An Investigation of the Recapture rates for Tagged Brown Trout Stocked into the River Ribble

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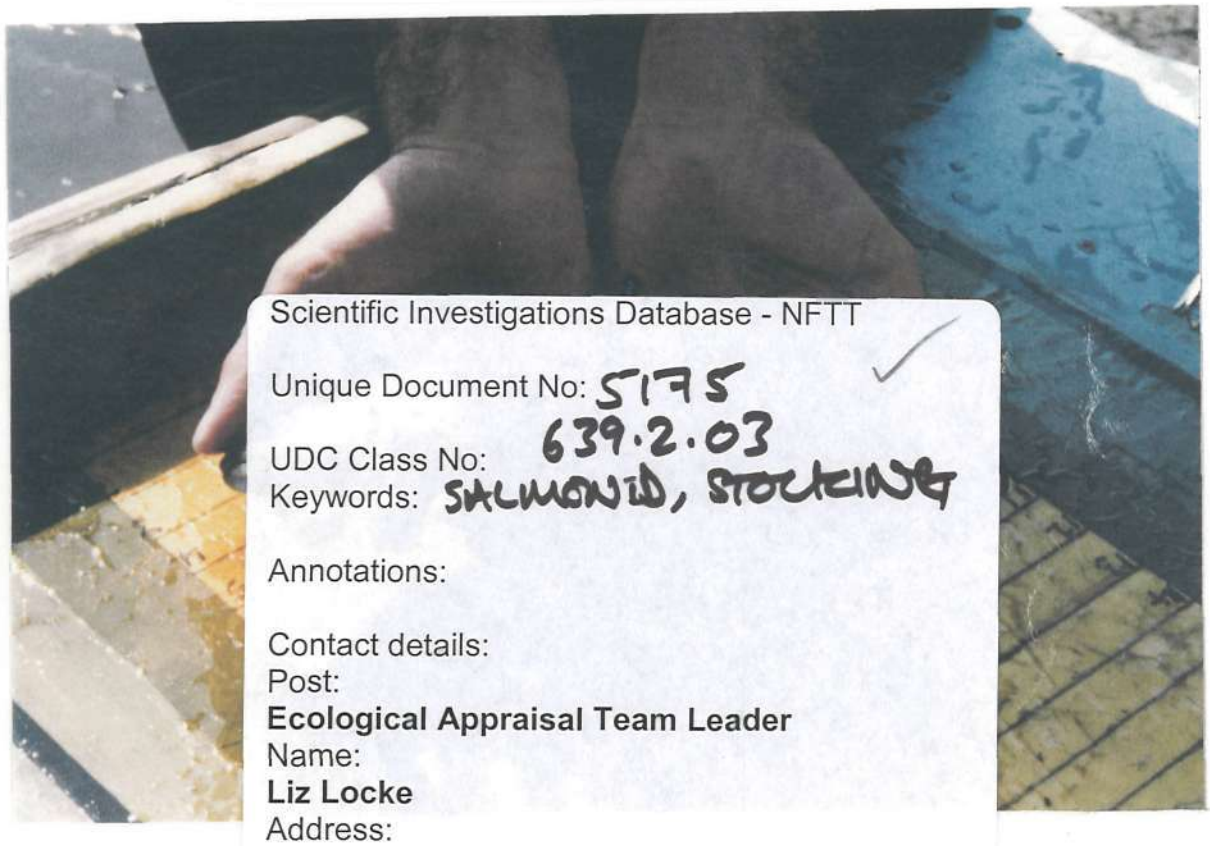

EA/NW/FTR/96/8 **August 1996**

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1. Introduction

The angling season for non-migratory brown trout, in the Environment Agency North West Region, runs from March 15th to September 30th. Each year, large numbers of farm reared brown trout are stocked into the rivers of the North West Region's Central Area. In 1994, approximately 20,000 brown trout were introduced into the River systems of the Lune, Wyre and Ribble by local angling clubs and fishery owners. Most of these fish were stocked at a length greater than that defined by local byelaws as the takeable size (200mm). Introductions are made to supplement the existing wild brown trout populations within the river and increase the probability of an angler catching a fish. Stocking with fish of a sufficient length allows the successful angler to remove the catch for their own use. In this way, stretches of the rivers are effectively managed as "put and take" fisheries for brown trout.

