A REPORT ON THE STRATEGIC STOCK ASSESSMENT SURVEY OF MINOR CATCHMENTS IN SOUTH CUMBRIA 1994 WITH PARTICULAR REFERENCE TO SALMONIDS

VOLUME 1

NRA/NW/FTR/94/16

December 1994

A REPORT ON THE STRATEGIC STOCK ASSESSMENT SURVEY OF MINOR CATCHMENTS IN SOUTH CUMBRIA 1994 WITH PARTICULAR REFERENCE TO SALMONIDS.

VOLUME I

COLTON BECK

RIVER EEA

RIVER GILPIN

RUSLAND POOL

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Front Cover Photo :

A REPORT ON THE STRATEGIC STOCK ASSESSMENT SURVEY OF THE COLTON BECK CATCHMENT 1994 WITH PARTICULAR REFERENCE TO SALMONIDS

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CONTENTS

1.0. SUMMARY

Colton Beck has excellent densities of sea trout (*Salmo trutta*) and a small population of salmon (*Salmo salar*) in its lowest reaches.

The total productivity is very good throughout the catchment.

Stocking of sea trout fry in 1993 has enhanced the population with survivors through to parr probably adding to the scoring of double class A at two sites in the survey in 1994.

Stocking was not undertaken in 1994, but the population appears to be maintaining itself at a very high level.

2.0. INTRODUCTION

The NRA under the Water Resources Act 1991, has a responsibility to maintain, improve, and develop fisheries. To accomplish this, baseline data on the populations of fish present in North West region is required.

The stock assessment task group has identified a number of key areas for the application of stock assessment data:

1. To assess long term change.

2. To help conserve fish species.

3. To evaluate stocking programmes, habitat and water quality improvements.

4. To assess or predict the impact of activities which the NRA or other organizations may have on fish populations.

5. To comment on the fisheries implications of developments when the NRA is a statutory consultee to planning authorities.

This report forms one part of the third year of a triennial survey programme for the South West Cumbria and South Cumbria catchments.

3. DESCRIPTION OF STUDY AREA

3.1. SITE SELECTION

A total of 7 sites were selected throughout the catchment. These sites were chosen at approximately 1km distances apart, where access was possible and were representative of the area of river immediately around the site.

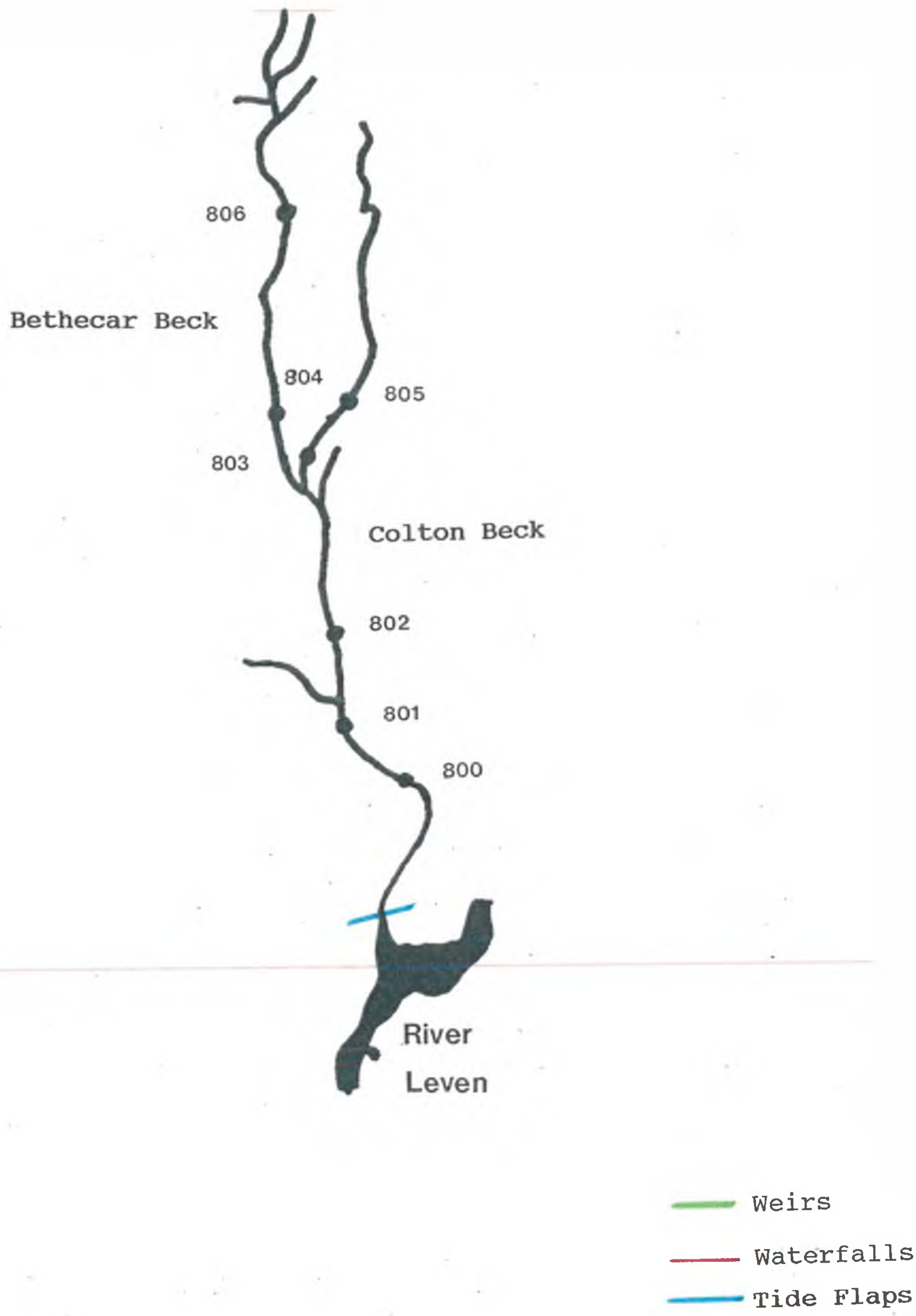
3.2. OBSTACLES

Obstacles, for example weirs, waterfalls and tide flaps, can act as important factors affecting the distribution of fish within a catchment (Gardiner 1990). Figure 1 shows the tide flaps known to exist within the catchment.

3.3. WATER QUALITY

The spring 1994 water quality survey on Colton Beck found water quality, in the site sampled, to be class 1A (Appendix 1).

Figure 1 : Known Obstacles to Migratory Fish 1994.



4. METHODS.

All the sites sampled in 1994 were fished using an Electracatch pulsed DC control box powered by a 1.5KW Honda generator.

For five of the six sites, the team fished once through in an upstream direction for around 50m without stop nets. The sixth site was fished multiple times between stop nets. The reason for this was to further assist in calibrating the 50m single fish method (without stop nets) Farooqi *et al* 1993.

At this multiple fishing site, fishing was over 60m. The first fish was started at least 5m upstream of the bottom stop net and halted 5m below the upstream stop net. Subsequent fishings were from net to net. Fishing was continued until an acceptable decline in catch was recorded. The first run was used to calculate the minimum fish densities and population estimates required for this report.

All fish were collected, except where numbers of minor coarse fish (minnows, bullheads, stickleback and stoneloach) were so high as to make accurate netting impossible without inordinate effort. In these cases an abundance category was assigned, Appendix 2d.

A number of other details were recorded, including temperature, conductivity, water level, velocity, general habitat details and the team's specific tasks.

Measurements of site length and widths at 10m intervals were recorded, Appendix 2a.

Target fish (salmonids and major coarse fish species) were anaesthetised when necessary using phenoxyethanol and then measured to the nearest 0.5cm (rounding down). Where the number of fish in any age class appeared to be in excess of 100, a sub sample of about this number was measured.

For each target species and age class (salmonids only), a minimum density (number of fish caught divided by the area fished, multiplied by 100) per 100m^2 was calculated. This information is tabulated in Appendix 2b.

The calibration site data has been collected as part of a regional attempt to determine the accuracy of the single fish data used in this report. The relationship between these two methods of sampling and their results forms part of a separate report, NRA/NW/FTR/93/4 but a summary of statistics is included in Appendix 6. A strong correlation was achieved in all age classes for salmonids.

5.0. RESULTS BY SUB-CATCHMENT

See Figs 2-5

5.1. Lower Colton Beck

Three sites were sampled on the lower Colton Beck, below Bethecar Beck. The lowest site was at Colton Bridge, one site downstream of Beckside farm, and one site at Waste Bridge where the calibration survey was carried out.

The lowest site (800) was situated in pasture land. Some flood defence gabions were present but the stream had retained much of it's natural cover of boulders and cobbles. Overhanging vegetation was limited to small areas of bramble and cow parsley. Good areas of spawning gravel were found.

The site downstream of Beckside Farm (801) flows through deciduous woodland. The substrate consists of mainly bedrock with some boulders and gravel, the profile was steep and the flow was correspondingly fast.

The site at Waste bridge (802) flowed through agricultural land. The substrate consisted of bedrock, cobble and gravel with some siltation in pools.

5.1.1. Results

Salmon densities were relatively low in the lower Colton Beck. Salmon fry scored class D at the lowest site (800) and were completely absent from the two sites above. Salmon parr scored class B at the lowest site, class D at the site above, and were completely absent from site 802.

Trout densities are quite different, with fry scoring class A at the lowest site, class C at the site above and class B at site 802. Trout parr scored class C at the lowest site, class A at the site above and class B at site 802. There were no >1+ trout observed.

Eels and bullheads were very abundant at the site at Waste Bridge (802).

5.2. Upper Colton Beck

Two sites were surveyed on the upper Colton Beck above the confluence with Bethecar Beck. Both sites had gravel substrate with some cobble. The lower site (803) flowed through agricultural land, and had a large amount of bankside cover. The site above this at Oxon Park flowed through moorland.

5.2.1. Results

Salmon were absent from both sites.
Trout scored double class A for fry and parr at both sites.

5.3. Bethecar Beck.

The lower site on Bethecar Beck at Bandrake Head flowed through agricultural land. The substrate consisted of bedrock, with boudlers and cobbles, the profile was uneven and the flow was fast. There was some bankside cover in the form of deciduous trees.

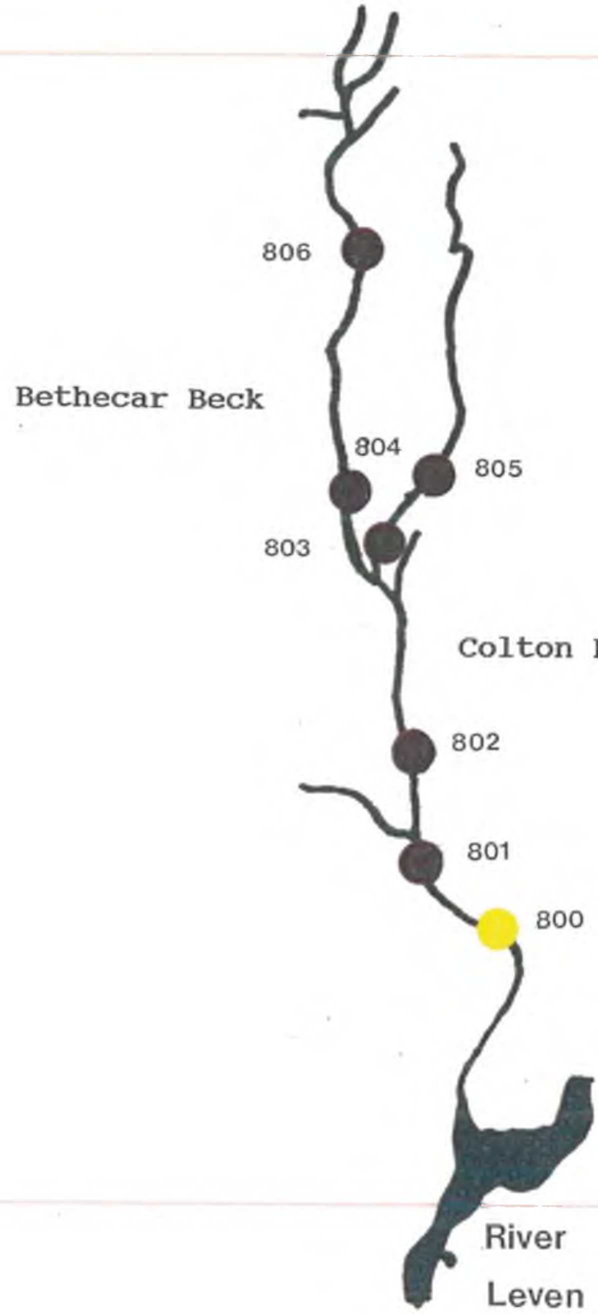
The site above this, the uppermost site of the catchment flowed through moorland. The substrate consisted of cobbles and gravel.

5.3.1. Results

Salmon were completely absent from Bethecar Beck.

Trout fry scored class A at the lower site, and class D at the site above. Whilst trout parr scored class A at both sites.
A few older trout were present at both sites suggesting a small population of resident brown trout.

Figure 2 : 0+ Salmon Densities in the Colton Beck Catchment 1994.



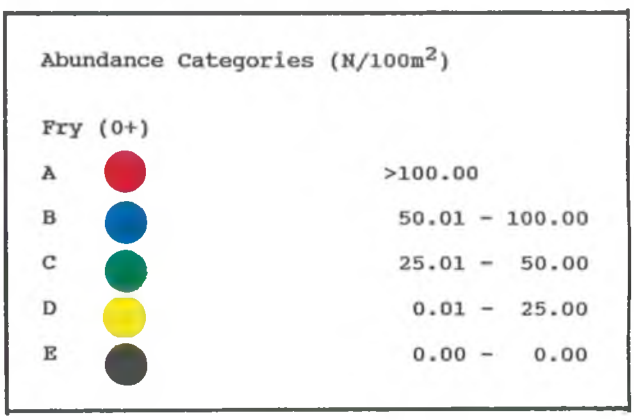


Figure 3 : Salmon Parr (>0+) Densities in the Colton Beck Catchment 1994.

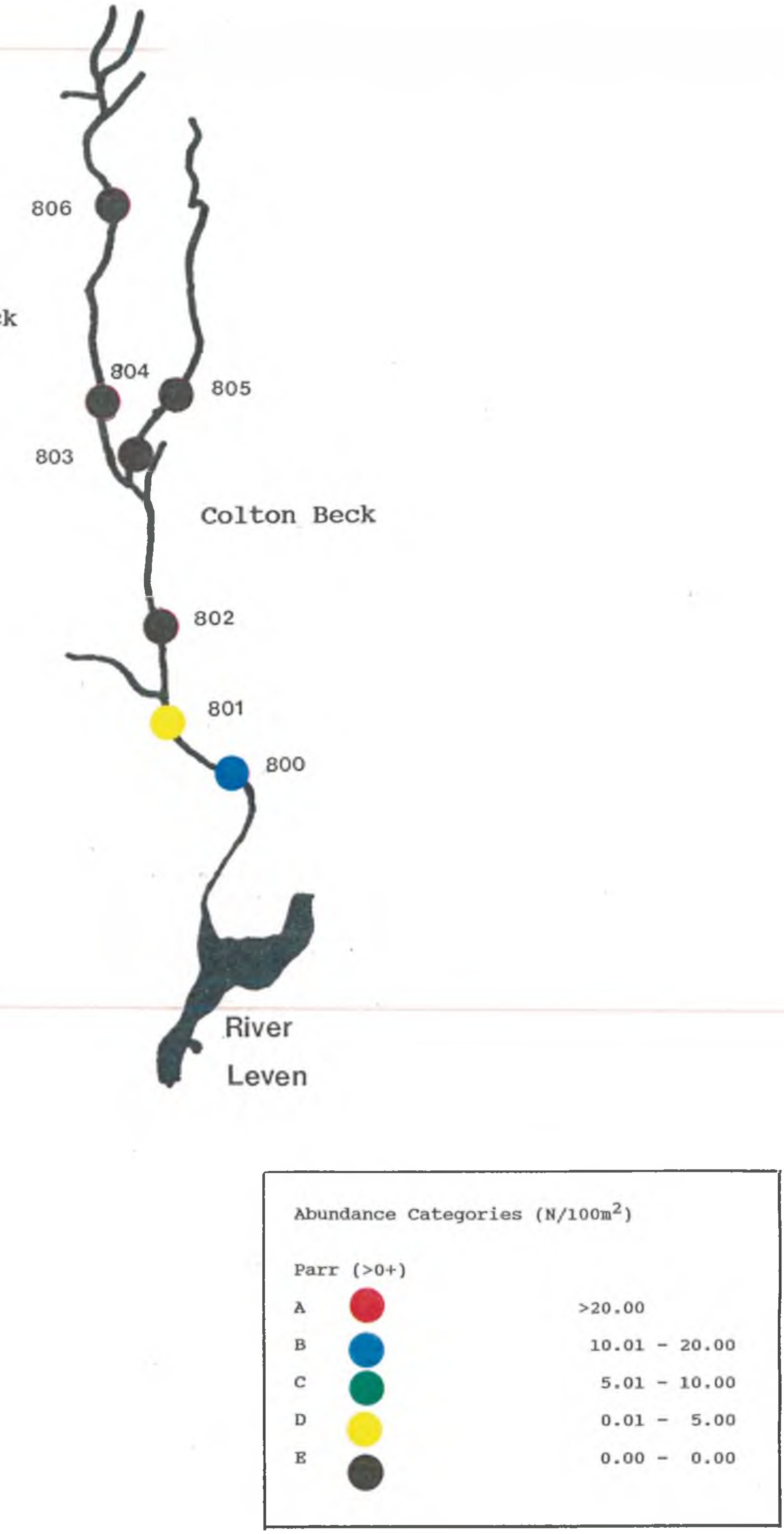
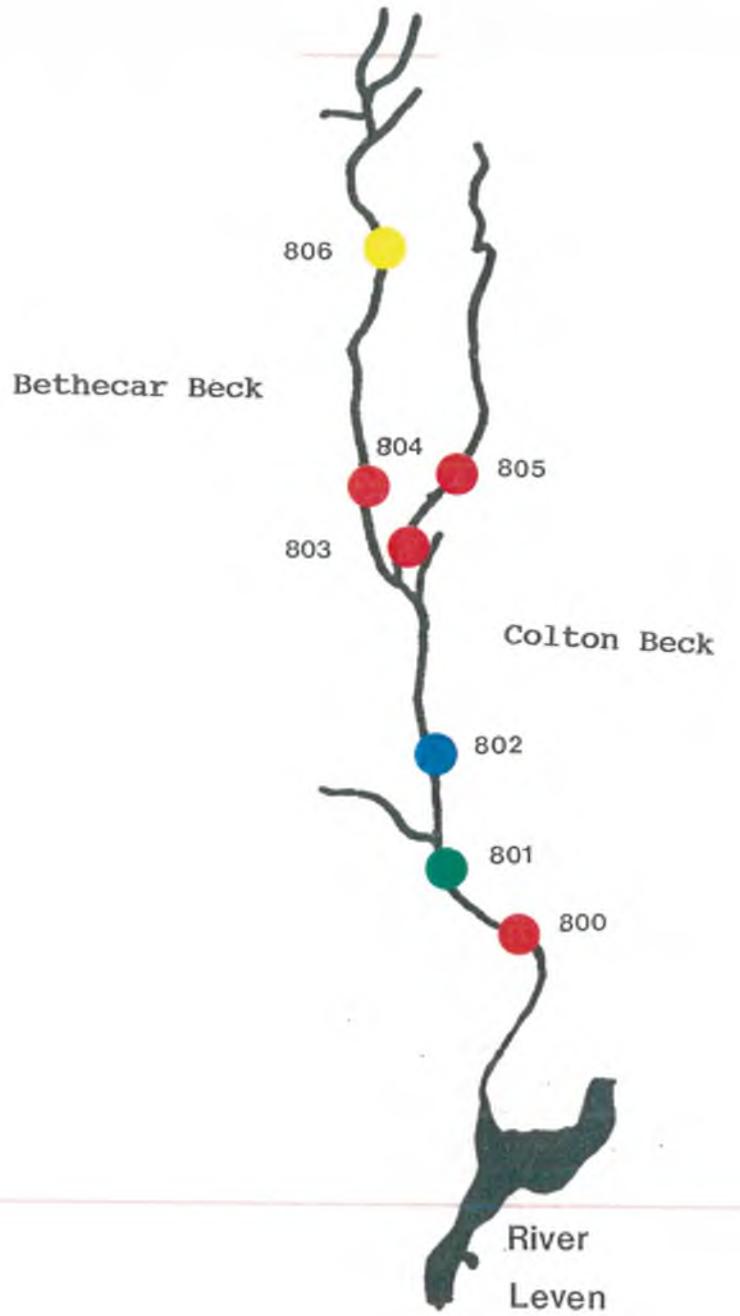


Figure 4 : 0+ Trout Densities in the Colton Beck Catchment 1994.

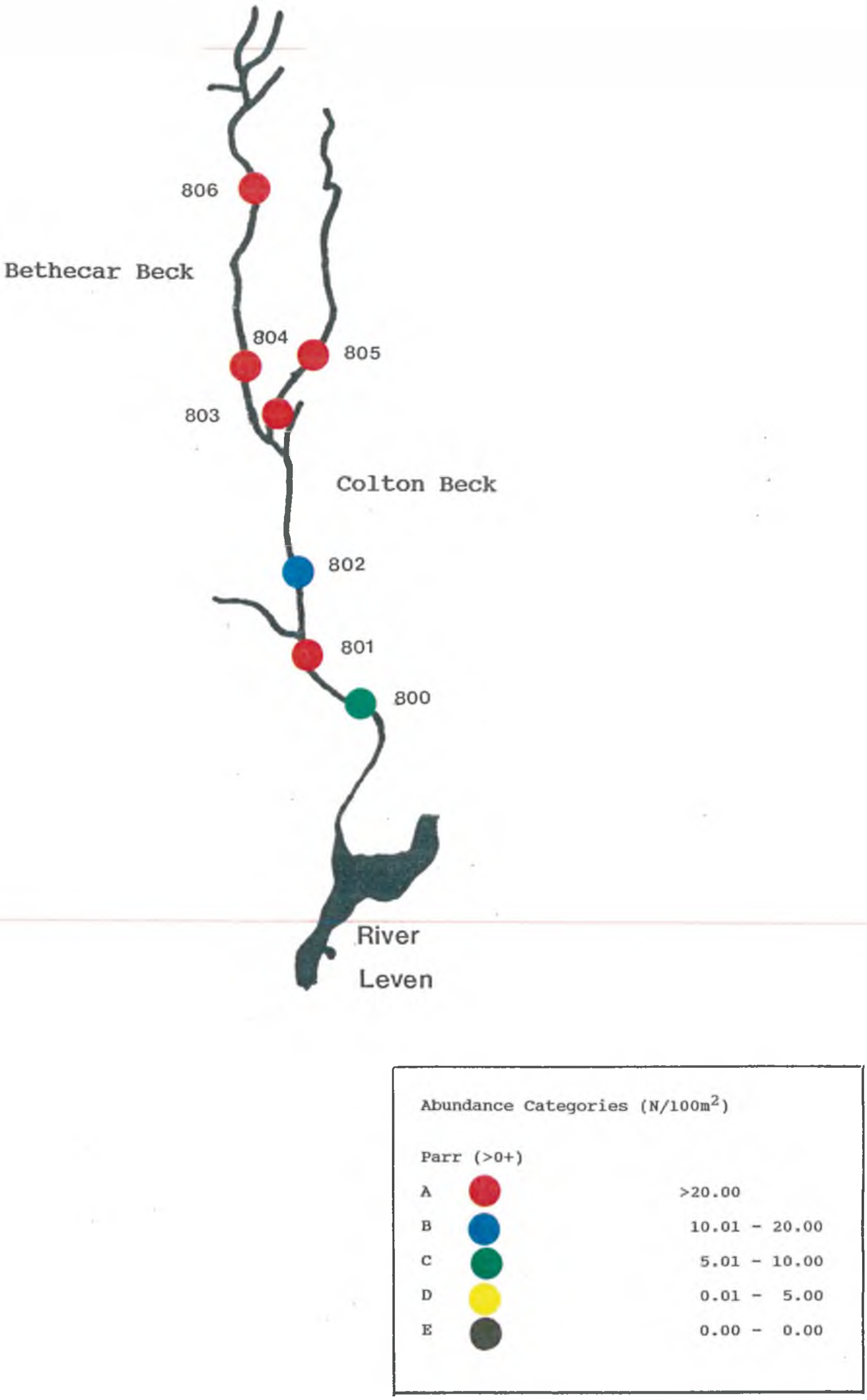


Abundance Categories (N/100m^2)

Fry (0+)

A	red	>100.00
B	blue	50.01 - 100.00
C	green	25.01 - 50.00
D	yellow	0.01 - 25.00
E	black	0.00 - 0.00

Figure 5 : Trout Parr (>0+) Densities in the Colton Beck Catchment 1994.



6.0. OVERVIEW

From the detailed discussions on each site, it can be seen that overall Colton Beck has good densities of salmonid production with areas of excellent trout production.

6.1. SALMON

6.1.1. Salmon Production

Salmon are restricted to the lowest reaches of Colton Beck, with only the two lowest sites having salmon present in any numbers.

6.1.2. Salmon Productivity

In an effort to determine the productivity of the Colton Beck system in terms of salmon parr numbers, the densities of parr found at each site combined with the width data collected were used to calculate a figure for parr production over a number of "reaches". The choice of the length of these reaches was based on comparable widths at all sites where accessibility to adult salmon was observed by the presence of juveniles of this species.

The figures are tabulated below.

TABLE 1. ESTIMATED SALMON PARR PRODUCTION USING MEAN DENSITIES AND WIDTHS OVER SUB CATCHMENT LENGTH.

Sub Catchment	Length (km)	Mean Width (m)	Mean Parr Density nos/100m^2	Parr Production (nos)
Colton Beck Bridge	2.2	3.4	11.11	831
Lower Colton Beck	1.4	3.47	4.06	197
TOTAL				**1028**

Using data from studies by Shearer (1984a) and Mills (1989), an estimate of the likely adult return of salmon from this number of salmon parr can be calculated. Assuming a 50% mortality of parr before smolting and a 10% survival of smolts at sea, an adult salmon run of 50 fish should result in 1996.

6.1.3. Comparison with Salmon Redd Counts

Of the juvenile fish surveyed in 1994, the fry are the progeny of the 1993 spawning and the parr are the survivors of the 1992 spawning. The salmon redd counts are a minimum figure and follow the same pattern of distribution as was found in the electrofishing surveys of juveniles.

The redd count of 1993/4 (Appendix 3a), shows three salmon redds in the lowest reaches below site 800 and four salmon redds further upstream between sites 801 and 802. In the survey, no fry were observed at the upstream site 801, but site 800 scored class D for salmon fry.

The redd count data of 1992/3 (Appendix 3b), the parr of the survey year shows five redds at the lower site 800, but none elsewhere. In the survey salmon parr were found at both sites, but in greater numbers at the lower site.

If we assume that an average redd may contain around 5,000 eggs, we have a total egg deposition in Colton Beck of 25,000 in 1992/93. This suggests that survival rates through to parr are in the region of 4.1%. Although this is not low, higher levels are found in other systems for example River Calder 9% and River Mint 6-7% (McCubbing 1994a and b). It would appear that, with this level of survival, the salmon population although limited is being maintained at a relatively steady state.

6.1.4. Juvenile Salmon Production versus Adult Returns.

As no fishery exists on Colton Beck, no catch returns are available. This leaves redd counts as the only measure of adult population.

6.2. TROUT

6.2.1. Trout Distribution

Trout were found at every site surveyed in very high densities, with two sites scoring double class A for fry and parr on the upper Colton Beck.
In 1993, 8,000 sea trout fry were stocked in the upper reaches of Colton Beck, the parr of the survey year. The survey results indicate good densities of parr with three double class A sites, and two class A sites out of a total of seven sites.

6.2.2. Trout Productivity.

Trout productivity can only be measured as that for resident and migratory trout together, as it is not possible to determine visually which juvenile fish originate from which parents. However, as a comparison to the salmon parr production data, a table of trout 1+ parr production for all sites has been included below.

TABLE 3. ESTIMATED 1+ TROUT PARR PRODUCTION USING MEAN DENSITIES AND WIDTHS OVER SUB CATCHMENT LENGTH.

Sub Catchment	**Length** (km)	**Mean Width** (m)	**Mean Parr Density** nos/100m^2	**Parr Production** (nos)
Colton Beck Bridge	2.3	3.4	5.47	428
Lower Colton Beck	1.9	3.17	23.36	1407
Upper Colton Beck	2.8	1.44	50.51	2037
Bethecar Beck	3.1	2.0	32.93	2042
TOTAL				**5914**

Upper Colton Beck and Bethecar Beck provide the greatest trout parr production, this is the area where stocking occurred in 1993 which explains the high production. Bethecar Beck had a small number of older trout present and so a proportion of the parr production will be resident brown trout. The lowest reach of Colton Beck at Colton Beck Bridge is the area of lowest parr production.

