

AN ASSESSMENT OF THE RELATIVE  
IMPORTANCE OF FARM-REARED BROWN  
TROUT AND RAINBOW TROUT TO SPORT  
FISHERY MANAGEMENT IN SCOTLAND

By

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## ABSTRACT

Trout sport fisheries in Scotland, especially in the central zone, in order to meet the increasing demand are stocking their waters with farm-reared fish either substituting or supplementing the indigenous brown trout.

The objective of the present study is to assess the dependence of these fisheries on artificially reared trout, to estimate the current production of farm-reared trout for restocking purposes, to investigate the stocking policy of fisheries and finally to highlight farmers', fishery owners' and anglers' attitudes towards brown and rainbow trout. A questionnaire was sent by mail to trout fish farms with a few simple questions included (see appendix 1). Visits were arranged to some fisheries in the central zone of Scotland where owners or managers were interviewed using a questionnaire (see appendix 2). During the visits to these fisheries forty interviews were made with willing anglers using another questionnaire (see appendix 3). Finally, individuals with experience on the relevant subjects were contacted in Government Departments, angling clubs or federations of anglers.

Briefly, the results of the present study are as follows:

The current production of trout for restocking purposes by commercial fish farms is about 150 tons/year plus whatever the production is counted out by farms belonging to angling clubs, federations of anglers or individual fisheries. Fisheries in order to be maintained and meet current demand stock their waters with farm-reared trout. They prefer takeable fish which are stocked in waters mainly before and during the fishing season. Rainbow trout has become the basis for restocking due to its cheapness and high recovery rate to anglers. The majority of fishermen prefer the native brown trout which offers better quality fishing but rainbow trout gives them a better chance of catching fish.

In conclusion, fisheries close to big population centres are turning to 'put and take' fishing in order to meet the increased demand. The majority of anglers are brown trout devotees but more and more are gradually becoming rainbow enthusiasts. Rainbow trout fisheries on a 'put and take' basis seem to be the main development occurring in trout fisheries at present in Scotland. It also seems the only development that is likely to satisfy the increasing demand for high quality trout fishing.

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## INTRODUCTION

In Scotland, there is a growing demand for trout fishing due to increased leisure time in Britain leading to an ever expanding influx of tourists. Recent indications show that more and more visitors in Scotland come in order to enjoy some form of water activity. A survey in 1973 by the Scottish Tourist Board revealed that 10% of tourists participated in some form of water recreation with the majority being trout anglers.

Certainly, angling as a sport has been popular for many years but, its recent growth has highlighted the need for more angling waters to accommodate the demand.

The working week in Britain has contracted from 46 hrs in 1900 to approximately 35 hrs in 1976 and will probably drop to around 30 hrs in 2000. Coupled with this there has been rapid improvement in communications and transport, particularly noticeable in Scotland where remote areas are quickly becoming accessible to tourists.

All these factors have led to increased pressure on Scottish trout waters. Good trout waters are concentrated in Scotland which has meant that it bears the brunt of angling tourists. This is made particularly worse by the fact that England lacks many suitable trout waters due to either industrial pollution or enrichment of lakes. Hence, English anglers tend

to travel to Wales or particularly Scotland for their fishing.

The main pressure on Scottish trout lochs occurs in the central lowlands and Border regions but, with improved transport other lochs further North are also feeling the pressure. Trout fishing in still waters is also a cheaper sport in terms of equipment and permits than salmon or seatrout fishing, so this is a further reason for increased pressure on the former.

Certainly, trout permits for a day's fishing often average around £1 with many waters being free.

The increase in demand for trout fishing started just after world war II. At the time, it was soon realised, that many lochs would require to have their natural trout production supplemented by farm-reared fish if fishing demand was to be met. Brown trout proved difficult and costly to rear so, fishery managers turned to N. American rainbow trout Salmo gairdneri.

In the USA and Canada, this trout species had proved amenable to farm-rearing and hence production costs were relatively low compared with brown trout.

It also proved successful fish in terms of investment for the owner of a fishery as angling returns were high and hence customer satisfaction good. For these reasons, trout fisheries in Scotland began

supplementing brown trout populations with rainbow trout and so the growth at the 'put and take' trout fishery was ensured.

This started in the mid-forties and has led to a major tourist industry in Central Scotland where many small lochs have rainbow trout transplants for angling purposes.

However, demand is still growing for trout fishing so, to meet this and the future requirement for this activity careful management is needed. To aid management, information is essential on the present state of trout fisheries, how they are being managed and where improvements are required. This dissertation is concerned with these problems and is an attempt to throw light on the following points:

- 1) The state of trout angling at present in Scotland
- 2) Managerial policy with regard to some Scottish trout fisheries
- 3) Farm production of trout for angling waters.

The author has had to fulfil the above objectives by going to lochs, speaking to anglers and fishery managers, and fish farm owners.

The quality and amount of information varied with the whims of the people concerned and it soon became apparent that either few or no records were ever kept



or, people were unwilling to divulge them.

This being the case, it has made interpretation of trout angling and its management in Scotland very difficult, also recommendations for the future can only be tentative.

These points should be borne in mind when considering this project.

Certainly, it becomes increasingly apparent that if fisheries are to be carefully managed then present owners will have to be more willing to provide information.

LITERATURE REVIEW

Recent indications in Scotland show that the number of participants in water recreational activities and especially in trout sport fishing is increasing. This was highlighted after a survey carried out by the Scottish Tourist Board (1973). The same trend has been occurring in England and Wales over the last 30 years according to a survey carried out by the National Opinion Polls (1970).

Macfadden (1969) considered the trends in Freshwater Sport fisheries in North America and found that in year 2000, 18% of water users will be fishermen and that 70% of these will be fishing in freshwater.

Seeley, Tharratt and Johnson (1963) carried out a survey about California Inland Angling for 1959 and 1960 and they found that trout fishing is the most popular kind of angling. Over half of the licensed anglers in the State fish for trout each year.

In 1971, the Government White Paper on game angling in Scotland (H.M.S.O., 1971) stated that there existed a great need to make more waters available to the resident population and to visitors in Scotland.

A complete reorganisation of angling was suggested including the evolution of a new body,

The Scottish Anglers Trust (S.A.T.).

Cambell (1971) considered the growth of brown trout in Northern Scottish lochs and the possibility of the improvement of these fisheries. He pointed out that there are many thousands of trout lochs in Northern Scotland but, much of the angling has always been of poor quality, and in many cases improvement measures cannot be implemented for physical reasons.

Management of trout sport fisheries in order to meet the current demand must utilise farm-reared trout either to supplement insufficient natural reproduction or to substitute it, especially on areas with heavy fishing pressure. Barber (1976) referred to freshwater fisheries management in U.S.A. where private fisheries are most commonly 'put and take' lakes and many of the public waters have been managed by the Government on a 'put and take' basis.

Rainbow trout has become the main species for stocking waters due to its lower cost of production compared with brown trout and the former's higher recovery rate. Hunt (1972) carried out a brief assessment of the rainbow trout in Great Britain. He investigated the origin of present stocks of this species in U.K. and referred to some effects of this species on the native pop-

ulation of brown trout.

A more detailed study of rainbow trout in Britain and Ireland was done by Frost (1974). She referred to the acclimatisation of this species and its distribution in Britain and Ireland. It was found that there were only 5 waters in Britain (none in Scotland) where self-maintained population of rainbow trout existed.

Nowadays, stocking waters with farm-reared fish has become a useful tool in fisheries management. Whereas there are only a few reasonably managed trout fisheries in Scotland, there are very many in England, especially on standing waters.

Fleming-Jones (1974) described the development of a trout fishery at Grafham Water, administered by the <sup>Anglian</sup> Great Ouse Water Authority in England. Here the rainbow trout has proved to be more suited to the Fishery than brown trout since 1966 when the reservoir was the first time opened to trout fishing.

Some of the controllable factors affecting angling catch at Grafham Water Trout Fishery were investigated by Fleming-Jones and Stent (1975). It was found that there was a close relationship between annual catch and annual stocking in the case of rainbow trout.

A broad study which covered eighteen British reservoirs was carried out by Crisp and Mann (1977). They considered their management systems in an attempt to clarify options which are open to the managers of reservoir fisheries. Unfortunately none of those reservoirs are located in Scotland.

Millin<sup>m</sup>chap (1974) considered the conditions of a well-balanced, self-supporting ideal trout fishery and the changes likely to occur when the water is overfished. He analysed the function of a 'put and take' fishery and presented some useful ideas for their management.

Some very important information of the survival and vitality of hatchery-reared rainbow trout of catchable size come from a study carried out by Nielson, Reimers and Kennedy (1957) at Convict Creek in California. They pointed out the high mortality rate of rainbow trout during the winter and the importance of time of stocking.

The poor survival of autumn stocked rainbow trout was pointed out by Cragg-Hine (1975) for some lakes in Northern Ireland. He suggested the stocking of takeable fish before and during the angling season in order to overcome this problem.

Hammond and Lackey (1976) made some progress in fishery management by developing a computer-

implemented catchable trout fishery simulator as a new technique in testing alternative management objectives.

They stated the importance of catchable trout stocking activity in North America, supplying millions of anglers with an outdoor recreational experience. They referred to the public opinion which has always been strongly in support of trout stocking programs and is likely to so continue in the foreseeable future. Finally Hails (1977) considering the development of trout angling in Scotland attempted to determine the criteria used by fisheries managers in selecting different management methods and the magnitude of costs involved in management methods.

CHAPTER 1: TROUT ANGLING IN SCOTLAND1.1 The Distribution and Type of Trout Waters in Scotland

## a) What constitutes a good trout water.

Still waters (lochs-lakes-reservoirs) in order to be considered as good for trout they must be fed by streams with unpolluted water with good spawning grounds present. Trout survive in temperatures between  $0^{\circ}\text{C}$  ( $32^{\circ}\text{F}$ ) and  $25.3^{\circ}\text{C}$  ( $77.5^{\circ}\text{F}$ ) with an optimum around  $13^{\circ}\text{C}$  ( $56^{\circ}\text{F}$ ).

Certainly, growth is slow below about  $7^{\circ}\text{C}$  ( $44.5^{\circ}\text{F}$ ) and also above  $19^{\circ}\text{C}$  ( $66^{\circ}\text{F}$ ).

Regarding hardness of water, generally speaking, growth, is good in 'hard' alkaline waters and it is poor in 'soft' acid waters. A pH of between 7.0 and 8.0 is ideal for trout.

A sufficient amount and variety of good quality food must be available in the water. Trout must also be in waters of high dissolved oxygen concentration.

Regarding rainbow trout, they have very close requirements to brown trout but, they can tolerate higher water temperatures and lower concentrations of oxygen than brown trout. Shallow limestone lakes with high pH appear to be most favourable.

The above characteristics make a water suitable for trout but something more is needed in order to be a good

sport trout fishery.

The water must be accessible, otherwise it will remain as an unexploited resource. Sport fishermen are naturalists and they want to feel isolated when fishing from the banks. Thus a good vegetation cover is desired with anglers' swims hidden from each other. The angling water should also be relatively weed free because weeds interfere with fly-fishing.

Finally, if good facilities are provided by proper management this will make the waters attractive to anglers.

b) Where do trout waters occur.

(i) Highlands

Lochs and lochans in this area mostly on hard rocks or in peaty areas. Nutrient status of lochs is low due to poor mineralisation of surrounding soil, thus food supply for trout is low and the size of trout relatively small. Most populations here are self-maintaining and the anglers' pressure low due to problem of accessibility e.t.c.

(ii) East Coast/Moray Firth Waters

Partly as for highlands where lochs and lochans occur in hills but many lochs occur in lowlands.

Here farming occurs around lochs and enrichment through fertilizer run-off takes place. Also better mineralisation of soil and leaching of nutrients into loch waters occur, trout food organisms.



are more plentiful and trout grow larger. Angling pressure is higher here due to ease of access and there is more need to supplement natural trout production.

(iii) Central Belt

As for (ii), but angling pressure is extremely high due to concentration of people in the large towns of Glasgow, Stirling, Perth, Edinburgh and Dundee. Most of the trout fisheries in this zone are on a 'put and take' basis.

(iv) Borders Region

The situation is the same as in Central Belt with the exception of the occurrence of some lochs in nutrient poor waters.

Lochs in both (ii) and (iii) areas are on sedimentary rocks which wear more easily and produce richer soils. This in turn provides greater nutrient inflow to the lochs and hence higher trout production (e.g. Loch Leven).

At present some reservoirs which exist for hydro-electric schemes and mainly for domestic water supply are used for trout fishing.

However, in the highland areas in particular, there is a strong prejudice against the utilisation of reservoirs for angling because of fears of pollution.<sup>7\*</sup>

Reservoirs in Scotland are usually up on the hills, located on pollution free areas, where water is almost drinkable without treatment.

Hence, filter stations are designed to cope with relatively unpolluted water. These reservoirs would provide a very attractive stretch for recreational purposes but, they have been built for water supply and there must be a control on the amount of the recreational activities. Fishermen may cause pollution and with the present equipment at most reservoirs, water can not be adequately treated if it becomes too polluted.

Maybe for 200 people enjoying the reservoir's facilities, several hundred thousand pounds might be needed in order to protect water consumers against pollution caused by recreational activities. In England the situation is different, their reservoirs are pump-storage whereby the water is pumped from a river usually heavily polluted or enriched.

Therefore, recreational activities on English reservoirs do not create a problem in terms of pollution because the water purification systems are already built to deal with gross pollution from river water. In this sense, the minute amount of pollution which might occur due to angling is of no importance. Hence, reservoirs such as Grafham water in Huntingdonshire, have highly successful trout fisheries

even though they are domestic water supply reservoirs

Regarding Hydroelectric development which started in Scotland before the second world war, it should be observed that those schemes eliminate some spawning and feeding grounds for brown trout due to fluctuating water levels in the reservoir and inundation of spawning areas.

