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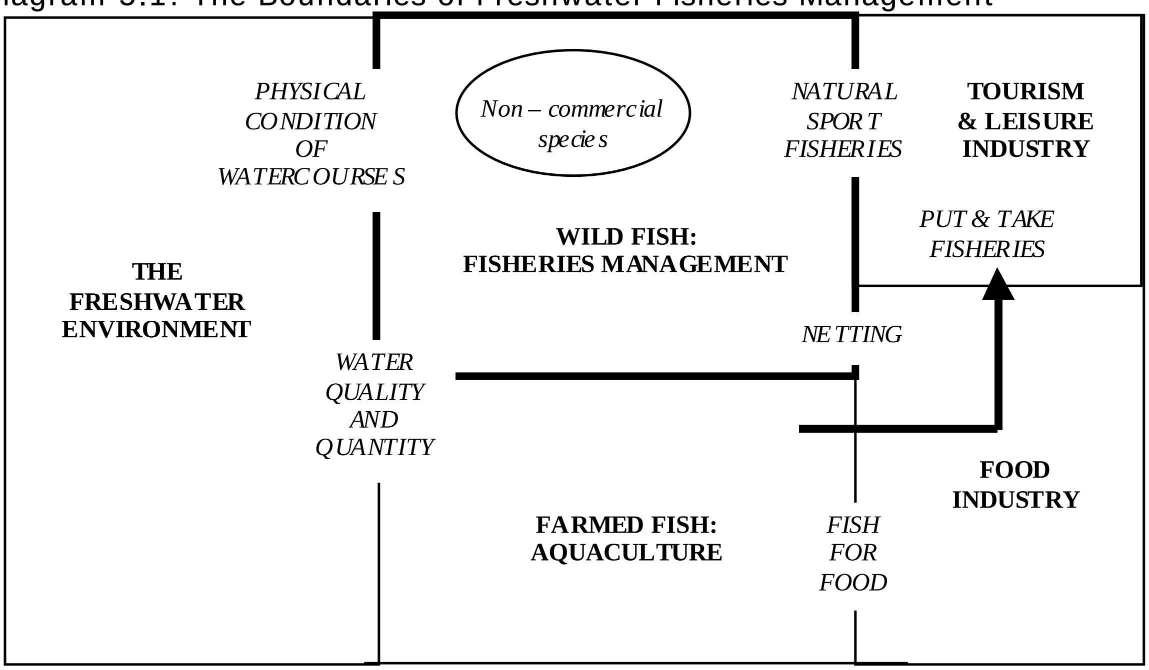
SECTION 5: THE FRAMEWORK FOR FISHERIES MANAGEMENT IN THE FISHERIES DISTRICT

(A) The boundaries of "Freshwater Fisheries Management" : These can be defined as in Diagram 5.1 : They lie, nowadays, in the area between the Freshwater Environment and the Tourism and Leisure Industries as the field is, essentially, about the provision of a product of the natural environment (wild fish) to visiting and local anglers who pay for this service. At present, only a small (and decreasing) number of wild fish are used by commercial nets to provide material to the food industry but in the past, this was the dominant use of wild fish.

Diagram 5.1: The Boundaries of Freshwater Fisheries Management



Closely related to Fisheries Management is Aquaculture. This field has a similar dependence on the Freshwater Environment for one of its raw materials - a sufficient supply of clean water - though the physical condition of rivers and streams and of the aquatic environment generally are not concerns for it as they are for Fisheries Management. The purpose of Aquaculture is provide fish as a raw material for the food industry, though there are offshoots in the provision of living fish (usually adult trout) for stocking into "Put and Take" fisheries and in the rearing of Salmon Smolts for

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
Charity No. SC011055
A charitable trust established by the River Tweed Commission to promote the development of fish stocks in the Tweed River System

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release for artificial Salmon fisheries ("Ranching") which are both part of the Tourism and Leisure Industry

Contained within the field is the conservation of non-commercial species. These are, obviously, not part of the "business" side of fisheries management but can be of major biological and natural historical interest. Unlike the commercial species, they do not earn revenue but (in most cases) they benefit from any protection and improvement of the general freshwater environment undertaken for the commercial species. In that respect they are subsidised by the business side of fisheries management which thus supports the conservation of fish species in general, not just of commercial species. Some of these "non-commercial" species, notably Lampreys and Eels, are actually important commercial species elsewhere in the world and could, if fashions change, become so in Scotland, either as wild or farmed produce. Their present conservation therefore, also contains an element of the preservation of possible future economic value.

The "Commercial" fish species have natural history value as well - the Salmon, for instance, is one of our largest native vertebrates (a 20 lb Salmon is larger than the average Fox and a 40lb one is larger than the average Roe Deer) so fisheries management of Salmon and Trout has to balance the commercial and conservation aspects of these species. In that both aspects benefit from measures to increase the abundance of these species, there is mutual benefit as long this is based on promoting natural reproduction and the health of the stocks and the environment on which this necessarily depends. Conflict does arise, however, if natural reproduction is abandoned as the source of fish for the fisheries and artificial stocking or ranching is adopted instead. As such factory methods of reproduction do not require any great attention to be given to the health of the freshwater environment on which all fish species depend, they also remove much of the support of the Salmon and Trout fisheries from the conservation of catchments.

(B) The Content of Freshwater Fisheries Management : The various layers and chains of impacts, natural and man-made influences, techniques and knowledge requirements that go to make up the field are shown in Diagram 5.2 :

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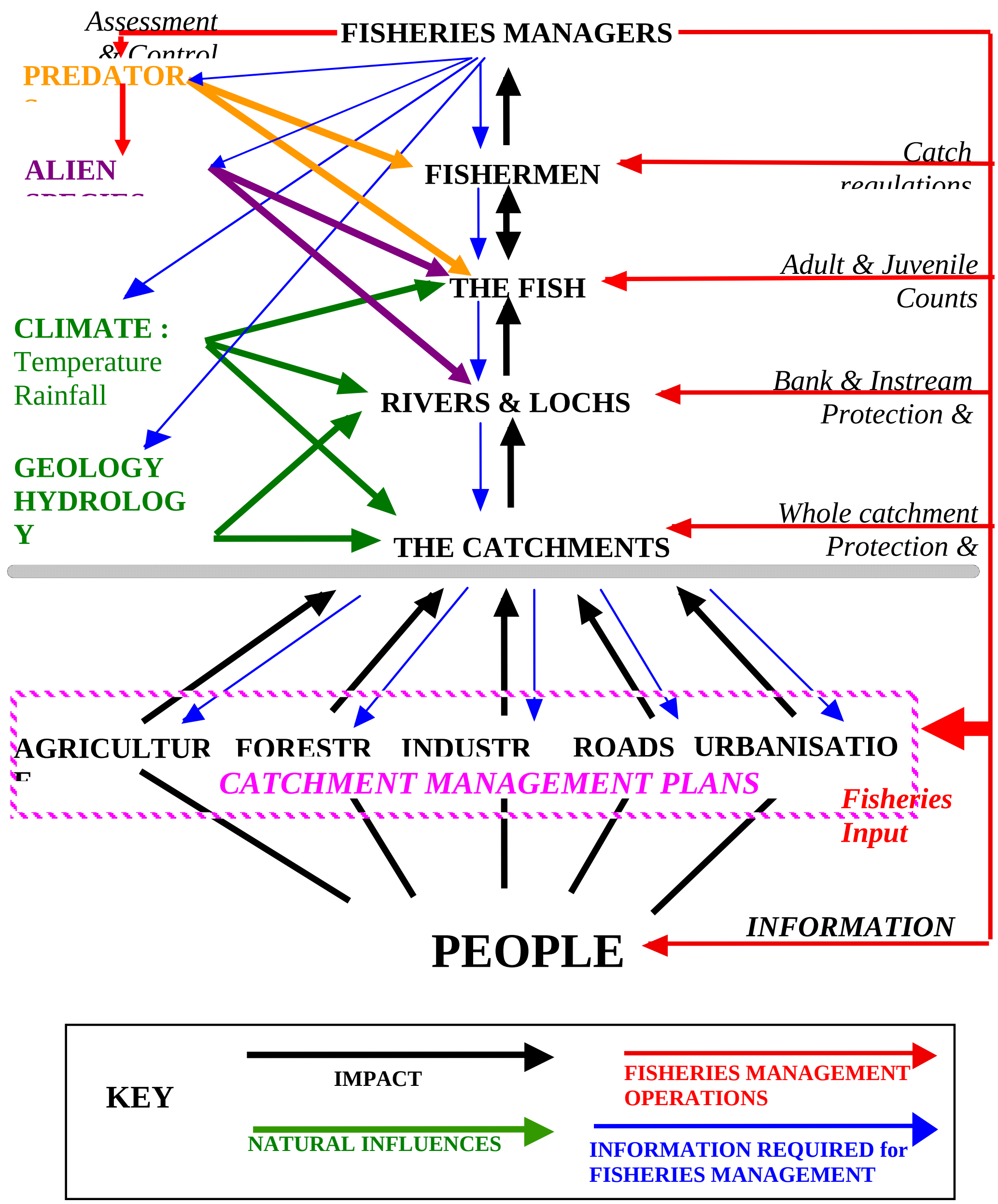
Diagram 5.2 : The Content of Freshwater Fisheries Management



THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
Charity No. SC011055

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The role of a “Fisheries Manager”, as shown in this diagram, is therefore to understand the impacts on fish stocks of the many natural and man-made factors that affect the freshwater environment (and therefore the fish) and as well as the impact of any fisheries. To do this requires the gathering of factual information, as shown by the blue arrows on the diagram. Once such information has been understood and analysed, appropriate responses at different levels can be made, as shown by the red arrows. As is obvious from this diagram, “Fisheries Management” is a wide and varied field of many interconnections and parts, all of which need to be integrated for any effective, practical, programme.

(C) The Objectives of Freshwater Fisheries Management : For Salmonids, these are :-

1: Ensuring enough adult fish of each stock are escaping all dangers and fisheries to fully fill their nursery areas with spawn for the next generation
2: Maintaining and, where appropriate, maximising production of juveniles

and the work of fisheries management is directed towards these aims, as shown in Diagram 5.3

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
Charity No. SC011055
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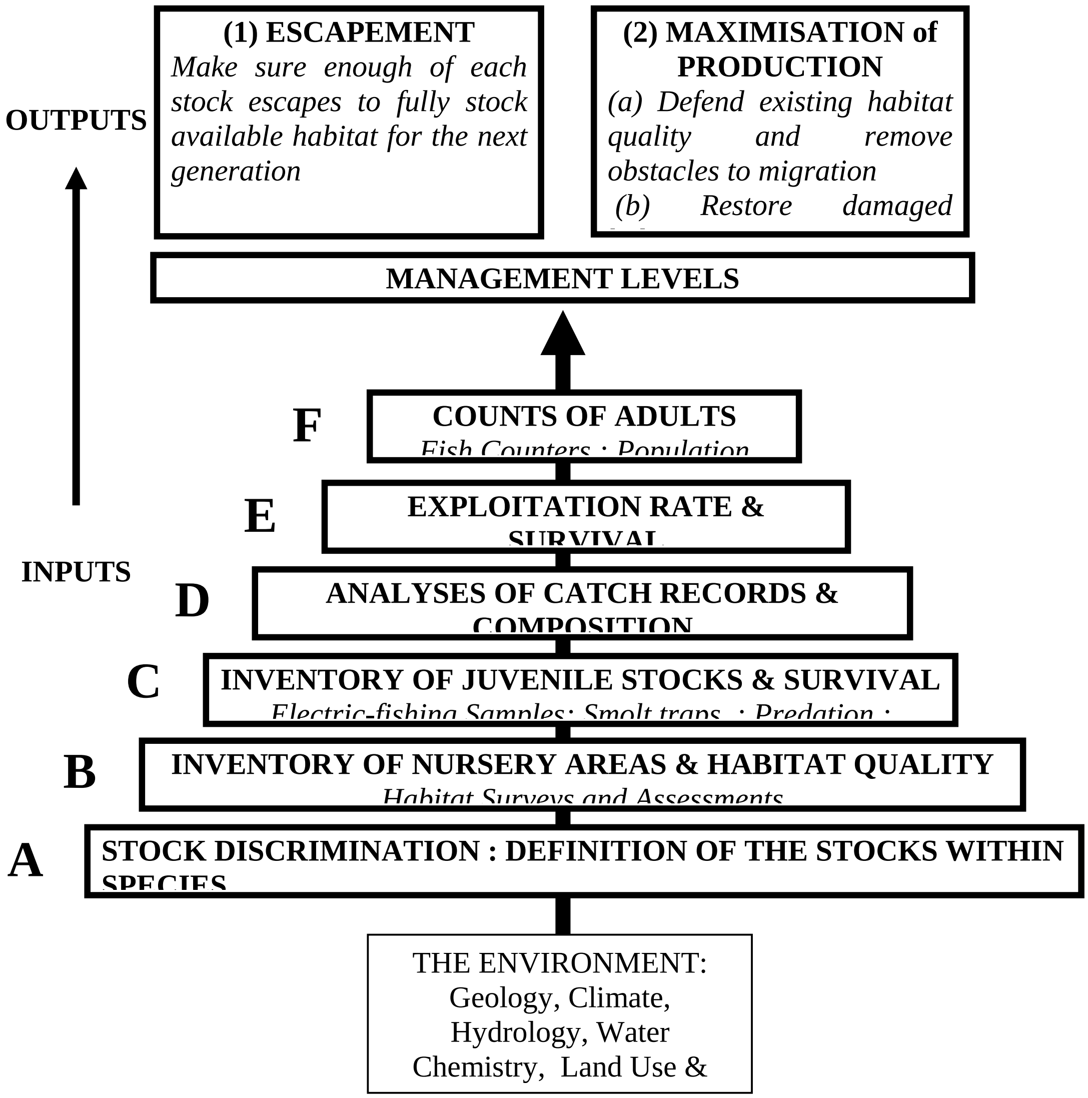
Diagram 5.3: The Contents and Objectives of Fisheries Management



The aims of Fisheries Management are, in fact, its "Outputs" - fish populations that can sustain all the pressures put on them and continue to support the fisheries that depend on them at the maximum level of production. To produce these outputs, information or "Inputs" are needed, and these are about the nature, location, reproduction, catches, pressures and extent of fish

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
Charity No. SC011055
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populations as shown in Diagram 5.3. The definitions of these Inputs and Outputs are :-

INPUTS :

A: The most basic knowledge needed for any river system is the number of different stocks of fish that are present in it. This not only refers to the number of species there are, but also to whether there are different stocks within species e.g. Autumn Salmon or Spring Salmon and how distinct these stocks might be (= "Stock Structure") . This is an absolutely fundamental requirement, since just about all aspects of management have to be on a stock-by-stock basis - It is not, for instance, the total number of salmon escaping to spawn in a river system that needs to be known, but the number of each stock that is doing so.

B: The extent, location and quality of nursery areas needs to be known - these are the places that spawning fish are heading for and where the next generation will hatch and grow up. The extent of these areas gives an idea of the numbers of adult spawners needed and assessments of their quality will show if juvenile numbers and survival are as good as they could be. Knowing what stocks of fish spawn where allows priorities to be set - for instance, if a Spring Salmon stock is of great importance within a system, then more expensive habitat restoration techniques can be considered in its nursery areas than in nursery areas of less valuable Salmon stocks.

C: The numbers of juveniles in the nursery areas can show trends and changes in how well these are being stocked by adult spawners. Low densities can show areas where habitat restoration would increase the numbers of young fish. If the stock structure of a system can be worked out on a geographical basis so that it is known, for instance, which areas Spring Salmon spawn in and which others are used by Autumn Grilse, assessments of juveniles can then be made on a stock-by-stock basis.

