LANGCLIFFE HATCHERY INVESTIGATIONS 1982

1. INTRODUCTION

Langcliffe Hatchery on the River Ribble near Settle was built by the Lancashire River Board to provide facilities for rearing salmon through to the parr stage. An account of the early years of the operation of the hatchery is given in "A Report on the Working of the Langcliffe Rearing Station", prepared by the Lancashire River Unit of the N.W.W.A. in 1975.

Initially results were satisfactory, but since 1970 persistent problems with mortality of fry have been experienced, and in recent years the mortality rate has been particularly high. Typically, the problem has appeared during the swim-up stage in fry being reared in river water. Affected fish show symptons of gill irritation, with inflammation of the opercular region and the production of large quantities of mucus from the gills. Large scale mortality then occurs over a period of a few weeks, and in some years almost the entire stock of fry has been lost. None of the standard treatments for bacterial gill disease have had any significant beneficial effects. Salmon, sea trout, brown trout and rainbow trout all appear to be affected in the same way. Samples of affected fish have been examined at the Authority's own laboratories, at the M.A.F.F. Fish Disease Laboratory at Weymouth, and at the M.A.F.F. Veterinary Investigation Centre near Penrith. Hyperplasia and erosion of the gill filaments, together with accumulations of silt and infections with Myxobacteria and fungi have been reported. These infections are usually secondary invaders, and no infective agents which were likely to be the primary cause of the condition have ever been found. This suggests that the cause of the problem is related to the quality of the river water supply, and this supposition is supported by the fact that alevins and fry reared in the limited quantity of spring water which is available at Langcliffe do not exhibit any symptons until they are transferred to river water. A problem with the river water supply was identifed in 1971 and 1972 when large diurnal fluctuations in dissolved oxygen concentrations occurred, caused by heavy algal growths in the mill lodge from which the river water supply was drawn. To overcome this problem, a pipeline was laid along the bed of the lodge to enable the water supply to be drawn from a position near to the inflow from the Ribble. However, chemical analysis of samples of water taken from time to time from the Ribble near to this take-off point has failed to reveal any pollution which could account for the fish mortalities. Biological sampling has shown that this part of the Ribble has a varied and abundant fauna, confirming that there is no significant pollution problem.

At one time it was suspected that the high suspended solids which can occur naturally in this part of the Ribble during spates could be the root of the problem by causing abrasion of the gill tissues. It had been noted that the problem was less acute during dry springs when the fry were exposed to high suspended solids on fewer occasions. Accordingly, during the late winter of 1981 a gravel filter was constructed at the take-off point at the entrance to the mill lodge, and filtered water fed down the pipe to the hatchery. However, large scale mortality of fry occurred again during the spring of 1981, indicating that gill damage from suspended solids could not be the only problem.

After lengthy discussion of the problem during the latter part of 1981, it was agreed that a detailed investigation should be carried out at Langcliffe in 1982, to attempt to identify the cause of the fry mortalities. Although various possible causes had been investigated in previous years with negative results, it was agreed that a comprehensive study was required, if only to confirm that certain possibilities could be eliminated.

2. THE 1982 INVESTIGATIONS

(a) Fry Rearing Arrangements

The hatchery building at Langcliffe houses four rearing troughs which permitted four separate batches of fry to be reared under different conditions. Initially 5,000 eyed ova were placed in each trough. One trough was fed with river water via a charcoal filter, one was fed with spring water, and two were fed with 'raw' river water. It was intended that pH modification would be attempted on one of the latter troughs to bring the pH down to a constant 7.0, but this idea had to be abandoned as no automatic pH monitoring/acid dosing apparatus could be devised in time or at reasonable cost.

Ova and alevins were reared in the normal way, with minimal disturbance other than picking out casualties, the taking of samples and the occasional cleaning of the troughs. When fry began to swim up, feeding was commenced using finely sieved liver initially and progressing to a proprietary dry starter diet.

