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FINAL REPORT OF THE STOCK ASSESSMENT TASK GROUP

The first report of this Task Group has been amended and a second draft is attached.

It should be noted that Irvin Forbes (NRA, Anglian) and Robin Wyatt (WRC) have met to produce a clearly worked example (including software) to show how Bohlins' formula can be used to calculate the precision level attained by current fish surveys. When available this will replace Appendices I and II of this draft report.

In addition the Group has addressed their final two terms of reference:

1) to identify stock assessment data which can be used to develop a fisheries classification system.

2) to establish a common basis for costing survey work and to determine what aspects of fish stock assessment can be used as performance measures.

Their findings are presented as a separate report.

STOCK ASSESSMENT TASK GROUP

FIRST REPORT

(2ND DRAFT)

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1. INTRODUCTION

The main objective of the Task Group was to consider how the NRA currently assesses fish stocks and from this determine common methodologies which will enable consistent monitoring programmes to take place throughout England and Wales.

This report broadly deals with the first three tasks in the Group's terms of reference, namely to:

i) determine common methodologies for assessing fish stocks.

ii) evaluate the role of different survey techniques such as electric fishing, netting, fish counters, traps, catch statistics, and hydroacoustic surveying in fish stock assessment.

iii) develop a common method of collecting and analyzing survey data to produce nationwide stock assessments.

However, the report more specifically addresses the following questions:

- How should stock assessment be defined?
- Why does the NRA need stock assessment?
- What are the aims of the NRA's stock assessment programme?
- What broad strategy should the NRA adopt in carrying out its programme of stock assessment?
- What methodologies or survey techniques are available to obtain stock assessments and how, when and where they should be used?
- What data should be collected and how should it be presented?

2. DEFINITION OF STOCK ASSESSMENT

For the purposes of this report stock assessment is defined as the best practicable means of describing the fish resource of a catchment. Such descriptions may be "quantitative" providing data on density, biomass, length frequency, age structure and growth rates of the fish present. However, normally quantitative data can only be obtained for part of the catchment, for certain species or for certain age classes. Commonly quantitative data is supplemented by "qualitative" estimates which may or may not have a numerical component.

3. THE NEED FOR STOCK ASSESSMENT

The NRA's statutory duty to maintain, improve and develop fisheries can only be accomplished if there is adequate information on the numbers of each fish species present.

Stock assessment is needed for a wide range of management purposes which include to:

i) survey for fisheries management purposes including the assessment of long term changes.

ii) help conserve all, especially rare species of fish.

iii) evaluate the effectiveness of restocking and habitat/water quality improvements.

iv) fulfil the statutory duty to compile statistics from catch returns.

v) assess or predict the impact of a variety of activities carried out by other NRA functions or outside agencies on fish populations.

vi) assess damage resulting from pollution incidents.

vii) comment on the fisheries implications of developments when the NRA is a statutory consultee to planning authorities.

4. THE AIMS OF THE NRA'S STOCK ASSESSMENT PROGRAMME

At present the major aims of carrying out stock assessments are to:

i) provide information on the distribution and abundance of fish. (Ultimately to assess whether the natural carrying capacities of rivers to support fish are being fully utilised).

ii) provide a national database of annual trends in abundance of populations which will allow comparisons to be made between key rivers and between regions.

iii) identify and evaluate the effect of environmental factors and of man's activities on the status of stocks.

5. STRATEGIES FOR CARRYING OUT STOCK ASSESSMENT

5.1 Reactive vs Strategic Surveys

In the past, many stock assessments were reactive. Surveys were carried out to investigate a particular problem or crisis. This approach resulted in a lack of consistent monitoring on a National basis and a scarcity of baseline information.

It is recommended that in future, a programme of strategic stock assessment surveys should be introduced.

The advantages of such programmes are that up-to-date information would be immediately available for management purposes, such as those listed in Section 3, as well as the development of a greater understanding of how fish populations respond to less evident environmental changes.

5.2 The need for Annual and Triennial Surveys

There are situations where annual stock assessment is both necessary and practicable, such as when using:

i) catch statistics to monitor both adult migratory salmonids and adult coarse fish.

ii) electric fishing to sample juvenile salmonids. Less frequent sampling could fail to show a significant decline in numbers of a particular year class.

iii) counters to monitor adult migratory salmonids.

However, for coarse fish and non-migratory salmonids, sampling every three years should be adequate to show up a weak year class and/or identify a potential decline in population numbers. This allows time for appropriate management action to be taken.

It is recommended that although reactive stock assessment exercises will still need to be carried out, a strategic programme of annual and triennial stock assessment should be introduced. Annual surveys will be carried out mainly to monitor migratory salmonids whilst for coarse fish and non-migratory salmonids, triennial surveys should be adequate.

6. METHODS OF STOCK ASSESSMENT

Stock assessment techniques fall into three main categories:

1. Survey methods - which are used to sample fish (electric fishing and netting).
2. Census methods - which count fish or redds directly (counters, traps and redd counting).
3. Catch data methods - which use catch and catch per unit effort as an indicator of stock.

6.1 SURVEY METHODS

Irrespective of whether electric fishing or netting is chosen the same basic principles apply as to how the stock assessment should be carried out.

