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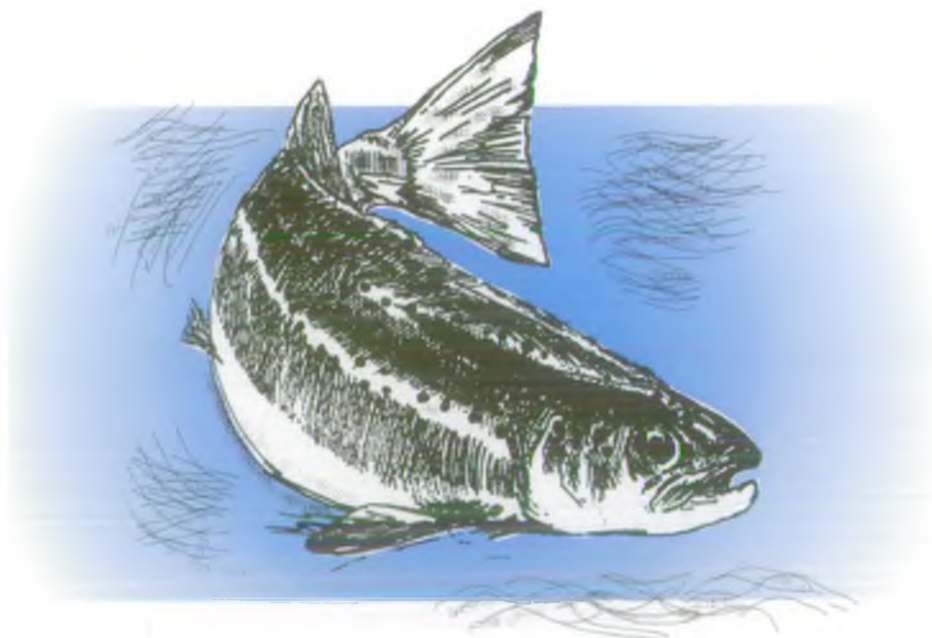
National Rivers Authority

SEA TROUT
IN ENGLAND AND WALES



FISHERIES TECHNICAL REPORT

1

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1. Sea Trout in England and Wales.
2. Analysis of Sea Trout Catch Statistics for England and Wales.
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Published by:

National Rivers Authority
Rivers House
Waterside Drive
Aztec West
Almondsbury
Bristol
BS12 4UD

Tele: 0454 624400
Fax: 0454 624409

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FISHERIES TECHNICAL REPORT NO.1

SEA TROUT IN ENGLAND AND WALES

March 1992

SUMMARY

1. National catch statistics suggest that rod catches of sea trout were well below average in 1989 and 1990, whilst commercial catches were reduced only in 1990.

2. Long term regional catch data show that in Wessex, North West, Welsh and South West rivers there has been a recent decline in both commercial and rod catches of sea trout, with significantly reduced rod catches in 1989 and 1990. In contrast, the long term trend in North East rivers shows an increase in catches.

3. It is difficult to establish the exact relationship between catch, stock, and factors such as fishing effort and environmental variables which often vary on an annual basis. However, analysis of the data suggests that the long-term trends in catch statistics probably reflect real changes in sea trout populations.

4. Thus at present, some English and Welsh sea trout stocks appear to be declining but the cause of this decline and whether it will continue are not known. There are no confirmed reports of English or Welsh sea trout showing similar symptoms to those affecting sea trout in Western Ireland.

5. Sea trout catch statistics can also be used to identify the performance of individual rivers in terms of their overall mean annual catch and the variability in catch between years.

6. This classification of poor to good sea trout rivers may have profound implications for stock management. Analysis of historical catch records may help to identify the original or potential sea trout status of a river and consequently which fisheries management strategy (e.g. habitat improvement, restocking) would be most appropriate.

7. A brief summary of the NRA's present and proposed research programme on sea trout is outlined.

8. In order to maintain, improve and develop sea trout stocks as a sustainable resource the NRA needs to implement an action plan to:

   - **Improve stock assessment.**
   - **Improve knowledge about the basic biology of sea trout.**
   - **Understand how sea trout populations are regulated, with particular emphasis on critical life stages.**
   - **Determine the pattern and levels of different forms of exploitation.**
   - **Establish how to enhance sea trout stocks.**
   - **Preserve the genetic variability found in sea trout stocks should any population collapse take place.**

SEA TROUT IN ENGLAND AND WALES

CONTENTS PAGE

1. INTRODUCTION

Under the Water Resources Act (1991), the National Rivers Authority has a duty to maintain, improve and develop fisheries including those for sea trout. The formation of the NRA makes it possible to develop consistent policies for the management of sea trout stocks throughout England and Wales and to institute a national programme of sea trout research.

The aims of this report are to:

i) Assess current information on the status of sea trout stocks in England and Wales.

ii) Consider what information and resources are required to manage sea trout stocks effectively.

iii) Propose a strategy for the future management of sea trout stocks by the NRA.

Much of the source material for this report has been provided by three separate studies which were commissioned by the NRA during 1990/1991. These studies, referred to frequently within this report, are published as NRA Fisheries Technical Reports 2, 3 and 4 (2. Elliott, 1992; 3. Elliott, et al, 1992; 4. Cross and Rogan, 1992).

2. BACKGROUND

2.1 The life cycle and characteristics of the sea trout.

Both forms of indigenous trout (i.e. brown trout and sea trout but not rainbow trout) in the British Isles are one species *Salmo trutta* L. However, the fisheries manager and angler distinguish between trout that migrate to sea, commonly called sea trout (or sewin in Wales and finnock, peal, whitling etc in various parts of England) and those that remain in fresh water, known as brown trout. In practice, such distinctions are not always clear because *Salmo trutta* is a polymorphic species demonstrating a high degree of morphological, physiological and ecological variation.

Although adult sea trout can usually be distinguished from brown trout by their appearance and size, juveniles cannot. Migratory and resident trout may spawn separately or interbreed but in all cases their progeny are morphologically indistinguishable until those destined to become sea trout turn into smolts and migrate to sea. At present, juvenile trout stocks in river systems containing both resident and migratory trout have to be managed as a single stock.

The life cycle for one year class of sea trout is illustrated in Figure 2.1. It is important to note that juvenile sea trout do not all smoltify, nor do they migrate to sea at the same age. In the British Isles, most sea trout smolts migrate at the beginning of their third year although some may not leave fresh water until their fourth or, in rare cases, fifth year.

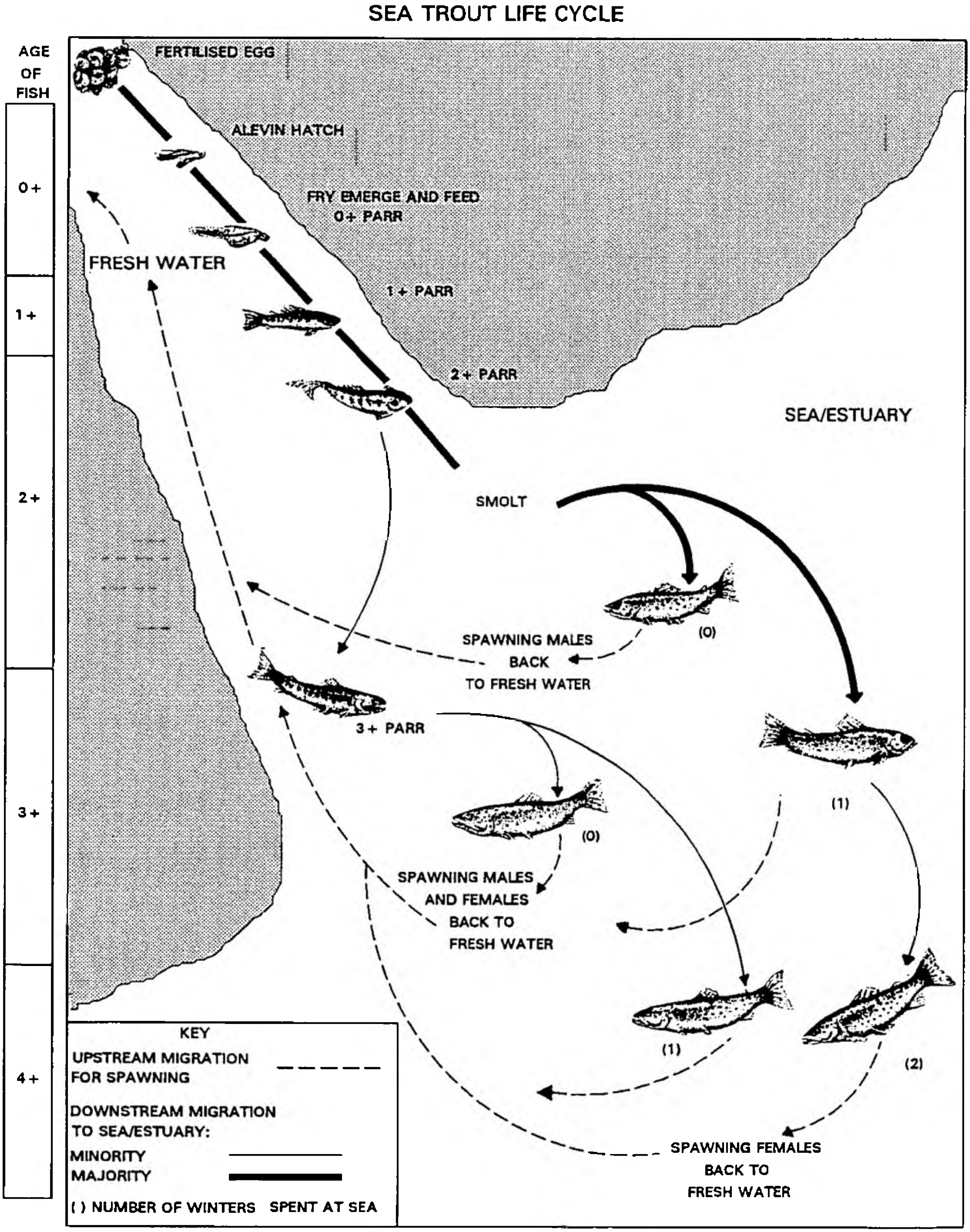


Figure 2.1.
Modified from Elliott (1988b)

Likewise, the period of time spent in the sea varies from as little as three months to over three years. Sea trout that have spent less than a year at sea may return to fresh water and overwinter without spawning, but one-sea-year old and older sea trout normally spawn on their return and many survive to become multiple spawners.

This characteristic of divided migration to and return from the sea makes it very difficult to monitor particular year or age classes. The number of age categories that could be represented in a stock is a product of the duration of smolt life multiplied by the maximum sea life. Superimposed upon this are different life strategies, behavioural and physiological responses to differing climatic and environmental factors in order to gain maximum advantage in terms of feeding and/or reproductive success, for example returning to fresh water but not spawning or returning and spawning.

Detailed scale analyses have shown there may be up to 40 different such life strategies within a single sea trout stock. However, for most stocks of sea trout in England and Wales, there is only limited information about the average smolt age, mean duration of sea life and overall age composition. The need to gather more of this basic biological information is an essential first step in the proper management of our sea trout stocks.