In lowland lochs, there is a danger of trout fisheries disappearing due to eutrophication or enrichment of waters from fertiliser run off from farm land. Loch Leven is an example where increase in use of fertilisers on surrounding farmland has increased the nitrate and phosphate levels in the lochs. This in turn has created large <sup>no</sup> weed and algal growths resulting in poor fishing conditions.

Further, when algal blooms have died down in the late summer, trout kills have occurred either due to oxygen depletion or release of toxins from the dying plants. Lowland lochs and lakes are good waters as far as food is concerned but, the majority of them, especially in the central belt of Scotland, have poor spawning facilities.

Loch Leven is an example where there is a self-maintained population of brown trout, so no stocking takes place. There are seven excellent feeder streams coming in over excellent spawning gravel beds.

In the best trout waters permits may be expensive as maintenance is costly in order to keep the waters in first-class condition.

Towards the end of the 19th century angling on many trout waters in the highlands, particularly lochs, was available to the patrons of the hotels which at that time catered largely for sportsmen. The widest exploitation of highland took place before the first world war, and since then angling pressure has built up considerably on the more accessible waters, while the less accessible are still often neglected (Cambell, 1971).

At present, most trout angling proprietors cannot stop unauthorised fishing on their waters and they take no steps to improve the fisheries. However anglers maintain in turn, that if legislation is changed to protect these privately-owned waters, then they will become exclusive and permits for fishing far too expensive. Therefore, trout fishing will become too costly for the ordinary angler. Mills (1970) noted that the anglers' fears were somewhat unjustified. Many estates have already leased fishing and are trying to improve fisheries in spite of unauthorised angling. Mills also states that lochs are charging reasonable prices so that angling for trout is not in danger of becoming exclusive. However, it is apparent that there are far too many

lochs which are privately-owned which are not being managed and could provide good trout fisheries.

In 1971 the Government White Paper on game angling in Scotland stated that there existed a great need to make more waters available to the recreationists in Scotland. A complete re-organisation was suggested for the developing of angling including the evolution of a new body to organise trout angling in Scotland, the Scottish Anglers' Trust (SAT).

In conclusion, there are numerous trout waters in Scotland but most of them, <sup>no</sup> inaccessible to fishermen. The good quality, accessible fisheries, have been overfished and so demand for good waters is creating a necessity for proper management. Sources for trout sport fishing in areas near big city centres cannot, with only a few exceptions, offer fishing opportunities any longer and in order to meet the tremendously increasing demand they have to turn to "put and take" fisheries.

## 1.2 Rainbow Trout and the Possibility of Self Maintained Populations in Scottish Waters

The rainbow trout has a range which is restricted to an area in North America extending from Alaska to Mexico. It is easily recognised by its caudal fin which has dark brown spots on, plus the presence of

a magenta band along the lateral line. The rainbow trout is at once distinguishable from the brown trout which has numerous brown spots, often with dashes of red.

Its introduction to Europe dates back about 100 years, when in 1882 it was first brought from the Sacramento and McCloud rivers in the Shasta mountains of California. Introduction into Britain occurred in 1884 when eggs from the United States were brought to England. Unfortunately, the first attempt at introducing this trout was unsuccessful and was followed by a second the year after, when eggs were sent to the National Fish Culture Association at Delafield and also to the Howietoun hatchery, in Scotland.

There are two forms of the rainbow trout, i.e. the steelhead trout which is a rainbow that has spent some time at sea feeding and the rainbow which has spent all its life in freshwater. This is similar to brown trout where some individuals remain in freshwater and others go to sea to return as sea trout. Both species spawn in small streams rich in gravel beds. In addition to the migratory habits the "steelhead" can be distinguished from the freshwater rainbow by the numerous smaller spots on the head, the less pronounced magenta band, the larger

head and the more elongated shape.

Worthington (1940) presented a tentative classification for spawning races of rainbow; the "shasta" spawning in late autumn and early winter and the "irideus" type spawning in spring. This is not recognised as a taxonomic difference but is simply used in Britain to indicate to which spawning race a fish belongs.

Worthington also stated that early introductions of rainbows consisted mainly of the "Shasta" type whereas later imports were mainly "irideus" and hybrids of the two races.

Present stocking of rainbow trout includes mixtures of "steelhead" and non-migratory rainbows. However, where stocking has occurred in waters with connections to rivers, or in rivers, rainbows tend to migrate seawards. There has also been records of "steelheads" entering Scottish streams from rainbow transplants in Continental waters. From about 1939 onwards farm rearing of rainbows started in Britain and stocks for fisheries were increasingly obtained from this source.

At present, there is complete mix in the gene pool of the species such that young produced from parents spawning in autumn, will contain individuals spawning throughout the year.

Information about the present distribution of

rainbow trout in Britain come from a study done by Dr W.E. Frost (1974). The number of waters in Britain holding rainbow trout in 1940 was about fifty to fifty-five, and from those only one in Scotland, the Howietoun Fish Hatchery (Worthington 1941). The survey by Frost indicated that four hundred and ninety one waters were known to hold rainbow trout in Britain, but the real number could be higher.

Rainbow has been stocked in both still and running waters, also in man-made and natural lakes, gravel pits and reservoirs. Rainbow can exist in a wide range of temperatures but the optimum is between  $12^{\circ}\text{C}$  and  $20^{\circ}\text{C}$  whilst extreme temperatures below  $5^{\circ}\text{C}$  and above  $25^{\circ}\text{C}$  affect their feeding behaviour. This species is also tolerant to a wide range of pH and grows well in hard<sup>no</sup> and soft water. Most of the waters holding rainbow in Scotland are standing waters, almost certainly reflecting the increased demand for trout fishing during the past twenty years.

The 1971 survey showed that rainbows were only able to successfully reproduce in five waters in the UK.

Four of the above self-maintained populations are in limestone regions, the water spring fed and alkaline in reaction but Lough Shure lies on non-limestone formation (granite) with water definitely acid in reaction.



*Dartmouth*

The Wye river with self-maintained population was stocked by accident with selected Blagdon rainbows in 1910. Rainbow soon became numerous and replaced the brown trout populations. Temperatures in Wye remain fairly constant throughout the year, rarely falling below 54°F (Hunt, 1972).

If only these three factors, pH, hardness and temperature are decisive to the rainbow's successful reproduction then, many waters in Britain should be capable of having self-maintaining populations of rainbow trout.

A possible reason for the failure of rainbows to naturally reproduce could be the effect of interactions with the native brown trout. The effect of the brown trout on the rainbow's life history may be one of predation on fry and occupation of feeding sites suitable for rainbow trout fry. Brown trout fry appear in March as this species spawns in November-December. Rainbows, in contrast, spawn in February and fry emerge in May. By this time, the brown will have occupied all the best territories and rainbow trout fry will find it hard to displace them. Brown trout will also have had a month to six weeks start, in terms of growth, and so may be of a size where they could predate the small rainbow fry or certainly their older counterparts could predate the rainbows.

Often many rainbow trout populations have little chance to form self-maintaining populations due to the combination of competition with brown trout and predation by anglers. It may be that the latter has the effect of reducing rainbow numbers to a level at which they cannot compete successfully with browns. Possibly, if left unpredated by anglers, rainbows would compete far more successfully with brown trout than they do at the moment.

In Scotland, only rainbow trout in the Lake of Menteith, are known to spawn but generally not successfully enough to maintain the population. Perch rapidly deplete the fry (Nisbent, pers. comm). However, Sedgwick (pers. comm) has noted rainbow trout fry in two rivers in Scotland so this species may be adjusting to the environment in more waters than realised at present. However, even though these cases occur most waters still require continual stocking of rainbows to maintain their populations. The fear is growing amongst conservationists and anglers in Scotland that eventually rainbows will establish "wild populations". Certainly, with the mixed genetic stock being used haphazardly for stocking fisheries, it is very plausible.

Therefore, there could be a danger that some native brown trout stocks might be endangered by

competition with rainbows and eventually replaced as in the Wye.

Scotland has been renowned for its Brown trout, particularly the wide varieties of this species occurring in isolated lochs. The dilemma is how to ensure the native trout is not endangered while at the same time rich fishing is provided for the ever increasing number of trout anglers.

### 1.3 Trout Angling and the Law in Scotland

For trout fishing the law is not very stringent in Scotland. There is a statutory close season for brown trout from 7th October to 14th March inclusive.

The angler in Scotland does not require a rod-licence, but he has to obtain the written permission of the proprietor owning fishing rights on a particular whether that proprietor is a private individual, a company, a local authority or an angling club.

Trout sport fisheries in Scotland are covered by the Act of 1976, according to which there is no public right of fishing in freshwater. This is contrary to widely held belief of the angling public. The only water where there is a public right for brown trout fishing is the tidal from which salmon and sea trout are excluded. The rights of fishing

for trout belong to the riparian landowner, and where a stream forms the boundary between properties, the general rule is that the boundary runs along the middle line of the water body. Fishing rights may be held independently from the riparian ownership.

Trout fishing is only permitted by single rod and line with legal lure, whereas using otter-boards, cross-lining or set-lining is illegal.

Most of the trout fisheries do not permit fishing on Sundays and where it is looked on with disfavour in some Northern and Western areas. The reason for this is that overtime for staff on Sundays mean higher cost and this is what water owners want to avoid. Also, the church dictates that no work or sports activities is allowed on a Sunday, very common in Western Highlands and Islands.

Basket limits, methods of fishing, minimum takeable size and any other regulations are set by the individual fisheries.

Brown trout in Scotland is considered a natural heritage and you can fish anywhere, although legislation has been before Parliament and has been passed to produce a "Protection Order" on certain waters, under the provisions of the Freshwater and Salmon Fisheries (Scotland) Act of 1976.

Regarding rainbow trout which is not indigenous in Scotland, it is considered as a private property and taking them without the proprietor's permission constitutes a criminal offence (i.e. theft).

There is no statutory close season for rainbow trout and the general rules for fishing do not apply to them.

Most of the rainbow fisheries operate in a period between April and September.



Figure 1.  
The distribution of  
visited trout fisheries  
in Scotland.

Key

⊙ Trout Fishery

Scale 1:2 500 000

## CHAPTER 2: SPORT TROUT FISHERIES MANAGEMENT

### 2.1 Stocking Policy

Data collected for this study comes from twelve fisheries located in the central zone of Scotland which is the most heavily populated part of this country.

Those waters are either pure 'put and take' fisheries or natural trout fisheries supplemented by farm-reared fish, because of their low natural reproduction which is insufficient to meet the current high demand for trout fishing.

Visits were arranged to those fisheries and their management policy was discussed with the owners or managers. Some of their responses regarding species stocked, number of fish put into the water, size of fish planted, season of the stocking operations and numbers of fish caught by anglers are tabulated in appendix 4.

Due to the nature of some questions (See appendix 2) not all the responses could be included in the table, but they are presented in other parts of this study.

In spite of the many differences in stocking policy among the fisheries, a general pattern does emerge. What follows is an attempt to present these general management concepts together with specific knowledge gained from visits to individual fisheries.

Many things, some quantifiable others not, determine a fishery manager's approach to satisfying anglers needs. The overriding factor is economic, that is the cost of stocking. Fisheries must make a profit so the cheaper a species is the more likely it will be used. Obviously, a fishery will only be profitable if the anglers frequent it. Therefore, anglers requirements must be met. Here, one encounters many intangible factors, Some anglers want a high success rate for the money they pay, others simply want to catch a large fish, yet others are not interested by numbers or size but like a good fight for their fish. All of these needs have to be fulfilled to some extent in every trout fishery. Aesthetics may also be important, in that anglers also wish to fish in pleasant surroundings so management in terms of landscaping may also be necessary.

Finally as fish which are caught inevitably end up on the table, the eating quality of fish is also crucial.

#### 2.1.1 'Put and Take' and 'Long Term' Concept

In Britain and Continental Europe, the situation in most sport fisheries is that too many anglers



are chasing too few fish. Overfished waters are often not capable of producing sufficient 'wild trout' through natural production to satisfy the present demand of anglers, or provide the same quality fishing as in the past (Sedgwick 1973).

Certainly most anglers note that many lakes and rivers have deteriorated in their quality of trout fishing compared with times past. Only those lochs in remote areas or protected on private estates seem to maintain healthy angling stock due to low fishing pressure.

Frost and Brown (1972) stated that the tendency for over-fishing trout waters was not only because of angling pressure in terms of numbers, but, also because of improved angling technology. Due to both of these factors, the need for managing trout waters became apparent soon after the last war.

The first type of management policy to be implemented was the 'long term' concept. That is brown trout waters, which failed to provide sufficient fish under increased angling pressure, had their natural populations supplemented with young farm-reared fish. These young fish were stocked below a takeable size and utilised natural food in the environment to achieve the weight at which they could be taken.

This policy was very effective where angling was relatively light. It also had the advantage of maintaining the 'wild' nature of the trout population. That is the small fish would take on 'wild' characteristics very quickly and provide good sport to the angler. Two problems were the cost of rearing brown trout and the poor survival of small fish in the wild. Various researchers have shown that in order to crop one two year old fish, 250 fry must be initially stocked in the water. Therefore, if one has a takeable trout population of 2,000, 20 cm (8") trout, one would need to stock 250,000 fry in order to increase this by even 50% and it would probably need two years from stocking before the increase became noticeable.

Millichap<sup>m</sup> (1974) pointed out the economic impracticability of this type of management policy because 1000 2 year old fish is cheaper to stock with than 250,000 fry.

With the increased angling pressure in recent years, it became apparent that this expensive leisurely approach to management policy would not do. The most widely adopted management scheme for trout waters at present is the 'put and take' policy.