(b) Water Quality Monitoring

A comprehensive programme of water sampling and analysis was agreed with the Technical Support Section. The locations of all the sampling points are shown in Fig. 1. Samples were taken on a daily basis from the river water supply within the hatchery building, although not necessarily at the same time every day. Full sanitary analysis was carried out on these samples, plus analyses for heavy metals (cadmium, copper, lead, mercury, nickel, zinc), pesticides (Aldrin, Dieldrin, Gamma BHC, DDT, Chlorpyrifos) and anionic synthetic detergents. Samples analysed for the same determinands were taken at weekly intervals from the river at the Locks weir intake to the mill lodge, from the lodge itself adjacent to the alternative take-off point for the hatchery supply (the turbine intake), and from the spring water supply into the hatchery. Samples of the water being discharged from the troughs were also taken once per week and subjected to normal sanitary analysis. In addition, water samples for determination of ammonia levels were taken from within the hatchery troughs. Two samples were taken from each trough on each occasion using a pipette, one sample near to the water surface and the other from the middle of an aggregation of fry. The purpose of this sampling was to investigate the possibility that localised accumulations of ammonia excreted by the fish could be occurring. Daily sampling was carried out initially, but this was reduced to 3 days per week after the first two weeks. Later in the investigation some samples were taken for mercury determination from the vicinity of the paper mill situated about 1 kilometre upstream of Locks weir, and from small tributaries which entered the Ribble upstream and downstream of this mill.

A biological survey of the Ribble in the Stainforth-Settle area was undertaken in late April by the Rivers Division Scientist's Department. A copy of the report of this survey is attached as Appendix 1. In addition to normal sampling of the macro invertebrate fauna, some samples of plant material were taken for analysis for toxic metals.

(c) Examination of Fish

Arrangements were made with the Veterinary Investigation Centre at Calthwaite, near Penrith, for samples of fry to be taken at 1-2 week intervals, preserved, and sent to the Centre for histological and pathological investigation. Six fish were taken from each trough on each occasion. Both 'sick' and apparently healthy fish were included in the samples.

3. RESULTS

(a) Fry Survival

Hatching of the ova began on March 22nd and was completed by April 2nd. Feeding with liver was tried during the last week of April, and regular feeding with liver plus dry feed was established by May 4th. Survival through the early alevin stage was good, but during the weekending April 23rd, when some of the alevins were nearing the swim-up stage, some distressed fish were observed and casualities began to increase. This was particularly noticeable in the trough supplied with river water via a charcoal filter. From this time onwards, until early June, large scale mortalities occurred in all the troughs being supplied with river water, with the trough on the charcoal filtered supply being significantly worse than the others. Cumulative numbers of casualties in each trough are given in Fig. 2 and the proportion of the stock dying in each week is given in Fig. 3. The fry from Trough No. 33 were planted out in mid-May. It had been intended to use this trough for experiments on pH adjustment, but when this proved not to be feasible, the fry were "salvaged" and used in the salmon stocking programme.

The symptoms shown by the casualties were typical of those seen in earlier years, with inflammation of the gill region and large quantities of mucous and entrapped debris in the opercular cavity.

Considerable numbers of fry also died in the trough on the spring water supply, but as Figs. 2 and 3 show, the pattern of mortality was different and fry did not start to die in significant numbers until late May, some 4-5 weeks after the commencement of large scale mortalities in the river water troughs. The cause of death in the fry held in spring water supply was undoubtedly starvation, as the water temperature was too low for the fish to feed properly. This problem has been experienced in previous years. During the week ending 28th May these fry were transferred to the river water supply. Casualties continued at a high rate for the next 2-3 weeks, but this may have been as much a hangover effect from the starvation as a consequence of transfer to river water.

During early-mid June the casualty rate declined markedly in all troughs, and from the third week in June until the time that the fry were planted out at the end of July, survival was very good.

(b) Water Chemistry

Summaries of the results of analyses of water samples from the principal sampling points are given in Tables 1-7. On the majority of occasions the samples from the river and river water supply contained nothing out of the ordinary, although there were considerable variations in pH, alkalinity and hardness associated with changes in flow. The general picture is of a water supply of very high quality which should be satisfactory for the culture of salmonid fish. However, a few of the samples taken during March and April contained small amounts of mercury, although in other respects these samples were satisfactory. Details of the sample dates and mercury concentrations are given in Table 8. In an attempt to identify the source of this contamination, additional samples were taken at various points upstream of the hatchery intake (sample points C, E, G, T and U in Fig. 1) on several occasions between 6th April and 22nd June, but none of these contained measurable amounts of mercury. Samples of plant material collected at these points were also analysed for mercury, but none contained significant quantities.

