The use of Catch Statistics to Monitor Fishery Change

Migratory Salmonid Study - Synopsis

Technical Report
W139

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Publishing Organisation:
Environment Agency
Rio House
Waterside Drive
Aztec West
Almondsbury
Bristol BS32 4UD

Tel: 01454 624400 Fax: 01454 624409

ISBN:NW-03/98-60-B-BBSP

Dissemination status
Internal: Released to Regions
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This report is aimed at fisheries managers and scientists and is to provide an overview of the methods avaialble for collecting and analysing migratory salmonid catch data.

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Amendments
Any corrections or proposed amendments to this manual should be made through the regional Agency representative on the Water Resources National Abstraction Licensing Group.

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EXECUTIVE SUMMARY

The overall objective of the R&D contract was to develop methods for estimating the stock size of migratory salmonids from catch statistics data and to examine new techniques for the collection of this data. However, due to the large degree of varaition in the datasets for a range of underlying reasons, it became obvious that to achieve estimates of stock size would be a difficult goal to achieve. Therefore the project focused towards examining methods for accounting for the variability in the data sets and for estimating trends of runs of fish into rivers. This work was coulped with an examination of the temperoral and spatial variability with and between river systems and the development of alternative data collection methods. As a result of the not being able to derive formulae to estimate of absolute stock size, it was agreed that the title of the project be changed. Outputs for the project are presented for migratory salmonids in R&D Technical Reports W27 and W139 and for coarse fish in R&D Technical Reports W140 and W141.

Compilation and examination of data sets for migratory salmonids were conducted between 1992-94. The historical annual catch records collected by the Water Authorities and National Rivers Authority (NRA) were obtained from the Ministry of Agriculture, Fisheries and Food (MAFF) and further detailed sets were obtained for some individual fisheries and rivers.

Methods were studied for the collection of data from migratory salmonid anglers using techniques analogous to the creel census surveys widely undertaken in the Untied States. A preliminary survey indicated that the encounter rate with anglers who had caught fish was low and therefore a single river was chosen with known popular fisheries for intensive study. The encounter rate of anglers catching fish was approximately 10% and this method would appear to have little value for the Agency as a survey method other than as an aid to the study of specific fisheries. It was concluded that the present method of catch returns for salmon and sea trout offers the most effective and realistic method of collecting data on a national basis. The use of logbooks may be used as a supplement to provide detailed data for specific rivers but should only be used on a regional basis. However, the current distribution systems for the issuing of logbooks needs to be formalised.

The Agency, formerly NRA, inherited a wide range of collection methods of data from net catches of migratory salmonids. This diversity reflected the range of capture methods that have evolved. A standardised data collection method was developed such that a National database could potentially be created. Based on the information currently collected two new catch return forms were produced which were designed for small and large catch net fisheries. It is considered that the new forms when coupled with a scale sampling programme would provide a more useful data set which would allow comparisons to be made on a countrywide basis.

Three approaches to the study of catch and stock size were developed for migratory salmonids:

- An ANCOVA method which allows catches to be assessed and compared with expected values. Of particular interest was an analysis of the effects of flow on angler behaviour and catches. The adjustment of the actual catch size arising from removal of variation arising from effort and flow would allow the true stock availability to be established. This method would have particular potential for the Agency in setting and evaluating spawning / catch targets for individual rivers by the comparison of expected catch, determined by flow, with actual catch. The method once established could potentially provide an assessment technique for the likely affects of flow abstraction and regulation schemes.

- An iterative technique which allows the trends of stock size to be established on rivers where no counting system is available. This provides a simple model estimation method which could be refined further by collection of detailed data to provide benchmark values for a range of input parameters for the model.

- The development of a classification system based on ANOVA techniques. Previous techniques were shown to be unsuitable when different time scales of data were utilised. The method developed showed groupings of sets of rivers based on catch. These rivers were usually geographically close and the similarity of the flow regimes appears to be an overriding factor affecting catch size. Recommendations were provided for further areas of study in the development of classification systems.

All the analytical techniques examined were developed from existing available data sets. Whilst it may be preferable to obtain more detailed data sets this is unlikely to be practicable on a national basis. Specific studies should be undertaken to address specific fishery or river based problems and to provide supplementary information to that presently collected. An important aspect to allow further development of models and techniques for studying migratory salmonid populations is the development of a national database which is accessible to fisheries staff of all regions.

KEY WORDS: Migratory salmonids, Catch Statistics, Population Size, Creel Census, Angling, Flow, Effort

1.0 INTRODUCTION

The R&D Technical Contract W27 was commissioned by the Environment Agency to examine the collection and analysis of catch statistics with a view to deriving formulae and models for estimating stock size. Following consultations with the Agency it was quickly realised that some of the goals of the original contract would be unachievable. This resulted from the combination of difficulties in examining systems with large numbers of variables and an absence of suitable data for some species. For example, it was agreed with the Agency that insufficient data of a suitable quality would be available for eel, grayling and brown trout. Therefore the contract concentrated on examining existing datasets for migratory salmonids and developing collection methods for migratory salmonids and coarse fish.

2.0 COLLECTION OF CATCH STATISTICS DATA FOR MIGRATORY SALMOINDS

The current collection of catch statistics for migratory salmoinds for both rod and net catches relies on three main systems:

- The statutory catch return system for rods and nets
- Agency Logbook Schemes for rods
- Fishery owner records i.e. Wye Owners

The statutory return system has provided a long-term data set for migratory salmonids for both rods and nets. Problems were highlighted with the system in particular with the poor response for requests for returns, changes in collection procedures, under and over reporting of catches and limitations of the detail of data that can be collected. It was concluded the catch return system despite its inherent biases still provided the best long-term data set for migratory salmonids in England and Wales but does not provide the level of data required for more detailed analyses. For example detailed data collected from the Welsh Dee, Wye and Lune have allowed detailed analyses to be undertaken for rod catch data for these systems.

Logbook schemes are a newer collection method and prove useful for the collection of information on a regional or specific river basis. Private owners data often provide the most detailed information but were not always available.

Alternative methods for catch statistics data collection were examined as part of the contract. These were:

1. The application of US type creel census techniques to UK migratory salmonid anglers.
2. Examination of the regional differences in the net catch return system to provided a return form which would standardise collection of these data on a national basis.

2.1 CREEL CENSUS OF MIGRATORY SALMONID ANGLERS IN ENGLAND AND WALES

The creel census technique as a method for collection catch statistics data for rod catches has received relatively little attention in the UK. Even within the United States and Canada, where angler surveys are routinely practised there appears to be few examples of creel survey techniques being used for the biological examination of migratory salmonids populations, for example estimating stock size. Most creel surveys are directed towards the collection of information on angling economics, sociology and angler satisfaction. Therefore the applicability of creel census techniques to UK migratory salmonid anglers was tested to determine the level of information on effort and catch that could be collected.

