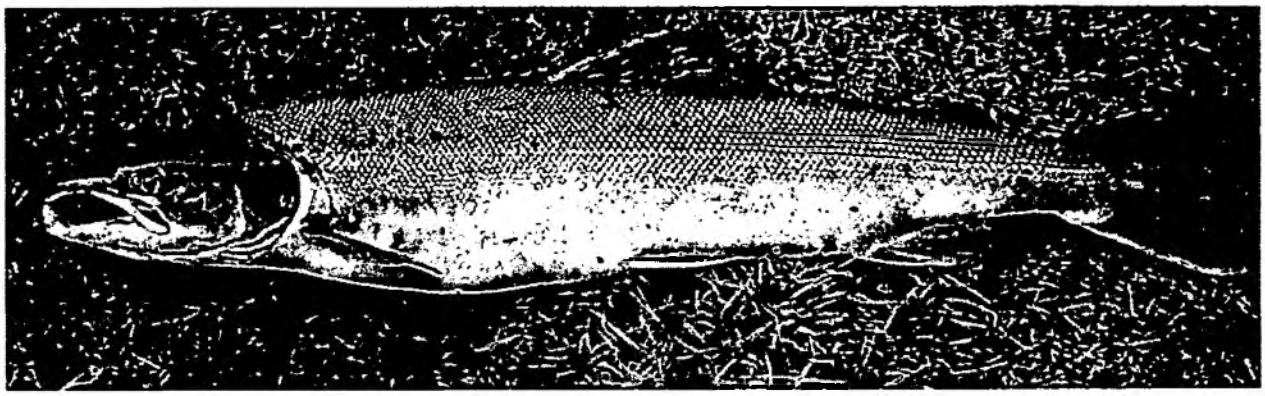
River Tamar Salmon Action Plan Consultation Report



Cornwall Area
South West Region
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EXECUTIVE SUMMARY

The River Tamar is one of the premier salmon rivers in the West country, supporting fifteen licenced estuary nets, and the second highest rod catch behind the River Exe. Currently catches consist predominantly of grilse, and some two sea winter salmon. Three sea winter salmon and previous spawners are rare. Current data suggests that 2195 spawning salmon are required to maintain a sustainable population. This target for spawning salmon has been achieved on the River Tamar in the last ten year period. However, as several years in the early 1990s have only marginally attained this target, clearly there is no room for complacency. Moreover, since the 1960s there has been a marked decline in the rod and net catches of spring salmon to a current level of the order of 10% of previous catches.

The aims of the River Tamar Salmon Action Plan are to identify:

- *Factors causing a decline in the spring salmon run.*
- *The actions and finance necessary to maintain the salmon stock to the mininmal biological acceptable level (**MBAL**).*

The most recent calculation (1995) for egg deposition is estimated to be 137% of the minimum required for the MBAL. Within recent years (1986) the egg deposition rate has been estimated to be as high as 323% of the target level. Rod and net catches have shown an overall decline since 1975, several factors are likely to account for the this. These have chiefly been identified as exploitation by distant water fisheries, poor utilization of the Upper Tamar catchment, and low fry and parr densities. Poor catchment utilization and low juvenile densities are likely to result from a combination of low river flows and habitat loss.

Catches for spring salmon have shown a marked decline. Recently (April 97) the estuary-nets have been subjected to a "buy back period" from 2nd of March to June 7th inclusive in a joint venture involving SWWSL, the Netsmen and the EA. This measure was undertaken as part of the Roadford reservoir mitigation scheme as an alternative to the hatchery programme. For the purpose of assisting the recovery of the depleted spring salmon. However this scheme will require measures to curtail rod exploitation, since current exploitation of spring salmon (during the period April to May) by the rods is estimated at 33%.

INTRODUCTION

- In February 1996, the **National Salmon Management Strategy** was launched by the Environment Agency's predecessor the National Rivers Authority (NRA, 1996).

- The strategy concentrates on four main objectives for the management of salmon fisheries in England and Wales. These are primarily aimed at securing the well being of the stock but in doing so will improve catches and the associated economic returns to the fisheries:

1. *Optimise the number of salmon returning to home water fisheries.*
2. *Maintain and improve fitness and diversity of salmon stocks.*
3. *Optimise the total economic value of surplus stocks.*
4. *Ensure necessary costs are met by beneficiaries.*

- These four objectives will be addressed through local **Salmon Action Plans (SAPs)** which the Agency will produce for each of the its principal salmon rivers by the year 2001. Each plan will review the status of the stock and fisheries on a particular river, identify the main issues limiting performance, and draw up a list of costed options to address these.

- A new concept introduced by SAPs is that of setting **'spawning targets'** to assess stock and fishery performance - providing a more objective approach than has previously been possible. The processes of target setting and compliance assessment are developing ones and are likely to be improved upon in the coming years. Nevertheless, the targets described in this document represent a sound starting point for using this important technique in the management of salmon stocks - one which has been successfully applied on Canadian rivers for a number of years and has recently been advocated by the North Atlantic Salmon Conservation Organisation (NASCO) to facilitate salmon management in the North Atlantic Commission Area.

- In delivering each SAP it is essential that the Agency seeks the support (including in some instances the financial support) of local fishery and other interests. This collaborative approach is vital to secure the best way forward for our salmon rivers at a time when stocks are generally at an historic low, environmental pressures are as great as ever, and funding for salmon fisheries is diminishing. Hence the document presented here is for consultation, will be circulated widely and is open to refinement in the light of comments received.

- The final SAPs which result from consultation will publicly define the Agency's intentions for salmon management into the next century, with a commitment to review progress on an annual basis. In turn, the local plans will be summarised in Regional and National plans which will guide the Agency's business activities in the wider context. Furthermore, each SAP will feed into Local Environment Agency Plans or LEAPs (the successors of Catchment Management Plans) which serve to integrate all environmental responsibilities within the Agency's remit, including management of air, land and water.

1 DESCRIPTION OF CATCHMENT

- The Tamar catchment extends from the south coast of the South West peninsular to within 10 km of the north coast and forms a natural boundary between the counties of Devon and Cornwall. The three main tributaries of the Tamar are the Inny, Lyd and Ottery.

- The geographical catchment area is 927.75 km².

- The geology of the catchment are hard mudstones, shales, siltstones, sandstones and minor limestones. The granitic mass of Dartmoor touches the eastern border. Intense tin, copper, arsenic and locally tungsten mineralization are found associated with the granitic mass.

- The underlying rocks of different origins, have low permeability and porosity, limiting groundwater flow and storage.

- The wetted surface area usable by salmon has been estimated to be 197 Hectares (1.97 km²)

- Average annual runoff 22.495 m³/s (Period 1957 - 1993)

- Human population 32,900 (1991 census)

- Agricultural land covers 92% of the Tamar catchment with the majority grassland. The dairy herds within the Tamar catchment have fallen over ten years by 12% to just under 33,000 cows but there has been a dramatic increase of 75% in beef cattle, from 8,000 to 14,000. A similar large increase has been seen in sheep. Agricultural practices particularly from increased land drainage are thought to be responsible for increased siltation of the river bed.

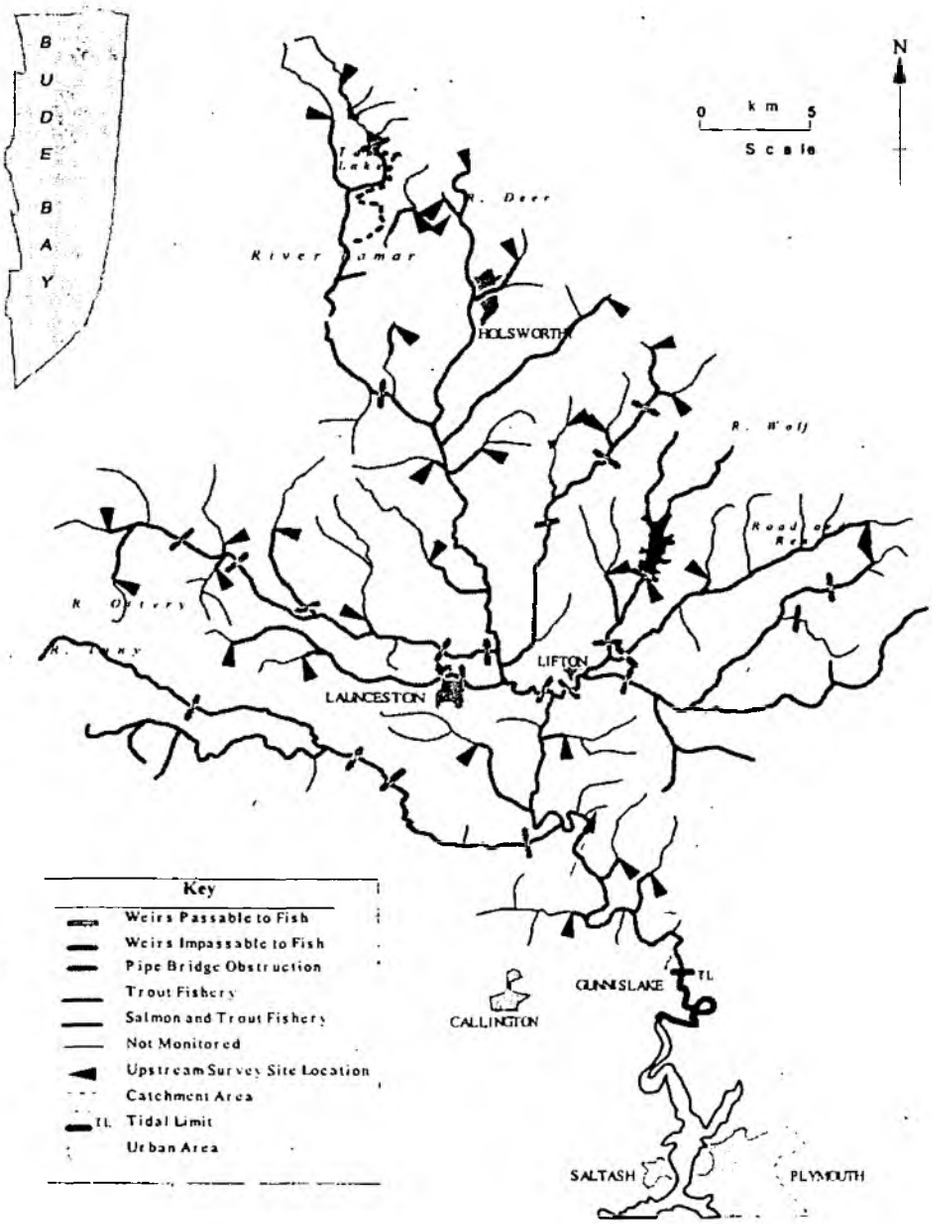
- In general the water quality objectives (WQO) for the Tamar catchment attained at least River Ecosystem (RE) Class 2, which is water of good quality and suitable for sustaining salmonid populations.

- Native Tamar fish species covered under the EC Habitats directive (92/43/EEC) include Atlantic salmon (*Salmo salar L.*), bullhead (*Cottus gobio L.)*, brook lamprey (*Lampetra planeri Bloch*) and sea lamprey (*Petromyzon marinus L.*). Whether river lamprey *(Lampetra fluviatilis L.)* occur within the Tamar is unknown at this time. However, all the above lamprey species are long listed within the EC Habitats Directive. Shad (*Alosa species*) occur within the Tamar estuary and sometimes are caught by licensed salmon netsmen. Shad have been found up to Gunnislake weir. It has not been ascertained whether both shad species occur within the Tamar estuary.

2 DESCRIPTION OF THE FISHERY

The River Tamar supports a major game fishery for Atlantic salmon, sea trout and brown trout from the upper reaches of the estuary to its headwaters and those of its tributaries. The salmonid rod fishery also extends for a mile below Gunnislake weir (the normal tidal limit). The main areas fished for salmon are on the three main tributaries (Inny, Lyd and Ottery), and the main Tamar below Launceston. There is no recognised riverine coarse fishery on the River Tamar or its tributaries other than for eels, grayling and dace. The most widely distributed non-salmonids are eel, bullhead, stoneloach, minnow and brook lamprey.

Figure 2 Tamar Fisheries



2.01 Regulations

Seasons : The open rod fishing seasons in the Tamar catchment i.e. the period when it is permitted to fish are : Salmon 1st March - 14th October and Migratory (sea) trout 3rd March - 30th September. The open season for the estuarine net fishery is 2nd March to 31st August. There are weekly close times, discussed later on. A weekly close period of 06.00hrs on Friday to 06.00hrs on Monday is enforced in the period March to May and 06.00hrs on a Saturday to 06.00hrs on Monday from June onwards.

Byelaws : Freshwater. In 1961 a byelaw was introduced to reduce the rod fishing season by four weeks. The new season began 1st March and ended 30th September. In 1973 the rod fishing season was extended by fourteen days to 14th October. This had a noticeable positive effect on rod catches (see rod catch effort data)

In 1994 the National Rivers Authority under the Water Resources Act, 1991 introduced a byelaw. This prohibits after the 31st August, the use of shrimp, prawn, worm or maggot as bait when fishing with rod and line for salmon or migratory trout.

In 1996 voluntary measures were proposed to reduce pressure on spring salmon stocks. Within the Tamar catchment anglers were requested to keep to a maximum limit of two salmon per person prior to the start of June. It is known that not all anglers respected this proposal.

