

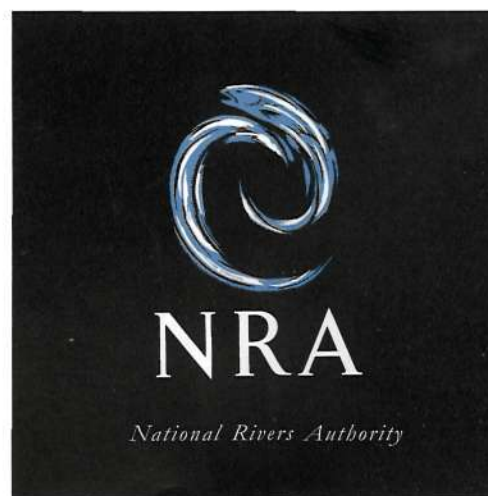
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# Evaluation of NRA Tracking Studies

**Future Projects and Technical Development**

**Scottish Fisheries Research Services**

**R&D Note 34**



## **EVALUATION OF NRA TRACKING STUDIES**

### **Future projects and technical development**

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R&D Note 34

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## EXECUTIVE SUMMARY

1. Fish tracking is a valuable technique for the provision of detailed information on the behaviour patterns of individual fish especially during estuarine and riverine migration.
2. Tracking studies help in the provision of a comprehensive description of the variety of fish behaviour patterns in response to factors such as water flow, obstructions and water quality.
3. There are advantages to be gained by complementing fish tracking studies with data collected from fish counters and *vice versa*.
4. An overall evaluation of NRA fish tracking projects is presented in the wider context of NRA strategic research objectives.
5. The requirement for future development of tracking equipment, improved data analysis techniques, better communication and more immediate report preparation is identified.
6. Individual project evaluation is given for NRA (or the appropriate Water Authority predecessor) tracking studies conducted on the Ribble estuary, the River Tamar, River Torridge, Rivers Test and Itchen, River Lodden, the Welsh River Dee, River Glaslyn, River Taff, River Tawe, River Tywi, River Usk, Rivers Avon and Stour and the River Frome.
7. An outline for future strategic research is provided which identifies particular areas for study:-
  - i) Identification of environmental factors which control the entry of fish into rivers.
  - ii) Improvement of the understanding of the relationship between water flow and upstream movement of salmonids.
  - iii) Examination of the detailed movements and behaviour of fish in relation to obstructions.
  - iv) Closer definition of water quality requirements for salmonid fish.
  - v) Definition of habitat preferences of salmonids in rivers.
  - vi) Subsidiary topics such as the movements of non-salmonid fish and the downstream migration of kelts and juvenile salmonids.

## KEY WORDS

NRA, tracking, salmon, sea trout, water flow, water quality, evaluation, management

## INTRODUCTION

This study was commissioned to :-

- a) Review available published and unpublished data and results of NRA salmonid tracking studies.
- b) Evaluate the effectiveness of tracking and counters in identifying the behavioural responses of adult salmon, *Salmo salar* L., and sea trout, *Salmo trutta* L., to changing water flow and quality conditions.
- c) Provide advice on the outline of a research programme to meet the likely future requirements of the NRA in this field.

The study began on the 7th January 1991 and was completed in June 1991. Two reports have been produced. R&D Note 33 describes NRA tracking studies, tracking techniques and fish counter technology. This second report published as R&D Note 34 evaluates NRA tracking studies and recommends future research. This report will be used solely for NRA management purposes.

This report briefly outlines the programme of the NRA, placing the Fisheries programme in the context of the work of the NRA as a whole, and viewing the tracking work against the broader requirements of the NRA Fisheries Function research programme. NRA fish tracking studies are evaluated and management, communication, staffing and project costs are discussed in Section 2. Future fisheries projects are discussed in Section 3 and Section 4 contains a summary and recommendations.

## 1. THE NRA PROGRAMME

The NRA has statutory duties and powers in relation to water resources, pollution control, flood defence, fisheries, recreation, conservation and navigation in England and Wales. The Authority is also responsible for managing, planning and conserving water resources, and for controlling the discharge of waste water and pollutants into rivers, estuaries and coastal waters.