2.1.1 Preliminary study

A preliminary survey was undertaken on a range of migratory salmonid fisheries in England and Wales. The summary findings of this initial study were:

- The encounter rate with migratory salmonid anglers was low due to low angler densities.
- Few of the anglers interviewed had caught fish and it appeared that the majority of fish were captured by a limited number of anglers.
- Migratory salmonid anglers were well distributed throughout a fishery and do not demonstrate the contagion around access points displayed by coarse anglers.
- The tendency of migratory salmonid anglers to wade in the river hampered the interview process.

2.1.2 Intensive creel census

An intensive study was undertaken on the River Lune following the preliminary study. 17 fisheries on the Lune were available for surveying although interviewing was mainly confined to two lower fisheries due to the low encounter rate with anglers on upstream beats. A total of 1337 interviews were conducted in 150 personnel days with a mean number of 9 anglers interviewed each day per person. The survey recorded a total catch of 146 salmon and 16 sea trout which represented 10.2% and 1.6% of the total declared rod catch for that year.

A summary of the main findings of the study were:

- The mean encounter rate with migratory salmonid anglers during creel surveys was low thus restricting the amount of information that can be collected.
- Peak numbers of anglers are usually encountered around flood events.
- Migratory salmonid anglers are normally well distributed through the fishery with 73% fishing the entire reach of the fishery.

- There is a general increase in overall angling effort as the seasons progresses (see Figure 1).

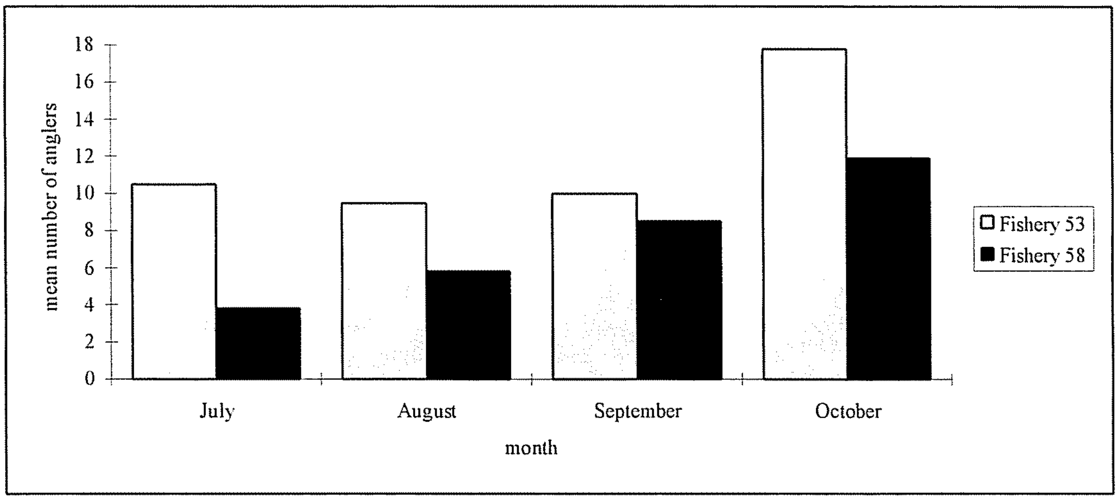

Figure 1: Mean numbers of anglers encountered per day on fisheries 53 and 58

- There was a significant relationship between angler effort and flow on the non-tidal fishery (fishery 53) (see Figure 2). This relationship was not significant on the lower fishery (fishery 58) which is subject to a tidal regime (see Figure 3).