The only other characteristic of the river water supply which may have had some significance for fish welfare was the wide ranging and sometimes rapidly fluctuating pH, although this was always on the alkaline side of neutral, and never reached the normally accepted upper tolerance limit of 9.0.

The spring water supply, although considerably harder and more alkaline than the river water, and with a higher nitrate content, was of good quality and showed smaller pH fluctuations than the river supply.

The analyses of the water being discharged from the troughs showed negligible deterioration in quality after passage through the troughs. Ammonia determinations on water samples from within the troughs (see Table 7) showed little evidence of accumulation of ammonia until towards the end of the sampling period, when considerable numbers of dead and dying fry were already present. Only one sample, taken on 15th May from amongst an aggregation of fry in the trough on the charcoal-filtered supply, contained a total ammoniacal nitrogen content which under the prevailing temperature and pH conditions would have given an unionised ammonia fraction exceeding the EIFAC recommended maximum of 0.025 mg/l. All other samples were well within this limit.

(c) Examination of Fish Samples

Samples of fry were taken for examination on 11th & 19th April (Yolk-sac fry), 4th, 11th, 19th & 24th May (swim-up and feeding fry), and 22nd June (fry originally reared on spring water only). No significant abnormalities were found in the yolk-sac fry. Fry taken from Trough 31 (charcoal filtered river water) on 4th May had small accumulations of debris in the opercular chamber with associated fungal hyphae, but nothing unusual was seen in fish from the other troughs. In the samples taken on 11th May, only the fry from Trough 34 ("raw" river water) showed any abnormality, and again this consisted only of accumulations of debris within the gills. The samples of 19th May were all clear, but fry taken from both Troughs 31 and 34 on 24th May had debris accumulating within their gills, although there was no sign of damage to gill epithelium. The single sample taken on 22nd June also had some debris in their gills, but no other abnormality.

4. DISCUSSION

In comparison with some previous years, survival of salmon fry at Langcliffe in 1982 was relatively good, with approximately 50% of the eyed ova laid down in the experimental troughs surviving until the end of July. The spring of 1982 was dry, with relatively low river levels for much of the time, and as noted previously, there has been a tendency in the past for survival to be better in such springs. However, the familiar problem was present, and 77% of the fry in one trough succumbed. Surprisingly, this was the trough supplied with river water which had been passed through a charcoal filter.

The autopsies and histological examination of the fish carried out at the M.A.F.F. Veterinary Investigation Centre failed to reveal any disease organisms which could have been a primary cause, but do provide some evidence that gill irriration had taken place, as the accumulations of debris in the opercular cavity would be likely to have resulted from the presence of excessive quantities of mucous.

The different patterns of mortalities in river water and spring water is clearly demonstrated in Figs. 2 & 3, and confirms earlier conclusions that it is some factor associated with the river water supply which is responsible for the onset of the problem. The only obvious feature of the river water supply which gives cause for concern is the intermittent occurrence of small quantities of mercury. The classic sympton associated with heavy metal poisoning in fish is damage to the epithelium of the gill filaments and lamellae, and according to reports quoted by Jones (1964) a coating of mucous may be formed over the gills. However, the concentrations of mercury measured in the Ribble supply were very small, the maximum level recorded being 0.85 ug/l, and the majority of samples were below the level of detection (0.10 ug/l). Surprisingly, there is relatively little published information on the effects of mercury on salmonid alevins and fry, and what little there is suggests that the amounts detected in the Langcliffe supply were smaller than those likely to be harmful to these fish, particularly in hard water. For example, Wobeser (1973) quotes a figure of 24 ug/l for the 96 hour LC50 for newly-hatched rainbow trout. McKim et al (1976) (quoted in the U.S.A. Environmental Protection Agency Water Quality Criteria) observed no adverse effects in American Brook Trout after long term continuous exposure to 0.29 ug/l mercury and showed that fish exposed to 0.93 ug/l mercury would survive and spawn, although their offspring showed reduced growth. However, the mercury levels in the Ribble supply fluctuated considerably, and it is possible that at times the concentration reached harmful levels. When investigating the uptake of organic mercurials by rainbow trout and Pacific salmon, Rucker & Anend (1969) found slight hypertrophy of gill epithelial cells after 4 days in 8" rainbow trout exposed to 96 ug/l mercury as ethyl mercuric phosphate for 1 hour each day, and after 8 days, extensive hypertrophy and some hyperplasia were present. There was no evidence of gill damage of this degree of severity in the Langcliffe fry, however, and the absence of significant amounts of mercury in the plant tisse analysed suggests that larger scale contamination of the Ribble was not occurring. The results of the other biological sampling bear this out. Nevertheless, it is possible that exposure to small amounts of mercury has been causing sufficient stress and irritation to affect the gill function and to weaken the fish at what is a particularly vulnerable stage in their development.

