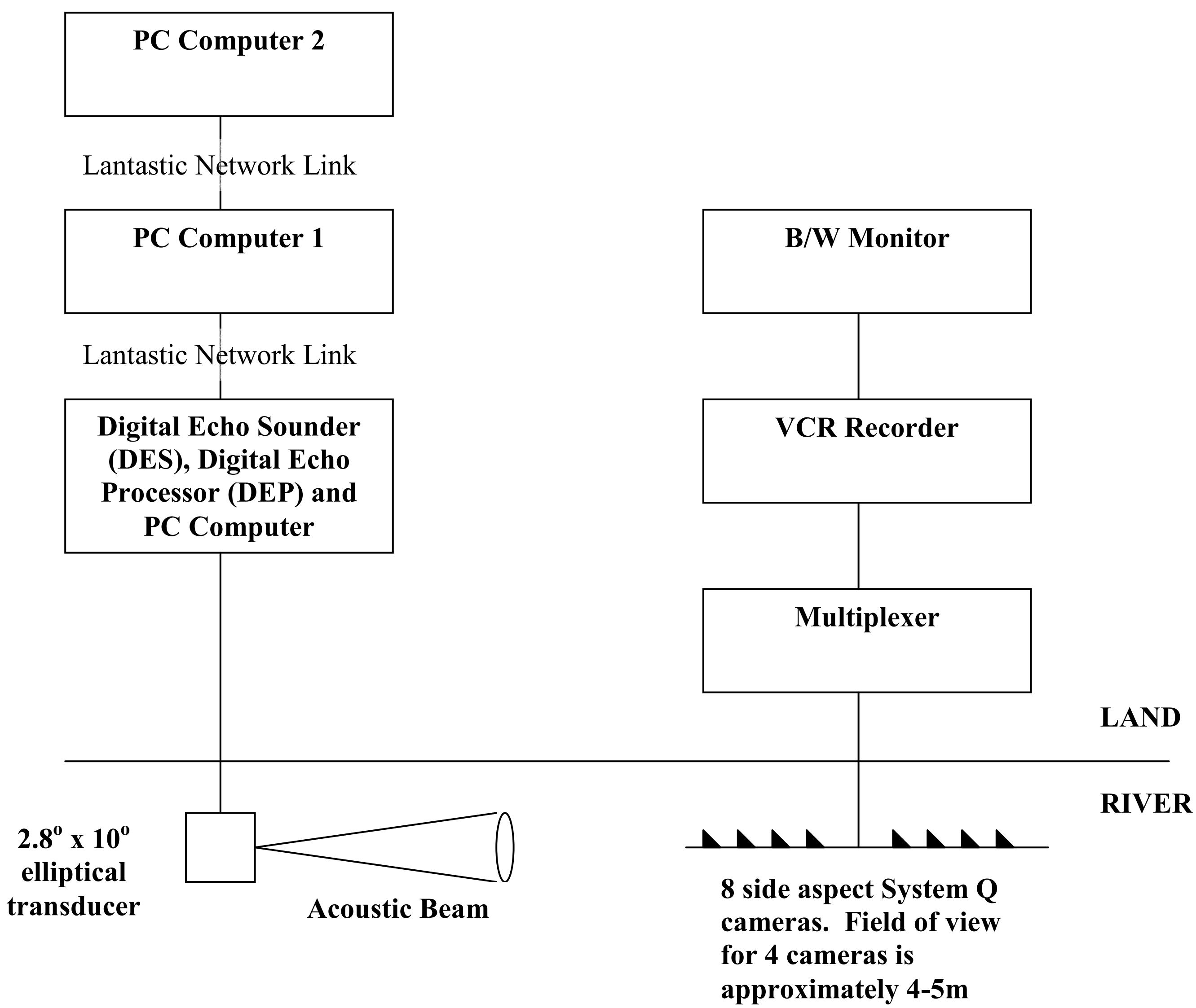
The results published in this document represent a sample from all the information gained during the three-year period, 1998 to 2000. These results indicate that the amount and quality of information gathered from the hydroacoustic counter project would be invaluable to the future management of the River Spey by the Spey Fishery Board, if funding were available.

2.0 Operational Procedure

2.1 System Operation

The equipment used during the past six years has been upgraded systematically when required. The most recent model of counter in use in the River Spey is an HTI model 243-split beam hydroacoustic system. Figure 3 is a schematic representation of the pieces of equipment, which form this system and also the pieces of equipment required for video validation.

Figure 3 - Basic River Spey Hydroacoustic System. All equipment was housed in a mobile unit located on the right hand bank at Collie Pot. A rotator was periodically used to position the transducer. PC Computer 1 was used for data collection and processing, and PC computer 2 was used for data processing and data storage.



Electrical signals are sent from the digital echo sounder (DES) to the transducer which converts them to sound pulses. Returning echoes, from fish or other items passing through the beam, are received by the transducer, converted to electrical signals and sent to the digital echo processor (DEP). The DEP contains software programmes, which allow the system to operate, analyse the returned acoustic information, and allow visualisation of the process by means of an echogram. These echograms and all associated data recorded at this time are collectively known as **raw data**.

Configuration files within the software programmes are set up to allow acoustic thresholds and fish tracking parameters to be set, below which a target will not be detected. These parameters enable the counter to detect fish greater than approximately 45cm in length.

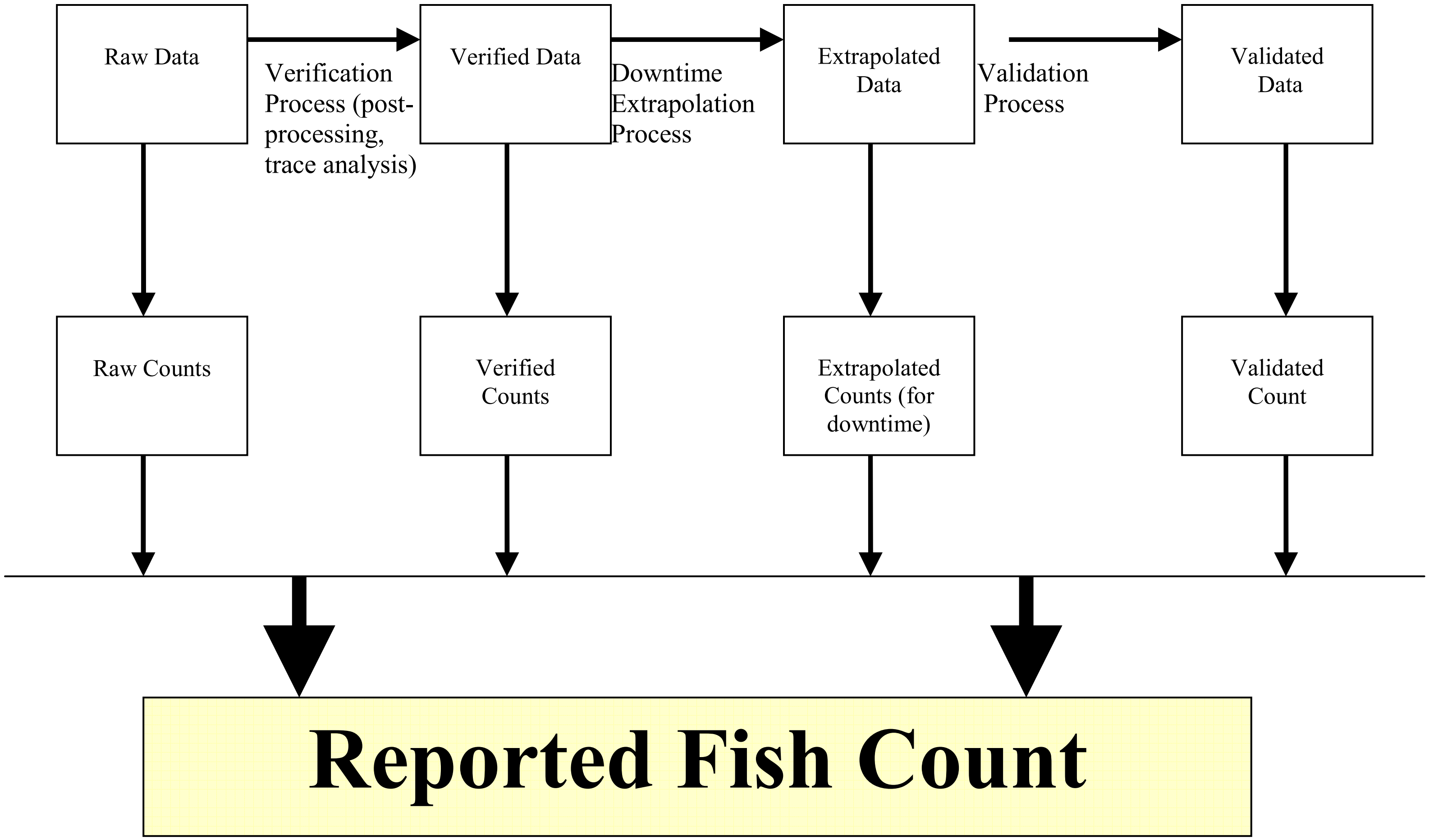
The automated method for tracking fish is not very reliable, and it is therefore necessary to manually process all the raw data files. This processed data produces information on fish numbers and upstream moving fish are distinguishable from debris and downstream moving fish. Numbers of salmon and large sea trout are combined, as the acoustic counter is unable to recognise individual species. The **verified count** is generated from this count of upstream salmon and sea trout only. Numbers of downstream fish are not meantime analysed further as there are currently difficulties in distinguishing between downstream moving fish and downstream moving debris and entrained air bubbles.