The fisheries resources inherited by the NRA are significant. Amongst the principal current fisheries objectives are assessing the status of fish stocks and formulating policies to maintain, improve, develop, restore and rehabilitate the stocks upon which the fisheries depend. A related objective of the Water Resources Function is to develop a policy to overcome problems caused to fish and fisheries by low river flows which are often associated with water abstraction.

A specific responsibility of the Authority is the management of the migratory salmonids, salmon and sea trout. Sound management practices require a knowledge of the behaviour of fish within rivers, in terms of their general preferences for particular conditions during different phases of their life history, their response to barriers and obstructions and their specific requirements during periods of active movement. It is into this general context that fish tracking studies fit.

Much of the NRA's programme of fish tracking has arisen in response to the need for information about the particular problems of individual rivers. These projects may have some relevance to the strategic aims of the Fisheries Function, but it must be recognised that they were originally initiated in very specific contexts, and were intended to be evaluated in terms of meeting their own local objectives.



## 2. EVALUATION OF THE NRA STUDIES

During the last five years, there has been a great increase in the number of fish tracking studies carried out within the UK. This was largely stimulated by MAFF's development of a range of versatile and reliable fish tracking equipment including tags, receivers, and automatic listening stations. It has been suggested, perhaps unfairly, that fish tracking is a technique looking for an application. To what extent is this true? Have the NRA studies provided valuable information about the movements and behaviour of salmonid fish in relation to water flow and quality? How successful have these studies been so far?

The problems encountered in obtaining detailed information on the NRA studies makes it difficult to answer these questions. With several notable exceptions (the Ribble, the Avon and Stour and the Glaslyn studies) reporting of the projects is poor and largely consists of statements of the problems to be solved, plus general descriptions of the work presently being carried out. Very little analysis of the collected data has been presented, and it is difficult to judge whether the main objectives of the various studies have been attained or are likely to be attained.

The scope of the Ribble study was tightly defined, and despite the technical and practical difficulties encountered, and the small number of fish tagged, a clear cut result was obtained. The study was well reported. The Avon study was also well defined, achieved its objectives, and regular reports were produced. Though the results have not yet been released more widely, there is undoubtedly scope for publishing findings in refereed scientific journals. The Glaslyn study was an early application of tracking techniques, which has been thoroughly described, and which was terminated when immediate management questions could be answered. The results have recently been reassessed in the light of new interest in the effects of barrages. All three of these projects attained their objectives and can be seen to have done so. They have made an important contribution towards answering local questions. Moreover, the results from the Avon study have relevance in a wider context, for example in developing operating rules for river management.

In contrast, several of the remaining studies have been more open-ended, have been poorly reported, and the results are difficult to assess. The Tamar study commenced in 1986, is continuing, but has been particularly poorly described. It is not clear how successful this project has been, or what contribution the study is able to make to our understanding of salmon migration, since even limited appraisal of the results to date is not possible. Both the three year Tywi and the four year Usk projects have now been completed, but final reports are not yet available.

Again, the relevance of the results to the original objectives has yet to be fully assessed. All three of these projects are large and expensive and have involved the tracking of large numbers of fish. A regular cycle of reporting and appraisal would have benefited each of them, if only from an internal project management standpoint. In terms of providing information of value to the NRA in a wider context, only time will tell how useful these projects have been.

There have been three short projects of more limited scope, with few fish tagged, which were subsequently terminated. Five salmon were tagged on the Torridge, but work was not continued once the Roadford Reservoir transfer scheme was reviewed. This study may be resumed in the future. A three month study of a small sample of fish on the Loddon (Thames) provided interesting observations on the behaviour of transported fish, but was not followed up. The trial may be repeated. Studies carried out in the Frome have experienced capture and handling problems, and a large proportion of the fish have been lost. The project is now under review. All three of these projects illustrate the practical and logistical difficulties which can beset a project and confirm that tracking studies should not be entered into without careful prior evaluation of their likely success.

There are four NRA projects which have just started, or are at the planning stage. The project on the Test and Itchen, started in 1989, has clearly stated objectives, and though difficulties have been encountered in obtaining fish at the right place at the right time, progress has been good. The first report on the project is now due. A study on the Welsh Dee has been planned, is ambitious in scope, and is closely linked with the DEESAP index river initiative. Little documentation is available, and a more careful statement of the aims and procedures to be followed might have been expected. A study on the Taff, planned to run for 10 years, began in 1990 but further progress will depend on the Cardiff Bay barrage development going ahead, and the developers paying the full costs of the study. Documentation on this project is also meagre. A pilot study has started on the Tawe, again associated with a barrage proposal though initially funded by the NRA. A report on the pilot study due in February 1991 is not yet available. All four projects represent a major investment of NRA resources, even though part of the costs may be borne by external customers.