A number of brown trout fingerlings are also introduced each year by angling clubs and fishery owners. These are stocked with the expectation that the fish will survive in the river to grow, over-winter, and eventually attain a takable size with an increased degree of "wildness". The lower cost of fingerlings, as opposed to trout of a takable length, makes their introduction more attractive to angling clubs since a greater number can be stocked for a given cost.

Although the practise of stocking brown trout has occurred for many years in the Central Area, there is little information of its success in terms of increasing anglers catches, or the survival of fish introduced. This study was initiated to determine the recapture rates by angling of brown trout following their introduction into a river fishery. The information gained from this study can then be used to give guidance to angling clubs and fishery owners on the optimal strategies for stocking fish.

2. Methods

The Environment Agency (formerly NRA) owned fishery at Mitton on the River Ribble was chosen as the site for this stocking experiment. The fishery is managed as a day ticket water for salmon, trout and coarse fish. A large proportion of permits sold are for brown trout fishing. This increases the potential number of anglers fishing for brown trout and should maximise the return of data.

The trout stocking experiment began in spring 1992 and continued in the years 1993 and 1994. One hundred fish were introduced twice yearly, in spring and in summer or autumn. Prior to stocking, the brown trout of length 250mm to 300mm (10 to 12 inches) purchased from Dunsop Bridge Trout Farm were anaesthetized using 2 phenoxy-ethanol. A numbered Carlin tag was attached to the base of the dorsal fin and the fish released at the Mitton fishery. The date of each trout stocking and the tag numbers are shown in Table 1.

All permit holders were required to submit a catch return after their days fishing which detailed the number and species of fish caught. In addition, a reward of £1.00 was offered for the return of any Carlin tags on brown trout.

Although all permit holders do not submit a catch return after their fishing trip, either through forgetfulness or non cooperation, it was possible to obtain the number and type of permits sold from dated and priced ticket stubs in the permit books for each year. These stubs were not available for 1992. An approximation of the number of permits sold in the weeks following stocking in 1992 can be obtained from known permit numbers. Both of these methods will only supply data on the number of anglers who bought permits and the maximum number fishing the site. They will not provide numbers and species of fish, tagged or untagged, that were caught on these missing permits although the reward for a Carlin tag should encourage the return of data on tagged fish.

Table 1. Stocking date and tag numbers

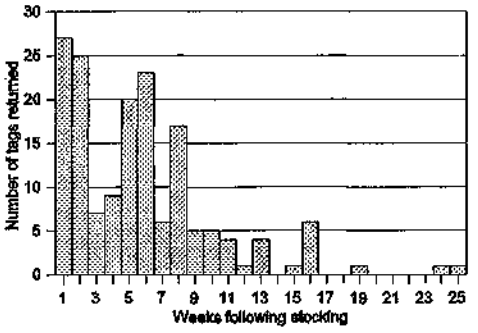
Stocking date	Number Stocked	Tag numbers introduced
9th April 1992	103	1 - 100 (plus 201,202,203)
20th August 1992	100	101 - 200
4th May 1993	100	301 - 400
1st July 1993	100	401 - 500
26th April 1994	100	501 - 600
8th September 1994	100	701 - 800
	Total 603	

3. Results

3.1 Overall tag returns

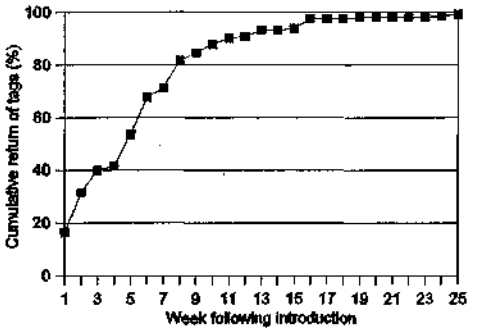
Of the 603 tagged fish introduced into the river over the 3 years of the experiment, a total of 164 Carlin tags were returned (27.2%). The number of tags returned in each of the weeks following stocking are shown in Figure 1.