It is difficult to determine what this production represents in terms of sea trout, since the actual proportion of migratory to resident trout is not known. If all of this parr production was represented by sea trout, an adult return of some 450 fish can be expected in 1996, assuming 50% winter mortality before smolting and 15% survival of smolts at sea (D. Evans pers comms.). This is an over estimate since this includes some resident brown trout, but it gives us an idea of what could be expected.

6.2.3. Comparison with Sea Trout Redd Counts.

The sea trout redd count data (Appendix 3a & 3b) shows the same pattern of distribution as was found in the electrofishing survey.

Trout fry are the progeny of eggs laid down in 1993/94 and were found distributed in high numbers throughout the catchment excluding the very highest site on Bethecar Beck where they only scored class D. The redd count data for this year class (Appendix 3a) also shows the same pattern with the greatest numbers being found in the upper Colton Beck reaches where trout fry scored double class A.

Redd count data for 1992/93 (Appendix 3b) shows 82 redds were counted in the mid area of Colton Beck. The parr surveyed are the progeny of eggs laid down in this year, and the electrofishing survey suggests a wider distribution than this. This can be explained by the stocking of sea trout fry in the upper reaches in 1993.

There was no stocking carried out in Colton Beck in 1994, but from the redd count data and survey data it appears spawning was successful in 1993/94 and stocking was not needed. The population now appears to be producing enough adults to maintain itself.

6.2.4. Comparison of Production with Adult Returns.

As no fishery exists on Colton Beck, no catch returns are available, and so a comparison with adult returns cannot be made.

6.3. TOTAL PRODUCTIVITY.

An attempt in this study has been made to determine the total productivity of the system as well as a total productivity on a site by site basis. The methodology used is described in Appendix 4.

Whilst acknowledging the possible flaws in the methodology used for determining the total productivity classes, some interesting results are obtained.

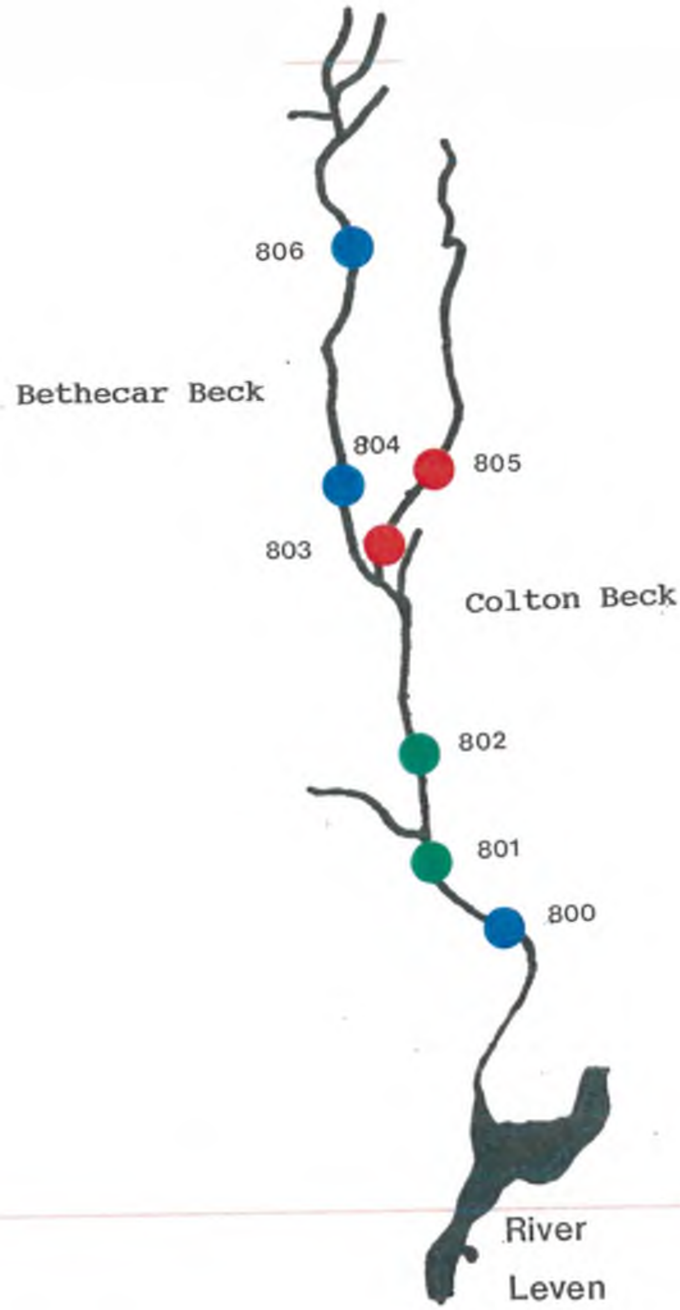
From Figure 6 it can be seen that the Colton Beck system is very productive across most of its area with no sites devoid of fish. There are the following numbers of sites in each productivity class;

Class	Nos of Sites	% of total
A	2	29
B	3	42
C	2	29
D	0	0
E	0	0

Upper Colton Beck has the highest total productivity with both sites scoring class A, this is due to the very high densities of trout which were partly as a result of stocking.

The lowest site (800) scored class B for total productivity and it had a higher diversity of species with salmon and trout both scoring high. The other sites did not have any salmon present, but because of the high densities of trout they still scored high for total productivity.

Figure 6 : Total Salmonid Production in the Colton Beck Catchment 1994.



7.0. CONCLUSIONS.

[1] Survival and production of salmonids in this catchment is of a sufficient level to maintain the population in a steady state.

[2] Salmon distribution is limited to the lowest reaches of Colton Beck. Trout are distributed throughout.

[3] There appears to be a small population of resident brown trout in the upper reaches of Bethecar Beck.

[4] Stocking of sea trout fry in 1993 appears to have been successful with the survivors through to parr scoring double class A at two sites.

8.0. RECOMMENDATIONS

Colton Beck is an excellent sea trout catchment, with previous stocking programmes probably enhancing this. It now appears that stocking in this catchment is no longer needed, since there are enough returning adults to maintain the population.

9. REFERENCES

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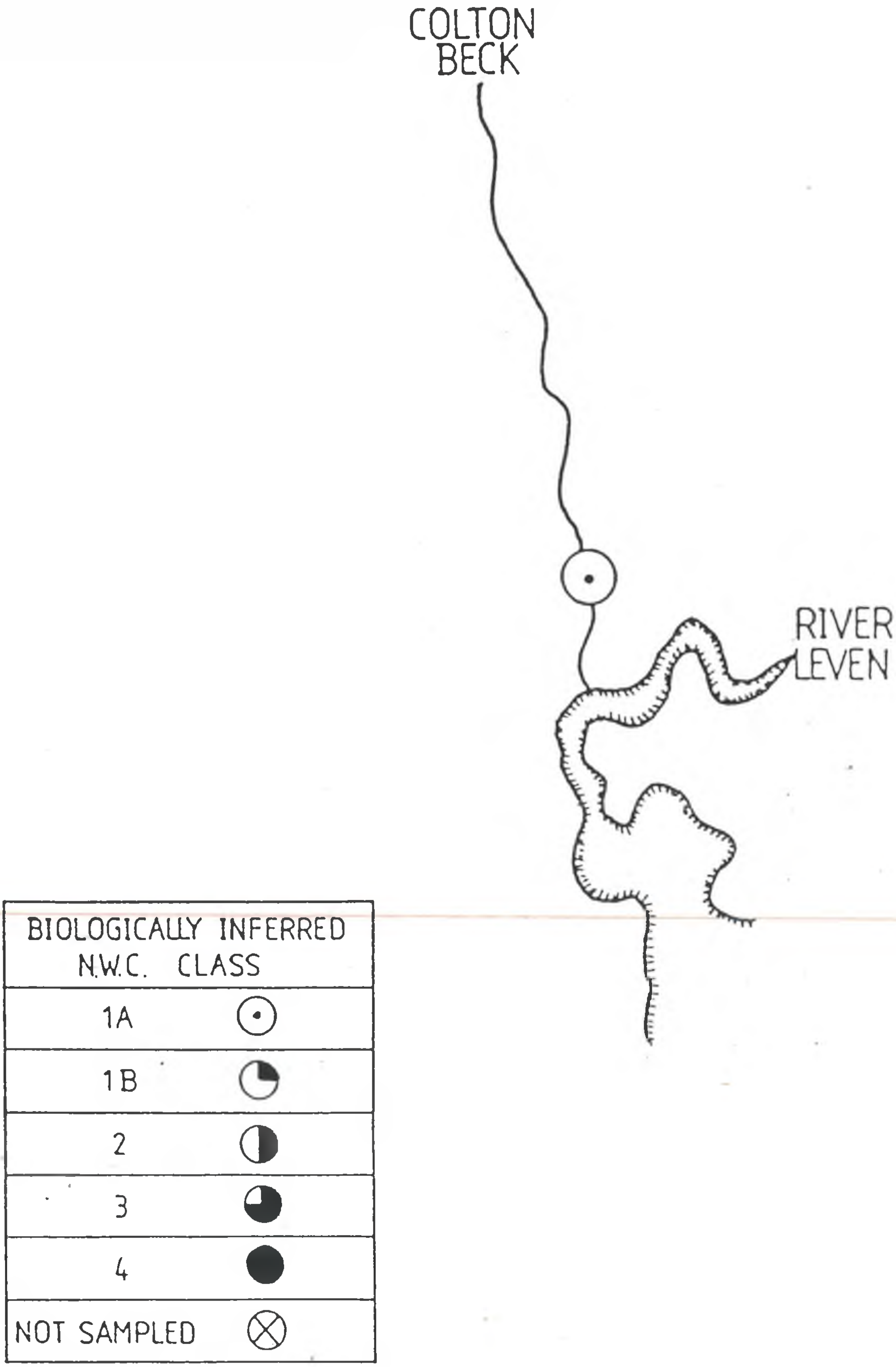
APPENDICES

Appendix	1	Water Quality in the Colton Beck catchment 1994
	2a	Table of Site Reference Data.
	2b	Salmonid Densities in the Colton Beck catchment.
	2c	Major Coarse fish species densities.
	2d	Minor Coarse Fish Densities - abundance.
	3a	Redd Count map data 1993/94.
	3b	Redd Count map data 1992/93.
	4	Methodology for calculation of total productivity.
	5	Minimum Salmonid Population Estimates.
	6	Statistical Basis for Calibration Estimates.

Appendix 1 : Water Quality in the Colton Beck Catchment.
Spring 1994.



Appendix 2a : Table of Site Reference Data.

Site nos	Site Name	Tributary	Date	NGR	Width mean (m)	Length (m)	Area (m2)
800.00	COLTON BK BRG	COLTON BK	08/07/94	SD321-845	3.40	50	170
801.00	DS BECKSIDE FM	COLTON BK	12/07/94	SD315-850	3.47	50	174
802.00	WASTE BRIDGE	COLTON BK	12/07/94	SD315-857	2.86	35	100
803.00	MEADOWS	COLTON BK	13/07/94	SD312-869	1.40	50	70
804.00	BANDRAKE HEAD	COLTON BK	13/07/94	SD311-872	2.25	50	113
805.00	OXENPARK	COLTON BK	13/07/94	SD316-873	1.47	50	74
806.00	STOCKWOOD	COLTON BK	13/07/94	SD311-890	1.75	50	88

Appendix 2b : Salmonid Densities in the Colton Beck Catchment 1994.

site nos	Tributary	Site Name	pop dens of 0+ salmo	pop dens of 1+ salmo	pop dens of 0+ Trou	pop dens of 1+ Trout	pop dens of >1+ trou
800.00	COLTON BK	COLTON BK BRG	13.15	11.11	144.60	5.47	0.00
801.00	COLTON BK	DS BECKSIDE FM	0.00	4.06	25.68	29.96	0.00
802.00	COLTON BK	WASTE BRIDGE	0.00	0.00	81.94	16.76	0.00
803.00	COLTON BK	MEADOWS	0.00	0.00	202.18	53.20	0.00
804.00	COLTON BK	BANDRAKE HEAD	0.00	0.00	110.41	21.42	1.10
805.00	COLTON BK	OXENPARK	0.00	0.00	216.42	47.82	0.00
806.00	COLTON BK	STOCKWOOD	0.00	0.00	4.23	44.43	2.84

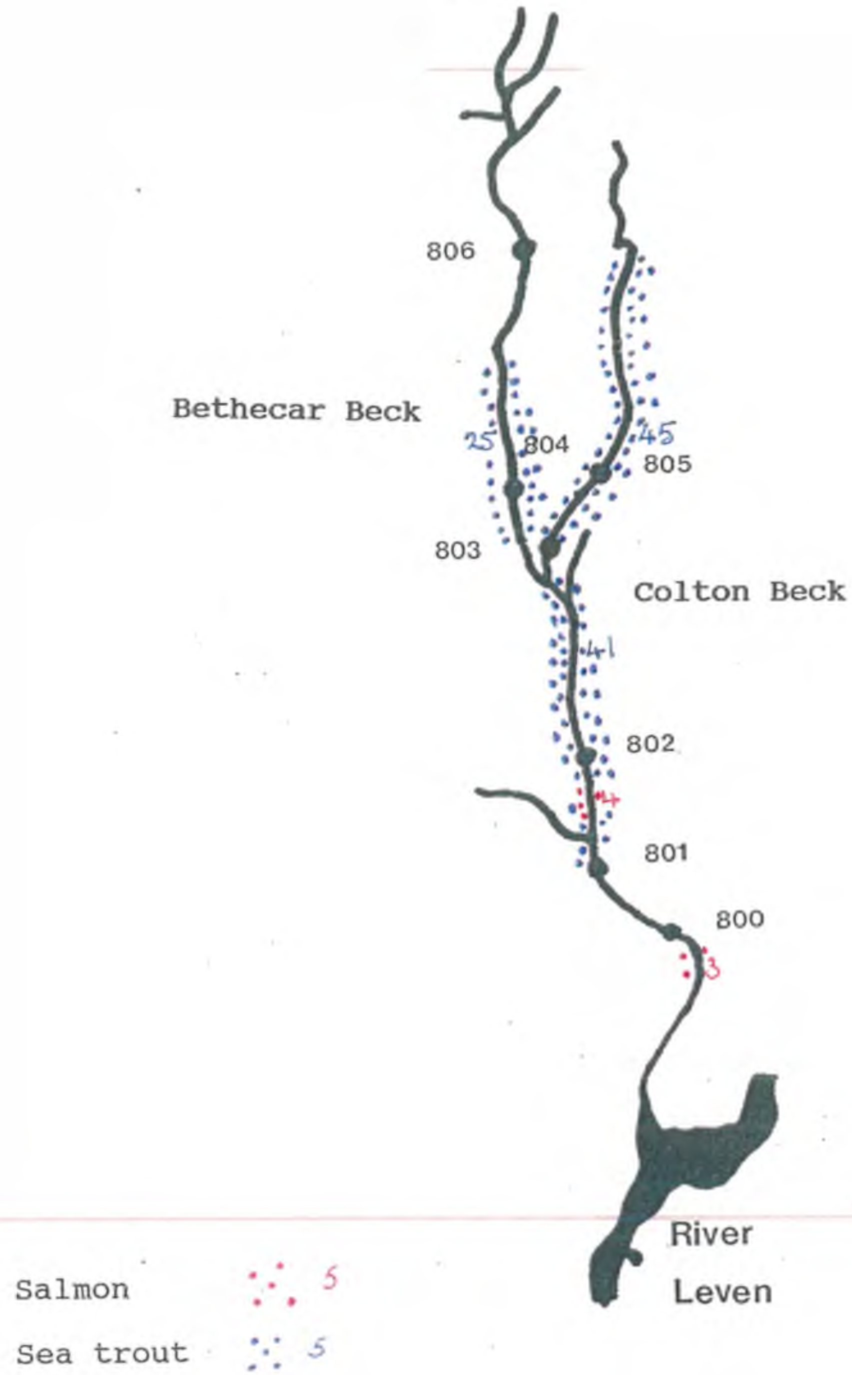
Appendix 2c : Major Coarse Fish Species Densities.

Site nos	Site Name	Tributary	Eels	Pike	Dace	Perch
				Density per 100m2		
800.00	COLTON BK BRG	COLTON BK	201-500	0.00	0.00	0.00
801.00	DS BECKSIDE FM	COLTON BK	0	0.00	0.00	0.00
802.00	WASTE BRIDGE	COLTON BK	201-500	0.00	0.00	0.00
803.00	MEADOWS	COLTON BK	1-10	0.00	0.00	0.00
804.00	BANDRAKE HEAD	COLTON BK	1-10	0.00	0.00	0.00
805.00	OXENPARK	COLTON BK	0	0.00	0.00	0.00
806.00	STOCKWOOD	COLTON BK	1-10	0.00	0.00	0.00

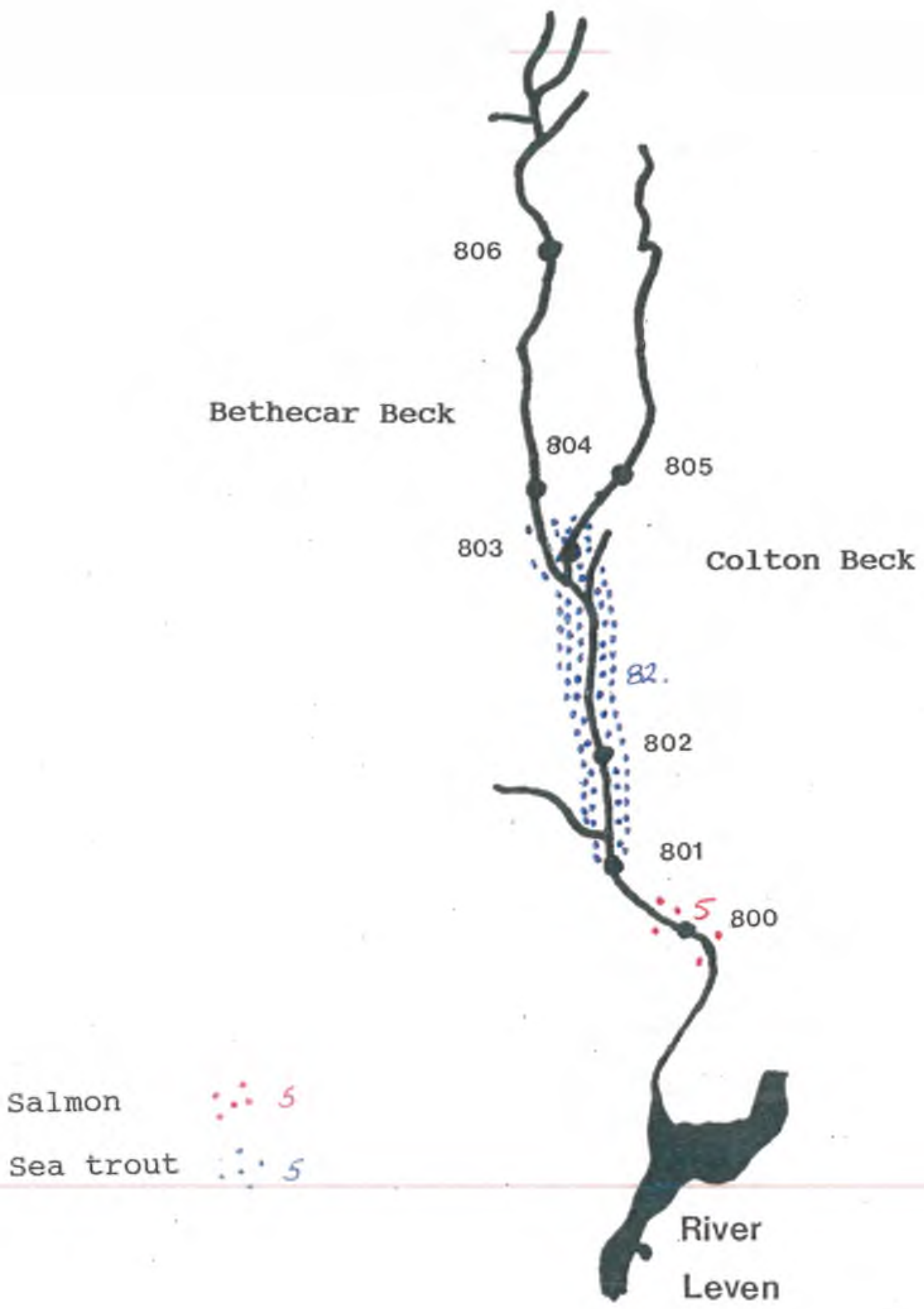
Appendix 2d : Minor Coarse Fish Densities in the Colton Beck Catchment 1994.

Site nos	Site Name	Tributary	Stoneloach	Bullhead	Minnow	Stickle-back
800.00	COLTON BK BRG	COLTON BK	0	11-100	0	0
801.00	DS BECKSIDE FM	COLTON BK	0	0	0	0
802.00	WASTE BRIDGE	COLTON BK	0	101-100	0	0
803.00	MEADOWS	COLTON BK	0	11-100	0	0
804.00	BANDRAKE HEAD	COLTON BK	0	0	0	0
805.00	OXENPARK	COLTON BK	0	0	0	0
806.00	STOCKWOOD	COLTON BK	0	0	0	0

Appendix 3a : Salmon and Sea Trout Redd Counts 1993/94.



Appendix 3b : Salmon and Sea Trout Redd Counts 1992/93



APPENDIX 4

Derivation of Total Salmonid Density Class

In order to create a class which related to Total Salmonid Density (i.e. all salmon plus all trout) it was necessary to rationalise the abundance categories for the two different age classes, i.e fry and parr.

The classes are based on the assumption that 1 in 5, or 20%, of fry survive to become parr. Thus by dividing the total fry density by 5, all densities could be related to the Abundance Class for parr.

An index for Total Salmonid Density was calculated using densities as follows :-

Index = 1/5 (Salmon 0+ + Trout 0+) + (Salmon >0+ + Trout >0+)

As this index was derived from both salmon and trout, the parr abundance categories have been doubled (Table *i*).

Table *i* : Classification for Total Salmonid Density Index (N/100m2)

Class			
A	>40.00		
B	20.01	-	40.00
C	10.01	-	20.00
D	0.01	-	10.00
E	0.00		

Methodology to determine Total Salmonid Productivity

To determine if the classes are set at a realistic level, a literature search was undertaken.

Work by Elliot on a Lake District stream has shown that a range of salmonid biomass from 8.86 - 33.9g/m^2 was recorded over a 25 year period. Similar work by Brynildson *et al.* 1984 in the USA, and Mortenson 1978 in Holland, showed a recorded biomass in the range of 12.2 - 36.0g/m^2 and 14.1 - 33.1g/m^2 respectively. However, Elliot postulates that these results are higher than in most studies.

From data collected on weight/length relationships for salmonids, we can calculate what, in biomass terms, our classification system is telling us. Typically, salmonid parr in South Cumbria averaged 13cm in length by the end of the survey year. This would equate to a weight of 25g/fish. Thus our classification system can be shown in terms of weight production (in grammes) per 100m^2.

Class	Nos of Salmonid Units per $100m^2$			Weight in grammes per m^2
A		> 40.01		>10.01+
B	20.01	-	40.00	5.01 - 10
C	10.01	-	20.00	2.51 - 5
D	0.01	-	10.00	0.1 - 2.5
E		0.00		

A class A result with a unit score of e.g. 63.7 fish would record a biomass of $15.9g/m^2$. This -*falls within the range of Elliot's work which, as stated, gave a variation of biomass productivity higher than in most experimental results published. It is thus concluded on present knowledge that the proposed total productivity classes are acceptable.

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Appendix 5 : Minimum Salmonid Population Estimates in the Colton Beck Catchment

Site Nos	Site Name	Salmon 0+	Salmon 1+	Trout 0+	Trout 1+	Trout >1+
800.00	COLTON BK BRG	7.06	4.71	77.65	2.94	0.00
801.00	DS BECKSIDE FM	0.00	1.72	13.79	16.09	0.00
802.00	WASTE BRIDGE	0.00	0.00	44.00	9.00	0.00
803.00	MEADOWS	0.00	0.00	108.57	28.57	0.00
804.00	BANDRAKE HEAD	0.00	0.00	59.29	11.50	0.88
805.00	OXENPARK	0.00	0.00	116.22	25.68	0.00
806.00	STOCKWOOD	0.00	0.00	2.27	23.86	2.27

Appendix 6

The relationship between the semi-quantitative (SQ) and quantitative (Q) results for salmonids using the arithmetic data and transformed data (Log_e n+1)

Age And Species	Arithmetic	Transformed
0+ Salmon	0+ SQ = 0.463 (+/-0.043) * Q (R^2 = 96.1%, $p < 0.0001$)	Log 0+ SQ = 0.710 (+/-0.078) * Log Q (R^2 = 89.0%, $p < 0.0001$)
>0+ Salmon	1+ SQ = 0.424 (+/-0.057) * Q (R^2 = 85.1%, $p < 0.0001$)	Log 1+ SQ = 0.661 (+/-0.059) * Log Q (R^2 = 90.0%, $p < 0.0001$)
0+ Trout	0+ SQ = 0.515 (+/-0.036) * Q (R^2 = 93.6%, $p < 0.0001$)	Log 0+ SQ = 0.800 (+/-0.037) * Log Q (R^2 = 95.2%, $p < 0.0001$)
>0+ Trout	>0+ SQ = 0.539 (+/-0.055) * Q (R^2 = 83.4%, $p < 0.0001$)	Log >0+ SQ = 0.775 (+/-0.088) * Log Q (R^2 = 86.3%, $p < 0.0001$)
1+ Trout	1+ SQ = 0.537 (+/-0.051) * Q (R^2 = 86.9%, $p < 0.0001$)	Log 1+ SQ = 0.778 (+/-0.051) * Log Q (R^2 = 87.0%, $p < 0.0001$)
>1+ Trout	>1+ SQ = 0.798 (+/-0.097) * Q (R^2 = 84.1%, $p < 0.0001$)	Log >1+ SQ = 0.839 (+/-0.083) * Log Q (R^2 = 85.3%, $p < 0.0001$)

Constant = $p > 0.05$

A REPORT ON THE STRATEGIC STOCK ASSESSMENT SURVEY OF THE RIVER EEA CATCHMENT 1994 WITH PARTICULAR REFERENCE TO SALMONIDS.

NRA/NW/FTR/94/16

A REPORT ON THE STRATEGIC STOCK ASSESSMENT SURVEY OF THE RIVER EEA CATCHMENT 1994 WITH PARTICULAR REFERENCE TO SALMONIDS.

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December 1994

NRA North West
Chertsey Hill
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Carlisle

CONTENTS

1.0. SUMMARY

Trout stocks in the River Eea appear on the whole good with parr densities particularly high. Stocking of sea trout fry in the past seems to have had little effect and it is recommended that this be discontinued unless a specific problem is identified requiring such action.

Salmon densities are also acceptable with natural production sufficient to maintain the current population. The large variance in redd counts suggest that environmental events strongly regulate salmon numbers probably as a result of the restricted spawning area and small population.

Nutrient levels in the catchment should not be allowed to increase and biological survey results need to be monitored to this effect.

2.0. INTRODUCTION

This report forms one part of the final year of a triennial survey programme for the South West Cumbria, and South Cumbria catchments. It is the first extensive survey of the River Eea catchment.

3.0. DESCRIPTION OF STUDY AREA

3.1. SITE SELECTION

A total of 9 sites were chosen on the River Eea catchment and all nine were subsequently fished. Sites were chosen at approximately 1km distances apart, where access was possible and were representative of the area of river immediately around the site.

3.2. OBSTACLES

Obstacles, for example weirs and waterfalls, can act as important factors affecting the distribution of fish within a catchment (Gardiner 1989). Figure 1 shows the weirs and waterfalls known to exist within the catchment.

3.3. WATER QUALITY

The summer 1994 water quality survey on the River Eea found predominantly good water quality but with mild enrichment, Appendix 1. Five sites were sampled in the catchment of which 1 was class 1A quality and four were class 1B quality.