To counteract 'long term' stocking problems and meet anglers' demand, managers stock fisheries

with farm-reared trout of a takeable size. This policy has the advantages that one is not reliant on natural food production in the loch to ensure growth of fry to a takeable size.

Secondly, there are plenty of large fish for anglers to catch. Often anglers will be quite happy to catch a few large fish rather than many small ones. Obviously, as brown trout have many problems in farm conditions the rainbow has been adopted as the main fish for 'put and take' trout fisheries. The use of this species has also been dictated by the type of angler who uses these types of fisheries. That is they are after a quick success which the rainbow provides. Many 'put and take' lochs are simply large keep tanks with trout often stocked above the carrying capacity of the waters.

Hails (1977) gives an example of an artificial fishery in Scotland where the fish are stocked at a density of about 100/acre (40/Ha). This represents a standing crop of Ca. 56 Kg/Ha of takeable fish. This standing crop is in fact the equivalent of the very best natural fisheries.

However, before food shortage becomes a problem anglers quickly reduce the population to a level

where competition for food is negligible.

A 'put and take' trout fishery can be developed in any standing water where the physical chemical and biological characteristics are suitable for trout.

Therefore, gravel pits, reservoirs, or even natural waters which lack spawning grounds can all be used. This is because one is no longer reliant on natural reproduction to maintain the population. Therefore, a wider variety of habitats can be used for trout fishing thus reducing pressure on the natural well-known angling waters.

#### 2.1.2 Time of Restocking

The time of restocking of a 'put and take' fishery is of paramount importance and successful sport fishery management very much depends on this factor.

There are several alternative policies and each of them has certain advantages and disadvantages and of course, each has its devotees amongst the water managers.

Brown (1969) advocates spring planting for both brown and rainbow trout. Her thinking behind this, is that stew pond reared trout, artificially fed until transferred and planted may well suffer

mortality if put in waters during a season when the natural food will be declining. Trout planted in spring encounter increasing food supplies and become acclimatised to a new natural environment without too much mortality.

Brown's thoughts refer to reservoirs where in winter there is a decreased food supply which could really affect the newly introduced fish. However, there are waters where even in winter there is a reasonable supply of food and in this case autumn stocking could be successful (Menteith lake-Portmore loch). D. Cragg-Hine (1975) referred to the results of an extensive programme of inland development in N. Ireland which had been carried out for seven years by the Department of Agriculture of Northern Ireland. The overwinter mortalities of rainbow trout estimated in these experiments ranged from 71 per cent to 98 per cent.

To find out the management policy as regards time of stocking in Scotland, a questionnaire was produced by the author. Individual water owners or managers were contacted personally and asked to fill in the questionnaire (see appendix 2 ). The following conclusions emerged for standing water fisheries in Scotland:

The bulk of the fish is stocked either before or during the angling period; the most popular time being spring (March-April-May). Some of the water owners put forward the reason of predation either by birds (mainly Cormorants) or fish (Pike and Perch). A pike of 24 kg weight was killed in <sup>C</sup>Gobbinshaw Loch and it had a trout of 1.0 kg in its stomach (Thomson, pers. comm).

In some cases brown trout is stocked in autumn, whereas rainbow in the same water is stocked either before or during the fishing season (i.e. the spring/early summer). The supporters of this policy believe that brown trout is a hard fish and can stand the winter's unfavourable conditions. Where lack of food is not a problem due to rich fauna and flora in the water, stocking takes place all through the year, with the main stocking done during the fishing period, month by month, especially with rainbow trout (lake of Menteith, Nisbent, pers. comm).

Two approaches to stocking occur. One is where a large stock of fish is introduced early in the fishing period. Angling is very good for several weeks then tails off and will not be of

the same quality until restocking occurs. Where lochs have a policy of one or two stockings per fishing season, fluctuations in angling quality as mentioned above will occur.

The second method is to restock continuously, that is weekly in the case of very heavily fished waters. In this way, fishing quality is maintained throughout the season, probably at some cost, in money, to the angler, (see Fig 2). Reducing the number of stocked fish and increasing frequency of plants have been suggested to provide a more uniform rate of return (Butler and Burgeson 1965).

The main disadvantage of the numerous stockings is that frequent transportations of fish from a commercial farm increase costs for the owner. To cut expenses fish are often kept in stew ponds near the fishery for regular transfer to the loch with no cost in transportation.

Another disadvantage of restocking during the fishing period, is the inability of the stocked fish to acclimatise to the new environment and attain the wild character and high sporting quality that natural fish provide to the fishermen. The above disadvantage is balanced to a degree by the presence of fish surviving from the previous year stock and of course 'wild' brown trout.

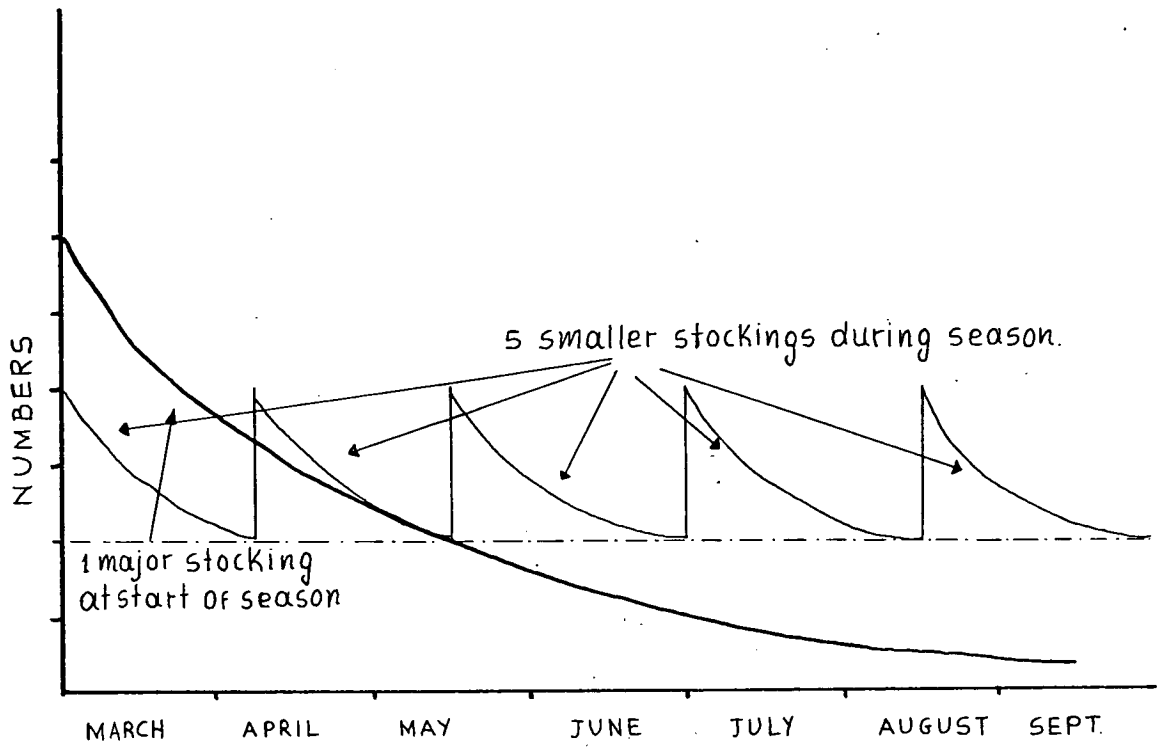


Figure 2. Timing of "put and take" fishery. (From Millichamp, 1974)



Time of stocking seemed to be very dependent on the character of the individual water, so that from questioning several fishery managers it seems they use a 'rule of thumb' guide of their own experience to decide stocking policy in most cases.

However, Templeton (1970) does come down strongly for spring stocking. He was looking at the advantages of spring or autumn stocking of brown trout in a Yorkshire reservoir.

### 2.1.3 Size of Stocked Fish

Size of fish to be stocked in a 'put and take' fishery is largely determined by two main factors:

- (i) The relationship of size to angler success
- (ii) The cost of producing a fish of the size required by (i) artificially

When one stocks with fry or yearling fish, there is always the problem of predation. Young fish are very much more susceptible, particularly below 20 cm. Another problem when stocking with young fish, is that reliance has to be placed on the loch's natural food supply to provide sufficient for the young trout to achieve a takeable size.

As food supplies fluctuate through the year, this can provide many problems and usually considerable loss in many young fish. If stocked at a small size, trout will also be open for a longer period of time to the chances of disease or attack by parasites, causing further mortalities. For one or all of these reasons, most fishery managers tend to stock with fish of a takeable size to the angler.

The relative costs involved in stocking with small or large trout were convincingly demonstrated by Hails (1977). He calculated the costs of a hypothetical fishery with a catch of 6500 brown trout per annum from a loch of 100 acres. The results are presented in table 1. His figures clearly show the economic advantages of stocking with large fish.

Age	% Survival to Creel	No. required	Cost £
0+	1	650,000	38,350
1-	5	130,000	15,730
1+	15	43,000	9,503
2-	40	16,250	6,906
2+	65	10,000	5,600

Table 1: Comparable cost of 6,500 takeable fish (From Hails 1977).

During visits to several fisheries by the author of this present study, he found that most fisheries stock rainbows at sizes between 28-35 cm, averaging 30 cm and brown trout between 23-30 cm, averaging 26 cm.

Rainbows were usually about 1+ and brown trout 2+ years old.

Workers in other areas have underlined the advantages of stocking with large takeable trout.

Oliver (1968) suggested that using stock fish of about 30 cm has the advantage that they consume unwanted coarse fish fry, particularly of Perch and Pike. This has the advantage of reducing both potential competitors and predators of future trout stocks. Crisp and Mann (1977) investigated 18 reservoir fisheries in England and they found that trout used for stocking varied from 13 to 41 cm in length, but most fell within the 25-33 cm range and consequently most of the stocked fish were of takeable size at the time of stocking.

To summarise, large trout be it brown or rainbow have better survival rates, lower costs and better returns to anglers than small fish.

#### 2.1.4 Stocking with Brown or Rainbow Trout?

The problem for most fishery managers is

whether to retain a fishery with native brown trout, have a species mix of brown and rainbow or, simply have rainbows if no natural trout population is present.

Rainbows have the economic advantage of growing rapidly to a takeable size (with low mortalities) in fish farms. These trout can usually be stocked in lochs at age 1+.

Concomitant with rapid growth is a short life span so, they need to be caught quickly or they will represent an economic loss.

However, rainbows are easily caught and have a high return rate in most angling waters.

Brown trout are the reverse in almost every aspect in that, they are difficult and costly to rear taking two years to reach a takeable size for stocking. However, slow growth has the advantage, that food requirements are lower in the natural habitat. Hence, in periods of low food supply such as winter, browns survive better than rainbows. Slow growth also means greater longevity so whereas, the rainbow only rarely achieves five or six years of age, a brown can live into double figures.

The brown trout also achieves a greater ultimate size hence its presence in a fishery is

useful because it will provide that occasional, large, high-quality fish for the keen angler.

Brown trout are also highly prized by many anglers because they are the indigenous species, this intangible quality may also be important in considering whether to stock with a species mix.

Rainbows do have the advantage of a wider tolerance of water quality particularly as regards oxygen levels. They can also withstand higher water temperatures than browns. Therefore, rainbows are excellent in shallow eutrophic reservoirs and lochs where relatively high water temperature and low oxygen concentrations may be common in summer.

Certainly, for fishery managers, rainbows are more economic than brown trout. The former are easier to catch than the latter and this is important in determining whether an angler will return to one's fishery.

Unsuccessful fishing days will deter the angler from returning to a particular water. Rainbows are therefore very desirable for short term stocking over the spring and summer season when most anglers visit trout lochs.

Browns provide the alternative high-quality sport fishing. The two species will therefore complement one another in a mixed fishery.

As Sedgwick (1977) points out browns are usually stocked for long term management. That is they will live longer, are more difficult to catch than rainbows and hence provide the occasional very large trout for the experienced angler.

Stocking with brown trout can be very successful as Beausang (1966) noted for Irish waters. These browns were stocked as autumn fingerlings at 60-80 fish per kg. At this size survival rates were high whether stocked in rivers or lakes even in the presence of 'wild brown trout'. These farm-reared browns also reverted to the 'wild characteristics' very rapidly on stocking such that they were difficult to catch but provided excellent sport for the good angler.

The characteristics of the two trout species are summarised in table 2.

The point which emerges from looking at the two species is that they provide very different types of alternatives for a fishery. The rainbows being easy to catch, are a useful species for in-

Characteristics	Brown	Rainbow
Growth in hatchery	Poor	Good
Growth in wild	Poor $\kappa$	Good
Life span	Long	Short
Winter mortality	Low	High
Catchability	Low	High
Quality for table	Good	Poor $\kappa$
Environmental need	Acid-alk. cold	Alk-high-er tempt
Disease susceptibility	U.D.N.	I.P.H. <sup>N</sup> , eye fluk

Table 2: Comparative characteristics of brown and rainbow trout.

experienced anglers or ones who simply want to catch a fish and nothing more. The brown trout being a good fighter and difficult to catch, provides a high-quality sport fish for the experienced angler. Therefore, a managers' choice of species will undoubtedly be dictated by the clientele and their needs.

From this present study, it became clear that most fisheries prefer a species mix so that a broad

spectrum of anglers can be satisfied.

However, the emphasis is on rainbow stocking because of economics and the fact that most anglers are not wanting to spend too long in catching a fish.

## 2.2 Some Factors Affecting Stocking Policy

### 2.2.1 Relative Cost of Each Species

Question No 2 of the questionnaire sent to fish farmers was related to the cost of trout reared for restocking purposes, but as the few replies received were vague, the author had to rely on the data given in table 3 by Game Fisheries. Game Fisheries Limited is a company managing a few fisheries in Fife County and they also produce fish for selling to other fisheries. Costs for brown and rainbow trout produced by this company are considered as an example of present market costs in Scotland for each trout species.