Counts are then corrected for any downtime (described in more detail in Results, p11) that occurred during data collection, to produce an **extrapolated count**. The count is then further corrected for any non-target species, which is known as the **false count rate**. There are no known alternative fish species present in the River Spey in numbers significant enough to effect the fish count other than salmon and sea trout, therefore the false count rate is considered negligible.

A **validated count** of fish is obtained through video validation. Video footage was collected using eight side aspect System Q underwater cameras. These were placed beneath the acoustic beam to detect fish passage through the acoustic beam. Verified counts, detected by the acoustic system, are matched with video recordings of upstream fish made at the same time. This comparison between two individual counting devices also enables the target detection rate to be calculated.

Having corrected the validated count for all these variables, a **total validated count** is generated. This gives an indication of the approximate total number of fish passing the counter upstream during a specified amount of time. The generation of the total validated count is represented by a series of equations (Equations 1 to 4) and diagrammatically (Figure 4). The following assumptions regarding the camera operation are made; the camera system detects 100% of the fish passage within a 5m range, the operation occurs in the optimum river conditions and that there is no human error involved in either the video validation or the processing of the data. These errors have been investigated and corrections can be applied, although they are not included in the current report.

Figure 4 – Diagram illustrating the processes fish counter data passes through to produce fish counts. Numbers can be produced at any stage and for management purposes it is important to understand to which processes the data has been exposed. Reprinted with kind permission from Gregory *et al*., 2001[b].



Equation 1 – Total validated count:

$$\textbf{Total Validated Count} = \Sigma_i (EC_i - (EC_i * Fc_i)) / D_i$$

Where EC = Extrapolated count, extrapolated for any downtime and sub-sampling
FC = False count rate
D = Detection Rate
i = 1 to n
n = number of validation cells

Equation 2 – The extrapolated count can be expressed in the following equation:

$$EC_t = (DH_t * \text{Fish per hour}_t) + VC_t$$

Where DH = number of hours of downtime
VC = verified count
t = time period

$$\text{Fish per hour}_t = VC_t / OH_t$$

Where VC = Verified count
OH = Number of hours for which the counter was operational
t = time period e.g. one month

Equation 3 - The false count can be expressed in the following equation:

$$\text{False Count (FC) rate for given ValidationCell} = (F_{atn} / (F_{atn} + F_{at}))$$

Where F_{atn} = Total number of non-target species observations recorded (from video).
F_{at} = Total number of target species observations simultaneously recorded by the fish counter.

Equation 4 - The target detection rate can be expressed in the following equation:

$$\text{Detection Rate (D) for given Validation Cell} = (F_{at} / F_v)$$

Where: F_v = Total number of target species observations recorded from video.
F_{at} = Total number of target species observations simultaneously recorded by the fish counter.

3.0 Results

3.1 Data Collection

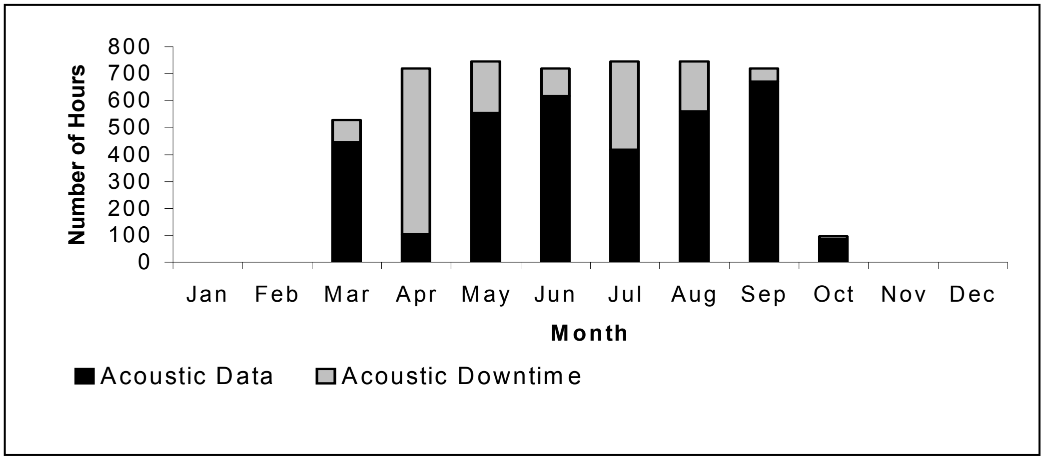
14,402 hours of acoustic counter data were collected between March 1998 and October 2000, 55% of the total number of hours available for data collection. During the remaining 45%, data was not collected (downtime). Downtime is defined as the period of time when the counter is *in situ*, but data is not collected for a variety of reasons. The majority of downtime during this project was due to equipment or power failure, and / or flooding at the site. In severe flooding the counter was removed from the site to a safe location.

Approximately 75% of the available data hours were collected each month during 1998, 1999 and 2000 as shown in Figure 5. In 1998 the counter was installed on 10th March and removed for the winter on 7th October. During this period a large spate reduced the data collection in April to only 14%. In 1999 the counter was installed on 12th March and removed on 12th November. The amount of data collected in June was significantly reduced due to frequent power failures. This was subsequently resolved with the purchase of a new generator. In 2000 the counter was not installed until 16th May due to other project commitments and high water levels and the counter was removed on 10th October. The percentage of data hours collected for 1998, 1999 and 2000 are listed in Table 1.

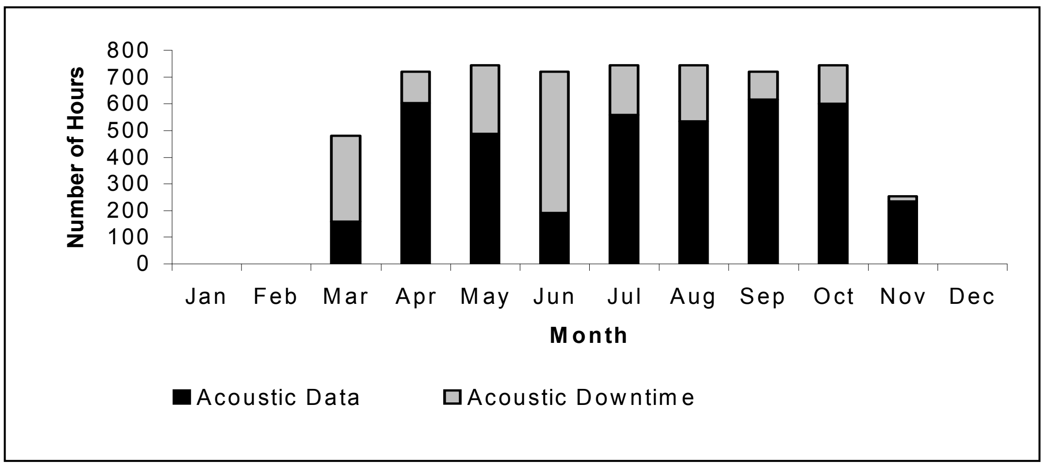
Table 1 – Percentage of hours collected during 1998, 1999 and 2000.