4.0. METHODS.

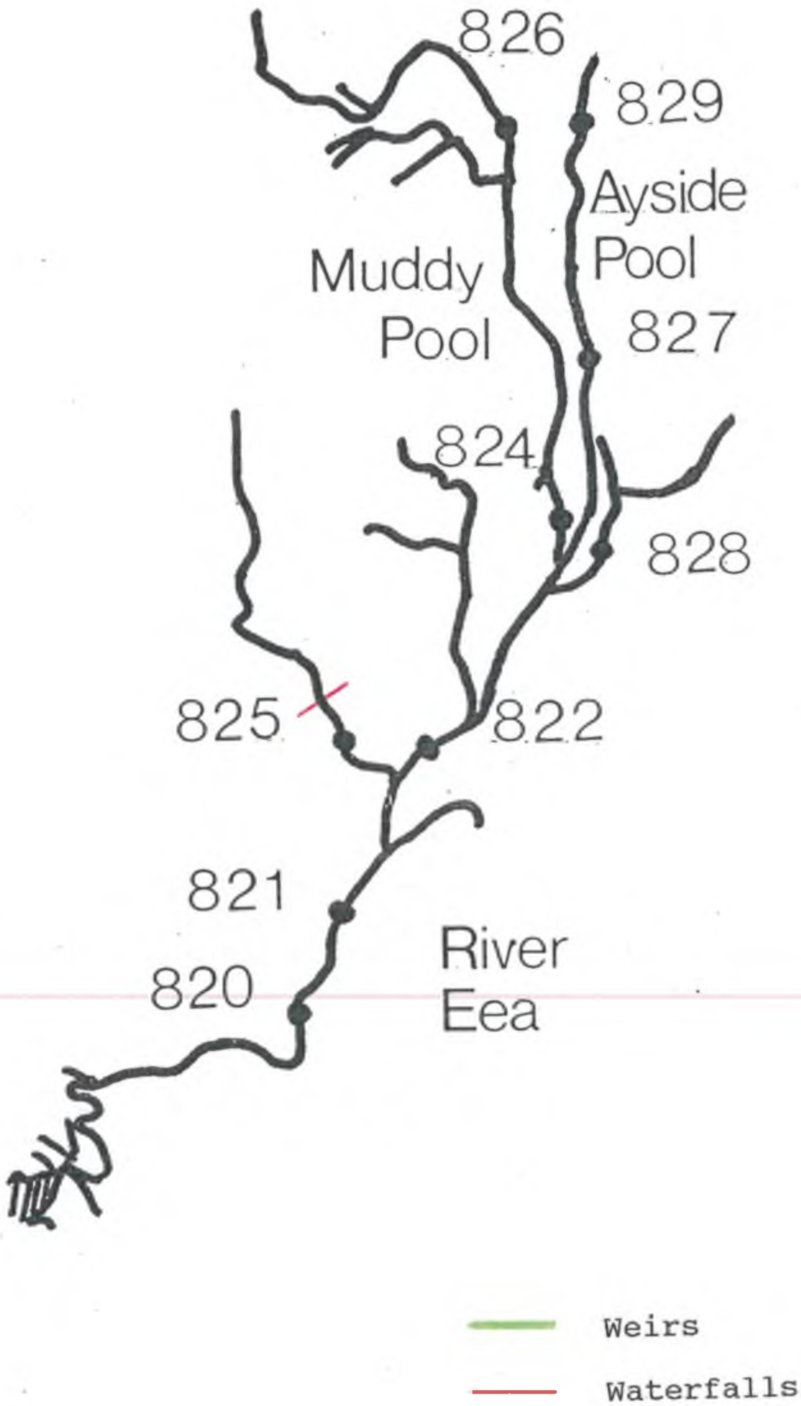
All the sites sampled were fished using an Electracatch Backpack with smoothed DC output. The team fished once through in an upstream direction for around 50m, without stop nets at all sites.

All fish were collected except where numbers of minor coarse fish (minnows, bullheads, stickleback and stoneloach) were so high as to make accurate netting impossible, without inordinate effort. In these cases an abundance category was assigned, Appendix 2c and 2d.

A number of other details were recorded, including temperature, conductivity, water level, velocity, general habitat details and the team's specific tasks.
Measurements of site length and widths at 10m intervals were recorded, Appendix 2a.

Target fish (salmonids and major coarse fish species) were anaesthetised when necessary using phenoxyethanol and then measured to the nearest 0.5cm (rounding down).

Figure 1 : Known Obstacles to Migratory Fish 1994.



Where the number of fish in any age class appeared to be in excess of 100, a sub sample of about this number was measured.

Scale samples, from salmonids, were taken at a number of sites to assist in determining age class/length boundaries.

For each target species and age class (salmonids only), a minimum density (number of fish caught divided by the area fished, multiplied by 100) per $100m^2$ was calculated. This data was the multiplied by a calibration factor to produce a population estimate. This information is tabulated in Appendix 2b.

The calibration site data has been collected as part of a regional attempt to determine the accuracy of the single fish data used in this report. The relationship between these two methods of sampling and their results forms part of a separate report, NRA/NW/FTR/93/4 but a summary of statistics is included in the appendix. A strong correlation was achieved in all age classes for salmonids.

5.0. RESULTS BY SUBCATCHMENT

See Figures 2-5.

5.1. River Eea

The two lower sites on the Eea consisted of riffles and pools with good amounts of bankside and instream cover. Substrate was a mixture of cobble, gravel and boulder. The upper site in contrast was largely made up of boulder and cobble with extensive tree cover. Bankside cover was very limited at this site. Riffles and small glides dominated.

All three sites sampled on the main Eea had salmon fry present although in low densities, class D. In comparison only the two lower sites had salmon parr present, probably as a result of downstream migration of salmon fry and the lack of suitable parr habitat at the uppermost site.

Trout fry densities were mixed in the main river stem, with two class D and one class B site. The class B site clearly exhibited the best trout fry habitat. Trout parr densities were reversed with parr scoring class B at the sites poor for fry and class C at the site with good fry densities.

5.2. Un-named trib (site 825)

This tributary was narrow and the bed largely made up of gravels and small cobbles. There was some overhead cover from gorse and brambles but much of the beck was exposed.

This tributary had no salmon present at the site sampled. Trout fry densities were high scoring class B, whilst trout parr densities were lower at class D, probably due to lack of cover for larger fish.

5.3. Muddy Pool

Habitat at the lower site was good for trout parr with extensive bankside cover. However accumulations of silt reduced spawning habitat. The upper site consisted of bedrock and gravel deposits flowing through pasture. Habitat was varied with pools and riffles.

Two sites were sampled on Muddy Pool, neither of which contained salmon. This is probably habitat related. Trout fry densities were average with one class C and one class D site. In contrast trout parr densities were high with one class A and one class B site.

5.4. Ayside Pool

The upper site was heavily choked with bramble and overhanging vegetation although good gravel was present. The lower site was also overgrown although with larger bushes and trees. Gravel was less evident, with siltation occurring.

Salmon fry were recorded at the lower site on Ayside pool (class D) but not at the upper site, whilst parr were absent from both. Trout fry densities were below average with one class D and one class C site, in contrast to parr densities of one class B and one class A.

5.5. Un-named trib (site 828)

This site had a mixture of cobble and gravel substrate. The river was fast flowing with riffles dominant. There was little bankside cover.

Salmon fry were present in low densities, but salmon parr were absent. Trout fry densities were better with fry present at class C and parr at class B densities.

Figure 2 : 0+ Salmon Densities in the Eea Catchment 1994.

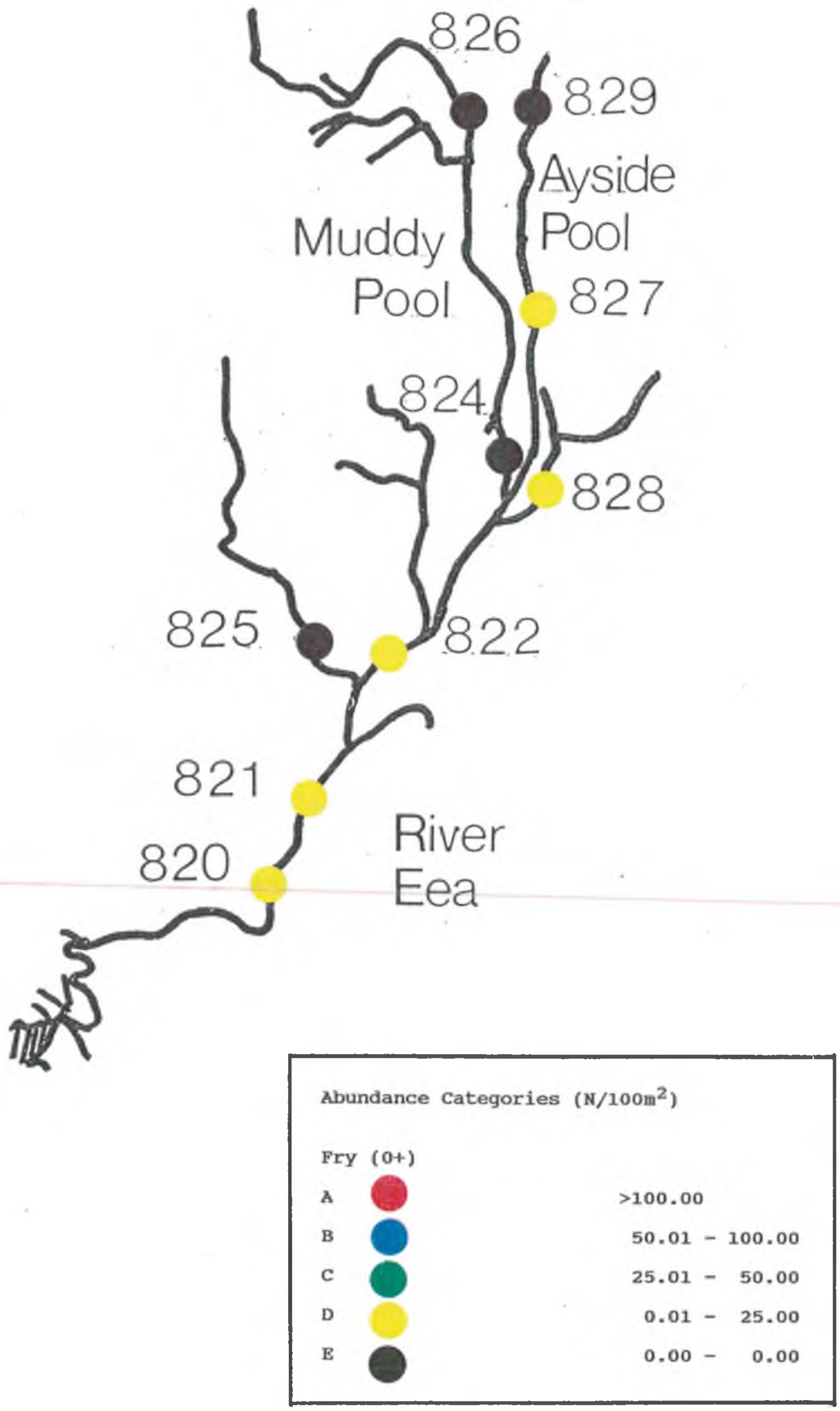


Figure 3 : Salmon Parr (>0+) Densities in the Eea Catchment 1994.

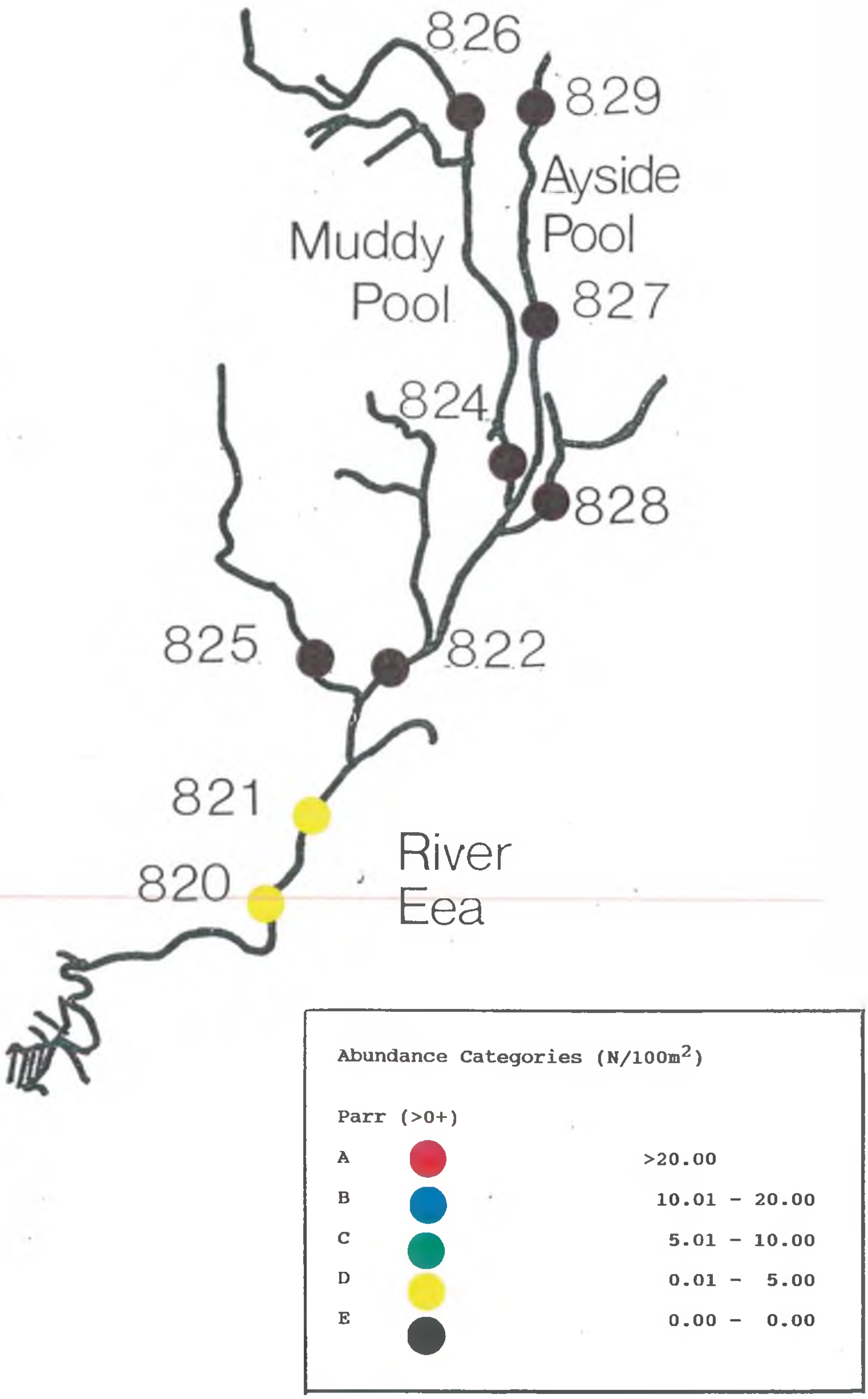


Figure 4 : 0+ Trout Densities in the Eea Catchment 1994.

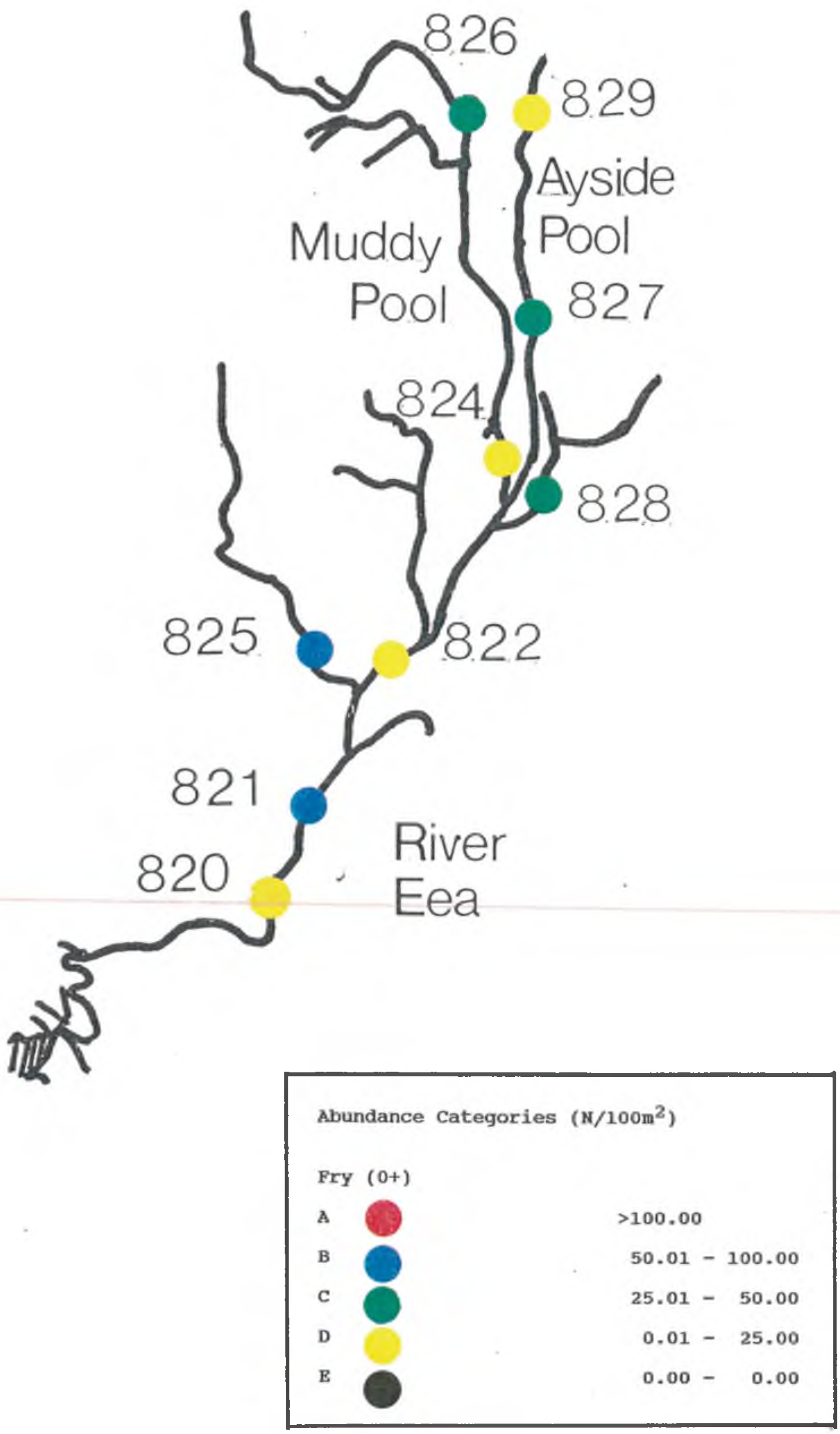
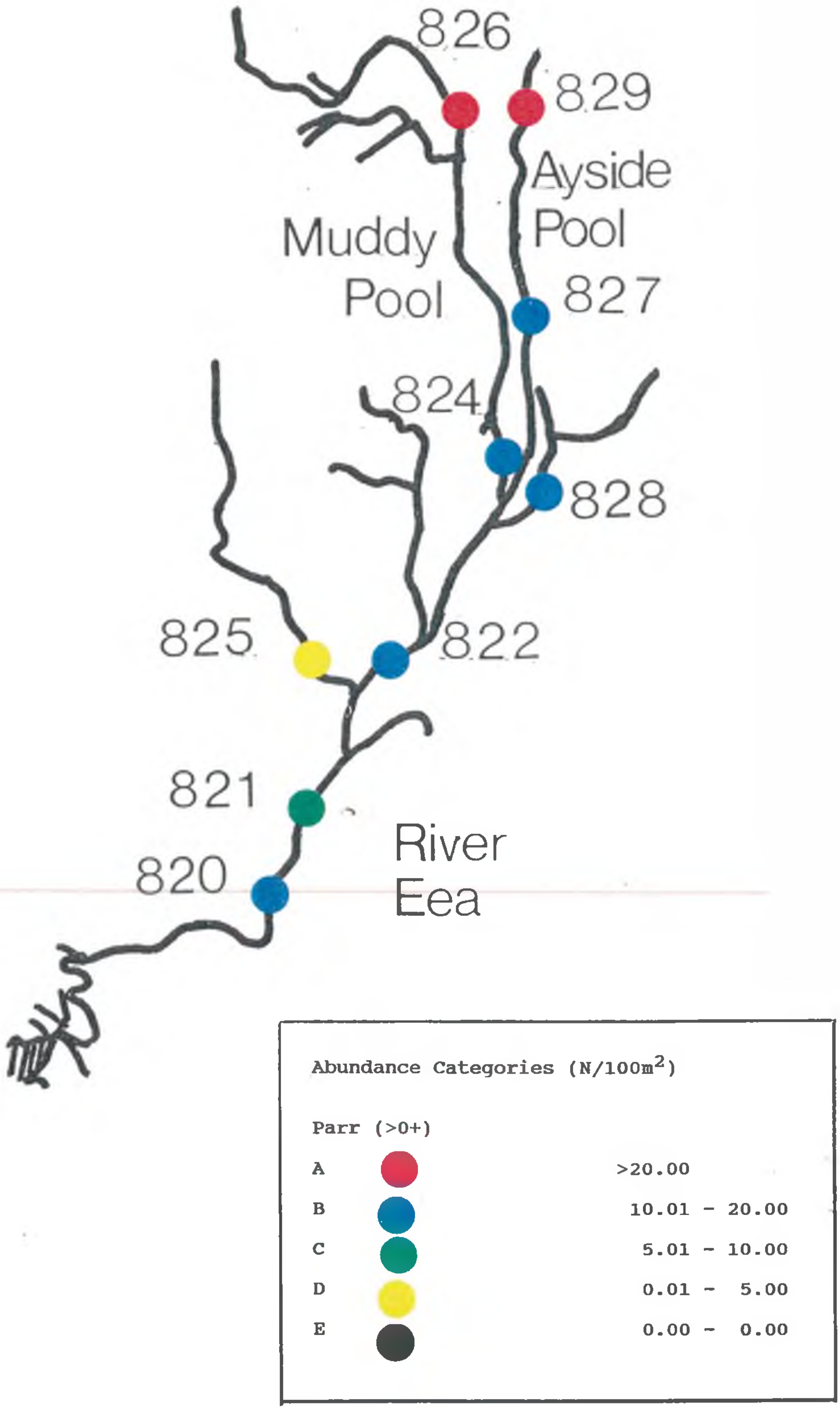


Figure 5 : Trout Parr (>0+) Densities in the Eea Catchment 1994.



6.0. OVERVIEW

From the detailed discussions on each sub-catchment, it can be seen that there are areas of good salmonid production throughout the catchment.

6.1. Salmon

6.1.1. Salmon Distribution

Juvenile salmon distribution is restricted by an impassable weir in the upper reaches of Black Beck, but no site was sampled above this obstruction. In theory the rest of the catchment is accessible to migratory fish.

6.1.2. Salmon Productivity

In an effort to determine the productivity of the Eea system in terms of salmon parr, the densities of parr found at each site combined with the width data collected were used to calculate a figure for parr production over a number of "reaches." The choice of the length of these reaches was based on comparable widths at all sites where accessibility to adult salmon was observed by the presence of juveniles of this species. In the case of the Eea this relates to the lower reaches of the main river only. Where salmon were not found upstream of a site, the area immediately upstream of this site was not considered, thus a slight underestimate in parr production may be inferred.

TABLE 1. ESTIMATED 1+ SALMON PARR PRODUCTION USING MEAN DENSITIES AND WIDTHS OVER SUB CATCHMENT LENGTH.

Sub Catchment	Length (km)	Mean Width (m)	Mean Parr Density nos/100m2	Parr Production (nos)
River Eea	2.0	5.1	3.23	330
Total				**330**

In terms of salmon productivity it can be clearly seen that the main River Eea in it's lower reaches is responsible for all of the salmon parr production in 1994. Fry production in the same year is however more widespread.

Mean salmon production over all sites where salmon were recorded was 3.23 salmon parr per 100m^2 (this represents only two sites). This level of production falls into the North West Classification system as a **class D.** In fact mean productivity in the Eea compares poorly with other South Cumbrian rivers for example the River Gilpin at 5.19 parr per 100m^2 (Cruddas 1994) and Colton beck at 6.01 parr per 100m^2 (Locke 1994). It also low compared with Ellson & Toumis study (1975) where they noted a range of 7.5 parr per 100m2 (River Dart 1973) to 37.9 parr per 100m2 (River Tweed 1973).

Scope for improvement in juvenile salmon numbers may thus be possible where juveniles are presently not found or are currently at low densities.

6.1.3. Comparison with Salmon Redd Counts

Salmon redd count data suggests that salmon are only known to have spawned in the recent past in the lower reaches of the River Eea in 1992/93. This would account for the parr distribution recorded.

Table 1 Historical Salmon Redd Count data.

Year	Salmon Redd Count
1983	3
1984	-
1985	11
1986	47
1987	-
1988	-
1989	-
1990	-
1991	-
1992	*
1993	7
1994	*

*** High water hampered counting.**

6.1.4. Juvenile Salmon Production versus Adult Returns.

As in many cases an accurate value for the adult run of migratory salmonids is not possible and in the case of the Eea can only be based on redd count data. This method of assessing population records has inaccuracies associated with the calculations involved making a true population estimate difficult.

Population estimates can be made from redd count data, if it is assumed that each redd relates to two salmon. This would give a range of salmon adults in the 1984-1994 period of between 6 - 94 fish.

The total run cannot be better assessed as accurate data on exploitation by the rod fishery is not available.

Data from the River Leven suggests a 10% survival rate for wild smolts at sea, whilst studies by Shearer (1993 per comm) suggested a range from 16-46% survival for salmon smolts on the North Esk, Scotland.

As the estimated parr production for the catchment is around 330 salmon parr, assuming a 50% mortality prior to smoltification and a 90% mortality at sea, then some 30 adult salmon could theoretically be produced from the current juvenile production.

This level of returning adults is unlikely as the method of calculating parr production does not take into account areas of poor or better production between sample sites. However even allowing for this, scope for at the very least, maintenance of the current adult populations is likely.

6.2. Trout

6.2.1. Trout Distribution

The distribution of trout fry and parr in the Eea catchment shows a quite different pattern when compared to that of salmon distribution. For salmon the lower main river area is of greatest importance, whilst trout fry and to a degree parr are found in greater numbers in the three major tributaries and the River Eea.

6.2.2. Trout Productivity.

Trout productivity can only be measured as that for resident and migratory trout together as it is not possible to determine visually which juvenile fish originate from which parents. However, as a comparison to the salmon parr production data, a table of trout 1+ parr production for all sites (both accessible and inaccessible to migratory fish) has been included below.

TABLE 3. ESTIMATED 1+ TROUT PARR PRODUCTION USING MEAN DENSITIES AND WIDTHS OVER SUB CATCHMENT LENGTH.

Sub Catchment	Length (km)	Mean Width (m)	Mean Parr Density nos/100m2	Parr Production (nos)
River Eea	3.0	4.9	10.4	1528
Muddy pool	2.0	1.8	23.0	828
Ayside Pool	3.5	2.4	24.0	2016
Black beck	0.75	1.5	2.5	30
Others	0.5	2.3	11.8	129
TOTAL		**n/a**		**4531**

It is very difficult to determine what this production of parr may represent in terms of Sea trout smolts as the percentage of migratory versus resident trout is not known. A reasonable resident brown trout population does occur in some of the upper tributaries with parr above the upper limit for smoltification occurring in good numbers.

6.2.3. Comparison with Redd Count Data

Redd count data is available for the sea trout for the period 1983-1993. The results are tabulated below.

Table 4 Historical Sea Trout Redd Count data.

Year	Sea Trout Redd Count
1983	124
1984	307
1985	338
1986	50
1987	423
1988	321
1989	251
1990	211
1991	nc
1992	183
1993	nc

nc * High water and staff shortages hampered counting.

6.2.4. Stocking Enhancement

Redd count information suggests that between 100 and 846 trout have spawned in any year within the Eea catchment since 1983. This is a large stock of fish compared to the overall parr production figures suggesting either low smolt mortality at sea or areas of parr production that were missed during the survey. One such area (a tributary of Muddy Pool) has since been identified.

6.2.5. Stocking and trout production

Stocking with 19,000 sea trout fed fry in 1994 seems to have little impact on Ayside Pool, and considering the high redd count for this area of river better results would have been expected even naturally. It is possible that competition between fry for resources is responsible for the results and stocking should not be continued until this has been ruled out.

Stocking in the upper reaches of Muddy Pool with 11,000 fed fry in 1993 may have resulted in at least part the high trout parr densities found in 1994, although it is possible they could have occurred from natural production.

The case for trout fry stocking appears limited in areas of the upper catchment with redd counts suggesting adequate natural spawning. Resources would perhaps be better spent on vegetation clearance in Muddy Pool particularly.

6.3. Total Salmonid Productivity.

An attempt in this study has been made to determine the total productivity of the system as well as a total productivity on a site by site basis. The methodology used is described in appendix 5.

Whilst acknowledging the possible flaws in the methodology used for determining the total productivity classes, some interesting results are obtained.