Incidentally, the U.S.A. EPA water quality criterion for mercury in fresh water is 0.05 ug/l, but this is aimed primarily at the protection of human consumers of fish and was arrived at by dividing the U.S.A. Food & Drugs Administration guideline of 0.5 mg/kg in edible fish by an estimated concentration factor of 10,000.

The likeliest source of contamination of the Ribble at Langcliffe with mercury is the paper mill just upstream. However, none of the samples taken in the vicinity of the mill during April, May or June showed any detectable quantities of mercury, and according to Ribble Division's Trade Effluent Inspector, the firm concerned discontinued use of mercury compounds several years ago.

One other feature of the supply from the Ribble which could impose some stress on fish is the considerable variation in pH which occurs, fluctuating between 7.0 and 8.5. The lowest alkaline pH at which damage to salmonids has been reported, however, is 9.0 (Daye & Garside, 1976), although the damage observed was to the gill epithelium and consisted initially of hypertrophy of the mucous cells. It is possible that fluctuating pH's at slightly lower levels might cause some stress and gill irritation, although there are no reports of this in the literature.

5. CONCLUSIONS

The 1982 investigation has provided confirmatory evidence that some feature of the river water supply to the hatchery is responsible for the mortality problems with salmonid fry. There are indications that the part of the Ribble from which the hatchery supply is drawn is contaminated with mercury from time to time. The quantities detected were small, and were only found intermittently during the early weeks of the investigation. However, the only abnormality found in the affected salmon fry was a sympton which is associated with poisoning by heavy metals such as mercury, although no signs of actual tissue damage to the gills was observed. In the absence of any other obvious reason, the possibility that poisoning with mercury is the primary cause of the mortality problem at Langcliffe should be taken seriously and any future investigations at the hatchery should include regular monitoring of water quality for the presence of mercury.

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TABLE 1

Summary of analytical results from water samples taken from River Ribble at Locks Weir intake

Determinand	No. of Samples	Mean	Standard Deviation	Maximum	Minimum
pH	10	7.93	0.501	8.50	7.00
Conductivity us/cm at 25°C	6	268	121	470	125
Chloride mg/l Cl	10	12.7	2.057	15	10
Alkalinity M.O. mg/l $CaCO_3$	10	110.1	24.28	140	62
Ammonia mg/l N	10	0.026	0.016	0.06	< 0.01
Nitrite mg/l N	10	0.007	0.001	0.01	< 0.01
Nitrate mg/N	10	0.493	0.221	0.74	< 0.02
Phosphate, sol.O mg/l P	10	0.015	0.005	0.02	< 0.01
C.O.D. mg/l O	10	10.4	2.458	16	8
B.O.D. 5 day mg/l O	10	1.0	0.496	1.8	0.4
Susp. solids - total mg/l	10	5.0	4.892	18	< 3
Hardness - totalmg/l $CaCO_3$	10	141	44.35	242	77
Cadmium total ug/l	8	< 2	0.0	< 2	< 2
Copper - total ug/l	8	3	0.154	< 4	3
Lead - total ug/l	8	<20	0	<20	<20
Mercury - total ug/l	18	0.12	0.185	0.85	< 0.1
Nickel - total ug/l	8	< 10	0.0	< 10	<10
Zinc - total ug/l	8	4.29	2.185	9	< 2
Aldrin - total ug/l	1	(< 0.02)			
Dieldrin - totalug/l	1	(< 0.03)			
Gamma BHC - total ug/l	1	(< 0.01)			
D.D.T. - pp total ug/l	1	(< 0.1)			
Chlorpyrifos ug/l	1	(< 0.03)			

NOTE: Date of first sample - 8/3/82
Date of last sample - 10/5/82
Samples for mercury determinations on 24/5, 21/6, and 22/6.

