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CONSERVATION AND DEVELOPMENT OF THE RIVER EDEN SPRING SALMON POPULATION

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AQUATIC POLLUTION & ENVIRONMENTAL MANAGEMENT

CONTENTS

CONSERVATION AND DEVELOPMENT OF THE RIVER EDEN SPRING SALMON POPULATION

1. INTRODUCTION

In common with many other rivers throughout Europe, the River Eden has been affected by a severe decline in the abundance of the highly valued spring salmon. This has naturally been of great concern to the local fishing community, who are anxious to see measures taken to conserve what remains of the Eden spring run, and if possible, to increase the numbers of early-running salmon. The main purpose of this report is to examine and comment on the options for conservation and development of the Eden spring salmon stock and to make appropriate recommendations. The report also summarises what is known about the extent and possible causes of the decline in the spring running habit as a background against which possible conservation and enhancement measures can be assessed. Spring salmon are defined as those fish which enter the river before May and which will not spawn until the autumn. They will have spent two or more winters in the sea since migrating as smolts, and are therefore classed as multi-sea winter (MSW) salmon. Of course, not all MSW salmon are spring fish, as many return to freshwater during the summer and autumn, at the same time as the one sea winter (1SW) grilse.

2. THE DECLINE IN SPRING SALMON RUNS

In 1994 the Government's Salmon Advisory Committee produced a report entitled "Run Timing in Salmon" which examined the decline in the spring runs of salmon in the British Isles (Salmon Advisory Committee, 1994). The Committee reviewed data on rod and net catches of salmon from nine different fisheries in Great Britain and from one in Ireland for which data sets of at least 50 years duration were available. One of these fisheries was the River Eden, for which data were available from 1936 to 1991. In particular, the Committee looked at long term changes in the pattern and timing of catches, and hence of the runs in from the sea. Both actual numbers of fish caught at different seasons and the relative proportions of the total annual catch taken in different seasons were examined.

The Committee concluded that co-incident changes in the seasonal timing of catches had been taking place in most of the salmon fisheries for which adequate data were available. These changes included :-

- an increase in the proportion of the catch that was taken in the spring from the beginning of the century to the mid 1920s;
- generally large numbers and proportions of spring fish in catches from 1920 to the 1950s;
- a run of slightly poorer years for spring fish from 1941 to 1947;

- a gradual but steady decline in the numbers and proportions of spring fish in catches from the secondary peak in about 1950, with spring catches remaining at a low level after the mid 1970s.

The Committee also concluded that most of the change in the proportion of the catch taken at different seasons reflected changes in the sea age of the returning adults, rather than shifts in run timing within sea age classes. In particular they noted the great reduction in the numbers of large 3 sea winter (3SW) fish (citing the Eden as one example), a downward shift in the overall mean weight of fish caught, and the increase in the numbers of grilse (1SW fish) associated with later timing of catches.

Gough *et al.* (1992) carried out a detailed review of the status of spring salmon in the River Wye and also highlighted the greatly reduced abundance of 3SW and 4SW spring salmon, particularly since the mid 1960's, but with an increasing trend for grilse. These authors also cite reports of declines in the spring runs in other rivers in Britain and also in France and Spain. Rogan *et al.* (1993), in a report on the genetics of spring salmon, comment that the main decline in spring runs in several rivers appears to have taken place since the mid-1960s.

Thus it must be concluded that the decline of spring salmon runs in the Eden, particularly that of the 3SW fish, is part of a universal trend over a wide geographical area which has been apparent for some 30 to 40 years. This decline is therefore most probably linked to changes in the environment, and cannot be attributed solely to the outbreak of Ulcerative Dermal Necrosis (UDN) in the mid-1960s. In fact, it would appear from inspection of the records that a decline in the rod catch of spring salmon may have started as early as 1960 in the Eden, but was interrupted by exceptionally good years in 1965 and 1966.

This change in the relative abundance of different sea age classes of salmon would appear to be a continuation of cyclical changes which have been occurring over the last 200 years. George (1984) examined data for Scottish fisheries since 1790, and found evidence for three 'multi sea winter salmon/grilse/low overall abundance' sequences since that time.