Month	Amount of Data Collected (% of hours available)		
	1998	**1999**	**2000**
March	84	33	
April	14	84	
May	74	65	71
June	86	26	84
July	56	75	81
August	75	72	62
September	93	85	58
October	88	81	37
November		93	

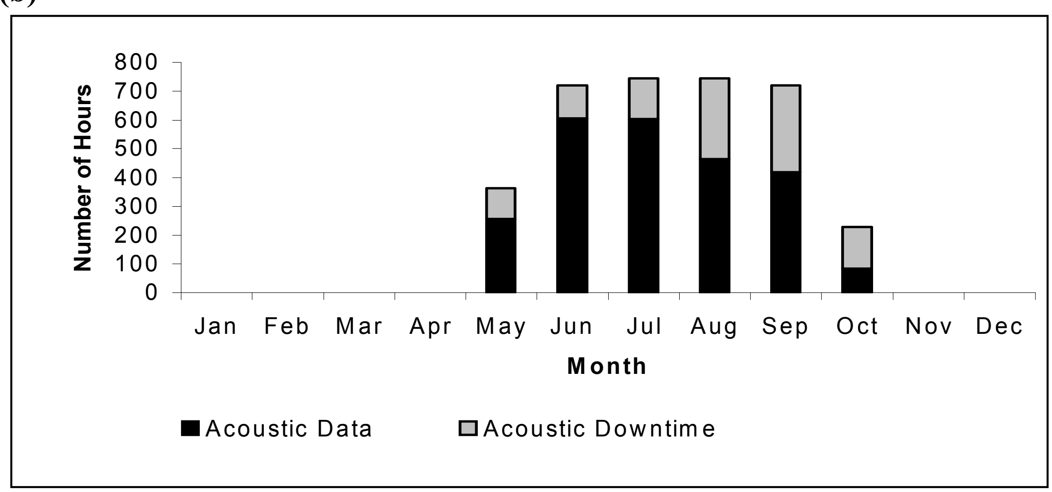
Figure 5 – Comparison of the amount of data collected and the amount of downtime incurred during (a) 1998, (b) 1999, and (c) 2000.



5(a)



5(b)

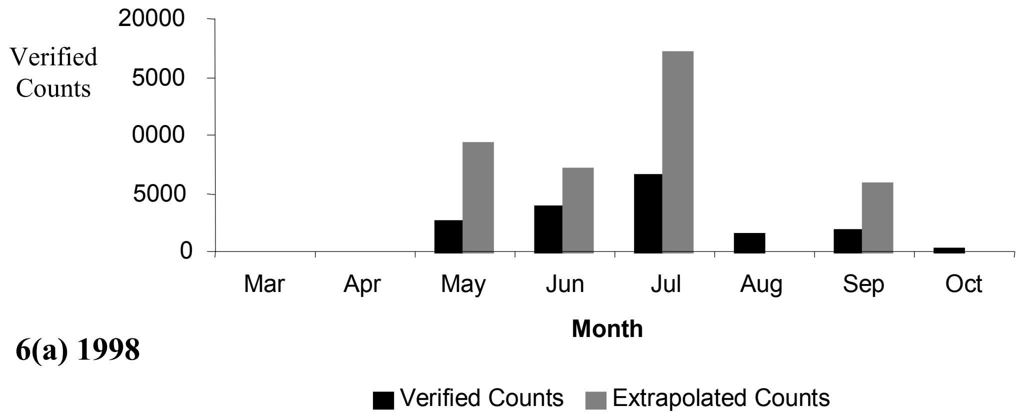


5(c)

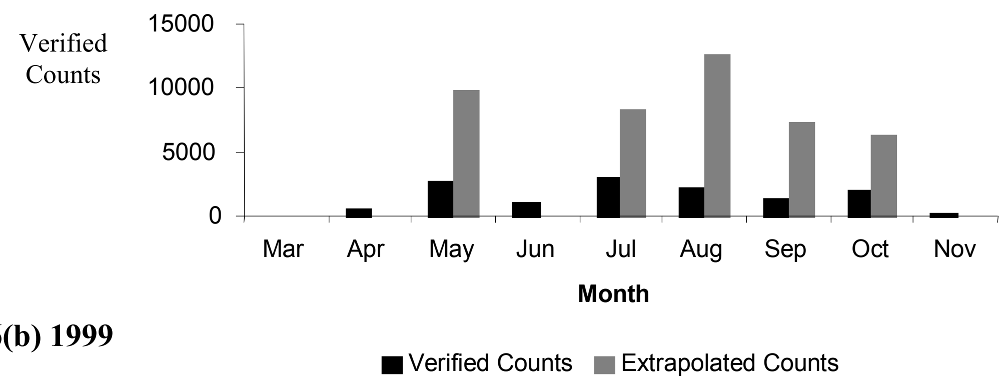
3.2 Daily Upstream Fish Passage

A comparison between the verified count and the subsequent total validated count in Figure 6 shows that in 1998 and 2000 numbers peak in July, whereas in 1999 fish numbers peak in August. There is no total validated count for August 1998 and June 1999 because no video footage was recorded due to problems with the camera equipment.

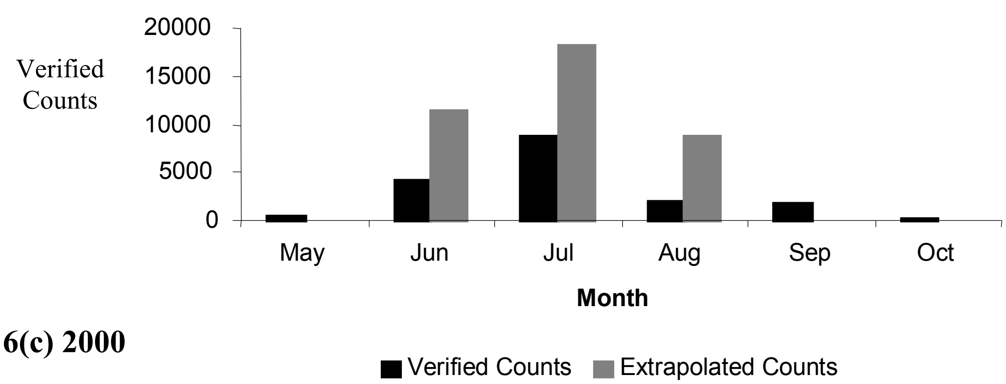
Figure 6– Comparison between verified counts (upstream) detected by the acoustic counter and the total validated count calculated from extrapolated data for (a) 1998, (b) 1999 and (c) 2000.



6(a) 1998



6(b) 1999



6(c) 2000

3.3 Rate of Upstream Fish Passage

Figure 7 – Rate of upstream fish movement (number of verified fish / hour) at Collie Pot, River Spey, during 1998, 1999 and 2000.