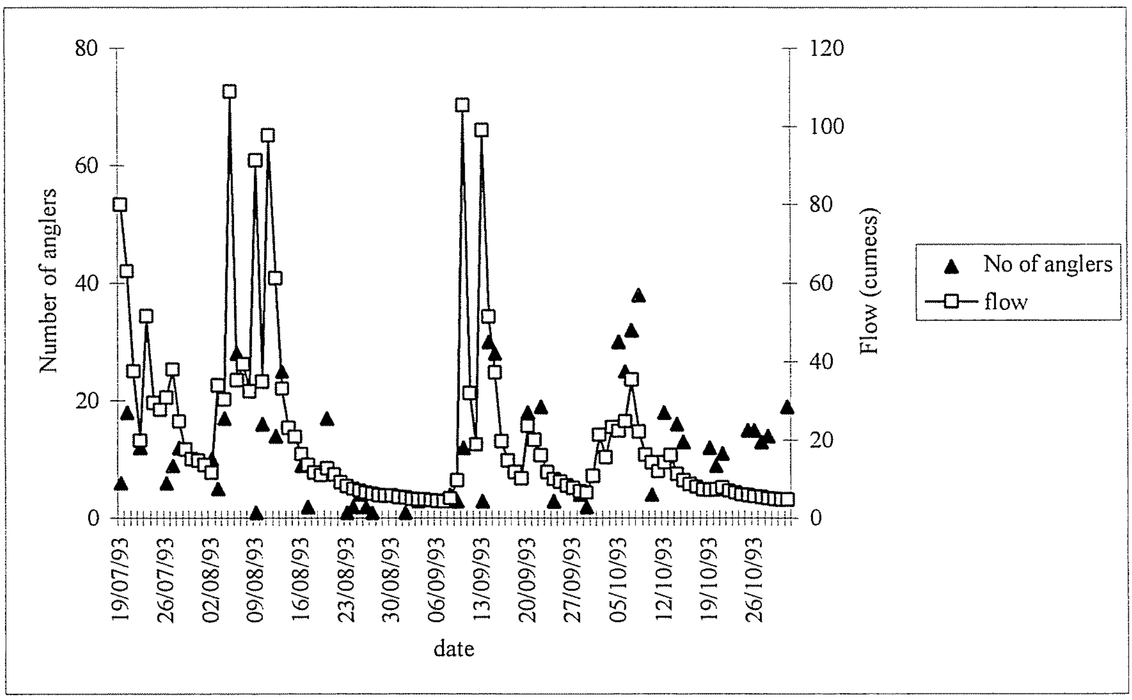

Figure 2: Number of anglers present on fishery 53 with flow

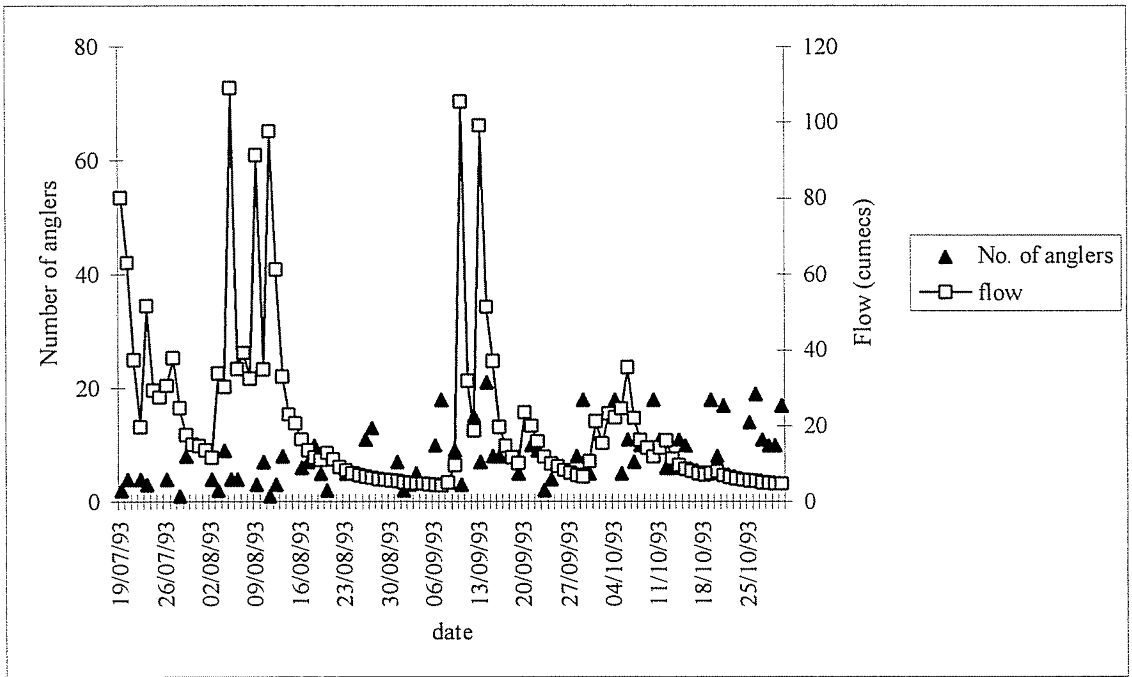

Figure 3: Number of anglers present on fishery 58 with flow

- The catch of 146 salmon encountered during the interviews was caught by 199 or 9% of the anglers.
- Comparison of the results obtained from the creel survey with 4 years Agency logbook data from the River Lune indicated that the anglers from the creel survey where generally less successful. This may result from the anglers willing to complete logbooks are more experienced and regular anglers when compared to the creel census which encountered anglers of all abilities.
- The creel census survey was not a cost effective method for collecting catch statistics in terms of personnel time requirements, particularly when compared to logbook schemes. The method is therefore most appropriate for studies on angling behaviour or intensive studies on specific fisheries.
- The distribution of logbooks should be formalised and implemented on a wider scale.

From the results of the study the application of creel census techniques to UK migratory salmonid anglers appeared to have limited value due to the personnel costs associated with the collection of data. The system may have uses for obtaining specific information on a study river regarding angler behaviour and fishery usage. This information may be useful when examining data obtained from other collection methods to identify sources of variability.

The contact between anglers and Agency staff resulting from creel census interviews is considered important from a public relations viewpoint.

2.2 NATIONAL NET CATCH RETURN FORM

There was no standardised method for the collection of catch statistics for migratory salmonids from net catches in England and Wales. This resulted from the catch return forms varying on a regional basis to reflect the fishing methods employed within each area. All the net return forms were collated from the regions and a new national form developed. The criteria set for the form were:

1. The form should be easily understood by net fishermen.
2. The form should cover all types of fishing instruments.
3. The form should be easily completed and require little additional information to that already collected.
4. The form should provide biologically meaningful information to the Agency.
5. The form should be easily completed for fisheries which produce small and large catches

Based on these criteria two new forms were produced to record returns from large and small catch fisheries. It was recommended that the forms were produced in the form of a bound A3 ledger with ink-pressure duplicate pages. Explanatory notes could be printed on the inside front cover of the ledger.

It was recommended that a long-term scale sampling programme be designed and implemented in conjunction with the new national form. Such a programme would need to be undertaken by Agency personnel on a regional basis. The data from the returns would then be pooled with the catch returns and available to all regions and MAFF (CEFAS) on a national database.

3.0 ANALYSIS OF HISTORICAL CATCH STATISTICS

3.1 INTRODUCTION

For many years anglers and netsmen have been required by law to send to the relevant Authority a return of all salmon and sea trout that they have caught during a particular year. This has resulted in a considerable data set of historical catch statistics being accumulated by the Environment Agency (formerly the National Rivers Authority). These data have recently been documented by MAFF (1995). The true worth of this catch data as an indicator of stock or even total catch is unknown, because the relationship between angler catches and stock has never been properly investigated (Small 1991). Additionally the quality of these data is doubtful (Aprahamian 1993). In more recent years this information has been collated and published as catch per month.

Examination of the data revealed that the degree of variation was high not only between rivers but between months and between the same month on the same river over a number of years. To improve value of these data a full understanding of the reasons for these variations were required. Consequently data sets were sought which could be examined to establish whether or not there was a consistent relationship between catch and effort and catch and flow which could be described by a mathematical model for any particular river system.

3.2 RIVER WYE - CATCH / EFFORT STUDY

3.2.1 Introduction

The first data set examined was initiated and partly analysed by Gee and others (e. Gee 1980) and relates to a study of catch and effort on the River Wye. For the present study the available data from the Wye Owners Returns were sub-divided so that comparisons could be carried out between (Spring) and (Summer) and between three reaches of the river:

- 'Lower' reach - below Monmouth
- 'Middle' reach - between Ross on Wye and Hereford
- 'Upper' reach - above Hereford

3.2.2 Angling Effort and Flow

For a comparison of the observed and expected levels of effort and catch it was clear that both variables were affected by flow and the effect was not constant within the three reaches. This indicated that anglers on different reaches were showing a significant preference for fishing on different levels of flow.

On the lowest reach anglers tended to select low flows and on the middle and upper reaches they tended to select flow near the daily mean for that section.

It must be remembered that daily mean flows for that section are viewed as relatively 'high' because the frequency distribution of flow is heavily skewed towards low flows.

Generalising, on the lower and middle reaches the observed catch was close to the expected for the effort deployed so catch / unit effort was constant with respect to flow. On the upper reach the catch was above the expected level for the effort deployed when flows were close to the mean daily flow and therefore catch / unit effort was not constant with respect to flow.