3. FACTORS LIKELY TO AFFECT THE SEA AGE OF RETURNING SALMON

3.1 Inherited Factors

There is evidence that the genetic make-up of a salmon has some influence on the sea age at which it matures. In particular, hatchery-based studies by the Salmon Research Trust for Ireland showed that there was a greater tendency for the progeny of 2SW parents to return as 2SW fish, although grilse returns predominated in all crosses, and some of the progeny of grilse parents returned as 2SW adults (Piggins, 1983). Other studies, both in Europe and North America, have given similar results, with offspring showing a tendency to have the same sea age at maturation and the same timing of return to freshwater as their parents, but often with significant proportions returning at different sea ages and times. In other words, like does not necessarily breed like. Explanations for this have been provided by Wilkins (1985) and Rogan *et al.* (1993), who suggest that sea age at maturation is likely to be determined by several or even many genes, each of which has a tendency towards or away from a particular age of maturation and may have its effects modified by environmental factors. Rogan *et al.* (1993) suggest that there is a continuum of genetic types in any salmon population, ranging from those most likely to be grilse to those most likely to be multi sea winter fish. Intermediate types will be the most common, and the extremes very rare; most salmon are therefore likely to contain some genes for the later maturation and early-running habit.

While considering inherited factors, there is another aspect of population genetics which needs to borne in mind. As techniques for studying the genetic make up of fish stocks have become increasingly refined, evidence has accumulated that there are local races of salmon within individual catchments which home to specific areas for spawning (Rogan *et al.*, 1993). Thus the early running component of the salmon stock of a particular river may utilise a specific part of the catchment for spawning and early development and, in fact, there is a widely held view that spring salmon tend to spawn in the upper parts of catchments. Rogan *et al.* (1993) stressed the need to determine the use of a river by different components of the stock before a restocking or management plan is implemented.

3.2 Smolt Age and Size

Studies on the relationship between age and/or size of smolts and subsequent sea age of return have provided contradictory results. Some studies have indicated an inverse ratio, with 1 year smolts producing relatively more 2SW fish and relatively few 1SW fish than 2 year smolts from the same parentage. Other studies have shown the opposite, for example some Scottish rivers, where it would appear that fish which develop quickly in fresh water tend to develop and mature more quickly once they go to sea. The Salmon Advisory Committee (1994) concluded that there is no fundamental causal mechanism linking freshwater growth and sea age.

3.3 Influence of the Marine Environment

There is evidence from work in Canada involving hatchery produced fish, which were either subsequently reared in sea cages or released to river and then recaptured as returning adults, that marine environmental factors may dominate effects of hereditary characteristics (Sanders *et al.*, 1983). In this experiment only 1% of the fish held in cages matured as 1SW fish, but 63% of the fish returning from the wild did so as grilse. The delayed maturation in the caged fish was attributed to the lower temperatures to which they were exposed during the winter. Rogan *et al.* (1993) consider that sea age at maturity has an environmental component which is larger than the genetic component (60 - 70% compared with 30 - 40%).

Various studies have shown that there are changes taking place in the marine environment over similar time scales to the long-term trends in salmon cycles. In particular, attention has been focused on changes in sea surface temperature. Surveys have shown that salmon in the sea are mainly located where sea surface temperature is between 4 and 10°C. In areas likely to be frequented by salmon during their first year at sea there was cooling from 1900 to 1920, followed by a period of warming which reached a maximum during 1950 to 1960. A period of cooling followed, with warming occurring again after 1985. Increases in sea temperature have been shown to be associated with larger numbers of salmon returning as multi sea winter (MSW) fish, and fewer as grilse (Martin and Mitchell, 1985). George (1991) considers that sea temperature is the principal factor controlling sea absence, with cold conditions favouring return of salmon as grilse and warmer conditions encouraging longer sea absence and return as MSW fish. Changes in salinity and reductions in abundance of zooplankton and forage fish such as capelin are also known to have taken place in the North East Atlantic since the early 1950s.

After reviewing evidence on factors such as those summarised above, the Salmon Advisory Committee concluded that there have been fluctuations in marine environmental conditions over such time scales that they could account for major changes in survival and time of maturation of salmon, and thus could be responsible for much of the observed change in sea age composition and run timing.