Figure 1. Tagged fish caught in weeks following stocking



Of the 164 Carlin tags returned, 88 (54%) were taken in the first 5 weeks following introduction of tagged fish into the river and 144 (88%) in the first 10 weeks (Figure 2).

Figure 2. Percentage tag return in weeks following trout introduction



One hundred and fifty eight (96%) of the tags returned by anglers were from fish that had been caught on the Mitton fishery itself. The remaining 6 tags were from fish caught within a few hundred metres of the fishery in the lower reaches of the River Hodder or on the River Ribble above or below Mitton.

One fish was caught after having over-wintered in the river. This was from the first stocking in April 1992, the fish was taken in May 1993. This produces a percentage of fish that survive over-winter and are subsequently caught as 0.17% of the fish introduced.

3.2. Tags returned in the weeks following individual stockings

The distribution of returned tags for each of the six stockings are shown in figures 3a to 3f.

Figure 3a. Stocked 9th April 1992

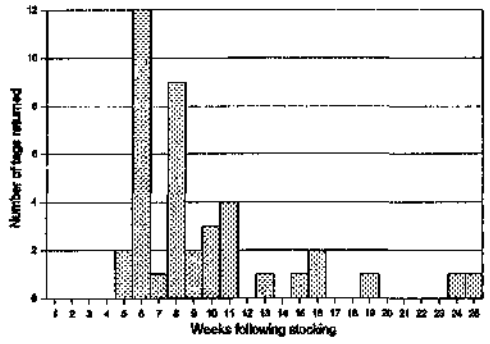


Figure 3b. Stocked 20th August 1992

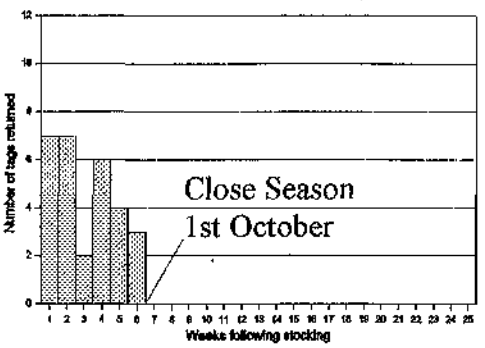


Figure 3c. Stocked 4th May 1993

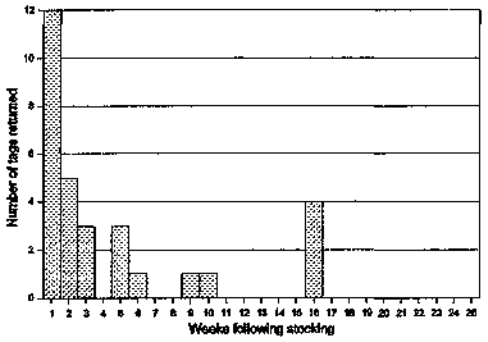


Figure 3d. Stocked 1st July 1993

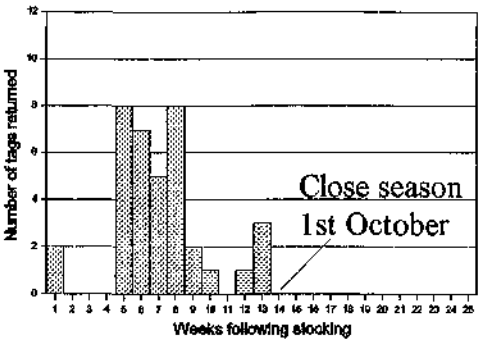


Figure 3e. Stocked 26th April 1994

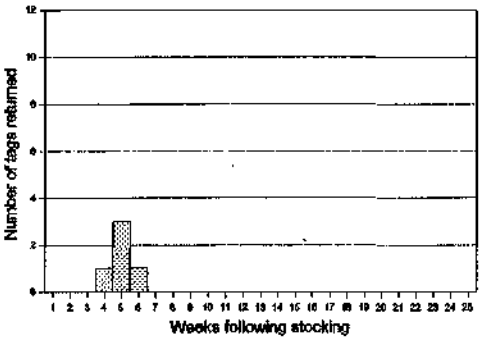
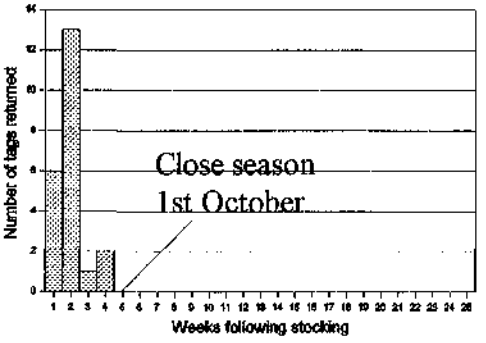


Figure 3f. Stocked 8th September 1994



The number of tags returned from each individual brown trout introduction varied from 41 to 5, see Table 2.

With the exception of the stocking undertaken in April 1994, there appears to be no difference between the number of tags returned following a stocking in spring compared with stocking in the summer or early autumn (Table 2). Chi squared analysis corroborates this theory ($p > 0.5$).

Table 2. Returns of marked fish per stocking.

Stocking Date	Number of marked fish introduced	Number of marked fish caught	Percentage of marked fish caught
April 1992	103	41	39.8