Byelaws : Estuarine Fisheries. The Ministry of Agriculture, Fisheries and Food (MAFF) with the Fisheries departments for Wales, Scotland and Northern Ireland have responsibility for the conservation of fish stocks and management of marine fisheries in UK/British waters. The main management tool is the EC Common Fisheries policy, which applies to fish stocks in coastal and offshore waters and endeavours to maintain them as a renewable resource.

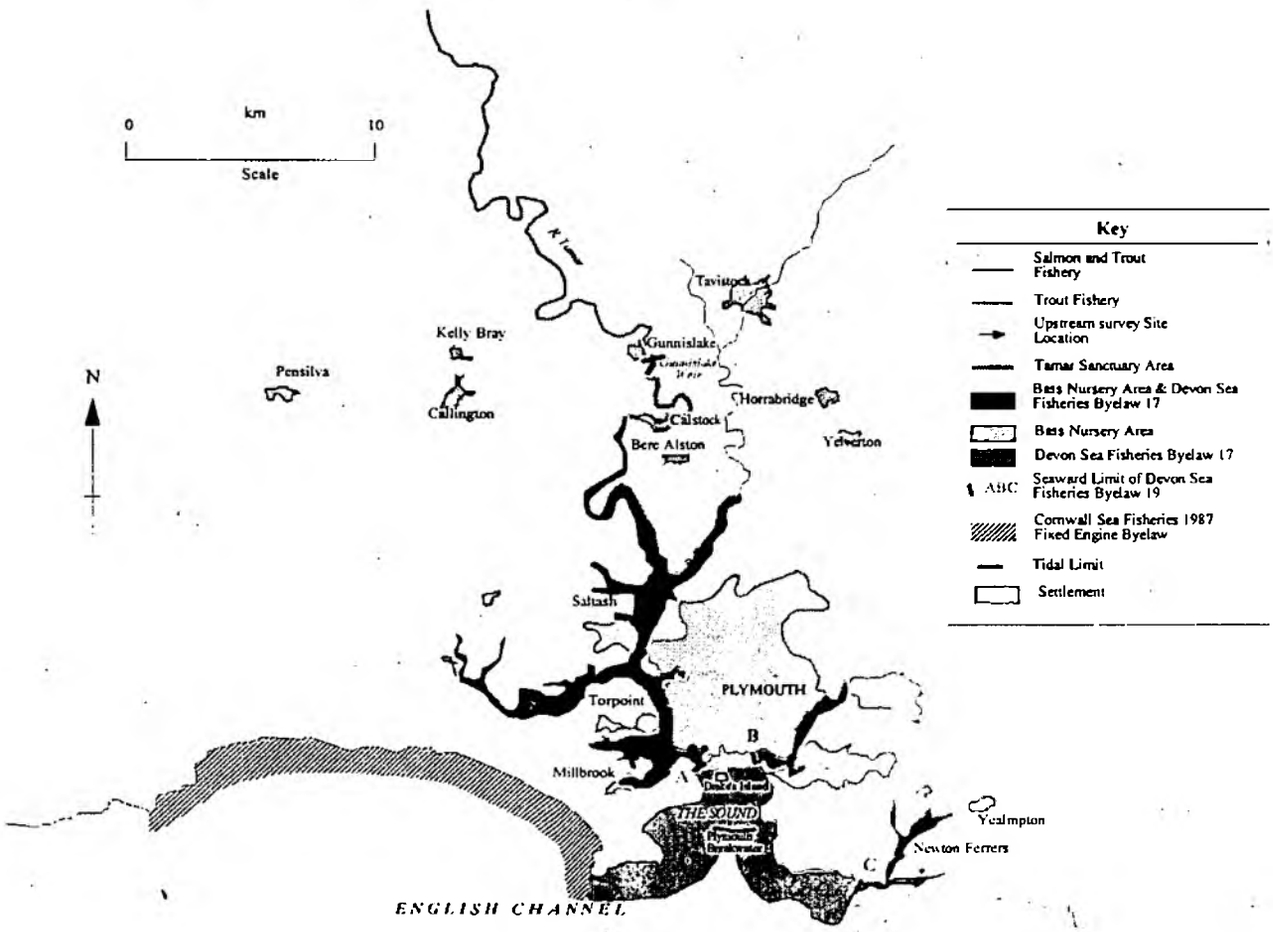
In the estuarine and coastal waters of England and Wales, sea fisheries out to six miles are regulated by Sea Fisheries Committees (SFC) established under the Sea Fisheries Regulation Act, 1966 and for migratory stocks by the Environment Agency. The Devon Sea Fisheries Committee (DSFC) regulates sea fisheries within the estuarine and coastal areas of this document. All byelaws made by these bodies have to be confirmed by the appropriate Minister. SFC's in common with other fisheries managers in the UK (including the Environment Agency), may regulate for strict fisheries management purposes and for the more general protection of the marine environment.

DSFC byelaws 17 (Fixed engine restrictions) and 19 (Netting prohibition introduced 1990) restricts the use of nets. Byelaw 19 prohibits all netting other than licensed fyke netting for eels, licensed salmonid seine nets and landing nets used in conjunction with rod and line within the Tamar estuary.

The Environment Agency also restricts the use of nets with Section 6 of the Salmon and Freshwater Fisheries Act 1975 (SAFFA 1975) and Section 33 of the Salmon Act 1986 (SA 1986). Both Acts contain restrictions relating to the use of fixed engines.

MAFF made two orders which enabled the designation of protected nursery areas for sea bass, and the subsequent prevention of sea fishing as a guise for salmon. The MAFF orders cover the estuaries of the Tamar, Lynher, Tavy, Plym and Yealm. They came into force in 1990 and are:
1. The Sea Fish (Specified Sea Area) (Regulation of Nets and Prohibition of Fishing Methods) Order 1989:SI 1989 No 1284.
2. The Bass (Specified Areas) (Prohibition of Fishing) Order 1990: SI 1990 No 1156.
In 1961 various byelaw changes were introduced affecting net and rod fisheries due to a major decline in the combined rod and net catch figures for the Tamar and Plym fishery district. This byelaw was known as the(Limitation of salmon and migratory trout netting licences order, 1961. The byelaw restricted the Tamar to 15 net licences. The Net Limitation Order (NLO) for the Tamar was renewed last during 1996 for a further 10 years.

Figure 3 Tamar Estuary



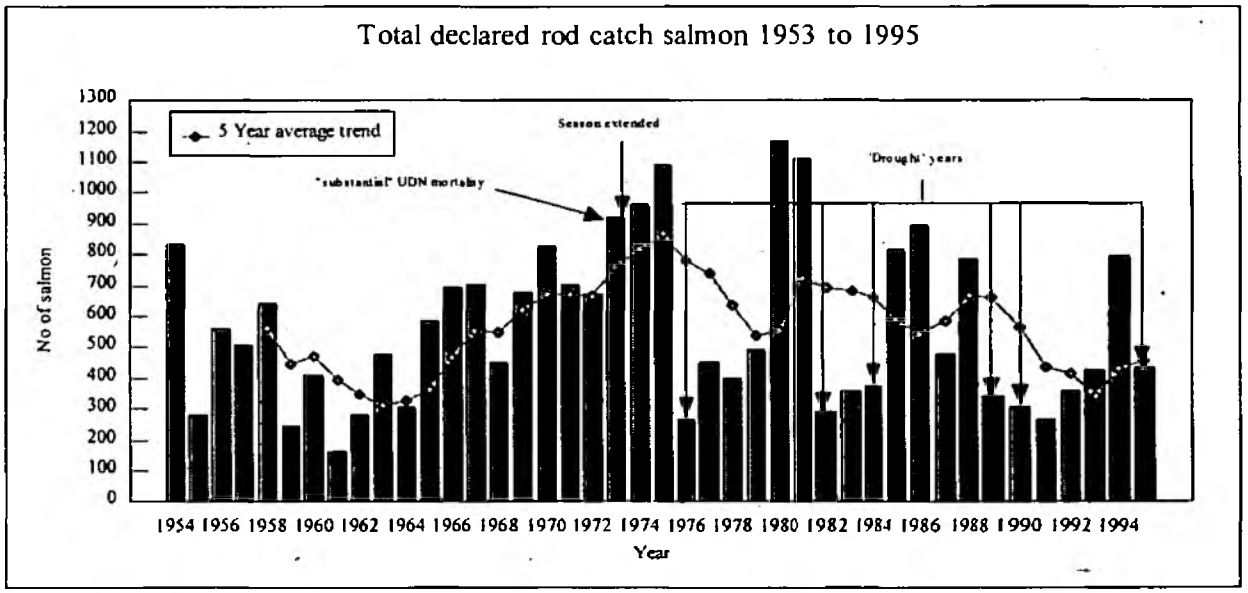
2.1 CATCHES AND CATCH EFFORT

Rod catch data : Reported River Tamar rod catches : 1953 - 1995

Atlantic salmon :	Maximum 1169 (year 1980)	Minimum 163 (1961)
Sea Trout :	Maximum 1105 (1981)	Minimum 134 (1956)

The River Tamar is one of the premier salmon fishing rivers in the West country with the second highest average rod catch (Average 567) behind the River Exe. Grilse (salmon which have been at sea for only one winter) and two sea winter fish (2SW) form the majority of the adult salmon population with three sea winter and previous spawners being rare. Catches vary considerably and there is no obvious trend in total catches (Figure 3). One factor we have been unable to take into account through insufficiently detailed data is changes in anglers fishing effort. The number of angling days on each river system has only been recorded since 1993 which is insufficient to recognise any underlying trends caused by varying effort. Monthly rod catches vary considerably, peaking any month between May and October. This is most likely caused through a combination of stock availability and river flow. Drought conditions have a strong negative influence on rod catches largely by inhibiting adult salmon migration from salt water.

Figure 4



Rod catch effort. The rod fishery extends upstream from Impham in the tidal section to the upper reaches of the tributaries (See Figure 3). The catch effort will have varied through the use of techniques, equipment and angling effort. It is likely that effort will have increased steadily. Since 1993, the number of angling days has been recorded and shows this trend. (see Table 3)

Rod catch data based on the catch return system has had varying return rates from anglers, as

well as different reminder and licence systems. Because of this, when interpreting rod catch data, these must be taken into account. Correction factors for years when return rate data, for the River Tamar were recorded are detailed in Table 1. The calculation of these correction factors are based on Small,I. (1991). The correction factors are calculated from the equation: Actual catch = Declared catch x ((0.3 / Return rate) + 0.7)

Table 1 Correction factors for known rod licence return rates.

Year	Return rate from anglers %	Proportion of declared catch	Correction factor
1968 - 1970	33 - 37	0.64	1.56
1986 - 1991	45 - 50	0.77	1.3
1992 - 1993	20 - 30	0.53	1.9
1994 - 1995	71 - 76	0.91	1.1

The fishing season for rods has always extended beyond the end of the netting season. Up to and including 1972 the rod season closed on September 30th. In 1973 a byelaw was introduced to extend the rod fishing season by fourteen days to October 14th. The reason for this extension to the rod season was to enable the rod fishermen to exploit the late run of salmon which is often associated with the equinoctial storms and spates of late September and October. From 1973 to 1995 the average number of salmon taken per year during this 14 day extension period has been 105. This is 17.5 % of the average total recorded catch for this period (599). The maximum 286 (1975), and the minimum 21 (1978).

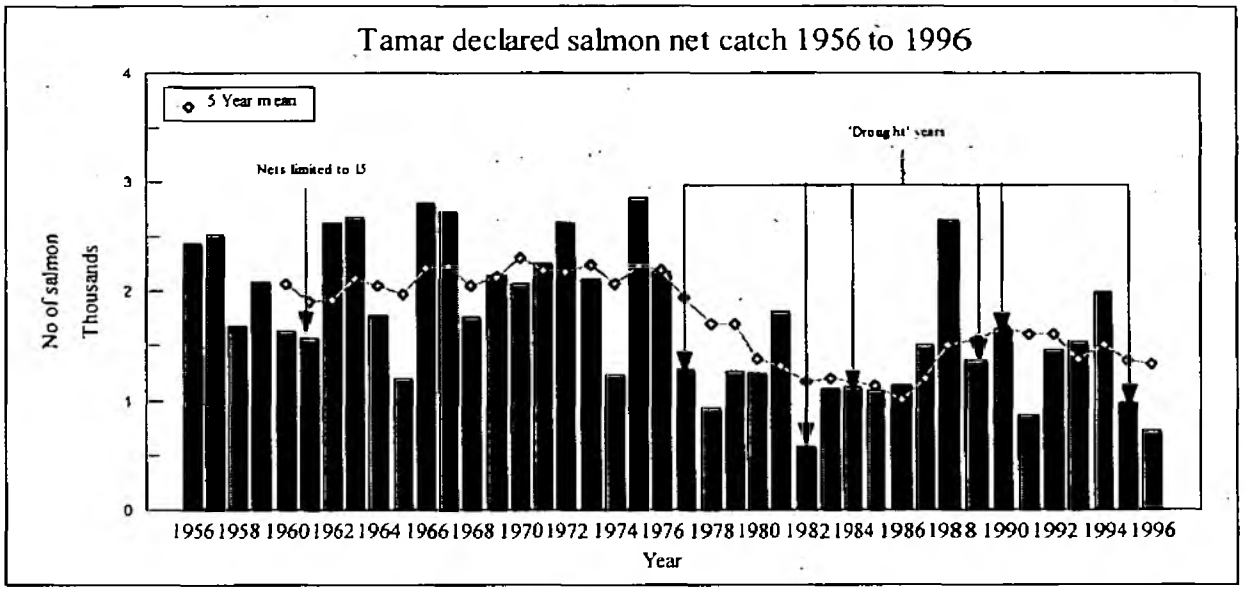
Solbe and Bell (1988) showed that, for the period 1969 to 1988, rod catches were dependent on flow. Indeed the total reported catch for the period 1970 to 1985 was significantly related to the flow in June, July and August. Thus flow is probably the overriding factor in determining the seasonal distribution of rod catches. However, catch data for the last 25 years indicates a diminishing trend in salmon caught during March, April and May. During these months a greater percentage of the available stock are exploited. (See Table 11)

Net Fishery data. Reported Tamar net catches : 1956 - 1996
Atlantic salmon : Maximum 2864 (1975) Minimum 580 (1982)
Sea Trout : Maximum 680 (1958) Minimum 80 (1986 & 1987)

The Tamar estuary along with neighbouring estuaries sustains one of the most productive net fisheries in the South West. July is usually the most productive month for the netsmen coinciding with main runs of grilse into the estuary. There are 15 net licences on the Tamar Estuary. All of these licences are for seine nets (includes one joint licence Tamar/Tavy). The actual number of licences has not varied since 1962. The number of endorsees has varied over time.