More information is also needed about the genetic variation between sea trout stocks. There is increasing evidence, both genetic and ecological, that trout are subdivided into a large number of reproductively isolated and genetically distinct populations. It is not known how significant this genetic variation is. Investigation of the genetic basis for these differences between allopatric (isolated) and sympatric (co-existing) stocks of the major sea trout rivers in England and Wales is required urgently.

2.2 The value of sea trout

Sea trout provide valuable commercial and recreational fisheries in England and Wales although the value of sea trout has often been overshadowed by that of salmon, which frequently share the same river system. However, in Wales, the importance of sea trout has been recognised and Cresswell (1989) proposed that rod catches of sea trout contribute equally with salmon to the total value of Welsh fishing rights (excluding the River Wye). This value was estimated to be £12 million in 1989.

Elliott (1989a) estimated the total value of sea trout for England and Wales to be £55 million. This figure was arrived at by multiplying the total national mean annual sea trout catch (1983 - 1986) by £500. Sea trout fishery valuations at that time were based on a minimum of £500 per fish caught.

Sea trout also have an intrinsic value as an indigenous species and are just as worthy of conservation as other aquatic animals or plants, should stocks become endangered.

3. THE PRESENT STATUS OF SEA TROUT STOCKS IN ENGLAND AND WALES

3.1 The perceived status of English and Welsh sea trout stocks in 1990.

During 1990, reports were made to the NRA of reduced catches of sea trout in many areas of England and Wales. In response to increasing public concern about a possible decline in sea trout stocks, a paper entitled "Status of Sea Trout Populations" was presented to the Chairmen of the NRA's Regional Fisheries Advisory Committees. At the time the report was written, not all the 1990 catch data had been collected. However, preliminary assessments from available catch returns and NRA regional fisheries staff suggested that sea trout catches were lower than normal in a number of areas.

The concern about a possible decline in English and Welsh sea trout stocks was voiced against a background of well publicised reports of a major decline in the sea trout population of Western Ireland.

3.2 The situation in Western Ireland

During the winter of 1989/1990, the Irish Sea Trout Action Group (STAG) devised a programme of scientific research to investigate the possible causes of their declining sea trout catches. This programme was co-ordinated by the Salmon Research Agency and in December 1990, it presented a report, "Declining Sea Trout Stocks in the Galway/South Mayo Region", to STAG. Based on this report, STAG published a bulletin, "Sea Trout News" which contained the following key points:

i) In 1989 and 1990, adult sea trout had largely disappeared from river systems located within a well defined area in Western Ireland.

ii) Up to half the sea trout that returned to fresh water during 1989 and 1990 were emaciated.

iii) The cause of the problem was unknown but had been shown to occur at sea.

iv) Fish farming, disease, climatic change, food shortage, netting and predation were suggested as possible causes.

v) A netting programme was carried out in an attempt to follow and monitor the progress of the 1990 smolts and kelts during their sea life.

vi) In early May 1990, some sea trout smolts and kelts had returned to river mouths as thin, non-feeding fish covered with sea lice. Such fish were recorded outside the defined area and also well offshore.

vii) Fish were screened for disease but no pathogen has yet been found.

viii) A project has been initiated to investigate sea lice which includes studying their incidence and control in coastal fish farms.

More recent reports from Ireland indicate that in 1991 some sea trout smolts again returned prematurely to fresh water, heavily infested with sea lice. However, it should be emphasised that it has not been demonstrated that sea lice are more abundant than in the past nor that sea lice are the cause of the decline in sea trout numbers.

There is no evidence in England and Wales of sea trout being emaciated, abnormally parasitised by sea lice or returning prematurely to fresh water. Nor was the scale of any decline in English or Welsh sea trout catches in 1990 comparable to that recorded in Western Ireland. However, the NRA decided to examine critically the status of sea trout stocks in England and Wales.

3.3 Methods of stock assessment

Salmon stocks can be monitored by assessing both juvenile and adults stocks. However, there is no current method of identifying sea trout juveniles because resident and migratory trout are morphologically indistinguishable during most of their freshwater life. Therefore it is not possible to assess accurately juvenile stocks of migratory trout, if part of the total stock remains resident in fresh water.

Thus stock assessment of sea trout is confined to monitoring numbers of adult fish. Smolts can also be monitored but at present downstream traps are operated at only a few sites on an experimental basis.

The methods currently available for assessing adult stocks of sea trout are resistivity fish counters and catch data. Although counters are installed on a number of rivers, these were mainly designed to count salmon rather than sea trout. Further problems associated with counters include:

i) no counters on many important sea trout rivers;

ii) few counters with data runs spanning many years;

iii) many counters are unreliable, particularly those using prototype technology.

In contrast, catch data have been collected over many years and are available for all commercial and significant recreational fisheries.

3.4 The national catch data for England and Wales (1984 - 1990)

The 1989 Fisheries Statistics Report gives details of both net and rod catches of sea trout in England and Wales from 1984 - 1989. In addition, unpublished data for the 1990 season have been incorporated.

It is accepted that the national catch statistics only represent the declared catch and as such are not an accurate record of the total numbers of fish landed. Returns from rod licence holders are known to be underestimates, and could be less than 10% in some cases. Furthermore, even if the catch data were wholly accurate, it is still difficult to establish the exact relationship between catch, stock, and factors such as fishing effort and environmental variables which often vary on an annual basis. However, as discussed below, there is strong evidence that the effects of such factors may be proportionally similar for all catches and, therefore, valid comparisons can be made between years.

i) Commercial catches

In 1989, returns of sea trout catches were made by 812 licensed commercial instruments in eight NRA regions. No commercial exploitation of sea trout was recorded in Thames or Severn Trent NRA regions.

From 1984 - 1990, the average annual commercial catch of migratory trout in England and Wales was 72,563 fish. A total of 75% of these fish was taken off the Northumbrian and Yorkshire coasts. Figure 3.1 shows the total commercial catch of sea trout for each year since 1984. Commercial catches of sea trout between 1984 and 1989 ranged from 62,452 fish in 1986 to 95,699 fish in 1984 but, until 1989, there is no indication of a downward trend. However, in 1990, the commercial catch was only 51,078 fish, 33% lower than the previous six-year mean of 76,102 fish. When the catch returns for 1990 were analysed for each region separately, it was clear that the decline in catches in Western regions (53%) was more acute than in Southern and Eastern regions (26%).

ii) Rod and line catches

During the period 1984 - 1990, the average total annual rod and line catch of migratory trout in 73 specified rivers in England and Wales, was 34,468 fish. Of these, 62% were taken in Welsh rivers. Figure 3.2 shows the total rod and line catch for each year since 1984. In contrast to the commercial catch, national rod catches of sea trout in 1989 and 1990 were well below average. As with the commercial catches, the decline has been greater in Western regions.

The only firm conclusions that can be drawn from these national catch statistics are that rod catches of sea trout were below average in 1989 and 1990 whilst net catches were reduced only in 1990. This pattern of catches may reflect the existence of one weak year-class. A weak year class of fish returning to fresh water after less than 1 year at sea in 1989 could have been responsible for poor rod catches during that year (rod and line exploits the full size/age range of sea trout) but it would not be until 1990 that net catches were affected (net fisheries normally selectively exploit one sea winter or older fish, depending on the mesh size used). However, these results should also be assessed in relation to short term climatic influences and historical fluctuations in catches.