August 1992	100	29	29
May 1993	100	30	30
July 1993	100	37	37
April 1994	100	5	5
September 1994	100	22	22
Total	**603**	**164**	**27.2**

3.3. Permits purchased and trout caught

The number of permits purchased in the first 10 weeks following stocking (as determined by the methods outlined in Section 2), and the number of marked brown trout caught in this time are detailed in Table 3. The percentage of tags returned by anglers in this period vary from 100% (in summer 1992, spring 1994 and summer 1994) to 71% (in spring 1992). In the case of the summer stockings (1992 and 1994) this 10 week period ended in the close season and so no returns would be expected before the following years season commenced.

With the exception of 1994, there was no significant difference in the number of tagged brown trout caught in the first 10 weeks following introduction for either spring or summer/autumn introductions (chi squared $p>0.5$).

The average number of marked trout caught per brown trout permit purchased varies from 0.06 per permit, following the spring 1994 introduction to 1.0 per permit, following the summer 1994 introduction. The number of brown trout caught per permit sold of all types varied from 0.03 to 0.21 marked trout caught per permit, with an average of 0.12 trout per permit. Chi squared analysis indicated no significant difference between the number of permits of all types sold in the 10 weeks following a spring introduction compared with the permit sales following a summer/autumn stocking event.

Table 3. Permits purchased and trout caught in 10 weeks following stocking

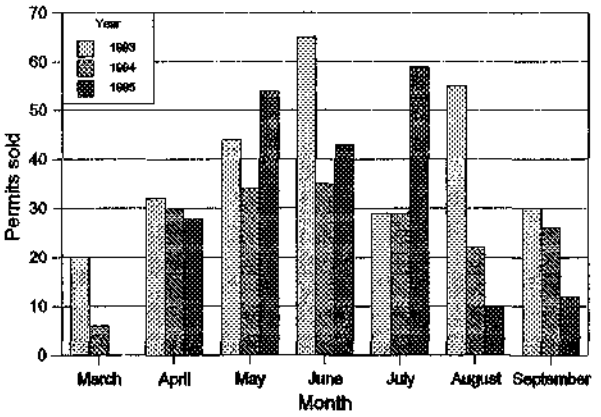
Stocking date	Marked trout caught	% Total tags returned	No. trout permits sold	Marked trout /permit	Permits sold all types	Marked trout /permit
09.04.92	29	71%	Not known	Not known	248	0.12
20.08.92	29	100%	Not known	Not known	135	0.21
04.05.93	26	87%	115	0.23	262	0.1
01.07.93	33	89%	87	0.38	254	0.13
26.04.94	5	100%	83	0.06	151	0.03
08.09.94	22	100%	22*	1	138	0.16
Total	144				1188	0.12

* No permits for brown trout fishing were sold after September 30th.