Commercial seine netting occurs between Cothele and Weir Quay. A 7km sanctuary area purchased in a collaborative move by the licensed netsmen, rod fishermen and Cornwall River Board on 19.08.59, exists from Calstock upstream to Impham where salmon rod fishing begins (See Figure 2).

Figure 5



Net Catch effort. 15 commercial seine nets (including one joint Tamar/Tavy net) currently fish within the Tamar estuary (see Table 4) and this has remained the same since 1961. The netting effort is considered by Solbe and Bell (1988) to have remained constant since the Tamar Net Limitation Order (1961) came into force; this can still be considered the case to date. However, of the number of endorsees for each licensed net, which has varied and may effect the overall effort per net for each year. Prior to 1961 the netting effort for the Tamar cannot be assessed as the number of licences varied.

The seine nets have a maximum length of 200 yards x 10yds depth and minimum mesh size 2 inches. Catch efficiency However, may have increased with the transition from natural to synthetic materials such as monofilament and multi-strand monofilament.

A byelaw exists which bans the use of any net of a monofilament material for taking salmon, trout, freshwater fish and eels. A High court ruling directed that 'monofilament' included multi-monofilament material. In 1994, licensed netsmen were informed that multi-monofilament net was illegal if used in a salmon net. All netsmen changed their nets to a synthetic twine by the beginning of the 1995 netting season. This change may have caused a reduction in net catches. Changes in the behaviour of netsmen in response to changing patterns of salmon migration and time spent fishing cannot be quantified before 1990. Since then the number of days in each month spent fishing have been recorded.

The netting season has remained unchanged and extends from March 2nd to August 31st. A weekly close period of 06.00hrs on Friday to 06.00hrs on Monday is enforced in the period March to May and 06.00hrs on a Saturday to 06.00hrs on Monday from June onwards. The 72hr close period in the spring is presumed to have been introduced to give some protection to spring salmon.

Net catches show a strong seasonal trend, with June, July and August accounting for the largest number of salmon. Peak catches occur during July. Through studies from Roadford and Environmental Investigations Team 1990, flow rates on the Tamar were found to have little effect on the net catch, though the study suggested that the overall effect of flows is positive. There was some indication that flows during June to August > 30 cumecs had a detrimental effect on net catches. High flows prevent or reduce the efficiency of netting operations and fish are attracted upstream by the increase in freshwater flow.

Table 2 Rod catch and net catch summary

	Pre -1st June catch		Post-1st June catch		Annual catch		Catch per licence-day (CPLD)	
	1995	5yr mean (90-94)	1995	5yr mean (90-94)	1995	5yr mean (90-94)	1995 season	2yr mean (93-94)
Rods	133	56	300	381	433	436	0.197	0.154
Nets	44	76	927	1426	971	1502	N/A	N/A

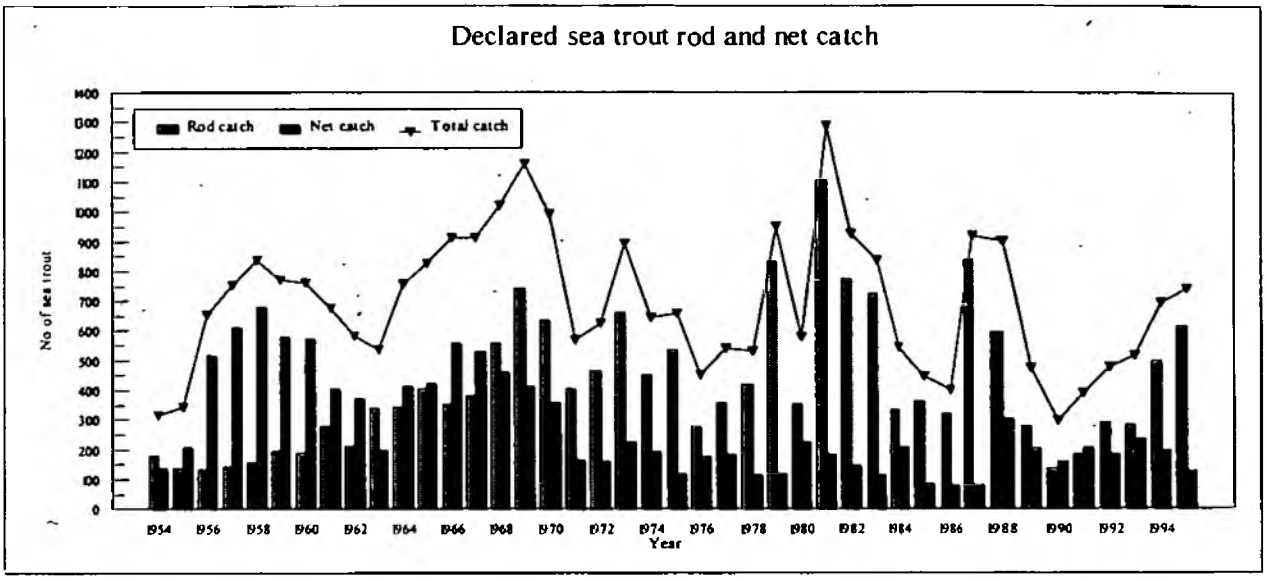
1.CPLD data for South West rivers is only available from 1993 onwards

2.In 1995 the Tamar catch/licence day was the fifth highest nationwide

Both the rod and net fishery have shown a marked decline in catches of spring salmon this is discussed later on.

Sea trout. From 1990 to 1995 catches have steadily risen. This may be due to the Estuary Closure Byelaw brought into effect in 1990. Average rod catch 1954 to 1995: 416. Average net catch 1954 to 1995: 277. Please refer to Figure 5.

Figure 6



Historical Trends. Catch return records available for the estuarine net fishery date back to 1901. For the Rivers Tamar, Tavy and Lynher, the number of net licences varied from 1 to 21 during the period from 1901 to 1919. With the data not recording the location of catches and the effort being widely variable, it is of limited use. However, some large catches of salmon were recorded, for example, during 1913, when 4637 salmon were recorded caught by 19 net licences. Such figures can be of use as they may assist by indicating the potential capacity of the Tamar fishery.

Reports between 1920 and 1949 are currently not available, though the Salmon and Freshwater Fisheries Act 1923 set up 3 Fishery districts of West Devon and Cornwall, the Tamar, Fowey and Camel. Records from 1950 to 1955 have salmon rod and net catch data for the Tamar, Tavy and Lynher fisheries combined. From 1956 onwards, data is split into the individual rivers of the Tamar Estuary.

Net licences vary from 1950 to 1961, with a maximum of 36 licences during 1957, and a minimum of 23 during 1951 for the Tamar District. Much of the data is also recorded in anecdotal form and is inconsistent between years. Even so useful figures are recorded which provide a historic indication of salmon stocks.

During 1970, 1971 and 1972, 104, 128, and 72 dead salmon from ulcerative dermal necrosis (UDN) were recorded on the River Tamar. In 1972 adults and juveniles were also widely recorded as having fungal infections. During 1973 UDN mortalities were recorded as "substantial" for Tamar spring salmon.
During the first spate after a period of drought in 1984. Significant fish kills occurred in the headwaters of the River Ottery and the River Kensey, mortalities have also occurred during other drought years. An investigation has linked the deaths to lowered pH and increased metal levels.

For the purpose of the River Tamar salmon action plan, a drought year can be defined as when the long term average (LTA) flow (40 years) is less than 55 % between April and September in any one year. Using this definition for the previous 40 years the following years have been drought years in ranking order of low flow:- 1976, 1984, 1990, 1982, 1995, and 1989.

2.2 NON- BIOLOGICAL FISHERY DESCRIPTION

2.2.1 Participation.

Table 3 Rod fishery participation

Number of Anglers		Days Fished		Total Number of anglers		Total days fished	
1995	2 year mean	1995	2 year mean	1995	2 Year mean	1995	2 Year mean
515	312	3994	2759	685	655	5192	5800

The total number of days fished is estimated from the catch return data. These final figures has been multiplied by correction factors listed in Table 1. However, the estimates of participation relate to both salmon and sea trout and may overstate the true picture.

Table 4 Net fishery participation.

Licensees		Endorsees		Total netsmen		Days fished	
1996	5 year mean	1996.	5 year mean	1996	5 year mean	1996	5 year mean
15	15	59	70	74	85	1054	1300

- *One of the Tamar net licences is issued to a River Tavy licence holder. 5 year mean from 1991 to 1995.*
- *It is illegal for endorsees to fish without the presence of the licence holder.*

2.2.2 ECONOMIC EVALUATION

Nett Economic Value. The Nett Economic value comprises the value to the fishery owners, to the salmon angler, and to the netsmen.

Mean declared catch. The mean declared rod catch is taken from the number of returns received from anglers who reported fishing effort on individual rivers. Since not all licence holders report their fishing effort, these figures are a minimum estimate and require adjustment. The factor of 1.10 (Refer to Table 1) is used to raise the declared catch figure to a total catch, to correct for the 30 to 40 per cent of anglers who did not make a catch return.

Mean Regional Value. The mean Regional value per salmon is derived from a survey (Radford *et al* 1991) in 1988 commissioned by CEFAS. This figure has been adjusted to allow for inflation. This is multiplied by the mean total rod catch to yield the market value to the rod fishery..

Market Value. The market value of the rod fishery estimates the mean market value for salmon. These figures subsume the value of the fishery for sea trout, and brown trout.

Anglers' consumers' surplus. The ratio of the angler's consumers' surplus to the market value of the fishery, indicates what the anglers are willing to pay for their fishery and what they actually pay. The anglers' consumers' surplus for salmon angling on a given river is the sum of the different surpluses of the individual anglers. For the purpose of this report a ratio of 1:1 has been derived.

Table 5 Value to fishery owners (Market value) and to salmon anglers (Anglers' consumers' surplus):

Mean declared rod catch 1994-95	Mean total rod catch 1994-95	Mean Regional value per salmon	Market (capital) value to rod fishery	Ratio Anglers' consumers surplus: Market value	Anglers' consumer surplus
627	690	£9,000	£6 million	1:1	- £6 million

Gross revenue. The gross revenue to netsmen is obtained by multiplying the declared weight of fish caught, and the market price. These figures, adjusted to reflect recent trends in prices and inflation, are shown in Table 6 for the SW Region.

Nett profit. The nett profits to netsmen are a maximum estimate of the nett economic value to the net fishery. They assume about 40 per cent of the gross revenue to be subtracted for operating costs incurred by the fishery.

Capitalised Nett profit. For comparison of capitalised nett profits in relation to the rod fishery, these annual profits also need to be capitalised, using the same discount (6% per annum) and time horizon (10 years) as for the anglers' consumers' surplus.

Table 7 Value to netsmen:

Species	Mean declared weight of catch 1991-95	Price Per Kg	Gross revenue	Nett profit	Capitalised Nett profit
Salmon	4654 Kg	£4.1	£19,000	£11,500	£80,000
Sea trout	268 Kg	£3.0	£800	£500	£4,000

Note: The Tamar estuary tributaries, the Rivers Lynher and Tavy, also have net fisheries. Through radio tagging studies on the Tavy, salmon caught in this estuary have been shown to run the Tamar.

Table 7 Fishery Nett Economic Value

Fishery group	**Value £**
Fishery owners	6.21 million
Salmon anglers	6.21 million
Netsmen	85,000
Minimum Nett Economic Value	12.5 million

Anglers' expenditure. The mean declared days fished from the anglers' catch returns provides a useful indication of the angling effort on the River Tamar. Combining this with the National average expenditure per angler per day produces a guide figure for the input to the local economy. The figure has been multiplied by the correction factor of 1.34 to allow for catch returns not received.

Radford *et al* (1991) estimated the total expenditure in England and Wales by salmon and sea trout anglers and the total number of declared days fishing. This indicates that the cost per day is about £40.This is an average figure. The expenditure for the River Tamar is likely to be greater because a substantial proportion of angling days will involve an overnight stay. Indeed a proportion of the fishing is run by Hotel fisheries. Therefore the figure of £40 is unlikely to cover the overnight accommodation alone.

Furthermore, this figure takes into account only the monies spent on fishing and accommodation for the angler. It does not include expenditure incurred from accommodation,

sustenance, and entertainment of families who often accompany anglers. Moreover, a high proportion of anglers are from outside the Devon and Cornwall area, particularly on the hotel fisheries. The day ticket waters comprise close to half local and visiting anglers. Thus a significant income to the area is from visiting anglers, boosting other tourist industries.