It is evident from inspection of these projects that project management procedures have varied widely between them. The subcontracting of work to others, as with the Avon and Stour study, with a requirement for regular reporting, has been successful, and should serve as a model to others. However, with many of the in-house studies it would appear that no requirement for self appraisal has been imposed, with the result that regular reporting to management has been patchy and almost certainly inadequate for further project assessment. This criticism does not reflect upon the staff engaged in the studies, all of whom show a

commendable enthusiasm for their work, and some of whom are continuing studies started by others. It is more a reflection upon the overall management of such projects. Sections 2.1 and 2.2 consider this problem of project management in more detail.

## **2.1 The Management of NRA Tracking Studies**

In carrying out the present review, it was recognised that there had been little or no monitoring or coordination of research activities on a national basis within the framework of the Water Authorities. Moreover, there has not yet been time within the NRA to develop methods for coordinating the work of the various regional groups carrying out research on fish migrations. The NRA Fisheries Function currently funds little of the tracking work undertaken, and has not been responsible for the establishment of the current portfolio of tracking projects. Hence the need for an overall review of these activities.

At present, the majority of NRA tracking studies have been commissioned by external bodies or by NRA divisions other than Fisheries, usually to examine specific problems. Where local Fisheries divisions have initiated work themselves, it has also been with a view to solving particular operational problems. However, many of these projects provide strategically important results. For the NRA Fisheries Function to co-ordinate tracking projects to provide strategic information there is a need for a central project review system of Operational Investigations.

It was clear that the majority of NRA Fisheries staff engaged in tracking work were not familiar with schemes for monitoring and assessing scientific activities. The most important recommendation to come from this review, therefore, is that the NRA ensures that in future the systems for describing, costing and appraising both its Regional Operational Investigations and National R&D programmes are strictly implemented. Such systems would allow the progress of all research activities to be monitored, and performance in meeting specific objectives to be assessed on an agreed timescale.

In some externally funded projects, the impression was given that customers were not especially concerned with monitoring year to year progress. Rather, tracking was viewed as meeting a general long term requirement for information. It is suspected that in some cases, particularly in long term studies, the research has been funded as a substitute for action. In these cases, it may be in the interests of some customers commissioning the work that the studies are open ended and that the results are not widely reported.

## **2.2 Communication and Staffing**

Some of the NRA regions engaged in fish tracking work, and their forerunners the Water Authorities, appear to give low priority to the reporting of results. In customer driven studies, this may be due to the confidentiality of those results. However, it was unusually difficult to obtain information for many of the projects reviewed. In some cases the only details available were from brief papers presented at conferences. Results from the last two years (since the 1989 AST/ Wessex Water Workshop) were not available for most of the projects outlined. Though one would not expect all the projects to yield the production of results in refereed scientific journals, it is not unreasonable to expect expensive scientific activities to be regularly reported upon. Where appropriate (i.e. where commercial confidentiality is not a primary consideration) such reports should be published or at least be available for scrutiny within the NRA.

Communication between regions engaged in similar activities appeared to be minimal. Discussion of problems, data analysis techniques etc would undoubtedly help in standardising methodologies, improve between river comparisons and aid the establishment and coordination of a national programme. More generally, the lateral dissemination of information through reports, meetings and seminars, should be actively encouraged. In this way the standard of work undertaken within the various regions of the NRA may be recognised and communication with other scientists both within and outside the NRA encouraged. Time must be allowed both for reporting results and communicating with others when staff responsibilities are decided.

An important factor in determining the success of a project is the continuity of project management. "In house" studies usually show strong continuity. However, it was clear that a number of the NRA tracking studies had experienced a rapid turnover of staff, which had been detrimental to progress and which had led to poor reporting of results. The NRA policy of fixed posts with individuals having to apply for positions elsewhere to further their careers inevitably leads to a movement of staff during the course of projects with some disruption to project progress. This system may be a nationally effective strategy which ensures that staff gain experience of a range of project types but it may be detrimental to the conduct of individual studies.