FIGURE 3.1

NATIONAL COMMERCIAL CATCHES OF SEA TROUT 1984-1990

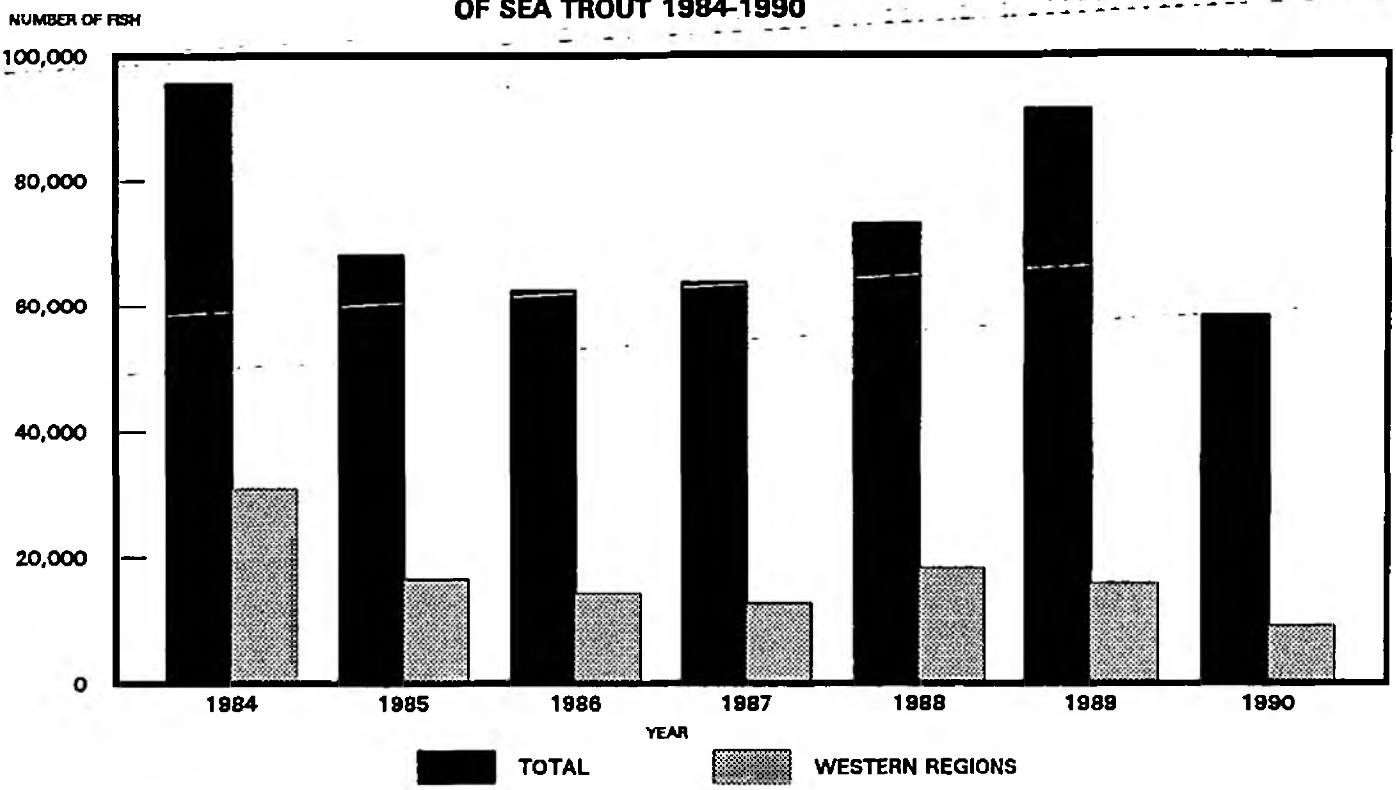
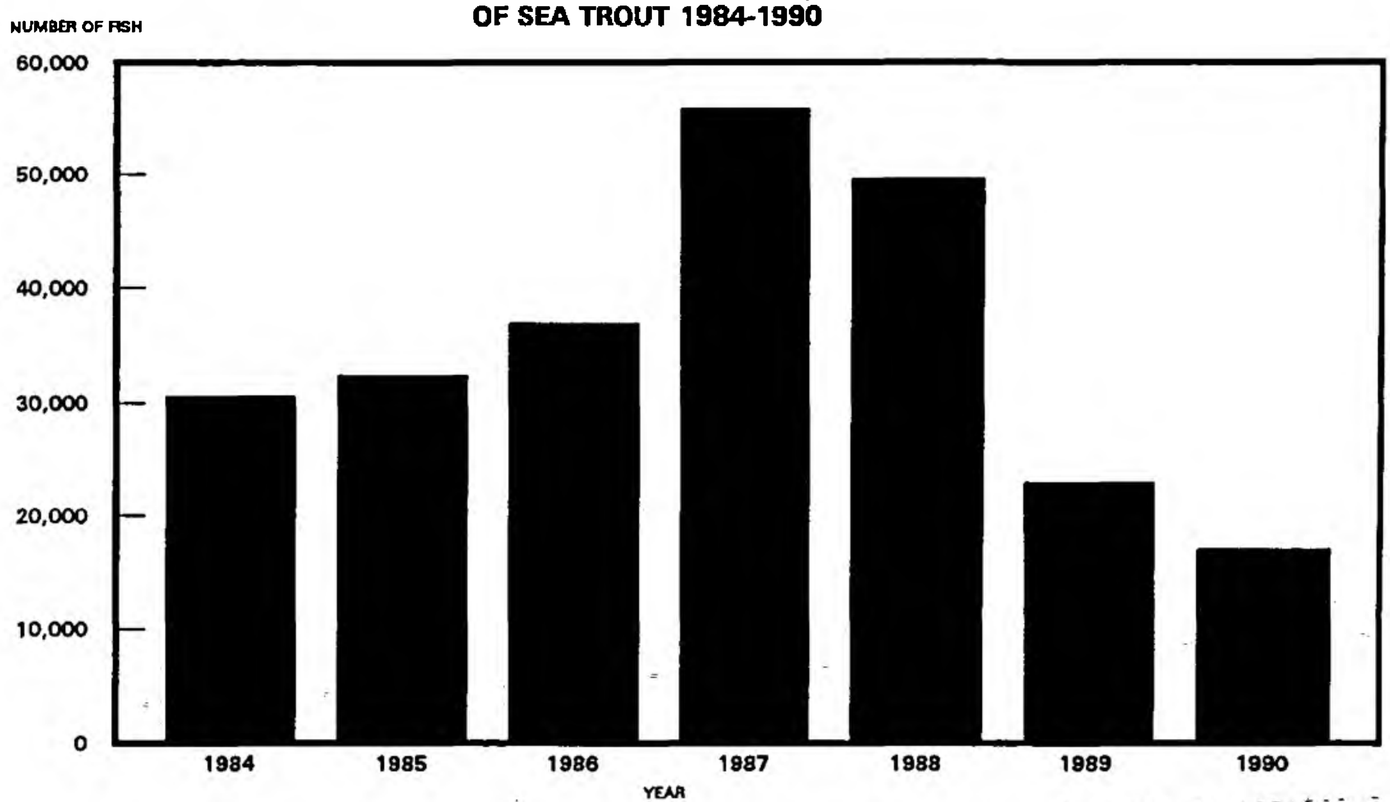


FIGURE 3.2

NATIONAL ROD CATCHES OF SEA TROUT 1984-1990



3.5 Possible climatic influences

Total annual rainfall was below average in those NRA regions containing major sea trout fisheries during 1989 and 1990 when compared with the previous five years (1984 - 1988). However, it is the summer rainfall that is most important in determining when sea trout are able to run into fresh water and both 1989 and 1990 were very dry summers, as Table 3.1 shows.

Table 3.1 Total monthly rainfall (mm) in Northumbria, North West, Yorkshire, Wessex, Welsh and Southern NRA Regions.

Month	1984 - 1988 (mean)	1989	1990
June	439	382	571
July	544	239	288
August	688	459	370
September	503	324	420
Total	2174 mm	1404 mm	1649 mm

It is reasonable to assume that these prolonged periods of below average summer rainfall in 1989 and 1990 resulted in low flow conditions. Such low flow might not only inhibit the movement of sea trout into fresh water but also prevent those fish that had already entered the system from moving upstream, resulting in fish being concentrated into the lower or tidal reaches of rivers. The effect of fishing at low water levels was the subject of a Salmon Advisory Committee report (S.A.C., 1989). This report dealt mainly with salmon but also analysed the effects of low river flow on declared catches of sea trout. Five rivers were selected in England and Wales: the Teign, Lune, Tywi, Teifi and Dee. The peak of the net catches of sea trout in these rivers was found to occur about a month earlier (June or July) than for salmon (July or August). Thus the highest net catches of sea trout were usually recorded before flows fell to low summer level and catches were generally low at times of lowest flows. For these same rivers, rod catches of salmon and sea trout often peaked about a month after respective net catches. However, in contrast to salmon, it was found that sea trout may be caught in large numbers by anglers during the summer months when flows were low. The overall conclusion of the Committee was that during times of low water flow, migratory fish were not particularly vulnerable to netting in estuaries and river mouths and whilst there was a lack of angling success for salmon during low flows, sea trout may be caught.

Though not discussed in the report, this may be because sea trout, unlike salmon, are commonly fished for and caught at night when flow conditions appear to have less influence on fishing success.

The precise effects of flow conditions on the behaviour and catchability of sea trout requires further investigation although it is likely that ongoing NRA radiotracking and counter studies will provide some additional information.

Flow conditions in rivers will also affect survival and growth of juvenile trout stocks, as well as the success of the downstream migration of sea trout smolts and kelts. Drought conditions may result in poor growth of juveniles because of high temperatures and in reduced or delayed recruitment of either juveniles or previous spawners. Such effects may be manifested in the form of lower stock levels during future years. Therefore, it should be borne in mind that reduced catches in 1989 and 1990 could have been due to the poor growth and recruitment of juvenile stocks if adverse climatic conditions occurred in the mid 1980s.

3.6 An analysis of sea trout catch statistics

At the end of 1990, the NRA commissioned an independent analysis of the historical catch record for sea trout (Elliott, 1992). The objective of this study was to assess both the temporal and spatial variability of sea trout catches from all significant commercial and recreational fisheries under the NRA's control.

Sea trout catch records for the study were supplied from five NRA regions and consisted of rod catch data for 67 rivers and net catches from 36 commercial fisheries in England and Wales. The longest data span was forty years, 1951 - 1990.

3.7 The accuracy and validity of catch data

The findings of Elliott (1992) do not support the commonly held view that catch data for migratory salmonids are wholly inaccurate. Factors such as wrongful identification (sea trout confused with resident trout or salmon), poor catch returns, selectivity of fishing methods and variations in fishing effort have all been thought to reduce the validity of catch data. However, although these factors must affect catch records, the analysis suggests that their effects are of a similar relative magnitude for all catches. The spatial and temporal variability of both rod and commercial catches were strongly density-dependent on mean catch. Therefore, it was concluded that in general an annual catch record does reflect the number of adult sea trout in a river and can be used to make relative comparisons both between rivers and between years.

3.8 The variation in catches from different rivers in any one year

Analyses of the spatial variability of sea trout catches clearly demonstrated that both rod and net catches of sea trout from different rivers within each NRA region varied synchronously with time. In other words, catches from rivers located in the same geographical area generally either increased or decreased together in any one year. In the case of North West, Welsh and South West NRA regions, the results suggest that it would be possible to treat catch data from all three regions as a single set in future analyses.

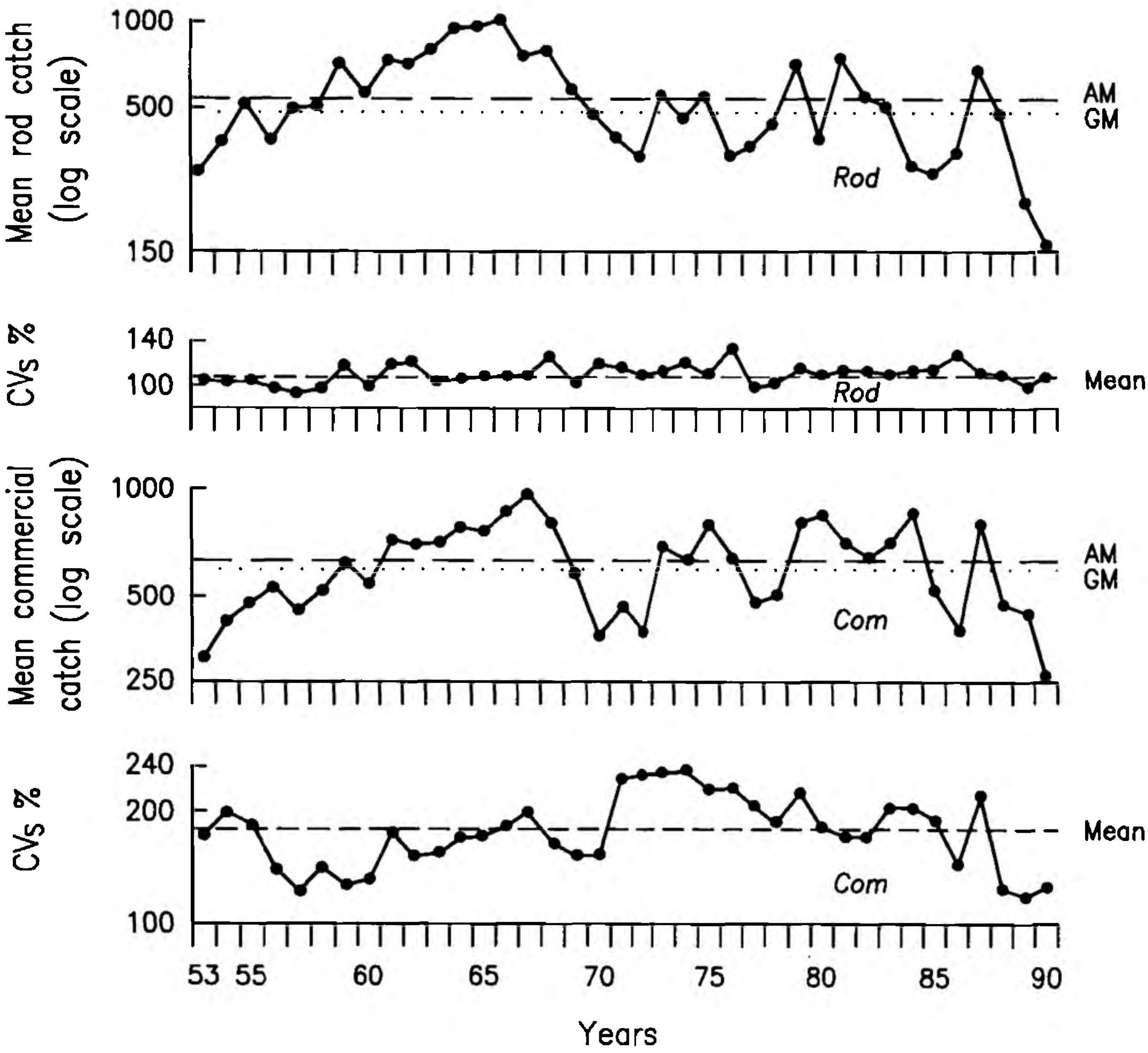


Figure 3.3. - South West rivers : temporal changes in the mean rod catch per river, mean commercial catch per river and their corresponding coefficients of variation (C.V.); mean catch is on log scale with overall arithmetic mean (AM) and geometric mean (GM).
From Elliott (1992)