Friedland and Reddin (1993) examined data on post-smolt growth and sea temperature in eastern and western portions of the North Atlantic and concluded that in recent years the area of suitable habitat available for the post-smolt year salmon from European rivers has been restricted, with adverse effects on growth because of intra-specific competition and therefore on survival. Rogan *et al.* (1993) pointed out that the European stock component referred to by Friedland and Reddin related only to the MSW stock, as European grilse are found nearer to home waters. Thus the effects of marine changes may be having a greater impact on survival of MSW salmon than of grilse.

3.4 Exploitation at Sea

High seas fisheries for salmon have taken place at West Greenland and the Faroes, and less distant water fisheries operate off both the Northern and Southern Ireland coasts. The West Greenland fishery was at a low level until 1960, but from then until 1964 the catches increased dramatically from 50 tonnes annually to 1539 tonnes. Catches remained at a high level and in 1976 a quota system was introduced, limiting annual catches to 1191 tonnes. Subsequently the quotas have been reduced but in some years have not been reached. Attempts to close down the fishery by 'buying out' the quotas have met with only limited success, but the fishery is now of a much smaller magnitude than formerly (the 1995 quota was only 77 tonnes). The fishery takes salmon destined to be MSW fish, (i.e. potentially spring fish) and exploits both North American (including Canadian) and

European stocks. Tagging studies have suggested that the exploitation rate on potential 2SW fish destined for rivers in Great Britain has been between 5% and 15% in recent years. It has not been possible to estimate exploitation rates of potential British 3SW fish but, if it parallels the exploitation rate for potential American 3SW salmon, it is likely to have resulted in a significant additional loss of early running salmon (Salmon Advisory Committee, 1994).

The Faroes fishery developed later than the Greenland fishery, peaking at a maximum of 1025 tonnes in 1981. Subsequently, a quota system was introduced, and recently the fishery was closed as the result of a 'buy out' of the quota. This fishery also exploited MSW salmon from several countries, principally those from Scandinavia, but some tagged fish originating from British rivers have been captured there.

It should be noted that both these fisheries underwent their major expansions at a time when the decline in spring runs was already apparent.

The drift net fisheries operating off the Irish coast exploit principally 1SW fish returning during the summer months and are therefore unlikely to have a significant impact on spring salmon stocks.

In home waters, there is a haaf net fishery for salmon and sea trout within the Solway Firth. Although the season commences on 25th February, it is essentially a summer fishery with relatively few people fishing early in the season, and probably has very little impact on the spring run.

3.5 Exploitation by Angling

There is considerable evidence that MSW salmon, and in particular early running 3SW fish, are more heavily exploited by angling than 1SW fish (Solomon and Potter, 1992). On the River Wye, Gee and Milner (1980) examined exploitation rates of different weight categories of salmon and concluded that large salmon were very heavily exploited, and that very few 3SW or older fish survived to spawn. The spawning stock was therefore made up of those 2SW and 1SW fish which had survived angling exploitation, plus those fish entering the river after the end of the season.

The result of such selective exploitation is that a potential spawning stock of spring salmon, likely to have already been reduced by environmental influences, is further depleted. There is also evidence from several studies that exploitation rates are actually higher at lower stock levels, thus further reducing what may be an already depleted stock.

3.6 Impact of UDN

Many salmon rivers in the British Isles were badly affected by the outbreak of UDN which appeared during the mid-1960s. The Eden was particularly badly affected from the 1967 season onwards for several years. The disease was most prevalent in the colder months of the year, when many spring salmon died in the early months of the year. Inevitably both the angling catch and spawning stock were adversely affected.

3.7 Conclusions

The fact that changes in the timing of runs and the decline in the abundance of spring salmon occurred more or less simultaneously in rivers spread over a wide geographical area inevitably leads one to the conclusion that some factor in the environment was responsible. Evidence that such changes have occurred in the past, and are of a cyclical nature, supports this conclusion. The exact mechanism which is involved is not understood, but it seems likely that changes in sea surface temperature and salinity, with consequent impacts on growth rates, time of maturation, and survival of salmon at sea are responsible. Hereditary traits in salmon populations are obviously involved to some degree in determining timing of maturation and return to the river, but these traits are evidently strongly influenced by environmental factors. Thus a genetic tendency for later maturation and return as a MSW spring fish may only become apparent when appropriate marine conditions are encountered.