3.2.3 Further Angling Effort Modelling

Further modelling on the logarithmically transformed data (Section 4.4) was carried out using the ANCOVA module in Minitab.
The basic assumptions for this model are the same as for Analysis of Variance (Section 10.4) but underlying the model is the composite hypothesis (which the module tests) that the variance of the daily recorded effort can be attributed to three basic sources.

- An annual effect (e.g. due to annual variation in recording, number of anglers or salmon abundance)
- A monthly pattern (e.g. due to variation in recording, availability of angler's time or salmon abundance)
- A regression relationship between effort (or catch) and flow.

The main summary points from these analyses were:

1. There was a significant curvilinear relationship between catch and flow from the daily catch and effort model. The addition of further variables to this model revealed that effort and catch were increased by preceding high flows and that effort and catch varied to some extent according to the day of the week.
2. The annual and main effects were highly significant and the pattern of monthly effort and catch between years varied independently of flow but, because of uncertainty regarding the consistency of data, recording these effects could not be attributed to any one cause. Overall these models were a poor fit (22% - 75% of the total sum of squares) and there were concerns regarding serial correlation in the observations.
3. Problems were encountered due to an unnecessary high level of precision in using daily data so the models were re-run using weekly data. This had the advantage of negating any variation due to the effect of weekend angling. These weekly data models were run and their respective fits for the three reaches (lower, middle and upper) were:

    - Effort on flow - 94%, 88% and 83%
    - Catch on effort - 91%, 83% and 88%
    - Catch on flow - 94%, 80% and 86%

It is apparent that the catch on flow model provides substantially the same fit as the catch on effort model and that effort was also closely related to flow.

It therefore seemed reasonable to examine the proposition that much of the monthly variation of catch on a river system could be accounted for by flow because effort was so closely related to flow that it could be considered as a surrogate. To investigate this the historical archive of catch returns for the River Wye were analysed.

3.3 ANCOVA APPLIED TO WYE CATCH RETURNS

3.3.1 Introduction

The River Wye catch returns have been reported on a monthly basis split into 5 reaches from 1920 and were considered to be more complete than those from other rivers.
These reaches were:

- Below Ross on Wye
- Hereford to Ross
- Hay to Hereford
- Builth Wells to Hay
- Above Builth Wells

However, data from suitable flow gauging stations are only available since 1944 so analysis was restricted to the period 1944-1991.

3.3.2 Distribution of Catch

Initially the relationship between the proportion of the catch taken below Ross on Wye was plotted against Log flow for all months and all years in the data set (see Figure 4)

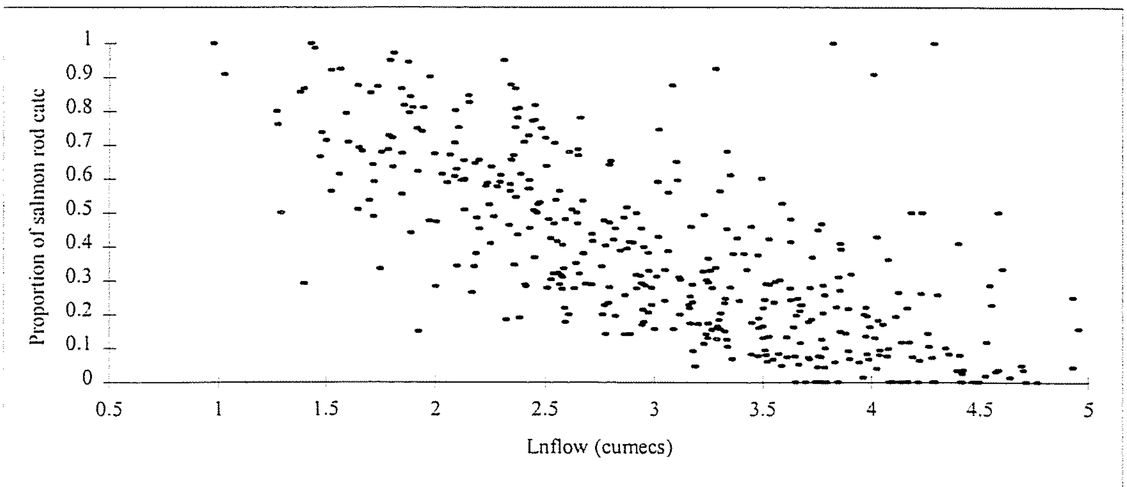

Figure 4: Proportion of salmon rod catch taken below Ross on Wye against lnflow

The negative correlation was confirmed by an ANOVA model.

Scatter plots of Logcatch against logflow for the highest and lowest reaches are shown in Figures 5 and 6.