From this table, it is obvious that brown trout is more expensive to rear than rainbow and in spite of the present demand by fisheries farmers are reluctant to rear them in sufficient quantities, because of the high investment required in time and money.



Species	Fish Length (cm)					
	20.5	23.0	25.5	28.0	30.50	33.0
Brown Trout	330.00	457.00	631.00	843.00	1038.00	1388.0
Rainbow Trout	300.00	379.00	506.00	598.00	756.0	935.00

Table 3: Prices of brown and rainbow trout (£'s/1000  
(Game Fisheries Limited).

From the present study it was found that fisheries have a tendency to stock with rainbows of mean size 30 cm and browns 26 cm (see appendix 4 ). We see from table 3 that 30.5 cm rainbows cost £756.00 per 1000, whereas brown trout of 25.5 cm cost £631.00/1000 so, one would think that brown trout is the cheaper fish for stocking.

In practice, the situation is different when browns and rainbows of the same size are compared. 30.5 cm browns cost £1038.00/1000 as compared with £756.00 for the rainbow so, undoubtedly the latter is cheaper to rear. In terms of economics the fishery manager likes to stock with small browns of about 25 cm but a dilemma occurs because the angler likes fish of 30 cm and above.

Fortunately, prices of trout at fish farms in Scotland have been stable for the last two years after an abrupt rise of 25% in 1976. This represents an

increase of 12.5% per year which is not an unreasonable increase in costs for the anglers to meet.

### 2.2.2 Recovery Rate

The numbers of fish caught by anglers as compared to the numbers of fish stocked is the recovery rate. This is of vital importance to the management of a fishery.

A high rate of return to the angler means he will be more likely to return and hence, the manager will sell more permits and have better returns on his initial outlay.

Recovery rate is determined by a combination of factors as listed below:

- a) Skill of fishermen. This varies and is dependent on their ability to assess what the fish are feeding on and adjust their tackles accordingly. Since on most Scottish waters only fly-fishing is permitted an angler must use either a 'wet' or 'dry' fly and this requires a certain degree of competency.
- b) Feeding biology of the species. Rainbows are considered surface feeders or just sub-surface and so, are more easily taken

by traditional fly casting. The brown trout is a deep water feeder and hence, requires far more skill to capture.

- c) Food availability. If food is abundant for the stocked fish then they may not take the fly except reluctantly. During food scarcity anglers catches would probably increase.
- d) Weather. This can have several effects on angler's catch. Wind for instance can be a problem when it is strong. High temperatures can also make the fish retreat from warm surface waters to the cool depths of the loch. Calm sunny weather has this adverse effect. The best conditions are a bright cloudy day, with a slight breeze causing slight surface ripple. This obscures the fishes' view of the angler and cloud plus wind keeps the surface waters cool.
- e) Angling pressure. Data for seven years from Cameron reservoir give a correlation coefficient between rod pressure and catch of  $+ 0.869$  ( $p = 0.05\%$ ) (see figure 4). Unfortunately most fisheries the author visited

Number of fish.

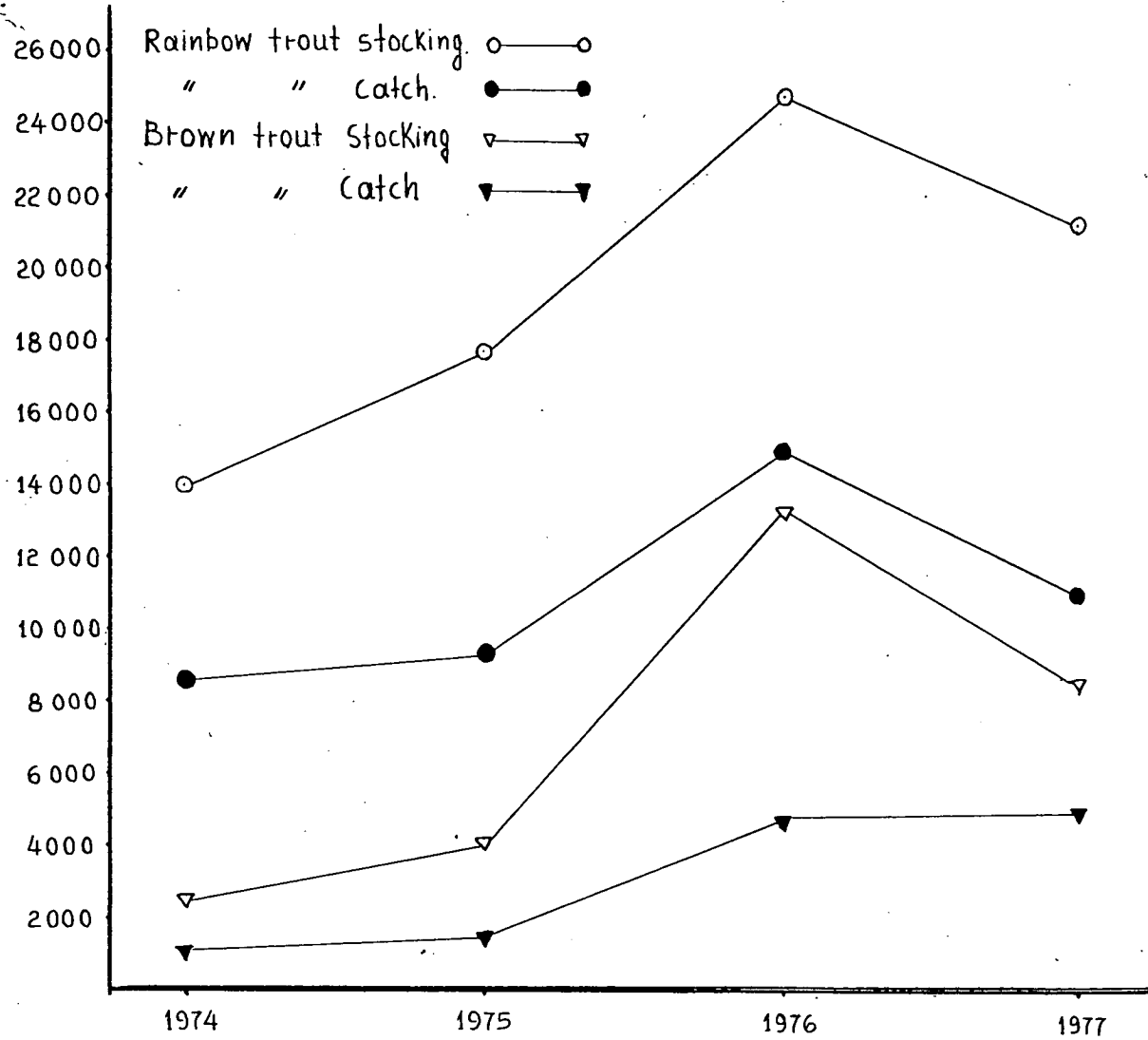


Figure 3. Four Fisheries: annual stocking and catch 1974-1977

did not provide such data either because they did not have or were reluctant to divulge it.

In figure 3 stocking per season and catch per season for both rainbow and brown trout, are plotted for the period 1974-1977 for four fisheries included in the present study.

The graph suggests a closer relationship between catch and stocking for rainbow trout than for brown trout. There is a linear relationship between catch and stocking with a correlation coefficient of +0.95 ( $p = 0.05\%$ ) and only +0.78 for brown trout.

Fleming-Jones and Stent (1975) showed a positive correlation between stocking and catch of rainbow trout in Grafham water in England  $r = +0.96$  ( $p = 0.05\%$ ). For brown trout in Grafham  $r = +0.69$  ( $p = 10\%$ ) which shows again that the relationship between initial stock density and anglers catch is not as significant for brown trout.

Of course not all anglers report their catch but, it is assumed that these are the ones who do not catch fish but there is the possibility of errors in returns.

Data from the catch returns are tabulated

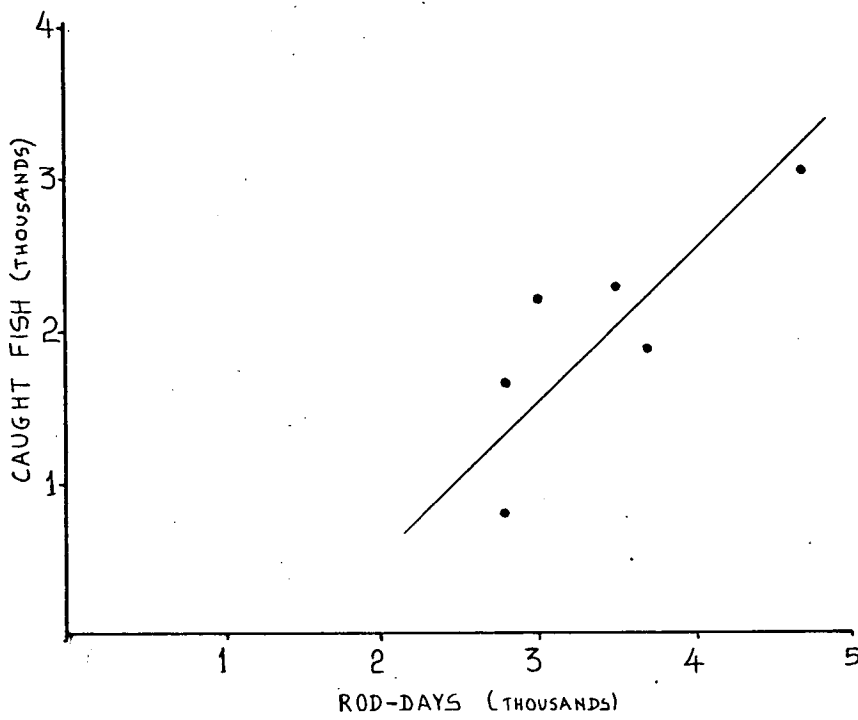


Figure 4. Relation between anglers' pressure and caught fish at Cameron reservoir.

in appendix 4 for 6 Scottish fisheries.

The recapture for rainbow trout during their year of release was on average, 53% and ranged from 45% to 65%.

The recapture for brown trout was about 48% and ranged from 36% to 73%. The extremely high return (73%) comes from the <sup>ζ</sup>Cobbinshaw Loch, a water fished by the members of a fishing club. This unusual brown trout catch may be due to the fact that 90% of all trout used for were browns. Therefore, one would naturally expect to catch more of this species than rainbows as the browns comprise the bulk of the population.

Another explanation for the high return of brown trout (the only exception to the waters studied here) could be the high elevation of the <sup>c</sup>Cobbinshaw loch, a water considered as typical brown trout's fishery.

Evidence from the trout fishery at Coldingham loch, claimed to show that stocking rainbows and browns at the same density ensured the best results for anglers returns. They had a high return of browns under these conditions.

If we exclude <sup>c</sup>Cobbinshaw then, the average recovery rate for brown trout was about 40% of initial stocking with a difference between the two species of about 13 per cent. This is very similar

to the findings of Crisp and Mann (1977) and those of Frost (1974). Comparative results of several studies are given in table 4.

Fishery	Author	Range of recovery rate		Mean Percentage	
		Brown	Rainbow	Brown	Rainbow
11 English reservoirs	Crisp & Mann (1977)	14.3 - 83.9	39.6 - 79.2	49	60
Grafham water (England)	Fleming - Jones & Stent (1975)	12 - 21	40 - 79	22	63
Eyebrook Res. England	Oliver (1968)	-	-	75	60
Present Study		36 - 44	45 - 65	40	53

Table 4: Comparative results of recovery rate.

### 2.2.3 Fishing Quality

There is no doubt that farm-reared fish fed at the water surface with pelleted food will behave differently to 'wild' trout when stocked in natural waters. As previously mentioned, reared fish will tend to congregates at the surface and take flies





more easily than wild trout, rainbows being easier to catch in this way than even farm-reared brown.

As these fish are taken so easily, anglers are sometimes not satisfied with the sporting quality of rainbows, that is they do not give a good fight. One answer maybe to stock rainbows before the angling season starts so that they have more chance to acclimatise and hence are not so easily caught. Late winter-early spring might be suitable but fish would still have to be stocked during the angling season to maintain anglers returns. Certainly, many anglers do prefer the sporting quality of the brown because of its fighting quality and the careful tactics required for its capture.

Fishing quality is therefore an important consideration in management policy and will be determined by the experience and needs of the angler. The angler will have to remember the higher the sporting quality that is sought, the more expensive the fishing is likely to be.

### 2.3 Interaction Between the Native Brown and the Exotic Rainbow Trout

When fishery owners were questioned as regards the effect of rainbow trout on brown, there was the following response: 50% of them said that interactions

did occur and were mainly of a competitive kind for food organisms. This idea is supported by the fact that the diet of rainbows both in running and standing waters is essentially the same as brown trout, namely adult and aquatic insect larva, molluscs and shrimps (Worthington 1940 and 1941).

Frost (1974) studied the inter-relationship between rainbow and brown with regard to food, living space and breeding facilities. He found that there was no basic conflict between the two species. It was recorded that rainbows did not affect the brown trout fishery, neither in size nor condition of the fish. The number and size of brown trout caught did not decrease in the presence of rainbows.

We have already referred to the possible competition between the autumn spawned fry (0+) of brown and the spring-spawned fry (0+) of rainbow trout.

Rainbow trout as a large predatory fish may affect to a certain degree brown trout fishery by adopting aggressive territorial behaviour.

An incident supporting this behaviour comes from Grafham water in 1966-67 when in the early months

of development, the rainbow dominated the fishery and gave the bulk of caught fish. Later in the fishing season the brown trout came into their own, due to the fact that large rainbows had been caught.

Tombleson (1978) relates his own experience when fishing a small gravel pit. The water had been stocked successfully with brown trout for many years but when rainbows were introduced the system was upset.