3.3.1. Trout permits purchased

Monthly sales of brown trout fishing permits throughout the seasons of 1993 and 1994 are shown in Figure 4. Monthly sales in 1995 are also shown for comparison. Brown trout permits are bought throughout the fishing season although numbers peak during the summer months of May, June and July.

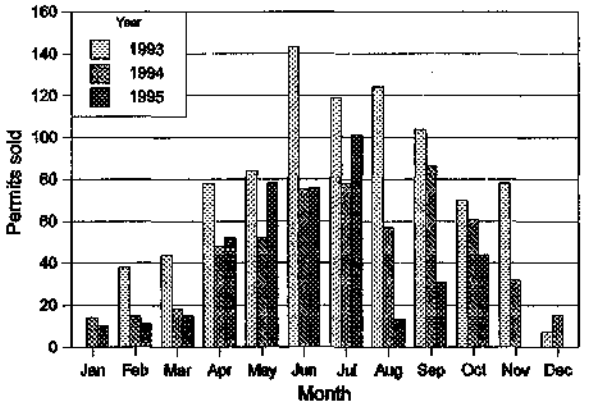
Figure 4. Number of Brown trout permits sold



3.3.2. Permits purchased of all types.

The monthly sales of permits of all types for the years 1993, 1994 and 1995 are shown in Figure 5. Permits are bought throughout the year though with peak sales in the months of June, July and August coinciding with a period when all of the fishing seasons are open. Monthly sales of permits vary greatly between years.

Figure 5. Permits of all types sold



The figures 4 and 5 clearly show a reduction in total licence sales between 1993 and 1995, they also indicate certain months of the year when fishing interest is increased. This information may be of use to angling associations deciding on optimal stocking strategies in order to maximise their revenue.

4. Discussion

4.1. Anglers return of Carlin tags

4.1.1. Recapture of introduced fish

The overall return of between 5 and 41 tags from each fish introduction and an average return of 27.2% is not unexpected. The stocking of hatchery reared fish into a wild environment is almost certain to lead to high mortality. The introduced fish were reared under controlled conditions with near constant environmental parameters and a regular supply of food, usually in the form of pellets. Following their introduction the fish must find a new food source and shelter, both from (previously unknown) predators, and from a fast flowing and rapidly changing environment (additional factors are discussed in section 4.4). The findings from the experiment at the Mitton Fishery were similar to other results reported in the scientific literature and to a similar experiment on the River Lune.

An experiment into the recapture rates of hatchery reared brown trout was also undertaken by Environment Agency staff on the River Lune fishery at Halton near Lancaster (D. McCubbing pers comm.). Hatchery reared brown trout (length 250-300 mm) were marked with numbered floy tags prior to their release into the river. Results on recapture rates are shown in Table 4. These show that the average recapture rate for brown trout was lower than that at Mitton on the River Ribble (18.4% compared with 27.2%). This was thought to have been due to the Halton fishery being wider and deeper than the Mitton fishery, thereby being less attractive to brown trout anglers and more favourable to salmon and sea trout fishermen.

Table 4. Results from River Lune Brown Trout Stocking Study

Date of introduction	Number introduced	Number tagged fish recaptured	Percentage rate of recapture.
April 1992	202	59	29.2%
April 1993	150	17	11.3%
August 1993	100	7	7.0%
Total	452	83	18.4%

Consideration of the available literature on the recapture rates of stocked brown trout indicates similar results to those from the North West Rivers. In a study by Kennedy et al. (1982) stocking brown trout into a 41 hectare lake in Northern Ireland, recapture rates varied from 1.4% for autumn stocked 0+ trout to 44.8% for spring stocked 2+ trout. Similarly, a paper by Cresswell (1981) summarised the available literature on recaptures of stocked trout into flowing waters. The results from introductions of brown trout of length greater than the takeable size are shown in Table 5.