On a more positive side, communication with the general public is good for some studies. For example, a very informative colour booklet detailing the work carried out on the Avon is available from Wessex Water. There is no doubt that radio tracking work is of considerable interest to the general public, to anglers, and to the media. The publicising of tracking and counting activities can readily be used to interest the general public in the scientific work of an organisation like the NRA.

### 2.3 Project Costs

Costs are shown on an individual project basis in R&D Note 33, Appendix A. The figures are based on information supplied by project managers and in most cases were estimated and probably minimised. Actual costs have been more readily identified by Wessex Region since their tracking projects have been contracted out to an independent consultant.

To allow for overheads, the manpower costs given in the project sheets have been multiplied by a factor of 1.5 (as suggested by the R&D Coordinator, NRA Head Office). However, we consider this to result in an underestimate of manpower costs. A more realistic factor would include all administrative costs, superannuation, accommodation, transport and common services.

Capital expenditure has been written off over a 3 year period. Costs therefore decline after the initial 3 years of a project. Once the essential equipment has been purchased tracking projects may be run effectively without any major additional capital costs for several years.

Where available the mean annual cost of each project is shown in Table 2.1. The costs have been adjusted to a 1991 price index for comparison.

Table 2.1 Mean annual project costs indicating the principal funding bodies. Costs have been adjusted to a 1991 price index. It is likely that these costs are underestimates.

River	Cost (£)	Funding body
Ribble	4,475	North West Water, WRC
Tamar	40,000	South West Water plc
Test	34,375	NRA (Water Resources)
Dee	60,000	NRA (WR, WQ and Fisheries)
Taff	29,700	Cardiff Bay Dev. Corp.
Tawe	11,500	NRA (at present)
Tywi	52,000	Welsh Water/NRA
Usk	34,275	Welsh Water plc
Avon	40,962	NRA (Water Resources)
Frome	7,441	NRA (Water Resources)

A representative annual cost per fish tagged (again adjusted to 1991 prices) is presented in Table 2.2. Some projects have not been included in Table 2.2 since they are at an early stage and have tagged few fish or are yet to begin. It should be borne in mind that within some of the project costings there are undoubtedly hidden contributions from collaborative bodies.

From Table 2.1 it is apparent that there is considerable variation in the costs of the tracking projects. Those projects which tag and track more fish inevitably incur higher total costs. In addition, the projects involving estuary tracking, which is extremely labour intensive, are also more expensive (eg. anticipated costs for the Welsh Dee project). Contracting out tracking projects on a consultancy basis appears to give good value for money with the additional benefit of providing continuity of specialist effort during the execution of the work. Judging from the success of the Avon study, such projects can also be most effective in meeting the objectives laid down. However, the costs of NRA staff involved in establishing and monitoring progress of such projects may be underestimated.

Table 2.2 Estimated average cost per fish tagged during each project

River	Cost (£)
Ribble	812
Tamar	477
Test	625
Dee	-
Taff	10,100
Tawe	2,080
Tywi	375
Usk	908
Avon	469
Frome	607

Table 2.2 shows the cost per fish tagged. Where projects are at an early stage, costs per fish tagged are of course unreasonably high, eg: Taff and Tawe. Apart from these exceptions, costs are within the same order of magnitude and vary from about £400 to £900 per fish tagged.

The greatest proportion of the expenditure once a project is established is incurred by manpower, which represents around 60% of the total annual project cost (range 52.3 to 72.7%). An estimate of costs for a river based tracking project aiming to tag 100 salmonids based on present day full economic costs would now be in the region of £70K per annum. This total allows for some capital expenditure but assumes that existing monitoring equipment would be employed. Estuarine studies require a greater manpower input and hence a similar scale of study would require an annual budget of about £110K and fewer fish could be tracked. The purchase of specialised equipment to commence such a project (sonar receivers etc) would of course need to be tailored to the particular study site.

Difficulty was experienced in determining the costs of most of the tracking studies under review, as no standard system for estimating and monitoring costs was in place. We believe that the figures provided are likely to be underestimates.

### 3. FUTURE FISHERIES PROJECTS

Most of the current NRA tracking projects were originally established to address local problems, nevertheless their results are potentially relevant to the broader strategic research interests of the NRA.