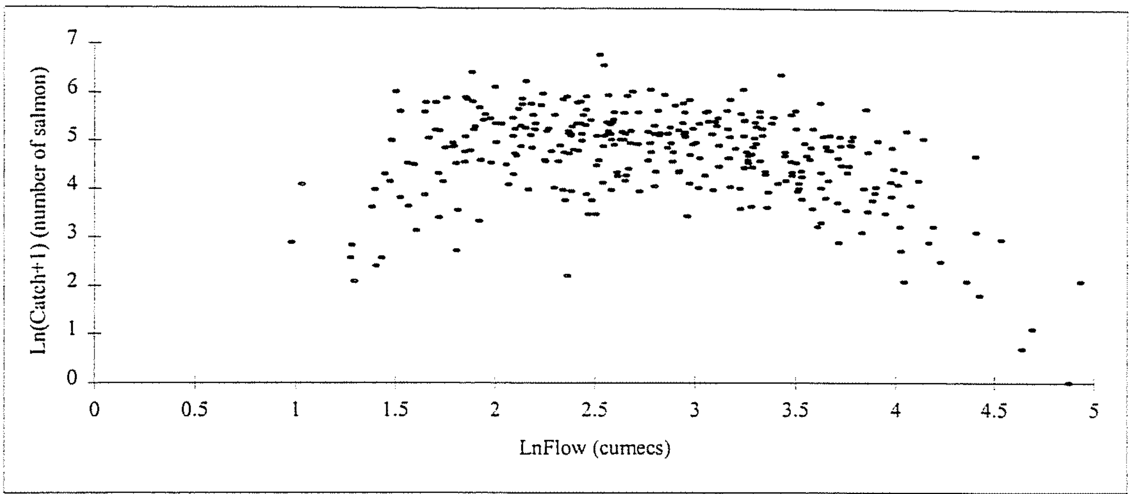

Figure 5: R.Wye - Relationship between salmon catch above Buith and flow

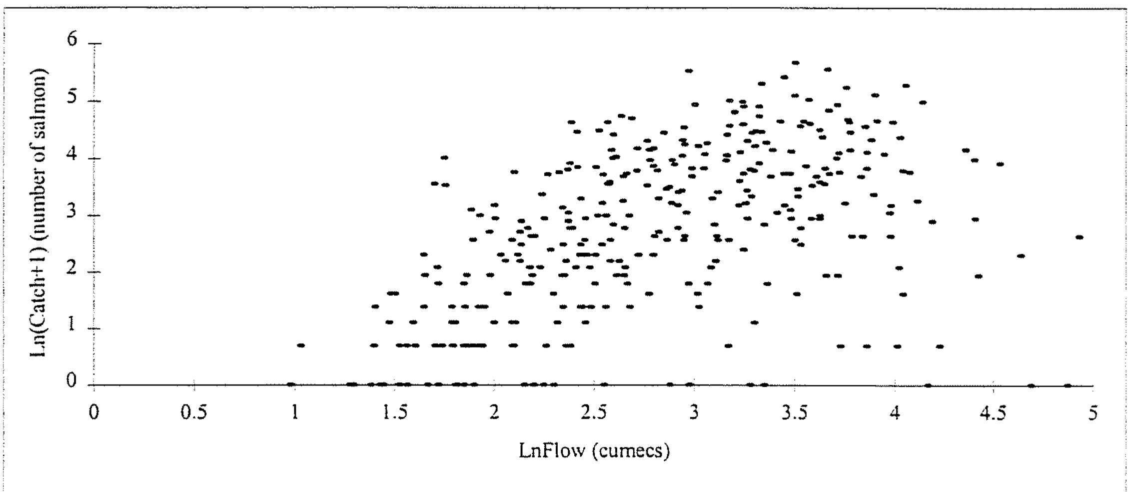

Figure 6: R.Wye - Relationship between salmon catch below Ross and flow

Figure 5 suggests a dome shaped curve and Figure 6 shows increasing catch with increasing flows. This was confirmed by a further ANCOVA model which examined the effect of flow and calculated the main effects over the 48 hour period for three seasons coinciding approximately with the timing of the 3SW, 2SW and grilse runs. The model accounted for 86% of the total sum of squares. However, the main effects, although correlated between reaches, only showed strong agreement between neighbouring reaches. The lowest reach was correlated with the next upstream reached but showed a generally lower agreement with all other areas.

3.3.3 Analysis on Net Catch with Rod Catch and Flow

The net catches demonstrated wide variability over the timescale of the data so they were de-trended before the model was fitted to ensure compatibility of the results of the two models. The rod catches were treated in the same way but the data for the lowest two reaches were examined separately and other areas omitted.

Similar levels of fit were obtained for the three models (73% for the nets and 74% and 83% for the rods) but the relationship of the rod catches with flow were positive and dome shaped whereas net catches decreased linearly with flow. In addition the main effects from the net catch and rod catch below Ross were positively correlated.

The correlation between adjusted means (estimated catch at overall mean flow level for each year) for net catches and rod catches provide support to the hypothesis that adjusted catch represented an index of availability, particularly as the response of the two methods of catching salmon to flow were so different. The positive correlation between the two was expected since both types of instrument are exploiting the same population.

The difference between the indices derived from the rod and net models might be due to the nets removing fish from the population and thus reducing the availability to the rods. The was tested by regressing the difference between the indices against the actual net catch. An identical model was fitted to the difference between the indices calculated for the lowest two rod fisheries.

In both models there was a significant negative correlation which suggested that the fishery through which the salmon pass first has a reducing effect on the catch of the next fishery but such a result could also be solely due to the variation in distribution unaccounted for by the catch/flow models.

3.4 ANCOVA APPLIED TO 4 RIVERS IN THE NORTH WEST REGION

The catch flow model used for the Wye catch returns was also fitted to rod catch return data from the following rivers in the North West region:

- River Hodder
- River Ribble
- River Lune
- River Derwent

Fits of the order of 90% were obtained but it was found that the quadratic relationship between catch and flow broke down in October and if this month was examined separately there was no correlation between catch and flow.

Since the catch flow relationship is dome shaped such a result is inevitable if the majority of observations are clustered around the stationary maximum point of the graph. However, Aprahamian (1993) has also suggested that at this time of year flows are generally suitable for angling, salmon catchability is higher and salmon abundance is high so anglers may be responding to their perception that October is the best month to fish regardless of flow.

It was noted that the annual main effects or potential population indices were similar for all four rivers. It was considered that this was probably due to the fact that the flow patterns were similar and if the previously conceived hypothesis regarding angler and fish behaviour was correct, angling effort and fish abundance would follow a similar pattern on all four rivers.

4.0 CLASSIFICATION BY CATCH

4.1 ELLIOTT'S CLASSIFICATION AND ANOVA APPROACHES

Further development of Elliott's method of classification (Elliott J.M (1991) Analysis of Sea trout catch statistics. IFE Contract Report No WI/T11050g5/2.) was considered but discounted on the grounds that whilst the method ordered the rivers according to the statistical attributes of the catch it did not relate these to physical attributes of the river systems. There seemed to be advantages in a physical attributes based system if future management is to be based on index rivers.

Fifteen years of salmon catches from 57 rivers and catches of sea trout from 63 rivers were examined using ANOVA.
This demonstrated that catches were lognormally distributed and from contour plots of residuals from the model fitting exercise that there were marked similarities in pattern of catch between certain rivers.

Cluster analysis confirmed this and demonstrated that although adjacent rivers tended to appear in the same cluster there were also notable and unexplained exceptions.

When the contour plots from the ANOVA models were redrawn with the rivers ordered according to their selection in the cluster analysis the patterns were more obvious and similar for both salmon and sea trout.

As a result the national mean salmon and sea trout catches were plotted for the 15 years of available data and found to be strongly correlated ($p<0.01$). Since it was thought that the underlying cause of the similarity in catches throughout the majority of England and Wales might be due to nation-wide similarities in weather, the national mean sea trout catches were then plotted against the summer flow for the Ribble and Wye (chosen solely because the data was easily available). The fit was very good for both flows which were then shown to be highly correlated ($r=0.95$ for 15 years data).

It is therefore suggested that the pattern of annual variation observed in salmon and sea trout catches is due to variation in flow which tends to be similar throughout England and Wales.

4.2 RELATIONSHIP BETWEEN SALMON AND SEA TROUT CATCH AND PHYSICAL ATTRIBUTES OF RIVER SYSTEMS

A very limited amount of data describing the geographical shape and size of river systems was available for 20 rivers in Wales.