6.1.1 Absolute vs Relative Parameters

Firstly, it is necessary to determine whether the aim of any particular study requires the assessment of absolute parameters, i.e. total population size or density, or relative parameters, such as temporal or spatial changes and trends? Regardless of whether or not it is chosen to measure absolute or relative parameters, it is important to distinguish between the accuracy and precision of the estimates obtained.

6.1.2 Accuracy vs Precision

Accuracy of methods used to estimate population size depends on the efficiency and selectivity of the gear used. Precision on the other hand depends mainly on the number of sites sampled.

The choice of precision level will strongly affect the field effort required. It is therefore of considerable practical importance to consider the level of precision required, in relation to the aim of the study, before commencing sampling.

For most management purposes it is recommended that the level of precision to aim for is Bohlin's second level of precision as defined below.

Bohlin 1990, proposed three precision classes. He uses a factor rather than an absolute difference to represent a population change in time or space. His three classes are:

1) Population changes by a factor of 1.2 (83-100-120%) High level of precision
2) Population changes by a factor of 1.5 (67-100-150%) Medium level of precision
3) Population changes by a factor of 2 (50-100-200%) Low level of precision

6.1.3 Relating the aim of the survey to the type of parameter, accuracy and precision level required

The choice of whether to use absolute or relative parameters and the level of accuracy and precision required depends on the aim of the study as outlined in Table 1.

Table 1 - The Precision levels, accuracy and method required to achieve specified aims.

AIM	Absolute/ Relative	Accuracy	Precision Level
To provide information on species distribution	Relative	Low	None
To estimate the abundance of a fish species or annual, triennial trends in abundance	Relative or Absolute	Low	2/3
To calculate actual density or biomass	Absolute	High	2 or above
To evaluate the effects of environmental or manmade factors on fish	Absolute	High	2 or above

In Sections 6.1.4 - 6.1.11, it is shown how these theoretical requirements can be implemented in practice.

6.1.4 Sampling Strategy

Bohlin describes how to carry out a sampling strategy at the stock level and the effort required at different precision levels.

Sampling takes place in three stages. The first is to select the target area. The second stage is the selection of the sites within the chosen target area and the last stage is to sample fish from within each site.

6.1.5 Target area

The target area is defined as the length or area of water course to which the stock assessment applies. In order to select the target area the distribution of the stock and the probability of their efficient capture needs to be considered.

6.1.6 Selection of sites within the chosen target area

These should be chosen by some method of random sampling. However as well as choosing which sites to sample it is crucial to select the correct number of sites or sample size to attain the required precision level.

6.1.7 Sample size

The number of sites selected for a study will be affected by a number of factors:

i) How much the population density varies from site to site within the target area or the "between site sampling variation".

ii) The level of precision required. The higher the precision needed the larger the sample size required.

iii) The "within site sampling variation". Sometimes crude estimates at site level necessitate a large sample size.

iv) The size of the target area. If the target area is very large, a large sample size may be necessary.

v) Studies estimating population change will usually require a smaller sample size than studies aiming at absolute stock size or density.

The importance of identifying the number of sites required has often been overlooked and has seriously reduced the value of many studies.

6.1.8 Estimating the numbers of sites

It is possible to estimate the number of sites which should be sampled.

This is determined by means of a formula (See Appendix 1) which considers the spatial variation of population size between sites, the "within sites" sampling error and the precision requirement. A similar calculation can be carried out using an index of population size (catch per site using a standard effort) rather than an absolute stock size or population density.

In Appendix II two worked examples, one for a coarse species and the other for a salmonid species, show how the number of sites are calculated in order to achieve a given level of precision.

It is recommended that these calculations should be made for all fish stock assessments. This will enable the determination of the precision level of the sampling and thus the ability to predict change in population size.

6.1.9 Sampling fish from within sites

How fish are sampled within a site determines the accuracy level of the sampling. See Table 2.

Table 2

ACCURACY LEVEL	PRACTICE
LOW	Fish until you catch something.
	Fish until you catch a particular species.
	Fish for set time or over a measured area with no stop net. (Relative measures of catch/effort)
	Fish 1 run with stop nets (minimum estimate).
HIGH	Fish for 2, 3 or more runs with stop nets (absolute estimate).

It is also possible to calculate how much sampling effort is required within sites. However, it is frequently found that such effort has little influence on the number of sites required. A large number of sites is usually required even for moderate precision levels, regardless of the sampling effort within each site.

6.1.10 Increasing sampling efficiency

Stock assessment programmes can require significant resources, and, therefore, the sampling must be highly efficient. There are a number of ways of achieving this.

Other ways of making sampling more efficient can also be adopted:

i) Stratification

By dividing the target area into more homogenous sub areas or strata, the effects of the clumped distribution of many fish populations can be reduced giving greater precision for a given sampling effort. Additional information on fish distribution can be obtained by further and qualitative sampling within the target area.

ii) Number of sites

By sampling the same number or more sites in fewer or only parts of rivers.

iii) <u>Size of sites</u>

It is often advantageous to use many small rather than few large

sites though the gain in precision depends on the fish distribution.

iv) <u>Serial sampling</u>

By sampling individual sites two or more times it is possible to provide the basis for within pair and between pair comparisons and thus increase the precision of statements about trends in populations numbers.

v) <u>Estimating Stock Change rather than Stock Density</u>

The sample size for a given level of precision which is required to assess stock changes, using paired observations, is often smaller than for stock density, (Bohlin 1990). Thus paired observations possibly using relative estimation can be a cost-effective sampling design for temporal stock monitoring.