The fact that during past cyclical changes in the timing of runs MSW fish with an early running habit have become re-established indicates that the appropriate genes were still present in the stocks, even during periods of grilse dominance and low overall abundance of salmon, and that these genes reasserted themselves when appropriate environmental conditions returned. The findings that breeding from 1SW parents can produce some offspring which return as MSW salmon is confirmatory evidence of the presence of these genes.

Set against this background of a natural cyclical fluctuation in run timing, there are other 'man-made' influences which are likely to have had some impact. The high seas fisheries, particularly the West Greenland fishery, which selectively exploited MSW salmon, almost certainly did not initiate the decline in spring salmon stocks, as reductions in their abundance were evident before these fisheries reached significant levels. However, they must have contributed significantly to the pressure on this component of the total salmon stock.

In freshwater, selective exploitation by angling of spring salmon, which appear more vulnerable to capture than later running fish, has been shown to have a major impact on this component of the stock in many rivers, leaving a spawning stock composed mainly of later running MSW salmon and grilse. Again, this is not likely to have been the initiating factor in the decline of spring runs, but may well have accelerated the decline by selectively reducing that part of the stock which had the strongest inherited tendency to later maturation and early running.

There is no evidence that UDN was a reason for the initiation of the decline in spring salmon stocks. However, its arrival coincided with the commencement of the decline and, because of the high mortality of spring salmon from this disease, it may well have hastened the rate of decline.

As far as the present status of the Eden spring salmon stock is concerned, rod catches, and therefore presumably runs, seem to have been reasonably stable, albeit at a low level, since the mid-1970s.

4. OPTIONS FOR CONSERVATION AND DEVELOPMENT OF THE RIVER EDEN SPRING SALMON STOCK.

4.1 General Considerations

The likelihood that it is conditions in the marine environment which are responsible for the changes in run timing and decline of spring salmon does restrict the options available for development of this component of the stock. Possible management actions have been considered by the Salmon Advisory Committee (1994), by the National Rivers Authority (Gough *et al.*, 1992), and by Rogan *et al.* (1993). There is general agreement that it is essential to conserve the remaining spring running fish and to do everything possible to ensure their successful breeding. These fish are obviously those which have the greatest genetic tendency to retain the multi sea winter early running habit, and their protection is vital if early recovery is to occur when environmental conditions once more favour later maturing and early running salmon. The NRA commissioned a study to review genetic characteristics of salmon of different sea ages and to assess the feasibility of enhancement of the spring salmon component (Rogan *et al.*, 1993). A major conclusion from this study was that exploitation in estuarial and riverine fisheries should be seen as a strong selective force against the early running MSW habit and must be decreased.

In addition to protection of the adult fish, the Salmon Advisory Committee also stressed the need to protect, and if necessary rehabilitate, the spawning and nursery areas used by spring salmon, where these areas can be identified. Consideration has also been given to the use of artificial breeding programmes to attempt to enhance the natural production still occurring.

These various options are considered in more detail below, and their relevance to the Eden situation discussed.

4.2 Protection of the Residual Components of the Spring Run

4.2.1 Commercial Exploitation

The impact of the high seas fisheries at West Greenland and the Faroes is now much less as a result of the reduced quotas and buy-outs. In any case, there is nothing which can be done at local level which can have any impact on these fisheries. However, there is the haaf net fishery which operates in the Solway Firth to consider and also the coops at Corby. The season for haaf nets opens on 25th February and for the coops on 1st April. These fisheries are principally summer fisheries and take relatively few fish during the spring months (in 1994 their total combined catch to the end of May was 50 fish out of a season's total of 2221 fish.). They probably therefore have only a limited impact on the spring salmon stock. However, if it is thought necessary to reduce this exploitation, it could best be achieved by deferring the start of the season. Closure of the haaf net fishery until 1st May would probably protect the entire spring run, whereas closure until 1st April would protect most of the 3SW fish. An alternative, but less effective action would be an extension of the weekly close times for the haaf nets and coops.

These variations would require byelaw changes, which could take time to obtain. In addition, it is appreciated that there are complications in the management of salmon fisheries in the Solway because of the two jurisdictions involved.