The rainbows dominated the littoral feeding areas and ate so much food that the browns deteriorated in condition having been forced into midwater where there was less available food.

Competition of this kind will only be a problem where fish are stocked at levels where the carrying-capacity of the water is exceeded.

In most 'put and take' fisheries interactions between browns and rainbows are generally reduced rapidly by anglers removing the more easily caught rainbow.

Unfortunately, so little work has been carried out on the behavioural patterns of both species of trout, in relation to each other that, trout sport fishery managers can only base their stocking policy on personal experience.

#### 2.4 Loch Fitty, A Case Study of an Intensively Managed Lowland Fishery

Loch Fitty is a natural lowland loch of 160 acres situated in Fife. It is near a number of populated areas such as Dunfermline and Glenrothes. It is a typical example of a trout water, managed completely as a 'put and take' sport fishery. It is fed by a small stream which is flowing in from the North West. The spawning facilities for the brown trout are poor, as the gravel in the burn has been badly silted through mining, quarrying and fire clay digging operations for at least 100 years. The effective length of the burn for spawning purposes is also no more than 2.5 km.

Game Fisheries Limited purchased the loch in 1969 and in the following year with the piscicide rotenone (concentration 0.025 p.p.m) all the coarse fish - mainly Perch, Perca fluviatilis and Pike, Esox lucius were cleared from the loch. Pike however, reappeared three years after treatment and pike gill netting now must be carried out annually.

Weed control is necessary each year because the loch is shallow eutrophic water Mackenzie (1975).

There are 16 boats available for letting to anglers, a furnished fishing lodge and also a fully stocked tackle shop. Only fly fishing is permitted

and further details about regulations are shown on table 5.

Time of fishing	Duration	Charge for fishing
Day Fishing	10 am - 5 pm	£7.50
Evening Fishing	5.45 pm - dusk	£9.00
	(In June it can be up to midnight)	(£8.00 before 14th of May and after 23rd July)

Table 5: Trout angling charges at Loch Fitty

An additional income for the fishery comes from the sale of brown and rainbow trout to other fisheries. Finally, the fishery runs an advisory service for other sport fisheries which are either being established or have no skill in managing trout.

The fishery is managed on a strictly 'put and take' basis and it depends entirely on farm-reared trout. After the loch was cleared of Pike and Perch, it was stocked for the first time in winter of 1970 and spring of 1971 with 28,000 (10-15 cm) yearling brown and rainbow trout.

Since then, stocking has become an indispensable part of the annual management so as to satisfy the increase in anglers. At the moment, there are 17,000 anglers' visits per year at Loch Fitty and there is still room for more. The success of the fishery depends very much on its stocking policy. The aim is to produce a catch of over 10,000 trout per year. In order to achieve this, a small trout rearing installation has been established. It consists of two 10 m tanks made of steel/glass with concrete bases and two 3 m fibre glass tanks. Water is pumped from the loch by the use of an electric pump which is linked to alarm systems in the case of electrical power failure.

Trout are bought from a commercial farm early in the year (usually in February) when they are about 25 cm long and then they are reared until the stocking time. By rearing trout themselves they avoid the transportation cost especially during the summer period when they restock frequently. Trout are reared at certain growth rate depending on the time the managers want to stock.

They start off with a standing crop of fish in the loch, which is the residue from the year before,

and so they have to build up that stock to a level which will ensure successful angling at the beginning of the season. Fishing is opened generally between the 11th and 15th of March and at that time of year it is still very cold. Therefore, fish are not usually surface feeding but are on the bottom and so heavy stocking is carried out at this time to provide a counter balance with surface feeding fish. They start stocking in February with about 2000 trout just slightly below 450 g in weight. About 10,000 more fish remain in the rearing tanks ready to be added to the fishery as the fishing season develops.

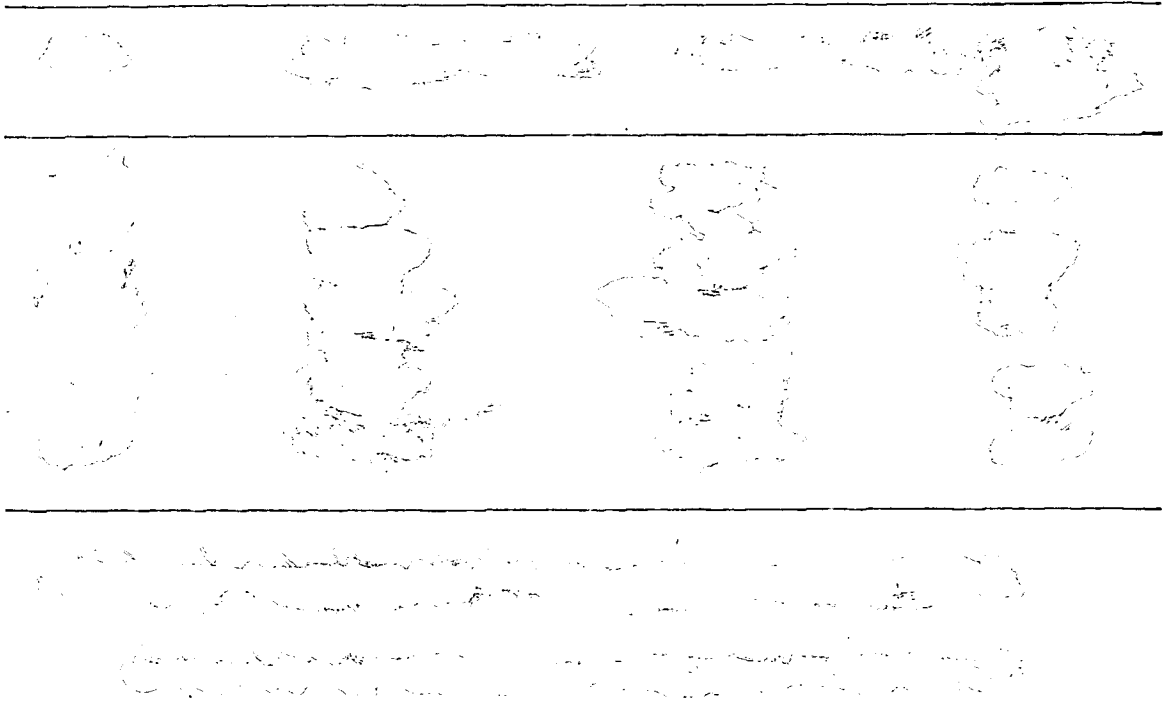
Sometimes, stocking is done weekly, but during the month of June when there is a peak of angling pressure and all available boats are booked day and night, the water is stocked daily.

Rainbow trout is never stocked in autumn because, according to their experience they overwinter very poorly. With brown trout things are better and if they are available they are stocked in autumn.

Trout introduced in the water are about 25 cm (0.56 kg). There is no bag limit except in the month of April when it is 20 fish/boat, which gives roughly 6 fish/angler.

There is no size limit of caught fish because it is thought that once a fish has been hooked and

landed by an angler in an unsuitable way, there is little hope of it surviving if returned. In Loch Fitty, rainbow trout predominate over brown and have a higher percentage recovery rate.



Loch Fitty started stocking with trout in winter 1970 and late spring 1971 when 28,000 yearling brown and rainbow trout were introduced ready for the opening of the fishing season in April 1972. The number of caught fish in this first season was a disappointment for brown trout. Only 3,000 (16.6%) of the original stocked were caught, whereas from 10,000 rainbow stocked the return was about 7,000 (70%).



Since then, more and more rainbow have been stocked and today the policy is to put in the loch 12,000-15,000 rainbow and only 1,500-2,000 brown trout.

There are, of course, commercial reasons why rainbow is preferred, because they are much cheaper to rear and produce for the fishery.

In conclusion, Loch Fitty is an intensively fished trout water managed on a 100% 'put and take' basis. It used to be a coarse fish water but, with proper management, it was converted to a trout fishery, which attracts fishermen seeking good fishing with facilities and are prepared to pay for them. The predominate species before the clearing with rotenone were Pike and Perch with a few big brown trout, which had managed to escape predation when they were younger. Now, after a proper management there is more brown trout than there was before with rainbow trout filling the niche of the coarse fish.

The managers of Loch Fitty attribute their success to rainbow trout because brown trout could never have produced a successful fishery due to their expense and difficulty in capture. The high recovery rate for rainbow trout has ensured its popularity with game fisheries and the visiting anglers. This

successful returns means the angler will come back, so profits are ensured.

My personal opinion is that if more private companies come into this sort of business almost all the accessible waters will offer quality and quantity trout sport angling do those fishermen who can afford to pay high prices for it. However, the high costs for fishing make the fishery exclusive, so what of the ordinary angler? This will be discussed later.

## 2.5 Other Case Studies

- A. Here three water supply reservoirs will be considered all owned by the Lothian Regional Council. There are about forty domestic water supply reservoirs and compensation waters belonging to this body and some of them are potentially very good sport trout fisheries. Unfortunately, there are no records kept for them and any study related to their management, as far as trout fishery activities are concerned is very limited.

The Regional Council is endeavouring to improve the management of these fishing waters, under its control by persuading anglers to fill forms of catch returns after a day's angling.

In England, for most of the fisheries developed on water supply reservoirs there are complete records of stocking and catch returns often from the time of first filling. Grafham water for instance, administered by the ~~Great~~ <sup>Anglian</sup> ~~Case~~ Water Authority was first opened to anglers in 1966 and since then complete and detailed records have been kept.

The three waters considered here are Donolly, Hopes and Whiteadder reservoirs, all located in the South-East of Scotland. Fortunately, for these reservoirs, some records are kept by the Sub-regional Engineers Water Service in Haddington presented in appendix 5 .

There is some natural reproduction of brown trout here but for several reasons trout of catchable size are becoming scarcer each year. Low levels of water, especially during the summer on all reservoirs seriously inhibit natural restocking and this is particularly true of Donolly where the spawning beds virtually dried up in 1972 and 1973. However, conditions are better now but there is little evidence of fish returning to the spawning areas. These waters follow a general pattern

for most upland reservoirs. Immediately after inundation and for 3-5 years, submerged vegetation breaks down releasing nutrients. These ensure a rich growth of food organisms for the trout. However, after 5 years or so, this source dies up and the reservoir can only rely on inputs of nutrients from the surrounding land. As these reservoirs are often in upland areas with moorland, nutrients inputs are low and hence trout food organisms are also low.

As mentioned in chapter 1 management of water supply reservoirs in Scotland is very much concerned with prevention of pollution and consequently little effort has been made to improve their fishing. The reservoirs considered here follow this general pattern and hence, are not sufficiently exploited as sport fisheries. The situation is changing gradually due to the increasing demand for the trout fishing.

From the records of caught fish in these reservoirs it was clear that the production of takeable fish was decreasing each year and in order to maintain them as sport fisheries attractive to anglers they decided to carry out a restocking programme but not on a strict

'put and take' basis. Therefore, brown trout were put in the reservoirs during the autumn and the catch return of fish showed a spectacular increase in the next fishing season (see figure 5).

Brown trout overwinter very well in these waters and it is preferred to rainbow which have a tendency to migrate and disappear. In 1977 Donolly, Hopes and Whiteadder reservoirs were stocked with rainbow trout because brown was not available from fish farms.

Management of those fisheries is sporadic and consequently almost none of the boats are booked and with the relatively low charge (daily permit is £1.50) managers face difficulties in covering the running costs of the fisheries. The cost of trout for restocking, boat repairs and replacement of equipment have been increasing each year.

In conclusion, the water supply reservoirs considered here are potentially good trout fisheries, provided that they are stocked with takeable trout every year. They could be managed as 'put and take' fisheries to a point where pollution caused by the recreationists does not

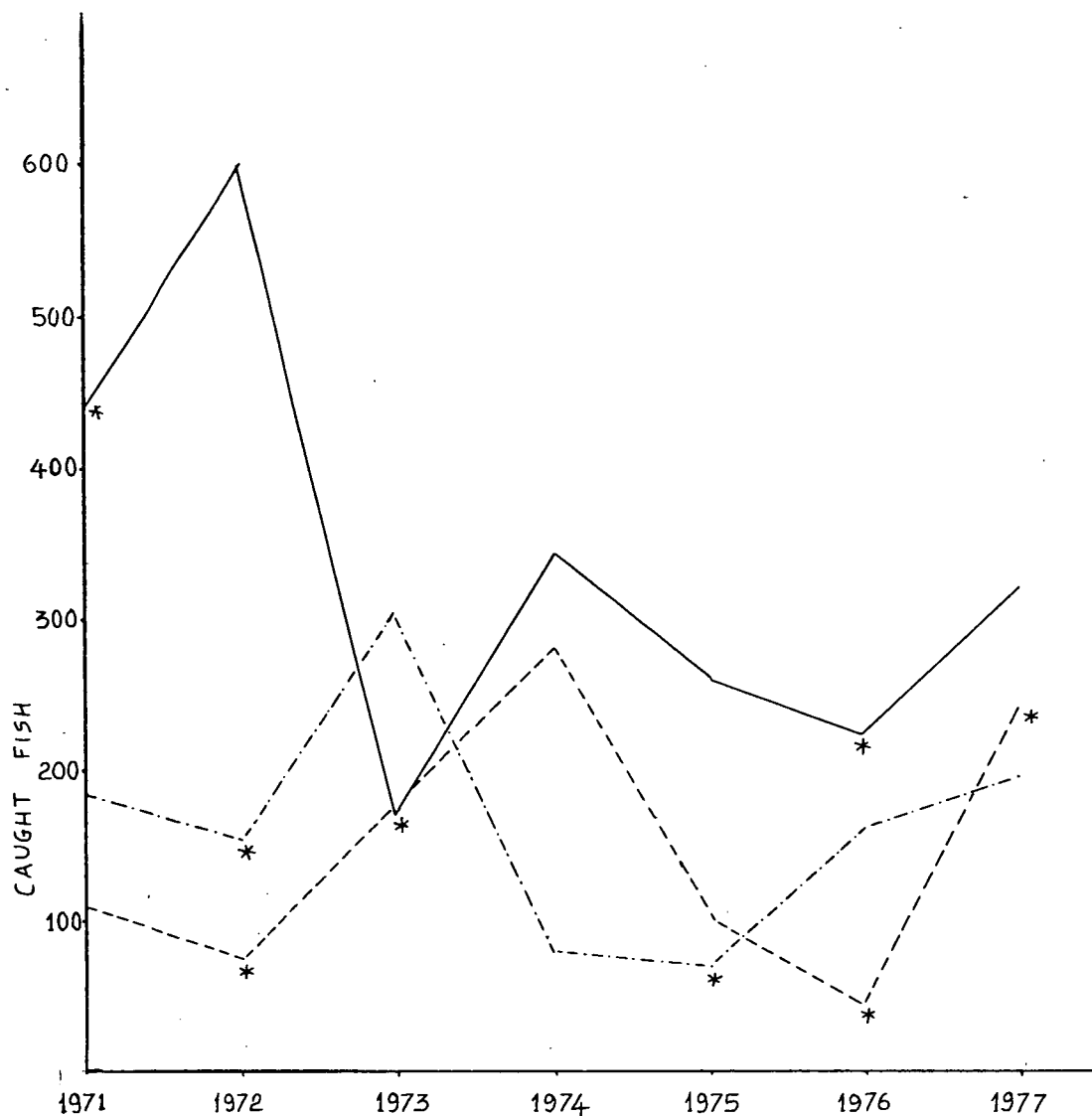


Figure 5.