It is recommended that the most cost-efficient way of making statements about stocks would be to reduce the effort within sites and use the effort saved to sample a large number of sites. Relative methods such as catch per unit of standardised effort or simple minimum estimates should be considered whenever appropriate.

6.1.11 <u>Choice of survey method</u>

Having developed a sampling strategy which includes defining the target area, selecting the appropriate number of sites to achieve the required precision level and determining the accuracy of sampling needed within sites, the last choice is the most suitable methodology to adopt.

This choice depends mainly on the type of habitat.

i) <u>Electric Fishing</u>

Electric fishing is the technique most commonly used by the NRA for assessing stocks of both salmonid and coarse fish in relatively shallow rivers. The range of techniques available and their applicability to waters of various dimensions has been described in: Methods for sampling fish populations in shallow rivers and streams (1983), HMSO (1988); Cowx et al, (1990).

In order to estimate the catch efficiency of electric fishing, it is recommended that depletion estimates are used. The number of runs to be made to satisfy the equations of either Seber and Le Cren or Zippin or Carl and Strube will be determined by the efficiency of capture. However, where the apparent probability of capture falls below 30% it is better to state the minimum estimate which is the actual catch.

For quantitative electric fishing for coarse fish and adult non migratory trout, the minimum length of site should be not less than 100 metres, isolated between stop nets. For juvenile migratory salmonids in small rivers the site length should be not less than 30 m, but a minimum length of x 10 the mean width is a useful guide. In certain wide, shallow rivers it may be necessary to subdivide the site into lanes. No anode should have to cover more than a 5 metre width of the stream.

ii) Netting

Seine netting may be used in wide, very slow flowing waters such as the Fenland waters and Broads. A standard methodology exists (I.J. Forbes, routine fish population survey methods used in the Anglian region of the NRA) and the same recommendations made for triennial surveys apply. Site lengths may need to be more than 100 metres in wide rivers. In addition to the depletion methods listed previously, mark, release and recapture can be used for fish > 10cm when netting.

Fish data from sites sampled quantitatively on a triennial basis may be usefully supplemented by qualitative data obtained from a single fishing run in the adjacent water. This technique may aid the surveyor to test how representative the survey site is but should not be regarded as substitute for proper quantitative sampling.

6.2 Census Techniques

6.2.1 Fixed site resistivity fish counters

Fixed site resistivity fish counters can now be both efficient and reliable. Further developments in data processing should result in more accurate counts and a better ability to distinguish between numbers of salmon and sea trout.

It is recommended that it should be a target for all rivers with significant migratory salmonid rod catches to have counters installed to monitor upstream runs and that consideration is taken to incorporate electrode arrays into appropriate new in river structures.

6.2.2 Hydroacoustic counters

These are at a much earlier stage of development than resistivity counters. Hydroacoustic equipment is being developed to count fish, especially coarse fish, in larger rivers and lakes but it could also replace or be used in conjunction with resistivity counters. Hydroacoustic counters have the advantages of being both more mobile and better able to count downstream as well as upstream migrants.

It is recommended that the NRA keeps abreast of hydroacoustic technology and investigates the feasibility of applying it to the monitoring of both adult and juvenile migratory salmonids as well as coarse fish.

6.2.3 Trapping

Traps (up- and downstream) are expensive to install and run and are unlikely to be widely used for stock assessment. However, traps could be useful in validating other means of stock assessment and determining stock recruitment relationships.

It is recommended that the NRA should run a small number of traps at suitable sites for research purposes.

6.2.4 Redd Counts

Redd counting is not a reliable quantitative method for stock assessment. It can be used to give an indication of the distribution of spawning fish and may be used for local descriptive purposes.

It is not recommended that redd counts are reported as part of any national stock assessment programme.

6.3 Catch data methods

6.3.1. Catch data of Adult Migratory Salmonids

By statute, catch returns have to be supplied to the NRA by net and rod fishermen. However, there are a number of limitations associated with these data. Not all catches are reported, fish running into certain river systems out with the fishing season may not be represented and there is a general lack of knowledge as to how catches relate to stock. At present, catch statistics provide some information about trends in population numbers during the in-season run. **It is recommended that catch statistics could be improved by:**

i) Maximising catch returns

ii) Collecting more effort data to generate a measure of catch per unit effort (CPUE), to be used in conjunction with the publication of national catch statistics.

iii) Analyzing the relationship between catch or CPUE data and stock perhaps in conjunction with other information such as counters, traps and/or juvenile monitoring.

The technique of Creel census is similar to the catch census discussed above but is generally associated with recording catches of salmonids. Often, individual anglers will keep detailed log books of their catches and fishing effort. Creel census could be used to obtain more detailed information from a selected number of the better regulated fisheries and such data could be used to investigate the relationships between catch, effort and environmental data. However it is not envisaged that this will form part of the national stock assessment programme.

6.3.2 Catch data of Non-migratory Salmonids and Coarse Fish

The Group recognised that the collection and analysis of catch statistics has a useful part to play in providing data for those rivers which are too large and/or deep for assessment by any other means.