4.2.2 Exploitation by Angling

In view of the likely selective and heavy exploitation of spring salmon by angling, it is apparent that the greatest scope for increasing the survival of early running fish through to the spawning season is a reduction in this form of exploitation.

Various ways in which this could be achieved have been considered in depth by the Welsh Region of the NRA (Gough *et al.*, 1992). Salmon seem to be particularly vulnerable to capture during their first 20 to 30 days in the river. Thereafter they are less likely to be caught, until perhaps the end of the season when male fish again seem vulnerable. Experience in rivers with large 3SW fish indicates that few if any of these particularly valuable fish are caught after the end of April. If spring fish could be protected during their initial period in freshwater, the numbers surviving to spawn could be significantly enhanced. One option is therefore to defer commencement of the fishing season, which starts particularly early in the case of the River Eden (15th January). An alternative, although less effective option, would be a restriction on angling methods during the first part of the season. In the spring months the majority of salmon are taken by spinning or bait fishing. Restriction of fishing method to fly only would therefore be likely to have a significant impact on the level of exploitation. In the case of the River Wye, the NRA have had byelaws confirmed by MAFF which prohibit the use of spinning before the 1st of May and the use of baits such as worm and shrimp before the 1st of June. Fishing is restricted to fly only again during the latter part of the season. In the case of the Rivers

Usk and Dee, the start of the season has been deferred by 5 weeks, and method restrictions have also been imposed.

Changes in fishing season and restrictions on fishing methods for the River Eden would require new byelaws if they were to be enforceable

Catch and release, often in conjunction with bag limits, has been adopted extensively in North America and Canada as a means of conserving stocks of MSW salmon, and is enforced by statute. It is often adopted voluntarily in this country during the later part of the season by anglers releasing coloured fish. There is very little information on the survival rates of released salmon and there is concern that large salmon in particular may become too fatigued while being played out, and may therefore die after release. Because of uncertainties about its effectiveness as far as spring salmon are concerned, the Welsh Region of the NRA recommended that some experimental work using radio-tagged salmon should be carried out to investigate the survival of rod-caught salmon after release (Gough *et al.*, 1992). The cost of such a programme was estimated at £20,000 to £25,000 per year at 1991 prices.

The Salmon Advisory Committee expressed reservations about the application of catch and release for protection of spring fish and supported the idea of further investigation of the technique, although they did not wish to discourage it as a voluntary restraint. If catch and release were to be adopted it would be likely to be more effective if fishing method was restricted to fly fishing with a single hook to facilitate unhooking.

4.2.3 Curtailment of Illegal Fishing

Because of the long duration of their period in the river, spring salmon are more vulnerable to poaching than later-running fish. Thus they are again exposed to selective exploitation. To be effective for this component of the stock, protection by enforcement staff needs to be concentrated on those holding pools where spring salmon are known to congregate and, later in the season, to concentrate on the areas used by spring salmon for spawning, where these are known.

4.2.4 Habitat Protection, Rehabilitation and Development

To ensure maximum production of smolts from those spring salmon which do spawn, it is essential that those parts of the river system associated with the production of potential early-running MSW fish are protected and, if necessary, rehabilitated. Where it has been possible to identify the areas where different runs of fish spawn, evidence has been obtained that the upper reaches of the river are utilised, whereas later running MSW and 1SW fish tend to spawn further downstream (Rogan *et al.*, 1993). It has been suggested that in some catchments deteriorations in habitat quality and acidification in the upper reaches may have contributed to the decline in spring runs. As part of any programme to conserve and develop spring runs it is therefore essential that any in-river habitat problems are identified and action taken to resolve them. This type of rehabilitation work can often be more cost-effective in the long term than restocking (Hendry and Cragg-Hine, in preparation). Attention should be paid to the following points:-

- ensuring good access for spawners by removal of obstructions and provision of fish passes where necessary.
- checking the availability and condition of spawning gravels and taking remedial action where necessary.
- improving channel topography to optimise habitat for juveniles.
- careful management of riverside vegetation, both to reduce excessive shading by overhanging trees and to provide buffer zones to intercept sediment in surface runoff.
- fencing of banks in vulnerable areas to prevent 'poaching' of banks by farm stock and subsequent erosion of sediment into the stream.