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
Charity No. SC011055
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D: Catch Analyses can, depending very much on the quality of records that have been kept, show the histories of the different species being exploited by fisheries and even of the different stocks within species, the most relevant example being the changes between dominance of Spring and Autumn Salmon that is such an obvious feature of catch records in Scotland over the last 100 years. Catch records also show how well fisheries are doing. Scale reading an adequate sample of catches will give their “Composition” - the ages and life-histories of the fish being caught - and may also be able to show that there are different types / stocks of fish being caught in different parts of a fishery and at different times during the season. Catches that depend on only one age class of fish are more vulnerable to fluctuations due to environmental effects on single spawning or Smolting years than those that exploit two or more age groups of fish and this is important information if the significance of fluctuations in catch totals is to be properly assessed.

E: If the numbers of fish escaping to spawn are to be known and managed, then the places and extent of catches (= “Exploitation Rate”) need to be identified. It is by regulating these losses that the number of fish finally escaping to spawn can be increased, if this is found to be necessary. Again, this needs to be done on a stock-by-stock basis. Early running stocks are generally more heavily exploited than later stocks because they are in a river for more of the fishing season and are behaviourally more catchable. Later running stocks, may, in fact be only very lightly exploited and if this can be shown, then it can indicate increased scope for fisheries.

F: The most basic requirement for setting escapements is to actually know the numbers of spawning adults that make it back to their nursery areas. This really needs fish counters to actually tally the fish and has to be done on a stock-by-stock basis, i.e. each distinct stock (ideally) needs a counter to record the numbers making it back to their nursery areas. As well as giving a result for the number of fish passing upstream of it, results from a counter also give checks on a wider range of data: e.g. the totals of a fish counter counting Spring or Summer fish up a tributary should

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mirror the catches of those fish in the main channel, if these are related to stock size.

OUTPUTS

The Outputs are produced by the Management Level identified as being appropriate for each stock: A "Management Level" is the package of policies and regulations that aims to ensure that: (1) Enough adults of each stock survive all the pressures on them to fully spawn their nursery areas with the next generation and (2) That there are no limits to juvenile production from difficult access to spawning areas or degraded habitat. These Outputs are defined as:-

Output 1 : **Spawning Escapement** (the number of mature fish escaping all dangers and fisheries to reach their spawning areas): The number of fish needed can be worked out from assessments of the nursery areas of each stock using the extent of the areas needing stocked and the density of juveniles that can be supported. There are various theoretical ways of doing this or it can be worked out experimentally by comparing the numbers of adult spawners counted into an area through a fish counter with the resulting abundance of Fry the next year. The latter method is better given the present state of knowledge. The number of spawning adults needed for a stock is its "Escapement Target" and achieving this target (or working towards it) is Output 1 of a Management Level, and involves catch regulations and "Catch & Release" if spawning targets are not being met.

Output 2 : **Maximisation of stocks.** This comes largely from habitat restoration work - opening up as much of a catchment as possible so there is the largest possible area for spawning and restoring the "Carrying Capacity" of damaged areas by increasing the amount of food and cover so that higher levels of juveniles can be supported. Appropriate work on habitat is part of the Management Level set for a stock.

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
Charity No. SC011055
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(D) The Theory behind Spawning Escapement and Maximisation of Production for Salmonids : An average, 70 cm long female Tweed Salmon will produce around 5000 eggs, so it is obvious that relatively few spawning adults will produce a great many young : 200 will produce around one million eggs. Any large number of spawning Salmon therefore produces a really vast number of eggs and this high gearing between the generations is one of the characteristics of the species (Diagram 5.4, line “A”). There is, however, a “ceiling” on the number of young fish that any nursery area can support (Diagram 5.4 line “B”) as fish, like any other animals, wild or domestic, are limited by the amount of food and space available for them. This means that the shape of the relationship between the numbers of adult Salmon spawning and the numbers of resulting young is not a straight line going ever upwards (line “A”) with more and more adults meaning more and more young: It is, in fact, a straight line only until the “ceiling” (line “B”) is reached and beyond this level of spawning there can be no increase in the number of resulting young fish as the nursery area cannot support any more. In areas with large numbers of spawning Salmon, 95% of the young that hatch will die within three months as their numbers reduce to the level that can be actually supported by the food and space available (which is called the “Carrying Capacity” of a stream). Carrying Capacity itself can be increased if the amount of food and space in a stream can be increased and there are various techniques of Habitat Restoration that can do this where it has been reduced and examples of these and their effects are given in Appendix B.

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
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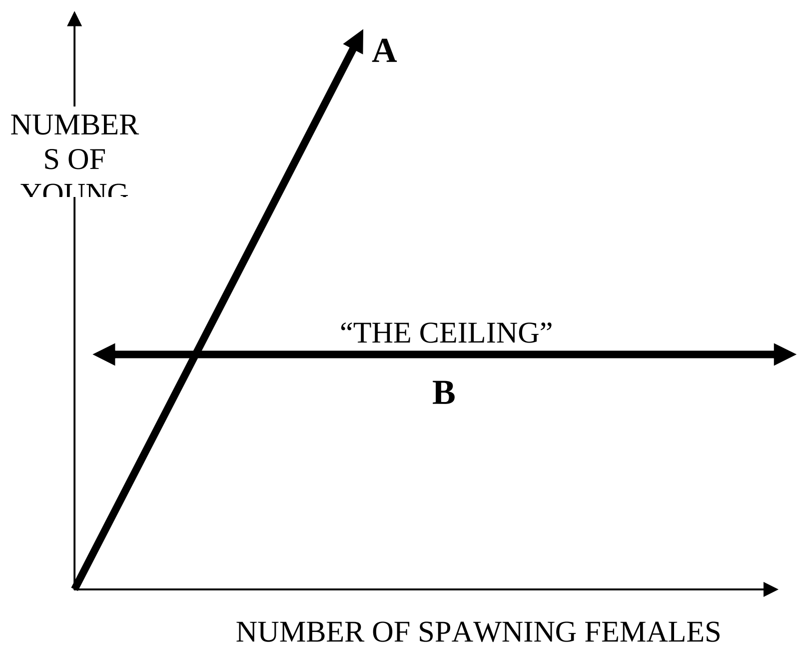
Diagram 5.4 : Schematic relationship between the number of spawning adults and the number of young fish in the next generation



The best information for Scotland on this pattern in the wild comes from research on the Girnock Burn, a tributary of the Aberdeenshire Dee. Here, for many years, an upstream trap for adult fish returning to their home stream and a downstream trap to catch Smolts leaving have been operated, so the Salmon belonging to this burn have, effectively, been counted out and counted in. The relationship between numbers of spawning adults and the number of resulting Smolts found at this trap can be generalised as in Diagram 5.5 :-

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
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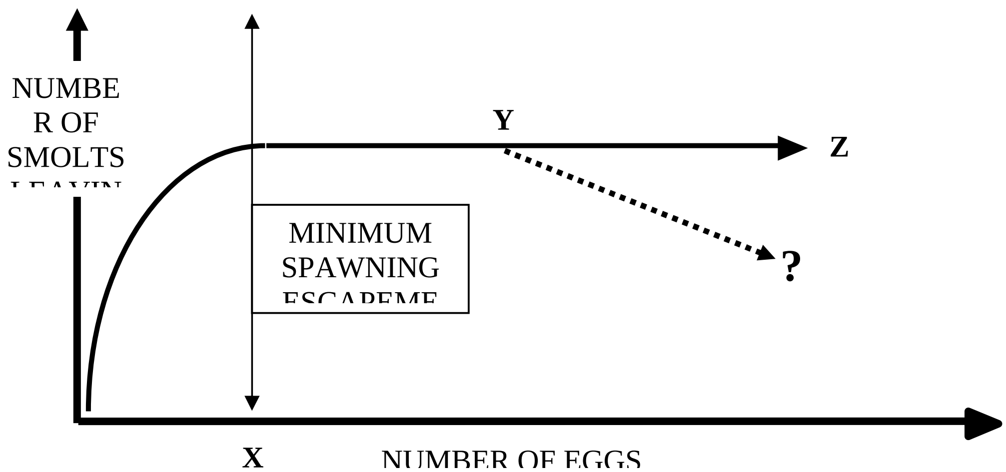
Diagram 5.5 : Generalised relationship between the numbers of eggs deposited and the resulting number of Smolts later leaving