Two methods of collecting catch data have been used. In Yorkshire

Region, paid census officers visit anglers and fill in census cards. An additional exercise involves asking fishing match secretaries to complete a simple return on match results. Difficulty in recruiting reliable census takers and the disadvantages of a passive collection system such that used for match results contribute to the limited use of these methods. However, the census card technique provides information very cheaply (£500 for 40 days work to produce 600 questionnaires from one site) and can be used to produce trends in catch rate as well as plot changes in species mix and length frequency distribution over time.

It is recommended that angling census should continue on rivers where it is already suitably employed and other Regions should consider using it where it is the only means of obtaining information. A small group should meet to agree a common procedure, format and means of presenting data as well as describing the potential or actual biases and errors associated with the technique. **However, it is not recommended that the data from the passive collection of catch statistics be regarded as part of national stock assessment,** though it is recognised that the collection of such data has a local value in maintaining contact and rapport with anglers.

7. DATA COLLECTION

Stock assessment requires considerable resources in the field. It is therefore essential to collect all relevant data on both the fish and the habitat. A greater amount of detail will have to be collected for the species previously identified as target species, and within these the target size ranges or ages, than for the non target species or the excluded portions of target species.

Because of excessive sampling bias the 0 group must be treated separately. Population estimates for target species of coarse fish should exclude the 0 group, although they may be separately calculated and presented in reports. For salmonids estimates will normally include all age groups, but again the 0 group should be separately identified. It is recognised that not all sites being sampled for juvenile migratory salmonids will require full quantitative population estimates. (See paragraphs 6.1.1 and 6.1.3.)

If there is likely to be any doubt about the ages of target species encountered it is recommended that 10cm be used as a cut off point for population estimates of target coarse fish, unless the sampling method employs a fine mesh seine, when estimates including all fish above 6cm should be possible.

7.1 Fish Data

The nature of the data collected is entirely related to the aim of the assessment. The following comments apply to quantitative field surveys.

Length: Fish should be measured to the nearest millimetre. Where fish of the same size or age group can be easily identified subsamples of 30 can be used.

Weight: Where fish need to be weighed then should be weighed to the nearest gram up to 200g, the nearest 10g from 201 to 1000g and the nearest 50g for fish heavier than 1kg. A subsample of 30 individuals of each species should be used where the catch is large. In such cases stratified sampling is recommended but bulk weighing of mixed size groups, and large numbers of fish are not recommended because of the risk of damage. Provided there are no contraindications weighing will not be necessary where length weight regressions derived from previous sampling in the same target area can be used.

Age: To determine the age structure, an adequate number of scales needs to be taken from each target fish species.

Numbers: All fish caught within the target size range of target species must be counted. It is essential to record all other fish seen to be present, ie fry and nontarget species. These should be recorded in the following categories:

Per site	- 0	-	10
	10	-	100
	100	-	1000
	>	-	1000

7.2 Habitat

In the future, it may be possible to make predictive statements about fish populations from habitat data by using predictive models. It is therefore recommended that habitat data are collected using the HABSCORE format on all strategic surveys. It is recognised that HABSCORE is not designed for low land rivers but this format provides a suitable basis, until further consideration can be given to the design of the required format. The HABSCORE format is provided in Appendix 3. These data should be supplemented by a descriptive sentence and not more than two colour print photographs taken from defined and repeatable vantage points.

8. DATA PRESENTATION

Stock assessment reports may have to be presented to the Authority's Committees, other NRA Functions, angling consultatives, clubs or other outside bodies. To this end the NRA Regions should aim for a uniform and high standard of presentation. **NRA stock assessment reports must be written in such a way as to be clear to the non specialist as well as the professional, and should be well illustrated with suitable graphs, maps and diagrams.** It is advantageous if reports present fishery data with other relevant environmental and biological data.

The following is a summary of the principal data which are required:

8.1 Strategic surveys

For each site surveyed quantitatively: density and biomass, length frequency distribution, age and growth of each target species as specified in paragraph 7.0 and 7.1. Qualitative description of density for other species and age '0' groups. Habitat data as specified in paragraph 7.2. For each river or catchment containing a number of sites: a summary of biomass, and density data, (these can be very effectively displayed on a map), plus a growth summary. Data on fish health and parasite loads are not required as a standard item, but may be included particularly if there is evidence that populations are being affected by a health problem.

The general discussion will deal with issues raised by the above, eg. signs of populations limited by environmental stresses, uneven recruitment etc., and should be followed by conclusions and recommendations.

The report of a triennial stock assessment should include any catch statistics available.

8.2 Other surveys

The data required for other surveys will vary considerably according to the aim. For juvenile migratory salmonids for example, the best use of resources is likely to be a mixture of strategic site surveys with others at which the principal measurement is the densities of the different age groups.

8.3 Adult migratory salmonids

Catch statistics, counts, analysis of sea and river age if available.