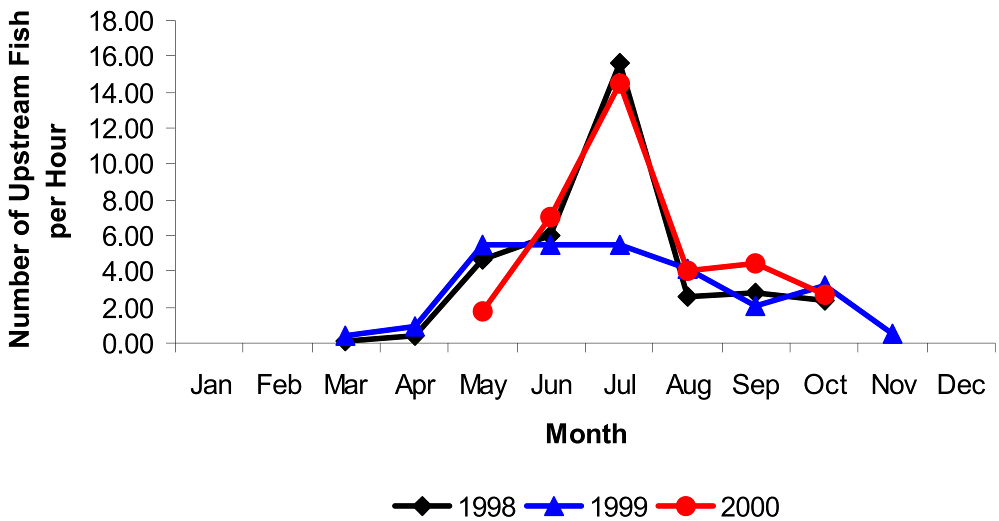


Figure 7 shows the variation of upstream fish passage (number of verified fish / hour) during 1998, 1999 and 2000. The rate of upstream fish passage in March and April is similar during 1998 and 1999. In May the rate is again similar for 1998 and 1999, however the rate during 2000 is considerably lower. During the month of June, the rate of upstream fish passage is similar for 1998, 1999 and 2000. In July 1998 and 2000 peak fish passage rates were recorded. The rate for 1999 during July shows no increase, and is slightly lower than the rate for June 1999. During 1999, the rate of upstream fish passage peaks during May, despite the maximum number of verified fish per month being recorded in August. The rate decreases sharply in August for 1998 and 2000, and all three years show a similar pattern of fish movement from August until October and November, although fish rates for 2000 are slightly higher than for 1998 and 1999.

Rod catch data is generally used to assess adult salmon and sea trout returns. However, on the Spey the angling season closes on the 30th September each year. Thus, catch data cannot be used to determine runs of fish into the Spey after the end of September. The acoustic counter continues to collect fish passage data and as shown above, reveals that there is still a significant amount of fish movement in October.

3.4 Comparison between rod catch and counter data

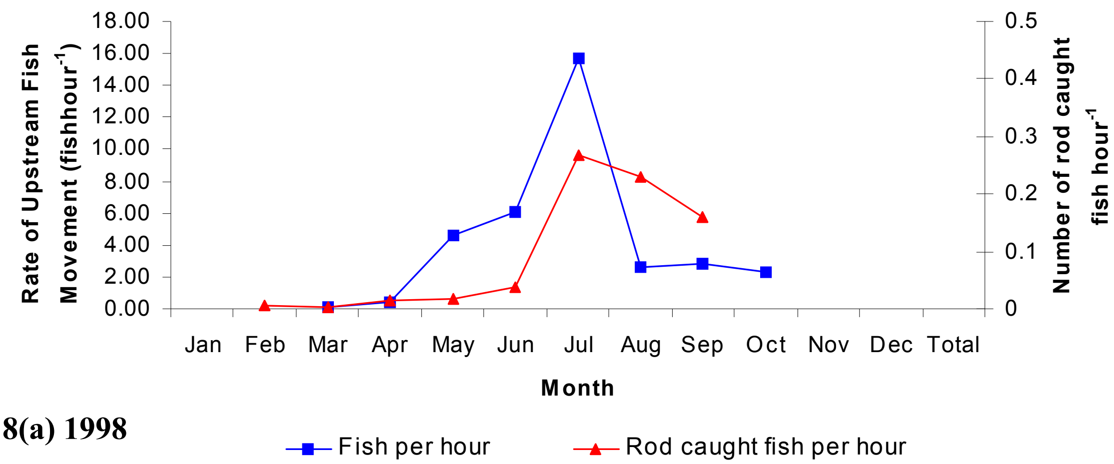
A comparison between the rate of upstream fish movement and catch per unit effort data (CPUE) is presented in Figure 8 as an example of the type of information gained using the acoustic counter. The rate of upstream fish movement is calculated using the number of verified fish per hour. Catch per unit effort is defined as the number of rod caught fish per hour within a specific area of the river. The CPUE data used in this report has been collected from the nearby Delfur beat and processed by the Spey Research Trust and Fisheries Research Services. Further details on this study are available in Smith, Laughton and Dora (1996).

The correlation between the two data sets is close. During 1998 and 2000 the rate of upstream fish movement detected by the acoustic counter and the rod catch per hour show a similar pattern. Both increase slightly in June, and peak in July. The rate of fish movement is then greatly reduced during August and remains fairly constant during September and October whilst the rod catch rate decreases more gradually during August and September.

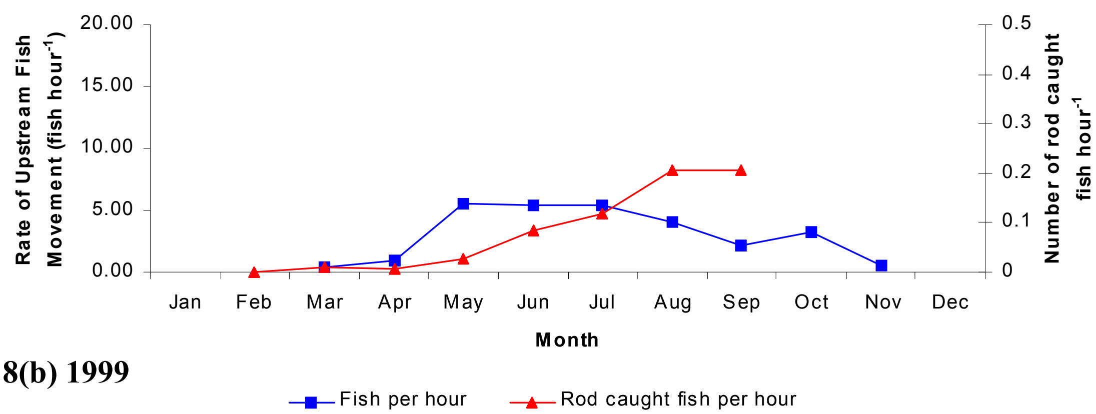
During 1999 however, there is no peak shown during July. The rate of upstream fish movement increases slightly during April and May and remains fairly constant throughout June and July before gradually decreasing in August and September. There is a slight increase in upstream fish movement in October but the rate decreases during November. The rate of rod caught fish remains low during February, March and April before gradually increasing from May until September.

This correlation of results indicates that both methods provide a useful index of fish passage, however, CPUE generates less quantitative data than the acoustic counter. CPUE statistics do not account for stock components that may enter outwith the angling season, or for temporally variable levels of stock migration and exploitation. Catch statistics also do not take into consideration the effect of certain conditions, for example, elevated flows and turbid water, which may reduce the opportunity for angling to occur. CPUE statistics are increasingly less reliable as restraint methods are introduced to reduce catches and exploitation (Gregory *et al.*, 2001[b]).

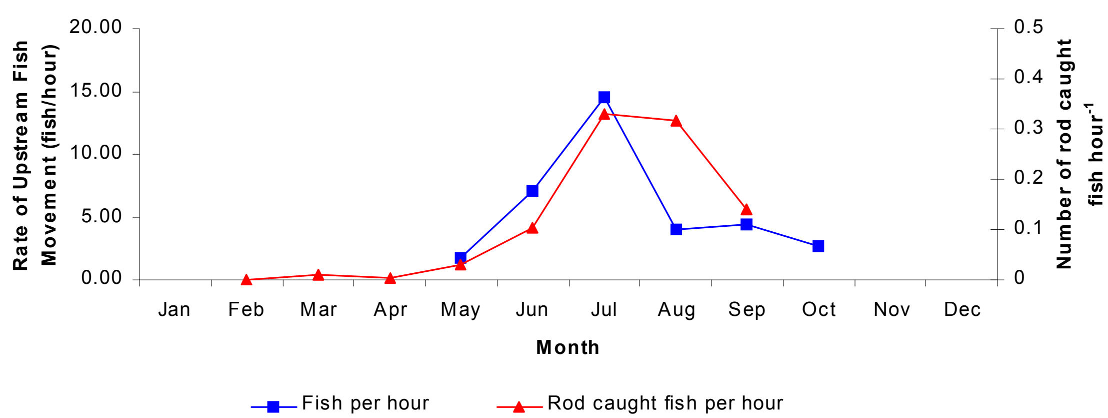
Figure 8 – Comparison between upstream fish movement recorded by the acoustic counter and the catch per unit effort statistics (CPUE) for Delfur beat, River Spey during (a) 1998, (b) 1999 and (c) 2000.