Through consultation with local rod fisheries a more accurate figure for anglers expenditure per day was estimated to be £100. This has been used in the table below

Table 8 Anglers' Expenditure

Mean declared days fished 1994-95	Mean total days fished 1994-95	Expenditure per day	Total expenditure
3648	4888	£100	£488K

2.2.3 OTHER ASPECTS OF ECONOMIC VALUE

The evaluation of Nett Economic Value has solely looked at the netting and angling value of the fishery. There are other values of the fishery to which a monetary value would be difficult or indeed inappropriate to assign.

Existence Value. There is a value derived from the existence of a salmon stock and fisheries on the River Tamar. This value can attract additional income to the area from tourism. Moreover, the presence of the salmon is one of the highest accolades that a river in the British isles can achieve with the species demand for pristine water quality. Its presence acts as an obvious biological indicator. Indeed the salmon can be considered a keystone species providing a powerful reason for maintenance of water quality and habitat in the area, with wider benefits for other flora and fauna, for example in aiding the re-establishment of the otter population within the Tamar catchment. Furthermore residents in the Tamar catchment who may not have direct involvement with the salmon, would feel a loss if the salmon were to disappear from the Tamar.

Historic and Bequest Value. There is also a historic and bequest value to the fishery. That is to say that both the net and angling fishery have been established on the Tamar for a minimum of 200 years. Cornwall River Board records contain information that in 1802 when the Tidal water fishery wasn leased by the Duchy of Cornwall for £300 per year. Furthermore attached to these fisheries are trades such as the netsmen, and ghillies which are handed down through generations. The value of such trades provides a historical identity locally other then mere employment, and should be safeguarded through the maintenance of salmon stocks.

3.0 DESCRIPTION OF STOCKS, CURRENT STATUS AND RELEVANT TRENDS

3.1 STOCK MONITORING

Stock monitoring is a fundamental requirement for effective stock management, this is carried out using various methods and targeting different life stages. Monitoring is carried out using the most suitable and accurate methods, within the constraints of finance and river conditions.

- **Spawners:** assessed in two ways: firstly the reported rod catch allows estimation of exploitation rates, and spawning escapement. Secondly mapping and counting of redds when river conditions allow.

- **Juveniles:** Electric-fishing surveys of the abundance of juvenile salmonids within the Tamar catchment were carried out in 1971, 1984, 1990, 1993 and 1996. Specific electric-fishing surveys within the Lyd sub-catchment were carried out in 1978 and 1986-1996. Results from the above surveys are given in Table 12 and Figures 8 & 9.

- **Adults:** Fish Counter : A resistivity fish counter was installed at Gunnislake Weir in 1991. It became fully operational in July 1992 and video validation commenced in June 1993.Validation is complete, and indicates that the counter is providing reliable data. Estimates of the numbers of salmon and sea trout recorded migrating upstream over the counter are shown in Table 9.

In addition studies of Tamar salmon have centred around investigations into the effects of Roadford reservoir on all freshwater life-stages of the salmon including their return migration through freshwater :- These include radio tracking studies carried out from 1986-1995, trapping of adult salmonids migrating through Gunnislake weir, Damsite, Cookworthy trap and Milford trap, scale reading surveys - 1971-1973, smolt trapping and aging was carried out from 1985 to 1993, and micro tagging of tagging of stocked and wild salmonids occurred from 1985 to 1987

3.2 ADULT SALMON RUN

3.2.1 Trends in abundance of particular stock components : Data from the Gunnislake fish counter exists from 1993, in order to look back further rod and net catch data need to be analysed. Net catches were shown to correlate with Gunnislake trap catches for the period 1987 to 1989. With this in mind and the general stability in catch effort for the net fishery since 1961, the net catch data generally provides a more reliable index for stock availability than the rod data.

Since the early 1970s the proportion of grilse to 2SW salmon has altered and there is currently a much higher proportion of grilse in the population. This change is being

investigated nationally. It may be cyclical in the long term, climate dependent or may be related to fishing on the high seas strongly selecting multi-sea winter fish. The outbreak of Ulcerative Dermal Necrosis (UDN) in the early 1970s affected spring salmon survival. Though relatively high rod and net catches were recorded during this period.
There has been a reduction in the declared rod and net catches of three sea winter salmon and previous spawners.

Table 9 Salmon and sea trout recorded at Gunnislake fish counter (1 Jan -31 December)

Year	Salmon	Sea trout
1993 •	3519	6464
1994	4769	11502
1995	4228	8152
1996	2989	7451

• Technical problems meant that the counter was unoperational for a proportion of time in 1993, therefore the 1993 estimate is affected and the actual numbers are probably higher

It should be noted that migrating salmonids can bypass the fish counter by using the Devon fish pass or by jumping the weir under high flows and on spring tides. From radio tracking studies suggest that 70% of salmon pass through the fish counter (Ref : Roadford Fisheries Liaison Committee. March 96).

Table 10 Run size and timing.

Method	Pre-1st June *		Post-1st June		Annual	
	1996	mean 94-95	1996	mean 94-95	1996	mean 94-95
Gunnislake fish counter	483	362.5	2506	4136	2989	4498.5

** Pre-1st June data includes all salmon recorded at Gunnislake from 1st January to 31st of May. This is likely to include late run salmon from the previous season.*

In the River Tamar, spring fish catches have historically been dominated by two sea winter (2SW) fish, for which May is typically the best month. Grilse do not appear in significant numbers before June, although catches of 2SW fish continue throughout the season. For this reason the most appropriate cut off date for classifying spring salmon on the Tamar is 31 May.

The spring fish (pre-1st of June) totals for each year are taken as the sum of catches during the months January to May. Post 31st of May salmon totals are taken as the sum of the catches during the remainder of the year, these salmon will include both grilse and MSW salmon.

Figures 6, shows the rod declared catch of spring salmon since 1969. This graph has a 5 year moving mean to assist with interpretation of trends. The rod catch has varied considerably over this time . The catches can be split into two distinct periods 1969 to 1981, when the average catch was 172 salmon, and 1982 to 1995 when there is definite decline and the average catch was 81 salmon. However, 1994 and 1995 reveal an increasing trend on 1992 and 1993, which were the two lowest recorded years. The upward trend shown during 1994 and 1995 cannot be relied upon to be significant because the data since 1969 has varied widely. During 1963 (see Figures 6 and 7) over 1000 spring salmon were netted, and in 1972 close to 1000 spring salmon were caught by the net and rod fishery.

Figure 7 shows the declared net catch data of spring salmon from 1963 to 1996. There is less variation in catches between consecutive years, when compared with the rod data. This is probably because net effort has been more consistent and is effected to a lesser extent by river flow variations.

The data shows a cyclic pattern with an underlying downward diminishing trend. Significant peak catches were recorded during 1963, 1966, and 1972. The highest catch during 1963 recorded 1036 salmon being caught. The average for the period is 238 salmon. The minimum catch was reported in 1993 and was 35 salmon. The diminishing trend revealed in the net fishery is more dramatic than the rod fishery. However, the increased catch trend recorded in the rod fishery during 1994 and 1995 is not reflected in the net catch data. This is probably because of a reduction in netting effort, for 1994 and 1995 due to low catches, particularly from 1992. During low catch years of less than 100 spring salmon, the rod catch generally exceeds the net catch.

A recent Environment Agency report on Spring fish stocks in the rivers of Devon and Cornwall (The status of spring salmon stocks in Devon and Cornwall, March 1995) demonstrated similar trends for all the major salmon rivers. Based on net catch data, the decline on the River Tamar was the fourth most serious after the Rivers Taw/Torridge, the River Exe and the River Tavy.

Annual salmon scale reading of a significant proportion of the rod and net catch is required to follow any further changes in the components of the Tamar salmon stock.

Figure 7

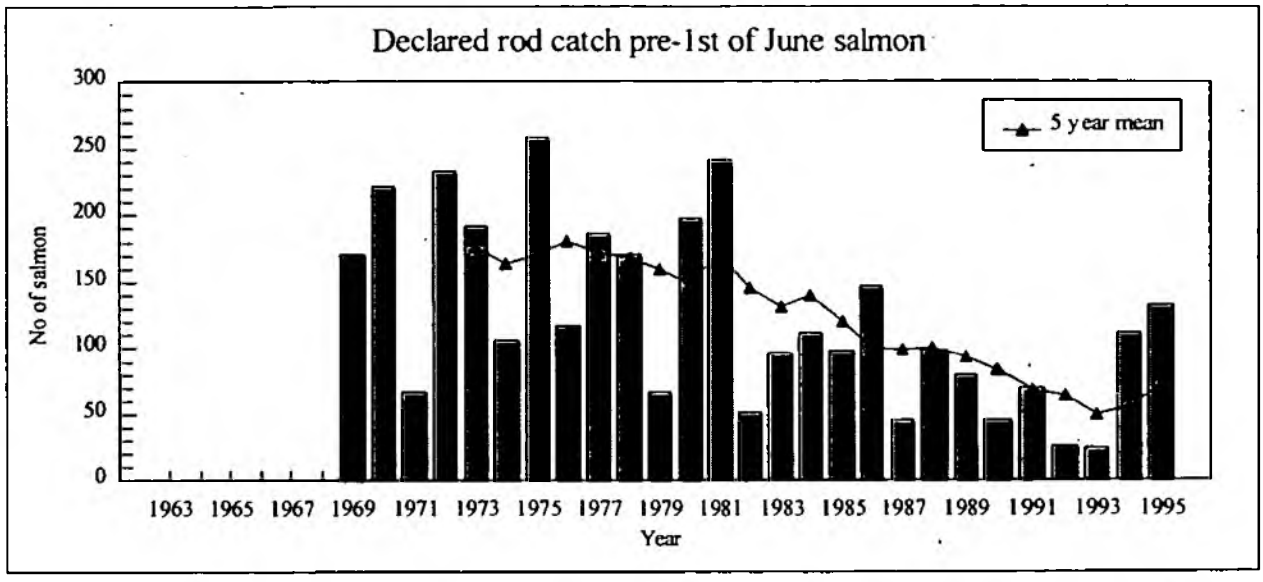
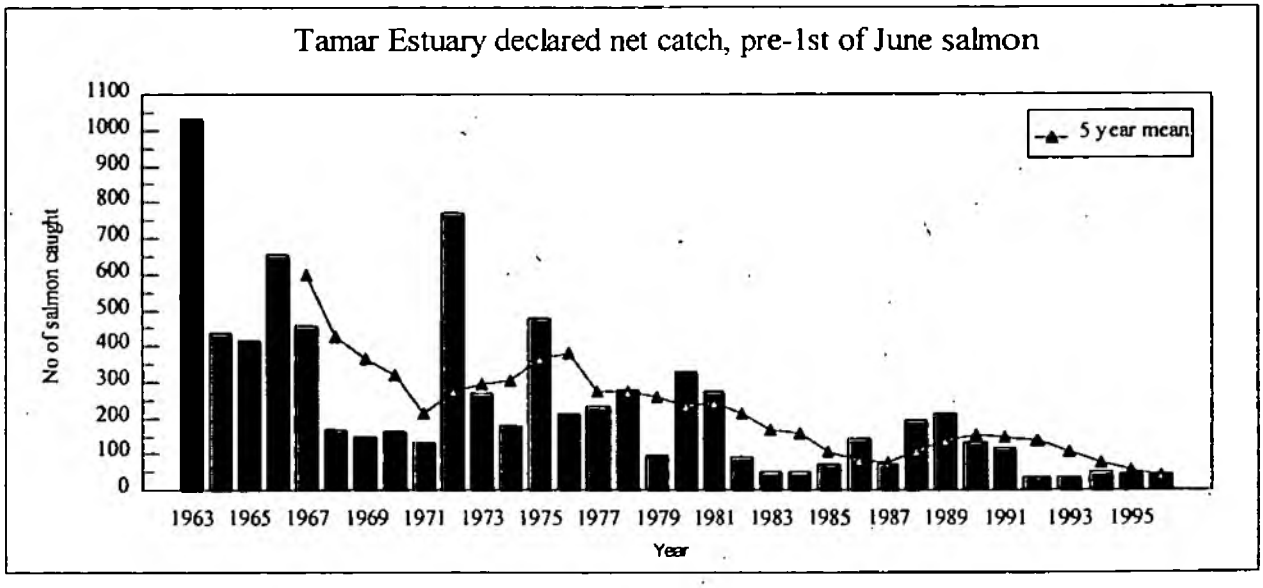


Figure 8



3.2.2 Exploitation. The exploitation rates of salmon for the Tamar are dependant upon data from catch returns from both the net and rod fisheries, and the Gunnislake resistivity counter. This is the best information currently available to calculate exploitation rates. However, there are certain inaccuracies which should be taken into account prior to interpreting this data.

- *Overall accuracy of the catch return system.*

- *Catch return rates vary between years.*
- *From studies 70% of salmon utilize Gunnislake fish counter. (Roadford Fisheries Liaison Committee March 96)*

- *Pre June fish (MSW or spring salmon) are exploitable throughout the year to the rod fishery.*

- *Salmon counted in January and a proportion during February are likely to be late run fish from the previous season and not pre- 1st June (spring) salmon.*

- *Ability of the fish counter to differentiate between salmon and sea trout*

Bearing these factors in mind the actual exploitation of the pre June salmon may be higher, particularly to the rod fishery. It is likely that the figures in Table 11 represent minimum exploitation rates.

Table 11 Summary of declared rod and net % exploitation rates of counted salmon.