9. RECOMMENDATIONS

It is recommended that:

i) The NRA should introduce a strategic programme of stock assessment throughout England and Wales.

ii) The aims and objectives of the NRA's stock assessment programme should be clearly defined and detailed for each catchment or subcatchment and the appropriate methodologies selected as set out in section 6 of the report.

iii) In order to harmonise the approach to this programme the attached proforma should be completed for all catchments in accordance with the guidelines also supplied in Appendix 4.

iv) In order to predict changes in population size, for most surveys the level of precision to aim for is Bohlin's second level of precision.

v) The most cost-efficient way of making statements about stocks would be to reduce the effort within sites and use the effort to sample a large number of sites. Relative methods such as catch per unit of standardised effort or simple minimum estimates should be considered whenever appropriate.

vi) It should be a target for all key rivers, with significant migratory salmonid rod catches, to have counters installed to monitor upstream runs. Electrode arrays should be incorporated into appropriate in-river structures wherever possible.

vii) The NRA keeps abreast of hydroacoustic technology and investigates the feasibility of applying it to the monitoring of both adult and juvenile migratory salmonids as well as coarse fish.

viii) The NRA should run a small number of traps at suitable sites for research purposes.

ix) Catch statistics are improved by maximising catch returns and collecting more effort data to generate a measure of catch per unit effort.

x) Angling census should continue on rivers where it is already suitably employed and other Regions should consider using it where it is the only means of obtaining information. A group should be set up to consider the best means of collecting and utilising angling census data.

xi) It is essential to collect all relevant data on both the fish and the habitat and to record everything that is caught during surveys including fry and non-target species. The applicability of HABSCORE both to salmonid rivers outside Wales and in particular to lowland coarse fish rivers needs to be investigated.

10. REFERENCES

Anon. 1988. Methods for sampling fish populations in shallow rivers and streams 1983. DoE Standing Committee of Analysts. HMSO.

Bohlin T. Estimation of population parameters using electric fishing: aspects of the sampling design with emphasis of salmonids in streams. In 'Developments in Electric Fishing', Ed. I.G. Cowx, 1990, pp 156-173.

Cowx I.G et al. Evaluation of electric fishing equipment for stock assessment in large rivers and canals in the United Kingdom. In 'Developments in Electric Fishing'. Ed. I.G. Cowx, 1990, pp 34-40.

The use of Bohlin's formula to calculate the number of sites required to achieve a particular precision level from: Fishing with Electricity edited by IG Cowx and P. Lamarque.

5.5.3 Number of Sampling Sites

Some methods for assessing the stock density, size and change, and the sampling errors associated with these parameters, all based on random sample of sites, have been described. As the sampling error is expressed in terms of the sample size *n* and the 'within sites' error, this presents the possibility of expressing *n* as a function of the total sampling error. This can be utilized to answer the important question: 'How many sites should be sampled and how much effort should be expended at each site?'

Consider the case where stock size or mean density is assessed by simple random sampling using a specific relative or absolute method at each site. The precision is chosen as one of the classes previously suggested. The number of sites to be sampled is determined from:

$$n = S\,(C_{pop}^2 + CV_i^2)/(S \cdot CV + C_{pop}^2) \qquad (36)$$

where C_{pop} is the spatial variation of population size among sites expressed as the coefficient of variation (standard deviation/mean), CV_i is the 'within sites' sampling error, expressed as the coefficient of variation (standard error/population size N_i) *in the specific case where* N_i is equal to the mean per site and CV is the precision requirement, expressed as standard error/mean. This expression makes it possible to approximate the number of sites required.

The following examples clarify the application of equation (36).

In a small trout stream, the target area was divided into S = 92 section of equal length (100 m). A random sample of n = 7 sites was selected as a pilot study. In each of these, three removals were carried out to estimate population size per site. The mean population size per section, and the standard deviation among sites were 127 and 86, respectively. C_{pop} is therefore 86/127 = 0.68. The catch probability, as estimated using the ML estimation was 0.60. Therefore CV_i using p = 0.6, number of removals = 3, and an average population size = 127, can be calculated either from equation (10) or inferred from Table 5.2. In this table, CV_i is found to be between 0.04 and 0.03, say 0.04. Finally, the precision level of the study to be carried out was chosen as Class 2, viz. CV = 0.10. Based on this pilot study, the number of sites required for Class 2 would be of the order of

$$n = 92\,(0.68^2 + 0.04^2)/(92 \cdot 010 + 0.68^2) = 30.9 \approx 31$$

If the level of precision is restricted to Class 3 (CV = 0.2), the sample size required would be about 11. For Class 1 (CV = 0.05), about 62 sites would have to be sampled – quite a formidable task.

A similar calculation can be carried out in relation to catch per site using a standard effort as an index of population size. Suppose that the aim in the example above was not to estimate absolute population density or stock size, but to obtain a relative estimate which could be used for comparisons with other streams where the catch efficiency can be assumed the same. One standardized fishing is performed in each of the seven sites of the pilot study. Using only the first catch in the example above, the mean of these catches, and the standard deviation among them was 76 and 54, respectively, yielding $C_{pop} = 54/76 = 0.71$. To calculate the 'within sites' coefficient of variation a measure of the catch efficiency is required (which cannot be estimated from just one catch). In this case, however, the catch efficiency is about 0.6, and that the average catch per site was 76. According to Table 5.1, this would correspond to a value of CV_i between 0.06 and 0.09, say 0.075. As before, $S = 92$. If Class 2 is sufficient ($CV = 0.1$), the sample size required would be

$$n = 92\ (0.71^2 + 0.075^2)/(92 \cdot 0.1^2 + 0.71^2) = 33$$

In the same way, Class 3 would require 12 and class 1, 64 sites.