TABLE 2

Summary of analytical results from water samples taken from Langcliffe lodge at turbine intake

Determinand	No. of Samples	Mean	Standard Deviation	Maximum	Minimum
pH	6	7.85	0.528	8.3	7.1
Conductivity us/cm at 25^{o}C	5	306	137.2	530	170
Chloride mg/l Cl	6	12.3	1.861	15	10
Alkalinity M.O. mg/l $CaCO_3$	6	99	28.35	126	52
Ammonia mg/l N	6	0.022	0.019	0.05	< 0.01
Nitrite mg/l N	6	< 0.01	0.0	< 0.01	< 0.01
Nitrate mg/l N	6	0.48	0.171	0.80	0.32
Phosphate, sol-O mg/l P	6	0.02	0.006	0.03	< 0.01
C.O.D. mg/l O	6	10	2.19	14	8
B.O.D. mg/l O	6	1.28	0.546	2.2	0.5
Susp.solids - total mg/l	6	7.28	8.298	24	< 3
Hardness - total mg/l $CaCO_3$	6	123.8	31.05	150	79
Cadmium - total ug/l	6	< 2	0.0	< 2	< 2
Copper - total ug/l	5	4.13	1.98	7	2
Lead - total ug/l	6	< 20	0.0	< 20	< 20
Mercury - total ug/l	6	< 0.1	0.034	0.15	< 0.1
Nickel - total ug/l	6	< 10	0.0	< 10	< 10
Zinc - total ug/l	6	5.3	2.50	10	3
Aldrin - total ug/l	1	(< 0.02)			
Dieldrin - total ug/l	1	(< 0.03)			
Gamma BHC -total ug/l	1	(< 0.01)			
D.D.T - pp total ug/l	1	(< 0.1)			
Chlorpyrifos ug/l	1	(< 0.03)			

Note: Date of first sample - 8/3/82

Date of last sample - 12/4/82

TABLE 3

Summary of analytical results from samples of the river water supply taken within the hatchery building.

Determinand	No. of samples	Mean	Standard Deviation	Maximum	Minimum
pH	69	7.8	0.327	8.5	7.0
Conductivity u/s cm at 25°C	28	349.8	150.1	760	110
Chloride mg/l Cl	66	14.0	6.683	64	9
Alkalinity M.O. mg/l $CaCO_3$	67	113.8	22.83	161	51
Ammonia mg/l N	69	0.032	0.027	0.15	$<$ 0.01
Nitrite mg/l N	69	$<$ 0.01	0.002	0.02	$<$ 0.01
Nitrate mg/l N	69	0.59	0.172	1.01	0.3
Phosphate, sol-O mg/l P	69	0.012	0.007	0.05	$<$ 0.01
Anion. Synth. Detergents mg/l	41	$<$ 0.03	0.013	0.07	$<$ 0.02
C.O.D. mg/l O	67	9.08	3.73	18	$<$ 4
B.O.D. 5 day mg/l O	63	1.02	0.502	2.8	$<$ 0.5
Susp. solids - total mg/l	69	4.45	3.411	22	$<$ 3
Hardness - total mg/l $CaCO_3$	68	138.7	24.95	184	70
Cadmium - total ug/l	51	$<$ 2	0.0	$<$ 2	$<$ 2
Copper - total ug/l	51	4.1	2.367	18	2.5
Lead - total ug/l	51	$<$ 20	4.294	44	$<$ 20
Mercury - total ug/l	44	0.119	0.126	0.65	$<$ 0.10
Nickel - total ug/l	51	$<$ 10	0.607	11	$<$ 10
Zinc - total ug/l	51	4.6	2.44	14	$<$ 2
Aldrin - total ug/l	14	$<$ 0.02	0.0	$<$ 0.02	$<$ 0.02
Dieldrin - total ug/l	14	$<$ 0.03	0.0	$<$ 0.03	$<$ 0.03
Gamma BHC- total ug/l	14	$<$ 0.01	0.0	$<$ 0.01	$<$ 0.01
D.D.T. pp total ug/l	14	$<$ 0.1	0.0	$<$ 0.1	$<$ 0.1
Chlorpyrifos ug/l	14	$<$ 0.03	0.0	$<$ 0.03	$<$ 0.03