	Pre 1st June Salmon				Total annual salmon			
Fishery	1996	1995	1994	Mean	1996	1995	1994	Mean
Rod %	na	34	33	33.5	na	10	17	13.5
Net %	8	10	14	11	19	19	29	22

Exploitation rates for the rod fishery peak during the spring Months of March, April and May. Although the highest rod catches are not recorded during these months. The exploitation rates for 1994 and 1995 average for the spring period is 33.5%. This figure is a minimum particularly because the 1994 figure includes salmon counted in January and February, the majority of which are likely to be late run salmon from the previous season.

Peak exploitation rates for the net fishery occur during June in and July, when the maximum number of salmon are also taken.

3.3 JUVENILE ABUNDANCE

An exact target for the maximum carrying capacity for salmonids has not yet been established. However, the Environment Agency is currently involved in implementing a classification scheme following a research and development project. This will enable the Environment Agency to set targets for the Tamar Catchment and also to view the Tamar fishery in a National context. The results of this work should be available prior to the publication of the action plan. The fish counter at Gunnislake will allow us to monitor and review these targets. Some survey data has been represented in Fisheries Classification classes (see Figures 8 and 9).

3.3.1 Fry abundance. Quantitative electric-fishing surveys suggest that, over the last two decades, salmon fry densities have been extremely poor in the upper Tamar area (above Launceston) Refer to Figures 8.

Comparative analysis of the 1984, '90, '93 with '96 data show little if any improvement. Some tributaries e.g. R. Carey and the Tala Water showed a small improvement in fry densities in 1996. However, this may be due to 1995 being an exceptionally good spawning season (regarding nos & distribution). Poor salmon fry recruitment in the Upper Tamar may be indicative of a number of detrimental occurrences.

The Rivers Ottery, Lyd & Inny are recognised as the best nursery areas for salmon fry in the Tamar catchment. These show consistently good salmon fry production, with indications of improving densities in the upper R. Ottery and the middle reaches of the R. Lyd in 1996. Again this may be due to the 1995 spawning success. This is also consistent with the high numbers of salmon redds observed in the middle reaches of the R. Lyd in 1995. One factor that should be noted is the absence of Salmon fry below Roadford Reservoir on the R. Wolf during 1996. Which coincided with the discontinuation of the EFP. This is most likely to be caused by the effect of the impoundment on flow, water quality and substrate composition.

Table 12 shows that 48 % of the sites surveyed for salmon parr on the Tamar catchment during 1996 were devoid (Class F) of parr. This is extremely high and may be due to in part to poor fry to parr survival. It is possible that some parr will move downstream into the main river, below the survey sites.

3.3.2 Parr abundance. The Juvenile surveys have highlighted very poor densities of Salmon parr in the upper Tamar area (Figure 9) this is a reflection of overall poor salmon recruitment in this area as discussed earlier. Again the lower tributaries on the R. Tamar accommodate the majority of the catchments salmon parr, with the Lyd and Inny sub-catchments showing consistently average to good salmon parr densities. A comparison of parr numbers found in 1996, to numbers found in the previous three routine surveys shows a decrease in all areas of the Tamar. Notably the River's Ottery and Kensey where some sites were devoid of parr. This is probably due to poor fry to parr survival rates during the summer drought of 1995, as

densities dropped consistently across the catchment. The majority of smolts are 2+ years, this may have altered since the last study, which would effect parr densities.

Table 12 Juvenile salmon abundance from routine survey data 1996, and the Fisheries Classification Classes.

	% Sites in each juvenile abundance class (Number of sites)					
	A	**B**	**C**	**D**	**E**	**F**
0+	11.8 (15)	16.6 (21)	8.7 (11)	18.9 (24)	22 (28)	22 (28)
>0+	1.6 (2)	0 (0)	9.4 (12)	10.2 (13)	30.7 (39)	48.1 (61)

3.4 DISTRIBUTION OF SPAWNING AND UTILIZATION OF THE CATCHMENT

Although salmon spawn throughout much of the Tamar catchment the most important areas are on the River Ottery, River Lyd and River Inny. This is confirmed by juvenile surveys and redd count observations. Although there are many productive areas within the Tamar catchment, there is still potential for improvement, particularly in the Upper Tamar area. Juvenile salmon densities (See Figures 8 & 9) have been consistently poor and there is also little indication of significant trout spawning in the Upper Tamar region . The smaller Upper Tamar tributaries are rarely used by salmon and no juveniles have ever been recorded on the Derrill Water, Small Brook and Tala Water (except the 1996 survey). Using information from Table 12 it is evident that a large proportion of sites surveyed showed low densities of both fry and parr. Particularly classes E and F. It is unclear wether or not this is caused by lack of spawning in many areas or indeed low survival rates.

Key sea trout and brown trout spawning areas occur in the headwaters of the River Ottery, River Carey, River Kensey, River Lyd (mainly in the River Lew) and River Inny (mainly in the Penpont Water). The inter and intra specific competition for spawning habitat, and subsequent availability of resources for juveniles has not been investigated.

Poor salmonid juvenile densities have also been recorded on the River Claw, upper Henford Water, Luckett Stream and the Ogbeare Stream. Luckett Stream has elevated metal levels, especially copper, which might prevent salmonids, However, the Portondown stream experiences similar copper levels but has a very healthy trout population. Reasons for poor densities on the other watercourses are currently not known.

Figure 9
Distribution of salmon fry on the Tamar Catchment 1996

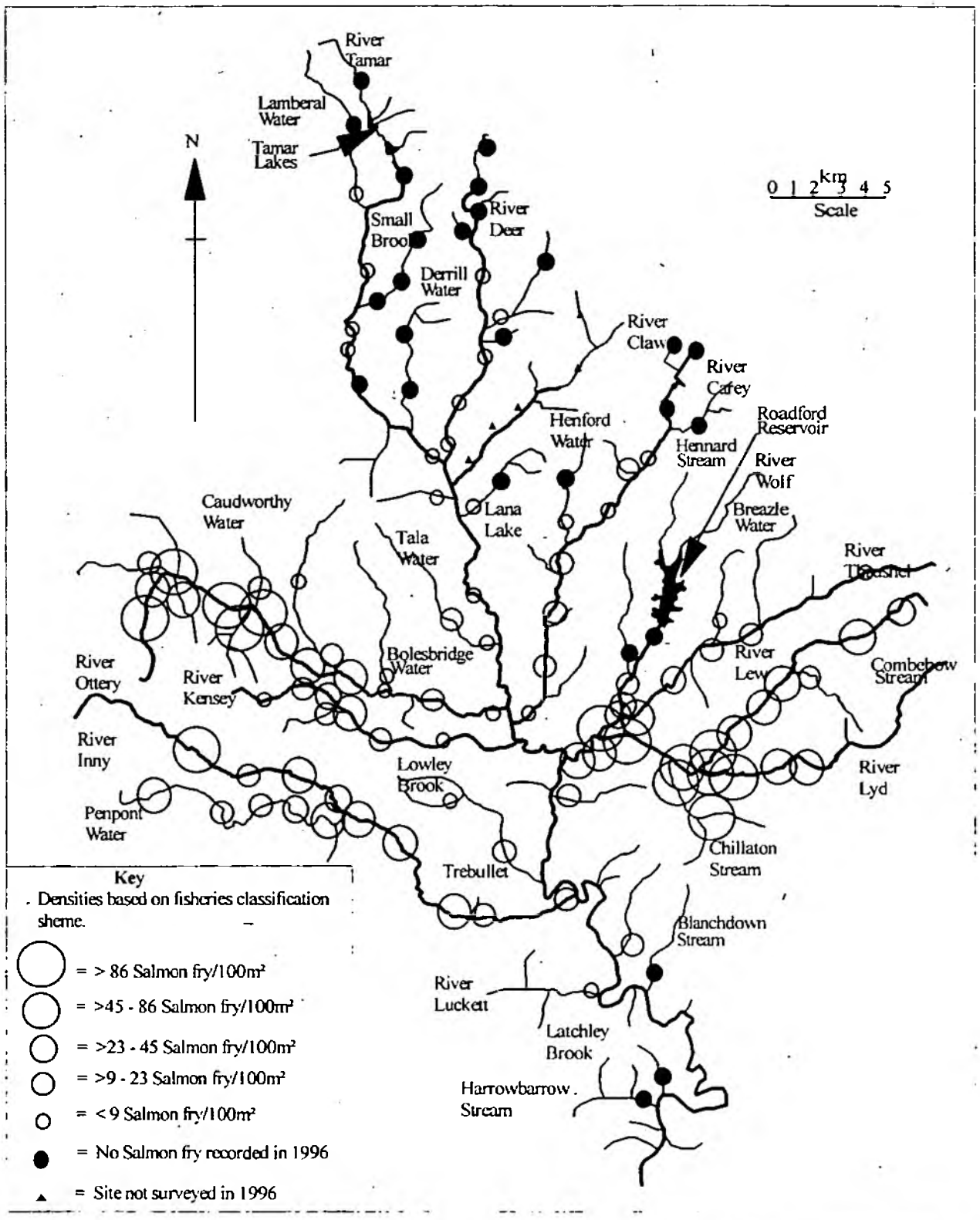
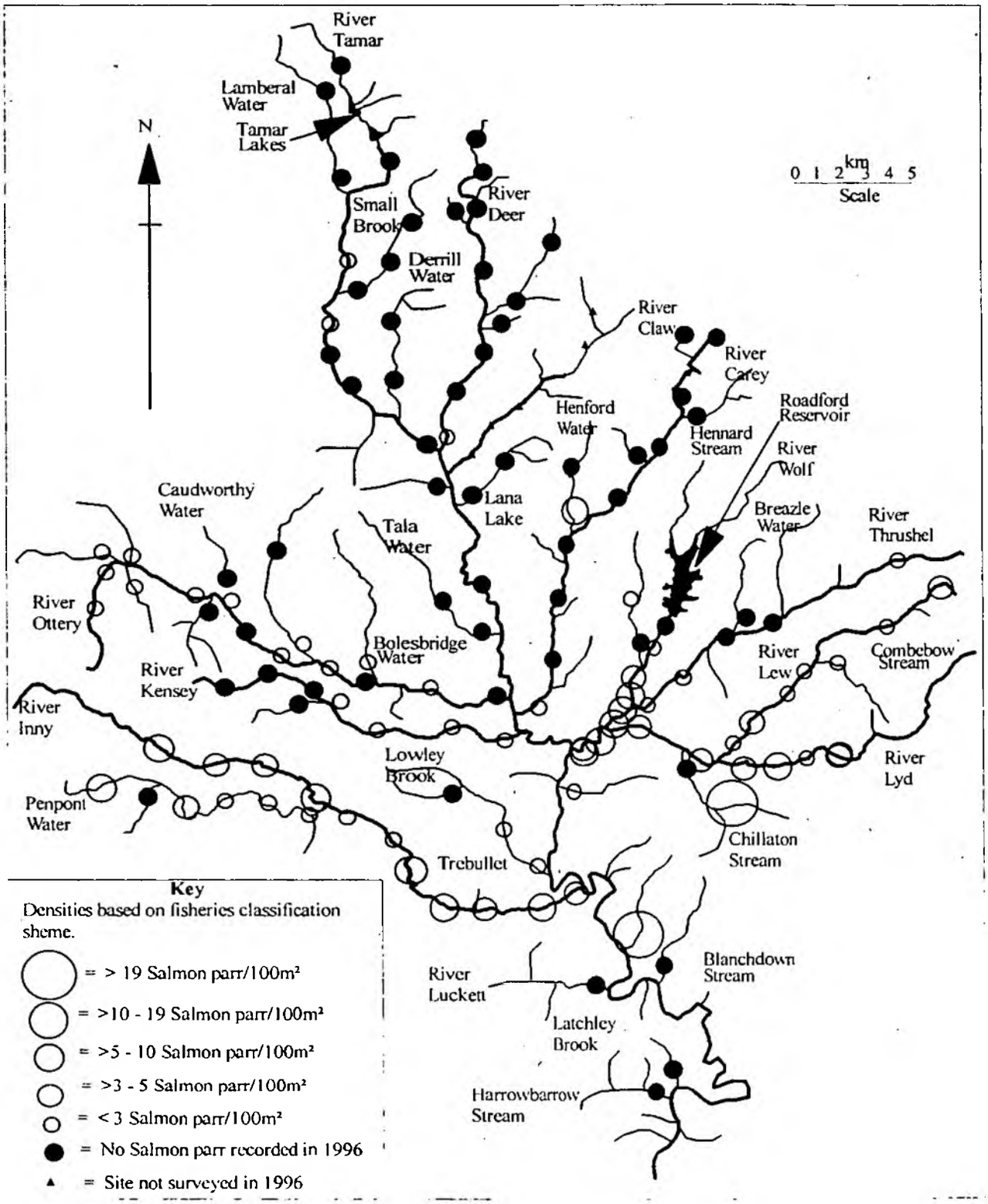


Figure 10
Distribution of salmon parr on the River Tamar Catchment 1996



4.0 ASSESSMENT OF STOCK AND FISHERY PERFORMANCE

4.1 SPAWNING TARGETS

The first objective of the Salmon Management Strategy is that:
"Individual salmon stocks and the environment in which they live should be managed to optimise recruitment to home water fisheries."