The number of eggs at “X” is enough to give the maximum number of Smolts that can be produced from the stream, which is “Y” on the diagram, the Carrying Capacity ceiling. Any further increase in the numbers of eggs deposited will not produce any more Smolts, “Z”, because the food and space for young fish in the burn is fully taken up by the young fish produced by the number of eggs at “X”. Such surplus numbers of spawning adults and eggs are the result of the large number of eggs that a single Salmon female carries. A stream with a Carrying Capacity to produce 1000 Smolts may only get 50 of them back as spawning females but these will deposit around 250,000 eggs – far more than the Carrying Capacity can sustain to Smolt age. If marine survival is good, more of these 1000 Smolts will return as adults, so increasing the surplus number of spawners - and increasing the surplus that can be safely taken by a fishery. If marine survival is poor fewer of the 1000 Smolts will return as adults, and there will be less of a surplus for fisheries, but with so many eggs being produced by each female, numbers returning have to get very low before egg deposition falls below the curved part of the graph (which is the minimum spawning requirement). However,

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
Charity No. SC011055
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populations can, and do, fall below the curve. Lower numbers of adults returning due to reduced marine survival and consequently increased fishery pressure on smaller stocks is one way in which this can happen. Reduced carrying capacity for juveniles due to habitat loss and degradation is another. One or the other, or a combination of both, can overcome even the abundant fertility of the Atlantic Salmon.

Problems can also arise from habitat degradation that reduces carrying capacity – fewer Smolts / juveniles are produced and so fewer adults return, but in this case the reduced carrying capacity can be fully supplied by a smaller number of adults, so increasing spawning escapement would have no effect. The practical question therefore is: Which is having the greater effect on a stock, a reduced number of spawning adults due to overfishing etc. or a reduced capacity to produce fish due to habitat degradation ? The answer needs to be correct or the work undertaken will have no success.

The downward arrow marked by the "?" in Diagram 5.5 refers to the idea that very high numbers of eggs will result in a decrease in production of Smolts due to excessive competition between juveniles or to destruction of redds by large numbers of spawning fish over-cutting. There is some evidence that this is a possibility under some conditions but it is unlikely to be a large scale factor under present circumstances. It should be noted that the destruction of earlier redds by later arriving fish is possible only in localised situations and cannot occur between Spring and Autumn fish which actually spawn in different parts of river systems, the Spring fish higher up and the later fish further down stream.

Diagram 5.5 gave a picture of the relationship between spawning levels (eggs or adults) and resulting Smolts (recruitment to the next generation) and is called the "Stock Recruitment Curve". The same sort of pattern is found in the relationships between other stages in the life cycle as well, such as the Fry to Parr transition. As older, and therefore larger, fish need more space than smaller and younger, it follows that Carrying Capacity for older fish in an area is less than that for younger fish. This limits the number of the younger age group that can make the transition to the older. Those that cannot find and hold sufficient territory as older fish have to leave the area or die off through being more exposed to predators. An example of this comes from Tweed

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
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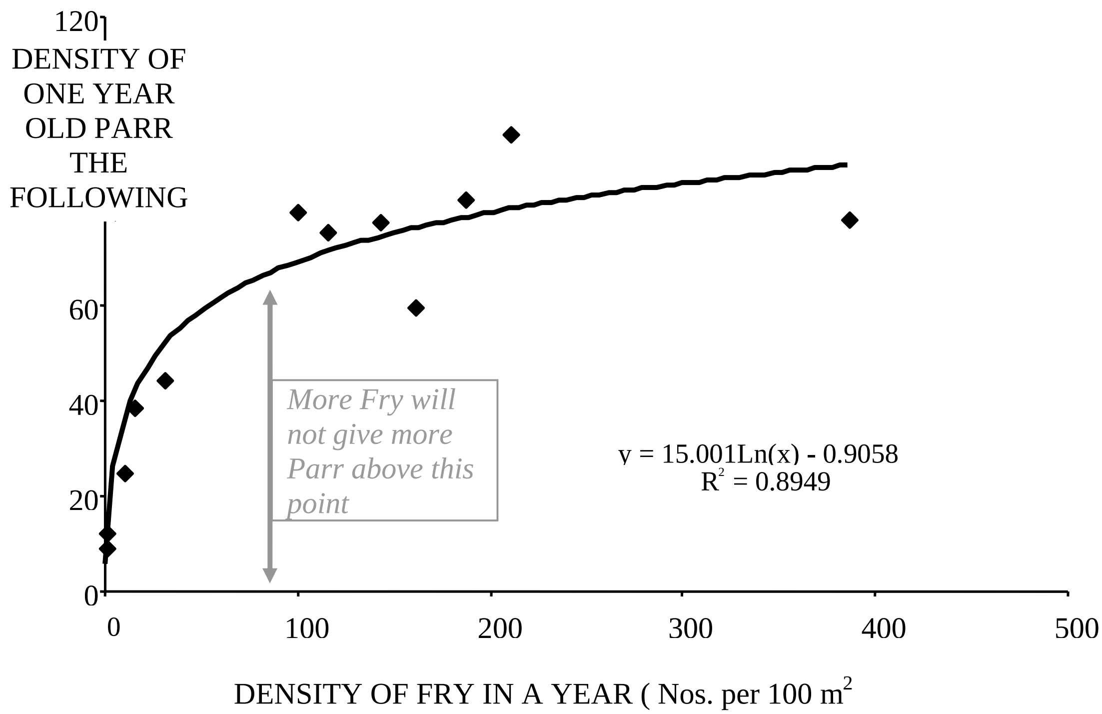
Foundation work on the Kirkburn, a small stream near Cardrona. As the same sections of this stream were electric-fished for several consecutive years the number of one year old Parr could be related to the number of Fry found the previous Summer and this is shown in Diagram 5.6:

Diagram 5.6 The Relationship between densities of Trout Fry in six sample sections of the Kirkburn and the densities of one year old Parr in the same sections one year later.



This shows that beyond a density of around 90 trout Fry per 100 square metres (one Fry per 1.1 sq m), any greater density will not result in there being any more one year old Parr in the sample sections the following year. This study was carried out over three years, from 1991-93 and was based solely on electric-fishing. A trap to count the numbers of spawning adults was run on this burn in 1971 and 1972 (Campbell 1977): 12 female trout were taken in the first year and 22 in the second. All but three were small, between

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
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20 and 30 cm long, the others being Sea-trout 50-60 cm long. Assuming roughly the same number of females to have been spawning in this burn 20 years later, it underlines the point made above that only relatively few female trout or salmon are needed to fully stock spawning areas due to the number of eggs that can be produced by each fish.

It follows from this that the "curve" in the graph (at "B" in Diagram 5.5) is the key to understanding how many Salmon or Trout are required to fully stock a nursery area. If the numbers of adults / eggs falls below the curve then the carrying capacity of the area will not be filled and fewer Smolts than is actually possible will be produced. This in itself is not a disaster, the stock is not directly threatened with extinction in such a situation, and should be able to heal itself naturally - fewer eggs being deposited should mean less competition between juveniles and so better survival and therefore more Smolts from the lower number of eggs - and so more returning adults to bring the stock back above the curve. This, of course, is similar to the way that Salmon colonise and build up their populations in new areas, as they did when the Leader and Gala waters became open to them in the 1950's – they now have some of the best stocks of juvenile Salmon in the whole Tweed catchment. If, however, there are factors that restrict the numbers of adults returning to the stock's nursery areas, such as heavy fishing pressure, the healing process will be slowed or stopped. If such heavy fishing pressure continued at the same level, the stock would continue at its reduced level so there would be stability, though at less than maximum production.