In the River Eden catchment there is a major water resource development which affects the flow regimes in the Rivers Lowther and Eamont. If these sub-catchments are identified as significant spawning and nursery areas for early-running salmon, it would be advisable to examine the existing abstraction and compensation water/prescribed flow arrangements to see if there is potential for improving flow conditions for these fish.

4.3 Supportive Breeding Programmes

There is considerable debate about the value of supportive breeding programmes using hatchery-reared fish in the conservation or enhancement of spring salmon runs. The NRA commissioned a review of the genetic aspects of spring run salmon which assessed the risks attached to such programmes, and described practical precautions which need to be taken (Rogan *et al.*, 1993).

The principal concern is the reduction in genetic variability of the wild stock which can result from ill-planned and implemented programmes. Obviously an enhancement programme can only be justified if the numbers of viable progeny resulting are greater than those which would result from natural breeding and if the numbers of extra adult fish produced are a significant addition to the wild production. The difficulty arises when only small numbers of brood fish are used. Ryman (1991) has shown that addition of large numbers of hatchery-reared fish produced from only small numbers of parents to a wild stock results in a significant reduction in the genetically effective size of the population. This can result in a serious depletion of genetic variability of the overall population, particularly where the absolute size of the wild population concerned is small. To avoid this risk it is essential that adequate numbers of brood fish are used. Where possible, 100 pairs of fish are recommended, and certainly no fewer than 40 pairs. Obviously, brood fish must come from the population which is to be enhanced; in the case of spring salmon this means collection either of fish which are known to be early running or taking of fish from areas known to be used by spring fish for spawning.

Gough *et al.*(1992) have considered the practicalities of obtaining suitable brood stock. If fish are captured early in the year they need to be held for many months before they can be stripped. Although some salmon rearing establishments have been able to hold brood fish taken later in the year successfully, great difficulty has been experienced in holding spring fish for several months and heavy mortalities have often been experienced. In view of the great value of these fish, this is regarded as an unacceptable risk. Confirming that salmon collected from spawning areas are spring-run fish by scale reading is made difficult by the erosion of the scales which takes place in freshwater.

Irving and Graham (1996) have suggested a method whereby spring fish could be identified and located on the spawning beds but this involves capture, handling and tagging of the fish, with associated risks of mortality. To meet the requirement for 40 pairs of fish for spawning, a considerable netting and tagging programme would be required, as well in excess of this number would need to be tagged to allow for mortality from causes such as handling stress during tagging, angling, poaching and disease, and from tag losses during the intervening months. Such a programme would be very costly. In addition, the difficulty of seeing and capturing individual marked fish should not be underestimated, particularly at high flows. However, the adoption of a more limited programme where fish were netted (or trapped), fitted with radio tags, and then released could be justified. This would provide information on the holding areas used by spring salmon, and subsequently the areas used for spawning, which would also be likely to be nursery areas. This could facilitate habitat protection and improvement by targeting appropriate areas. Gough *et al.* (1992) estimated that the cost of a radio-tracking programme involving 30 tagged salmon would be £20,000 to £30,000 at 1991 prices.

When considering the appropriateness of stocking with hatchery-reared fish to enhance a wild stock there are other factors which need to be borne in mind. Even if the parents are from a spring run it is likely that some of the offspring will return as grilse or later-running MSW salmon. There is evidence from various sources that hatchery-reared fish are more likely to return as grilse than wild fish (Cross, 1989). To minimise this 'hatchery effect', Rogan *et al.* (1993) recommend releasing hatchery-reared salmon at a relatively early stage, although they also made the point that stocked fish should be marked with microtags so that the effectiveness of the enhancement programme can be monitored. The minimum size at which fish can be microtagged safely is 8 - 9 cm, which means rearing fish through to at least the end of the first summer.

Finally, there is also the cost of running a rearing programme for the Eden to be taken into consideration. The Welsh Region of the NRA estimated the capital cost of a hatchery and ancillary buildings and equipment which would produce sufficient salmon smolts to add 550 additional MSW salmon to the river to be of the order of £0.5 million (Gough *et al.*, 1992). There are also annual running costs to consider, which could be of the order of £30, 000 - £50,000 for a hatchery of this size.