Sometimes S is very large in relation n, for example in a large lake or river. Expression (36) will, in this case, degrade to

$$n \approx (C_{pop}/CV)^2 \qquad (37)$$

If so, the 'within sites' variation does not have to be estimated, it will be included in the value of C_{pop}, and relative estimation will thereby cause no computational problems. As above, the value of C_{pop} can be estimated using a pilot study or from previous studies, if the population size and the sampling are similar. Indeed, this relates to absolute as well as relative estimation

APPENDIX II

The two tables show how to use Bohlin's method to calculate the precision level achieved by a survey.

1. Table 1 gives details of a strategic survey of roach (> 10cm) carried out on the River Ancholme in Anglian Region. The target area comprised 256 sites (628,864 m^2) of which 18 sites were sampled. The precision level achieved using a ratio estimator was Class 2.

2. Table 2 gives details of a strategic survey of 1+ salmon carried out on St John's Brook in North West Region. The target area comprised 115 sites (48,600 m^2) of which 6 sites were sampled. The precision level achieved using a ration estimator was Class 3.

3. It should be noted that :

   1) Habitat stratification was not carried out in either survey. If stratification took place, the precision level for a given number of sites might be increased.

   2) The precision level for a given number of sites will be, to some extent, dependent on the distribution and catchability of the target species. The fish species being surveyed in these examples might be expected to give better than average results. Roach are more evenly dispersed through the Ancholme system than for example bream which are a shoaling species and 1+ salmon are more catchable than 0+ Salmon.

   3) In these calculations, the precision level is estimated with and without a ratio estimator. In Bohlin's original calculations he used sampling sites of comparable size. However where site area varies considerably, it is better to use a ratio estimator for the calculation of the precision level obtained, i.e. using site area rather than just numbers of sites.

Table 1

NO.SITES(n)= 18 ROACH >10 (ALL SITES)
TOT.SITES= 256 TOTAL m2 628864

SITE DATA : NUMBERS

SITE	AREA	H1	H2	H3	(m) Mark	(c) H2+H3+m	(r) RECA	m*c/r	(N) ESTIM	(V(N)) VARIA
166	1221	329	83		76	159	29	405	546.52	2719.25
167	2334	87	105	142	44	291	31	402	437.58	1250.74
167A	792	32	2		5	7	5	7	34.13	.17
187	717	104	43		0	43	0	0	177.31	212.33
187A	434	41	8		18	26	17	27	49.47	.54
168	4207	705	249		78	327	59	426	1034.19	576.77
169	2321	180	78		75	153	56	203	284.46	113.78
169A	1953	84	8		7	15	6	16	93.33	1.46
186	886	165	24		64	88	58	97	191.48	5.17
170A	3736	555	12		45	57	43	59	567.56	.66
170	3125	334	35		49	84	43	95	373.88	11.8
171	2964	589	35		80	115	66	139	631.42	21.55
172	2629	778	65		60	125	32	229	899.88	539.01
172A	3781	1106	65		80	145	68	169	1182.47	31.3
173	3163	776	153		88	241	86	245	932.56	7.28
174	3570	352	189		87	276	64	371	608.92	417.98
175	3181	751	112		91	203	82	224	875.29	34.02
176	3203	725	85		102	187	93	204	818.23	18.64

NUMBERS : WITHOUT RATIO ESTIMATOR (ie site areas ignored)

SITE	AREA	EST	EST/UNIT		
166	1221	547.	546.52	SUM EST	9738.68
167	2334	438.	437.58	AVE EST	541.0378
167A	792	34.1	34.13		
187	717	177.	177.31	SPAT VAR	129221.5
187A	434	49.5	49.47	SITE VAR	5962.45
168	4207	1034	1034.19	TOT POP	138505.7
169	2321	284.	284.46		
169A	1953	93.3	93.33	SURVY VA	6675.493
186	886	191.	191.48	SE (N)	81.70369
170A	3736	568.	567.56	CV NO	.1510129
170	3125	374.	373.88		
171	2964	631.	631.42	Cpop	.6644155
172	2629	900.	899.88	NUMBER SITES	
172A	3781	1182	1182.47	CLASS 1	104
173	3163	933.	932.56	CLASS 2	38
174	3570	609.	608.92	CLASS 3	16
175	3181	875.	875.29		
176	3203	818.	818.23		

NUMBERS : WITH RATIO ESTIMATOR (ie site area included)

SITE	AREA	EST	NOS/m2		
166	1221	547.	.448	SUM EST	3.808
167	2334	438.	.187	AVE EST	.2115556
167A	792	34.1	.043		
187	717	177.	.247	SPAT VAR	48177.04**
187A	434	49.5	.114	SITE VAR	5962.45
168	4207	1034	.246	TOT POP	138505.7
169	2321	284.	.123	MSE(T)	1.6316e8
169A	1953	93.3	.048	SURVY VA	12773.36
186	886	191.	.216	SE (N)	49.89594
170A	3736	568.	.152	CV NO	.0922227
170	3125	374.	.12		
171	2964	631.	.213	Cpop	.4056883
172	2629	900.	.342	NUMBER SITES	
172A	3781	1182	.313	CLASS 1	62
173	3163	933.	.295	CLASS 2	15
174	3570	609.	.171	CLASS 3	6
175	3181	875.	.275		
176	3203	818.	.255** CHECK FORMULAE		