The measures were strongly correlated so a Principle Components Analysis was carried out. This is a technique which allows combination and transformation of the variable in such that uncorrelated measures are obtained of the factors causing variation and correlation of the original variables. The Principle Components were identified which seemed to relate to:

- Size of the catchment.
- the relationship between average tributary length and the number of tributaries in the catchment.
- The relationship between main river length and number of tributaries.

Regression analysis of the salmon and sea trout catches from the rivers examined on the Principle Component scores showed that those which provided a substantial salmon catch were large with a high proportion of main river to number of tributaries and those providing a substantial sea trout catch may also be large but must have a low ratio of main river to number of tributaries.

Ten of the rivers in this data set provided catch return data from 1956 onwards. Rod and net returns were examined by ANOVA which showed significant and similar temporal variation between the 10 rivers, however there was only strong correlation between salmon rod and net catches and salmon and sea trout rod catch. This suggests that rods and nets may exploit the same population of salmon but not sea trout.

There was also correlation between salmon net catch and rod sea trout catch but this follows almost inevitably because if any variable 'a' is correlated with 'b' and 'b' is correlated with 'c' then 'a' will be correlated with 'c'.

5.0 LONG TERM TRENDS IN ABUNDANCE

5.1 INTRODUCTION

The above studies suggest a method of adjusting catch to account for the short-term variation in effort as a result of flow and estimating availability indices.
However, the method developed does not account for longer term variation in effort due to the increase in the number of anglers which has occurred since 1950 (Gee & Milner 1980, Small 1981a).

Paloheimo and Dickie (1964) hypothesised that " for most stocks, catchability varies inversely with stock abundance and geographical area occupied by stock". Thus if catch / unit effort (C/f) and catchability (q) are known the stock size (N) may be estimated.

The general model describing the relationship between catch, effort and catchability is described by the following equations:

1) Catch per Unit Effort (C/f) $C/f = qN$ where:-
2) Catchability (q) $q = aN^b$ where:- ($-1<b<0$)
giving
$C/f = aN^{(b+1)}$
giving
3) Exploitation (C/N) $C/N = afN^b$

These equations provide satisfactory fits to data from 14 fisheries where effort, catch and count were recorded.

5.2 THE ESTIMATING MODEL

Equation 3 can be transformed to a temporal model based on the description of Small (1996). An estimate of run size is based on the calculation of three variable:

- Catch
- Effort
- Catchability

The estimate of run size is based on the following equation:

Estimated Run = (Catch /Effort Model) / Catchability Model

The method (described in Section 9) provides details of modifying available data and estimating to provide the necessary parameters required by the model. For example the formula for estimating effort where an incomplete data set is available is described by the equation:

Rod Effort = E*Rod Catch^F

Where E is a constant that ranges from 10 -300 depending on the units under consideration and where F is approximately 0.5. Similar descriptions are provide for adjusting Catch data and estimating Catchability.

Simple temporal models with linear trends for catchability were developed from data analysis on rivers with counters or traps.
The calculation of catchability is dependant on whether counting or trap data are available for the river. Three different catchability models were developed:

- An increasing catchability model
- A benchmark catchability value model
- A decreasing catchability model

All three models are usually calculated and applied to the data to determine which provides the best fit.

5.3 ESTIMATING TRENDS OF THE RUN

5.3.1 Estimating the trend of runs above estuarine nets (including the close season)

Three trend estimates were calculated using the following formula:

Estimated run = Rod CPUE / Catchability model

(each catchability is applied to test for fit)

5.3.2 Estimating historical trends of runs of salmon and grilse into the estuary (including the close season)

This estimate is calculated to add the within estuary net catches to the three trends obtained for the rod data.
The plots created are then assessed to determine which line or parts of the trend are likely to be reasonable. An example is presented in Figure 7 for the River Tweed for all 3 catchability models and demonstrate a decrease in salmon abundance over the time period.

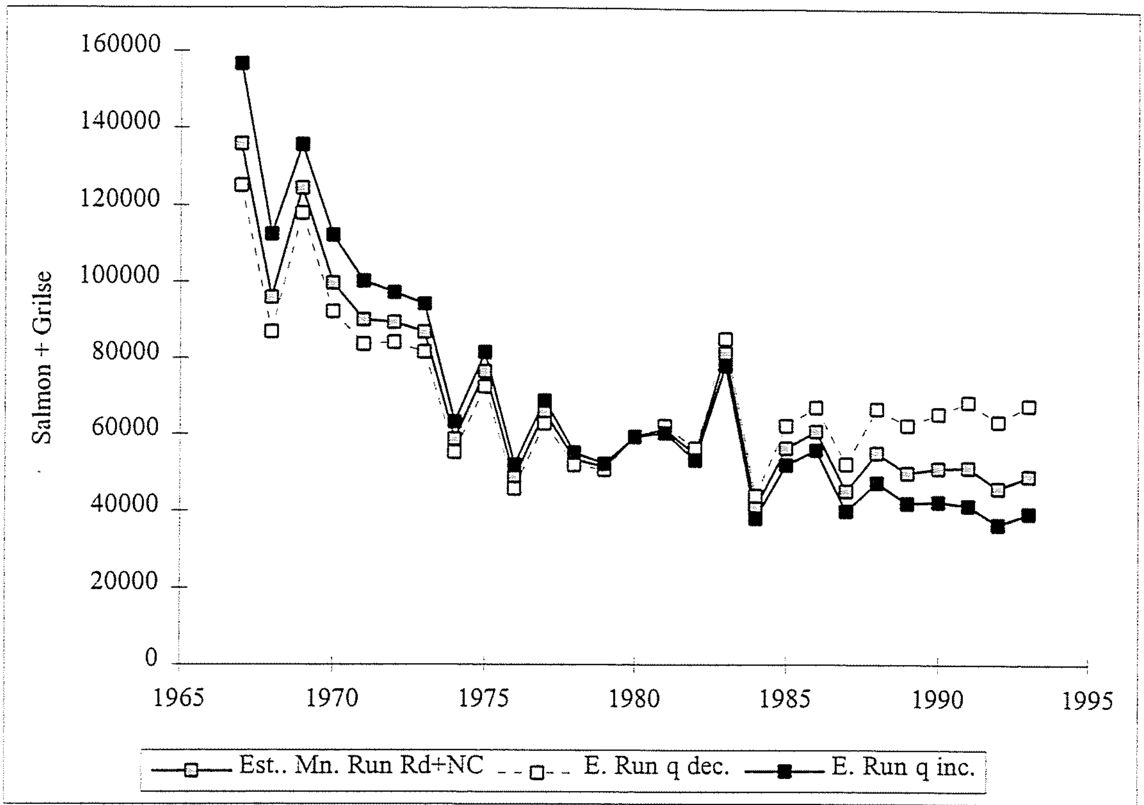

Figure 7: Estimated trends of runs of salmon and grilse into the River Tweed estuary under different catchability (q) scenarios

5.3.3 Estimating trends of relative exploitation and escapement rates

This can be calculated by dividing the following :

- Rod catches
- Net Catches
- Escapement

by the best estimate of run into the estuary (see Figure 8).