8(a) 1998



8(b) 1999



8(c) 2000

3.5 Environmental Data

3.5.1 The effect of river discharge rate on upstream fish movement

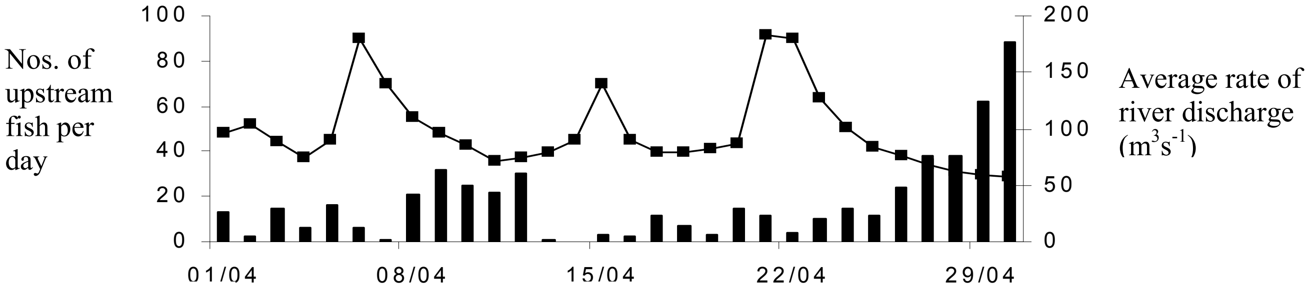
The river discharge rate was obtained from the Scottish Environment Protection Agency (SEPA), which was recorded at 15 minute intervals at the Boat O'Brig gauging station, located approximately 1km downstream of Collie Pot.

A number of authors indicate that upstream salmon movement increases following an increase in water flow (Alabaster, 1970), although there is no tendency for the same flow to be used by fish all year round. Figure 9 provides some examples of this from the acoustic data collected on the Spey. As the water flow gradually decreases following a small spate on 22nd April the number of upstream fish detected by the acoustic counter increases. During May another small increase in upstream fish movement occurs following a rise in water flow on the 13th May. The lag time between an increase in water flow and fish movement may be dependent on where the fish are moving from and the amount of distance that is travelled.

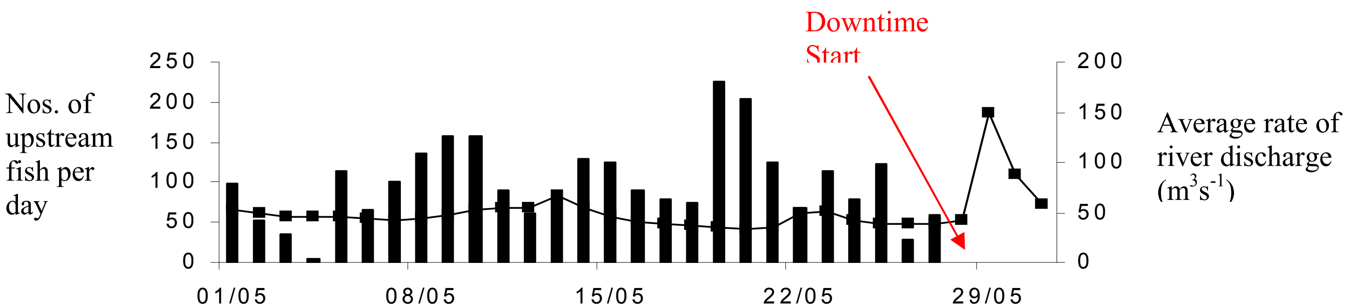
As well as showing the relationship between fish movement and water flow, Figure 9 also shows the relationship between increased water flow and downtime. On several occasions spate conditions resulted in equipment and / or power failure. During 28th May the increased water flow caused the acoustic counter to crash, and no further data was collected until the 21st June. On 26th August a small increase in water flow also resulted a counter crash.

During these spate conditions data hours have often been lost due to equipment failure and for a significant period after the spate, no data has been collected. The data lost following a spate is of great significance as it is during this period of flow that fish movement is often increased. The verified count detected by the acoustic counter may therefore under represent fish numbers and produce a reduced Total Validated Count.

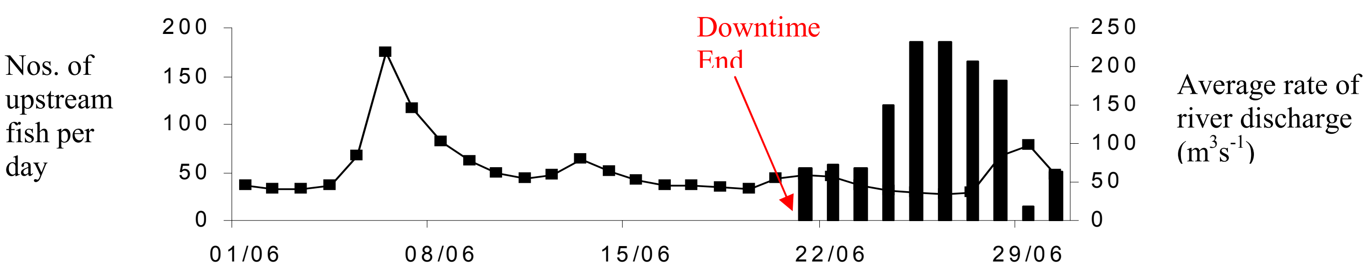
Figure 9 – The relationship between daily upstream fish movement and mean water flow during 1999 for (a) April, (b) May, (c) June and (d) August. Areas of downtime caused by high flow rates are indicated by red arrows. ▬, Numbers of upstream fish per day; —■— Average rate of river discharge (m^3s^{-1}).



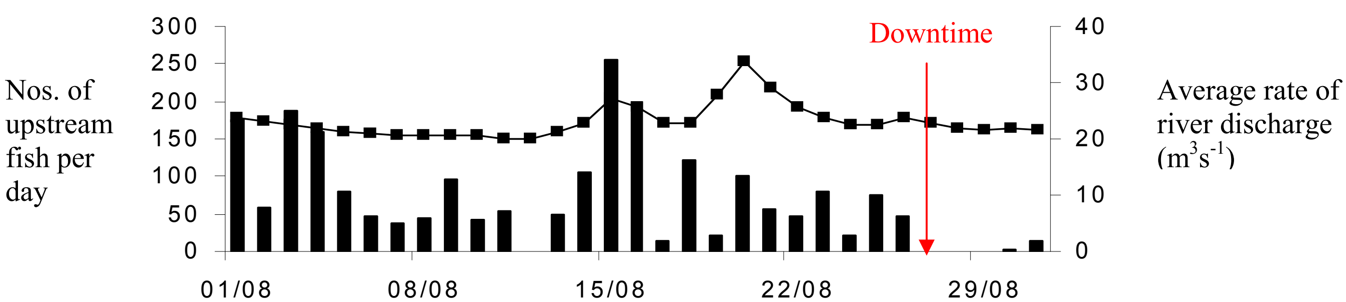
9(a) April



9(b) May



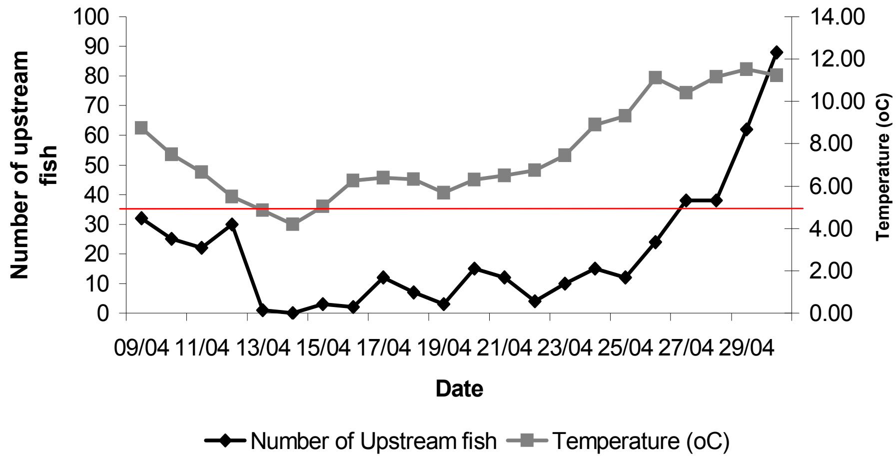
9(c) June



9(d) August

3.5.2 Effect of Water Temperature on Upstream Fish Movement

Figure 10 – The relationship between minimum temperature threshold (5°C) and upstream fish movement. The red line indicates the 5°C threshold, below which fish are known to reduce their activity.