Table 2

NO.SITES(n)= 6 SALMON 1++
TOT.SITES= 115 TOTAL m2 48600

SITE DATA : NUMBERS

SITE	AREA	H1	H2	H3	(m) Mark	(c) H2+H3+m	(r) RECA	m*c/r	(N) ESTIM	(V(N)) VARIA
1	670.3	46	15			15		0	68.26	31.46
2	453	28	9			9		0	41.26	18.03
3	376.3	12	3			3		0	16	2.96
4	540.7	65	10			10		0	76.82	3.46
5	360.1	7	13	9		22		0	29	0
6	337.7	36	3			3		0	39.27	.38
						0		0		
						0		0		
						0		0		
						0		0		
						0		0		
						0		0		
						0		0		
						0		0		
						0		0		
						0		0		
						0		0		
						0		0		

NUMBERS : WITHOUT RATIO ESTIMATOR (ie site areas ignored)

SITE	AREA	EST	EST/UNIT		
1	670.3	68.3	68.26	SUM EST	270.61
2	453	41.3	41.26	AVE EST	45.10167
3	376.3	16	16		
4	540.7	76.8	76.82	SPAT VAR	539.4597
5	360.1	29	29	SITE VAR	56.28
6	337.7	39.3	39.27	TOT POP	5186.692

SURVY VA	85.30056
SE (N)	9.235830
CV NO	.2047780
Cpop	.5149759
NUMBER SITES	
CLASS 1	55
CLASS 2	22
CLASS 3	10

NUMBERS : WITH RATIO ESTIMATOR (ie site area included)

SITE	AREA	EST	NOS/m2		
1	670.3	68.3	.102	SUM EST	.575
2	453	41.3	.091	AVE EST	.0958333
3	376.3	16	.043		
4	540.7	76.8	.142	SPAT VAR	223.0340**
5	360.1	29	.081	SITE VAR	56.28
6	337.7	39.3	.116	TOT POP	4803.201
				MSE(T)	467033.9
				SURVY VA	683.3988
				SE (N)	5.942598
				CV NO	.1422798

Cpop	.3311257
NUMBER SITES	
CLASS 1	32
CLASS 2	10
CLASS 3	4

** CHECK FORMULAE

HABSCORE III QUESTIONNAIRE
(June 1989)

PART A: GENERAL

Site :- Grid reference :-

Date :- Recorders :-

Flow conditions :-

Site Length :-

Site Comments (e.g. Fish stocking, pollution, barriers etc.) :-

PART B: TRIBUTARY

Q.1. PRINCIPAL RIPARIAN LAND USE (within 200m upstream) :- (tick box)

Moorland/Heathland	☐	Coniferous woodland	☐
Rough pasture	☐	Urban	☐
Improved pasture	☐	Industrial	☐
Arable	☐	Tips/Waste	☐
Deciduous woodland	☐		

Q.2. MEAN CONDUCTIVITY ($uS.cm^{-1}$) is :-

Q.3. MEAN HARDNESS ($mg.l^{-1}$ $CaCO_3$) is :-

PART C: REACH (50m)

Q.4. ALTITUDE (m O.D.) is :-

Q.5. VEGETATION. What percentage of water surface area is overhung (within ≤0.5m and >0.5m of surface respectively) by the following vegetation types :- (Enter A,S,C,F or D)

Absent	Scarce	Common	Frequent	Dominant
0%	1-5%	6-20%	21-50%	>50%

	≤0.5m	>0.5m
Herbaceous vegetation (e.g. grasses & rushes)		
Deciduous woody vegetation (i.e. shrubs & trees)		
Coniferous trees		

PART D: Sections (10m)

25.6cm

Take transects at 10m intervals along the reach, the first at the bottom net, and record 3 equally spaced depth measurements along each transect. Answer Q.9-Q.11 for the 10m sections between each transect. The length of the last (upstream) section may not be 10m, but should be between 5m and 14m so that the last transect is at the top net.

Q.6. SECTION LENGTHS :- (to nearest 1m)

d/s							u/s

Q.7. WETTED WIDTHS :- (to nearest 0.1m)

Q.8. DEPTHS :- (cm)

Right Bank							
Left Bank							

Q.9. SUBSTRATE. What percentage of stream bed area consists of the following substrate types :- (Enter A,S,C,F or D)

Absent	Scarce	Common	Frequent	Dominant
0%	1-5%	6-20%	21-50%	>50%

Bedrock							
Boulders	>25.6 cm						
Cobbles	6.4-25.6 cm						
Gravel	0.2- 6.4 cm						
Sand, Silt & CLay	<0.2 cm						

6.4cm

0.2cm

Q 10 FLOW. What percentage of water surface area consists of the following flow types :- (Enter A,S,C,F or D, as in Q.9)

Cascade/Torrential							
Turbulent/Riffle/Broken							
Glide/Run - Deep	(> 30cm)						
Glide/Run - Shallow	(< 30cm)						
Pool - Deep	(> 30cm)						
Pool - Shallow	(< 30cm)						

Q.11. FISH COVER. What percentage of stream bed area provides cover suitable for 10-20 cm trout as DEEP WATER or as SUBMERGED OVERHANG from the following items:- (Enter A,S,M,C or F)

Absent	Scarce	Moderate	Common	Frequent
0%	<1%	1-10%	11-20%	>20%

Boulders/Bedrock						
Tree-root systems						
Branches/Logs						
Undercut banks (not incl. above)						
Instream vegetation						
Deep water (not incl. above)*						
Other (please specify below)						

* For sections less than 5m wide, deep water is >50cm; for sections greater than 5m wide, deep water is >10% of width (e.g. on a 7m wide section, deep water must be deeper than 70cm).