Table 5. Review of stocked brown trout recaptured by anglers (from Cresswell 1981)

Number of brown trout stocked	Number of recaptures by anglers following stocking in:			
	Spring	Pre-season (<1month)	Open season	Autumn
32,456	6,900 (21%)			
2,000		647 (32%)		
6,667			2,028 (30%)	
15,220				2,165 (14%)

This summary data appears, in general, to support the returns from the Mitton Fishery. There would appear to be a reduced recapture rate for fish stocked in the Autumn, presumably because of over-wintering mortality prior to any significant angling pressure. These recapture figures should be borne in mind by any angling club proposing to stock their area of river with hatchery reared brown trout above the takable size limit.

The Mitton experiment suggests that there is little migration of fish from their initial stocking site. Six of the 164 tags returned (4%) were from fish caught outside of the Mitton Fishery. This result is in agreement with Cresswell's study, which indicated that 90% of the brown trout recaptured had dispersed less than 4.5 km from their original site of introduction, the majority of movement was downstream.

4.1.2. Catchability of introduced fish

The overall return of Carlin tags in the weeks following introduction (Figures 1 and 2) suggests that the majority of tagged fish are caught in a short period after stocking. This was found to be true for each individual stocking date (Figures 3a to 3f). This is not unexpected considering that the introduced fish are unused to living and feeding in a wild environment. This will cause them to be unsure of safe food sources and result in high catches in the short period following their introduction.

The high catchability of recently introduced trout is emphasised by the angling trip of an Agency employee who fished the Mitton Fishery shortly after the spring introduction in 1994. A total of 17 tagged brown trout were caught in a single session (J. Shatwell pers. comm.). All of the fish were subsequently returned to the river unharmed and still holding the Carlin tag. This suggests that the low returns of Carlin tags in 1994 were not due to unusually high mortality of the introduced fish, but were more likely due to a low level of returns from anglers.

4.2. Sale of permits.

The number of permits sold by a fishery throughout the year is likely to be dependent upon: fishing conditions, the time of the year, and the success of anglers fishing the waters. Certain weather types and water heights favour successful fishing and increases in permit sales are likely to occur at these times. In addition, and especially during the summer months, permit sales are likely to increase because of the better weather and because this is the traditional time of year for people to take their holidays. During the summer months all of the fishing seasons (coarse, brown trout and migratory salmonid) are open which should maximise permit sales of all types, as was indicated in Figure 4.

The success of anglers fishing a water will also tend to increase permit sales as news spreads by word of mouth. For this reason, vendors of day permits may find it financially expedient to advertise their notable catch returns throughout the season and the dates when fish of a takable size are to be introduced into the water. A failing of this experiment at Mitton was that fish introductions were not openly disclosed to the public. Although the permit vendor was informed of each fish introduction, revenue was inevitably less than the potential because of inadequate publicity.

These three factors are all interrelated, though the most important is the fishing conditions on the water. It is almost certainly no coincidence that, of the three years where we currently have most information, the highest permit sales were recorded in the year with the best fishing conditions (1993). During the summer months of 1994 little rain fell, whilst in the summer of 1995 there was a national drought with minimal rainfall from the beginning of August to the end of September. The period of the 1995 drought coincided with a dramatic reduction in permit sales compared with same months in both 1993 and 1994.

The low flows in these two exceptionally dry years make any comparisons of permit sales between years very difficult. They also prevent any statistical testing to determine whether permit sales during the period of the experiment were increased compared with sales in 1995 when no fish were stocked. It might be expected that when there were similar fishing conditions between years and adequate publicising of fish introductions, permit sales should increase in years when fish were stocked compared with years when they were not. The generally poor angling conditions in 1995, compared to other years, prevent such comparison. It is important that information is gathered in future years in order to test this theory.

4.2.1 Cost benefit of brown trout introductions.

Angling associations reading this report may decide that an average recapture rate of 27.2 per cent of the brown trout introduced is a low return on their investment. They must however consider the benefit of the introduction in terms of an increase in the number of anglers fishing their waters and must also take into account the satisfaction of their club members.