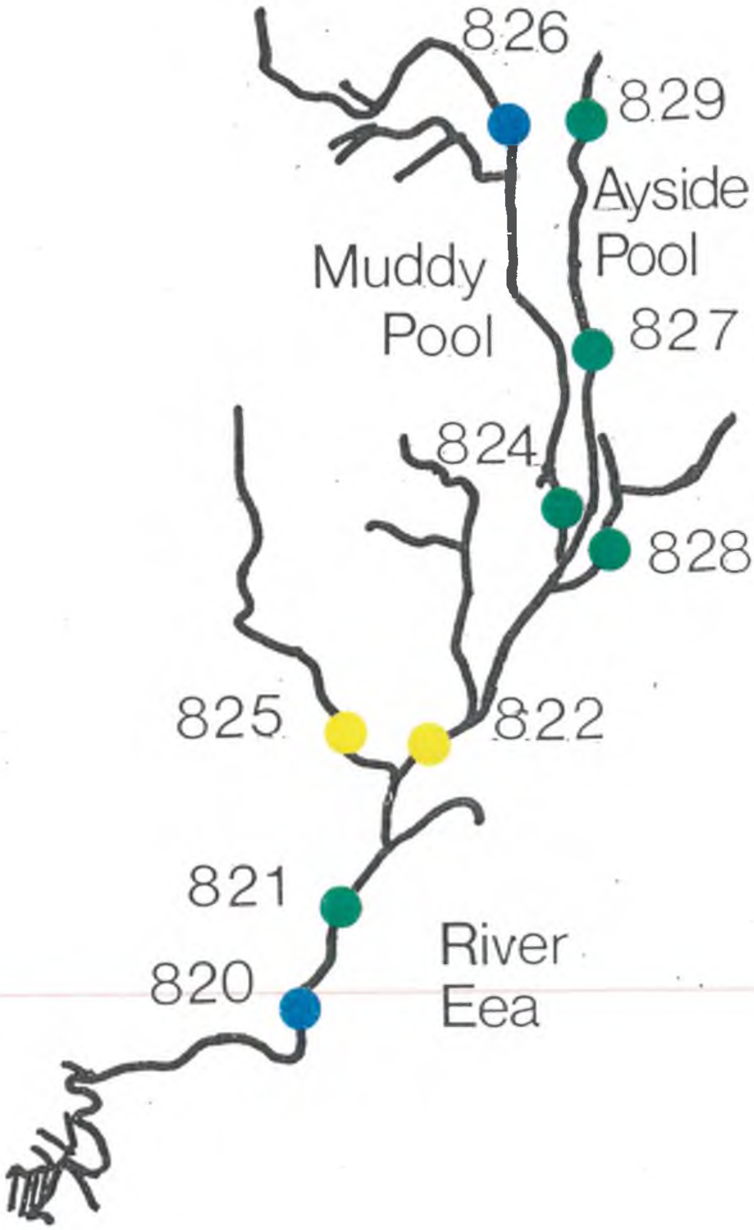
From fig 6 it can clearly be seen that the Eea system is productive across most of it's catchment area. There are the following numbers of sites in each productivity class;

1993

Class	Nos of sites	% of Total
A	0	0
B	2	22
C	5	56
D	2	22
E	0	0

The total productivity figures show the catchment is in a healthy state with 78% of sites with average or above average densities of fish present. Of the two sites with below average densities, one of these can be attributed to lowish flows whilst the other site was in thick woodland and had relatively poor trout habitat.

Figure 6 : Total Salmonid Production in the Eea Catchment
1994.



7.0. CONCLUSIONS

The River Eea is producing above average densities of juvenile salmonids. Resident trout and sea trout densities are all probably close to their theoretical maximum and it is likely little could be done to improve this situation. Salmon juveniles in this survey appear below the level expected for the catchment, although this may relate to competition with trout production. A large variance in salmon population probably occurs in the river Eea naturally as in many of the smaller south Cumbrian rivers.

8.0. RECOMMENDATIONS

This report recommends that in light of the good trout stocks in the River Eea, there is no requirement to specifically interfere with trout productivity.

Salmon densities are also acceptable and it is felt that stocking is not required with natural production sufficient to maintain the current population. The large variance in redd counts suggest that natural events strongly regulate salmon numbers thus making active management difficult.

Nutrient levels in the catchment should not be allowed to increase and biological survey results should be monitored to this effect.

9.0. REFERENCES

Ellson, P. F. & Toumi, A. L. W. (1975). The Foyle Fisheries: New basis for rational management. **Foyle Fisheries Commission, Londonderry.** pp 224.

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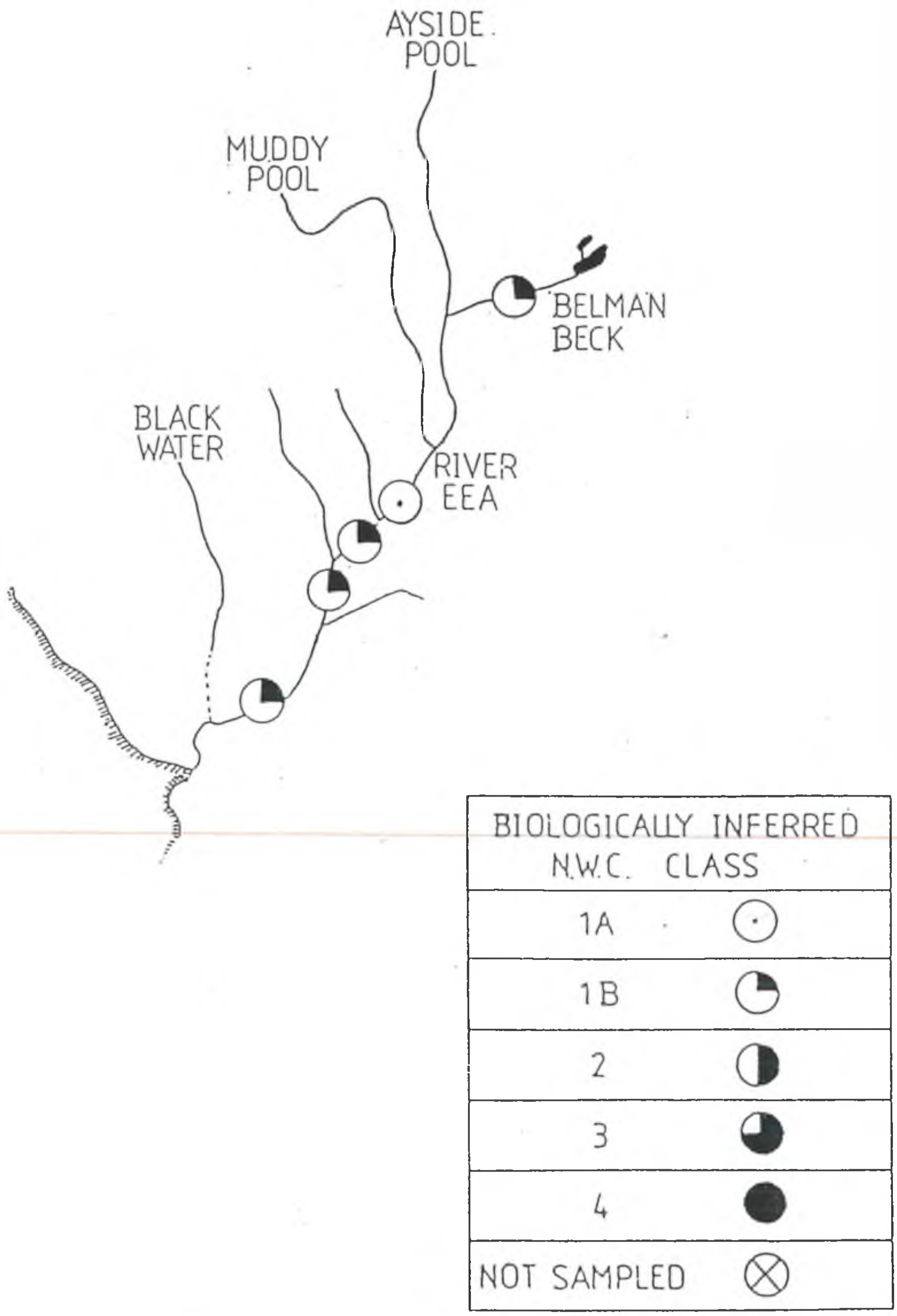
Cruddas, A. (1994) A report on the strategic stock assessment survey of the River Gilpin 1994, with particular reference to salmonids. **NRA North West NRA/NW/FTR/93/16**

Locke, V. (1994) A report on the strategic stock assessment survey of Colton Beck catchment 1994, with particular reference to salmonids. **NRA North West NRA/NW/FTR/93/16**

10.0. APPENDIX

Appendix	1	Water Quality in the Eea Catchment 1994.
	2a	Table of Site Reference Data.
	2b	Salmonid Densities in the Eea Catchment.
	2c	Major Coarse Fish Species Densities.
	2d	Minor Coarse Fish Densities - Abundance.
	3.	Redd Count Data 1992/93.
	4.	Stocking of Sea Trout Fed Fry in 1994.
	5.	Minimum Estimates of Salmonid Production.
	6.	Methodology for Total Productivity Classification
	7.	Statistical Basis for Calibration Estimates

Appendix 1 Water Quality in the River Eea Catchment
Summer 1994



Appendix 2 Site Reference Data

Site nos	Site Name	Tributary	Date	NGR	Width mean (m)	Length (m)	Area (m2)
820.00	Eea - Cark		21/09/94	SD366-766	5.20	50	260
821.00	Eea - Low Bank Side		01/09/94	SD369-774	5.00	50	250
822.00	Eea - Seven Acres		31/08/94	SD375-784	4.65	45	209
824.00	Eea - GREENBANK	Un-named	01/09/94	SD383-802	1.50	50	75
825.00	Eea-WALTON HALL	Un-named Trib.	01/09/94	SD368-784	1.50	50	75
826.00	Eea - High Cark Hall	Muddy Pool	21/09/94	SD380-824	2.10	50	105
827.00	Eea-Field Broughton	Ayside Pool	31/08/94	SD387-810	2.75	45	124
828.00	Borwicks	Un-named	21/09/94	SD385-794	2.30	50	115
829.00	Eea - High Cark	Ayside Pool	31/08/94	SD386-825	2.10	50	105

Appendix 2b Population estimates for salmonids River Eea 1994 (1993 calib)

Site nos	Site Name	Tributary	Salmon 0+	Salmon 1+	Trout 0+	Trout 1+	Trout >1+
820.00	Eea - Cark		20.06	3.63	18.62	3.58	8.2
821.00	Eea - Low Bank Side		14.90	2.83	54.38	3.72	5.0
822.00	Eea - Seven Acres		0.89	0.00	16.93	8.90	1.8
824.00	Eea - GREENBANK	Un-named	0.00	0.00	49.66	17.37	1.6
825.00	Eea-WALTON HALL	Un-named Trib.	0.00	0.00	81.94	2.48	0.0
826.00	Eea - High Cark Hall	Muddy Pool	0.00	0.00	30.15	24.82	2.3
827.00	Eea-Field Broughton	Ayside Pool	1.51	0.00	27.04	16.52	0.0
828.00	Borwicks	Un-named	3.24	0.00	34.00	9.72	2.1
829.00	Eea - High Cark	Ayside Pool	0.00	0.00	21.28	30.15	1.1

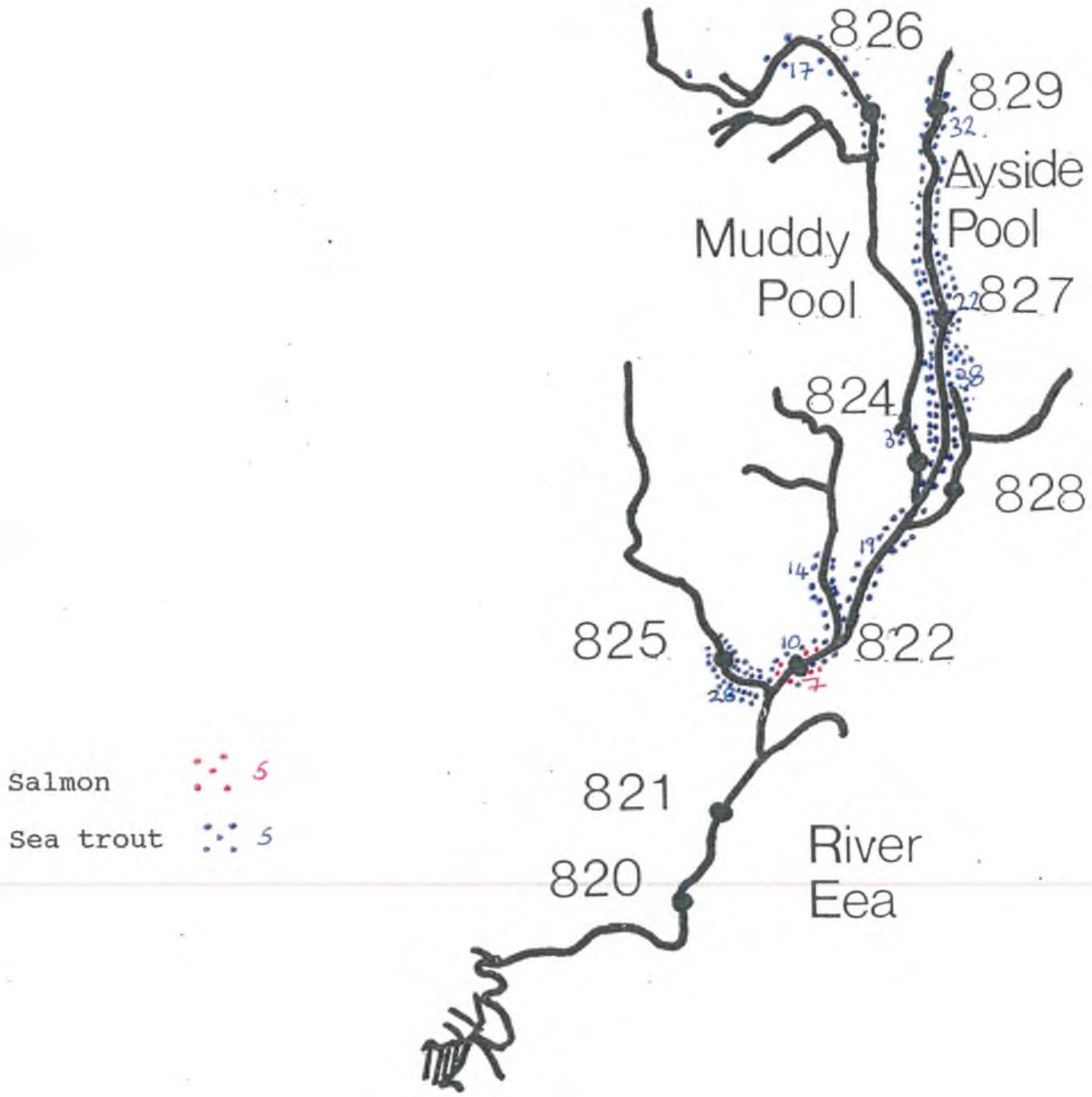
Appendix 2c : Major Coarse Fish Species Densities.

Site nos	Site Name	Tributary	Eels	Pike	Dace	Perch
				Density per 100m2		
820.00	Eea - Cark		11-50	0.00	0.00	0.00
821.00	Eea - Low Bank Side		11-50	0.00	0.00	0.00
822.00	Eea - Seven Acres		101-200	0.00	0.00	0.00
824.00	Eea - GREENBANK	Un-named	0	0.00	0.00	0.00
825.00	Eea-WALTON HALL	Un-named Trib.	1-10	0.00	0.00	0.00
826.00	Eea - High Cark Hall	Muddy Pool	1-10	0.00	0.00	0.00
827.00	Eea-Field Broughton	Ayside Pool	0	0.00	0.00	0.00
828.00	Borwicks	Un-named	1-10	0.00	0.00	0.00
829.00	Eea - High Cark	Ayside Pool	11-50	0.00	0.00	0.00

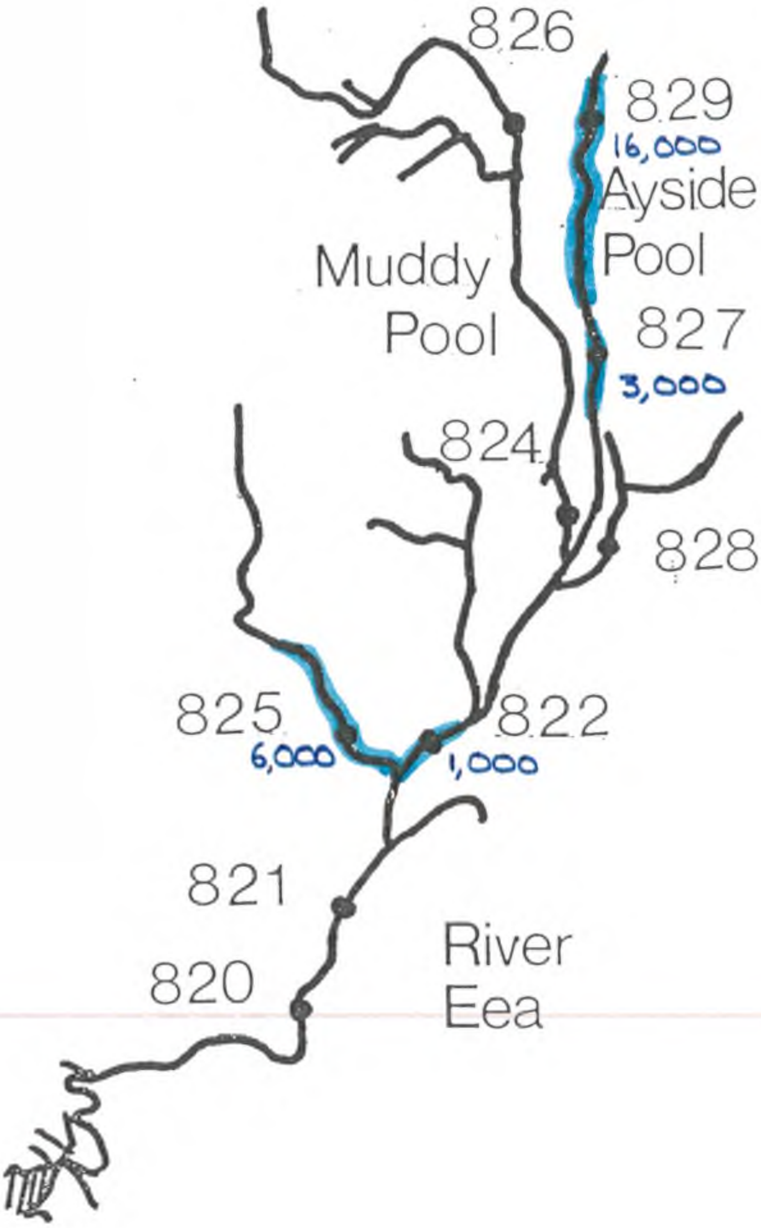
Appendix 2d Minor coarse fish abundance - River Eea 1994

Site nos	Site Name	Tributary	Stoneloach	Bullhead	Minnow	Stickle-back
820.00	Eea - Cark		0	101-100	0	1-10
821.00	Eea - Low Bank Side		0	101-100	0	1-10
822.00	Eea - Seven Acres		0	101-100	0	0
824.00	Eea - GREENBANK	Un-named	0	0	0	0
825.00	Eea-WALTON HALL	Un-named Trib.	0	101-100	0	0
826.00	Eea - High Cark Hall	Muddy Pool	0	101-100	0	0
827.00	Eea-Field Broughton	Ayside Pool	0	0	0	0
828.00	Borwicks	Un-named	0	1001+	0	0
829.00	Eea - High Cark	Ayside Pool	0	101-100	0	0

Appendix 3 : Salmon and Sea Trout Redd Counts 1992/93.



Appendix 4. Stocking with Sea trout fed fry 1994.



Appendix 5 : Minimum Estimates of Salmonid Production in River Eea 1994.

Site Nos	Site Name	Salmon 0+	Salmon 1+	Trout 0+	Trout 1+	Trout >1+
820.00	Eea - Cark	10.77	1.54	10.00	1.92	6.54
821.00	Eea - Low Bank Side	8.00	1.20	29.20	2.00	4.00
822.00	Eea - Seven Acres	0.48	0.00	9.09	4.78	1.44
824.00	Eea - GREENBANK	0.00	0.00	26.67	9.33	1.33
825.00	Eea-WALTON HALL	0.00	0.00	44.00	1.33	0.00
826.00	Eea - High Cark Hall	0.00	0.00	16.19	13.33	1.90
827.00	Eea-Field Broughton	0.81	0.00	14.52	8.87	0.00
828.00	Borwicks	1.74	0.00	18.26	5.22	1.74
829.00	Eea - High Cark	0.00	0.00	11.43	16.19	0.95

APPENDIX 6

Derivation of Total Salmonid Density Class

In order to create a class which related to Total Salmonid Density (i.e. all salmon plus all trout) it was necessary to rationalise the abundance categories for the two different age classes, i.e fry and parr.

The classes are based on the assumption that 1 in 5, or 20%, of fry survive to become parr. Thus by dividing the total fry density by 5, all densities could be related to the Abundance Class for parr.

An index for Total Salmonid Density was calculated using densities as follows :-

Index = 1/5 (Salmon 0+ + Trout 0+) + (Salmon >0+ + Trout >0+)

As this index was derived from both salmon and trout, the parr abundance categories have been doubled (Table *i*).

Table *i* : Classification for Total Salmonid Density Index (N/100m2)

Class			
A		>40.00	
B	20.01	-	40.00
C	10.01	-	20.00
D	0.01	-	10.00
E		0.00	

Methodology to determine Total Salmonid Productivity

To determine if the classes are set at a realistic level, a literature search was undertaken.

Work by Elliot on a Lake District stream has shown that a range of salmonid biomass from 8.86 - 33.9g/m^2 was recorded over a 25 year period. Similar work by Brynildson *et al*. 1984 in the USA, and Mortenson 1978 in Holland, showed a recorded biomass in the range of 12.2 - 36.0g/m^2 and 14.1 - 33.1g/m^2 respectively. However, Elliot postulates that these results are higher than in most studies.

From data collected on weight/length relationships for salmonids, we can calculate what, in biomass terms, our classification system is telling us. Typically, salmonid parr in South Cumbria averaged 13cm in length by the end of the survey year. This would equate to a weight of 25g/fish. Thus our classification system can be shown in terms of weight production (in grammes) per 100m^2.

Class	Nos of Salmonid Units per 100m^2			Weight in grammes per m^2
A	> 40.01			>10.01+
B	20.01	-	40.00	5.01 - 10
C	10.01	-	20.00	2.51 - 5
D	0.01	-	10.00	0.1 - 2.5
E	0.00			

A class A result with a unit score of e.g. 63.7 fish would record a biomass of 15.9g/m^2. This -*falls within the range of Elliot's work which, as stated, gave a variation of biomass productivity higher than in most experimental results published. It is thus concluded on present knowledge that the proposed total productivity classes are acceptable.

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Mortenson, E. (1978). The population dynamics and production of trout (*Salmo trutta* L.) in a small Danish stream. In *Proc. Wild Trout - Catchable Trout Symp.* ed. J.R.Moring, 151-160. Oregon: Dept Fish Wildl.

A REPORT ON THE STRATEGIC STOCK ASSESSMENT SURVEY OF THE GILPIN CATCHMENT 1994 WITH PARTICULAR REFERENCE TO SALMONIDS

NRA/NW/FTR/94/16 December 1994

A REPORT ON THE STRATEGIC STOCK ASSESSMENT SURVEY OF THE GILPIN CATCHMENT 1994 WITH PARTICULAR REFERENCE TO SALMONIDS

A. Cruddas
December 1994

CONTENTS

1. SUMMARY

Salmon distribution is limited in the Gilpin Catchment. They are not abundant in the lower main river or above the weirs at Crosthwaite.

Trout densities are exceptionally high in the upper reaches of the Gilpin and Pool.

Historical survey results indicate that the system is in a steady state, with a reasonably high population of sea trout progeny.

2. INTRODUCTION

The NRA under the Water Resources Act 1991, has a responsibility to maintain, improve, and develop fisheries. To accomplish this, baseline data on the populations of fish present in North West region is required.

The stock assessment task group has identified a number of key areas for the application of stock assessment data:

1. To assess long term change.

2. To help conserve fish species.

3. To evaluate stocking programmes, habitat and water quality improvements.

4. To assess or predict the impact of activities which the NRA or other organizations may have on fish populations.

5. To comment on the fisheries implications of developments when the NRA is a statutory consultee to planning authorities.

This report forms one part of the third year of a triennial survey programme for the South West Cumbria and South Cumbria catchments.

3. DESCRIPTION OF STUDY AREA

3.1. SITE SELECTION

A total of 12 sites were selected throughout the catchment. These sites were chosen at approximately 1km distances apart, where access was possible and were representative of the area of river immediately around the site. Site 874 was not fished as it was not wadeable.

Three sites on the lower main river were electro fished from a boat during June of 1994.

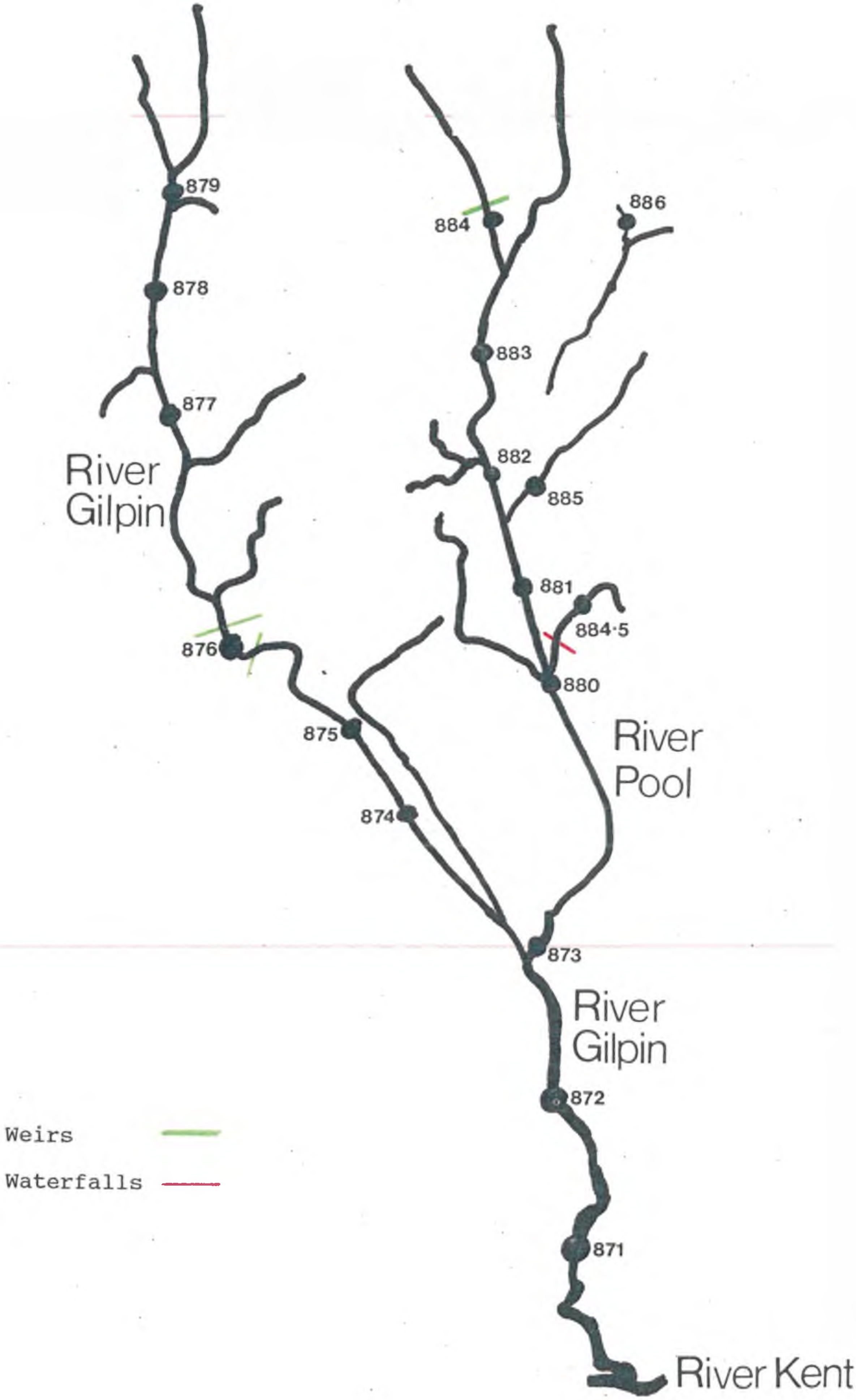
3.2. OBSTACLES

Obstacles, for example weirs and waterfalls, can act as important factors affecting the distribution of fish within a catchment (Gardiner 1990). Figure 1 shows the weirs and waterfalls known to exist within the catchment.

3.3. WATER QUALITY

The spring 1994 water quality survey on the Gilpin found water quality, in 2 of the 3 sites sampled, to be class 1A. The Gilpin near to site 874 (figure 1), scored class 1B. This site was borderline between 1A/1B, due to slight enrichment.

Figure 1 : Known Obstacles to Migratory Fish 1994.



4. METHODS.

All the sites sampled in 1994 were fished using an Electracatch pulsed DC control box powered by a 650KW Honda generator or an Electracatch Backpack Unit with smoothed DC output.

For all sites, the team fished once through in an upstream direction for around 50m without stop nets.

All fish were collected, except where numbers of minor coarse fish (minnows, bullheads, stickleback and stoneloach) were so high as to make accurate netting impossible without inordinate effort. In these cases an abundance category was assigned, Appendix 2d.

A number of other details were recorded, including temperature, conductivity, water level, velocity, general habitat details and the team's specific tasks.

Measurements of site length and widths at 10m intervals were recorded, Appendix 2a.

Target fish (salmonids and major coarse fish species) were anaesthetised when necessary using phenoxyethanol and then measured to the nearest 0.5cm (rounding down). Where the number of fish in any age class appeared to be in excess of 100, a sub sample of about this number was measured.

For each target species and age class (salmonids only), a minimum density (number of fish caught divided by the area fished, multiplied by 100) per 100m^2 was calculated. This information is tabulated in Appendix 2b.