A stock that is "below the curve" can suffer if pressure on it increases further. Angling exploitation levels on early running stocks of Salmon can be as high as 40% as effort is concentrated on small numbers of fish, and these fish are also behaviourally more inclined to take anglers' lures. Generally, the more fish there are in a river, the less chance each individual fish has of being caught. Unless steps are taken to reduce exploitation on small stocks there is a very real danger of them being exploited into extinction. Another danger at present is the decline in the rate of return from the sea as this too, will slow or prevent any healing process for stocks below the curve.

It can be seen therefore that the two Aims / Outputs of freshwater fisheries management for Salmonids lie on either side of the curve in the Stock

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
Charity No. SC011055
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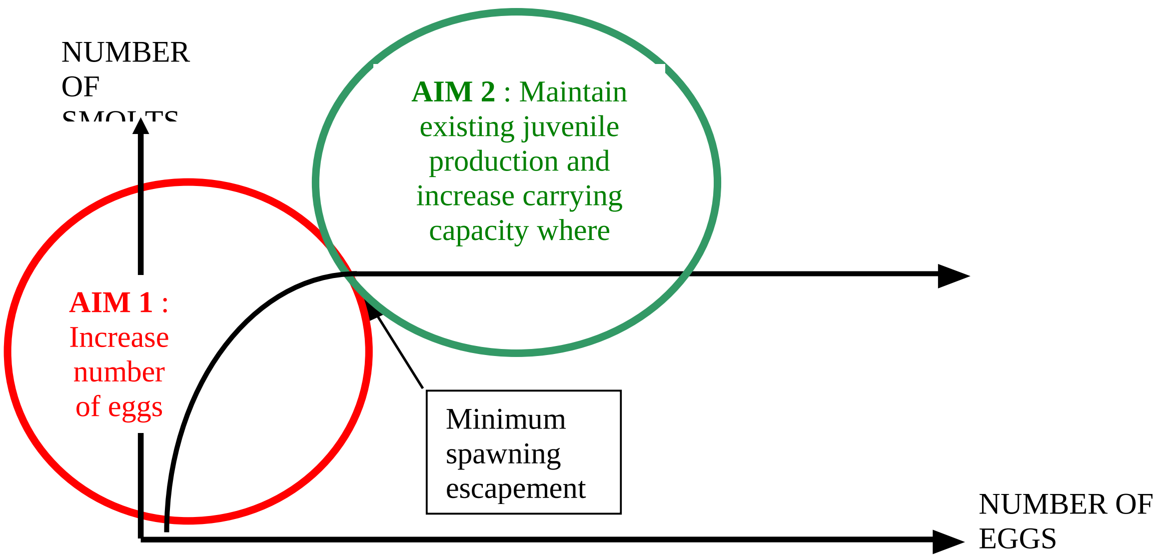
Recruitment relationship, as shown in Diagram 5.7. Below the curve, where there are too few adults to fully stock the nursery areas, the aim is to increase these numbers, and above the curve, the aim is to maximise carrying capacity by increasing the amount of food and space for the young fish so that more survive from the eggs that are laid, as was shown in Diagram 5.4:

Diagram 5.7 The two basic aims / Outputs of Salmonid management in relation to the stock recruitment curve



Problems can also arise from habitat degradation that reduces the spawning or carrying capacity – fewer Smolts / juveniles are produced and so fewer adults return, but in this case the reduced carrying capacity can be fully supplied by a smaller number of adults, so increasing spawning escapement would have no effect. However, in practical terms, access by spawning fish is the first factor that should be checked because it is often the easiest to deal with – and certainly the most likely to produce immediate benefits with improvement – and because it must be quite certain that enough spawning fish are able to get into an area before any other improvements become worth undertaking. If there are too few eggs being spawned in an area, the

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
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Carrying Capacity of the nursery area (even where this has been degraded) is unlikely to be much of a factor in determining the survival rate of the resulting juveniles, as there should be more than enough food and space for each and every one them.

As can be seen from all the above, there are many different layers, actions and aims within Freshwater Fisheries Management - and they all need to be co-ordinated (and prioritised) to give daily and annual fisheries management work its form, and this is done through fisheries management plans: The Tweed & Eye Fisheries Management plan forms Section 7 of this document.

(E) Setting the Management Levels to support the management aims for Salmonid Stocks: As shown in Diagram 5.3, the bases for practical fisheries management work are the "Management Levels", which are the packages of policies and regulations required to achieve, or work towards achieving, the two Outputs and these differ widely depending on the state of the fish stocks. Elliot (1995) discussed the nature and varieties of Fisheries Management levels as follows :-

> *"As an animal ecologist, I used to assume it was self-evident that if a species was a valuable resource, then ecological knowledge would be essential for its conservation and management. I have since realised that this was a naive assumption! One extreme, but not uncommon view is that the best way to manage a freshwater fishery is to put in the fish the anglers want and ensure that most are caught. The argument is therefore that most effort should be placed on the science of rearing fish in hatcheries and breeding fish that will please most anglers; the fish should be large and easy to catch. Another view is that all you need to do is ensure a high water quality and the fish will look after themselves. It may surprise some readers to learn that I have some sympathy with the latter view. Cummins (1992) stated : "The concept of 'management' is one of the more arrogant human notions".*
>
> *"Man's attempts to manage nature are most frequently seen in agriculture and forestry. Although there have been many successes, there have also been some disasters - some of these long after supposed "successes". The best management of wild species is probably to minimize human interference and rely on natural processes, a strategy followed to a certain extent in many of the world's national parks. Perhaps the ideal strategy is to manage the human populations and their activities, rather than the natural communities of plants and animals."*

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> *"..... It is clear, however, that there is a need for management of fish populations in rivers and that it should have an ecological base. The degree of management depends upon the extent to which the fish are exploited or stressed by human activities. It also depends on both financial and intellectual resources, the latter being the amount of ecological knowledge available for each species."*

As this makes clear, Fisheries Management can be at any level from the completely artificial production of fish with little or no interest in (or, perhaps, opportunity for) natural production to a purely natural, non-interventionary, system, based on protecting and encouraging natural reproduction, or as Elliot (above) put it:- *"The degree of management depends upon the extent to which the fish are exploited or stressed by human activities".* Fish are, of course, quite capable of growing and reproducing by themselves, without the assistance of humans - they were around millions of years before mankind appeared - and do not need any help to live naturally or to increase and extend their populations. As shown in Diagram 5.2, their problems are all created by human impacts - we block their migration routes with barriers; abstract and pollute their water; degrade or alter their environment through industry, agriculture and forestry - and then want to catch them for food. It is those human impacts at the base level and again at the fishery level of Diagram 5.2 that need managing, so Fisheries Management is not basically about managing fish, it is about managing people. As part of this process, however, we do need to know about the fish - where they live, how many there are, how they grow and reproduce and how they are being affected by human activities and so on or as Elliot (above) wrote *:-"It also depends on ...... intellectual resources, the latter being the amount of ecological knowledge available for each species."*

Determining what level of management is appropriate to a particular water's fishes (or to a particular stock of a fish species in a catchment) is therefore the key question, the answer to which can be found by following the steps shown in Diagram 5.3 to make "Stock Assessments". Essentially, the poorer the condition of the stocks, the more intensive the required level of management and, conversely, the better the state of the stocks, the lighter the level of management that is appropriate, as is summarised in Diagram 5.8.