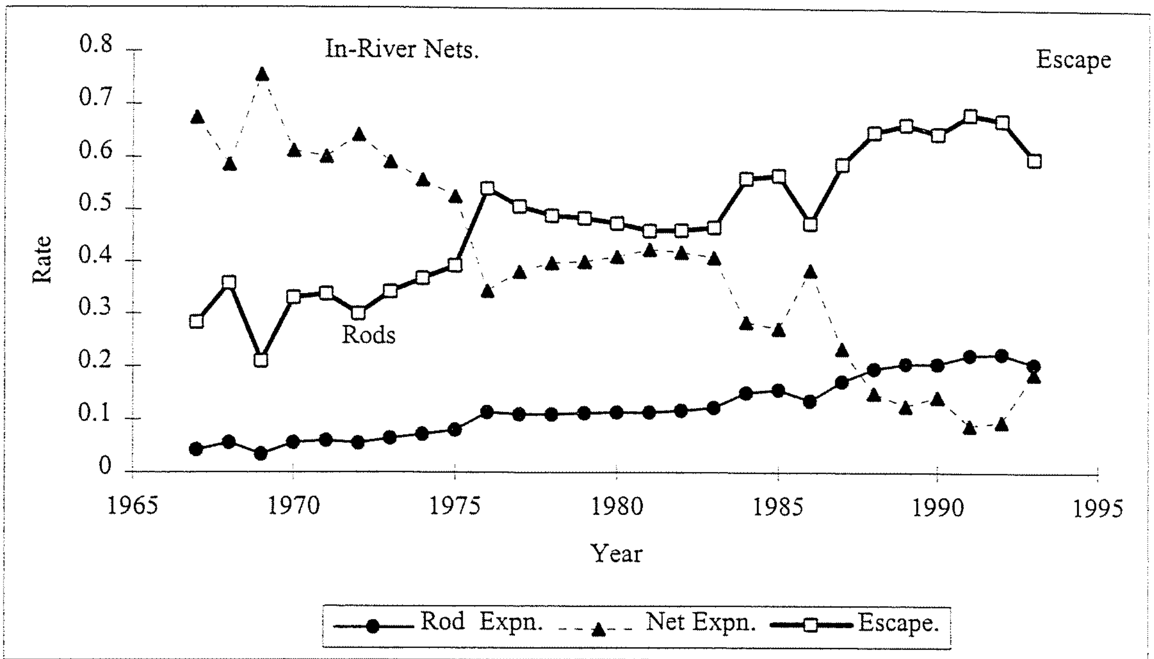

Figure 8: Salmon - trends of relative exploitation and escapement rates: Proportion of fish entering the River Tweed

5.4 USE OF MONTHLY DATA TO ESTIMATE WITHIN SEASON RUNS

Examination of monthly data revealed the following relationships:

- Logbook data indicated that during the latter half of the season there is a significant relationship between cumulative monthly counts of salmon (where counter is located at the tidehead) and whole river CPUE. Where the rod data comes from a fishery immediately adjacent to the counter, the relation is with monthly counts as described by:

Monthly Cumulative Count = C*(Monthly rod CPUE^d)

where 'd' tends to 1.0 and the unit of rod effort is 100hr.

An example obtained from River Lune logbook data is presented as Figure 9.

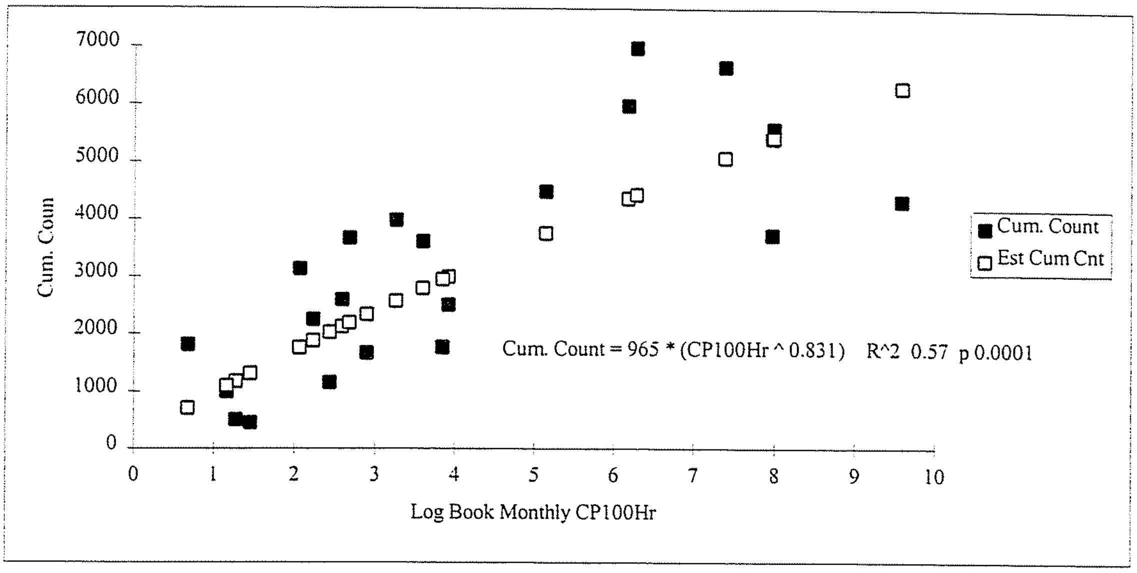

Figure 9: River Lune Salmon 1991-994, Estimate of monthly cumulative count from logbooks (June - October)

- There is a highly significant relationship of monthly logbook catches and recorded monthly statutory returns (Small 1997). This indicates that it may be possible to apply patterns of models derived from logbook data to recorded or adjusted rod catches in order to estimate trends of annual and in-season runs of fish where traps or counters are not installed.

5.5 FUTURE REFINEMENTS TO THE TECHNIQUE

This method of analysing trends relies upon catch, effort and catchability estimates for the migratory salmonid stocks in the river. Often the level of information available is of insufficient detail and estimates need to be calculated. As estimates are required the method is most useful at identifying long-term trends in population change, particularly on rivers where no counting devices are installed. Of particular importance to obtaining a reasonable estimate is in the choice of appropriate catchability model.