There is little doubt that stocking with good quality fish is excellent public relations for a fishery, especially the introduction of fish of a takeable size. Once in the water, all of these fish are perceived by the angling public to be catchable, regardless of their true recapture rate. This expectation of fishing success should almost certainly increase the number of permits sold, or angler visits, in the weeks following introduction. Whether this increase is sufficient to cover the costs of the introduction can be determined by a simple equation. Stocking is cost effective when :

$$\text{Increase in anglers fishing the water} = \frac{\text{Cost of introducing the fish}}{\text{Cost per permit}}$$

In pursuing this cost/benefit analysis it is also important to consider the price of the permit. If the price is set too high few anglers will fish the water and, although individual catches may be good, total revenue gained may be below the cost of introducing the fish. Alternatively, if the price is set too low, although a large number of anglers may fish the waters and recaptures may subsequently be high, regular restockings will be required to maintain angler interest which may place financial burdens on the fishery. A reworking of the above equation can be used to set a minimum price for the permit which will result in no financial loss to the club.

$$\text{Permit price} = \frac{\text{Cost of fish introduction}}{\text{Increased number of anglers fishing the water}}$$

The most important figure from this equation, and the most difficult to determine, is the increase in the number of anglers fishing a water following an introduction. Calculation of this figure requires a detailed knowledge of the effect that previous introductions had on permit sales, and also consideration of the requirements of angling club members. Clubs may find it expedient to canvas their members as to their likely reaction should any alterations to existing stocking policy be proposed in the light of this reports findings.

4.3. Introduction of alternative life stages

It should be emphasised that data discussed in this report applies to the survival of brown trout in the size range stocked during this experiment (greater than 200mm in length). Brown trout fingerlings are also introduced by angling clubs although no data were collected on their survival in this study and therefore no specific guidelines for their introduction in the Central Area can be proposed. We can however reproduce the results from other experiments and give advice based on this.

The study by Kennedy (1982) suggests that the returns from juvenile fish are very low: 1.4% for autumn stocked 0+ trout, 10.4% for spring stocked 1+ trout, and 15.6% for autumn stocked 1+ trout. This study also gave a similarly low percentage of fish that had over-wintered, 1.9% compared with 0.17% for the Mitton study. Cresswell (1981), reviewed the available data on percentage recapture rates from stocking with brown trout less than the takable size, these data are shown in Table 6.

Table 6. Recaptures of stocked brown trout less than the takable size (from Cresswell 1981)

Season fish stocked	Fish length	Number stocked	% Recaptured
Autumn	10 cm	506	0
Summer	Fingerlings	6,395	2.6
Autumn	17 cm	4,000	8.1

These results suggest a low overall recapture rate from stocking with fish below the takable size limit. Whether the reduced price of these smaller fish makes their introduction more cost effective than buying fish above the takable size, and whether these smaller fish attain a greater degree of "wildness" such that the overall fishing is improved, is outside the scope of this report.

4.4. Experimental problems

The potential problems associated with this experiment are identified and discussed below.

1. The experiment relies on the goodwill of anglers to return the Carlin tags from tagged fish. The reward offered will encourage this though there will always be a number of anglers who, for one reason or another, do not submit any catch returns to the Agency. This is likely to result in an underestimate of the recapture rate. In most years, when a majority of catch returns were submitted, this will lead to only a minor underestimate. However, in 1994 when very few returns were submitted there is the potential for major underestimation of the capture rate. For this reason the 1994 tag return data was ruled out from any detailed analysis.

2. Although the tag return histograms suggest that most tagged fish were caught in the first few weeks after stocking there may be a small reduction in tag returns from stockings in late August or early September because of the start of the close season. This is unlikely to have a major affect since the number of tags returned in these months drops off rapidly after the first few weeks following stocking.

3. It is assumed that a negligible number of Carlin tags are shed from fish after introduction into the river. If tags were to be lost in significant numbers, a correction factor would need to be applied. The method of fixing Carlin tags reduces the probability of tags being lost by the fish during its time in the river, however the possibility cannot be ruled out.