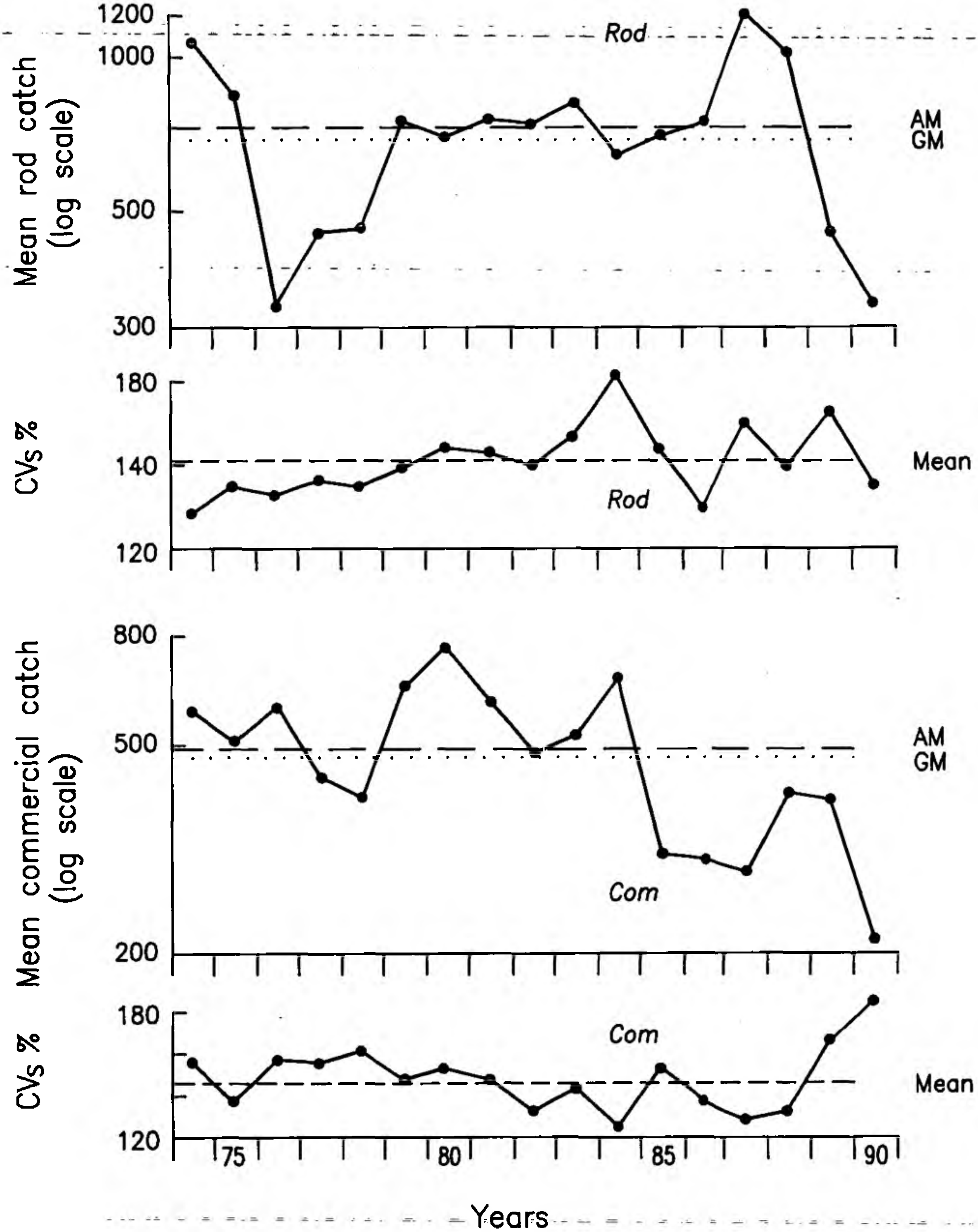


Figure 3.4. - Welsh rivers : legend as for 3.3.
From Elliott (1992)

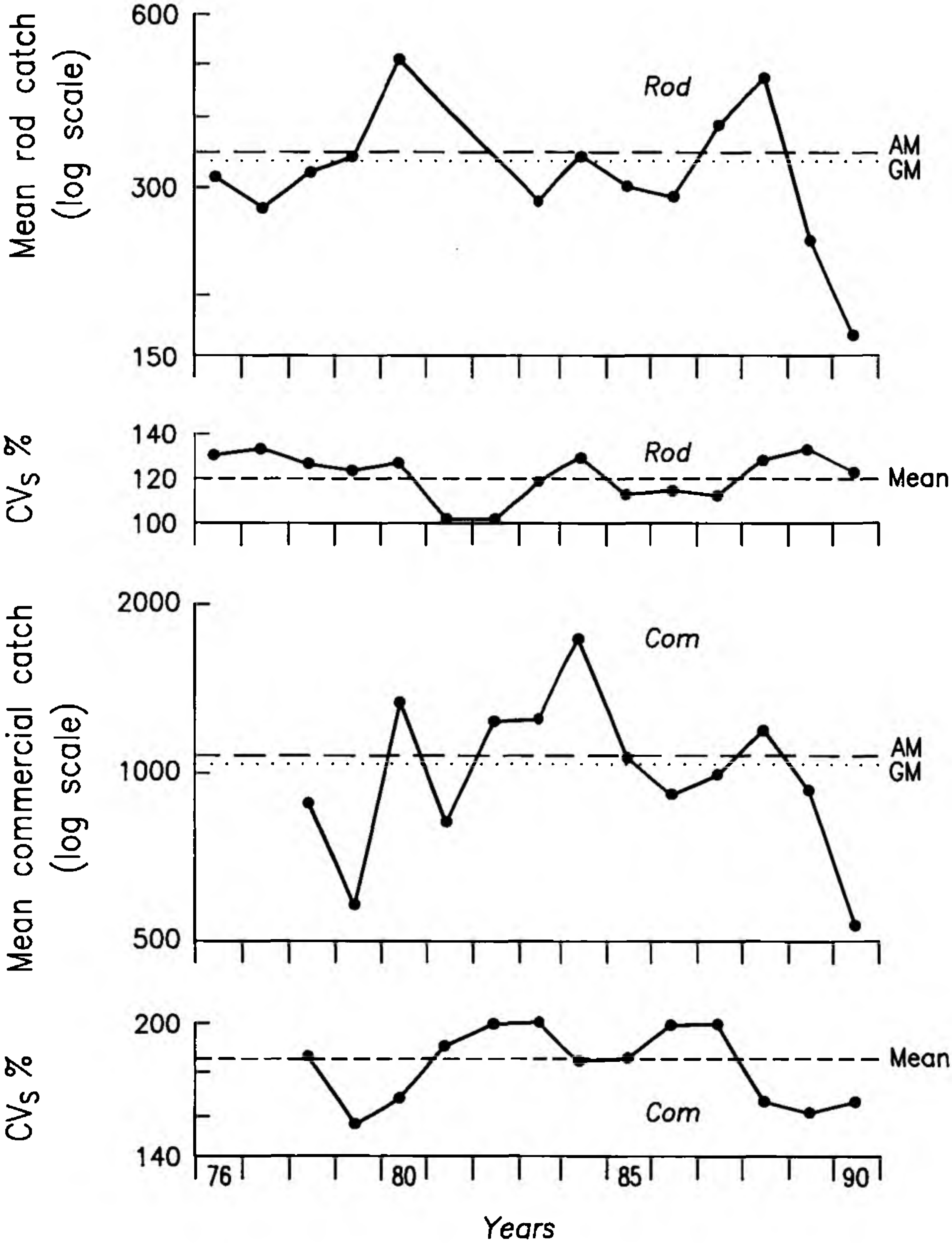


Figure 3.5. - North West rivers : legend as for 3.3.
From Elliott (1992)

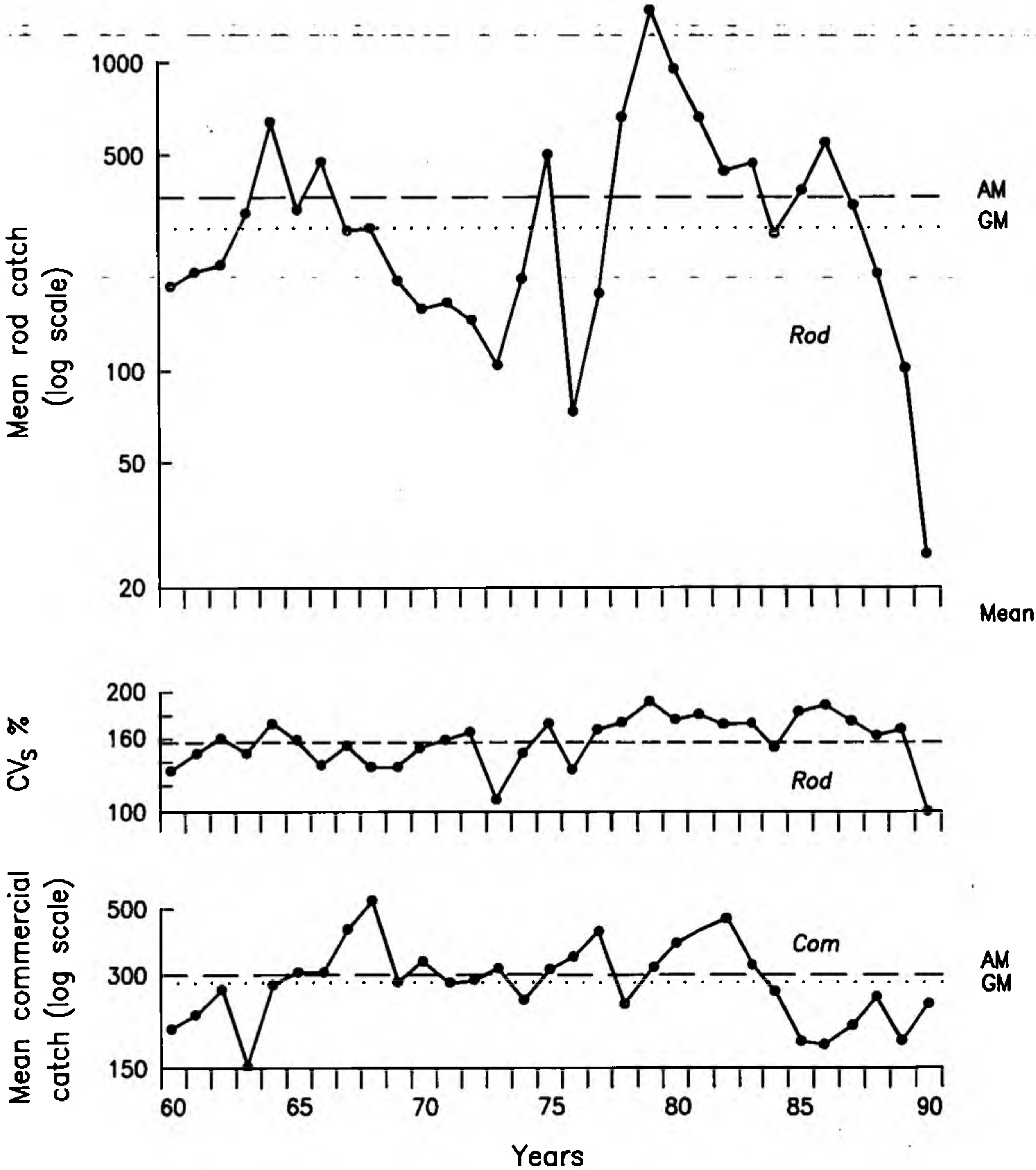


Figure 3.6. - Wessex rivers : legend as for 3.3.
From Elliott (1992)