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
Charity No. SC011055
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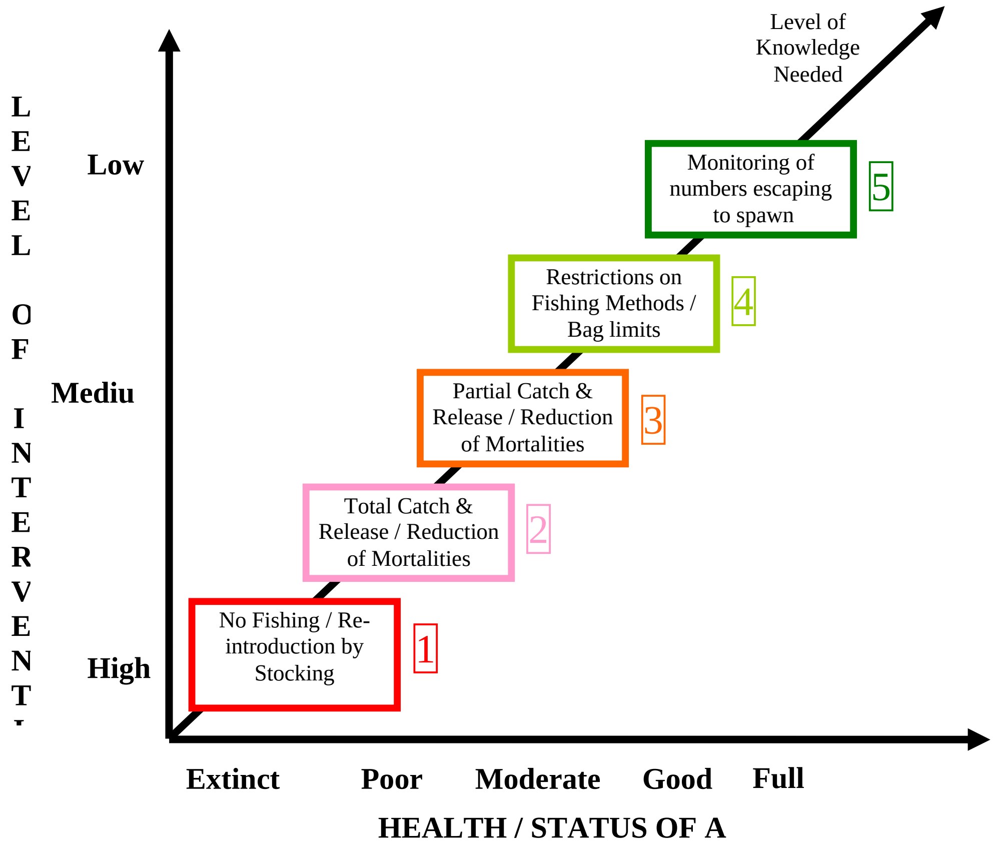
Diagram 5.8 : The different Management Levels for Salmonids



The Management Level descriptions are :

Level 1: Where the stock is either extinct, or so close to it that there are too few fish even to catch and keep as captive broodstock, introduction of suitable stock from elsewhere is required. No fishing can be allowed in such situations - all adult fish are required for breeding to build up a new stock and the risk of even the low casualty rate of Catch & Release fishing is not acceptable.

Before fish can be re-stocked in to a water that has lost them, the original problem that caused the loss has, of course, to have been

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
Charity No. SC011055
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dealt with - pollution and over-fishing being the commonest causes of extinction of fish populations.

Level 2: Where stocks are very low, keeping of captive native broodstock to supply extra eggs to the system is the most suitable policy. No fish can be killed by angling as all possible breeding fish are needed, though "Catch and Release" fishing is possible, particularly as it is a useful source of captive broodstock.

Unless the physical, chemical or biological problems that contributed to the original decline are removed or mitigated however, there can be no progress from this level to the next, as the original problems will continue to impact on the fish population and keep it at a reduced level - all that artificial rearing and stocking can do in this situation is to treat the symptom (lack of fish), it cannot treat any underlying causes out in the catchment or in the sea. Unless underlying problems can be solved, stocking of this type can only keep a population going, it cannot restore it to a self-supporting state.

At these lower two levels, the work is directed towards achieving sufficient spawning escapement and production (Aim 1 in Diagram 5.7, where a stock is below the curve). The following three levels are the management appropriate where there is both sufficient escapement and production (Aim 2 in Diagram 5.7, where a stock is above the curve).

Level 3: Where stocks are vulnerable or to some degree below full capacity or are just above it but not in serious trouble, reducing the angling kill through compulsory "Catch & Release" (total or partial, depending on circumstances) to allow more fish to spawn and so re-inforce the stock is the appropriate level of management, along with habitat restoration in the spawning areas to maximise production.

Level 4: Where stocks are good, catches need to be regulated as a precaution to prevent overkill, that could result in damage to the stocks in future: Restricting fishing methods and catch numbers and the encouragement of voluntary catch & release are the appropriate policies for this level, along with the preservation and defence of the

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
Charity No. SC011055
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water and habitat quality on which the good quality of the fish stocks depend.

Level 5: Where stocks are at full capacity, the situation simply needs to be monitored to ensure that enough fish always do escape to spawn so that problems will not arise in future. Any problems will then show up as soon as they develop and can be treated with minor interventions, such as restrictions on method or bag sizes. Obviously, such good stocks come from good water and habitat quality and these need to be defended and preserved.

The required degree of knowledge and understanding of the fish actually increases with the management level. Where there are no fish to start with, there is little knowledge required, or, indeed, available, and it is a simple matter of introduction and stocking. If management remains at this level (see below for the circumstances in which this happens) the knowledge requirement remains low. As Management Level rises, the need for knowledge about what stocks are present, their location and structure and whether each of these is being exploited at a sustainable level, also rises. For full Level Five management a complete, monitoring, infrastructure of fish counters and traps is required.

The actual, practical, situation on the ground will, of course, never be as neat as starting at a particular level and progressing upwards, step by step. Even if management was starting at Level 2, for instance, it would be necessary to have systems to monitor numbers of spawning fish, as for Level 5. However, the greatest call on resources would be for Level 2 work - getting the fish population going and growing. As the "centring" of management work moved up levels though, monitoring would become increasingly important until it became the main call on resources when Level 5 itself was reached.

Getting the Management Level wrong is immensely wasteful of resources - the classic example of this is when fish or eggs are brought in from elsewhere to stock a river that actually has a good population of its own, or when juveniles from hatcheries are planted into areas of rivers that are already full of naturally spawned young. It has probably been the case that the majority of stockings ever made in this country have been of this sort. Hatcheries

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
Charity No. SC011055
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began in this country in the 1840's but it was not till the arrival of electric-fishing in the 1960's that it actually became possible to catch and count the numbers of wild juvenile fish in spawning areas. Until then, stockings were inevitably being made without any information on how many wild fish were already present, and in most cases, were almost certainly made into naturally fully stocked areas. Even if the density of naturally spawned young fish is relatively low in an area, it may well be that that is all that is actually possible there due to its natural characteristics and so adding more fish simply creates massive extra competition resulting in (at best) no actual increase in numbers. There have been a number of experiments over the years in which artificially high stocking densities of Fry have been shown to produce no more older fish than lower densities because whatever the starting numbers, Carrying Capacity reduces the output to the same level

This is why there is no mention of "Enhancement Stocking" for the three upper Management Levels. The idea of this sort of stocking is to add fish reared artificially to rivers that already had natural spawning populations in order to add to the number of juveniles. However, the concept fails to take account of the fact that the number of juveniles that can live in an area is limited by the amount of food and space available to them - the "Carrying Capacity". Also, the adult fish that do return from this sort of stocking have actually never been shown to be "extra" to the number that would have been produced naturally rather than simply "replacements" for wild fish that were out-competed by the hatchery fish as juveniles and so died as a result of the stocking. Hatchery-reared juveniles are often larger than wild fish of the same age, and so can displace them and take their territories. However, hatchery rearing also makes fish less fit for life in the wild and so while initially successful they have poorer overall survival, and having displaced local fish are then less likely to reach Smolting themselves. There is, in fact, more than just a waste of money involved in such mismatches of situations and management: Actual biological damage can be the result when the genetic identity of original stock(s) is changed by interbreeding with introduced fish (a similar scenario to the interbreeding of wild and escaped farmed fish now causing concern on the West Coast).