5. RESULTS BY SUB-CATCHMENT

See Figs 2-5

5.1. LOWER MAIN RIVER (871 & 872) & LOWER POOL (873)

These are the sites which were fished from a boat. The sites were all deep, silty, slow flowing and canalised.

5.1.1. Results

Sticklebacks and flounder dominated in this reach.

One Salmon was caught at only one site, (872). At each of sites 872 and 873 a takeable trout was caught.

5.1.2. Discussion

The silty bed and slow flowing water is not suited to salmonids. There is a lack of cover availabilty and spawning areas.

5.2. MID REACHES OF THE GILPIN (875 & 876)

The lower site (875) had been straightened by flood defence/ land drainage work. The site downstream of the bridge had recently had the bankside vegetation removed. Upstream of the bridge the site had bankside trees and was unaltered. Site 876 was similar in nature to this upstream section, with lots of trees and bushes overhanging the reach. Both sites had fast flow, with cobble and gravel substrate.

Between sites 875 and 876 is a partial barrier to migratory fish in the form of a weir at Crosthwaite.

5.2.1. Results

Salmon scored class D for both fry and parr at site 875, but were absent at site 876.

Trout fry scored class D for fry at both sites. Parr scored class D at site 875 and class B at site 876.

5.2.2. Discussion

It would appear from the survey results and redd counts, (Appendix 3a & b) that although the weir at Crosthwaite is ascendable, few salmon migrate past it to spawn further up the system.

Trout parr were more abundant at site 876 due to the larger proportion of bankside cover.

5.3. UPPER GILPIN (SITES 877, 878 & 879)

The three upper sites on the Gilpin all have fast flow with cobble substrate. The lower site in this reach (877) had bankside cover provided by vegetation, whereas the top sites had bankside cover in the form of stone walls.

5.3.1. Results

Salmon were absent from all sites.

Trout fry scored class C at the lower site (877), class D at the middle site (878) and class B at the upper site (879). Trout parr scored class A at all three sites. The upper sites had exceptionally high densities of 1+ trout. Site 878 scored double class A, whilst site 879 scored triple class A.

5.3.2. Discussion

If any salmon ascend the afore mentioned downstream weir at Crosthwaite, then they will meet another obstruction upstream of Crosthwaite. From survey results and redd counts it would appear that no salmon spawn above this weir. Hence the total absence of salmon in the upper reaches of the Gilpin.

However, it would appear that sea trout do ascend the two weirs at Crosthwaite and have spawned in abundance upstream of them in 1992/93 giving the very high densities of parr found in the 1994 survey.

5.4. RIVER POOL (SITES 881, 882 & 883)

All three sites were shaded giving good cover under tree roots. The site at Greg Hall (881) had a loose substrate of cobbles and pebbles. The two upper sites (882 & 883) had a boulder and bed rock substrate. The flow was fast at all three sites creating riffles and pools.

5.4.1. Results

Salmon fry scored class D at all three sites. Parr scored class C at site 881, class B at site 882, but were absent from site 883.

Trout fry scored class D at all three sites. Trout parr scored class A at 881, class B at site 882 and class C at site 883.

5.4.2. Discussion

The habitat at all sites was suited to salmon fry, but the upper site at Beckside (883) was lacking in suitable cover for salmon parr.

Redd counts relating to trout parr are higher than those for the fry year class resulting in better densities for parr than fry.

5.5. POOL TRIBUTARIES

All sites except site 886 were tree lined.

Site 884 near Crook had a cobble and boulder substrate with a small stone wall running down one side.The water flow was fast. The site ended in a large pool.

Site 884.5 had a substrate of embeddded cobbles and bedrock. The stream was shallow and the water flow was medium with a small section of cascade. Access to migratory fish is prevented by a waterfall.

Site 885 was shaded by trees for the first section, but flowed through an open field for the upper section. The stream was medium flowing and shallow, with a cobble substrate.

Site 886 flowed slowly through a field. For the drier summer months this lower reaches of this stream dry up and it becomes isolated from the River Pool. However, in times of high flows the stream flows down to the River Pool and sea trout migrate upstream and spawn.

5.5.1. Results

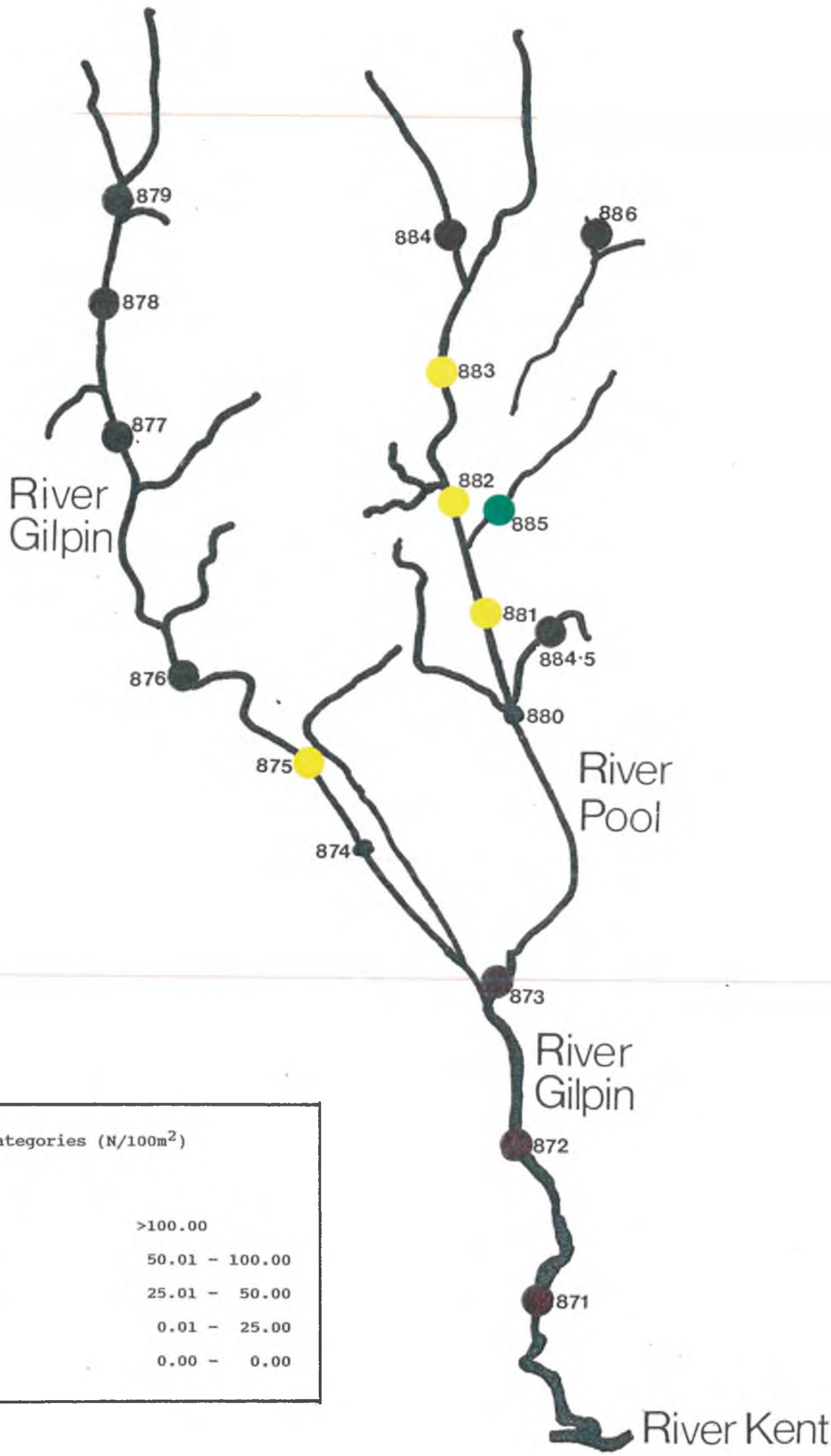
Salmon are absent from the tributaries, except for site 885. Fry scored class C and parr class D.

Trout fry scored two class D, one class C and one class B. Trout parr scored two class B and two class A.

5.5.2. Discussion

Site 885 is twice as wide as the three other sites (4.3m *c.f.* 1.4m), perhaps making it more suitable for salmon. Trout densities are good, but the parr year class is stronger than the fry year class. This is probably due to the more prolific spawning in 1992.

Figure 2 : 0+ Salmon Densities in the River Gilpin Catchment 1994.



Abundance Categories (N/100m^2)

Fry (0+)

A		>100.00
B		50.01 - 100.00
C		25.01 - 50.00
D		0.01 - 25.00
E		0.00 - 0.00

Figure 3 : Salmon Parr (>0+) Densities in the River Gilpin Catchment 1994.

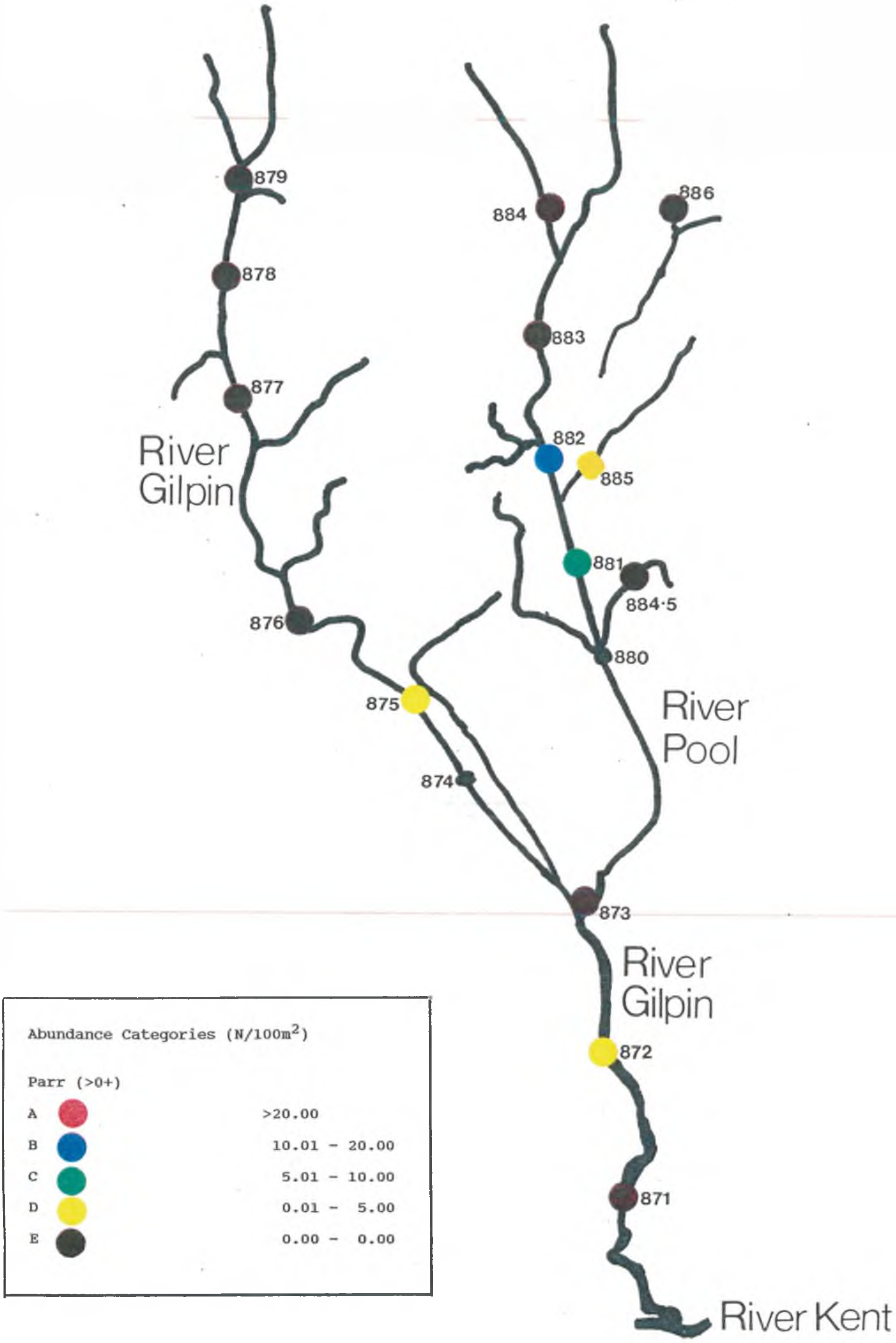


Figure 4 : 0+ Trout Densities in the River Gilpin Catchment 1994.

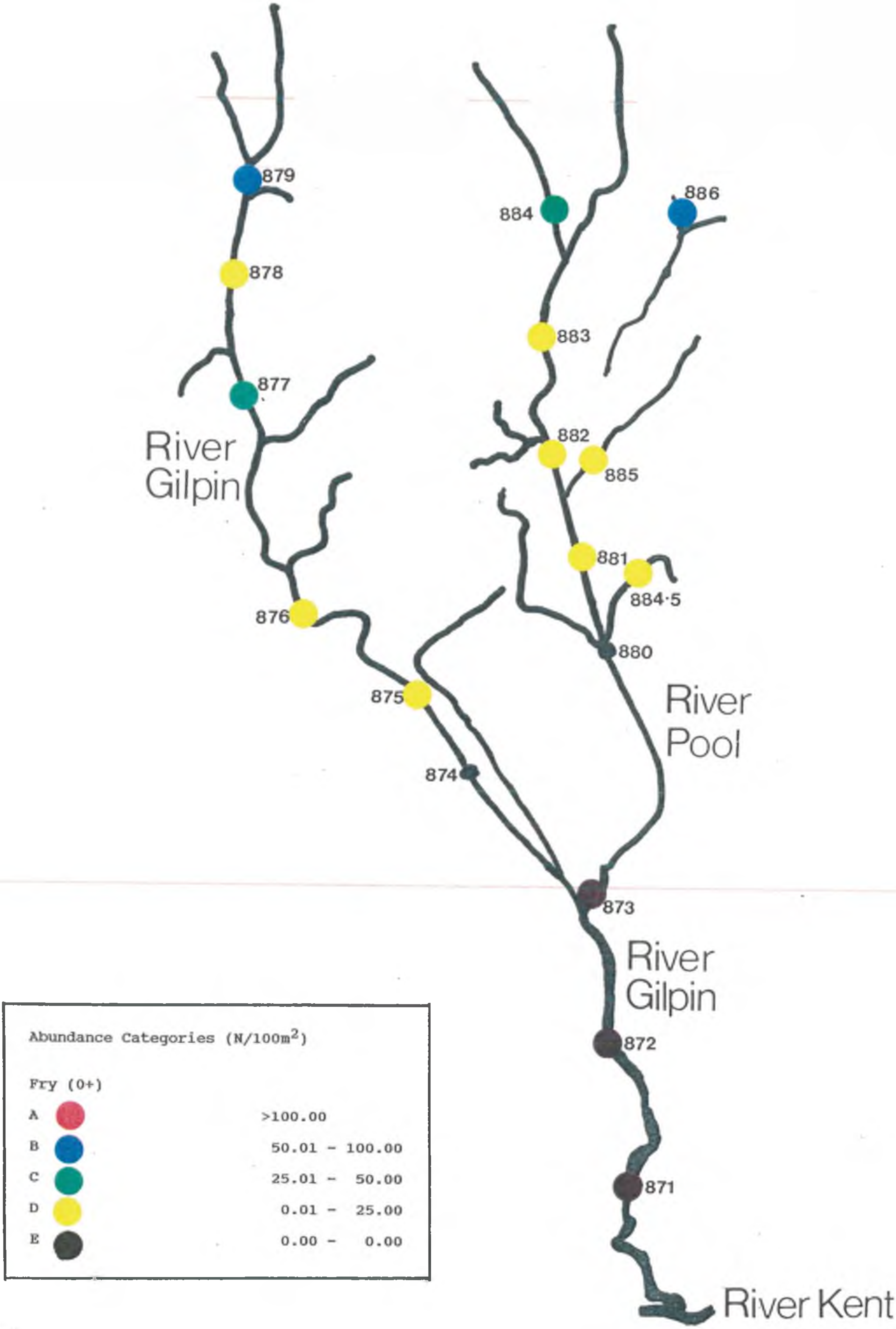
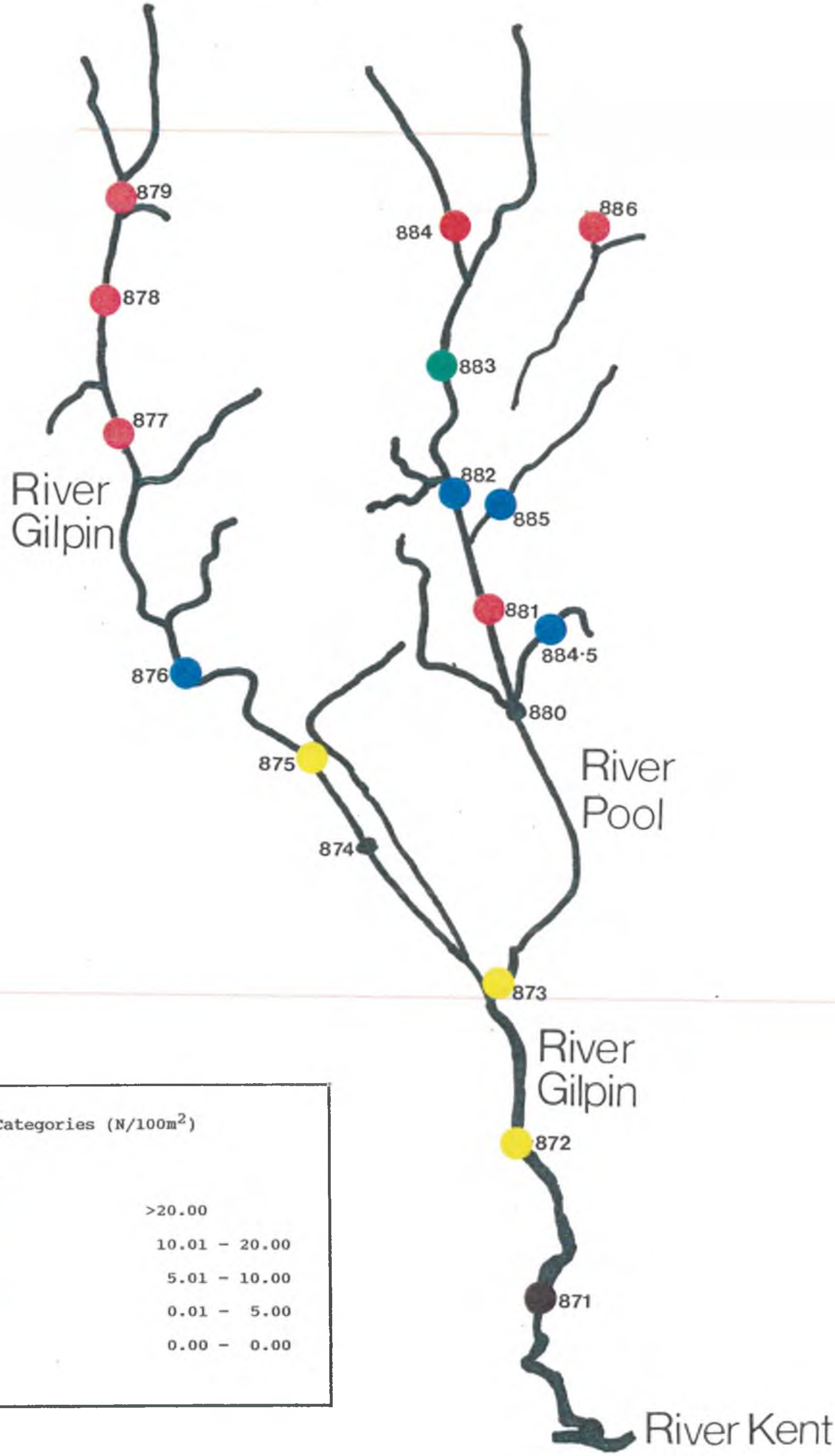


Figure 5 : Trout Parr (>0+) Densities in the River Gilpin Catchment 1994.



Abundance Categories (N/100m^2)

Parr (>0+)

A	>20.00
B	10.01 - 20.00
C	5.01 - 10.00
D	0.01 - 5.00
E	0.00 - 0.00

6. OVERVIEW

6.1. SALMON

6.1.1. Salmon Distribution

Salmon distribution is limited to the River Pool and the lower reaches of the Gilpin. They are absent in the River Gilpin from site 876 upstream, i.e. upstream of the weirs at Crosthwaite. They are also absent from 3 of the Pool tributaries.

6.1.2. Salmon Productivity

In an effort to determine the productivity of the Gilpin system in terms of salmon parr numbers, the densities of parr found at each site combined with the width data collected were used to calculate a figure for parr production over a number of "reaches". The choice of the length of these reaches was based on comparable widths at all sites where accessibility to adult salmon was observed by the presence of juveniles of this species.

The figures are tabulated below.

TABLE 1: ESTIMATED SALMON PARR PRODUCTION USING MEAN DENSITIES AND WIDTHS OVER SUB CATCHMENT LENGTH.

Sub Catchment	Length (km)	Mean Width (m)	Mean Parr Density nos/100m2	Parr Production (nos)
LOWER GILPIN	2.0	4.60	2.05	189
POOL	1.5	4.57	9.94	681
POOL TRIB.	0.5	4.33	3.63	79
			TOTAL	949

It can be seen from the table above that the River Pool has the greatest production of salmon parr, with a smaller contribution from the River Gilpin.

Using data from studies by Shearer (1984a) and Mills (1989), an estimate of the likely adult return of salmon from this number of salmon parr can be calculated. Assuming a 50% mortality of parr before smolting and a 10% survival of smolts at sea, an adult salmon run of some 48 grilse could result in 1996.

6.1.3. Comparison with Salmon Redd Counts

Of the juvenile fish surveyed in 1994, the fry are the progeny of the 1993 spawning and the parr are the survivors of the 1992 spawning. The salmon redd counts are a minimum figure and from the salmon distribution (figures 2 & 3) it can be seen that the juveniles are present in areas where redds were not counted, Appendix 3a and b.

TABLE 2 : SALMON REDD COUNTS 1983 - 1993

	Salmon
1993	22
1992	*
1991	16
1990	5
1989	*
1988	54
1987	*
1986	*
1985	21
1984	4
1983	2

* Redd Count unavailable due to high flows

Assuming two fish per redd, these figures give a population estimate of 4 - 108 fish in the period 1983-1993. The mean estimate is 34 fish.

6.1.4. Comparison with Historic Survey Data

The Gilpin system was surveyed in 1989. Three sites are in common with those in the 1994 survey.

Salmon fry densities have not changed classes since 1989. Salmon parr have increased from class D to class C at one site, but decreased from D to E. However, this class D was only one fish/100m^2.

TABLE 3: COMPARISON OF 0+ SALMON SURVEY RESULTS BETWEEN 1989 & 1994

CLASS	1989	1994
A	0	0
B	0	0
C	0	0
D	2	2
E	1	1

TABLE 4: COMPARISON OF >0+ SALMON SURVEY RESULTS BETWEEN 1989 & 1994

CLASS	1989	1994	SHIFT
A	0	0	0
B	0	0	0
C	0	1	+1
D	2	0	-2
E	1	2	+1

6.2. TROUT

6.2.1. Trout Distribution

Trout are present in all of the Gilpin catchment, although in varying densiites.

6.2.2. Trout Productivity.

Trout productivity can only be measured as that for resident and migratory trout together, as it is not possible to determine visually which juvenile fish originate from which parents. However, as a comparison to the salmon parr production data, a table of trout 1+ parr production for all sites (accessible to migratory fish and inaccessible) has been included below.

TABLE 5. ESTIMATED 1+ TROUT PARR PRODUCTION USING MEAN DENSITIES AND WIDTHS OVER SUB CATCHMENT LENGTH.

Sub Catchment	Length (km)	Mean Width (m)	Mean Parr Density nos/100m2	Parr Production (nos)
GILPIN				
LOWER (875)	1.0	4.60	0.80	37
MIDDLE (876/7)	2.5	4.30	16.32	1754
UPPER (878/9)	4.0	3.20	61.56	7880
RIVER POOL	6.0	4.7	14.69	4143
POOL TRIBS.	*	*	*	1622
			TOTAL	15436

* = These values were calculated for the individual streams and were not meaned.

The upper Gilpin and the River Pool are the main areas of production for trout. Using the same freshwater mortalities as for salmon, but a 15% marine survival rate (D. Evans pers. comms.) a maximum estimate of sea trout production can be gained. A returning adult sea trout run of 772 fish is possible in 1996. The majority of the >0+ fish caught in the survey were 1+. This implies that many of the fish may be sea trout progeny and not resident trout.

6.2.3. Comparison with Sea Trout Redd Counts.

TABLE 6 : SEA TROUT REDD COUNTS 1983 - 1993

	Sea trout
1993	144
1992	321
1991	266
1990	190
1989	167
1988	323
1987	280
1986	205
1985	488
1984	353
1983	299

Assuming two fish per redd this gives a returning adult population estimate between 288-976 in the period 1983-1993. With a mean figure of 552 fish.

If we assume 1,400 eggs per redd (J.Foster per comm), there was an egg deposition of 449,400 in the Gilpin catchment in the 1992 spawning season. This resulted in an estimated 15,436 trout parr in 1994. This gives a survival rate from eggs to parr of 3.4%, which is good.

6.2.4. Comparison with Historic Data

TABLE 7: COMPARISON OF TROUT 0+ SURVEY RESULTS FROM 1989 TO 1994

CLASS	1989	1994	SHIFT
A	0	0	0
B	0	0	0
C	0	0	0
D	3	3	0
E	0	0	0

TABLE 8: COMPARISON OF TROUT >0+ SURVEY RESULTS FROM 1989 TO 1994

CLASS	1989	1994	SHIFT
A	2	1	-1
B	1	1	0
C	0	1	+1
D	0	0	0
E	0	0	0

Trout fry densities have not altered greatly since 1989. Trout parr have dropped from A to B and from B to C respectively at the two sites. However, sea trout redds, despite there being similar numbers, may have had different distributions in 1987 and 1992, thus as the numbers of sites compared is small, too much should not be read from these small changes.

6.3. TOTAL SALMONID PRODUCTIVITY.

An attempt in this study has been made to determine the total productivity of the system as well as a total productivity on a site by site basis. The methodology used is described in appendix 4.

Whilst acknowledging the possible flaws in the methodology used for determining the total productivity classes, some interesting results are obtained.

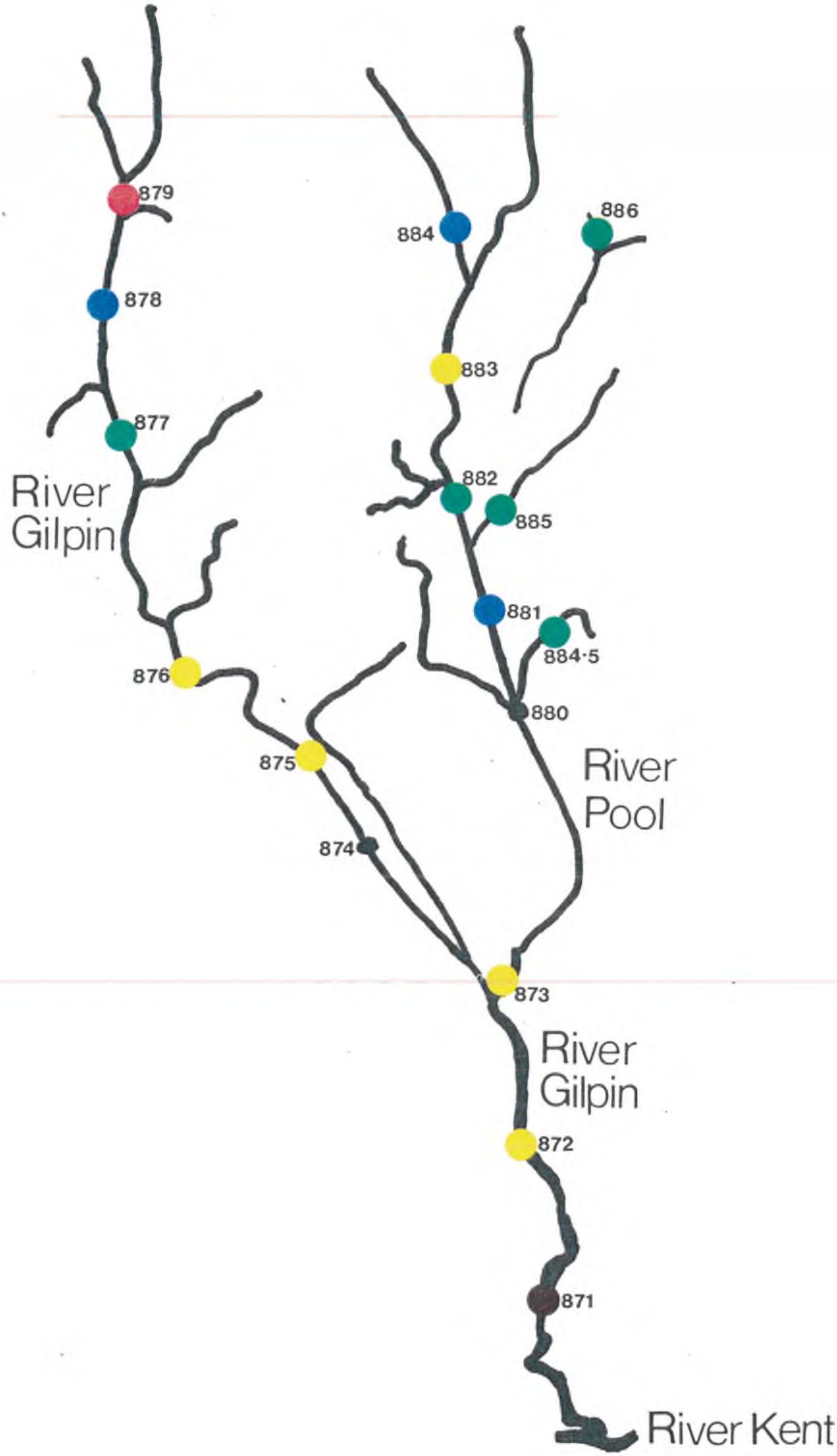
From fig 6 it can be seen that the River Gilpin system is reasonably productive across most of its area, with very productive sites in the upper reaches, but there are sites devoid of fish (or minute densities), in the lower reaches. There are the following numbers of sites in each productivity class;

Class	Nos of Sites	% of total
A	1	7
B	3	20
C	5	33
D	5	33
E	1	7

6.4. INTERSPECIFIC COMPETITION.

Trout are present in high densities in the upper reaches of the Gilpin, where salmon are absent. However, this is not a result of competition, this is due to the partial barriers at Crosthwaite which seem to prevent salmon migrating, but not sea trout.