From Figure 10 it is apparent that the gradual decrease in temperature to below 5°C coincides with a decrease in the number of upstream fish detected by the acoustic counter. As the water temperature increases above 5°C, the number of fish detected by the counter also increases. This is similar to the findings of Jensen, Johnsen and Hansen (1989) who indicate that excessive movement in low water temperatures may use up a large amount of energy reserves. This may be costly to the fish in the long term by reducing spawning success. Menzies (1939) as cited in Jensen *et al.*, (1989) reports that salmon in the River Spey would never proceed beyond 15 or 20 miles from the head of the tide when the temperature was below 4.5 °C.

4 Counter Location

4.1 Collie Pot

The Collie Pot site, located 1.6km south of Boat O'Brig was selected for establishing an acoustic counter because it meets many of the criteria required within a riverine environment (Locke 1997).

As work has progressed there has been an increasing need to ensure that the counter is consistent and not missing many upstream fish passing through the beam. This accuracy is however being compromised by a number of logistical problems which have been uncovered whilst working at Collie Pot.

The river bed substrate at Collie Pot, in common with large areas of the River Spey main stem, is rough, consisting of boulders (greater than 25cm) and cobbles (between 5cm and 25cm). This reflects the acoustic signals and generates a large amount of reverberent 'noise' which masks traces of fish passage. To minimise this noise the beam is lifted away from the riverbed. However, this results in a gap between the riverbed and the acoustic beam, through which, fish can pass undetected.

In addition the surface of the riverbed is not smooth and there are channels through which fish can also pass undetected. To ensure a good beam fit and a smooth non-reflective riverbed an area of $50m^2$ was covered in sandbags beneath the acoustic beam in 2000. The introduction of this sandbag mat did reduce the amount of reflected noise and the amount of space between the riverbed and the acoustic beam. Initial problems were encountered with the camera frame protruding into the beam but this was solved by placing the cameras between the sandbags, flush with the surface. Any further development of the counter would benefit from the use of sandbag mats to smooth the riverbed.

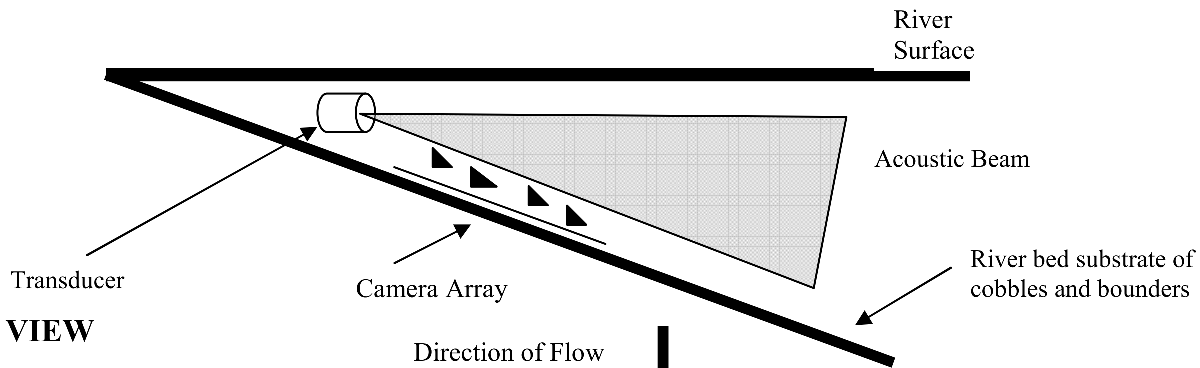
4.2 Equipment Displacement

The nature of the riverbed substrate also creates problems with the risk of equipment being moved by increased water flows whilst *in situ*. There are several pieces of equipment such as the transducer and cameras within the river at one time, and all are required to work together to detect fish movement (Figure 11). No permanent features such as bedrock are present to anchor the equipment to, so instead the equipment is secured on frames and anchored with a number of sandbags (Figure 12).

During increased flows and spate conditions, these sandbags are often not enough to maintain the relative positions of the equipment. The transducer and/or the cameras may be shifted or tilted downstream and this introduces a degree of variability when collecting the data. Analysis of the data involves a comparison between counts recorded by the acoustic counter and fish detected by the cameras. If both pieces of equipment have been moved by an unknown amount during fast river flows it becomes very difficult and often inappropriate to compare the two data sets.

Figure 11 – Typical river set up of transducer and mount. A. Side View, B. Plan View.

A. SIDE VIEW



B. PLAN VIEW

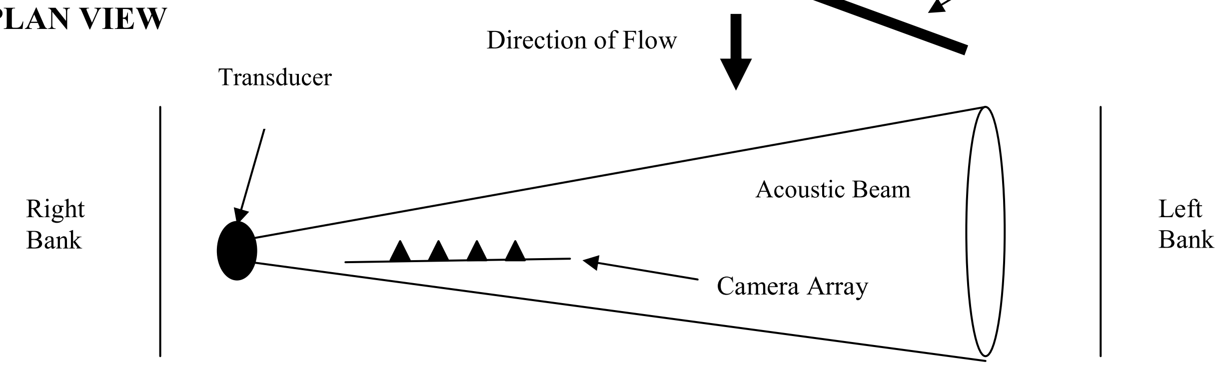
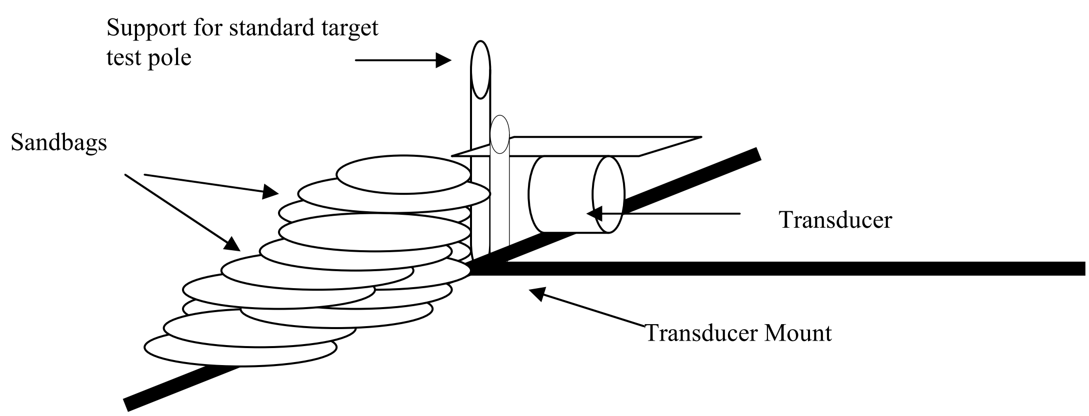


Figure 12 – Acoustic Transducer and mount. The mount and support for the standard target test pole are made of scaffolding poles.