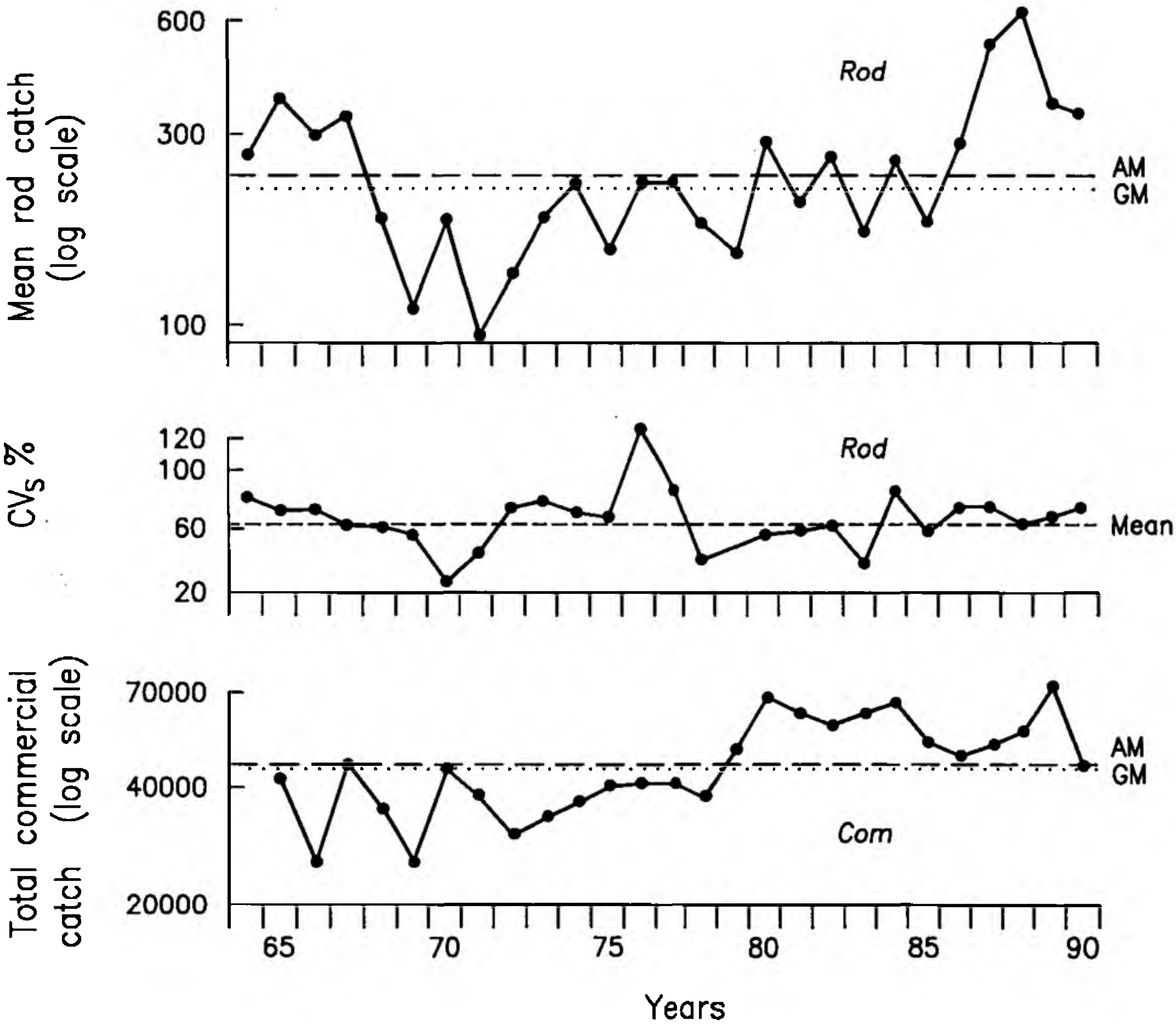


Figure 3.7. - North East rivers : legend as for 3.3.
From Elliott (1992)

3.9 The variation in catches from different rivers over time

Figures 3.3 - 3.7 illustrate a time series of mean catches of sea trout for each region. There are four graphs in Figures 3.3 - 3.5 and three in Figures 3.6 and 3.7. Two of these show mean annual catch over time, one for rod, the other for commercial catches. Below these is an additional graph which plots the respective Coefficient of Variation (CV) over time. As there were only two commercial catches for Wessex and North East regions, it was impossible to calculate a CV. The CV is a measure of the relative variability of mean catch and is defined as the variability (measured by standard deviation) expressed as a percentage of the mean catch. In this case, CV measures the extent to which the mean annual catch of individual rivers in a region varies from the mean annual catch of the region as a whole. Comparison of mean catch and CV shows that in most cases, although the mean annual catch for the region often varies markedly between years, the CV generally does not. Thus the time series of mean catches for the region is broadly representative of all rivers in that region.

Overall, the analysis of sea trout catch statistics has established the following principles:

i) Annual sea trout catch data appear to reflect the number of adult sea trout in the river and can be used to make valid comparisons both between rivers and between years.

ii) Both rod and net catches within each NRA region varied synchronously with time.

iii) The extent to which the mean annual catch from individual rivers within a region varied was found to be similar to that found for the region as a whole.

Having established these principles, it is possible to assess the historical catch record on a regional basis with reasonable confidence that it is both representative of the fluctuations in the number of adult fish present and of what is happening in most rivers in that region.

3.10 Regional catch records

i) South West rivers (Figure 3.3)

There has been a decline in the annual mean rod catches of sea trout in South West rivers since 1987. The mean rod catches in 1989 and 1990 being the two lowest recorded since 1953.

The mean commercial catches have followed a similar pattern to that of the rod catches over the same period (1953 - 1990). Annual mean net catches have also decreased since 1987 and the 1990 mean catch was the lowest recorded.

ii) Welsh rivers (Figure 3.4)

The annual mean rod catches in Welsh rivers, like those in the South West, have steadily declined since 1987. The mean rod catches in 1989 and 1990 were well below the arithmetic or geometric mean. However, similarly low mean catches were recorded in 1976, 1977 and 1978.

Annual mean commercial catches of sea trout in Welsh rivers have been below average every year since 1985 and the 1990 mean catch was the lowest recorded in this time series.

iii) North West rivers (Figure 3.5)

The pattern of annual mean rod catches in North West rivers followed a similar pattern to that of both Welsh and South West rivers. The 1989 and 1990 mean rod catch in the North West were the lowest recorded since 1976.

Since 1976, both annual mean rod and net catches have fluctuated in a broadly similar pattern. However, there has also been a decline in commercial catches since 1988, though the mean annual net catches in 1989 and 1990 were within the same range as previously recorded.

iv) Western rivers

The spatial variabililty of sea trout catches in South West, Welsh and North West rivers has been shown to be similar. It is not surprising therefore that the time series of mean catch data for all three regions in Figures 3.3 - 3.5 show similar trends. Throughout the Western NRA regions, mean annual rod and net catches of sea trout have declined since 1987. In South West and North West rivers, the recent levels of both rod and net catches were lower than previously recorded in the available data set. In Welsh rivers, mean rod catches have also declined in recent years but are still within the range previously recorded. However, in the same region, commercial catches of sea trout have been declining since 1984 and the 1990 mean catch is the lowest recorded in the time series.

v) Wessex rivers (Figure 3.6)

Since 1986, there has been a steep decline in the mean annual rod catches of sea trout in Wessex rivers. The 1990 mean catch was well below any previous record made since 1960.

Mean commercial catches have been below average since 1984 but there is no apparent decline and the values are within the range previously recorded.

vi) North East rivers (Figure 3.7)

In contrast to all other regions, the annual mean rod and net catches of sea trout in North East rivers were above average in recent years. The mean rod catch in 1988 and the mean net catch in 1989 were the highest recorded since 1964. Both mean rod and net catches declined in 1990 but were still above (rod catches) or near (net catches) the long-term average.

3.11 The present status of sea trout stocks in England and Wales

Examination of both national and regional catch data has shown that in Wessex and the three Western NRA regions, there has been a recent decline in both commercial and rod and line catches of sea trout. Declining catches have been recorded since 1987 but it was in 1989 and particularly in 1990 that catches were greatly reduced.

In the North East rivers, although both mean net and rod catches declined in 1990, they were still above average and the long-term trend is one of increasing catches.
In both 1989 and 1990, summer rainfall was below average and many anglers believed that this factor was partly responsible for the low catches of sea trout in these years. It is possible that during the summers of 1989 and 1990, extremely low flows reduced the availability of sea trout to anglers by preventing fish from entering fresh water or, if already in the river, from migrating further upstream. Such low flows could also have influenced angler behaviour by reducing fishing effort. However, the limited amount of research investigating the relationship between low flows and catches neither suggest that netsmen take an increased proportion of the catch nor that rod catches of sea trout are reduced during low flow conditions.

The recent decline in sea trout catches in England and Wales was not as severe as in Western Ireland where during 1989 and 1990, catches from recreational fisheries were virtually non-existent. Furthermore, there have been no confirmed reports of sea trout in England and Wales showing any of the symptoms (emaciation, sea lice infestation, early return to fresh water) affecting Western Ireland sea trout.

However, it must be cause for concern that in 1990 the mean rod catches in South West and North West NRA regions and the mean net catches in all three Western regions were lower than any previous value in the time series of catch data which were analysed.