Figure 6 : Total Salmonid Production in the River Gilpin Catchment 1994.



7. CONCLUSIONS

[1] Exceptionally high densities of trout are present in the upper reaches of the Gilpin and Pool.

[2] Salmon migration is inhibited by the weirs at Crosthwaite.

[3] Salmonids are almost devoid from the lower reaches of the Gilpin, due to lack of suitable habitat and canalization of the rivers.

[4] Historical survey results imply that the Gilpin system is at a stable population level.

8. RECOMMENDATIONS

Fish passes over the weirs at Crosthwaite may aid the migration of salmon to the upper reaches of the Gilpin, however preliminary costings of a fish pass have proved that a cost benefit investigation would need to be undertaken, prior to any developments.

The Lyth Valley has a great deal of land drainage. There are many drains and a flood relief channel alongside the main river which receives pumped water from the main river in times of high flow. This prevents flooding of prime agricultural land. Habitat changes in the main river channel may improve the holding for migrating adult fish, however it is unlikely that this will become a reality as farming is a priority in this area.

9. REFERENCES

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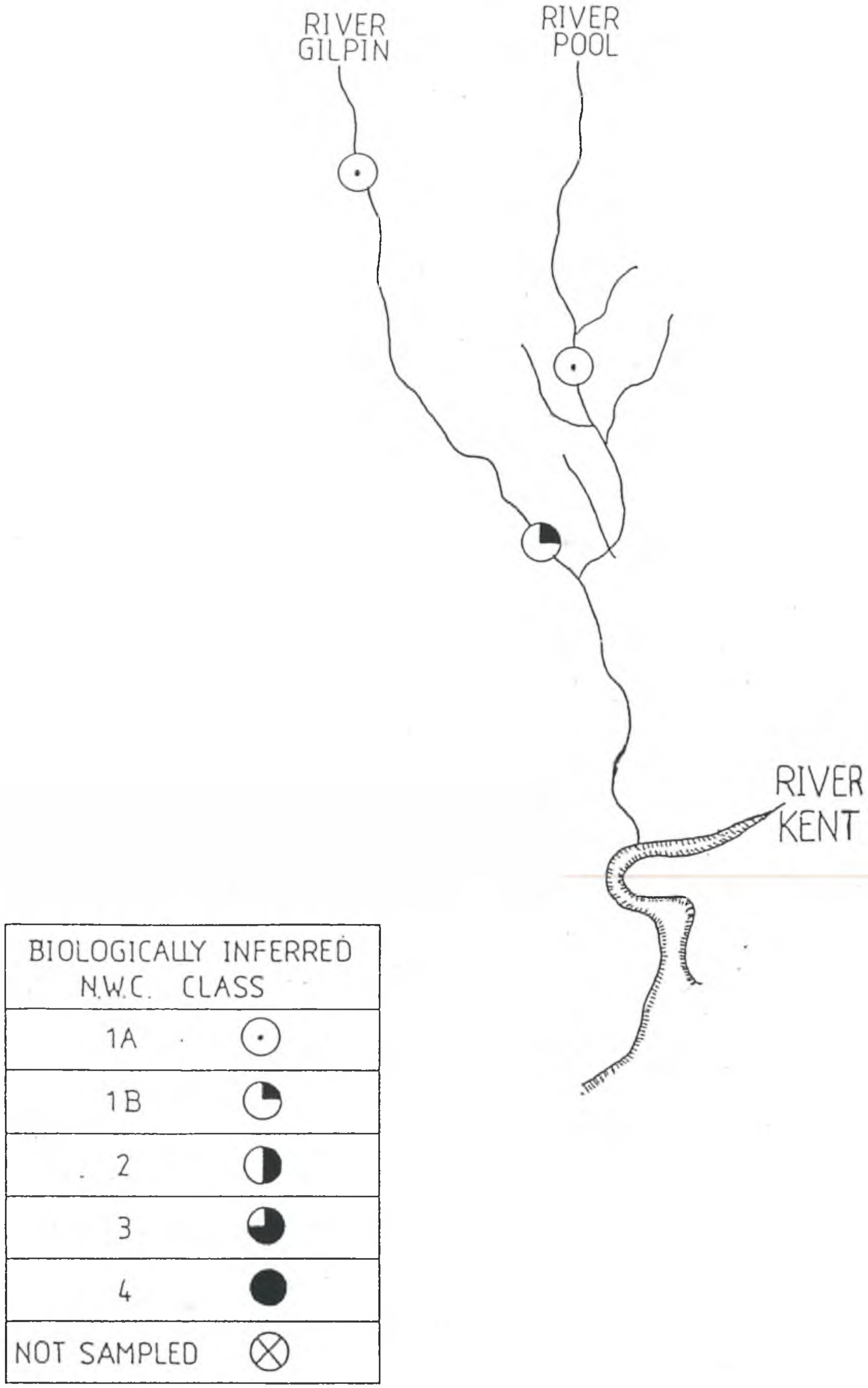
APPENDICES

Appendix	1	Water Quality in the Gilpin catchment 1994
	2a	Table of Site Reference Data.
	2b	Salmonid Densities in the Gilpin catchment.
	2c	Major Coarse fish species densities.
	2d	Minor Coarse Fish Densities - abundance.
	3a	Redd Count map data 1993/94.
	3b	Redd Count map data 1992/93.
	4	Methodology for calculation of total productivity.

Appendix 1: Water Quality in the Gilpin Catchment 1994



Appendix 2a : Table of site Reference Data

Site Nos	Site Name	Tributary	Date	NGR	Width Mean (m)	Length (m)	Area (m2)
871.00	Gilpin-Sampool	Gilpin	01/06/94	SD473-856	6.00	100	600.00
872.00	Gilpin-Nr. NRA	Gilpin	01/06/94	SD468-867	6.00	100	600.00
873.00	Gilpin-PTC Gilp	Pool	01/06/94	SD467-879	6.00	100	600.00
875.00	Durham Bridge		30/08/94	SD448-901	4.60	50	230.00
876.00	Gilpin-Crossthw		09/08/94	SD435-914	4.80	50	240.00
877.00	Gilpin-Foxhole		09/08/94	SD434-926	3.80	50	190.00
878.00	Gilpin-Gilpin M		09/08/94	SD432-941	3.10	40	124.00
879.00	Gilpin-Spigot H		09/08/94	SD433-950	3.30	40	132.00
880.00	Gilpin-Tullythw	Pool	01/01/94	SD467-906			
881.00	Gilpin-Gregg Ha	Pool	31/08/94	SD466-914	5.50	40	220.00
882.00	Gilpin-Kirkby h	Pool	30/08/94	SD463-927	3.64	40	146.00
883.00	Gilpin-Beckside	Pool	30/08/94	SD463-938	5.03	50	252.00
884.00	Gilpin-Nr. Croo	Pool	19/09/94	SD463-948	2.00	50	100.00
884.50	Nr Tullythwaite	Un-named	30/08/94	SD471-912	2.37	40	95.00
885.00	Gilpin-Public H	Un-named	30/08/94	SD468-923	4.33	45	195.00
886.00	Gilpin-Brundrig	Pool	02/08/94	SD482-950	1.40	50	70.00

Appendix 2b : Salmonid Densities in the River Gilpin Catchment 1994

site nos	Tributary	Site Name	pop dens of 0+ salmo	pop dens of 1+ salmo	pop dens of 0+ Trou	pop dens of 1+ Trout	pop dens of >1+ trou
871.00	Gilpin	Gilpin-Sampool Brd	0.00	0.00	0.00	0.00	0.00
872.00	Gilpin	Gilpin-Nr. NRA Pum	0.00	0.40	0.00	0.00	0.21
873.00	Pool	Gilpin-PTC Gilpin	0.00	0.00	0.00	0.00	0.21
875.00		Durham Bridge	21.04	2.05	22.66	0.80	1.09
876.00		Gilpin-Crossthwait	0.00	0.00	22.50	10.09	0.00
877.00		Gilpin-Foxhole Ban	0.00	0.00	36.26	22.55	0.00
878.00		Gilpin-Gilpin Mill	0.00	0.00	15.01	52.57	2.02
879.00		Gilpin-Spigot Hous	0.00	0.00	63.48	70.54	2.84
880.00	Pool	Gilpin-Tullythwait					
881.00	Pool	Gilpin-Gregg Hall	22.01	8.58	10.15	25.40	1.14
882.00	Pool	Gilpin-Kirkby hous	17.86	11.30	21.68	12.76	1.72
883.00	Pool	Gilpin-Beckside	5.90	0.00	15.51	5.90	0.50
884.00	Pool	Gilpin-Nr. Crook	0.00	0.00	29.80	11.17	13.78
884.50	Un-named	Nr Tullythwaite	0.00	0.00	9.80	17.64	1.32
885.00	Un-named	Gilpin-Public Hous	27.69	3.63	16.24	11.45	0.00
886.00	Pool	Gilpin-Brundrigg	0.00	0.00	55.87	21.28	0.00

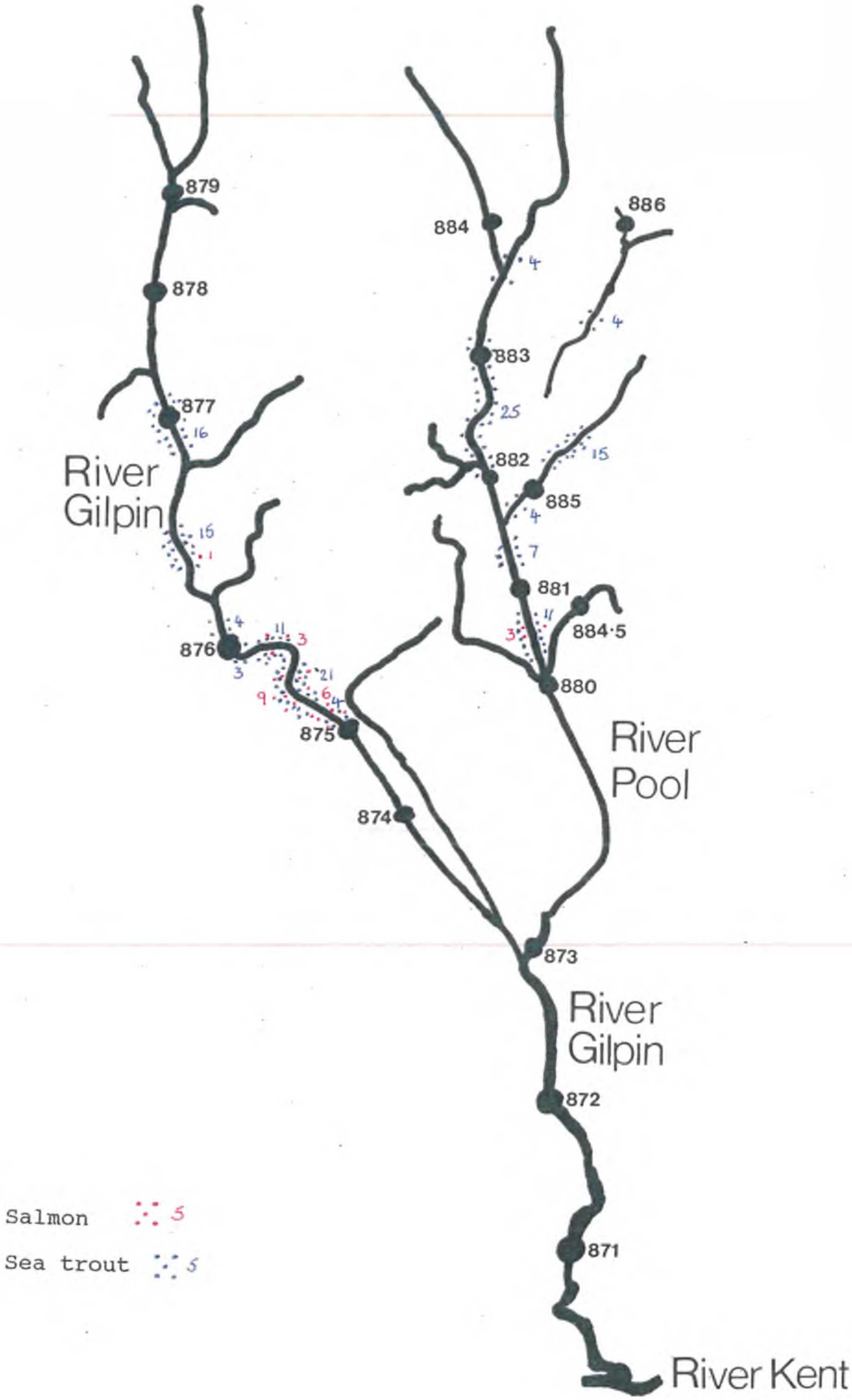
Appendix 2c : Major Coarse Fish Species Densities.

Site nos	Site Name	Tributary	Eels	Pike	Dace	Perch
				Density per 100m2		
871.00	Gilpin-Sampool Brdg	Gilpin	51-100	0.00	0.00	0.00
872.00	Gilpin-Nr. NRA Pump	Gilpin	51-100	0.00	0.00	0.00
873.00	Gilpin-PTC Gilpin	Pool	51-100	0.00	0.00	0.00
875.00	Durham Bridge		11-50	0.00	0.00	0.00
876.00	Gilpin-Crossthwaite		101-200	0.00	0.00	0.00
877.00	Gilpin-Foxhole Bank		51-100	0.00	0.00	0.00
878.00	Gilpin-Gilpin Mill		51-100	0.00	0.00	0.00
879.00	Gilpin-Spigot House		51-100	0.00	0.00	0.00
880.00	Gilpin-Tullythwaite	Pool				
881.00	Gilpin-Gregg Hall	Pool	51-100	0.00	0.00	0.00
882.00	Gilpin-Kirkby house	Pool	11-50	0.00	0.00	0.00
883.00	Gilpin-Beckside	Pool	11-50	0.00	0.00	0.00
884.00	Gilpin-Nr. Crook	Pool	1-10	0.00	0.00	0.00
884.50	Nr Tullythwaite	Un-named	11-50	0.00	0.00	0.00
885.00	Gilpin-Public House	Un-named	51-100	0.00	0.00	0.00
886.00	Gilpin-Brundrigg	Pool	1-10	0.00	0.00	0.00

Appendix 2d : Minor Coarse fish species - abundance

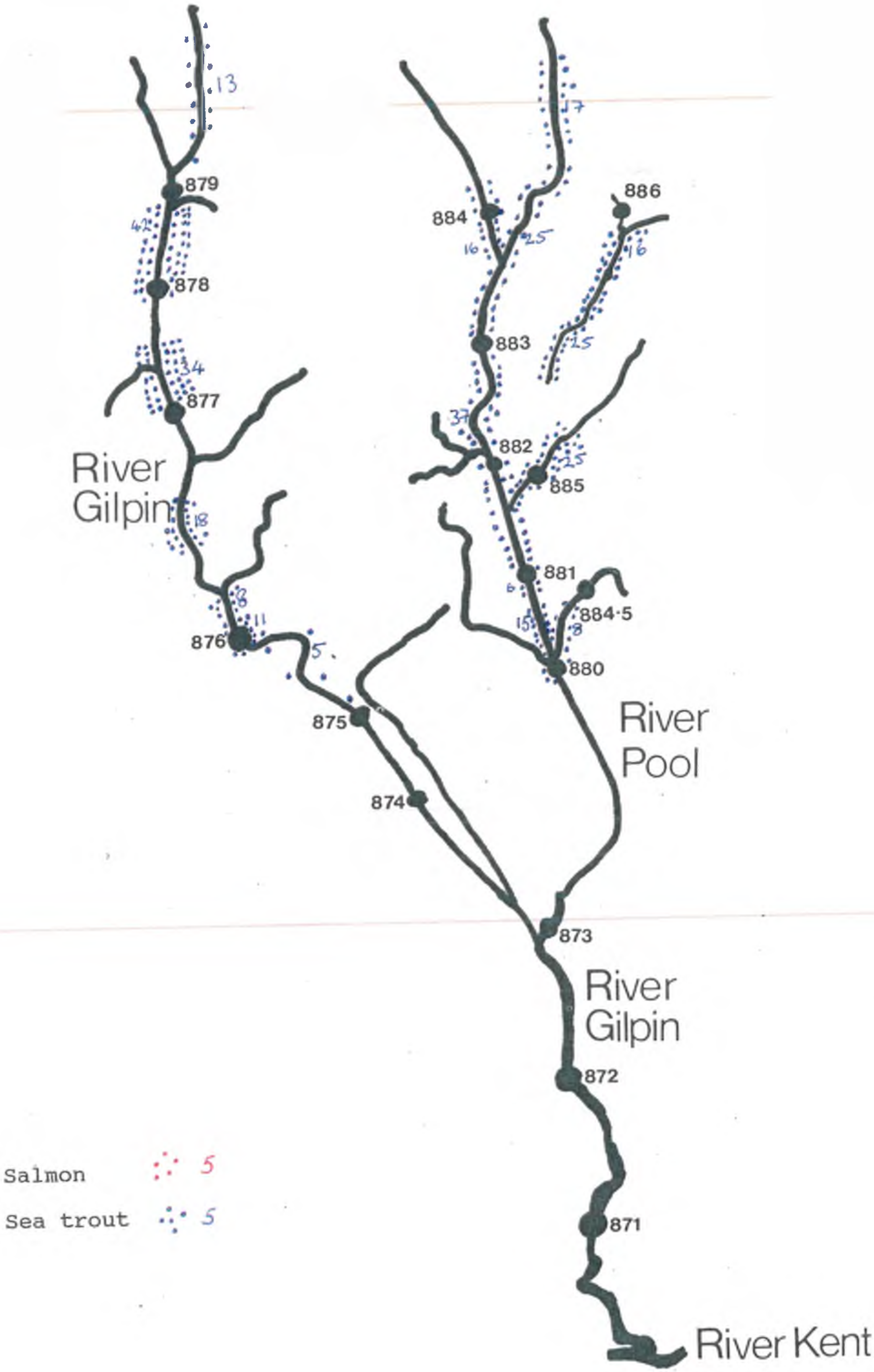
Site nos	Site Name	Tributary	Stoneloach	Bullhead	Minnow	Stickleback
871.00	Gilpin-Sampool	Gilpin	0	0	0	11-100
872.00	Gilpin-Nr. NRA	Gilpin	0	0	0	0
873.00	Gilpin-PTC Gilp	Pool	0	0	0	1-10
875.00	Durham Bridge		0	0	0	1-10
876.00	Gilpin-Crossthw		0	0	0	0
877.00	Gilpin-Foxhole		0	0	0	0
878.00	Gilpin-Gilpin M		0	0	0	0
879.00	Gilpin-Spigot H		0	0	0	0
880.00	Gilpin-Tullythw	Pool				
881.00	Gilpin-Gregg Ha	Pool	0	0	0	0
882.00	Gilpin-Kirkby h	Pool	0	0	0	0
883.00	Gilpin-Beckside	Pool	0	0	0	0
884.00	Gilpin-Nr. Croo	Pool	0	0	0	0
884.50	Nr Tullythwaite	Un-named	0	0	0	0
885.00	Gilpin-Public H	Un-named	0	0	0	0
886.00	Gilpin-Brundrig	Pool	0	0	0	0

Appendix 3a : Salmon and Sea Trout Redd Counts 1993/94.



Appendix 3b : Salmon and Sea Trout Redd Counts 1992/93.

Salmon redds were unable to be counted owing to high waters.



APPENDIX 11

Derivation of Total Salmonid Density Class

In order to create a class which related to Total Salmonid Density (i.e. all salmon plus all trout) it was necessary to rationalise the abundance categories for the two different age classes, i.e fry and parr (Table 9).

The classes are based on the assumption that 1 in 5, or 20%, of fry survive to become parr (Table 9). Thus by dividing the total fry density by 5, all densities could be related to the Abundance Class for parr.

An index for Total Salmonid Density was calculated using densities as follows :-

Index = 1/5 (Salmon 0+ + Trout 0+) + (Salmon >0+ + Trout >0+)

As this index was derived from both salmon and trout, the parr abundance categories have been doubled (Table 9).

Table 9 : Classification for Total Salmonid Density Index (N/100m2)

Class			
A		>40.00	
B	20.01	-	40.00
C	10.01	-	20.00
D	0.01	-	10.00
E		0.00	

Methodology to determine Total Salmonid Productivity

To determine if the classes are set at a realistic level, a literature search was undertaken.

Work by Elliot on a Lake District stream has shown that a range of salmonid biomass from 8.86 - 33.9g/m^2 was recorded over a 25 year period. Similar work by Brynildson *et al.* 1984 in the USA, and Mortenson 1978 in Holland, showed a recorded biomass in the range of 12.2 - 36.0g/m^2 and 14.1 - 33.1g/m^2 respectively. However, Elliot postulates that these results are higher than in most studies.

From data collected on weight/length relationships for salmonids, we can calculate what, in biomass terms, our classification system is telling us. Typically, salmonid parr in South Cumbria averaged 13cm in length by the end of the survey year. This would equate to a weight of 25g/fish. Thus our classification system can be shown in terms of weight production (in grammes) per 100m^2.

Class	Nos of Salmonid Units per $100m^2$			Weight in grammes per m^2
A	> 40.01			>10.01+
B	20.01	-	40.00	5.01 - 10
C	10.01	-	20.00	2.51 - 5
D	0.01	-	10.00	0.1 - 2.5
E	0.00			

A class A result with a unit score of e.g. 63.7 fish would record a biomass of $15.9g/m^2$. This -*falls within the range of Elliot's work which, as stated, gave a variation of biomass productivity higher than in most experimental results published. It is thus concluded on present knowledge that the proposed total productivity classes are acceptable.

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A REPORT ON THE STRATEGIC STOCK ASSESSMENT SURVEY OF RUSLAND POOL CATCHMENT 1994 WITH PARTICULAR REFERENCE TO SALMONIDS

NRA/NW/FTR/94/16 October 1994

A REPORT ON THE STRATEGIC STOCK ASSESSMENT SURVEY OF RUSLAND POOL CATCHMENT 1994 WITH PARTICULAR REFERENCE TO SALMONIDS

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October 1994

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CONTENTS

1. SUMMARY

Salmonid production in Rusland Pool is reasonable with certain areas being more productive than others.

Dale Park Beck and Grizedale Beck are most productive for trout (*Salmo trutta* L.).

Grizedale Beck is inaccessable to migratory fish. Salmon (*Salmo salar* L.) production is limited to Ashes Beck, Bell Beck and the main river.

The afforestation of the upper catchment does not appear to have a detrimental effect on the salmonid production of Rusland Pool, although it may affect year class strength in Grizedale Beck.

The survival and juvenile production is sufficient to maintain the population in a steady state and to allow a limited level of exploitation of adult stocks.

2. INTRODUCTION

The NRA under the Water Resources Act 1991, has a responsibility to maintain, improve, and develop fisheries. To accomplish this, baseline data on the populations of fish present in North West region is required.

The stock assessment task group has identified a number of key areas for the application of stock assessment data:

1. To assess long term change.

2. To help conserve fish species.

3. To evaluate stocking programmes, habitat and water quality improvements.

4. To assess or predict the impact of activities which the NRA or other organizations may have on fish populations.

5. To comment on the fisheries implications of developments when the NRA is a statutory consultee to planning authorities.

This report forms one part of the third year of a triennial survey programme for the South West Cumbria and South Cumbria catchments.

3. DESCRIPTION OF STUDY AREA

3.1. SITE SELECTION

A total of 18 sites were selected throughout the catchment. These sites were chosen at approximately 1km distances apart, where access was possible and were representative of the area of river immediately around the site.

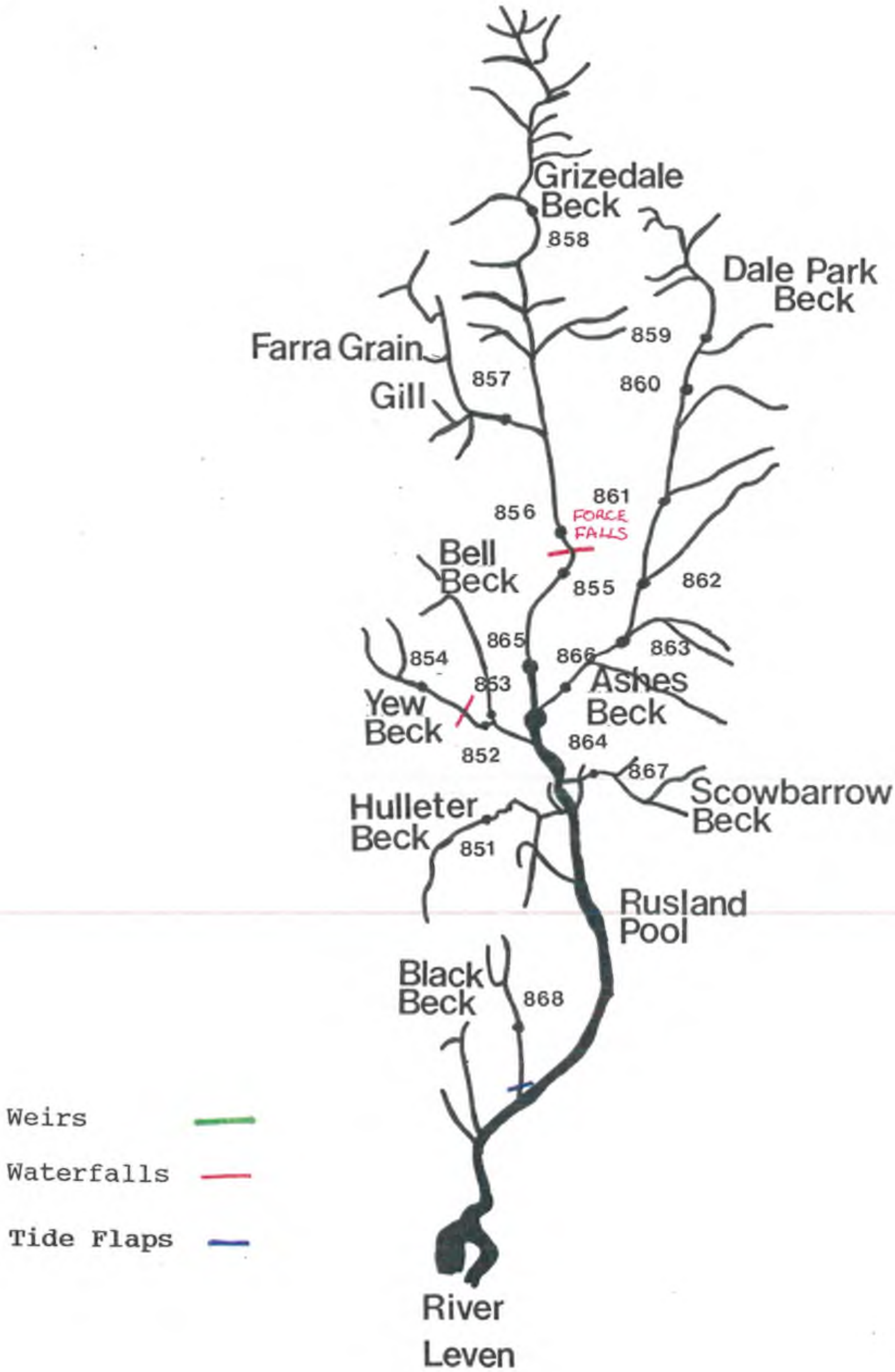
3.2. OBSTACLES

Obstacles, for example weirs and waterfalls, can act as important factors affecting the distribution of fish within a catchment (Gardiner 1990). Figure 1 shows the weirs, waterfalls and tide flaps, known to exist within the catchment.