4.3 Site Flooding

A disadvantage of the Collie Pot is its location within an area renowned for localised flooding problems. The counter equipment is kept in a mobile unit on the right hand bank, so that it can be easily removed when required. However, this results in valuable data being lost during periods of elevated flow.

5 Operation of the Acoustic Counter

5.1 Labour Requirements

A minimum of two staff is required to manage the day to day running of the acoustic counter. This is a health and safety requirement but is also necessary to maintain effective data collection and processing.

As with all fish counters, the acoustic counter requires calibration, validation, routine interrogation, downloading and detailed data analysis. Analysis of the acoustic data is very labour intensive and requires a high level of expertise and training to accomplish. Similarly the analysis of video data is also very time consuming and requires a high level of expertise. Acoustic data and video hours are collected as constantly as possible to build up a good long-term data set and an unmanageable backlog can very quickly accumulate if not analysed on a regular basis. To produce information on overall fish numbers and movement whilst running the counter is difficult due to the time demands of each area, unless at least two members of staff are available.

5.2 Equipment Requirements

The logistical problems outlined above with the Collie Pot site must be considered if the accuracy of the counter is to be improved. Installation of a structure to ensure that the counter is fixed to one spot or relocation of the counter to a structure that is already permanently fixed in the river (such as a bridge support) will be necessary to ensure the quality of data is further improved. Engineers have been contacted to review this.

Depending on the chosen location of the counter, an additional transducer may also improve coverage of the entire river width. Operation of a second transducer would minimise the areas through which fish could pass undetected and increase the accuracy of the counter. HTI has provided estimates for an additional transducer.

The existing cameras have reached the end of their life span due to internal condensation problems and are no longer adequate. Their replacement is considered important to allow ongoing validation of the counter. Suppliers have been contacted for costs of suitable replacements. Development of in-river mounts for the cameras is also required.

5.3 Data Management

The data generated by the acoustic counter is processed in a number of ways using programmes such as Microsoft Access and Microsoft Excel. Storage of the data generated by the acoustic counter is now in the form of a database, Anaconda, which has been designed and standardised specifically for use with riverine acoustic counters. Once the various pieces of data are entered into the database, not only are they stored in a manageable form, they can also be analysed further. This database has now reached a format, which has been adopted for use by members of the National Hydroacoustics Collaborative Project throughout the UK.

Due to the large amount of raw and processed data produced from the acoustic counter project a strict back-up procedure must be followed to ensure that no data is lost. Raw data is transferred to a number of computer workstations during its collection. Once processed, the data is stored on a computer hard drive and copied to two CDs. These CDs are stored in separate locations, one in the Spey Research Trust office and one in another independent location.

6.0 Recommendations for Site Location and Development

Deployment of the hydroacoustic system in the present location at Collie Pot has enabled collection of a large amount of information over the past six years on the upstream movement of fish in the main stem of the River Spey. It is now possible to calculate the detection rate of the counter with the aid of the underwater camera system and apply a range of correction factors to obtain a total validated count of upstream salmon and sea trout combined. However, a number of limitations are currently known to reduce the detection rate of the counter.

Three different recommendations are discussed below to further the development of the Spey counter. Where possible an estimate of the funding needed is also included.

6.1 Option 1

Option 1 is to continue running the acoustic counter and cameras at Collie Pot, with no major alterations to the site or purchase of any additional pieces of equipment, although, the underwater cameras have reached the end of their life span and will require replacement. The operating procedure, site and set up are well known for Collie Pot and collection of data could begin again straight away. Continuing to operate in this manner would provide a useful indicator of fish trends. It is unlikely, however, that the detection rate of the counter could be further improved if Option 1 is selected, since flooding and the risk of in-river equipment displacement are known to be major disadvantages of the present set up.

Funding would only be required for the day to day running of the acoustic counter site and for the maintenance of the existing equipment. The costs for Option 1 would be approximately £40,000 for the first year, and £38,000 for subsequent years, see Table 2.

Table 2 – Costs for Option 1

Description	Cost (£)
8 low light monochrome cameras with 12 LED's & 100m cable per camera, Bowtech Products Ltd.	1263.00
Video Grabber Unit, Bowtech Products Ltd.	235.00
Salaries for two full time personnel	28000.00
Vehicle and running costs	6000.00
Miscellaneous running costs	2000.00
Equipment upgrade and maintenance	2000.00
TOTAL (1st year)	39498.00
Ongoing costs per annum	38000.00

6.2 Option 2

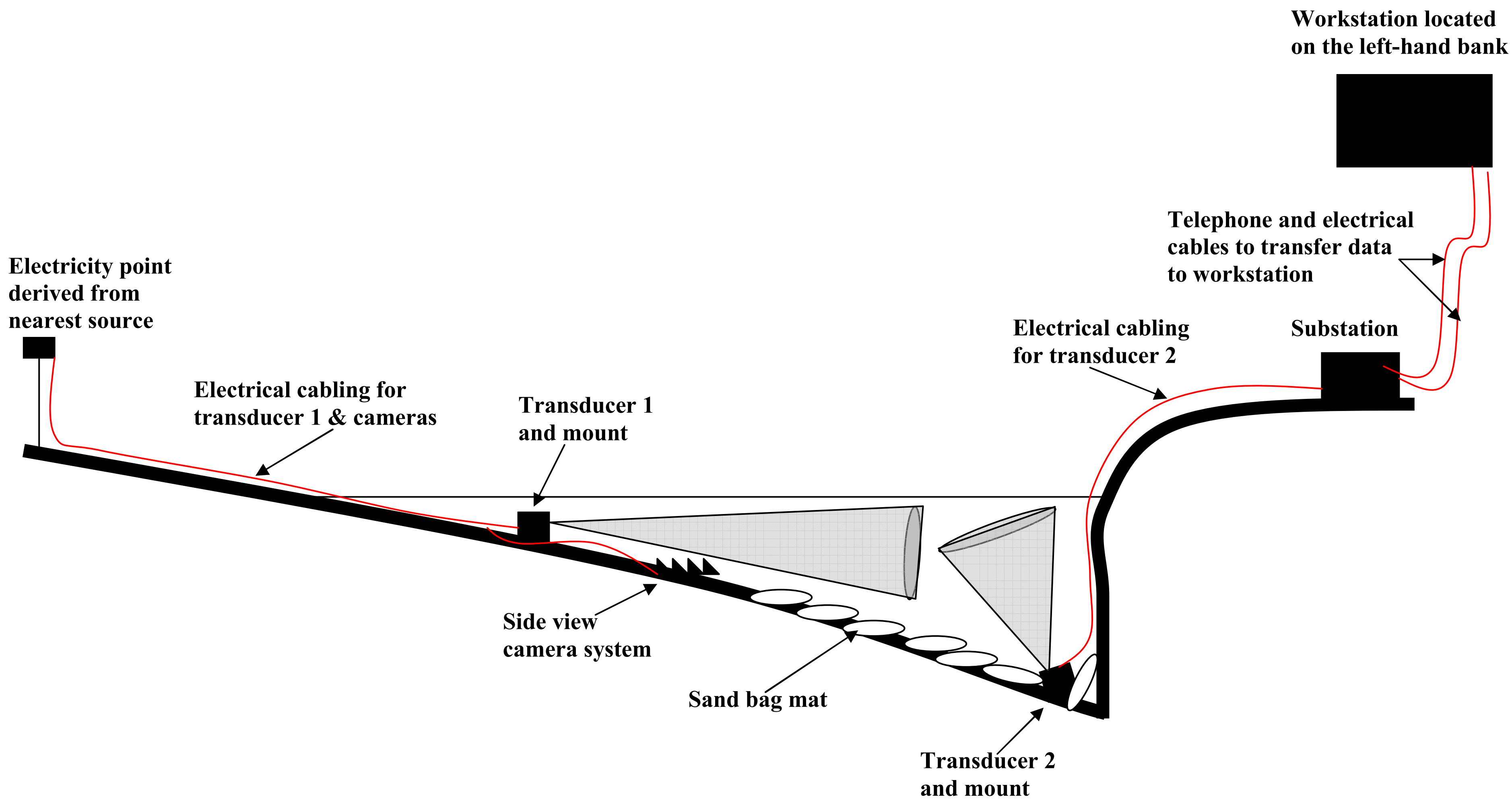
Option 2 is to continue the present operational procedure at Collie Pot but carry out a limited amount of site development to reduce the risk of equipment loss during spate conditions. Relocation of the 'dry' electrical equipment to Collie Pot Farm would ensure that the risk of flooding was minimised and would benefit from mains electricity supply and telephone connection. Construction of a substation would be required as well as the conversion of a farm building into a workstation. Introduction of a telephone line would allow the site to be monitored remotely and require less labour on site. However, in-river maintenance and monitoring would still be required.