Stocking where there are no natural populations is, however, a useful way of increasing the total number of juveniles in a river system, such areas being

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
Charity No. SC011055
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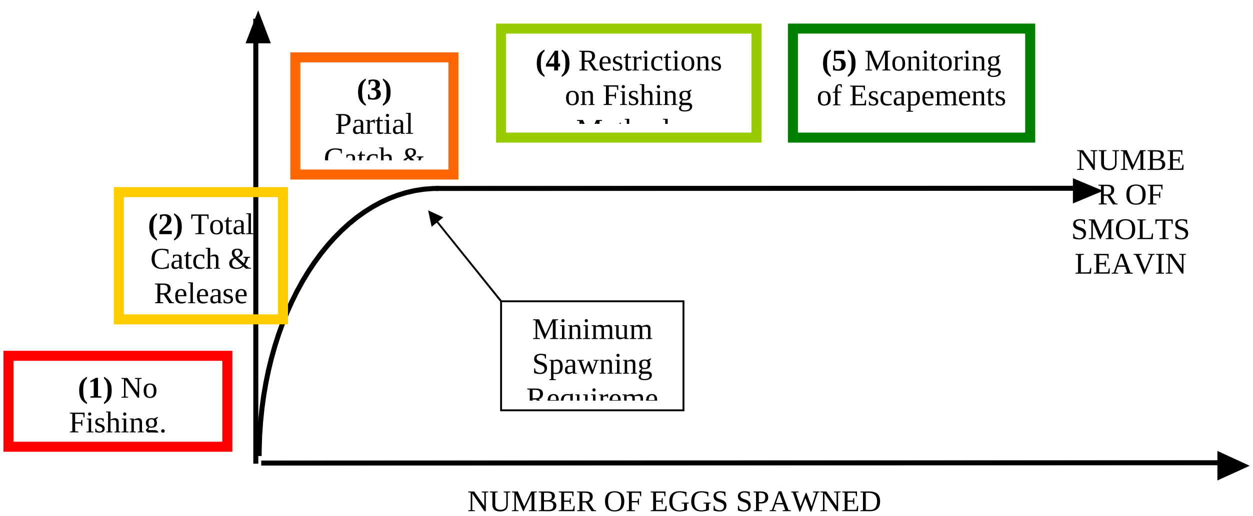
mainly above waterfalls and dams where access to spawning fish is difficult or impossible. In such situations, it is the symptom of a problem - the lack of fish - that is being treated by stockings, and not the underlying cause -the waterfall or the dam. The problem, of course, in treating symptoms rather than causes is that nothing actually ever gets any better, the underlying problem is not dealt with and the remedy has to be applied perpetually - and be paid for perpetually - so it is economics that determines whether on not such stocking is a practical thing to do. This again relates back to the different stocks in a river - stocking of high-value, early running fish is more economically justifiable that that of later-running fish that may have very low exploitation rates.

The different Management Levels actually reflect different positions of stocks on the Stock Recruitment curve that was shown in Diagram 5.4, as is shown in Diagram 5.9 :

Diagram 5.9 : Management Levels as reflections of position on the stock recruitment curve



Management Levels 1 and 2 are about increasing the numbers of deposited eggs and spawning adults; Level 3 is about keeping a stock from “falling” over the curve into a state in which there are not enough adults escaping all

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
Charity No. SC011055
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the pressures on them to fully spawn the next generation; Levels 4 and 5 are firstly to do with keeping stocks "above the curve" and defending existing spawning levels and then with maximising production where feasible and desirable.

The actions listed as appropriate for each Management Level shown in Diagram 5.8 are all to do with managing direct pressures on fish, but there are also habitat management actions that can be employed as well. The reason that they are not shown in the diagram is that the states of fish stocks and their supporting habitats are not necessarily in synchrony. If loss and degradation of habitat has not been a significant cause of damage to a fish stock, the damage being due instead to some direct factor such as overfishing or pollution in an estuary, then the river habitat may actually be pristine and in no need of any actions, despite the lack of fish. The habitat works that can be appropriate for different management levels are :-

Levels 1 & 2 (When natural stocks are either non-existent or very poor): If habitat loss has been the main - or a major - cause of the problem, then it is likely that whole watercourses or large sections may need to be re-engineered in order to be able to support fish again. An example of this comes from Ireland, where extensive arterial drainage of rivers in the 1960's turned rivers and streams into ditches and drainage canals removing, in many cases, even the areas of gravel needed by spawning salmonids. Restoration of such rivers has required their re-engineering and the replacement of gravels.

Level 3 (When a stock is under some stress, but is still in reasonable numbers) : In this situation, restoration of damaged, poor quality areas within the nursery area(s) of the stock(s) in question would be appropriate in order to strengthen juvenile production.

Levels 4 & 5 (When a stock is in good health) : Defensive measures are appropriate here, to protect the present, good, situation - this would mean mainly bankside fencing and the cutting back of any extensive areas of overshadowing tree cover. Habitat restoration, a much more expensive and intensive procedure, would not generally be justified at these Management Levels, even if some localities within the nursery areas of such stocks were

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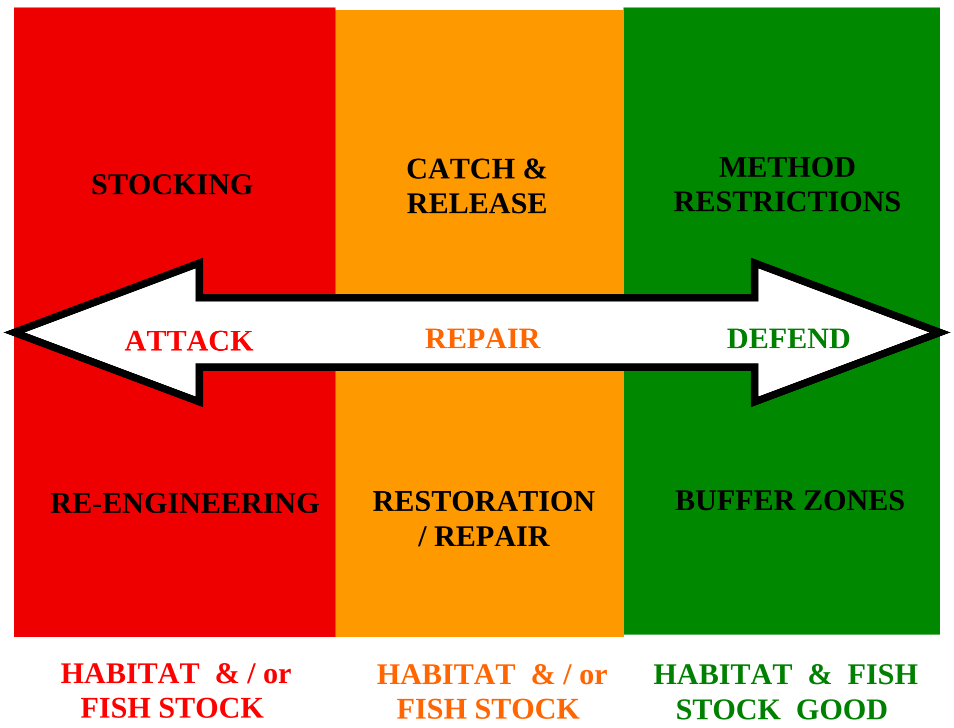
not in good condition and could be restored. It is, in effect, the value of the fish stock occupying an area that decides whether the more expensive procedures are appropriate, not the physical state of the area itself. If, however, the stock was a particularly important one, such as an early running Salmon stock, habitat restoration work to increase production further, above existing adequate levels, could be justified.

Diagram 5.10 - The "Attack" and "Defend" Continuum in Salmonid Management



Both the fish stock and habitat management actions can be combined into a continuum from "Attack" to "Defence". At the former end are the intensive, interventionist approaches such as stocking; compulsory Catch and Release and river re-engineering that are needed to "attack" problems and at the latter, the precautionary measures such as catch and method limits and the creation of buffer zones that can be used to "defend" satisfactory situations and ensure problems will not arise in the future, as shown in Diagram 5.10:-

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
Charity No. SC011055
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All the above assumes that progress is possible from poorer conditions to better, from the lower to the higher management levels defined here, but this is not always possible. The situations in which this can be the case are:

(1) Where badly damaged rivers or streams cannot be re-engineered, the most common examples of which are canalised watercourses through towns.