There would be major advantages in expanding the strategic objectives of some existing or future tracking projects. Clearly, not all projects would be suited to addressing these broader objectives. However, the addition of a more strategic role could be expected to greatly enhance larger tracking projects. Such an approach, with firm direction and monitoring from the NRA, might prevent a duplication of effort between projects by ensuring that each of the more important strategic questions becomes the stated responsibility of one of the project leaders.

Thus, there is scope for building into one of the existing projects the broader objective of examining all those aspects of river flow and other environmental factors that are important in inducing fish to leave the sea or the saline waters of the estuary and enter fresh water. It is important to note that an extensive system for monitoring environmental parameters such as temperature, salinity, and flow would be required for such a study. The lack of such facilities for the estuarine studies carried out hitherto has greatly limited their value. A "monitored" river should be considered as a prime site for such a study. The current existence of active programmes on appropriate rivers points to the selection of one of them as a favoured site. It would be sensible to build into one of the riverine studies a requirement to develop more advanced models of the relationship between salmon movement and flow, with the broad objective of improving knowledge on river management and setting operating rules for the regulation of water release and abstraction. So far, this approach has only been adopted on the Avon. This may well be an atypical site, and the establishment of a well focused study elsewhere, on a river with a more varied pattern of flow, would have advantages. It is important that before additional fish are tracked, some simple preliminary modelling is carried out, and the actual data requirements fully specified.

The importance to the NRA of improving the passage of salmonid fish through barriers and other obstructions in estuaries and rivers is very clear, and several projects are already attempting to examine the effects of coastal barrages. It may be advisable to charge one particular group of scientists with investigating the detailed behaviour of fish in and around obstructions, and subsequently giving that group responsibility for the provision of advice on the design of barrages and their associated fish passes. Such a group should not merely examine the behaviour of fish in and around particular fixed barriers to movement. There is also scope for a detailed experimental study of the movements of salmon and sea trout with respect to variation in flow within a river channel, and around obstructions. The



requirement for better fish pass design would more readily be met by such an experimental study than simply by site specific tracking studies - valuable though the latter may be.

Another area where a degree of concentration of effort might be appropriate is in the definition of water quality requirements for fish moving through estuaries. The close degree of environmental monitoring necessary for such a study has already been revealed in NRA studies. There are two approaches which can be adopted: the placement of telemetering transmitters on the fish themselves thus measuring the environmental parameter values favoured by the fish, or through intensive monitoring at a number of locations along the estuary. Either way, the degree of expense involved would make it advisable for such work to be concentrated on a particular estuary, and not spread over several independent projects.

It is worth considering whether this requirement for detailed investigation of the influence of water quality could be combined with the requirement for information on the effect of river flow on fish in estuaries. Both studies require careful and extensive monitoring of environmental parameters.

A further strategic area where little work is underway, and which could be included within the mandate of a particular project, is the closer definition of the habitat preferences of salmonids within rivers. Only limited information is available on the freshwater locations preferred by returning adult salmon though such information is important in meeting the environmental needs of these fish and to general considerations of habitat improvement. Studies of the movements of fish have tended to concentrate on the routes followed and the timing of the movements. In order to understand and predict movement patterns, however, it is necessary to define the habitat preferences or requirements of fish, which will vary through the various phases of their migrations. There would be advantages in carrying out a detailed study of habitat preferences within the context of a larger riverine tracking project. Particular attention needs to be paid to defining the choices and preferences of fish during their long quiescent period within rivers, and also the more active spawning periods.

There is a need to develop tracking equipment and data logging systems for future radio tracking projects. In particular the technical constraints of tagging larger numbers of fish may be overcome by the development of coded tags. MAFF are currently engaged in such development work and hope to produce coded transmitters in the near future. The collection of environmental data using data storage tags carried by individual fish is also feasible, although considerable development work still has to be conducted. The manufacture of even smaller transmitters, with reasonable power output and battery duration, for tagging juvenile salmonids and smaller fish species would obviously be a considerable advantage.

The quality of data collected from tracking projects can be improved by careful planning of the siting of automatic listening stations (ALSTNs) during the studies. Because of variable

sensitivity depending on locality and aerial deployment problems of overlap and imprecise position fixing can occur. The importance of such problems may be significantly reduced by placing stations several kilometres apart and reducing the sensitivity of each station.