Caught fish from 1971 to 1977 in three water supply reservoirs in E. Lothian.

— Whiteadder reservoir  
 ---- Donolly       "  
 -.-.- Hopes       "

\* Restocking took place

deteriorate the quality of the water to a considerable degree. The fact that permits issued were more in years when the reservoirs were stocked with catchable fish shows that anglers above all, are interested in fisheries with plenty of takeable fish in their waters. This desire for simply having a catch is coupled with the fact that anglers do not mind catching farm-reared trout. All they mind is having blank days which means they will go elsewhere to fish.

In England, most reservoirs are being developed for recreational uses and provide excellent trout fishing. Likewise in Continental Europe with coarse and game fish. Reservoirs in U.S.A. absorb about one-fourth of all United States freshwater fishing (Bureau Sport Fisheries and Wildlife, 1966). Yet in Scotland the majority of them remain undeveloped as sport fisheries. The Department of Recreation and Leisure, responsible for the management of water supply reservoirs and compensation waters as fisheries has identified the fact that many of them are potentially good fisheries provided that restocking programme

will be carried out annually. (Langmuir, pers. comm).

B. This case study is a typical water supply reservoir near <sup>t.</sup> ~~Saint~~ Andrews in Fife named 'Cameron Reservoir'. It is worthwhile referring briefly to its management because it is considered a well managed trout sport fishery. There are both boat and bank fishing available at a reasonable charge. Trout are stocked early in April, just before the opening of the fishing season with brown trout of about 23 cm and rainbow of about 28 cm.

Size limit is 28 cm which means that rainbow trout is takeable immediately after being stocked in the water, whereas brown trout has to stay in the water for at least one year in order to come up to a legal size.

The purpose of the above stocking policy is to offer the fishermen the opportunity to catch fish immediately: the rainbow trout having a high catchability, and, at the same time to provide the occasional more difficult fish to catch, i.e. the brown trout.

Management is decided by a Committee and initially, they wanted to stock only with brown trout, but it has been found that rainbow trout attract more fishermen. Hence, rainbows are now stocked each year. Reasonable records



have been kept since the fishing started which has helped in planning future management. (See figure 7).

Year	Stocked fish		Caught fish		Rod Days	% of Catch returns	
	Brown Trout	Rainbow Trout	Brown	Rainbow		Brown	Rainbow
1971	3,000	-	2,210	-	2,900	74	-
1972	4,000	-	807	-	2,802	20	-
1973	-	-	-	-	-	-	-
1974	3,000	1,000	851	800	2,788	28	80
1975	3,500	3,220	1,460	804	3,495	42	25
1976	4,000	500	1,492	383	3,716	37	77
1977	4,000	500	2,651	425	4,703	66	85

Table 7: Stocked fish-caught fish and angling pressure at Cameron Reservoir.

Management of 'Cameron' reservoir depends entirely on farm-reared fish. This is because it has not sufficient habitat for a self-maintaining brown trout population, spawning areas being too few and angling pressure too high.

Until 1974 the water was not stocked with fish regularly and figure 6 shows that there was relatively low demand (number of rod-days per year).

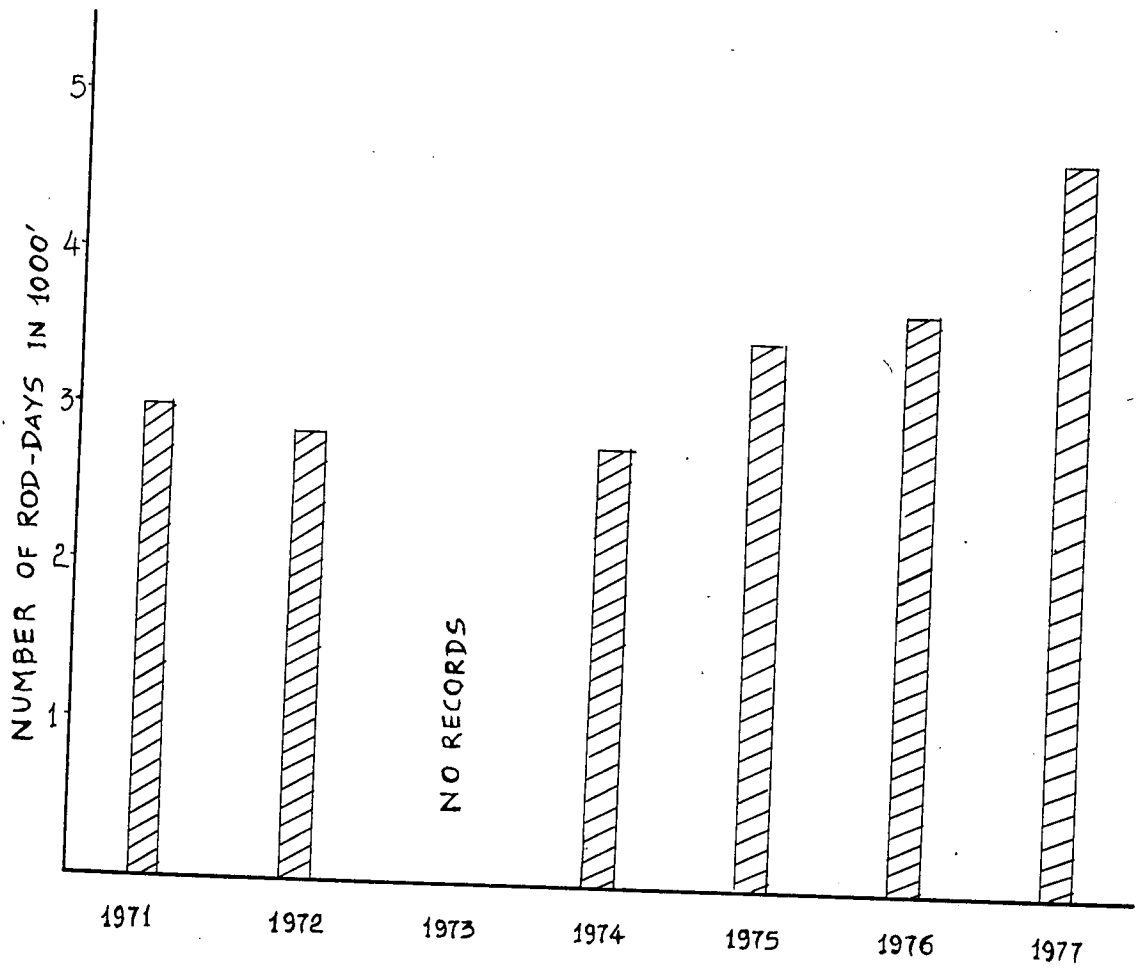


Figure 6. Visits of anglers at Cameron reservoir.

Since 1974 stocking with brown and rainbow trout has been operated and a marked increase in angler-visits followed this policy. Compared with 1974, demand in 1977 was 70% higher when the fishery was placed on 'put and take' basis. Since this new development brown trout have had lower catch returns (45%) than rainbows (67%).

In conclusion, Cameron reservoir shows that a successful trout fishery under careful management can be developed on a domestic water supply reservoir.

Water engineers in Scotland are terrified by the possible danger on a reservoir, but it seems that up to a certain point such waters can be exploited as sport fisheries without noticeable contamination.

One can appreciate engineers' attitudes towards the problem of pollution in water supply reservoirs. Certainly, it is not wise to spend thousands of pounds annually on purifying water for domestic use in order to offer fishing enjoyment to 200 or more anglers. However, the majority of reservoirs especially those close to big centres of population, could absorb a considerable part of the anglers' pressure.

With careful management, pollution would be negligible and no new cleansing devices would be required for the waters.

## 2.6 Anglers' Preferences and Factors Affecting Them

During the visits to several fisheries in the Central belt of Scotland anglers were asked to complete a short questionnaire covering their preferences with regard to brown and rainbow trout. As most fishermen did not like to be disturbed when they were fishing it was almost impossible to interview more than two or three of them at each water.

In all forty personal interviews were conducted with fishermen to determine their preferences towards brown and rainbow trout. Certainly, this sample is not representative of the trout angling public in Scotland but, at least it is some indication of trout fishermen's attitudes. Unfortunately, the time available for this study was too short to implement a comprehensive survey and one had to make do with this cursory sample.

The responses given by anglers are tabulated in appendix 6 but, some mention will be made of details regarding their attitudes to angling.

As to their preference for catching either brown or rainbow trout 53% of them preferred brown trout, 35% rainbow and 12% had no special preference. Most of the brown trout devotees were aged over fifty and it seems that fishermen who have spent most of their fishing activities in brown trout waters, especially in the North of Scotland preferred brown trout.

Some of the anglers justified their predilection to brown trout only because of the fact that it is native to this country, others expressed enthusiasm about the fishing quality offered by the exotic rainbow trout.

48% of the fishermen believed that brown trout offered better sport fishing, 30% gave this advantage to rainbow trout, whereas the remaining 22% said that each species has advantages and disadvantages and they did not think either species was superior to the other in terms of fishing quality.

Opinions varied with some enthusiasts of brown trout alleging that this species was wilder, a better fighter and not so easily caught as rainbow trout. They did not like fish that were easily hooked. There were fishermen who do not bother if they caught nothing but, if this occurred for too long, then they would consider the water poor and they would move on to another fishery and not return.

Anglers having been asked why they prefer trout to salmon/sea trout waters, 37% of them attributed their preference to trout waters being more available and cheaper than salmon waters. 53% of anglers forward cost as the overriding factor determining their choice of trout waters. 10% of anglers preferred trout to any other species and neither availability or cost governed their preference.

73% of the respondents ate the fish they caught. Only 15% did not eat the trout they caught but, gave them to friends or relatives. Finally 12% replied that they only eat the fish provided that it has been in the water for a relatively long period feeding on natural food. They stated that farm-reared fish caught quickly after being stocked in a fishery had soft white flesh instead of the hard pink flesh of wild trout. It was apparent that the anglers knew the quality of trout present in the water they had decided to fish.

The majority of the respondents (55%) did not mind if the fish came from a farm, 23% of the anglers preferred a native wild fish and if they thought the trout they might catch could be an artificially reared fish then they were annoyed. 22% of them said as long as the fish was a good fighter they were not worried from where it came. They did

mind however, if they went fishing and in half an hour they reached their bag limit because the fish were very tame.

Most of the anglers admitted that they would like to catch a large trout at some time and wanted the opportunity to be there to catch the occasional large trout. In terms of sport 60% of the respondents preferred to catch several medium sized trout to one relatively large one. A few 0.5 - 0.8 kg trout seemed to satisfy the average fisherman's desire concerning a good fishing day. 28% of anglers just looked for the one big trout and they were not interested with smaller fish.

Finally, in response to the last question the anglers seemed to approve the present trend in trout fishery management, as far as stocking with farm-reared trout is concerned.

85% of them thought that stocking still waters with trout improve the fishery to a significant degree. 10% of the anglers did not express any idea about that while 5% disagreed with this policy for several different reasons.

One has to bear in mind that the sample of anglers was small and probably does not reflect the true body of anglers opinion for Scotland as a whole.

However, it does provide some insight into how anglers regard trout fisheries.

Angler's opinions varied widely probably as a result of several factors such as experience, previous types of waters visited and so on. What would be needed is to have a truly representative sampling programme which would overcome the biases inherent in small scale sampling as carried out in this study. This is certainly something which is necessary in order to predict future requirements for trout angling. Just to compare with this study, a questionnaire survey by M. Duttweiler (1976) at Cornell University (U.S.A.) discovered that of anglers fishing in Owasco Lake, 21% preferred the native lake trout whereas 17% the rainbow trout. Regarding the size of the preferred fish 72% liked catching several medium sized fish rather than one large fish (21%) or large numbers of small fish (5%). Therefore, although the sample of anglers questioned in this study was small, it has provided results very similar to Duttweiler's.



## CHAPTER 3: FARM-REARED TROUT AND SPORT FISHERY

### 3.1 Freshwater Trout Farming in Scotland

There are sixty five farms producing trout in Scotland for the table market and restocking purposes. Of these, at least fourteen belong to angling clubs, angling associations or federations of anglers, whereas an unknown number belong to owners of trout waters and the farms produce trout exclusively for restocking. Of the above trout farms, twelve produce brown trout Salmo trutta entirely for restocking purposes. Twenty two produce both brown and rainbow and thirty one produce rainbow trout only.