Note. Date of first sample - 8/3/82

Date of last sample - 16/5/82

TABLE 4

Summary of analytical results from samples of the spring water supply taken within the hatchery building

Determinand	No. of Samples	Mean	Standard Deviation	Maximum	Minimum
pH	10	7.37	0.275	7.8	7.0
Conductivity us/cm at 25°C	6	485.8	205.3	710	165
Chloride mg/l Cl	10	21	3.197	27	17
Alkalinity M.O. mg/l $CaCO_3$	10	211	6.88	219	195
Ammonia mg/l N	10	0.019	0.014	0.05	<0.01
Nitrite mg/l N	10	<0.01	0.0	<0.01	<0.01
Nitrate mg/l N	10	1.58	0.236	1.90	1.10
Phosphate sol-O mg/l P	10	0.05	0.016	0.07	0.03
C.O.D. mg/l O	10	4.47	1.912	8	<4
B.O.D. 5 day mg/l O	9	0.70	0.528	1.8	<0.5
Susp.solids - total mg/l	10	3.7	2.359	9	<3
Hardness - total mg/l $CaCO_3$	10	243.9	14.1	270	225
Cadmium - total ug/l	7	<2	0.0	<2	<2
Copper - total ug/l	7	5.5	2.101	9	4
Lead - total ug/l	7	<20	0.0	<20	<20
Mercury - total ug/l	6	<0.10	0.031	0.15	<0.10
Nickel - total ug/l	7	<10	0.0	<10	<10
Zinc - total ug/l	7	3.8	1.467	5.5	1
Aldrin - total ug/l	1	(<0.02)			
Dieldrin - total ug/l	1	(<0.03)			
Gamma BHC - total ug/l	1	(<0.01)			
D.D.T. p.o. total ug/l	1	(<0.10)			
Chlorpyrifos ug/l	1	(<0.03)			

Note : Date of first sample - 8/3/82

Date of last sample - 10/5/82

TABLE 5

Summary of analytical results from samples of discharge from troughs fed by river water

Determinand		No. of Samples	Mean	Standard Deviation	Maximum	Minimum
pH		10	7.8	0.429	8.3	7.2
Conductivity us/cm at 25°C		6	343.3	234.2	700	110
Chloride	mg/l Cl	10	14.2	4.80	27	10
Alkalinity M.O.	mg/l $CaCO_3$	10	108.5	27.09	138	50
Ammonia	mg/l N	10	0.04	0.019	0.06	$<$0.01
Nitrite	mg/l N	10	$<$0.01	0.001	0.01	$<$0.01
Nitrate	mg/l N	10	0.56	0.150	0.79	0.36
Phosphate, sol-O	mg/l P	10	0.017	0.015	0.05	$<$0.01
C.O.D.	mg/l O	10	11.8	4.158	20	6
B.O.D.5 day	mg/l O	9	1.08	0.533	2.4	0.6
Susp. solids - total	mg/l	10	6.3	5.10	18	$<$3
Hardness - total	mg/l $CaCO_3$	10	126.2	34.0	159	66
Cadmium - total	ug/l	2	$<$2	0.0	$<$2	$<$2
Copper - total	ug/l	2	4.5	2.121	6	3
Lead - total	ug/l	2	$<$20	0.0	$<$20	$<$20
Mercury - total	ug/l	2	$<$0.10	0.0	$<$0.10	$<$0.10
Nickel - total	ug/l	2	$<$10	0.0	$<$10	$<$10
Zinc - total	ug/l	2	8	2.83	10	6
Aldrin - total	ug/l	1	($<$0.02)			
Dieldrin - total	ug/l	1	($<$0.03)			
Gamma BHC - total	ug/l	1	($<$0.01)			
D.D.T. pp - total	ug/l	1	($<$0.10)			
Chlorpyrifos	ug/l	1	($<$0.03)			