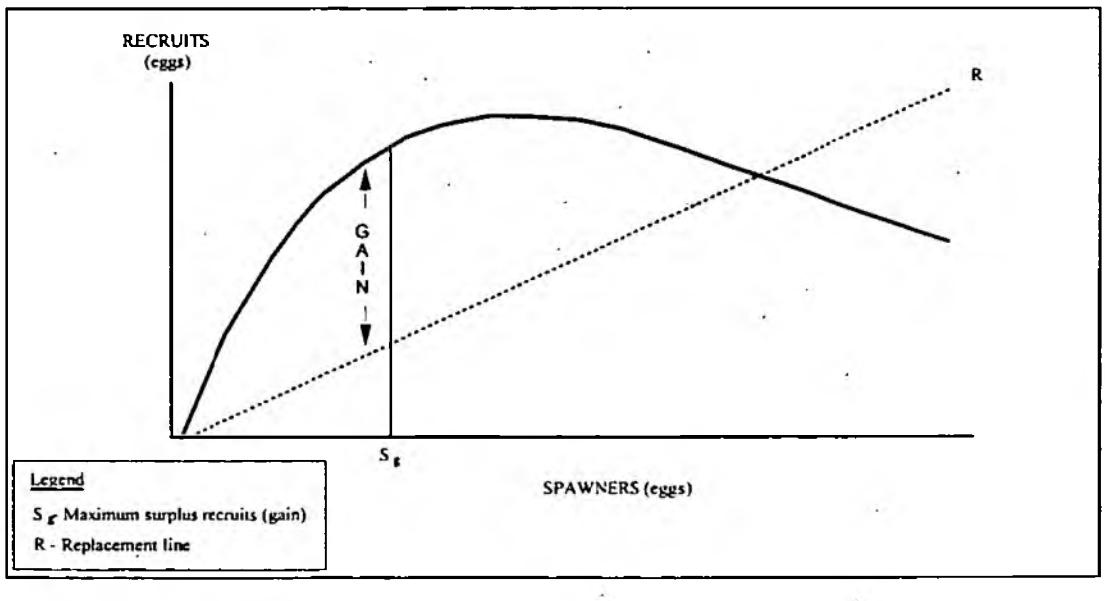
This objective needs to be expressed in terms of biological targets. To do this nationally requires a common approach across the Agency's regions to the setting of targets and the assessment of compliance (Environment Agency, 1996).

- Although several types of target can be set for the management of salmon, ICES (1995) has recently recommended that spawning stock at maximum gain should be the standard target defining the **Minimum Biological Acceptable Level (MBAL)** of a stock's abundance to assure its continuation.

- MBAL has been adopted by the Environment Agency as the target most closely describing the objectives of the Salmon Strategy, whilst recognising that, due to natural stock variability and environmental influences, the target should be regarded as a minimum.

- The relationship between spawners and recruits can be summarised as a stock-recruitment (S-R) curve (figure 10). The replacement line represents the relationship between recruits and spawners and the difference between this and the S-R curve is referred to as "gain". These are the surplus fish (recruits) potentially returning to the system above the level required to replace the spawning stock that generated them. Maximum Gain, S_g, is thus a mathematically definable unambiguous point on the curve.

Figure 10 Diagrammatic stock recruitment curve



- MBAL has been definitively calculated for only one river in the UK - the River Bush, Northern Ireland. The target egg deposition for the Bush (563 eggs per 100 m^2 of "usable" habitat) is used as a benchmark which can be transported to other rivers using a system devised by WRC.

- The corresponding target for the River Tamar is 293 eggs per 100 m^2 of total wetted surface area, which equates to a total of 5.8 million eggs. The calculation of this target is summarised in Table 13 .

Table 13 Parameters for the calculation of the spawning target for 1995

TARGET	VALUE
Maximum Gain (MG)	293 /100 m^2 or 5.8 million eggs
Spawners equivalent to MG egg target	2195
Total rod catch equivalent to MG target	419
Declared rod catch equivalent to MG target	381

Parameters used to calculate above:
GIS Area = 197 hectares
Marine survival (to high seas fishery) = 22.9
Fecundity = 5322
Females = 49.4 %
Post rod fishery mortality = 9 %
Rod exploitation = 14.8%
Rod catch declarartion = 91%

- It is the objective of this plan to identify and promote actions that will achieve the target egg deposition on the Tamar within 5 years.

- It should be noted that methods for the calculation of spawning targets are relatively crude at present and will benefit from further refinement. The figures quoted should therefore be viewed as a first attempt and may change as our knowledge and understanding of the stock and its interaction with its habitat improves.

- Therefore, nominal "passing" or "failing" of targets *in isolation* does not guarantee a correct management decision. Professional scientific judgement, combined with consideration of the full range of other factors acting on a fishery is essential to come to the correct conclusions.

4.1.1 Historic egg deposition. Egg deposition was calculated for the period 1986 to 1995 according to the national protocol and is shown in figure 11. The percentage compliance and estimated egg deposition per 100m² are shown in Table 14.

Figure 12

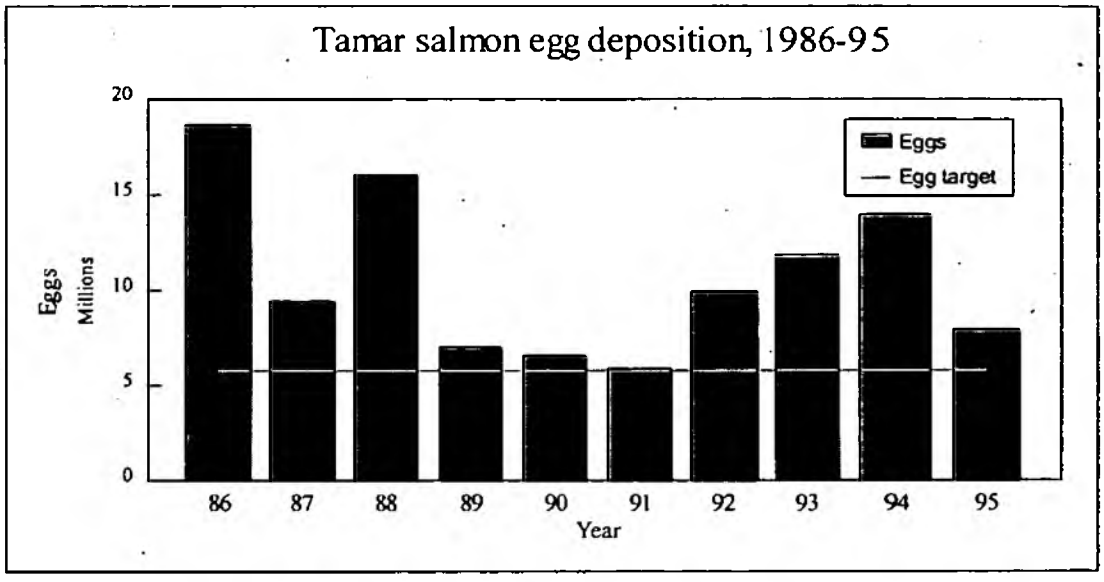


Table 14 percentage egg target compliance from 1986 to 1995

Year	Estimated egg deposition 100m²	% compliance
1986	948	323
1987	480	164
1988	816	279
1989	357	122
1990	331	113
1991	296	101
1992	505	172
1993	601	205
1994	707	241
1995	401	137

4.1.2 Egg target compliance.

- The MBAL spawning target for the River Tamar, expressed in terms of egg deposition, is 293 eggs per 100 m^2 of total wetted area. This equivalent to 5.8 million eggs or 2195 spawning adults.

- A declared annual rod catch of 381 fish would be expected for the stock at target level. The parameters used to derive these figures are given in Table 13.

- Since 1986 the Tamar has achieved the egg deposition targets. However, 1988 to 1991 the target was reached by a narrow margin. With a the lowest year attaining 101%. Compared to 1986 which attained 323%.

- During 1995 the latest year with available data the target was achieved by 137%, a fall from the previous 3 years. Demonstrating that the deposition rates are relatively close to the target level

Table 15 Egg deposition 1995

1995 Total number of eggs	Target number of eggs	Has compliance failed within last 3 years ? (Y/N)
7.9 million	5.77 million	N

4.1.3 Fishery performance at target spawning levels.

- Just as catch can be used to assess compliance against the egg deposition target, so this spawning target can be expressed as an equivalent rod catch. It represents the catch that would prevail on average if the run size to the river was at a level which maintained the optimum spawning stock.

- On the Tamar the spawning target corresponds to a total rod catch of 419 fish. This figure is based on the 1995 estimated catch return rate of 91%. Rod data is available from 1954, though catch return data has varied and cannot be determined consistently since 1986. From 1986 the Tamar has consistently performed at it's spawning target.

4.2 FRESHWATER PRODUCTION.

The spawning targets suggest that the River Tamar has been achieving its egg deposition targets, albeit with several near misses, particularly 1991. However, low fry and parr densities suggest that a large proportion of the catchment is not achieving its full potential.

4.3 DIVERSITY AND FITNESS.

Atlantic salmon within the Tamar catchment were sampled for genetic variation using electrophoretic techniques in 1987/1988 (Hurrell and Price, 1993) and 1991 by Thompson and James (CEFAS). These electrophoretic analyses identified genetic variation at four loci within the juvenile Tamar salmon sampled from the Inny, Lyd and Wolf tributaries.

A full analysis of the Tamar data in conjunction with data from 75 other rivers in the United Kingdom and Ireland (Jordan, 1992) revealed staistically significant genetic differences both among salmon samples from within catchments and between catchments based on large sample sizes but with a low number of loci exhibiting genetic variation. The following stockings into the Tamar of non-native Atlantic salmon ova or juveniles have been recorded :- Origin-Iceland,no river name,1971; Scotland,R.Thurso,1901-1914 & 1966-1968; Scotland, R.Dee, 1949; Scotland, no river name, 1978 and possibly some offspring from the Devon R.Taw and R.Lynher. Obviously other stocking events of non-native salmon may have occured but were not identified following an extensive check of stocking records from 1901-1991. It is noteworthy that certain genetic variation found within samples of Thurso and Dee salmon (Jordan, 1992) were not located amongst the salmon sampled from the Tamar.

The diminishing run size of spring salmon as part of the stock component is of some concern. Measures need to taken to protect this component to ensure there is a large enough population to regenerate stocks to healthy levels.

5.0 LIMITING FACTORS

5.1 Freshwater phase

5.1.1 Roadford Reservoir. The construction of Roadford Reservoir has denied salmon and trout access to approximately 35% of the River Wolfs original length. The wetted area has been reduced by 50%. Mitigation programmes continue, incorporating a stocking programme as well as the Enhanced Flow Programme.

South West Water Services Limited (SWWSL) have set out an Enhanced Flow Programme (EFP). This provides for special releases of water during the year to encourage fish migration in the River Wolf, notably for migratory trout and effectively makes use of the surplus water in the reservoir which is available during the early years of the scheme. There was no EFP during 1995 and 1996 due to low water levels in Roadford Reservoir.

Siltation of gravels is considered to have caused a decline in the River Wolf trout population and salmon redds below Roadford Reservoir seem unproductive, possibly due to siltation. Roadford Reservoir regulates river flows and releases are generally of clean water (low suspended solids). The Enhanced Flow Programme includes winter releases to aid flushing the gravels of silt but further releases may be required. SWWSL are working with the

Environment Agency and others to achieve increased populations of wild salmonids. Catchment protection of the Wolf Valley may be required to manage suspended solid loads.

5.1.2 Lower Tamar Lake: Low Flows downstream of lake. The Environment Agency is concerned that at times of low flow there has been a severely depleted or dry stretch of river immediately downstream of Lower Tamar Lake which has reduced the habitat available for juvenile salmonids.

The input to Lower Tamar Lake is made up of the compensation release from Upper Tamar Lake and flow from two small tributary streams. One drains into the short stretch of stream between the two lakes whilst the other drains directly into the lower lake itself. As there is no abstraction from Lower Tamar Lake there should be sufficient inflow to guarantee a compensation flow at least equivalent to the compensation flow from Upper Tamar Lake. The impact of low flows from the operation of Tamar Lakes has been identified by the Environment Agency as a possible limiting factor to salmonid production in the Upper Tamar area. The continuation of the Upper Tamar ALF studies; and, the results of the current environmental assessment by SWWSL will give an indication of remedial action needed and where sustainable rehabilitation could be achieved.

5.1.3 Obstructions. There are only two impassable obstructions in the Tamar Catchment, the dams at Roadford Reservoir (Lyd subcatchment) and Tamar Lakes (Upper Tamar). All other obstructions are deemed to be passable..

Access to spawning areas may be limited by major physical obstructions, largely trash dams (dams forming from wood and other natural debris).The Environment Agency seeks to remove significant blockages which may impede the passage of migratory fish. Significant blockage can also cause a localized change in the flow regime resulting in impoundment of water and possible siltation of gravels upstream of the blockage. However, overhanging trees and smaller partial blockages are a natural part of the river system. They provide substrate, food and shelter for in-stream organisms and may scour out pools and possibly rejuvenate gravels downstream. The importance of these effects on all river life is recognized by the Environment Agency. An internal code of "best practice" on where and how to clear trash dams is currently being developed.

A new fisheries survey site on the Caudworthy Water at South Wheatley revealed a good salmon fry density in an area made more accessible by river clearance work in 1992. Trash dams on the River Inny were cleared in 1994 and also on the Lana Lake which may have been impeding salmonid migration.

Trash dams are a recognized problem, limiting access to spawning areas on the River Thrushel, River Wolf and River Lew. Tributaries that would also benefit from trash dam clearance are Derril Water, Small Brook, Tala Water and the Portondown Stream.