There is a lack of official government statistics about the production of freshwater fish farms in Scotland and this creates problems to any study related to this subject.

Since February 1977, the National Farmers' Union of Scotland has been responsible for fish farming in this country and it is expected that they will include in their activities, the collecting of statistical records.

From the responses to a questionnaire sent to fish farmers, it is obvious that the majority of them are reluctant to give any information related

to the costs and amount of annual production (mainly for restocking purposes).

Their reluctance is due to the fact that most of the financial arrangements from a tax point of view and from the point of view any grants they may get, are based on the commercial production of trout for the table market and not for restocking waters. Therefore, if they have sold a certain quantity of trout for restocking purposes they tend to keep quiet about it.

Question 1 of the questionnaire was concerned with the annual production of brown and rainbow trout for the table market and for restocking. Although from the replies received, nothing can be concluded about the absolute annual production of trout, it is clear that farmers tend to sell their annual surplus of rainbow trout for restocking purposes, and selling to this market is more lucrative than to table market. This is probably due to the fact that after selecting the good quality portion fish for the table market they dispose of the unsuitable ones for restocking.

From the questionnaire and information given by the authorities and governmental departments in the freshwater fish farm industry, it was found that the total production of trout in Scotland for

the year 1977 was about 1,280 tons, of which 150 tons was for restocking purposes.

A few farms produce the bulk of commercial trout for restocking and they are the 'Howietown & Northern Fisheries' Farm, the West of Scotland Trout Farm, the Solway Fishery, and the Cantray Trout Farm Limited.

Freshwater trout farming goes back about 100 years in Scotland, when the production was entirely for restocking lochs and rivers.

Commercial freshwater trout farming in Scotland started in 1966 and figure 7 shows how the production of trout has increased from 40 tons in 1968 to almost 1,300 tons in 1977. The major attraction in fish farming seems to be the presence of an open market for the product in U.K., since prior to 1966 all trout for the table market were imported (2,000 tons) from Denmark and Japan.

Currently, food costs are about half the total annual cost in trout farming. Most of trout farmers feed dry pellets, whose price is linked with the cost of fish meal. The price of fish meal had an abrupt increase after 1972 and this has led to a lower profit margin.

In the South of England, the time cycle for trout production from egg to marketing size is about

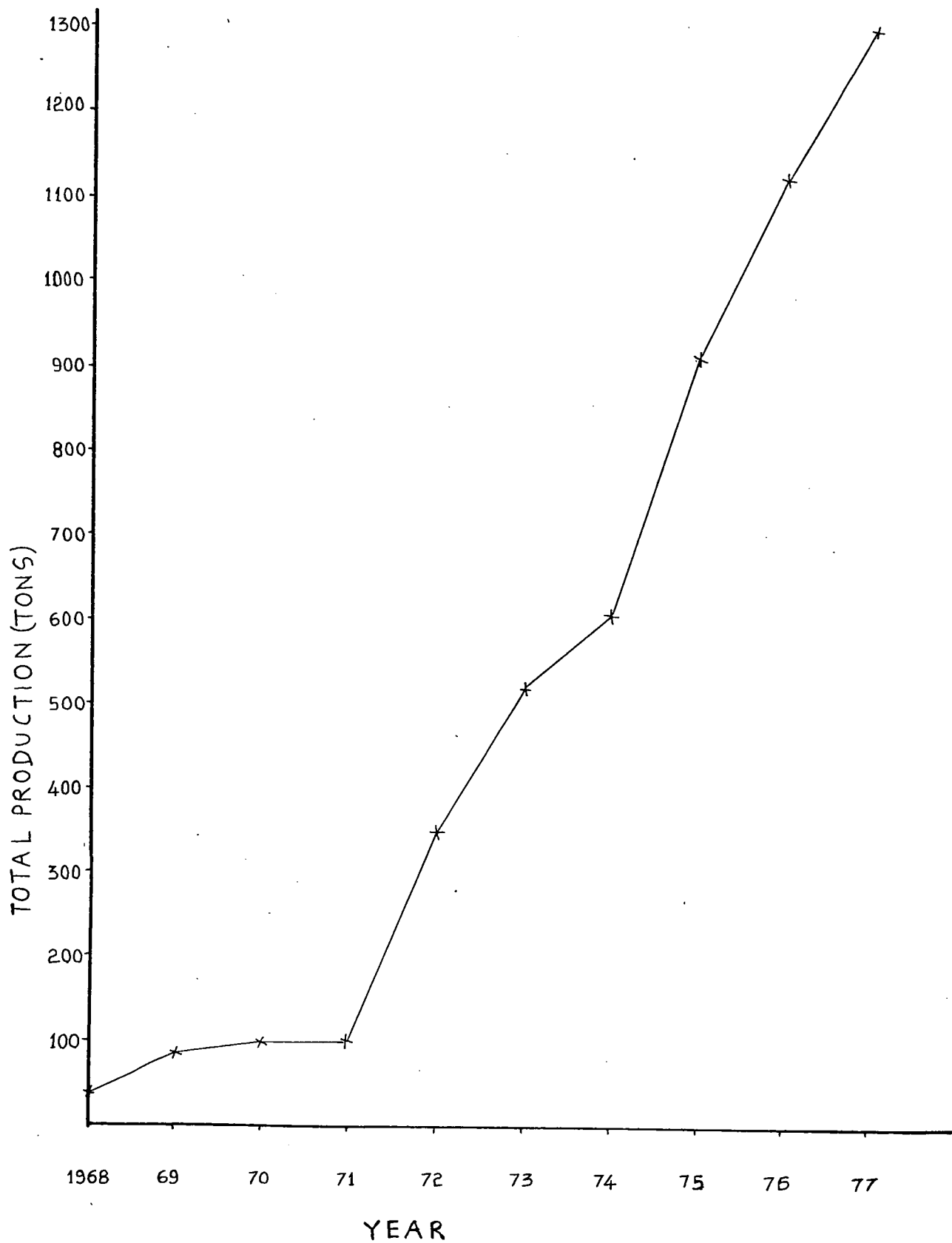


Figure 7. Total annual production of freshwater trout farms in Scotland.

10 months, whereas in Scotland this time is increased to 18 months, due to the lower water temperatures and that means that the cost of production is higher.

Trout farming can never be thought of as a get-rich-quick business and anyone involved in it must be prepared to expect no more than a fair return for personal effort and capital investment (Sedwick 1973). The most important factor affecting trout farming is the availability of suitable water supply. Scotland has the advantage of abundant inland waters suited for trout farming activities.

Compared with similar facilities elsewhere in Europe, Scottish water resources remain relatively unpolluted and fish stocks display a high degree of freedom from diseases. These factors make the Scottish industry a competitive one.

The above advantage does not mean that all rivers in Scotland are perfect for trout farming and fulfil all the needed conditions. There are a number of factors which affect the suitability of a water for trout production.

The water should be of high dissolved oxygen content, low in pollutants, silt, bacteria, algae and debris, with a water temperature in the range of 10 to 15°C. A neutral or mildly alkaline water

is to be preferred with a pH of 7.0 - 7.5. A pH of less than 6.0 should be avoided, and it is important to make sure that the pH does not fall below this level following periods of rainfall when a surface run-off water increases.

Clearly, the quantity and quality of water supply is of basic importance in trout fish farming and with conventional techniques trout production of 100 tons per annum would require the use of 10 to 20 million gallons of high quality water per day. Regarding the investment of money, a conventional farm producing 50 tons per annum would require a total investment of about £80,000 (50,000 for capital works and 30,000 for running costs). The cost of food is variable, but to produce 1 ton of trout takes about £300 of food which gives a production cost of about 31p per pound (1975 prices). Since the average wholesale price was about 35p per pound, the profit margin was very narrow (Solomon et. al. 1975).

The condition and appearance of trout reared for restocking purposes must be superior to that required for the table market and this is generally done by rearing less fish in the tanks thus making the cost higher. Some fisheries buy trout from a commercial farm when they are about 6-7 cm and raise them up to a takeable size.

### 3.2 Farmers' Attitudes Towards Brown and Rainbow Trout

Unfortunately, the questionnaire sent to trout fish farms of Scotland had a return rate of only 50%, in spite of only a few simple questions being asked. Due to the poor returns one can not come to definite conclusions about farmers' attitudes, but, some tentative suggestions can be put forward.

Obviously personal visits to the farms would have been the ideal solution but time and costs were limiting. Question No2 of the questionnaire referred to costs of trout production per ton, but, farmers were reluctant to give any records related to those costs. It is obvious that rearing brown trout is more expensive than rainbow, because it takes almost twice as long to rear them to a certain weight than the latter. This seems the main reason that farmers prefer to rear rainbow in much more greater quantities than brown trout.

Question No.3 was related to the resistance of the two species to diseases in the farm. 56% of the farmers said that rainbow trout is more resistant to diseases in the farm whereas 44% said brown trout were more resistant. In fact, each of these species is susceptible to its own diseases. Brown trout for instance is susceptible

to fungal diseases and to Furunculosis, while it is not very susceptible to Eye Fluke. Rainbow trout is very prone to the latter but more resistant to fungal diseases.

Regarding the size of 'catchable' fish they produce for restocking purposes which reflects their clients' preferences, it is about 27 cm (10.5") for brown and 29 cm (11.5") for rainbow trout.

The response to the question No 5 "which of the two species do you prefer to rear in your farm" was 66% for brown and 32% for rainbow. This was really surprising because rainbow is more lucrative to their business. Therefore, the farmer is a devotee of brown trout, but, also recognises the value of rainbow trout in terms of economics.

Many water owners can not find the quantity of brown trout they want to restock their waters and finally they buy rainbow trout. This shortage will be more obvious in the future when demand for trout sport fishing is expected to be higher.

### 3.3 Value of Artificially Reared Trout to Sport Fishery

Management of trout sport fisheries can either depend entirely on farm-reared fish, as is such with the extreme case of an artificial fishery or can depend on supplementing low natural reproduction



with farm-reared fish. There are of course, waters with good spawning grounds and sufficient food for fish but they can only stand a light angling pressure.

Completely artificial fisheries may be adopted where the fishing pressure is high and this is the situation where fisheries are in close proximity to large urban areas. Such waters are 'put and take' fisheries where takeable fish are put into the water in order to be caught quickly and satisfy the angling demand.

In these fisheries the density of stocked fish is usually above the carrying capacity for the waters. Apart from the above extreme case farm-reared trout are used in sport fishery management in the following situations:

- 1) In reservoir fisheries where spawning grounds are absent or very poor. (e.g. Cameron and Hopes reservoirs).
- 2) Where there is a degree of natural reproduction due to the existence of short spawning streams but this is inadequate to meet the high fishing pressure. This is the case of Menteith Lake where in spite of the good food available to trout, natural reproduction can not balance the angler's demand.

- 3) Where natural coarse fisheries are cleared of their fish with rotenone and then restocked with farm-reared fish. e.g. Loch Fitty. These types of fisheries usually require continual restocking.

Artificial trout fisheries have several disadvantages compared with natural ones. Two major disadvantages are the cost of farm-reared fish whether purchased from a commercial farm or reared by the fishery itself. Secondly, farm-reared fish have a higher mortality rate in the natural environment than wild fish, as the former is better adapted to hatchery diets and hatchery environment (lack of stamina, and adaptability) or generally to a treatment which tends to produce fish which are not fit to withstand the stress of a natural environment.

Finally, it is clear that native trout offer better fishing quality, they fight better and they are wilder than the farm-reared counterparts. This disadvantage of artificial fishery is alleviated to a degree if fish are planted in the water sometime before the beginning of the angling period.

Farm-reared trout are easily caught and anglers who are seeking good sport resent this easy fishing whereas fishermen who simply want a catch are readily satisfied.

Despite the management problems involved when "catchable" fish are planted, this practice continues to increase in Scotland. Anyway, in other countries like the U.S.A. it has become the main policy of managing trout sport fisheries. Barber (1976) describes the situation in the U.S.A. where apart from the numerous private 'put and take' fisheries, there are such units mentioned by the States managed for restocking with rainbow trout.

#### 3.4 Small Trout Fisheries Ponds - A New Concept

A new type of trout sport fishery which has developed in Japan has been appearing in Scotland and seems quite popular.

A fish farm establishes small ponds which are subsequently stocked with large numbers of "takeable" rainbow trout. These ponds are then given over to angling. There are three such fisheries in Scotland at the moment. In contrast there are very many of them in England. One of the Scottish farms was visited by the author.

The following data comes from the Tullibole Mill Fish Farm at the crook of Devon; Kinross, which established such a fishery two years ago.

There are five small ponds of about 0.1Ha each where water is coming in from the River Devon. Permits are issued to the visitors and rods are available for hire. Regulations of this fishery are presented in appendix 7, and catch and return and numbers of visits are given in table 8.

Year	Visitors	Caught Fish
1976	12,000	300
1977	15,000	2,000
1978	19,000*	4,000*

\* expected according to visits up to the end of August.

Table 8: Visits and Caught Fish at Tullibole Mill Fish Farm

After the end of the angling period those fish remaining in the ponds are collected and sold for the table market and ponds are drained. In this way, the losses due to winter mortality or bird predation e.t.c. are avoided.

The number of visitors is very high and continually increasing which indicates how popular this sort of fishing can be. Many of the visitors have never fished before and quite a few have never seen a rainbow trout. This sort of recreation is particularly popular to visitors from England and city dwellers from Scotland.

There is no element of sport in this kind of fishing and a father who's son was fishing there characterised it as "slaughtering". At least, this type of fishing does allow the opportunity for youngsters and some adults to get a first taste of trout and possibly an inkling of the enjoyment that fishing can give.