3.3. WATER QUALITY

The spring 1994 water quality survey on Rusland Pool found water quality, in all of the 4 sites sampled, to be class 1A, Appendix 1.

Figure 1 : Known Obstacles to Migratory Fish 1994.



4. METHODS.

All the sites sampled in 1994 were fished using an Electracatch pulsed DC control box powered by a 650KW Honda generator.

For all sites, the team fished once through in an upstream direction for around 50m without stop nets.

All fish were collected, except where numbers of minor coarse fish (minnows, bullheads, stickleback and stoneloach) were so high as to make accurate netting impossible without inordinate effort. In these cases an abundance category was assigned, Appendix 2d.

A number of other details were recorded, including temperature, conductivity, water level, velocity, general habitat details and the team's specific tasks.

Measurements of site length and widths at 10m intervals were recorded, Appendix 2a.

Target fish (salmonids and major coarse fish species) were anaesthetised when necessary using phenoxyethanol and then measured to the nearest 0.5cm (rounding down). Where the number of fish in any age class appeared to be in excess of 100, a sub sample of about this number was measured.

For each target species and age class (salmonids only), a minimum density (number of fish caught divided by the area fished, multiplied by 100) per 100m^2 was calculated. This information is tabulated in Appendix 2b.

5. RESULTS BY SUB-CATCHMENT

See Figs 2-5

5.1. MAIN RIVER

Three sites were sampled on the main river downstream of Force Falls (NGR SD 339-910). This stretch drains mixed woodland for 2 km then a mixture of pasture and mixed woodland down to its confluence with the river Leven. Below site 864 the river is canalised and tidal and as a result was not surveyed.

5.1.1. Results

Salmon fry densities were low in the main river scoring class D at the two lower sites and absent at the upper site. However, salmon parr densities were excellent with one class A and two class B's.

A similar pattern is evident for trout with fry scoring class D at all three sites. For trout parr the lower site was class B, the middle class D and the upper site class A.

5.1.2. Conclusions

The higher densities of parr than fry for both species is probably habitat related. The main river sites were fast flowing and the sustrate was relatively large.

5.2. GRIZEDALE BECK

Three sites were surveyed on Grizedale beck and a main tributary Farra Grain Gill. These sites were above Force Falls which are impassable to migratory fish. The catchment is predominantly coniferous plantations with the riparian zone dominated by pasture except for the upper section.

5.2.1. Results

Salmon were absent from all sites due to the falls.

All trout present would be resident brown trout. Fry densities were low scoring class D on Farra Grain Gill and the lower site, but were absent on the highest site. Parr densities were high with all classes scoring class B. The upper site of Grizedale Beck had a greater density of >1+ trout than the other two sites which consisted of mainly 1+ fish.

5.2.2. Conclusions

The sites surveyed had habitat suitable entirely for juveniles, with the exception of site 858 which had a greater proprtion of pools. This explains the higher densities of older fish at the top site, but not the low densities, and absence, of fry at all sites.

It would appear that there has been a difference in year class strength between the 1993 and 1994 year classes. Redd counts for resident trout are not available for comparison. However, there are a few explanations relating to possible environmental differences.

Due to the large amount of coniferous woodland in the catchment it is possible that acid flushes may have occurred whilst the fry were at a vulnerable stage. Also heavy rainfall in 1993 during the brown trout spawning period caused high flows which may have disturbed the redds and washed out some of the eggs.

5.3. ASHES BECK / DALE PARK BECK.

The whole of this system is accessible to migratory fish as the confluence with Rusland Pool is downstream of Force Falls. Dale Park Beck also drains coniferous woodlands, but Ashes Beck drains pasture.

5.3.1. Results

Salmon were present in the lower three sites where redds were counted, but were absent in the top three sites where redds were not observed. Where present, fry scored class C at two sites and class D at the others. Salmon parr had the same upper distribution limit as the fry, but different densities. The lowest site had no salmon parr present, whilst the other two sites scored class D and class B.

Trout were present throughout the beck. High Redd counts figures indicate that many of the trout present are likely to be sea trout progeny, as there was a noted lack of large adult brown trout in the survey area. Fry were present in reasonable densities, three sites scoring class C and three class D. The >0+ densities were excellent for all but the lower site which scored class D. The two class A and three class B sites were mainly 1+ fish and few older fish were found.

5.3.2. Conclusions

Dale Park Beck is shallow and narrow and as a result salmon migrate only a certain distance up Ashes Beck. Parr are absent from the lower site due to unsuitable habitat, few older trout were caught at this site either.

Due to the high redd counts and the low proportion of older trout it would appear that the majority of trout in this part of the system are sea trout.

5.4. LOWER TRIBUTARIES.

The catchment of the lower tributaries, (Bell, Yew, Hulleter, Black and Scowbarrow Beck) is composed of deciduous woodland and agricultural land. The becks vary in size. Scowbarrow and Hulleter beck are about 1.5 metres wide, whereas Bell and Black Beck are about 2.5 metres wide in comparison.

5.4.1. Results

Salmon are present only in Bell Beck. Fry densities are class A and parr densities are class C.

Trout fry are present at all the sites, with two class D, one class C and three class B. >0+ trout were absent at the bottom of Yew Beck and scored two class D, two class B and class A at the top of Yew Beck, where half the older fish are >1+.

5.4.2. Conclusions

Bell Beck is the only salmon production area for the lower tributaries. This is perhaps due to the larger size of stream and also its proximity to uncanalized main river. Black beck has its confluence with the main river below the tidal limit and has tidal flaps.These may prevent migration, except on large floods.

The main river below site 864 is tidal and canalised with no holding for adult fish. It is likely that on a flood large enough to encourage upstream migration, salmon move straight up the main river to the Rusland area and then select Bell Beck, Ashes Beck and the main river below Force Falls as spawning areas.

The sea trout whose presence are indicated by high redd counts and low densities of older trout appear more likely to migrate up the smaller becks at the bottom of the system, giving good densities of juvenile trout.

The falls on Yew beck prevent sea trout migrating up to Ickenthwaite (site 854). However, there are high densities of resident trout.

Figure 2 : Salmon fry (0+) densities in the Rusland Pool Catchment 1994

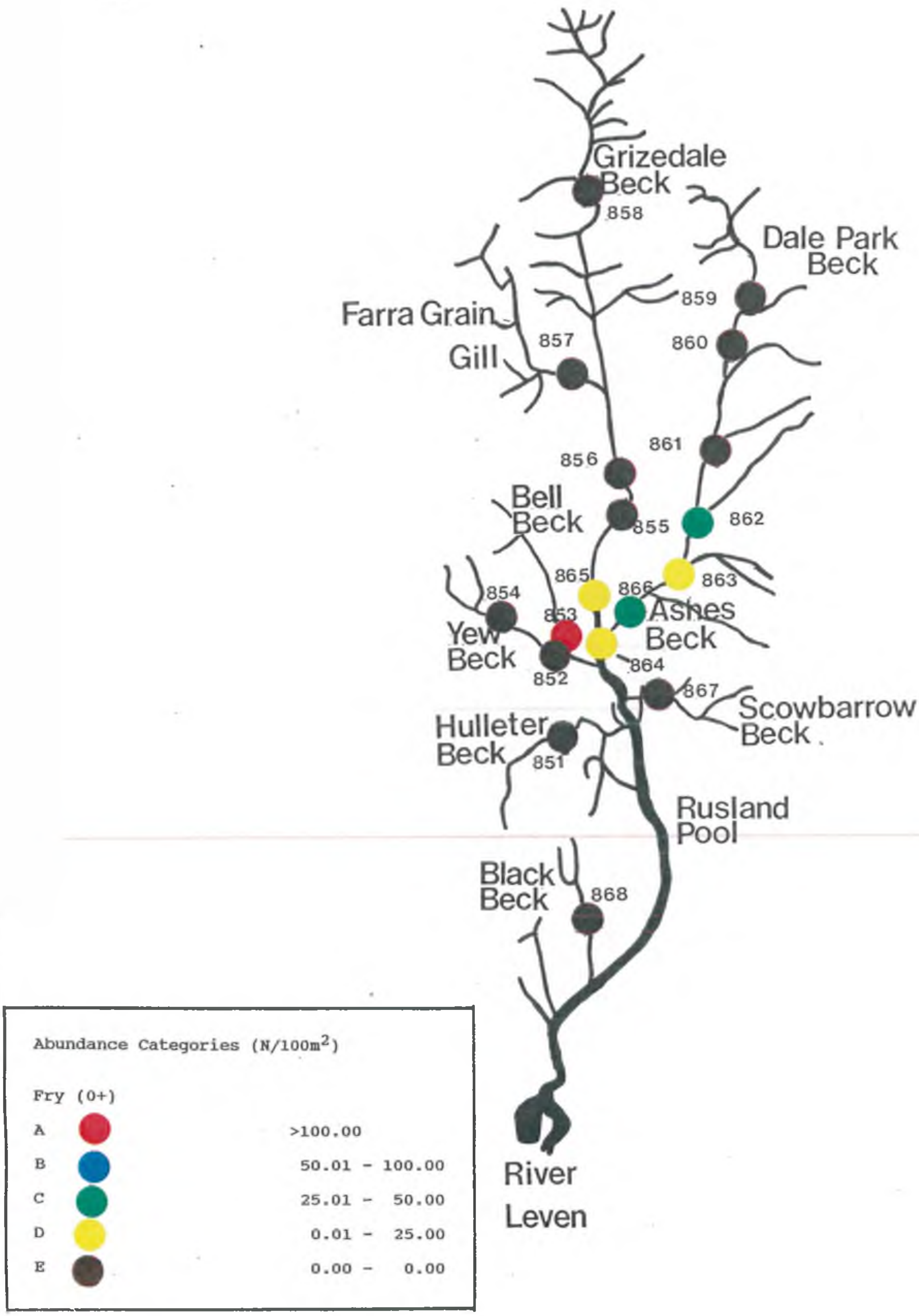


Figure 3 : Salmon parr (>0+) densities in the Rusland Pool Catchment 1994.

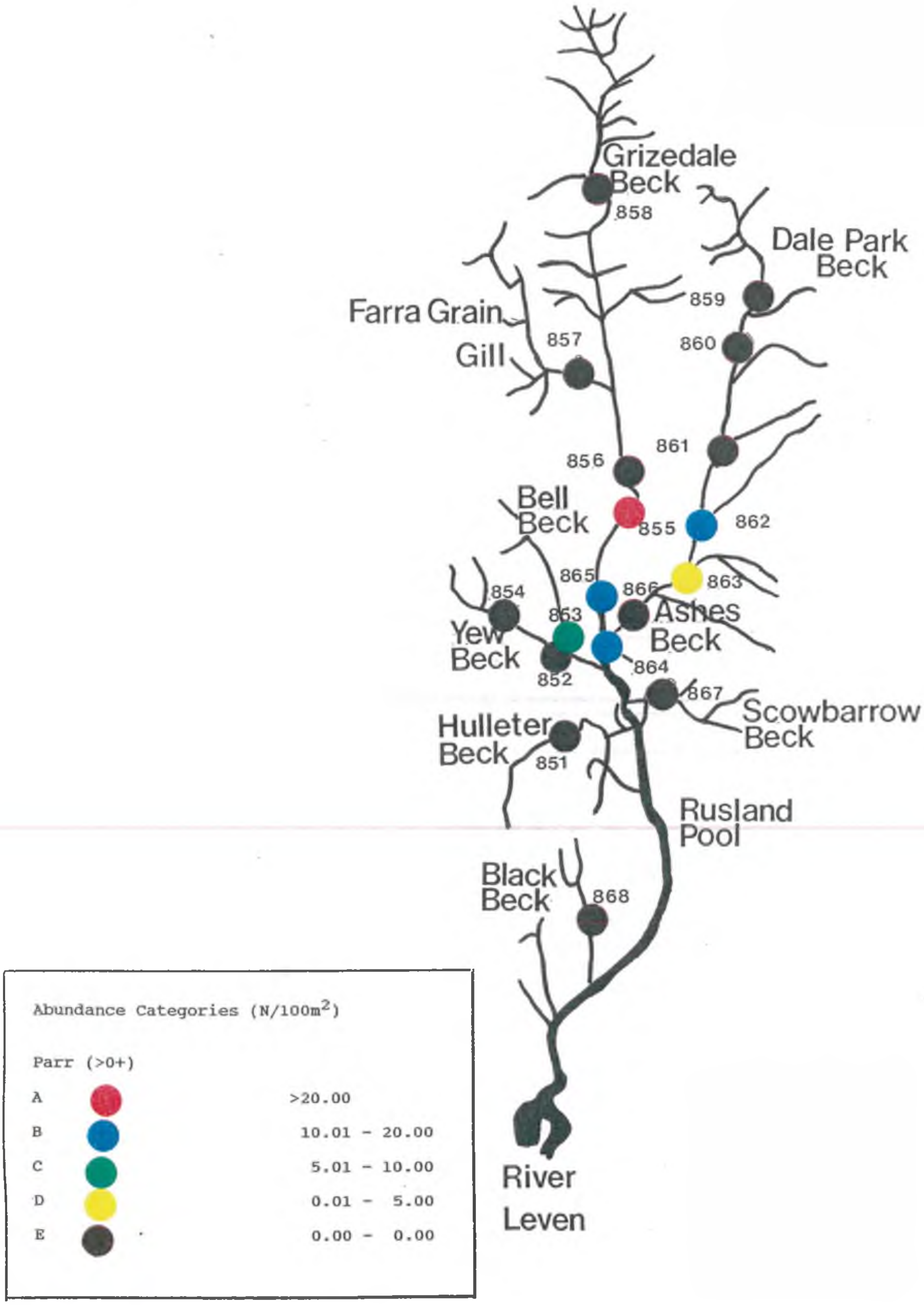


Figure 4 : Trout fry (0+) densities in the Rusland Pool Catchment 1994.

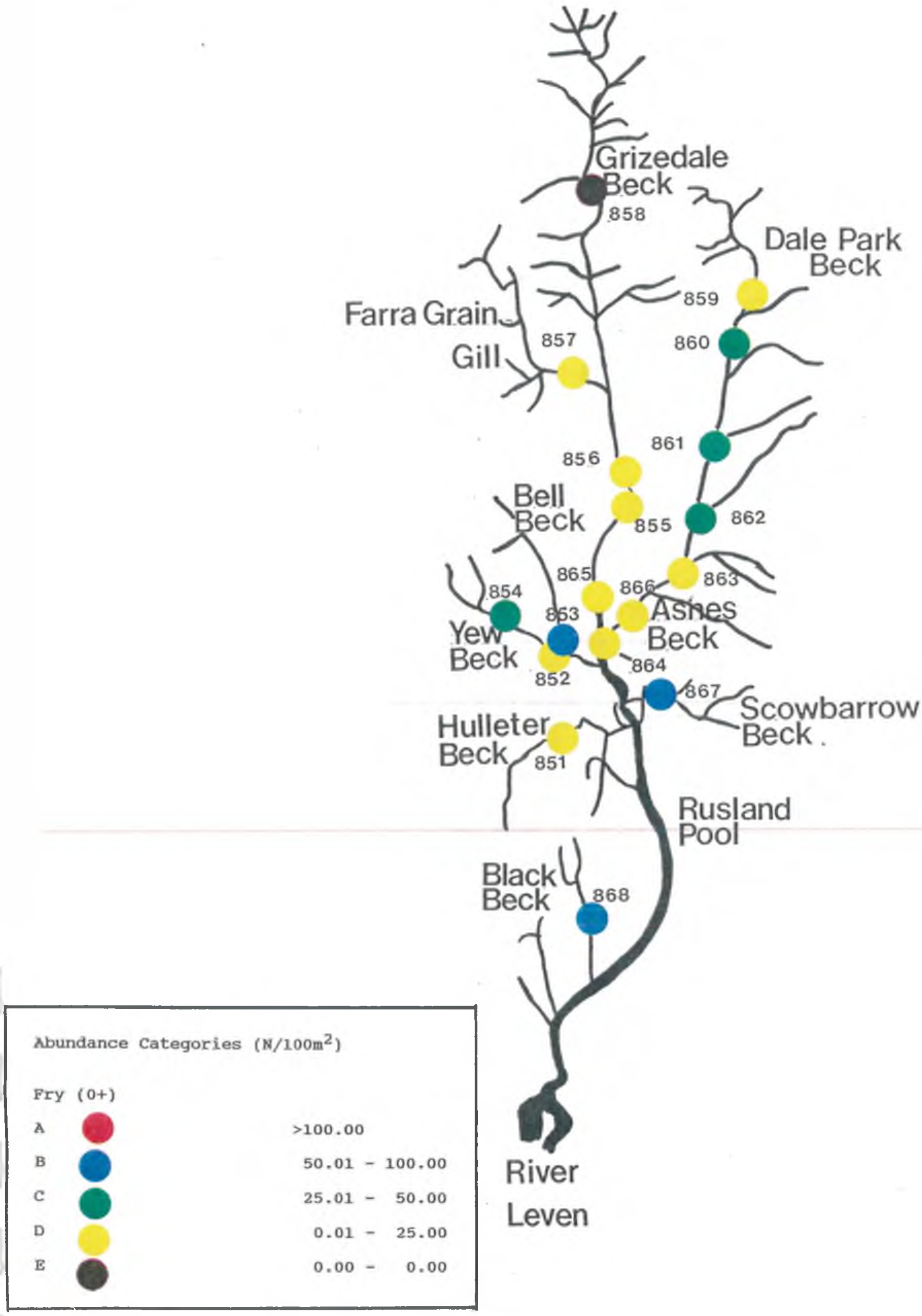
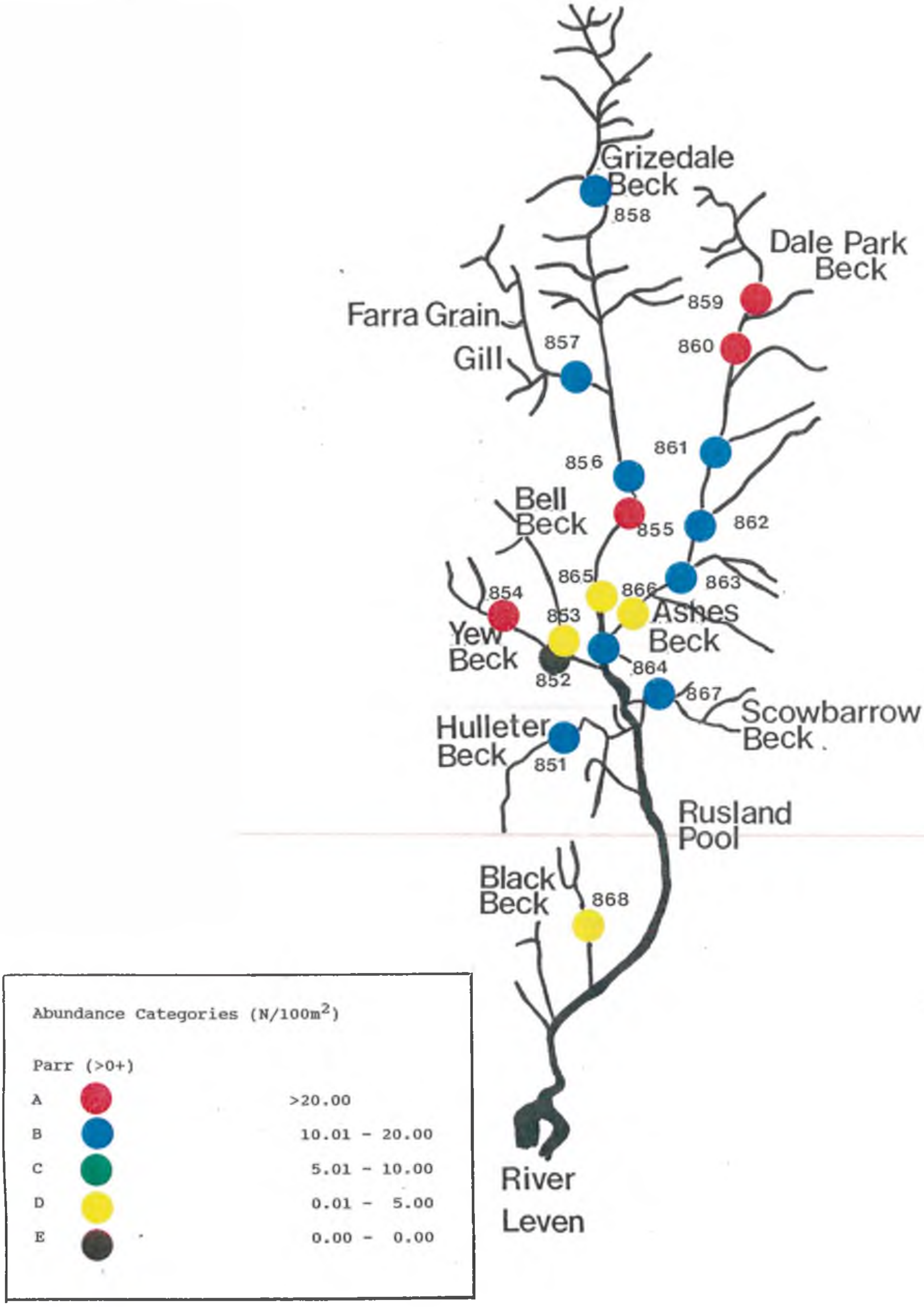


Figure 5 : Trout parr (>0+) densities in the Rusland Pool Catchment 1994.



6. OVERVIEW

From the detailed discussions on each sub-catchment, it can be seen that there are areas of good salmonid production throughout the catchment.

6.1. SALMON

6.1.1. Salmon Production

Salmon are restricted to the central area of streams around Ashes Beck, Bell Beck and the main river below Force Falls.

6.1.2. Salmon Productivity

In an effort to determine the productivity of the Rusland Pool system in terms of salmon parr numbers, the densities of parr found at each site combined with the width data collected were used to calculate a figure for parr production over a number of "reaches". The choice of the length of these reaches was based on comparable widths at all sites where accessibility to adult salmon was observed by the presence of juveniles of this species.

The figures are tabulated below.

TABLE 1. ESTIMATED SALMON PARR PRODUCTION USING MEAN DENSITIES AND WIDTHS OVER SUB CATCHMENT LENGTH.

Sub Catchment	Length (km)	Mean Width (m)	Mean Parr Density nos/100m2	Parr Production (nos)
Rusland Pool	2.0	5.2	15.99	1663
Ashes Beck	2.0	4.23	7.76	656
Bell Beck	1.5	2.50	7.55	283
TOTAL				**2602**

It can be seen from the table above that the main river has the greatest production of salmon parr, with Ashes Beck producing a substantial contribution.

Using data from studies by Shearer (1984a) and Mills (1989), an estimate of the likely adult return of salmon from this number of salmon parr can be calculated. Assuming a 50% mortality of parr before smolting and a 10% survival of smolts at sea, an adult salmon run of some 100-150 (actual calculated value, 130) fish should result in 1996.

6.1.3. Comparison with Salmon Redd Counts

Of the juvenile fish surveyed in 1994, the fry are the progeny of the 1993 spawning and the parr are the survivors of the 1992 spawning. The salmon redd counts are a minimum figure and from the salmon distribution (figures 2 & 3) it can be seen that the juveniles are present in the main river where redds were not counted. Also salmon fry were found in high densities in Bell Beck where all redds in 1993 were recorded as sea trout.

TABLE 2 : SALMON REDD COUNTS 1989 - 1993

	Salmon
1993	30
1992	11
1991	31
1990	61
1989	53

Taking this one step further, if we assume that an average redd may contain around 5,000 eggs, we have a total egg deposition in Rusland Pool of 55,000 in 1992/93. This suggests that survival rates through to parr are in the region of 4.7%. Although this is not low, higher levels are found in other systems for example River Calder 9% and River Mint 6-7% (McCubbing 1994a and b) However, the parr production has been calculated using parr found in areas where redds were not recorded (e.g. Bell Beck and main river). This survival rate of 4.7% will in reality be the maximum survival rate possible and the true figure may be lower.

It would appear that with this level of survival the salmon population, (based on redd count) is being maintained at a relatively steady state.

6.1.4. Juvenile Salmon Production versus Adult Returns.

As no fishery exists on Rusland Pool and no catch returns are available. This leaves redd counts as the only measure of adult population.

6.2. TROUT

6.2.1. Trout Distribution

Trout were found at every site surveyed. In Grizedale Beck and at the top of Yew Beck these fish were definitely brown trout. The fish in Dale Park Beck appear to be predominantly sea trout as discussed earlier. The other streams contained a combination of sea and brown trout of unknown proportions.

6.2.2. Trout Productivity.

Trout productivity can only be measured as that for resident and migratory trout together, as it is not possible to determine visually which juvenile fish originate from which parents. However, as a comparison to the salmon parr production data, a table of trout 1+ parr production for all sites (both accessible and inaccessible to migratory fish) has been included below. As there is a substantial area of trout production in Grizedale Beck and Yew beck which can only be brown trout due to impassable falls this proportion has been calculated. The remaining fish are possibly sea trout or brown trout progeny.

TABLE 3. ESTIMATED 1+ TROUT PARR PRODUCTION USING MEAN DENSITIES AND WIDTHS OVER SUB CATCHMENT LENGTH.

Sub Catchment	Length (km)	Mean Width (m)	Mean Parr Density nos/100m2	Parr Production (nos)
Rusland Pool	4.0	5.20	11.26	2342
Ashes	2.0	4.23	8.88	751
Dale Park	4.0	3.26	28.40	3703
Grizedale	5.0	5.40	14.40	3888
Farra Grain Gill	0.5	4.30	14.39	309
Bell	2.0	2.50	4.47	224
Yew	3.0	1.98	11.91	707
Hulleter	2.5	1.50	15.31	574
Scowbarrow	1.0	1.70	10.95	186
Black	2.0	2.10	1.77	74
TOTAL				**12758**
			(Total brown trout	**4904) 38 %)**
			(Total brown or sea trout	**7854) 62%)**

Grizedale Beck produces the greatest numbers of trout parr. However, due to the impassable falls these fish are definitely resident trout. This is also the case for Farra Grain Gill and Yew Beck. It is likely that the majority of the trout production in Dale Park Beck, Ashes Beck and Black Beck are sea trout progeny as the majority of >0+ fish are 1+ and few older fish were caught.

6.2.3. Comparison of Production with Adult Returns.

It is difficult to determine what this proportion of the possible 62% represents in terms of sea trout, since the actual proportion of migratory to resident trout is not known. If all of this parr production was represented by sea trout, an adult return of some 590 fish can be expected in 1996, assuming 50% winter mortality before smolting and 15% survival of smolts at sea (D. Evans pers comms.). This is an over estimate since this includes some resident brown trout, but it gives us an idea of what could be expected.

There are no rod catch returns for sea trout. However, a number of adult fish were caught in the strategic survey. Three were caught at the lowest main river site (864) and a couple more were observed, but not caught. Two were found at the highest site on the main river below Force Falls. One adult was found halfway up Dale Park Beck (site 861). The survey was carried out in mid August and these fish had already reached the spawning grounds. This maybe as a result of the lack of holding pools in the main river. The lowest area that fish can 'hold up in' is near site 864 (M. Dixon pers. comms.).

6.2.4. Comparison with Sea Trout Redd Counts.

TABLE 4 : SEA TROUT REDD COUNTS 1989 - 1993

	Sea trout
1993	130
1992	172
1991	109
1990	137
1989	75

Between 1989 and 1993 the average redd count for sea trout was 125. If all of the possible adult sea trout from the parr production in 1994 returned, and it is assumed two fish per redd, approximately 295 redds could be expected in total in 1996. This figure may be higher than historical data for a number of reasons, including; incomplete counts historically with some streams not counted and/or a portion of the trout parr being from resident brown trout and/or an increase in juvenile production in 1994.

Either way, it would appear from the comparison of current production and historic redd counts that the population is producing enough adults to maintain the adult population.

6.3. TOTAL SALMONID PRODUCTIVITY.

An attempt in this study has been made to determine the total productivity of the system as well as a total productivity on a site by site basis. The methodology used is described in Appendix 4.

Whilst acknowledging the possible flaws in the methodology used for determining the total productivity classes, some interesting results are obtained.

From fig 6 it can be seen that the Rusland Pool system is reasonably productive across most of its area with no sites devoid of fish. There are the following numbers of sites in each productivity class;

Class	Nos of Sites	% of total
A	0	0
B	5	28
C	5	28
D	8	44
E	0	0

The sites which are highest in productivity are those with high parr production, particularly Dale Park / Ashes Beck. In addition to the salmonid production in this tributary, there were high numbers of bullheads found.