5.1.4 Habitat. The removal of bankside trees and shrubs that provide cover and habitat for adult and juvenile fish. This also increases the rate of bank erosion, and siltation of the river bed. On the upper Tamar this is thought to have had a considerable impact. Particularly from land drainage schemes, which have compounded the problem of soil erosion.

5.1.5 Low juvenile survival. There is evidence of low fry to parr survival rates. This is probably complex involving several factors. However, the major effects are are thought to be caused by low river flows, and loss of habitat. Inter specific competition may also be contribute. Do determine suitable ameliorating actions, further investigative work is required.

5.1.6 Water quality. On the upper Tamar suspended solids and run off from farms during spates, is thought to negatively impact on salmonid populations. The scale of the impact has yet to be determined

5.1.7 Lack of spawning gravels. At various locations on the River Tamar system there is an identified formation of a solidified channel bottom, known as concreted gravels. This is a particular problem when it occurs in areas where salmon would normally spawn because they are unable to do so, the gravels being too hard for them to excavate their redds.

A brief study of concreted gravels indicates the frequent presence of "Black Ram", a conglomeration of gravels cemented together by manganese and iron oxides. It is naturally formed and is uncovered by the eroding watercourse. The thickness can vary and can reach 1.5m. At such thicknesses it becomes difficult for the watercourse to cut through the formation and so work might be considered to artificially break it, and to reestablish spawning areas.

Siltation of gravels is considered to have caused a decline in the Wolf trout population and salmon redds below Roadford Reservoir seem unproductive. Roadford Reservoir regulates river flows and releases are generally of clean water (low suspended solids). The Enhanced Flow Programme includes winter releases to aid flushing the gravels of silt. Unfortunately tis was not carried out in 1995 and 1996, further releases may be required. SWWSL are working with the Environment Agency and others to achieve increased wild salmonids. Catchment protection of the Wolf Valley may be required to manage suspended solids loads.

The continuation of the Roadford environmental monitoring and investigations work (with an extensive electric fishing survey in 1995 on the River Wolf) will enable the Environment Agency to monitor the situation and consider alleviation measures.

5.1.8 Poaching. The River Tamar and its tributaries are vulnerable to illegal netting, snaring and other illegal methods. Variable amounts of illegal netting occur in the River Tamar Estuary. The impact on the freshwater fishery could be significant. Extensive day and night patrols by fisheries staff, keep the impact of these activities to a minimum.

5.1.9 Natural predation by mammals and birds occurs throughout the fishery. At present it is not known if this is causing a significant impact on fish stocks. The Environment Agency works with fisheries owners and CEFAS to advise on preventative measures. The impact of piscivorous fish has also not been determined. Predation may have an impact particularly with larger stocked brown trout.

5.2 Marine phase

5.2.1 Natural mortality: Advice to NASCO suggests that natural mortality during the marine phase, although variable, has been increasing over the last 5-10 years. Fewer smolts are therefore surviving to become salmon. Changes in ocean climate may be a factor. The abundance at sea of salmon which would return as multi-sea-winter fish is strongly related to the availability of ocean at temperatures preferred by salmon (6-8 deg. C). The amount of such suitable thermal habitat has been lower in the 1980s and 1990s than during the 1970s (Reddin and Friedland 1996).

5.2.2 Greenland fishery: There has been a net fishery on the west coast of Greenland since the 1960s. Catches peaked in 1971 at 2689 tonnes. Since 1976, only Greenland vessels fish it and the catch has been usually been limited by an quota agreed at NASCO. Since 1993 the quota has been related to estimates of the pre-fishery abundance of salmon and have been declining. About 15% of the catch is thought to be derived from rivers in England and Wales. In 1993 and 1994, the fishery did not operate, netsmen being paid not to fish. As a result about 5000 additional multi-sea-winter salmon are estimated to have returned to parts of England and Wales in each subsequent year (Potter 1996). In 1995 and 1996, catches in the fishery were 81 and 70 tonnes respectively.

5.2.3 Faroes fishery: Also developed in the 1960s, this fishery uses long-lines. The catch peaked at 1027 tonnes in 1981 but subsequently has been controlled by an annual quota. Unlike Greenland this quota has not been directly related to salmon abundance. Since 1990, the permitted quota has been 550 tonnes but this has never been taken. From 199/2, commercial fishing has ceased due to compensation payments and only a research fishery has operated, which now takes only about 5 tonnes a year. Potter (1996) estimated the number of extra salmon which returned to home waters due to the reduction in the fishery. For all of England and Wales this only amounted to about 1200 salmon each year, of which 750 would have been grilse.

5.2.4 International fishery: An unregulated high seas fishery operates in international waters by countries who are not signatories to the NASCO convention. Annual catches are though to be between 25 and 100 tonnes, comprising predominantly European stocks.

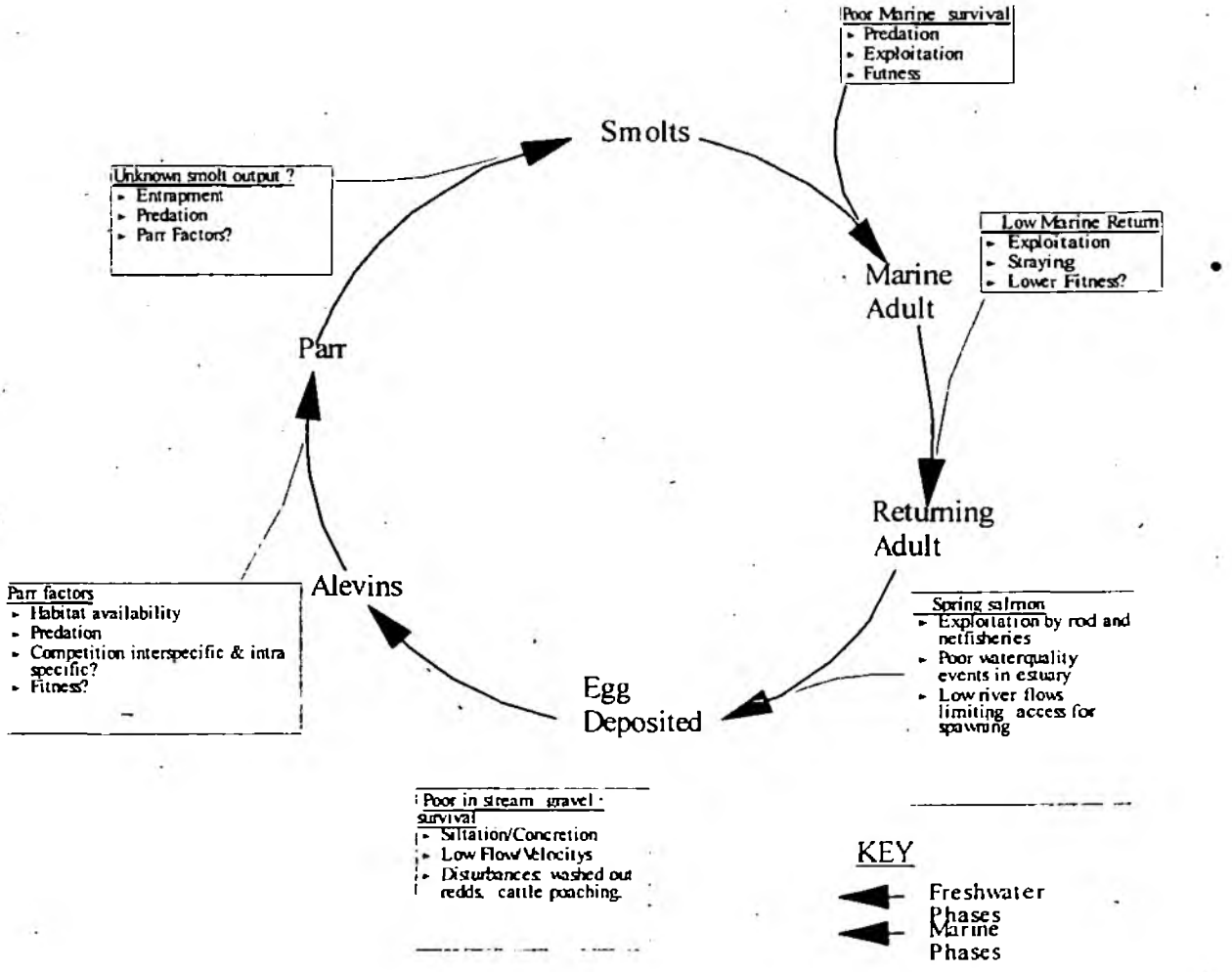
5.2.5 Irish fishery: The reported catch of salmon in Ireland increased from about 700 tonnes in the 1960s to a peak of over 2000 tonnes in the mid-1970s. This coincided with the expansion of a coastal drift net fishery. About three-quarters of the Irish salmon catch, some

700 tonnes in 1995, is currently taken by the drift nets.

Tagging studies indicate that these nets take a significant, though variable, proportion of the stock of salmon destined for English and Welsh rivers. For rivers in the south and west (e.g. Test, Taff and Dee) about 10-20% of the stock is thought to be taken by the Irish drift nets.

For stocks from rivers in the north (e.g. Eden and Wear) the level of exploitation is likely to be less, perhaps 5%. The catch comprises mainly but not exclusively grilse. The Irish Government has recently announced additional controls on the driftnet fishery, including delaying the season until 1 June and restricting fishing to daylight and within 6 miles. These measures may reduce exploitation on English and Welsh stocks. However, there is no intention, as yet, to phase out this mixed stock fishery.

Figure 13 Limiting factors on the life cycle of the salmon on the River Tamar



6 ISSUES AND ACTIONS

Table 16 Issues and proposed actions

Issue	Limiting Factors	Options	Responsibility		Cost £K	Priority
			Lead	Others		
1) Diminishing run size of pre 1st of June salmon	A) Net exploitation	i) Buy out of licences for part of season.	Agency(F) SWWSL	Netsmen	Confidential	High
		ii) Introduce Byelaw to change season.	Agency(F)	Netsmen MAFF	Unknown	
	B) Rod exploitation rate (94&95 average33.5%)	i) Restrictions to fishing methods	All options	MAFF	Unknown	
		ii) Change season dates				
		iii) Catch limits (numbers/size).	Agency(F) and Fishery owners/ clubs	If byelaws required	Unknown	
		iv) Catch and release of early season salmon			Unknown	
	C) Spawning success of spring salmon	i)Identify areas where spring salmon are likely to spawn. (Radio tracking study)	Agency(F)		1 FTE + 25K	
		ii) Improve spawning habitat in areas utilised by spring salmon.	Agency(F)		10K+	

Issue	Limiting Factors	Options	Responsibility		Cost £K	Priority
			Lead	**Others**		
2) Habitat Maximisation (35% of catchment not utilized to full potential).	A) Water Quality	i) Investigate areas of low juvenile densities.	Agency(F)		1 FTE (2 Years) 50K	High
	B) In stream cover and bank erosion	i) Fencing project -materials available for all rivers	Agency(F)		10K	
		ii)Advice and assistance to Riparian owners	Agency(F)	Riparian Owners / Clubs		
	C) Compaction / siltation of spawning gravels	i) Assessment of effectiveness of potential gravel rehabilitation projects	Agency(F)	Riparian Owners /Clubs	30K	
		ii) Carry out cleaning/maintenance in appropriate areas.	Tamar 2000		Dependant on (i)	

Issue	Limiting Factors	Options	Responsibility		Cost £K	Priority
			Lead	**Others**		
3)Exploitation of mixed salmon stocks in distant water fisheries.	A) Exploitation by Irish drift nets	i) Buy out/limit Irish drift net catch	Both options MAFF Irish Minister for the Marine NASCO	Both options Agency/ MAFF	-	High
	B) High Seas Fishery	i) Limit quota levels			-	High

Issue	Limiting Factors	Options	Responsibility		Cost £K	Priority
			Lead	Others		
4) Poaching	A) Size of freshwater catchment, estuary and coastal area.	i) Intelligence data base ii) Increase frequency of targetted enforcement patrols. iii) Maximise collaborative operations with other parties.	Agency(F) Agency(F) Agency(F)	Police, QHM, MAFF, DSF, Riparian Owners	1/2 FTE 5 FTE -	High
	B) Number of Enforcement staff and resources.	i) Maximise number of full time enforcement officers ii) Maximise use of part time enforcement officers. iii) Maximise use of available technology.	Agency(F) Agency(F) Agency(F)		- - -	
5) Trash dams	A) Obstruction to fish migration and siltation of upstream gravels.	i) Sensitive removal of 'trash' dams as there are many habitat benefits of these features.	Agency(F and FD)	Fishery owners	Core work	medium

Issue	Limiting Factors	Options	Responsibility		Cost £K	Priority
			Lead	Others		
6) Fish Deaths due to Poor Water Quality in Tamar Estuary	A) Low summer flows and High temperatures /Poor Water Quality	i) Monitor water quality ii) Compensatory flows from Roadford fisheries bank.	Agency (WQ) Agency(F)	SWWSL SWWSL	10K -	medium
7) Stocking of brown trout	A) Competition/predation Disease	i) R&D into effects of stocking trout on native salmonids (awaiting report)	Agency(F)	Fishery owners	-	Medium

Note: FTE= Full time employee

7 FUNDING THE PLAN

7.1 THE FUNDING BACKGROUND

The Environment Agency currently spends about £9 million on salmon and sea trout fishery management, of which about 12% comes from rod licence income and 2% from net licences. 82% will come from grant in aid (GIA) during 1997/98. GIA continues to decrease, a further 5% reduction to £7.4 million in 1997/98 has been announced. Therefore the Agency must look to secure more funding from beneficiaries to achieve objective four of the Salmon Strategy.