The farm was visited by the author who saw three generations fishing shoulder to shoulder, the grand-father, the father and the grand-son, all handling a rod for the first time in their life. They decided to finish their fishing adventure only after they had caught about 4 Kg of trout, fully satisfied and promising to return again.

It seems that this sort of fishing will grow fast in Scotland but it does not seem able to absorb any part of the increasing demand for real trout fishing. Anglers still seeking quality

fishing can not see themselves being satisfied by this type of development. In fact, this type of fish farm may even encourage more people to turn to real trout angling so increasing the demand in this sector.

### 3.5 The Future for Trout Sport Fishery in Scotland

From the latest developments, it seems that the future of trout angling in Scotland is not very clear. Some changes will take place anyway by the further development of more waters.

Changes in the law concerning trout fishing are expected as, for instance, the imposition of a licensing system with statutory protection of fisheries.

Anglers are expected to be organised properly with more effective representation. According to White Paper On Angling (M.M.S.O. 1971) "Trout fishing is particularly popular in Scotland. It is a pastime enjoyed by many people from all walks of life. As there is no public right of fishing in Scottish rivers, there is only a limited number of water where trout anglers in general can fish; and there is a great need to make waters available to the Scottish public and for visitors".

What this paper suggests is the organisation of angling in Scotland by the establishment of a new body, the Scottish Anglers Trust with responsibility for the development of trout sport fishing in Scotland. Therefore, waters will become available to trout angling in order to meet the demand.

The main purpose of this body will be the aquisition of waters and their improvement to good fisheries on behalf of its members. A collection of statistical records will be organised in order to help the formation of management policy.

Given that the demand for trout fishing will increase in the future according to the present trend, the role of farm-reared fish probably will become more important.

Even if proper management will take place for the improvement of natural trout waters, many of their indigenous trout populations will probably not be able to maintain themselves under sustained angling pressure. Therefore, it seems probable that more and more waters will turn to 'put and take' fisheries depending entirely on farm-reared fish, or will be supplemented by reared fish in order to be maintained as attractive

fisheries.

Rainbow trout will continue to be the most favourable species for stocking waters due to the lower cost of production compared with brown trout and the higher percentage of catch return to anglers. An expansion of future farm production is expected provided that the capital and operating costs, especially food, do not rise too quickly. Fish culturists are expected to improve the survival and other characteristics of hatchery-reared trout through better methods, improved diets and selective breeding.

As more knowledge is gained concerning the requirements of fish in trout waters, management will be placed on a more systematic and scientific basis. The average trout angler at present can afford the cost of day permits but with the rising trend in prices there will be a time in the near future when the angler might not be able to find a good fishery with the money he is willing to pay.

Therefore, organisation of anglers into associations which can obtain fishing rights on waters will counteract this trend in costs. Such organisations as the Scottish Angler's Trust work on behalf of anglers.



## CONCLUSIONS

There has been an increasing demand for trout sport fishing in Scotland since World War II due to improvement of public transport and communications and to the fact that trout fishing is cheaper than salmon.

There are numerous trout waters in Scotland but the majority of them are inaccessible to anglers. Therefore, waters offering quality fishing have been overfished, especially in the central zone of Scotland where population density is higher.

Waters previously available for trout fishing are being lost due to pollution and water abstraction. Natural reproduction of trout where it exists is too low to meet the high demand with only a few exceptions (e.g. Loch-Leven).

Fisheries in order to meet the high demand, stock water with farm-reared trout either to aid natural recruitment or to substitute for it. Most of the fisheries in the central belt of Scotland depend on artificially reared fish with the extreme case being those managed on a 'put and take' basis.

Rainbow trout was introduced in this country almost 100 years ago and has become the main species

for stocking waters. As rainbow trout seems unable to establish itself, man has to provide recruitment by constant restocking. At the moment there are no self-maintaining populations of rainbow trout in Scotland but, with so many strains being released in both still and running waters, there is a chance that a natural population may become established.

The present law concerning trout fishing is not very strict in Scotland. There is a statutory close season for brown trout but not for rainbow which is considered as a private property so the general rules for fishing do not apply to them. Many anglers can therefore fish for rainbows during the close season for browns and often catch the latter accidentally.

From data collected by the author during visits to several fisheries in the central belt of Scotland, the following conclusions come up as far as their stocking policy is concerned:

1. Stocking takes place mainly in spring before the fishing season but, there are many fisheries which also stock during the angling season.
2. Brown trout are often stocked in autumn

as they can withstand winter conditions. However, rainbows are stocked in the spring, these fish are not able to withstand very low temperatures.

3. Brown trout is stocked at 2+ years of age (26 cm) whereas rainbows are stocked at 1+ years of age (30 cm).
4. Mean recovery rate for rainbow trout was found to be 53% and there was a linear relationship between catch and stocking with a correlation coefficient of +0.95 ( $p = 0.05\%$ ). The correlation coefficient for brown trout was +0.78 ( $p = 0.10\%$ ) and the mean recovery rate about 40%.
5. Among the factors affecting catch return of fish are the skill of fishermen, the feeding biology of trout, the availability of food in the water, weather conditions and angling pressure.
6. The majority of the fisheries stock with both brown and rainbow trout in order to attract more fishermen. Browns offer quality fishing and rainbows a good opportunity to catch a fish.

7. Some of the factors affecting stocking policy are the cost of each species with the brown trout obviously being more expensive than rainbow. The quality of fishing offered by the stocked farm-reared fish is another important factor coupled with the recovery rate.

Well organised artificial fisheries are scarce at the moment in Scotland. Most of the managers are amateurs and the lack of records is a problem to the improvement of management.

Regarding anglers' preferences, there is an indication that most of them prefer the native brown trout but rainbow trout enthusiasts are increasing. Many anglers are getting used to the idea of fishing waters containing farm-reared fish. Certainly the majority of anglers seem to approve of this management policy. Most of them like to catch a few medium sized trout and they appreciate the good quality fish for the table. Trout fishing is cheaper and trout waters more available than salmon for most anglers.

Most fish farmers seem to be brown trout devotees but due to the high cost of production,

they turn to rainbow trout which require lower investment costs and probably higher marginal profit.

Regarding production of trout for restocking waters, it was found from several sources that it is about 150 tons/year on a commercial scale plus the unknown quantity produced by angling clubs and individual fisheries.

With the present increase in demand for trout fishing, especially in Central Scotland, it seems that 'put and take' fisheries will become the main type of fishery in the future. This line of development has already occurred in England and the U.S.A.

More reservoirs will be available for trout fishing up to a point where pollution is not a problem.

Finally, the emerging new artificial fishery on small ponds established by fish farms seems to create a new kind of water recreation especially for youngsters but, it is doubtful that they will contribute very much to the alleviation of fishing pressure in the future.

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APPENDICES

APPENDIX 1

QUESTIONNAIRE TO TROUT FRESHWATER FISH FARMERS

NAME OF OWNER .....

NAME OF FARM .....

LOCATION .....

1. FISH SPECIES REARED (tons) 1971 1972 1973 1974 1975  
1976 1977.

1.1 Rainbow Trout

1.1.1 For table market .....

1.1.2 For restocking .....

1.2 Brown Trout

1.2.1 For restocking .....

2. COST OF REARED TROUT FOR RESTOCKING PURPOSES (per ton)

2.1 For Rainbow Trout .....

2.2 For Brown Trout .....

3. WHICH OF THE TWO SPECIES IS MORE RESISTANT TO DISEASES  
IN THE FARM?

4. WHICH LENGTH OF "TAKEABLE" TROUT DO SPORT FISHERY  
WATER OWNERS OR MANAGERS PREFER?

4.1 For Rainbow Trout .....

4.2 For Brown Trout .....

5. WHICH OF THE TWO SPECIES WOULD YOU LIKE TO REAR  
IN YOUR FARM?

Thank-you

APPENDIX 2QUESTIONNAIRE TO TROUT SPORT FISHERY  
WATER OWNERS OR MANAGERS

NAME OF OWNER .....

LOCATION .....

1. Kind of water (loch-lake-reservoir)?
2. Do you stock on a "long term" or on "put and take" basis?
3. Stocked numbers of trout for the last 5 years?
  - 3.1 Rainbow trout
  - 3.2 Brown trout
4. Length or weight of stocked fish?
  - 4.1 For rainbow trout
  - 4.2 For brown trout
5. Time of restocking the water?
  - 5.1 For rainbow trout
  - 5.2 For brown trout
6. Caught fish per year (weight or number)?
  - 6.1 For rainbow trout
  - 6.2 For brown trout
7. Number of rod-days per year?

## Appendix 2 cont/...

8. Does the introduction of the exotic rainbow affect the native brown trout in your water? How?
9. Which of the two species do the majority of fishermen prefer? Why?
10. How much does your management policy depend on farm-reared trout?
11. Is there natural reproduction of rainbow trout?
12. How much does the natural reproduction of brown trout contribute to the annual recruitment of the population?
13. Reasons for mortality after the trout are stocked?
14. Is the demand for trout sport fishery increasing?

APPENDIX 3QUESTIONNAIRE TO TROUT SPORT FISHERMEN

1. Which of the two species do you prefer to catch?  
Why?
2. Which of the two species offer better sport fishing quality?
3. Why do you prefer trout fishing to other types of angling?
4. Do you eat the trout you catch?
5. Do you mind if the fish you are catching comes from a farm?
6. Do you prefer to catch one big fish or several medium-sized during a fishing day?
7. Do you think that restocking still waters with farm-reared trout improves the trout fishing to a significant degree?

## RECORDS OF SOME STILL WATER FISHERIES IN THE CENTRAL SCOTLAND

NAME OF FISHERY	PERIOD OF DATA	Time of stocking		Length of stocked fish		Number of stock		Numbers of catch		Catch/ stock %		BROW + RAIN BOW
		Rain bow	Brown	Rain bow cm	Bro wn cm	Rain bow	Brown	Rain bow	Brown	Rain bow	Bro wn	
Butterstone Loch	1974-77	Spring	-	30	-	12,000	-	7,425	-	62	-	62
Fitty Loch	1974-77	Spring + fishing period	-	30	30	58,100	-	32,100	-	55	-	55*
Coldingham Loch	1976-77	Autumn	Autumn	28	23	13,000	13,000	8,424	4,813	65	37	51
Linlithgow Loch	-	Fishing Period		30	24	RECORDS NOT AVAILABLE						
Morton Loch	1970-77	All Seasons		29	26	1,775	3,200	808	1,168	45	36	40
Gobbinshaw Loch	1973-77	Spring	Spring	28	26	2,000	14,000	915	10,190	46	73	69
Menteith Lake	-	All Seasons		29	27	RECORDS NOT AVAILABLE						
Cameron Res.	1971-77	Spring	Spring	28	23	5,220	21,500	2,412	9,451	46	44	45
Portmore Loch	1976-77	Spring	Autumn	35	30	RECORDS NOT AVAILABLE						
Donolly												
Hopes	Res.	These reservoirs are not stocked with fish every year and all records kept are presented in Appendix 5 .										
Whiteadder		*Less than 10% is brown trout and there are no separate records for fish caught										

APPENDIX 5

RECORDS FROM THREE RESERVOIRS IN EAST LoTHIAN REGION

YEAR	DONOLLY RESERVOIR - 16 acres				HOPES RESERVOIR - 35.16 acres				WHITADDER RES- 193 acres			
	Total catch	Catch per acre	Aver. Weight	No of permits	Total catch	Catch per acre	Aver. Weight	No of permits	Total catch	Cath per acre	Aver. Weight	No of permits
1974	282	17.6	0.6	116	80	2.3	0.4	92	344	1.6	0.62	269
1975	102	6.4	0.8	101	72*	2.05	0.5	72	262	1.2	0.5	241
1976	45.5*	2.8	0.85	95	163	4.6	0.44	99	247*	1.3	0.58	291
1977	239*	14.9	0.71	120	197	5.6	0.45	115	322*	1.7	0.5	202

\* Restocking took place

APPENDIX 6RESPONSES OF FORTY INTERVIEWS WITH TROUT ANGLERS

Question 1: Which of the two species do you prefer to catch?

Brown Trout	Rainbow Trout	no preference
21	14	5

Question 2: Which of the two species offer better sport fishing?

Brown Trout	Rainbow Trout	both the same
19	12	9

Question 3: Why do you prefer trout fishing to other types of fishing?

It's cheaper	More available	Trout attracts me
21	15	4

Question 4: Do you eat the trout you catch?

YES	NO	It depends
29	6	5

Question 5: Do you mind if the fish you are catching comes from a farm?

YES	NO	It depends
9	22	9



## Appendix 6 cont/...

Question 6: Do you prefer to catch one big fish or several medium sized during a fishing day?

One big fish	Several medium sized	No opinion
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11	24	5
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Question 7: Do you think that stocking still waters with farm-reared trout improves the trout fishing to an considerable degree?

YES	NO	No opinion
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34	2	4
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APPENDIX 7REGULATIONS AND CHARGES OF THE TULLIBOLE MILL FISH FARMCHARGES

<u>Permit:</u>	£2.00	for adults
	£1.00	for children
	£0.20	for visitors

Pellet food for fish: (one plastic bag per permit)  
included in the above price.

Rods for hire: available at the hut for £1.00 each.

Caught trout under 1.5 Kg (3 lbs)	£1.90/Kg
Caught trout over 1.5 Kg	£2.40/Kg

REGULATIONS

1. Fishing period: May-September.
2. Daily working hours: from 11 am to 8 pm.
3. Only fly fishing is permitted.
4. Caught trout under 1.5 Kg weight must be kept by anglers, they cannot return them to the water.
5. Caught trout over 1.5 Kg weight is kept by the farm itself if anglers do not want to pay for them.
6. There is no restriction on the duration of fishing and of course, visitors may catch any quantities of trout provided that they are prepared to pay for them.