(2) Where a barrier to fish migration such as a major dam cannot be removed or bypassed, preventing either adults gaining access to spawn or juveniles making a successful migration downstream, or both.

(3) Where natural reproduction is difficult or impossible. The best known example of this in this country is Acidification: Eggs and newly hatched Fry are much more vulnerable in acidified waters than older life stages and so reproduction can be impossible in such areas, even though older fish can live in the waters. Rearing fish in hatcheries and then stocking them out at sizes that can survive the conditions is therefore a method of maintaining populations, but progress towards self-sustaining populations is not possible as long as a the acidified conditions persist. Another Scottish case is the situation for Sea-trout and Salmon on the West Coast. So many Smolts are killed by Sea-lice from fish farms that far too few adults return to sustain the populations. Keeping adult broodstock safe in hatcheries is the only possible, though expensive, solution at present

Another well known example is the Ranga River in Iceland, where a Salmon fishery is maintained completely artificially by ranching with hatchery-reared Smolts as the water temperatures and substrate (river bottom) are almost entirely unsuitable for natural spawning. No useful natural population could ever establish here, so it is, in effect, run on a variation of “Put and Take” management.

(4) Where angling pressure is so heavy that the chances of fish surviving to breed naturally are very low and there is little or no chance of removing or lightening the pressure - in stretches of river that run through towns, for example or in popular commercial stillwater fisheries.

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
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These can be regarded as situations of "arrested development", where progress from intensive to light management is prevented by unsolvable problems

Wherever it is possible, however, the aim of Fisheries Management should be to move to the higher levels, 4 and 5 where it becomes a form of Wildlife Management. When this happens, the two dimensions of fish - as the prizes of anglers and as wild, native, animals - are combined to the benefit of both anglers and the community in general. At these higher levels, angling is a source of money for the conservation of wild fish stocks and the maintenance and restoration of rivers and lochs, benefiting all freshwater (and bankside) species, not just the anglers' particular fish, thus funding the wider community interest. In return, the community is increasingly recognising the wider conservation benefits provided by these levels of fisheries management, and is adapting agricultural and forestry financial supports to promote practices in those industries that co-ordinate with the work of these levels of fisheries management. In this way, both groups, the anglers with their specific interest in particular fish and the wider community with its general interest in fish as wild animals and freshwaters as scenery combine to mutual advantage.

The ideal end for all fisheries management is therefore, whatever the starting situation, to create a state in which only "defensive" actions are needed, where fish stocks and their habitats are in such good condition that the appropriate management is simply to monitor and defend the *status quo* whilst continuing research to understand the basic mechanisms of fish production as insurance against future problems - the more that is known about the fish, the more economical and precise the responses can be to any problems that arise. To reach this stage requires the knowledge of what adversely affects fish to be widely disseminated through the land-using community, and the more that the community in general supports "best practice" in these land-using industries, the fewer the problems that will be created for fish (Diagram 5.11). In the final, mature, stage of freshwater fisheries management in a catchment, therefore, people are being managed for fish, rather than fish for people - essentially, treating the causes of problems (the activities of people) rather than the symptoms of the sufferers (low fish numbers).

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
Charity No. SC011055
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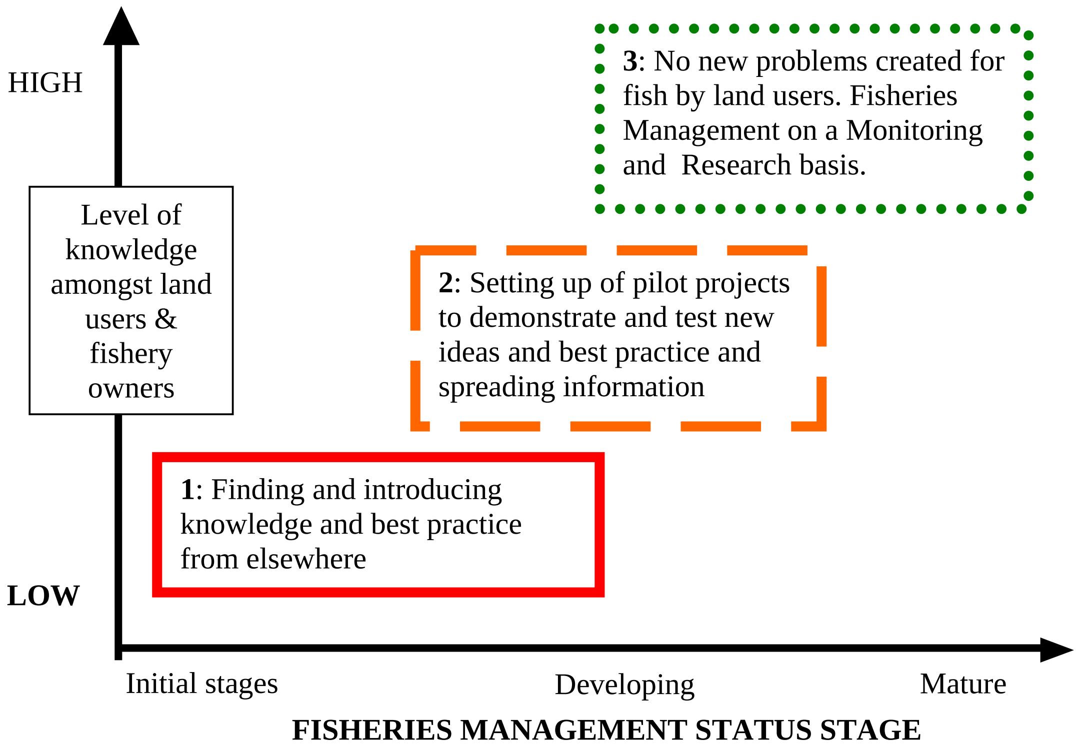
Diagram 5.11 - Managing people for fish



(F) Summary and Related Frameworks : The framework outlined in this Manual can be summarised as the identification of the present status of fish stocks and habitats, through the comparison of past and present states, and then the selection of the appropriate level of management to restore those stocks and / or habitats that have been damaged to a better condition and to protect those that are already in good condition so that they do not suffer any reduction in quality.

This is a similar strategy to that of the E.U. Water Framework Directive which calls for the present status of water bodies to be classified in relation to a baseline of "pristine" condition; plans to be drawn up for the restoration of damaged waters to the highest achievable status and no deterioration to be allowed in existing waters of good status - essentially " attacking" problem waters and "defending" good ones. A similar programme is envisaged in the

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Tweed Catchment Management Initiative consultation document (Anon. 2002), where the overall aim of the catchment management planning process is to :-

> "*to conserve, enhance and, where appropriate, restore the total river environment through effective land and resources management across the Tweed catchment*"

This strategy is, of course, similar to many others in many fields, but the point often lost sight of in Salmonid management is that it has to be more than just "crisis management", it also has to identify and defend stocks and habitats that are in good condition as prevention is not only better than cure, it is a lot simpler and a lot cheaper. The need to be "defensive" of fish stocks and habitats that are in basically good condition, as well as taking action to restore damaged habitat is also recognised in the NASCO "Plan of Action" for the protection and restoration of Salmon habitat (Anon. 2002). Among the guiding principles identified in this plan are :-

1) Protect the current productive capacity of existing habitat

2) Restore, in designated areas, the productive capacity of habitat which has been adversely impacted

- which is precisely what is meant by "defence" and "attack" in relation to habitat in this Management Plan (Diagram 5.10)

THE TWEED FISH CONSERVANCY CENTRE, DRYGRANGE STEADING, MELROSE, ROXBURGHSHIRE TD6 9DJ
Tel: EARLSTON (01896) 848271 Fax: EARLSTON (01896) 848277
email: info@tweedfoundation.org.uk
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