Data from similar tagging studies have shown Carlin tags to be effective. A comparison of 6 tag types on 27,753 sea-trout in the Baltic Sea showed that the best results were obtained from Carlin tags (Bartel et al. 1987), similarly an experiment comparing the performance of 9 types of external tags on rainbow trout indicated tag losses with Carlin tags at 2% after 30 days and 15% after 90 days for trout kept in a raceway (McAllister et al. 1992). These studies suggest that tag losses will be minimal for the few weeks following brown trout introduction when most of the tagged trout in this experiment were caught.

4. It is possible that tagged fish have reduced survival in the river because the tag is : more attractive to predators; affects the behaviour of the fish making it more or less likely to be caught; or increases disease in the fish through infection of the puncture wounds.

In the study by McAllister (1992), hatchery reared rainbow trout were seen to exhibit aggressive behaviour because of competition for food and position, especially when approaching the spawning season. This behaviour included attacking tags on other fish. Assessment of tag induced injury showed Carlin tags to have some of the lowest levels of tag induced injuries 90 days after tagging. These effects may reduce the survival and recapture rate of the tagged fish though it is unlikely to have a major effect in a large river and for the short periods that tagged fish were caught in this experiment.

In spite of these potential problems with the experimental methods, the results can be considered valid and useful guidelines for future fish introductions can be proposed.

5.0 Options for Brown trout stocking

The following stocking options are made using the data obtained from this stocking study on the Mitton fishery and from consideration of the available scientific literature. Returns for other fisheries, even on the same river, will depend on fishing methods and the level of angling pressure unique to that water.

It should be emphasised that the available data suggests a likely return by rod and line fishing from any introduction of brown trout at approximately 27% of the total number of fish stocked. This return rate should be considered in terms of cost and benefit to the Angling Association concerned with respect to financial costs of the fish and increased revenue from permit/season ticket sales, and, most importantly, what the Association require from their stretch of river. It should also be noted that the results from this experiment were not sufficiently diverse as to be able to categorically indicate that introductions of brown trout increase the total number of trout caught at a water, nor can they suggest the ecological impact of these introductions on the river. Some of these questions are the subject of a national R&D project on "The effects of stocked brown trout on the survival of wild fish populations" (R&D Note 490), which is due for publication in the near future.

If an Angling Association do choose to stock their fishery with brown trout the following should be taken into consideration.

1. **Stock early**. Fish introductions should begin in spring or early summer. This will maximise the opportunities of anglers to catch fish over a longer time period.

2. **Stock in small numbers**. Areas of rivers should be stocked with small numbers of fish every 6-10 weeks from spring/summer and stocking should be stopped 6 weeks prior to the close season unless the introduction is for a specific purpose, eg. a fishing match.

3. **Stock in several areas**. The data on the location of tagged brown trout capture suggests that there was very little movement of the fish from where they were introduced.

4. **Do not stock takeable fish to over-winter**. The data suggests that only a very small proportion of the fish survive a winter in the river, introductions should not be undertaken late into the fishing season.

5. **Consider the cost effectiveness of your stocking policy.**

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Appendix 1.

Monthly sales of permits at Mitton Fishery 1993 - 1995.

Month	1993		1994		1995	
	Brown trout	**All permit types**	**Brown trout**	**All permit types**	**Brown trout**	**All permit types**
January				14		10
February		38		15		11
March	20	44	6	18		15
April	32	78	30	48	28	52
May	44	84	34	52	54	78
June	65	143	35	75	43	76
July	29	119	29	78	59	101
August	55	124	22	57	10	13
September	30	104	26	86	12	31
October		70		61		44
November		78		32		
December		7		15		
Total	275	889	182	551	206	431

Appendix 2.

Permit prices at Mitton Fishery 1992-1996

Permit Type	Price		
	1992	**1993-1995**	**1996**
Salmon to July 31	£ 7.50	£ 8.00	£ 9.00
Salmon from August 1	£ 15.00	£ 15.00	£ 16.50
Brown trout	£ 3.00	£ 6.00	£ 7.00
Coarse Fish	£ 2.00	£ 4.00	£4.50

Reduced duty permits are also available.