If catch statistics are a reasonably accurate indicator of fluctuations in stock levels, and the available evidence suggests they are, then sea trout stocks in Western and Southern areas of England have declined in recent years. However, it must be emphasised that the absolute relationship between catch and stock is poorly understood. Apart from limited counter data from some rivers, the NRA has no measure of absolute sea trout abundance. It is, therefore, not known if the recent reduction in sea trout catches reflects a decrease in adult sea trout stocks to a level below that needed for self sustaining populations.

4. A CLASSIFICATION SCHEME OF THE MAJOR SEA TROUT FISHERIES IN ENGLAND AND WALES

4.1 The classification scheme

The analysis of sea trout catch statistics by Elliott (1992) has not only helped to assess the status of sea trout stocks but has also led to an additional use for sea trout catch data: the identification of the performance of individual rivers both in terms of their overall mean annual catch and their variability in catches between years. The latter is expressed as the

Coefficient of Variation (CV as a percentage). Analyses of the temporal variability of catch data showed clearly that rivers can be arranged along a gradient whereby as the mean annual catch of a river increases, the relative temporal variability in catch generally decreases.

At one end of the gradient are "poor" rivers with a low mean annual catch and a high variability of catches between years, whilst at the other end are "good" rivers with a high annual catch and low variability of catches between years.

This gradient is illustrated in Figure 4.1 which shows the relationship between the variance and the mean and between CV and the mean annual catch for rod catches. Figure 4.2 provides similar information for commercial catches.

Table 4.1 classifies 67 sea trout rivers according to their mean rod catch and temporal variability in catches. There were 11 rivers with high variability (CV > 86%) divided into 10 with low catches (< 105 fish per day) and only one (River Tyne) with a medium annual catch (105 - 1000 fish); 32 rivers with medium variability (CV 50 - 86%) divided into 9 with low catches (< 105 fish), 20 with medium catches (105 - 1000 fish) and 3 with high catches (> 1000 fish); 24 rivers with low variability (CV <50%) divided into 15 with medium catches (105 - 1000 fish) and 9 with high catches (>1000 fish).

Similarly, Table 4.2 classifies 36 sea trout rivers according to their mean commercial catch and temporal variability in catches.

For commercial catches, there were 4 rivers with high variability (CV >86%), all with low annual catches (< 105 fish); 15 rivers with medium variability (CV 50 - 86%), divided into 10 with low catches (< 105 fish) and 5 with medium catches (105 - 1000 fish); 17 rivers with low variability (CV < 50%), divided into only one (River Usk) with a low catch (< 105 fish), 7 with medium catches (105 - 1000 fish) and 9 with high catches (> 1000).

4.2 Management implications

The classification scheme provides a basis for monitoring and managing sea trout populations. For example, by monitoring one of the more stable rivers where catches have been high and their variability low, any trend of decreasing catch would be of particular concern. In contrast, a low catch in a river that generally performed poorly and where catches were always variable could be of lesser significance.

The management of "good" and "poor" rivers might also require different strategies. "Good" rivers with high catches and low temporal variability demonstrate greater stability of catches between years. This in turn indicates that density-dependent factors (such as predation and competition for food supply and space) probably predominate in regulating the population size. Artificial stocking of these rivers could reduce the number of survivors and/or decrease variation in their size with the subsequent loss of the large specimen fish sought by anglers (Elliott, 1985, 1989b). Probably the only way of making such rivers more productive would be either to enhance the spawning or juvenile nursery areas or to avoid competition by stocking with smolts that will only remain in fresh water for a short time before migrating to sea.

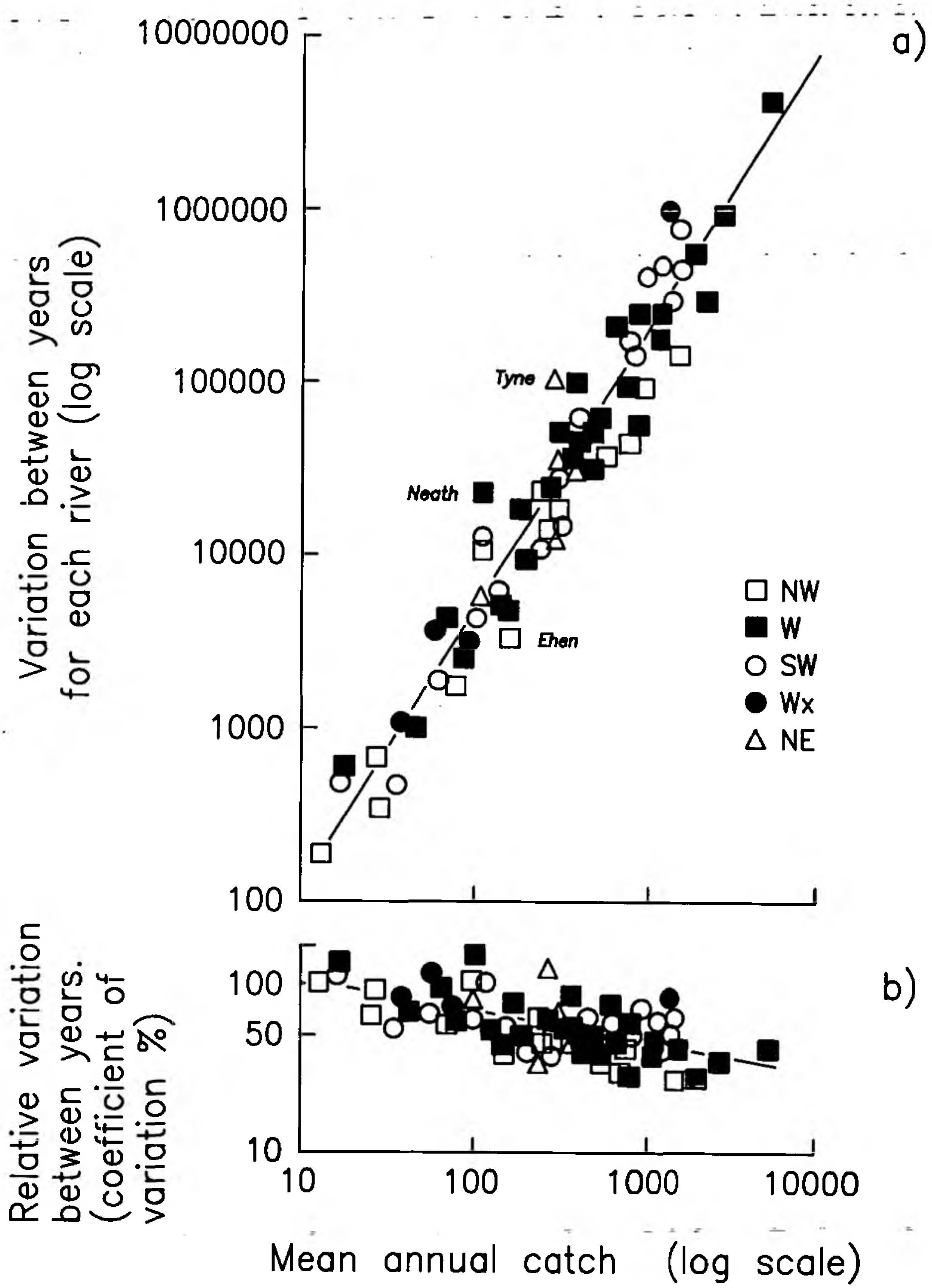


Figure 4.1. - Rod catches : relationships between variance and mean, and between C.V. and mean annual catch.
From Elliott (1992)

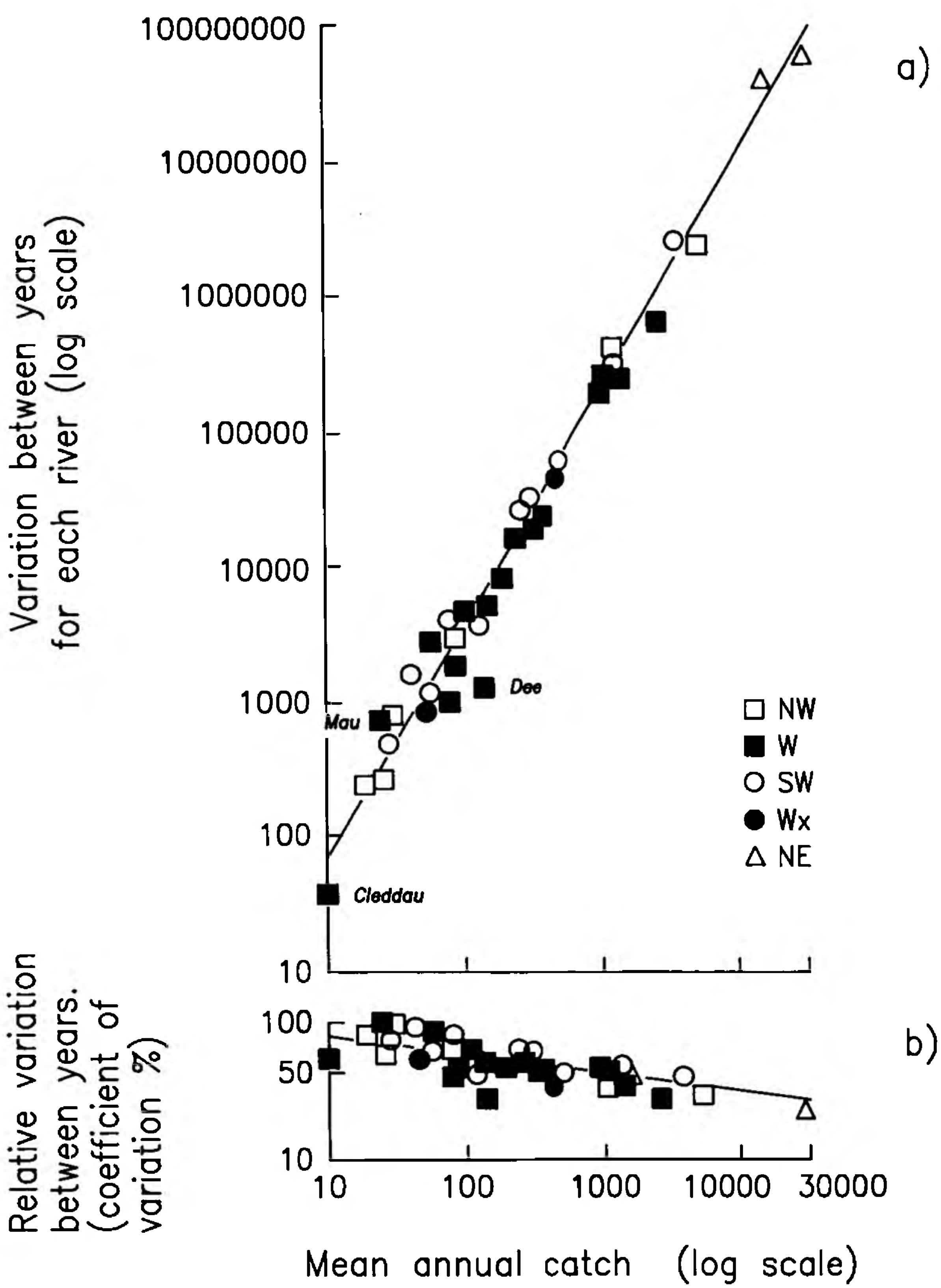


Figure 4.2. - Commercial catches : relationships between variance and mean between C.V. and mean annual catch
From Elliott (1992)