Finally, it is necessary to stress the considerable advantages to be gained from closer integration of the various NRA tracking and counting projects. There has been little evidence of any coordination between projects to date, though there has been great overlap between them, both in terms of the techniques being applied, and the objectives being followed. The value of bringing the various project participants together to discuss topics of mutual interest cannot be overestimated. Moreover, there is a strong case for the NRA taking the overall lead in promoting the discussion and coordination of work on fish movements within the UK. This may be achieved through the setting up of workshops for disseminating information on existing studies, bringing together different groups to discuss the more strategic issues, and promoting the development of technical methods.

## **4. SUMMARY AND RECOMMENDATIONS**

Fish tracking, whether by means of acoustic or radio tags, has now been in use for over 40 years. Essentially, tracking provides a great deal of detailed information about the behaviour of individual fish. It can provide a comprehensive picture of the overall variety of behaviour, and allow detailed information to be obtained on the habitat preferences of individual fish during the different phases of their life history. Fish counters, on the other hand provide data on the numbers of fish moving past a given point but no biological data other than length distribution.

They can provide accurate census data, and information of the movements of populations as a whole. Used in pairs, counters can indicate the propensity of fish to respond to particular environmental cues. The techniques of fish tracking and fish counting complement one another, and there are advantages to be gained from using them together. Both have now reached a degree of technological development which allows them to be used routinely.

### **4.1 Current NRA Studies and their evaluation**

Thirteen tracking projects were examined during this review, and are listed below:-

North West Region  
Ribble Estuary

South West Region  
River Tamar  
River Torridge

Southern Region  
Rivers Test and Itchen

Thames Region  
River Lodden

Welsh Region  
River Dee  
River Glaslyn  
River Taff  
River Tawe

Welsh Region (continued)

River Tywi

River Usk

Wessex Region

Rivers Avon and Stour

River Frome

Each of these studies has its own local objectives. Some have received external funding from the Water Authorities or plcs (Tamar, Torridge, Loddon), and commercial developers (Taff, possibly the Tawe in the future), while others have been commissioned by NRA Water Resources (Test and Itchen, Avon and Stour, Frome), or are jointly funded (Ribble, Dee, Tywi, Usk). Nevertheless, each study has also incorporated elements capable of contribution to the broader, more strategic objectives of the NRA Fisheries Function, including:

- i) Examining the effect of flow, and defining the environmental factors controlling the upstream movements of salmonids, especially in relation to water abstraction and water release schemes. (Tamar, Test and Itchen, Dee, Tywi, Avon and Stour, Frome).
- ii) Investigating the effects of obstructions, especially coastal barrages, on the passage of salmonids. (Tamar, Test and Itchen, Dee, Taff, Tawe, Usk).
- iii) Studying the effects of water quality upon the passage of fish through estuaries and rivers. (Ribble, Dee, Usk).
- iv) As a subsidiary aim, estimating the population size of salmonid stocks, and determining exploitation rates. (Test and Itchen, Dee, Tywi, Avon and Stour).

Three of the projects (Ribble, Avon and Stour, Glaslyn) have been completed, attained their specific objectives and reports have been prepared for each. The results from the Avon and Stour study may have relevance in a wider context, for example in relating environmental factors including flow to the upstream movements of fish, in order to perhaps assist in the development of operating rules for river management.

In contrast, the Tamar, Tywi and Usk studies have been more open-ended, have not been fully reported upon, and only limited analysis of the collected data has been performed. Only time will tell whether these projects have met their specific local objectives, or are able to contribute to our wider understanding of factors affecting the movements of fish.

There have been three short projects of limited scope, with few fish tagged, which were subsequently terminated (Torridge, Loddon, Frome). All three encountered logistical difficulties. The Loddon and Frome studies may be resumed if various practical difficulties can be overcome. Work on the Torridge may be resumed if interest in a local water transfer scheme is revived.

Four NRA projects have just started, or are at the planning stage (Test and Itchen, Dee, Taff, Tawe). Two of them, the Taff and the Tawe projects are associated with barrage developments (new work on the Usk may also be considered, if plans for the Usk barrage proceed). The Dee study is ambitious in scope and closely linked with the DEESAP index river initiative. The project on the Test and Itchen has clearly stated objectives, and is making use of both fish tracking and fish counting.