The salmon action plan is a vehicle for promoting this and should creatively explore all avenues for alternative funding, such as:

- beneficiaries, i.e. riparian owners and angling clubs
- local businesses
- English nature
- Local wild life trusts (RSNC)
- County councils
- European community (through the Habitats Directive, LIFE Fund)
- National Lottery
- Millennium Fund
- Cross funding from other Agency functions
- Tamar project 2000
- Mitigation funds from SWWSL
- Sports council
- The Tourist Board

7.2 CURRENT ACTIONS

Table 17 Current actions within the catchment

Activity	Description	Annual cost
Enforcement	Rod and net licence checks byelaw checks, antipoaching operations in river and offshore	
Monitoring	juvenile salmonid monitoring, fish counter, catch return analysis, and redd counting. Alleviation of low flow monitoring Also monitoring of habitat improvement projects	
Habitat improvement	Gravel cleaning. Clearance of in stream obstructions likely to effect adult and smolt migration. Roadford Enhanced flow programme	
Hatchery	Roadford mitigation stocking programme	
Regulation	Planning liaison, controlling activities of developments, abstractions, discharges, stockings etc Byelaw changes, net buyouts etc	
Total		

These activities are funded by sources outlined in 7.1 and by Agency cross functional support. In order to carry out the initiatives outlined in Table 16, funding other than from Agency Fisheries sources are required.

7.3 COLLABORATIVE FUNDING

There are a number of potential sources of collaborative funding for example: the National Lottery, EU sources, and Development Agencies. Assistance from such sources has yet to be obtained for the River Tamar. Such initiatives have been secured on other rivers. For example funding on the River Tweed for reinstatement of habitat work was obtained from the EU. In many instances it may be more successful for beneficiaries to apply for such funds, although the Agency could advise and support applications.

8 CONSULTATION PLAN

Table 18. Consultation agenda

Step	Consult with	Means	Aim	Timescale
1	Agency Regional function managers	Circulate draft plan internally	Account for cross functional comments	March
2	National salmon group	Copy of draft plan	Quality check; ensure consistency across agency	March 17th
3	Area Management Team	Circulate draft plan to AMT for comment	Ensure approval and agreement	Early May
4	RFAC and AEG	Circulate agreed draft plan to members for direct comment	Raise awareness and publicise process; Receive initial comments; initiate external consultation	Late May
5	External interest groups: Tamar fishing clubs and associations, riparian owners, Net licensees, South West Rivers Association, West country Rivers asoc Game Conservancy Trust, English Nature, CEFAS, SWWSL, Fisheries Forum	Press releases and circulation of draft documents to known contacts	• Raise awareness of , and publicise consultation process • Provide opportunity for all interests to review and comment	June 15 th - August 31st

Step	Consult with	Means	Aim	Timescale
6	Review feedback Redraft plan and extend/amend responsibilities section	Project team	Account for external comment; accommodate accepted new issues and proposals for actions.	Sept St.- Sept 30th
7	RFAC, AEG and NSG	Submit final plan to all groups	Final endorsement	Sept/Oct
8	RMT	Submit final plan	Final endorsement	Oct/Nov
9		Publish and publicise final plan	Achieve wide ranging awareness of plan and commitment to it	Dec

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10 GLOSSARY OF TERMS

Accessible habitat: the total area of the catchment accessible to adult salmon.

Alevins: juvenile salmon during the life stage between hatching and absorption of the yolk sac, whereupon they become free swimming and referred to as fry.

Brood stock: adult salmon removed from the river catchment, to provide eggs/sperm, to produce artificially reared juveniles. These juveniles are stocked into the river to enhance the natural production of juveniles where this is identified as a limiting factor in increasing smolt production.

Buffer strips: areas adjacent to the river channel where natural vegetation is allowed to thrive, thereby reducing the chemical and particulate (silt) elements of surface water runoff from surrounding land entering the river.

CEFAS: Centre for Environment Fisheries and Aquaculture Science. (Successor to MAFF)

Cohort: a year class of the population, from egg deposited to returning spawner.

Concretion: calcification of gravel, leading to an effect not unlike concrete in the top layer of the river bed. Digging of redds by spawning salmon is thus severely impaired.

ICES: International Council for the Exploration of the Seas. The mission of which is to collate, research and report data on the international status of salmon stocks.

Exploitation: removal of stock through legal/illegal fishing.

EC/EU: European Community/ European Union. As members of the EC/EU we are obliged to act upon European law, issued in the form of directives.

EFP: Enhanced Flow Programme. This involves flushes of water relased by SWWSL from Roadford reservoir.

Entrapment: the trapping and/or delay of smolts and/or adults by structures or channel features, leading to death or delays in migration.

Escapement: the stock remaining after exploitation.

Extant: when applied to fish stocks (eg. extant stock), refers to the total population of that year class/cohort at any point in time.

Fecundity: the total number of eggs produced by one mature female.

Fertility: the number/proportion of fertile eggs produced by one mature female.

Fitness: specific genetic adaptation to a particular environment. Artificial propagation, influx of non native genotypes, and changing environmental conditions may lower the natural 'inbuilt' suitability of salmon for their environment.

Fry: juvenile life stage between alevin and parr, where the alevin becomes free-swimming and actively hunts for food.

GIS: Geographic Information System, a computer programme used to estimate river channel lengths/width from high resolution digital maps.

MAFF: the Ministry of Agriculture, Fisheries and Food.

MBAL: Minimum Biologically Acceptible Level. Defines, from a Stock Recruitment curve, that level of spawning which maximises the sustainable catch (total catch, comprising all marine and freshwater fisheries).

Microtag: a coded wire rod of of 1.5mm long and 0.25mm diameter, inserted into the nasal cartilage (snout) of fish. Detectable in live fish, but only readable after removal.

NASCO: North Atlantic Salmon Conservation Organisation. A convention of signatories including all North Atlantic countries with salmon interests, which advises and formulates policy on the management/exploitation of salmon stocks. As a member of the EU, the UK is represented by their delegation to NASCO.

NSG: Environment Agency National Salmon Group

Parr: juvenile lifestage, following fry, where the fish exhibit characteristic parr marks/bars as dark vertical stripes upon their flanks.

Redd: salmons 'nest' in riverbed. Dug out of gravel/stony beds by spawning adults, with eggs deposited in displaced material.

Run: the number of adult salmon ascending, or smolts descending, a given river in a given year.

RFAC: Regional Fisheries Advisory Committee.

RFIT: Roadford Investigations Team.

RSNC: Royal Society for Nature Conservation.

Siltation: deposition of waterborne suspended solids in/on the riverbed. Siltation blocks gaps between substrate particles, preventing the through passage of water, necessary for egg survival.

Smolt: lifestage between freshwater parr and seawater 'adult' phase, where parr undergo a process of pre-adaption to a saltwater environment. As a part of this process, smolts acquire a characteristic silver appearance, similar to adult salmon, prior to migration down river and out to sea.

SSSI: Site of Special Scientific Interest. A designation, administered by English Nature, intended to conserve the biological interest of a given site through legal restrictions on development/management practices.

Straying: the habit of some salmon to return to rivers other than that of their parent stock.

Substrate: the composition of the river bed.

The Agency: the Environment Agency, successors to the National Rivers Authority (NRA).

Trash dams: Naturally occurring instream obstructions, typically caused by fallen trees and subsequent gathering of flotsam. Trash dams often prove to be a barrier to adult salmonid migration. However, they also provide useful cover, often forming pools and scouring gravels down stream.

WRC: Water Research Council.

Year Class: the population of salmon, of all life stages, resulting from one years spawning.

10 APPENDICES

Appendix 1

Spawning Targets in management.

In setting spawning targets, the Environment Agency is following the recommendation of NASCO (1995) and drawing on extensive experience in the use of targets for salmon management in North America since 1977. The basic rationale behind this approach is outlined below.

The main reason for using targets in salmon management is to provide an objective standard against which to assess the status of the river's salmon stock. The standard is selected to ensure the long term sustainability of the stock and the fishery it supports. The principle is simple. The numbers of salmon a river can produce (and consequently the catches which

result) are a function of the quality and quantity of accessible spawning and rearing area. This is why, in general, big rivers have larger catches and have correspondingly bigger total spawning requirements than small rivers. Thus, for any given size of river there should be a preferred or optimum level of stock which the target seeks to define.
There are three stages in the use of targets: setting the target, estimating actual egg deposition and assessing compliance against the target. The procedures used are described in detail elsewhere (Environment Agency, 1996).

The Environment Agency defines targets in terms of optimum spawning levels, expressed as egg deposition (eggs laid per $100m^2$, or the total number of eggs per river). This is because spawning level is regarded by salmon biologists as the primary factor controlling the number of smolts likely to come out of a river section. On average, more eggs deposited means more smolts being produced, up to some level beyond which output levels off or may even decrease. This occurs because young salmon are strongly territorial and there is a maximum number that a river section can support. This level of production is often referred to as the carrying capacity. If data are available, then for a given river a curve can be plotted showing the change in smolt production (or adult "recruiting" back to fisheries) accompanying increasing spawning stock level. This is known as a "stock-recruitment" (S-R) curve. A characteristic feature of such curves, even when numbers are accurately and precisely measured, is the wide variation in recruitment which occurs at any one stock level; this is mainly due to the effects of random factors influencing survival.

The target chosen for SAPS is derived from one recommended by NASCO which defines, from an S-R curve, that level of spawning which maximises the sustainable catch (total catch, comprising all marine and freshwater fisheries), and it is termed the **M**inimal **B**iologically **A**cceptable **L**evel (**MBAL**). If exploitation rate increases above the sustainable catch level then, although catch may temporarily increase, the stock will eventually reduce. Thus, MBAL is a threshold spawning level below which it is inadvisable to go. Indeed, in order to give some leeway on the estimate it is preferable to establish a long term spawning level rather higher than MBAL to insure against the effects of unforeseen exceptional events leading to low survival.

Some buffer is incorporated into the statistical compliance procedure adopted in SAPS, but it may be felt that more insurance is desirable. This should be a local management decision and depends on circumstances, for example particular uncertainty over the deposition estimates may lead a manager to set a higher target to reduce risk of the potentially damaging effect of overfishing.

Because S-R curves are not available for most rivers, the procedures use one taken from the River Bush in Norther Ireland, where long term studies have given a working model of the relationship between spawners and recruits. The shape of S-R curves controlled by the productivity of the freshwater habitat and the survival rate. So, correcting for these features allows the Bush model to be transported to other rivers. This gives an improved approximation of a river-specific target.

It is most important to recognise targets for what they are - valuable, objective reference points to guide managers in local stock assessment and a standard framework to report stock status nationally. Moreover, although spawning targets have been internationally accepted as a good working practice for some years, there is still a need for improvements in understanding and methodology.

Numerous factors *could* lead to misinterpretation of a target set for a whole river. A particular problem is the possibility of stock structuring on large rivers which in theory might require targets to be set for different stock components originating from different parts of the catchment and having different age, run and exploitation characteristics. Currently, such tight sub-catchment management is impracticable, although special measures to protect or enhance run components, particularly spring-running fish, must be brought in when they are shown to be necessary. It may be possible for some rivers to define objectively separate spawning targets for grilse and multi sea-winter fish, and this is the subject of continuing research.

Therefore, nominal "passing" or "failing" of targets *in isolation* does not guarantee a correct management decision. Professional scientific judgement, combined with consideration of the full range of other factors acting on a fishery is essential to come to the correct conclusions.

Appendix 2

Calculation of exploitation rates

The exploitation rates for the rod fishery and have been calculated for each month from the rod catch data for the month as a percentage of the total accumulated count subtracting the previous months declared rod catch. Where Er = Monthly % rod exploitation
r = monthly declared rod catch. C = Total number of salmon counted for year up to month analysed. R = Accumulated declared rod catch up to month analysed.

$Er\ \% = (r / (C-R)) \times 100$

The net fishery exploitation rates were calculated from the net catch return data as a percentage of the total accumulated count in addition to the accumulated net catch. This gives a corrected figure for fish exploited before they reach the counter. Where En = % Monthly *declared net exploitation rate. n = declared monthly net catch, C = Total number of salmon counted for year up to month analysed. N = Accumulated declared net catch up to month analysed.*
$En = (n / (C+N)) \times 100$

Table 19 Impact assessment and potential benefit of resolution

Factor	Comment	Confidence in assessment (1) 5,3,2,1	Impact rating (2) 10,6,8,4,2	Potential benefit on resolution (3) 5,3,2,1	Weighted impact score (1)x(2)x(3)
Exploitation distant water fisheries.		3	8	5	120
Low flows, and WQ	Fry and Parr survival/Adult migration	3	8	5	120
Compaction / siltation of spawning gravels	upper Tamar & tribs, Thrushel, and Wolf.	5	6	3	90
Impact of limited understanding and requirement for R&D	Parr/fry survival, utilization of catchment, smolt output, habitat loss, fish counter calibration, High seas fishery	4	6	3	72
Exploitation of spring salmon	Estuarine net and rod fishery	5	4	3	60

Factor	Comment	Confidence in assessment (1) 5,3,2,1	Impact rating (2) 10,6,8,4,2	Potential benefit on resolution (3) 5,3,2,1	Weighted impact score (1)x(2)x(3)
Deoxygenation in estuary	periodic during late summer and a dry year	5	4	3	60
Poaching	Highly variable	3	6	3	54
Competition/predation for resources from stocked brown trout	Impact may be higher in some areas, particularly from stocked fish	3	4	3	24
Access	trash dams	3	2	2	18