	I. High Temporal Variability (CV>86%)					II. Medium Temporal Variability (CV50-86%)					III. Low Temporal Variability (CV≤50%)				
	River	(region)	x year $^{-1}$	CV%	n	River	(region)	x year $^{-1}$	CV%	n	River	(region)	x year $^{-1}$	CV%	n
(a) Low Annual Catch (<105)	1 Ellen	(NW)	12.9	101	14	1 Duddon	(NW)	26.9	66	14					
	2 Exe	(SW)	17.3	122	37	2 Yealm	(SW)	36.5	57	37					
	3 Wye	(W)	17.6	131	16	3 Usk	(W)	43.6	71	16					
	4 Wyre	(NW)	27.9	90	14	4 Otter	(SW)	59.2	70	37					
	5 Piddle	(Wx)	35.9	89	36	5 Irt	(NW)	69.1	58	14					
	6 Stour	(Wx)	58.3	105	39	6 Frome	(Wx)	74.9	70	40					
	7 Gwyrfai	(W)	67.1	95	16	7 Dee	(W)	83.2	60	15					
	8 Neath	(W)	99.3	154	15	8 Axe	(SW)	97.5	66	37					
	9 Esk	(NW)	101.4	101	14	9 Aln	(NE)	97.8	75	26					
	10 Lyn	(SW)	104.3	106	37										
(b) Medium Annual Catch (105-1000)	1 Tyne	(NE)	264.6	121	26	1 Artro	(W)	132.9	53	16	1 Ehen	(NW)	149.1	37	14
						2 Looe	(SW)	135.3	54	31	2 Dwyryd	(W)	151.1	45	16
						3 Loughor	(W)	168.5	79	15	3 Lynher	(SW)	236.9	43	37
						4 Ogwen	(W)	184.7	51	16	4 Coquet	(NE)	251.3	45	26
						5 Leven/ Crake	(NW)	231.4	64	14	5 Kent	(NW)	252.6	45	14
						6 Dysynni	(W)	250.6	63	16	6 Avon/ Erne	(SW)	271.2	44	37
						7 Plym	(SW)	259.5	64	37	7 Derwent/ Cocker	(NW)	281.2	47	14
						8 Nevern	(W)	280.6	81	16	8 Conwy	(W)	430.6	40	16
						9 Wear	(NE)	298.2	57	26	9 Ribble/ Hodder	(NW)	529.8	36	14
						10 Yorks Esk	(NE)	315.6	55	26	10 Glaslyn	(W)	530.3	38	16
						11 Taf	(W)	343.4	54	16	11 Aeron	(W)	670.4	45	16
						12 Ogmore	(W)	359.2	86	15	12 Esk Border	(NW)	671.9	31	14
						13 Ystwyth	(W)	373.0	57	16	13 Eden	(NW)	721.6	41	14
						14 Tamar	(SW)	418.7	58	37	14 Tavy	(SW)	767.7	48	37
						15 Seiont	(W)	428.6	53	16	15 Rheidol	(W)	781.0	30	16
						16 Tawe	(W)	486.3	51	14					
						17 Llyfni	(W)	598.1	77	16					
						18 Dart	(SW)	690.9	59	37					
						19 E/W Cleddau	(W)	812.9	61	16					
						20 Torridge	(SW)	879.4	72	37					
(c) High Annual Catch (> 1000)						1 Camel	(SW)	1124.5	60	37	1 Clwyd/ Elwy	(W)	1049.1	40	16
						2 Avon	(Wx)	1148.9	86	40	2 Mawddach	(W)	1078.8	46	16
						3 Taw	(SW)	1369.4	61	37	3 Teign	(SW)	1153.5	45	37
											4 Lune	(NW)	1394.0	28	14
											5 Fowey	(SW)	1441.1	46	37
											6 Dwyfawr	(W)	1596.4	44	16
											7 Dyfi	(W)	1880.0	29	16
											8 Teifi	(W)	2499.9	38	16
											9 Tywi	(W)	4750.3	42	16

Table 4.1. - Rod Catches : Classification of 67 rivers
From Elliott (1992)

	I. High Temporal Variability (CV > 86%)					II. Medium Temporal Varibility (CV50-86%)					III. Low Temporal Variability (CV<50%)				
	River	(region)	x year^{-1}	CV%	n	River	(region)	x year^{-1}	CV%	n	River	(region)	x year^{-1}	CV%	n
(a) Low Annual Catch (<105)	1 Mawddach	(W)	24.1	113	16	1 E/W Cleddau	(W)	10.3	58	16	1 Usk	(W)	77.5	40	16
	2 Kent	(NW)	31.2	92	12	2 Leven	(NW)	19.2	82	11					
	3 Lyn	(SW)	42.1	93	36	3 Ribble	(NW)	26.3	61	12					
	4 Nevern	(W)	55.2	92	13	4 Exe	(SW)	28.4	78	37					
						5 Frome/ Piddle	(Wx)	51.2	61	39					
						6 Lynher	(SW)	54.1	62	37					
						7 Camel	(SW)	79.5	80	35					
						8 Duddon	(NW)	82.5	66	12					
						9 Conwy	(W)	84.3	51	16					
						10 Ogwen	(W)	99.7	67	16					
(b) Medium Annual Catch (105-1000)						1 Foway	(SW)	123.0	50	37	1 Dee	(W)	132.7	26	16
						2 Taf	(W)	134.0	53	16	2 Dysynni	(W)	194.6	47	16
						3 Tavy	(SW)	241.5	66	37	3 Seiont	(W)	305.0	46	16
						4 Glastyn	(W)	241.6	52	16	4 Dwyfawr	(W)	352.3	45	16
						5 Tamar	(SW)	287.6	62	37	5 Avon/ Stour	(Wx)	458.9	47	39
											6 Dart	(SW)	529.5	46	37
											7 Teifi	(W)	972.2	47	16
(c) High Annual Catch (> 1000)											1 Clwyd	(W)	1136.8	47	16
											2 Lune	(NW)	1254.9	49	12
											3 Teign	(SW)	1299.0	44	37
											4 Dyfi	(W)	1387.9	37	16
											5 Tywi	(W)	2503.3	31	16
											6 Taw/ Torridge	(SW)	3737.4	43	37
											7 Eden/Border Esk	(NW)	5108.9	31	12
											8 Yorks Coastal	(NE)	15512.6	40	25
											9 Northum Coastal	(NE)	30128.3	26	25

Table 4.2. - Commercial catches : Classification of 36 rivers
From Elliott (1992)

High performance sea trout rivers, although probably less susceptible both to over-exploitation and long-term, adverse environmental effects, will be the most productive and valuable fisheries and are worth preserving even at high cost.

At the other end of the scale are the "poor" rivers with low mean catches and much higher temporal variability. These river systems are probably mainly regulated by density-independent factors and it has been proposed that the most important of these are associated with fluctuations in climate (Elliott, 1987, 1988a, 1989b). Restocking could be effective; however, the subsequent survival of stocked fish might be dependent on the alleviation of adverse environmental conditions. Even if this were possible, the relatively low fisheries status of such rivers might not justify the probable high expenditure necessary to improve catches by even a relatively small amount.

Within the classification was also a large number of so called "medium" rivers. These may have been "good" rivers in the past, until catches declined due to some adverse, long-term but localised effect. Alternatively, "medium" rivers may be regulated by a combination of density-dependent and independent factors. Analyses of their historical catch records might help to identify into which category rivers, presently classified as "medium", truly belonged and therefore which management strategies would be appropriate.

5. PRESENT KNOWLEDGE AND RESEARCH

At present, some English and Welsh sea trout stocks appear to be declining but the cause of this decline and whether it will continue are not known. This highlights how little is known about how sea trout populations are regulated and their basic biology. It is therefore a necessary first step to review what is known about sea trout and what further research is required.

5.1 Sea trout literature review and bibliography

The NRA commissioned a sea trout literature review and bibliography. This extends to the scientific literature on sea trout from England, Wales, Scotland, Ireland, France and Scandinavia. Based on key papers from this bibliography, four expert reviews have resulted which cover;

i) The early life stages of sea trout.

ii) The ecology of juveniles in fresh water.

iii) The ecology of adult sea trout.

iv) Physiology, disease, genetics and taxonomy.

Full details of these reviews and the bibliography can be found in NRA Fisheries Technical Report No. 3. (Elliott <u>et al</u>, 1992) which also summarised 16 key problems that require further investigation.

Despite the large number of scientific papers which have been published on sea trout, there is still only limited knowledge of their biological characteristics, population biology and marine life. It would not be possible for the NRA in the short term to carry out all the research recommended in the review. However, a significant research programme on sea trout is required and this has already commenced.

5.2 The NRA sea trout research programme

i) NRA Fellowship

Sea trout is now a subject area in the NRA Fellowship Scheme, the emphasis being on basic research which is not entirely tied to immediate NRA operational activities. A postdoctoral study will look at smolting rates in sea trout/brown trout populations. The ability to differentiate juvenile trout will considerably benefit enhancement work.

ii) Operational Investigations

The Fisheries Function in a number of NRA regions is already carrying out investigations on sea trout to address specific operational needs. These are targeted at specific local problems, not national issues.

iii) NRA National R & D Programme

Strategic sea trout research over a longer period of time that is relevant to national issues, not immediate local problems.

a) A collaborative study with MAFF, investigating the behaviour of salmon and sea trout smolts during their seaward migration through short and long estuaries by the use of acoustic tags.

b) The genetic variation of salmon and sea trout stocks in Wales and is being carried out by Swansea University.

c) The major NRA initiative in national sea trout research is a new 5 year project for 1992/1993. "Sea Trout Investigations".

Many useful suggestions for future research have been made by Elliott et al (1992) and some further research needs will be identified in the next section which proposes a strategy for the future management of English and Welsh sea trout stocks.

6. TOWARDS A STRATEGY FOR THE FUTURE MANAGEMENT OF SEA TROUT STOCKS IN ENGLAND AND WALES

In order to maintain, improve and develop sea trout stocks as a sustainable resource, the NRA must:

i) Continue to assess stock levels.

ii) Fill the gaps in our knowledge about the basic biology of sea trout.

iii) Gain an understanding of how sea trout populations are regulated naturally with particular emphasis on critical life stages.

iv) Determine the pattern and levels of different forms of exploitation.

v) Establish how to enhance sea trout stocks.

vi) Preserve the genetic variability found in sea trout stocks should any population collapse take place.

6.1 The future assessment of stock levels

There is an ongoing need to monitor sea trout stocks and to develop more accurate methods of doing so. Research presently being carried out into improving resistivity and developing hydroacoustic counters should result in an extension of our ability to count adult sea trout. As sea trout are generally smaller than salmon, counters need to be designed to record them specifically but problems will still be encountered in distinguishing large sea trout from small salmon in some rivers. The NRA's long-term aim should be to have counting facilities available on all major sea trout rivers in England and Wales, or at least on representative or key rivers using the classification scheme outlined in Section 4.1.