Note: Date of first sample - 8/3/82

Date of last sample - 10/5/82

TABLE 6

Summary of analytical results from samples of discharge from troughs fed by spring water

Determinand		No. of Samples	Mean	Standard Deviation	Maximum	Minimum
pH		8	7.4	0.242	7.9	7.2
Conductivity us/cm at 25^{o}C		4	488.7	243.4	700	165
Chloride	mg/l Cl	8	19.4	2.503	24	16
Alkalinity M.O.	mg/l $CaCO_3$	8	213.2	4.71	220	206
Ammonia	mg/l N	8	0.02	0.009	0.04	0.01
Nitrite	mg/l N	8	< 0.01	0.0	< 0.01	< 0.01
Nitrate	mg/l N	8	1.65	0.219	1.9	1.3
Phosphate sol-O	mg/l P	8	0.049	0.020	0.07	< 0.02
C.O.D.	mg/l O	8	5.3	3.044	10	< 4
B.O.D. 5 day	mg/l O	7	0.70	0.66	2	< 0.5
Susp.solids - total mg/l		8	4.7	2.584	10	< 3
Hardness - total mg/l $CaCO_3$		8	248.1	16.93	275	230

Note: Date of first sample - 22/3/82

Date of last sample - 10/5/82

<u>TABLE 7</u>

<u>Ammonia Determinations - Langcliffe Hatchery Troughs</u>

(Results expressed as mg/l N)

Week beginning	No. of days on which samples taken	Mean/Maximum Total Ammonia Concentrations: Trough No. 31 (River water via charcoal filter)		Trough No. 32 (Spring water)		Trough No. 33 ("Raw" river water)		Trough No. 34 ("Raw" river water)	
		Mid-trough	Amongst fish	Mid trough	Amongst fish	Mid-trough	Amongst fish	Mid-trough	Amongst fish
8/3	7	0.01 / 0.02	0.04 / 0.12	0.01 / 0.02	0.02 / 0.05	0.01 / 0.03	0.02 / 0.04	0.01 / 0.01	0.01 / 0.04
15/3	7	0.01 / 0.01	0.01 / 0.05	0.01 / 0.01	0.01 / 0.01	0.01 / 0.04	0.01 / 0.01	0.01 / 0.01	0.01 / 0.02
22/3	3	0.03 / 0.05	0.04 / 0.10	0.01 / 0.01	0.01 / 0.01	0.02 / 0.05	0.04 / 0.10	0.02 / 0.05	0.02 / 0.04
29/3	2	0.03 / 0.04	0.03 / 0.03	0.01 / 0.02	0.01 / 0.02	0.02 / 0.03	0.02 / 0.03	0.02 / 0.02	0.02 / 0.02
5/4	3	0.03 / 0.05	0.03 / 0.04	0.03 / 0.04	0.13 / 0.32	0.03 / 0.06	0.03 / 0.06	0.05 / 0.11	0.03 / 0.04
12/4	3	0.02 / 0.02	0.02 / 0.02	0.01 / 0.02	0.02 / 0.02	0.02 / 0.02	0.02 / 0.02	0.02 / 0.02	0.03 / 0.05
19/4	3	0.02 / 0.03	0.03 / 0.03	0.01 / 0.01	0.01 / 0.01	0.02 / 0.03	0.02 / 0.03	0.03 / 0.06	0.09 / 0.15
26/4	1	- / 0.04	- / 0.09	- / 0.01	- / 0.02	- / 0.03	- / 0.04	- / 0.03	- / 0.03
6/5	2	0.03 / 0.04	0.06 / 0.11	0.05 / 0.09	0.08 / 0.08	0.18 / 0.33	0.10 / 0.12	0.06 / 0.08	0.09 / 0.09
11/5	3	0.09 / 0.14	0.51 / 1.10	0.19 / 0.27	0.13 / 0.20	0.04 / 0.04	0.06 / 0.11	0.19 / 0.39	0.27 / 0.60