NOTES ON THE FIELD USE OF HABSCORE III

METHOD

The Habscore III questionnaire may be used on sites of any length, but site lengths close to 50m are preferable. Lay out a cord, marked at 10m intervals, along one stream bank starting at the bottom net. Take transects at 10m intervals along the the reach, first at the bottom net, and record 3 equally spaced depth measurements along each transect. Answer Q.9 - Q.11 aafor the 10m sections between each transect. The length of the last (upstream) section may not be 10m, but should be between 5m and 14m so that the last transect is at the top net (Fig.1).

Q.1 If possible, tick one category that best describes the riparian land use within 200m up stream of the site. If necessary, more than one box may be ticked.

Q.2 and Q.3 Give mean figures for the tributary.

Q.4 Estimate attitude from a 1:50000 map.

Q.5 Record the surface area of the reach overhung by the three vegetation types, by assigning one of the five abundance categories. Vegetation that is <0.5m above the water surface is scored separately.

Q.6 State lengths of sections which should be 10m, apart from the upstream section.

Q.7 Record wetted widths to nearest 0.1m at each of the transects ensuring that the transect is at right angles to the stream channel. If the stream channel is split, see section on Split Channels below. Ensure that the up/down-stream convention is followed.

Q.8 Record three equally spaced depth measurements along each transect. If a depth measurement falls on a boulder, then measure the nearest representative water depth. Ensure that the right/left bank convention is followed.

Q.9 There are five abundance categories which should be assigned strictly according to percentage area; the most abundant substrate type does not necessarily score a "D". For discrete areas of substrate such as boulders or patches of sand, it is recommended that Table 1 is used, at least initially, to help estimate what the abundance categories represent in terms of area, given the section width. For example, in a 4m wide section you would need 2 sq.m (= 1.41m x 1.41m) of boulders for them to be common. For areas of mixed substrate types, a subjective estimate of proportions is easiest. Emergent boulders are included in the total stream bed area. Bars of lengths 25.6, 6.4 and 0.2cm are showed at the edge of the form to help distinguish between substrate types.

Q.10 Abundance categories are the same as in Question 9, and definitions of flow types are given in Table 2. Table 1 should be particularly useful for assigning abundance categories to flow types.

Q.11 Abundance categories are re-defined for this question to expand the lower percentages. The area of suitable submerged overhang provided by the cover items should be scored, not the total areas occupied by the items. Fig.2 illustrates submerged overhang. Fig.3 shows examples of what 1% and 10% overhang looks like. It is strongly recommended that measurements are taken, in conjunction with Table 1, to help estimate percentage overhang when necessary. Each type of fish cover should be assessed in the order given on the form; deep water under a tree-root system is therefore scored only once as tree-root overhang. The importance of deep water in providing fish cover is dependent on stream width. For sections less than 5m wide, deep water is >50cm; for sections greater than 5m wide, deep water is >10% of width (e.g. on a 7m wide section, deep water must be deeper than 70cm).

Split Channels

When a split channel occupies half or less of a 10m section, score the section as a single channel, and if the channel is split at a transect, measure the total wetted width and representative depths closest to the transect. If more than half of any 10m section is a split channel, then Questions 1 - 5 are answered twice for that section. Draw a line through the boxes of the relevant sections and score the channel closest to the left bank in the left half of the box, and the channel closest to the right bank in the right half of the box. An imaginary line may be necessary to enable the entire section to be scored as two discrete channels (Fig.4).

STOCK ASSESSMENT PROGRAMME

1) Catchment Name ....

2) Target Length (km) * (See Note 1) ....

3) Objective ** (See Note 2 and quote relevant number) ....

4) Number of survey sites proposed (Preliminary) ....

5) Proposed level of precision and Accuracy (See Table 1) ....

6) Survey Methods *** (See Note 3 & quote relevant number) ....

7) Resource implication in man days ....

STOCK ASSESSMENT PROGRAMME (GUIDANCE NOTES)

Note 1 The target length denotes any length of river which it is intended to consider as a unit for the purposes of the stock assessment methods as outlined below. A catchment is likely to contain a number of target lengths.

Note 2 Objectives : the objectives are summarised:

1. Strategic survey.
2. Evaluate for classification system.
3. Evaluate the success of restocking or habitat or water quality improvements.
4. Assess or predict the impact of the activities of other NRA functions or outside agencies and influences.
5. Pollution damage assessment.
6. Assess implications of developments or planning applications.
7. Conservation of rare fish species.

One or more objectives may be served by a single survey.

Note 3 The methods to be quoted are:

1. Electricfishing.
2. Netting.
3. Census.
4. Counting. This could refer to a whole catchment or part of a catchment.

Once the data outlined in Appendix 4 has been collected for all target lengths, it will be necessary to produce a summary for each catchment as given in Note 4.

Note 4 Summary for Catchment

Total target lengths (km) for survey methods....................
Total target lengths (km) for angling census methods ....
Total target lengths (km) for automatic counting ....
Total man days for a single survey of all target lengths ....