To fulfil the potential of the model the following would be required:

- Accurate measures of catch
- Accurate measures of effort
- Counts (for validation purposes)
- Local knowledge and surveys (to provide background data and assist with interpretation of the results)

6.0 CONCLUDING SUMMARY

6.1 INTRODUCTION

This R&D contract may not have produced a definitive method of analysing and using salmon and sea trout catch statistics to estimate stock size. However, the study has increased the understanding of variability in catches both between and within river systems and has highlighted a number of areas where further research is required. This additional study is required not only to examine the hypotheses formulated in the present work but also because much of the data utilised were of unknown provenance, to check on these findings.

In this summary section the main sources of variation and the models used to identify them are discussed from the viewpoint of stock monitoring and targeting.

6.2 EFFORT

It has been demonstrated that anglers tend to target certain flows in angling for migratory salmonids. Virtually any book on salmon angling will confirm this but the information has never been used by fishery scientists. the most likely reason for this relationship is that the targeted flow brings fresh fish into the river system and anglers know that there is a higher chance of success. In other words effort is related to the anglers' perceptions of the likelihood of success and this may even be influenced by recent catch history. This is important for two reasons.

1. Any measurement of angling effort without consideration of river flow is likely to lead to a misleading interpretation especially if catch per unit effort (CPUE) is calculated. There were indications in the work that CPUE remained relatively constant when measured against increasing flow or effort. Therefore it seems unlikely that in the short-term CPUE reflects abundance.

2. Broadly speaking it is likely that there are two main types of migratory salmonid anglers. There are those who are able to fish when they please and have the opportunity to target the best times and those who lack both experience and opportunity who cannot. The former are probably at the root of the often quoted aphorism that 10% of the anglers catch 90% of the fish. The 90% are most likely to be weekend and holiday anglers. The efficiency of the effort applied by these two categories of anglers is dramatically different and should be taken into account whenever effort is measured or examined.

6.3 FLOW

It is clear from this work that the distribution and size of catch is related to monthly mean flows. However, the underlying relationship is probably between catch and effort

which itself depends on the distribution and abundance of salmon which are not responding to a mean flow but the frequency, size and timing of spate conditions.
Mean flow is merely a readily available measurement which can be utilised as an approximation of those conditions which affect salmon movement and therefore catch.

6.4 THE ANCOVA MODEL

This model can be used in number of different ways but has not been tested against counter data. Nevertheless it is difficult to conceive of an explanation of the main effects other than that they can be interpreted as indices of abundance. However, the indices relate to the abundance of salmon in a river system which almost certainly depends on the recent flow pattern. The indices are unlikely to reflect either the abundance or availability of salmon outside the river system although this may be possible with data from estuarine nets. Neither do they represent the abundance of the eventual spawning stock or post angling season run although the indices for September and October may relate to the number of spawning salmon in the system.

A further problem with the ANCOVA model is that the time of arrival of different age classes overlaps and the anglers generally fish for a mixed age class stock. Therefore the assumption that there is a relatively constant pattern of arrival of salmon is only relevant prior to the arrival of the grilse run and then only in rivers with few 3 sea-winter salmon or second spawners. this gives rise to a loss of precision in estimating the indices.

It is therefore considered that the main value of this method is to predict the effect on catch of proposed abstraction or river regulation schemes and it will not normally be helpful in estimating returning annual recruitment or residual spawning stock.

6.5 A SIMPLER MODEL WITH WIDER AND MORE FLEXIBLE MANAGEMENT IMPLICATIONS

Even with long-term data sets of semelparous species, such as Pacific salmon the determination of the Minimum Biological acceptable Level (MBAL) from a stock recruitment curve gives rise to very wide confidence limits, even at the 50% significance level. Therefore the current spawning targets for English and Welsh rivers extrapolated from the River Bush data are likely to have even larger confidence intervals and great care should be exercised in their use as management parameters until a greater level of precision can be introduced into their calculation.

The determination of spawning and recruitment levels is a prerequisite of salmon management by spawning targets, but this presents some problems due to variation resulting from measurements, process and random errors. The Agency is examining ways to establish the uncertainties involved in both target setting and assessment in order to set management decisions in a risk framework. The type of procedures outlined in this project will contribute to these improvements.

A possible fallback for the Agency is to define desirable performance bands for the fisheries within their jurisdiction. This suggestion has not previously formed part of this report.

However, with the exception of the early spring and possibly October, all the rivers examined demonstrated significant correlations between catch and mean monthly flow if the relationship was examined on a month by month basis.

Therefore it is possible to fit a regression line to each individual month and examine the residuals (the distance each point lies above or below the regression line) for each year. Each residual contains two elements:

- an element related to the overall availability of salmon able to respond to flows in that month (i.e. abundance in the sea).
- an element related to error.

It is possible to conceive a system whereby these residuals are considered as indices of availability of salmon for each month and thus could be used as the data for examination using a statistical quality control package. This method would lend itself to graphical presentation and could be used as a monthly performance measure for a fishery. It is also possible that with additional information regarding the age class composition and sex distribution for each month that the indices could be combined to calculate an index of stock prior to exploitation.

Further examination of the hypothesis that the October or end of season index relates to spawning stock is required before the two indices could be used in a stock recruitment relationship or even to assess performance of the fishery against a given spawning target.

6.6 CLASSIFICATION OF RIVER SYSTEMS

Only a limited number of data were examined for this study but it seemed probable that salmon catches in most West Coast rivers were correlated as a result of the relationship between catch and flow and the fact the mean monthly flows tend to be highly correlated between these systems. Thus any attempt to classify these rivers according to patterns of catch was more likely to result in a classification according to the pattern of flow. Such a classification would be meaningless in fishery terms unless the effects of flow could first be removed from the data.

Although the data available were limited it does seem likely that a system of classification by physical geography may be possible. From information for the Welsh rivers it appeared that catches of salmon and sea trout are highest in large rivers and the relative production of the two species depends in some way on the proportion of main river stem to tributaries.

Therefore catches of migratory salmonids are related to production in the river which is likely to be related to the availability of suitable habitat. The availability of suitable habitat is almost certainly defined by gross physical geography.

Such a classification system would enable direct comparisons between river systems and therefore an examination of relative performance of their fisheries by an extension of the methods described in sections 6.4 and 6.5.

6.7 CONCLUSION

This R&D contract has identified the main variation in salmon catches and has developed or suggested methods by which rivers can be classified in a manner which is meaningful to fisheries management. Further development work is required before these methods can be implemented as standard procedures.

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