The advantages of Option 2 are that the effect of flooding might be reduced, and the operating procedure, site set up and data limits are already known. However, potential in-river equipment displacement would still remain a problem. The costs for Option 2 would be approximately £61000 for the first year, and £38000 for subsequent years, see Table 3.

Table 3 – Costs for Option 2

Description	Costs (£)
Salaries for two full time personnel	28000.00
Vehicle and running costs	6000.00
Miscellaneous running costs	2000.00
Equipment upgrade and maintenance	2000.00
Camera System	2000.00
Construction of substation on left hand bank	10000.00
Modification of a building for a work station	10000.00
Electricity connection on right hand bank	2000.00
TOTAL (1st year plus site set up)	61000.00
Ongoing costs per annum	38000.00

Figure 13 - Cross section view of Option 3, with the workstation situated on the left-hand bank.



6.3 Option 3

Collie Pot, the current counter site, was selected five years ago as the most suitable location to deploy the acoustic counter in the main stem of the River Spey (Locke, 1997). The amount of information gathered over the past six years at this site has provided invaluable experience on counter deployment and the logistics involved in riverine acoustic counter operation. However, the river bed substrate, which is predominantly loose cobble and boulder, and the increasing regularity of flood events reduces the detection rate of the acoustic counter and the amount and quality of data gathered.

Option 3 is to develop the Collie Pot site for long-term counter deployment by carrying out further engineering works and purchasing additional equipment, as shown in Figure 13. Relocation of the 'dry' electrical equipment to Collie Pot Farm would ensure that the risk of flooding was minimised and would benefit from mains electricity supply and a telephone connection for remote monitoring. Construction of a substation would be required as well as the conversion of a farm building into a workstation. Installation of two transducers would ensure that the acoustic beam covered most of the entire width of the site. The additional transducer would be installed at the left-hand bank and subsequently should increase fish detection rate at this site. Substantial engineering works are recommended to ensure that;

a) the site is made suitable for a more long-term installation,
b) both the transducers and the underwater camera systems remain in permanent positions within the main stem to reduce the discrepancies introduced through equipment displacement. Trials to test the best method available would be recommended prior to a full-scale development of the site.

This would reduce the threat of flooding, allow continuous data collection and ensure that data quality was not effected by in-river equipment displacement.

Table 4 – Costs for Option 3

Description	Costs (£)
Salaries for two full time personnel	28000.00
Vehicle and running costs	6000.00
Miscellaneous running costs	2000.00
Camera System	2000.00
Equipment upgrade and maintenance	2000.00
Construction of substation on left hand bank	10000.00
Modification of a building for a work station	10000.00
Electricity connection point on right hand bank	2000.00
Additional tranducer and mount	20000.00
Bed stabilisation plus improved equipment mounts	50000.00
TOTAL (1st year)	**132000.00**
Ongoing costs per annum	**38000.00**

Option 3 would require the greatest amount of funding, not only for the day to day running of the acoustic counter, but also for the different trials at the site and all subsequent engineering works. Capital costs are estimated at £94000 and revenue costs at £38000 per annum.

6.4 Alternative Sites for Counter Deployment

All three options listed above have been designed using Collie Pot as the site location. However, options 2 and 3 could also be applied to another site, which met the criteria required for acoustic counter deployment in the River Spey. Relocating the counter site may be necessary because Collie Pot has altered since the counter was first deployed and the criteria, which made it suitable initially, may now no longer apply.

The site selection survey carried out in 1997 selected Aultdearg, Brae Water, as the second most suitable deployment site after Collie Pot and a recent visit to Brae Water indicated that there may be other potential sites which are suitable for the deployment of the acoustic counter. One advantage to relocating the counter further downstream would be the increased value of the data set. This is because fish in the lower beats would also be included in the count that may otherwise be lost to angling methods.

However, no long-term acoustic data sets have ever been collected in other areas of the Spey and the risks involved in relocating to a new site would have to be considered. The redeployment of the acoustic counter to a new site would not guarantee an increase in the fish detection rate. Also, the problems experienced at Collie Pot may be common to the entire main stem, and therefore relocation to another site might not be beneficial.

6.5 Spey Research Trust Recommendations

In consideration of the costs and data acquired so far, Option 3 is recommended to the Board as the most suitable option. It is recognised that the costs involved are substantial and it may be more practical to undertake the works recommended for Option 2 and gradually carry out the further engineering works recommended in Option 3 over a specified period of time.

The Spey acoustic counter currently detects between 50% and 60% of upstream moving salmonids and this is unlikely to be increased unless the works listed in Options 2 and 3 are carried out. An increase in the detection rate would produce more accurate river-specific data on run timing and sizes, exploitation rates and how these are influenced by flow, which will be essential for future effective and precautionary stock management.

7.0 Recommendations For Use Of The Acoustic Data

The purpose of the acoustic counter has been to count the number of fish ascending the main stem of the River Spey and subsequently provide the Spey Fishery Board with reliable information on which to base their management strategies. As the past years have been regarded as a trial phase, the information that has been collected has been treated with caution due to the sensitive nature of the subject. To date, the acoustic counter is known to detect between 50 and 60% of the upstream fish that pass through the beam. This detection rate should be increased if further engineering works, as detailed in Section 6, were carried out.

The use of acoustic counters within a riverine environment is still a relatively new science, and methods and approaches will constantly be updated as new ideas are introduced. The acoustic counter on the River Spey is one of the leading sites of its kind, and has much information to offer in terms of acoustic counter deployment and management.

Already this project has demonstrated that information gained from the acoustic counter corresponds closely to the information gained from catch records. During this trial phase this is an extremely useful piece of information to have, since it confirms that both the acoustic counter and the catch records provide a useful index of fish passage. However, the acoustic counter collects data in ‘real time’ and requires less time to collate than catch data. Also, ‘Catch and Release’, one of the restraint methods supported by the Board, has become increasingly popular on the Spey and it may prove more difficult to determine the relationship between catch data and stock numbers. Acoustic data however, should remain unaffected.

In the future it will undoubtedly be instructive to install the counter outwith the fishing season when there are no catch records. The counter is particularly needed to gain more information on the Spring run, especially at a time when fish numbers are drastically reduced. It is, however, difficult to deploy at this time due to elevated flows.

During 1998 the acoustic counter detected the movement of smolts downstream. The Spey Counter is unique in these findings and further work on the detection of smolts using hydroacoustic sonar is recommended. This research would provide the Spey Fishery Board with additional information on smolt populations and the status of the different fish populations.

In conclusion, the acoustic counter is an extremely useful tool for the management of salmon and sea trout populations within the River Spey. The last six years of data collection has provided information on riverine acoustic counter deployment and has indicated trends in upstream fish movement and fish numbers. This type of information will become increasingly valuable to the Board as the demand for high quality data increases through the designation of the River Spey as a Special Area of Conservation and in the future with the impending implementation of the Water Framework Directive.

8.0 Acknowledgements

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