Standards of management and planning have varied widely between these projects. The subcontracting of work to a consultant on the Avon and Stour, with a stated requirement for regular reporting, has been especially successful in management terms, the project serving as a model for others - though a final report has yet to be received. This is not to say that projects like those on the Tamar, Tywi and Usk have not yielded great quantities of data, or that they are not capable of providing considerable insight into the behaviour patterns of fish, once analysis has been completed. It is simply that full evaluation of these projects is made almost impossible by a lack of written material, and especially a lack of analysis of the data collected. It would appear that no requirement for periodic appraisal of these projects has been imposed. It is possible that some of the customers commissioning the work wished these projects to be open-ended, with no strict requirement for the reporting of the results. However, it is not desirable that this deficiency should continue. A standard system for describing, costing, monitoring and reporting on all research projects is required.

It is recognised that the NRA Fisheries Function has yet to develop methods for coordinating the work of the various regional groups carrying out research on fish migrations and promoting communication between them. Hence the need for this review. It is clear however, that a system is required for reviewing progress in Operational Investigations, for appraising the degree of success with which particular projects have met their objectives, and for ensuring that collectively these projects address the more strategic objectives of the NRA with minimum duplication of effort. In addition to instituting a programme review procedure, however, there is also a need for more lateral dissemination of information. Indeed, there may be a case for the NRA seeking to promote coordination of fish tracking and counting work across the UK, including other outside agencies.

## **4.2 Future Strategic Research**

Fish tracking and fish counting are merely techniques. They are essentially no different from other fisheries research techniques like electrofishing, or chemical monitoring. As the techniques become more accessible and reliable they will be used increasingly for the solution of local problems on individual rivers. Provided each individual proposal is evaluated beforehand in terms of the specific objectives each is intended to meet, there should be no unnecessary proliferation of tracking and counting techniques. However, tracking and counting also have a major role to play in meeting some of the more strategic future research requirements of the NRA. There would be major advantages in meeting these objectives through the expansion of existing or planned projects. Clearly, not all projects are suited to taking on these broader objectives, but in the case of the larger ones the addition of a more strategic role would greatly enhance them, with benefits for the more specific local objectives. Such an approach, with proper prior evaluation, firm direction, monitoring and reporting, should assist in preventing a duplication of effort between projects.

Particular strategic areas of work which have been identified are:-

- i) Identification of those environmental factors, including river flow, which control the entry of fish into fresh water from the sea or the saline waters of the estuary.
- ii) Within the river, there is a need to improve understanding of the relationship between water flow and the upstream movement of migratory salmonids, because of the considerable relevance of this relationship to the regulation of water abstraction and water release. Though fish tracking and counting techniques have already been applied to this problem, an element which has been lacking from earlier projects has been the prior modelling of the relationship between movement and flow, and the setting up of simple hypotheses which can be tested in the field. The wider use of fish counters especially in series, would also bring benefits to this area of study.
- iii) Detailed examination of the movements of salmonid fish with respect to the patterns of water flow within river channels and at obstructions and fish passes. The development of better methods for easing the passage of fish through rivers is presently hampered by ignorance of the precise requirements of migratory fish. Though such a study might employ fish tracking and fish counting, the use of other techniques - such as video observations, would almost certainly be necessary.
- iv) Closer definition of the water quality requirements of salmonid fish, especially within estuaries. It is possible that this work could be combined with a study of those factors which induce fish to leave the estuary and enter the river (described in i) above). Both studies

require the intensive and extensive monitoring of environmental parameters along an estuary. It is possible that some of these parameters can be monitored by means of telemetering tags attached to the fish.

v) One area of interest which has not yet been addressed by means of tracking techniques is the better definition of the habitat preferences of salmonid fish within rivers. The movements of fish through rivers have so far been described rather crudely, in terms of distances travelled upstream, or the environmental factors which control the movements themselves. Improvement and rehabilitation of the habitat available for adult salmon within rivers, both during upstream movement, and during spawning itself, requires a more detailed examination of the habitat choices made by fish.

vi) Subsidiary research topics which might benefit from the application of fish tracking and counter techniques include the downstream movements of smolts and kelts, and the movements of non-salmonid fish. Estimation of the population size of salmonid stocks and determining exploitation rates are important secondary results from some projects.