However, in the shorter term, any national assessment of sea trout stocks will be mainly based upon catch statistics. Further research is needed to establish the relationship between catch and stock and the effect on catch of fishing effort and other environmental variables. This report has highlighted the need for more information about the effects of low flows on catches of sea trout. Some progress has been made in developing a more sophisticated approach to the analysis of sea trout catch statistics. This included the development of a classification system which may provide a more accurate basis for the interpretation of catch statistics by identifying rivers that provide a more sensitive measure of possible changes in population size. A major constraint on the interpretation of catch statistics is the lack of knowledge about the basic biological characteristics of sea trout. At present, it is only possible to describe the pattern of catches for total sea trout stocks. However, such stocks are made up of a number of year-classes, the success of which may be critical in determining the overall stock size. More information about the mean smolt and sea age of individual river stocks would enable the monitoring of individual year-classes. This would allow rapid management decisions to be taken in response to any year-class failure.

6.2 Establishing the basic biological characteristics of individual sea trout stocks

There is an urgent need to determine the extent of the genetic differences of sea trout populations between the within river systems. Such differences may be very important in determining the ability of individual sea trout stocks to tolerate particular environmental conditions and could be critical in determining the success of restocking programmes.

More information is also required about characteristics such as age, size, sex, state of maturity and fecundity. Such data are essential when interpreting catch statistics, and many other sea trout research findings. It is recommended that the initial objective of the national R&D sea trout project should be to set up a national sampling programme to collect and analyse such information. More information could be generated relatively easily and any sampling programme should concentrate initially on existing data sources such as commercial sea trout fisheries or other marine fisheries which exploit sea trout as a by-catch. Similarly, within river, maximum use should be made of counters, traps, rod catches, fish kills and redd counts to sample sea trout.

Information about juvenile trout stocks will be collected as part of the Strategic National Stock Assessment Programme, although more detailed studies may also be required. More data on sea trout smolts are needed and smolt traps on some rivers will be necessary. The sampling of sea trout smolts should be one of the objectives of any "monitored" river.

6.3 The investigation of how sea trout populations are regulated

Such investigations require a lengthy period of research. The long term study on Black Brows Beck has greatly increased our knowledge about the mechanisms of population regulation in juvenile trout (Elliott 1987,1988 and 1989b) . However, important gaps remain, which include the energy and habitat requirements of juvenile trout, the effect of environmental factors (especially extreme events) on population densities and the interaction between juvenile salmon and trout. Such instream, ecological studies will be important in determining what factors regulate juvenile populations and thus how, when and where restocking might be undertaken.

The smolt transformation and migration to sea is a vulnerable and stressful stage of the life cycle. The behaviour of sea trout is already being investigated in the acoustic tracking project, however further research may be required on factors affecting the survival of sea trout smolts and their physiology during smoltification and sea water adaptation.

The population dynamics of sea trout, from the smolt to adult spawner stage, also need investigation. This can only be achieved in "monitored" rivers such as the Burrishoole river system in Ireland or the River North Esk in Scotland. It is recommended that at least one "monitored" river is created for sea trout in England or Wales. This will require installing trapping facilities in a suitable sea trout river and a commitment to counting ascending adults and descending smolts over at least a twenty year period. The choice of river will depend on practical considerations such as the hydrology, the cost of installing traps and the support of riparian owners. However, it is recommended that a river with a medium mean annual rod catch of sea trout and medium variability in catches is chosen as such a river would be more representative than any other category in the classification scheme and would enable the effects of both density-dependent and independent factors to be studied.

Very little is known about the marine life of sea trout and especially what factors regulate population size during this stage of the life cycle. Sampling in the sea, other than in commercial fisheries, would be difficult and costly. However, the feasibility of such a project should be assessed. The NRA should also develop a comprehensive tagging programme which could generate information on migration patterns, survival and growth rates as well as the pattern and level of commercial exploitation. It is, therefore, recommended that, in future, as many sea trout juveniles as possible which are stocked by the NRA should be finclipped and microtagged. In addition, any sea trout used as broodstock should be tagged with an appropriate external tag before release.

6.4 Determining the pattern and levels of different forms of exploitation

In response to the drastic decline of sea trout catches in Western Ireland during 1990, the Irish Department of the Marine introduced an emergency byelaw making it illegal to kill or sell sea trout under any circumstances.

As already discussed, the recent decline of sea trout catches in England and Wales has been very much less severe than in Ireland. Nevertheless, the NRA must ensure that sea trout fisheries do not over exploit stocks and that sufficient spawners are allowed to migrate upstream to maintain a self-sustaining population. In order to do this, it is necessary to know the level and pattern of exploitation by different methods of fishing.

Sea trout are exploited by licensed rod and net fisheries and it is a legal requirement that all holders of rod and net licences submit accurate and complete catch returns. However, whereas for net fisheries 100% catch returns are usual, returns from rod fishermen are often very poor (< 10%). There is an urgent need to increase the level of rod catch returns for sea trout if more accurate assessments of stock abundance are to be made.

Further examination of commercial catches is needed to determine the efficiency of different fishing methods, the pattern of catches throughout the season and the effects of varying levels of fishing effort on catches. In addition, a sampling programme will generate information about the size and age of fish taken by different fishing methods at different times of the season. These data will enable the NRA to assess how best to regulate commercial fisheries in terms of method of fishing, type of gear, number of licences issued, length of season and weekly close times.

The calculation of exploitation rates (the number of fish caught expressed as a percentage of the number of fish present) for commercial sea trout fisheries will be difficult because of the need to obtain a measure of stock. Some data on exploitation rates will be generated if a programme of microtagging stocked sea trout is adopted although estimates of exploitation rates of wild fish by nets are also needed. These could be obtained from mark and recapture experiments, i.e. by returning tagged net caught fish and examining their recapture rates in relation to those of unmarked fish. However, it is recognised that many offshore and estuarine sea trout net fisheries catch a mixture of different river stocks making it difficult to assess the exploitation of sea trout derived from or destined for a single river system.

Within rivers, a limited number of exploitation rates of sea trout by rod and line have been measured, varying from 2.3% to 18.8% (Mills, 1991). Clearly, more data are required on the pattern and level of exploitation of sea trout by rod and line.

Further research is also needed on a number of rivers to determine the proportion of the total stock exploited during the angling season in relation to the stock entering the river before and after the period of in-river exploitation.

6.5 Enhancing sea trout stocks

The first priority is to establish the most effective form of enhancement for individual rivers. As discussed in Section 4, in rivers where density-dependent factors regulate the population, restocking may decrease rather than increase stocks. In these rivers, enhancement of the spawning or juvenile nursery areas may be the only effective way of increasing juvenile production. Such habitat enhancement techniques are already being investigated in a separate national R&D project.

In those rivers where restocking is appropriate, it is essential that its success is fully evaluated. In the past, Water Authorities reared and stocked out sea trout progeny at various life stages. However, the results of these restocking programmes were rarely, if ever, evaluated. All future NRA sea trout restocking programmes need to be fully monitored and, as recommended above, if juvenile trout are large enough when stocked out, they should be finclipped and microtagged. There is an urgent need to establish the optimum method(s) of enhancing sea trout stocks. Factors which need to be considered include:

i) The genetic make up of the donor population.

ii) The life stage to be stocked.

iii) The release strategy, especially the place and timing of release.

iv) The numbers of fish to be stocked in relation to natural productivity and existing wild populations of salmonids.

v) The interactions of juvenile salmon and sea trout.

vi) The efficacy of sea trout smolt ranching.

vii) The preservation of unique genetic stocks of sea trout.

It is recommended that at least part of this work is carried out in the national R&D programme.

Until more genetic information is available, it is strongly recommended that all stocking is with fish reared from the indigenous population. These should always contain the optimum genotypes for a particular location.

When populations of sea trout are completely lost from a river system, restocking will be essential to restore the population. However, under these circumstances, particular strategies may be required.

6.6 Restoring sea trout stocks

The dramatic decline in sea trout stocks in Western Ireland prompted the NRA to consider how it would preserve and/or restore sea trout stocks should a similar problem occur in England and Wales. Consequently, the NRA commissioned a report on the feasibility of establishing a gene bank for sea trout. The full results of this study are published as an NRA Fisheries Technical Report, No. 4. (Cross and Rogan, 1992)

The major conclusion from this report is that the preservation of sea trout genetic material is feasible both by using cryopreservation of milt and/or living gene banks. However, the success of using these techniques in a restoration programme depends upon:

i) Learning more about the genetics of different sea trout and co-existing brown trout populations, in order to establish the suitability of donor genetic material should restoration become necessary.

ii) Establishing the degree to which sea trout interbreed with conspecific resident brown trout and the efficacy of using reared brown trout to re-establish sea trout runs.

iii) Ensuring that the progeny of sea trout can be reared successfully and that the rearing regime does not reduce the propensity of sea trout to go to sea.

iv) Establishing optimum methods for sea trout restocking.

Although both cryopreservation and living gene banks will be costly to set up and will require skilled personnel, it is recommended that the NRA develops these facilities on a limited scale. The ability to preserve genetic material will almost certainly be relevant to the management of other fish species by the NRA.

However, even when these facilities are available, attempts to restore sea trout populations may be hampered by our present lack of knowledge about sea trout genetics, ecology, culture and restocking.

ACKNOWLEDGEMENT

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HEAD OFFICE
Rivers House
Waterside Drive
Aztec West
Almondsbury
Bristol
BS12 4UD
Tele: (0454) 624400
Fax: (0454) 624409

LONDON OFFICE
30-34 Albert Embankment
London SE1 7TL
Tel: (071) 8200101
Fax: (071) 8201603

ANGLIAN REGION
Kingfisher House
Goldhay Way,
Orton Goldhay
Peterborough PE2 0ZR
Tel: (0733) 371811
Fax: (0733) 231840

NORTHUMBRIA REGION
Eldon House
Regent Centre
Gosforth
Newcastle upon Tyne
NE3 3UD
Tel: (091) 2130266
Fax: (091) 2845069

NORTH WEST REGION
Richard Fairclough House
Knutsford Road
Warrington WA4 1HG
Tel: (0925) 53999
Fax: (0925) 415961

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Sapphire East
550 Streetsbrook Road
Solihull B91 1QT
Tel: (021) 7112324
Fax: (021) 7225824

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Guildbourne House
Chatsworth Road
Worthing
West Sussex BN11 1LD
Tel: (0903) 820692
Fax: (0903) 821832

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Manley House
Kestrel Way
Exeter EX2 7LQ
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Fax: (0392) 444238

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Kings Meadow Road
Reading RG1 8DQ
Tel: (0734) 535000
Fax: (0734) 500388

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St Mellons
Cardiff CF3 OLT
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Fax: (0222) 798555

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Bridgwater
Somerset TA6 4YS
Tel: (0278) 457333
Fax: (0278) 452985

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