In view of the general uncertainties associated with the use of supportive breeding to enhance spring salmon runs, Rogan *et al.* (1993) advised that it should not be adopted as a first line option. More research into the effectiveness of such stocking was required before it could be recommended, and they advised that reducing exploitation in estuaries and rivers and ensuring that spawning and nursery areas were protected and improved should be given priority. The Salmon Advisory Committee were also unable to recommend that selective breeding should be implemented on a general basis at present because previous attempts to introduce or boost spring runs have either failed or been of questionable success, and because of the potential for genetic damage. However, they recommended that a properly designed pilot scheme should be implemented.

5. RECOMMENDATIONS

From this review of the situation regarding the present status of spring salmon and the options for increasing the abundance of these highly-prized fish, it is apparent that opinion is generally not in favour of attempting to enhance the spring salmon stocks by introduction of hatchery-reared fish because of the uncertainties about the effectiveness of the technique, and because of the risk of genetic damage to the remaining wild stocks. Rather it is being recommended that efforts should be concentrated on ensuring that as many as possible of those MSW salmon still entering rivers early in the year should be allowed to spawn. Also, efforts should be made to ensure that the spawning and nursery areas used by spring fish are maintained in an optimum condition. The benefits of such measures would not, of course, be evident immediately in terms of an increased number of adults because of the likely minimum 4 year life cycle of spring salmon. However, it would help to ensure that there are more smolts with a strong genetic tendency to late maturation and early running entering the sea to respond to changes in the marine environment which favoured this habit, thus accelerating a recovery of the spring run.

In relation to the River Eden situation it is recommended that the following steps are considered:-

a) Commercial Exploitation.

The exploitation of spring fish by the commercial fisheries should be monitored and, if it appears to be increasing, consideration should be given to promoting byelaws to delay the commencement of the fishing season for haaf nets and coops.

b) Exploitation by Rods.

It should be recognised that the rod fisheries are likely to be taking a large proportion of the spring run and that the most effective way of increasing the numbers of spawners is a reduction in the take by the rods. This could be achieved most effectively by deferring the commencement of the fishing season, but restricting method to fly only would also be an option, although less effective. Method restrictions could also be applied towards the end of the season to protect ripening fish. Such measures would require new byelaws if they were to be enforceable.

c) Catch and Release.

Although the effectiveness of catch and release is still being debated, and is therefore unlikely to be acceptable as a byelaw, a voluntary code agreed between fishery owners and fishermen relating to salmon caught early and late in the season could be encouraged. In this context, a byelaw restricting fishing to fly only with a single hook would be helpful.

d) Illegal Fishing.

Spring salmon should be protected as much as possible from illegal fishing by focusing anti-poaching patrols on holding pools where spring salmon are known to congregate and, later in the season, on areas likely to be used by spring salmon for spawning.

e) Habitat Rehabilitation.

To ensure maximum breeding success and production of smolts from spring salmon, the areas used as spawning and nursery areas should be surveyed and, where spawning gravel is inadequate in quantity or quality and where habitat for juveniles is poor, appropriate remedial action should be taken. In the absence of specific information on the areas used by spawning spring salmon, it should be assumed that the upper reaches of the catchment are being used. Although rehabilitation work of this type may initially appear costly, when the costs are spread over the expected life of the scheme it can often be shown to be a more cost effective means of producing additional fish than restocking, particularly where investment in a hatchery is required.

f) Accessibility of Spawning Areas.

Where access for adults is impeded, for example by fallen trees or waterfalls, obstructions may need to be cleared or fish passes may be required.

g) Selective Breeding Programmes.

The use of selective breeding and stocking with hatchery reared fish is not recommended at this time because of the uncertainties involved. Both the capital costs of providing the necessary hatchery facilities on the scale required to make any impact, plus the annual running costs, make this a very expensive option, even if results could be guaranteed. As it is, environmental factors may well dominate, resulting in many of the returns being grilse or later-running MSW fish.

h) Tracking Studies.

Consideration should be given to carrying out tracking studies with spring running salmon tagged with radio tags. Information on the behaviour of the fish and on the areas they frequent and those they use for spawning could be obtained by this means. This information would be invaluable for concentrating anti-poaching activities and for locating spawning and nursery areas so that habitat evaluation and improvement measures could be properly focused. Also, in the event of a decision being taken in the future that some selective breeding and restocking was justified, it would identify those areas where appropriate brood stock might be collected.

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