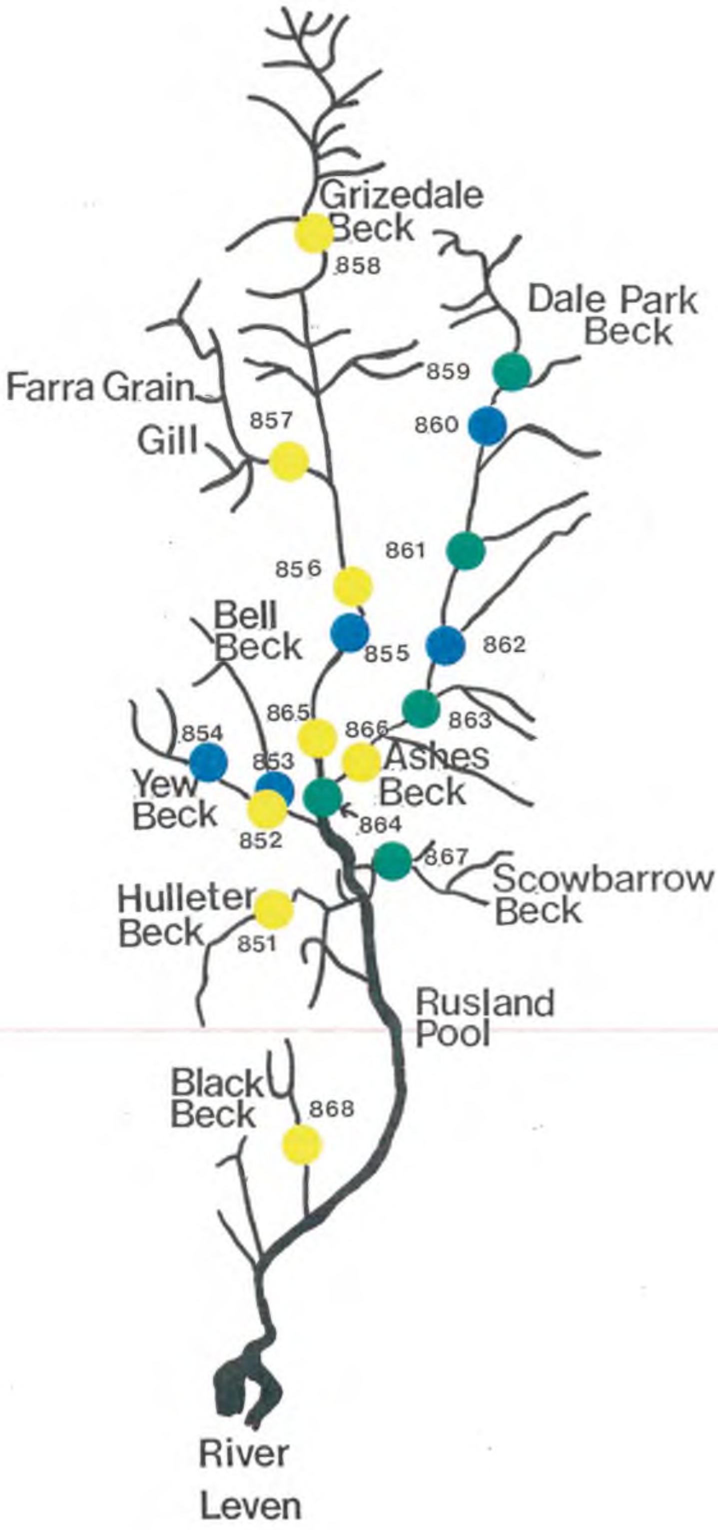
The densities and production of trout parr in Grizedale Beck are comparable with those found in Dale Park Beck, but the total productivity of Grizedale Beck is reduced by the lack of migratory fish as a result of the impassable falls.

6.4. INTERSPECIFIC COMPETITION.

Trout densities are greatest where salmon are absent. However, this does not neccesarily imply that competition is occurring as habitat characteristics may be more suited to trout than salmon.

Salmon densities do not appear to be inversely correlated to trout densities. Competition does not appear to occur in Rusland Pool.

Figure 6 : Total Salmonid Production in the Rusland Pool Catchment 1994.



7. CONCLUSIONS

[1] Survival and production of salmonids is of a sufficient level to maintain the population in a steady state.

[2] Salmon distribution is limited to the central area of streams, by factors preventing migration. Trout distribution is ubiquitous.

[3] Salmon production is greatest in the main river section.

[4] Dale Park Beck appears to be the main production area for sea trout.

[5] There appears to be a difference in brown trout year class strength in Grizedale Beck, between 1992 and 1993 spawnings.

8. RECOMMENDATIONS

The flood defence work carried out on the lower reaches of Rusland Pool have resulted in a loss of habitat for both juvenile and returning adult fish. To return the river to a suitable state for spawning and juvenile salmonids is unrealistic and not feasable. However, it may be possible to develop some adult fish holding in the main river if a fishery was to be developed.
Current juvenile population levels will allow limited exploitation without detriment to the population as a whole.

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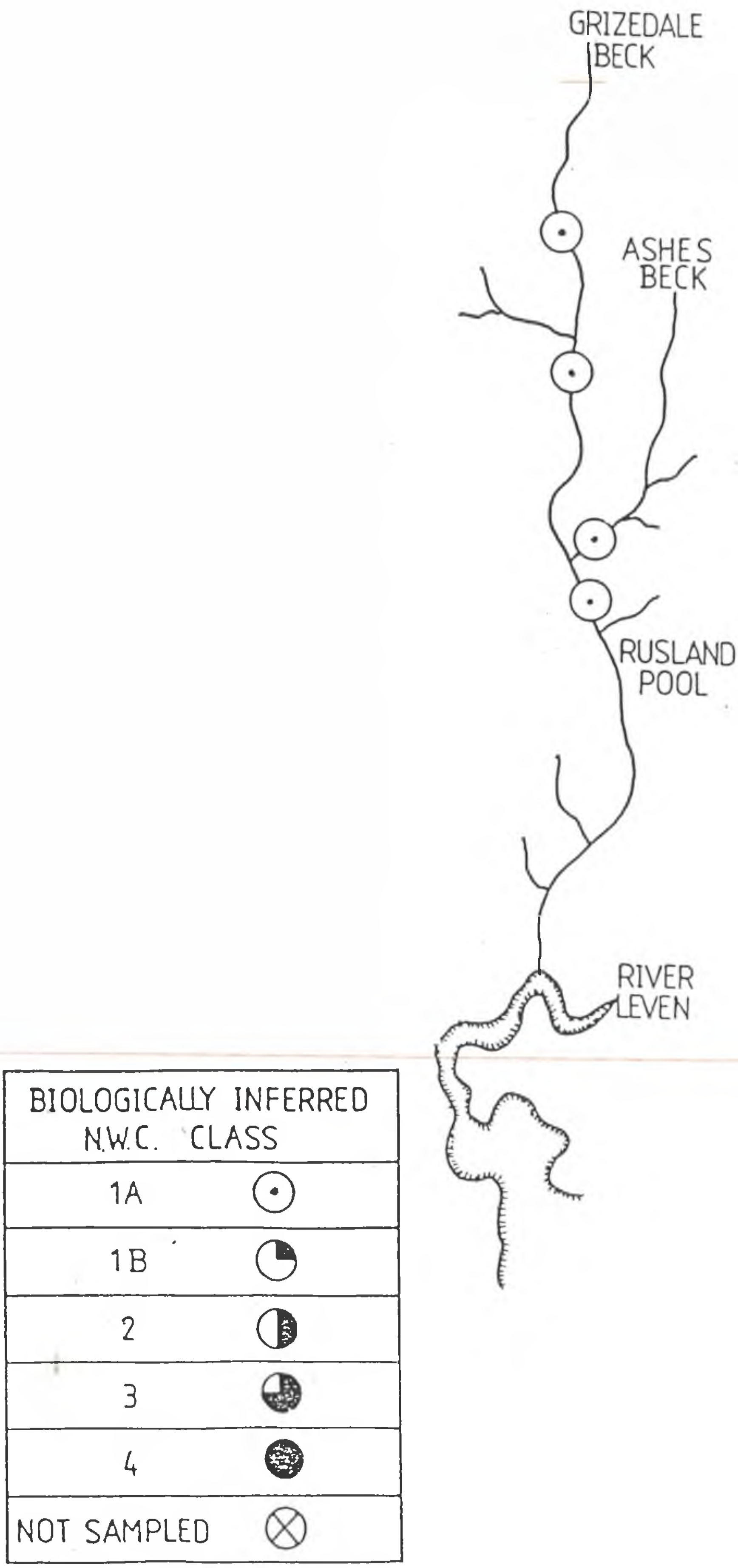
APPENDICES

Appendix	1	Water Quality in Rusland Pool catchment 1994
	2a	Table of Site Reference Data.
	2b	Salmonid Densities in Rusland Pool catchment.
	2c	Major Coarse fish species densities.
	2d	Minor Coarse Fish Densities - abundance.
	3a	Redd Count map data 1993/94.
	3b	Redd Count map data 1992/93.
	4	Methodology for calculation of total productivity.

Appendix 1 : River Quality Survey - Spring 1994



Appendix 2a : Table of Site Reference Data.

Site nos	Site Name	Tributary	Date	NGR	Width mean (m)	Length (m)	Area (m2)
851.00	RUSLAND-Hulleter	Hulleter Beck	23/08/94	SD328-881	2.90	25	73
852.00	RUSLAND-PTC Bell Bk	Yew Beck	18/08/94	SD331-892	2.05	50	103
853.00	RUSLAND - D/S Bridge	Bell Beck	18/08/94	SD332-894	2.50	50	125
854.00	RUSLAND-Ickenthwaite	Yew Beck	18/08/94	SD325-895	1.90	45	86
855.00	RUSLAND-Force Mills		15/08/94	SD337-908	5.50	50	275
856.00	RUSLAND-Bowkerstead		16/08/94	SD338-913	7.10	35	249
857.00	RUSLAND-Scale Green	Farra Grain Gil	23/08/94	SD333-925	4.30	45	194
858.00	RUSLAND-Picnic Site	Grizedale Beck	16/08/94	SD335-947	3.70	50	185
859.00	RUSLAND	Dalepark Beck	17/08/94	SD354-934	3.30	50	165
860.00	RUSLAND-High Dale Pk	Dalepark Beck	17/08/94	SD352-928	2.40	50	120
861.00	RUSLAND-Low Dale Pk	Dale Park Beck	17/08/94	SD350-917	4.10	40	164
862.00	RUSLAND-Thwaite Head	Ashes Beck	16/08/94	SD348-905	4.40	40	176
863.00	RUSLAND-Farm	Ashes Beck	17/08/94	SD346-901	3.70	50	185
864.00	RUSLAND-Strands Brdg		15/08/94	SD335-893	5.20	48	250
865.00	RUSLAND-D/S High Brg		15/08/94	SD335-895	4.90	50	245
866.00	RUSLAND-Lin Bridge	Ashes Beck	18/08/94	SD338-896	4.60	50	230
866.00	RUSLAND-Lin Bridge	Ashes Beck	18/08/94	SD338-896	4.60	50	230
867.00	RUSLAND-Rusland Hall	Scowbarrow Beck	23/08/94	SD343-886	1.70	50	85
868.00	RUSLAND-Black Bk Fm	Black Beck	23/08/94	SD335-856	2.10	50	105

Appendix 2b : Salmonid Densities in Rusland Pool Catchment 1994.

Site nos	Site Name	Tributary	Salmon 0+	Salmon 1+	Trout 0+	Trout 1+	Trout >1+
851.00	RUSLAND-Hulleter	Hulleter Beck	0.00	0.00	5.10	15.31	0.0
852.00	RUSLAND-PTC Bell Bk	Yew Beck	0.00	0.00	1.81	0.00	0.0
853.00	RUSLAND - D/S Bridge	Bell Beck	128.12	7.55	58.10	4.47	0.0
854.00	RUSLAND-Ickenthwaite	Yew Beck	0.00	0.00	43.31	23.82	13.1
855.00	RUSLAND-Force Mills		0.00	22.29	4.06	20.32	2.2
856.00	RUSLAND-Bowkerstead		0.00	0.00	4.49	15.70	1.0
857.00	RUSLAND-Scale Green	Farra Grain Gil	0.00	0.00	4.80	14.39	3.2
858.00	RUSLAND-Picnic Site	Grizedale Beck	0.00	0.00	0.00	13.09	6.7
859.00	RUSLAND	Dalepark Beck	0.00	0.00	24.82	27.09	0.7
860.00	RUSLAND-High Dale Pk	Dalepark Beck	0.00	0.00	49.66	38.79	1.0
861.00	RUSLAND-Low Dale Pk	Dale Park Beck	0.00	0.00	48.83	19.31	0.7
862.00	RUSLAND-Thwaite Head	Ashes Beck	39.14	17.43	37.04	13.76	2.1
863.00	RUSLAND-Farm	Ashes Beck	4.02	3.82	9.05	12.09	2.7
864.00	RUSLAND-Strands Brdg		2.23	15.09	7.45	10.43	6.5
865.00	RUSLAND-D/S High Brg		10.63	10.59	3.04	3.04	1.5
866.00	RUSLAND-Lin Bridge	Ashes Beck	36.44	2.05	12.14	0.80	0.0
867.00	RUSLAND-Rusland Hall	Scowbarrow Beck	0.00	0.00	72.29	10.95	0.0
868.00	RUSLAND-Black Bk Fm	Black Beck	0.00	0.00	74.49	1.77	0.0

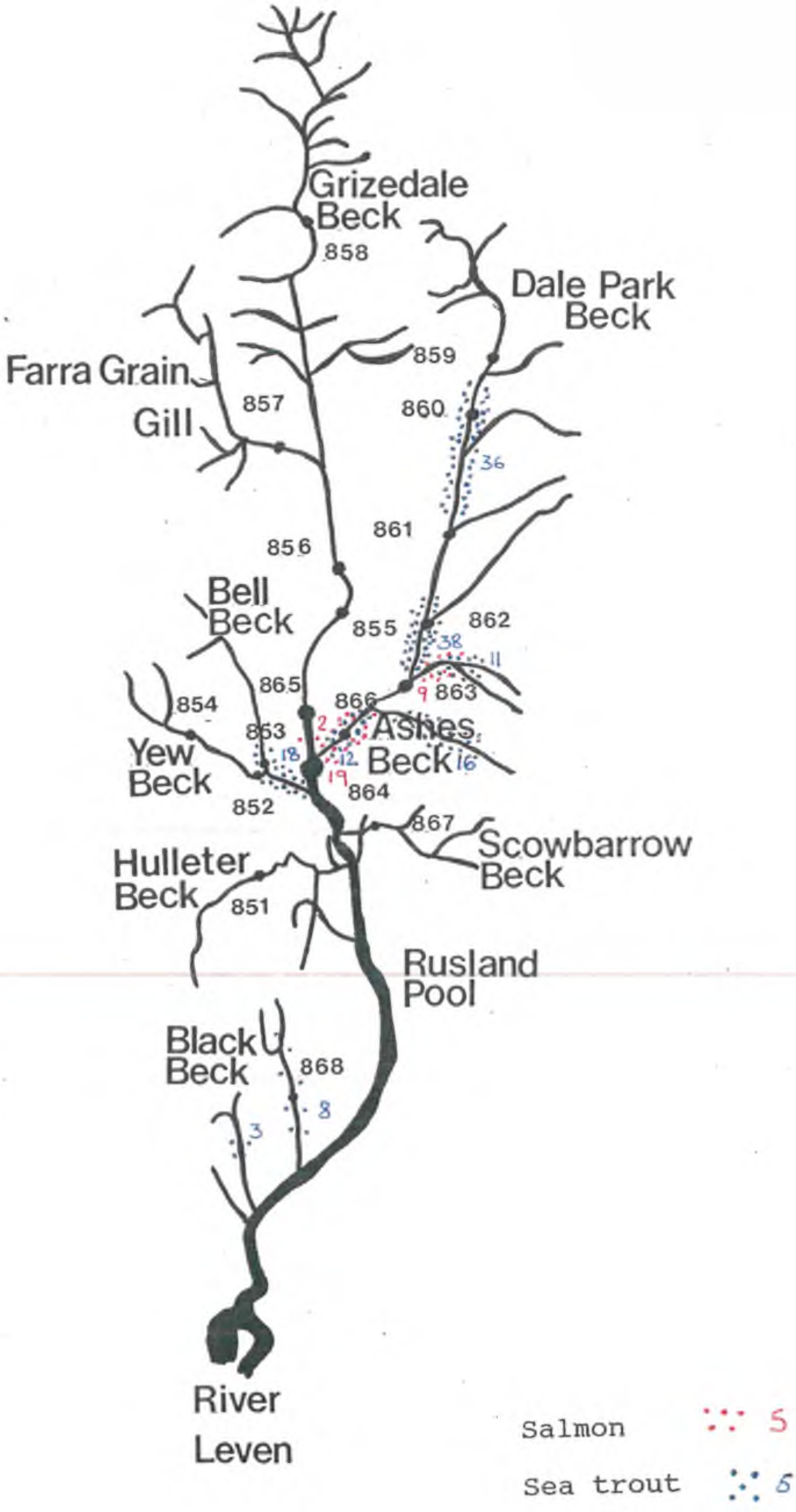
Appendix 2c : Major Coarse Fish Species Densities.

Site nos	Site Name	Tributary	Eels	Pike	Dace	Perch
				Density per 100m2		
851.00	RUSLAND-Hulleter	Hulleter Beck	1-10	0.00	0.00	0.00
852.00	RUSLAND-PTC Bell Bk	Yew Beck	0	0.00	0.00	0.00
853.00	RUSLAND - D/S Bridge	Bell Beck	51-100	0.00	0.00	0.00
854.00	RUSLAND-Ickenthwaite	Yew Beck	1-10	0.00	0.00	0.00
855.00	RUSLAND-Force Mills		51-100	0.00	0.00	0.00
856.00	RUSLAND-Bowkerstead		1-10	0.00	0.00	0.00
857.00	RUSLAND-Scale Green	Farra Grain Gil	1-10	0.00	0.00	0.00
858.00	RUSLAND-Picnic Site	Grizedale Beck	0	0.00	0.00	0.00
859.00	RUSLAND	Dalepark Beck	1-10	0.00	0.00	0.00
860.00	RUSLAND-High Dale Pk	Dalepark Beck	1-10	0.00	0.00	0.00
861.00	RUSLAND-Low Dale Pk	Dale Park Beck	1-10	0.00	0.00	0.00
862.00	RUSLAND-Thwaite Head	Ashes Beck	11-50	0.00	0.00	0.00
863.00	RUSLAND-Farm	Ashes Beck	1-10	0.00	0.00	0.00
864.00	RUSLAND-Strands Brdg		101-200	0.00	0.00	0.00
865.00	RUSLAND-D/S High Brg		51-100	0.00	0.00	0.00
866.00	RUSLAND-Lin Bridge	Ashes Beck	101-200	0.00	0.00	0.00
867.00	RUSLAND-Rusland Hall	Scowbarrow Beck	11-50	0.00	0.00	0.00
868.00	RUSLAND-Black Bk Fm	Black Beck	11-50	0.00	0.00	0.00

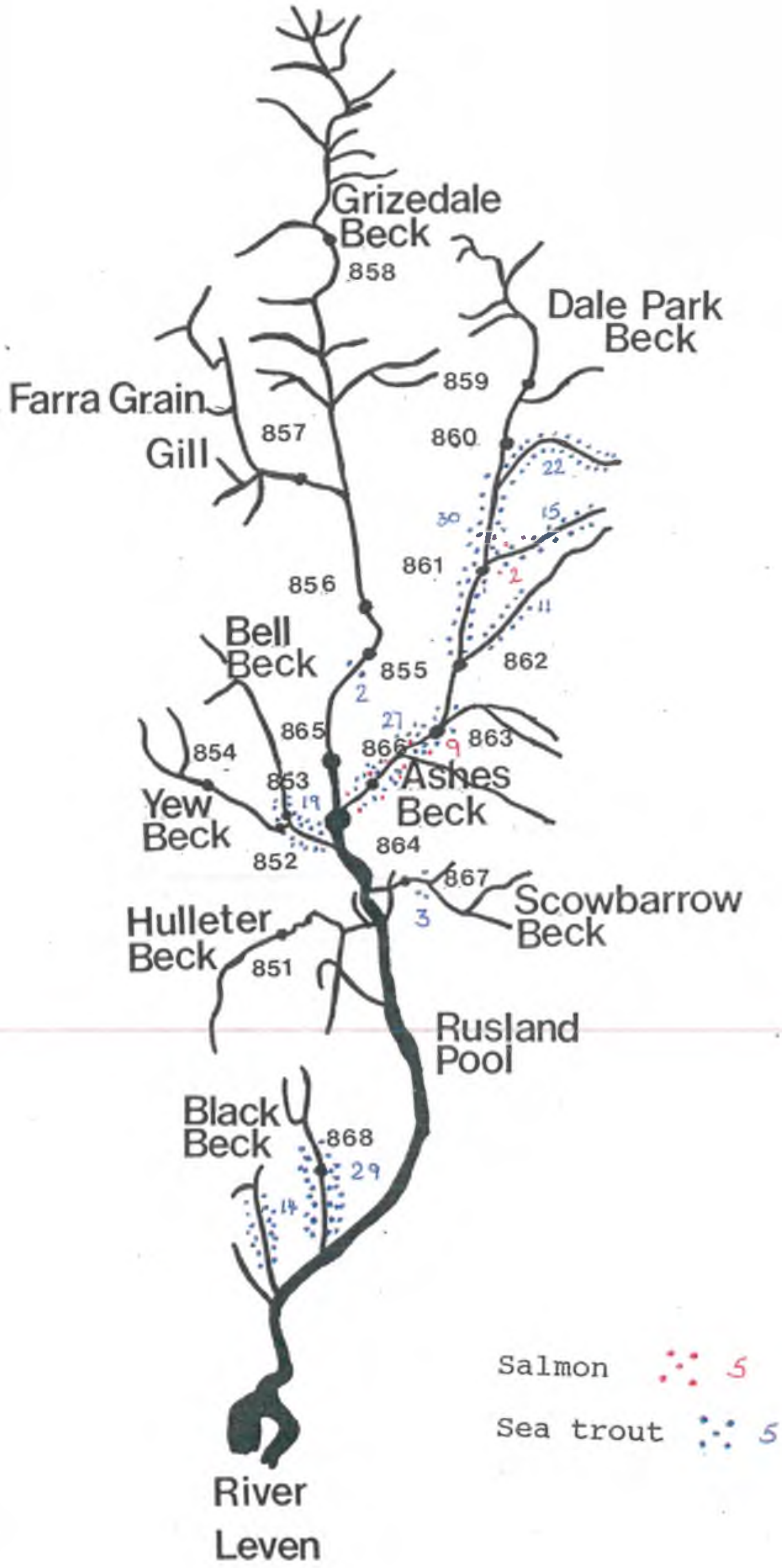
Appendix 2d : Minor Coarse Fish Densities - Abundance.

Site nos	Site Name	Tributary	Stoneloach	Bullhead	Minnow	Stickle-back
851.00	RUSLAND-Hulleter	Hulleter Beck	0	0	0	0
852.00	RUSLAND-PTC Bell Bk	Yew Beck	0	0	0	0
853.00	RUSLAND - D/S Bridge	Bell Beck	0	101-100	0	0
854.00	RUSLAND-Ickenthwaite	Yew Beck	0	0	0	0
855.00	RUSLAND-Force Mills		0	0	0	0
856.00	RUSLAND-Bowkerstead		0	0	0	0
857.00	RUSLAND-Scale Green	Farra Grain Gil	0	0	0	0
858.00	RUSLAND-Picnic Site	Grizedale Beck	0	0	0	0
859.00	RUSLAND	Dalepark Beck	0	101-100	0	0
860.00	RUSLAND-High Dale Pk	Dalepark Beck	0	101-100	0	0
861.00	RUSLAND-Low Dale Pk	Dale Park Beck	0	101-100	0	0
862.00	RUSLAND-Thwaite Head	Ashes Beck	0	101-100	0	0
863.00	RUSLAND-Farm	Ashes Beck	0	0	0	0
864.00	RUSLAND-Strands Brdg		0	11-100	0	0
865.00	RUSLAND-D/S High Brg		0	11-100	0	0
866.00	RUSLAND-Lin Bridge	Ashes Beck	0	101-100	1-10	0
867.00	RUSLAND-Rusland Hall	Scowbarrow Beck	0	0	0	0
868.00	RUSLAND-Black Bk Fm	Black Beck	0	0	0	0

Appendix 3A : Salmon and Sea trout redd counts in the Rusland Pool Catchment 1993/94.



Appendix 3B : Salmon and Sea trout redd counts in the Rusland Pool Catchment 1992/93.



APPENDIX 4

Derivation of Total Salmonid Density Class

In order to create a class which related to Total Salmonid Density (i.e. all salmon plus all trout) it was necessary to rationalise the abundance categories for the two different age classes, i.e fry and parr.

The classes are based on the assumption that 1 in 5, or 20%, of fry survive to become parr. Thus by dividing the total fry density by 5, all densities could be related to the Abundance Class for parr.

An index for Total Salmonid Density was calculated using densities as follows :-

Index = 1/5 (Salmon 0+ + Trout 0+) + (Salmon >0+ + Trout >0+)

As this index was derived from both salmon and trout, the parr abundance categories have been doubled (Table *i*).

Table *i* : Classification for Total Salmonid Density Index (N/100m2)

Class			
A		>40.00	
B	20.01	-	40.00
C	10.01	-	20.00
D	0.01	-	10.00
E		0.00	

Methodology to determine Total Salmonid Productivity

To determine if the classes are set at a realistic level, a literature search was undertaken.

Work by Elliot on a Lake District stream has shown that a range of salmonid biomass from 8.86 - 33.9g/m^2 was recorded over a 25 year period. Similar work by Brynildson *et al.* 1984 in the USA, and Mortenson 1978 in Holland, showed a recorded biomass in the range of 12.2 - 36.0g/m^2 and 14.1 - 33.1g/m^2 respectively. However, Elliot postulates that these results are higher than in most studies.

From data collected on weight/length relationships for salmonids, we can calculate what, in biomass terms, our classification system is telling us. Typically, salmonid parr in South Cumbria averaged 13cm in length by the end of the survey year. This would equate to a weight of 25g/fish. Thus our classification system can be shown in terms of weight production (in grammes) per 100m^2.

Class	Nos of Salmonid Units per 100m^2			Weight in grammes per m^2
A		> 40.01		>10.01+
B	20.01	-	40.00	5.01 - 10
C	10.01	-	20.00	2.51 - 5
D	0.01	-	10.00	0.1 - 2.5
E		0.00		

A class A result with a unit score of e.g. 63.7 fish would record a biomass of 15.9g/m^2. This -*falls within the range of Elliot's work which, as stated, gave a variation of biomass productivity higher than in most experimental results published. It is thus concluded on present knowledge that the proposed total productivity classes are acceptable.

Elliot, J. M., Crisp, D. T., Mann, R. H. K., Pettman, I., Pickering, A. D., Pottinger, T. G. & Winfield, I. J. (1992). Sea trout literature review and bibliography. *NRA Fisheries Technical Report No. 3.*

Elliot, J. M. (1993). *Quantitative Ecology and the Brown Trout.* Oxford Press 286pp

Brynildson, O. M. & Brynildson, C. L. (1984). Impacts of flood retarding structure on year class strength and production of wild brown trout in a Wisconsin coulee stream. *Winsconsin Dept of Nature Research, Technical Bulletin,* **146**, 1-20.

Mortenson, E. (1978). The population dynamics and production of trout (*Salmo trutta* L.) in a small Danish stream. In *Proc. Wild Trout - Catchable Trout Symp.* ed. J.R.Moring, 151-160. Oregon: Dept Fish Wildl.

Appendix 5 : Minimum Salmonid Population Estimates in Rusland Pool 1994.

Site Nos	Site Name	Salmon 0+	Salmon 1+	Trout 0+	Trout 1+	Trout >1+
851.00	RUSLAND-Hulleter	0.00	0.00	2.74	8.22	0.00
852.00	RUSLAND-PTC Bell Bk	0.00	0.00	0.97	0.00	0.00
853.00	RUSLAND - D/S Bridge	68.80	3.20	31.20	2.40	0.00
854.00	RUSLAND-Ickenthwaite	0.00	0.00	23.26	12.79	10.47
855.00	RUSLAND-Force Mills	0.00	9.45	2.18	10.91	1.82
856.00	RUSLAND-Bowkerstead	0.00	0.00	2.41	8.43	0.80
857.00	RUSLAND-Scale Green	0.00	0.00	2.58	7.73	2.58
858.00	RUSLAND-Picnic Site	0.00	0.00	0.00	7.03	5.41
859.00	RUSLAND	0.00	0.00	13.33	14.55	0.61
860.00	RUSLAND-High Dale Pk	0.00	0.00	26.67	20.83	0.83
861.00	RUSLAND-Low Dale Pk	0.00	0.00	26.22	10.37	0.61
862.00	RUSLAND-Thwaite Head	21.02	7.39	19.89	7.39	1.70
863.00	RUSLAND-Farm	2.16	1.62	4.86	6.49	2.16
864.00	RUSLAND-Strands Brdg	1.20	6.40	4.00	5.60	5.20
865.00	RUSLAND-D/S High Brg	5.71	4.49	1.63	1.63	1.22
866.00	RUSLAND-Lin Bridge	19.57	0.87	6.52	0.43	0.00
867.00	RUSLAND-Rusland Hall	0.00	0.00	38.82	5.88	0.00
868.00	RUSLAND-Black Bk Fm	0.00	0.00	40.00	0.95	0.00