TABLE 8

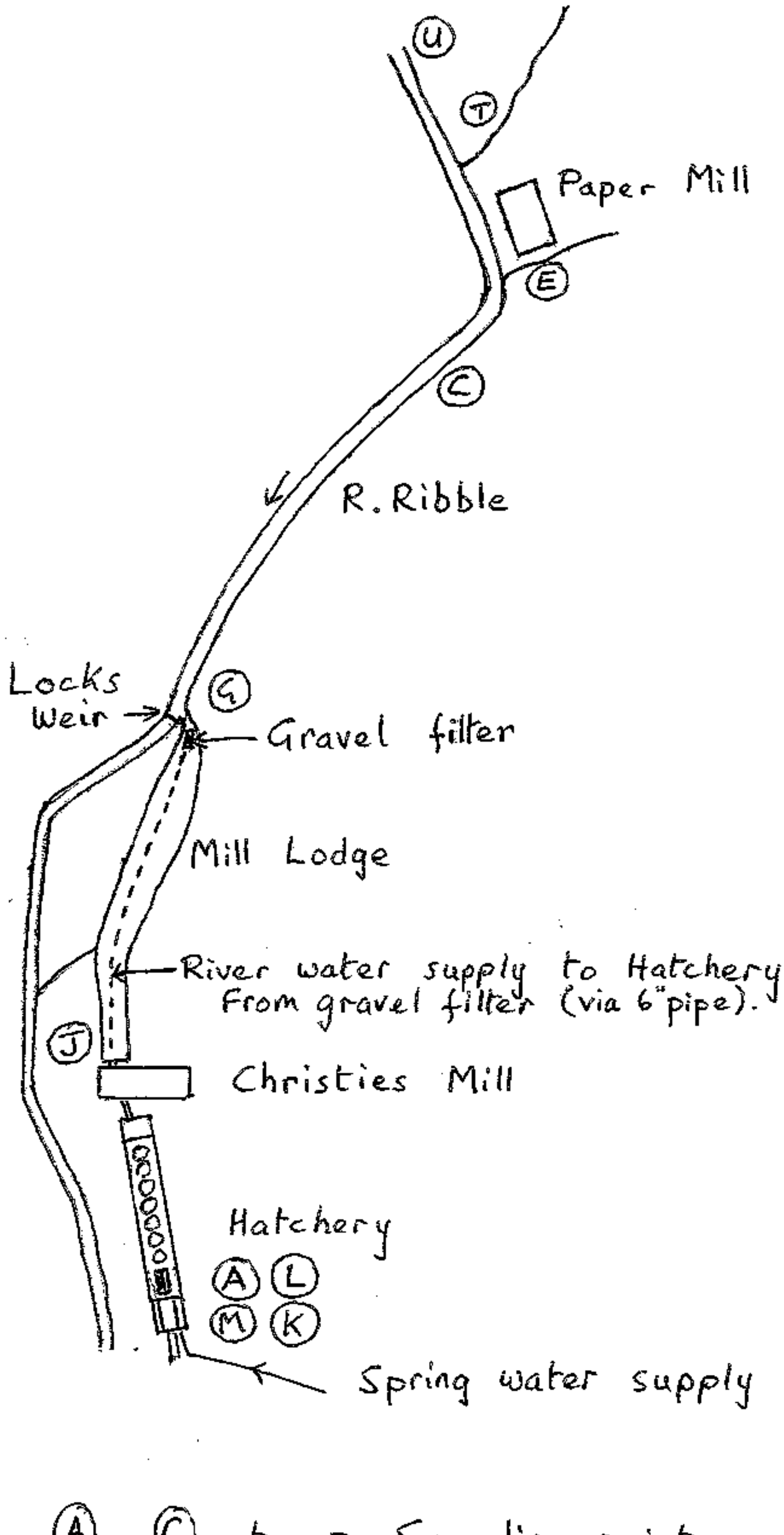
Water Samples Containing Significant Quantities of Mercury

Sampling Point	Date	Mercury Concentration (ug/l)
Ribble at Locks Weir	29/3/82	0.85
- do -	26/4/82	0.20
River Water Supply within hatchery	13/3/82	0.30
- do -	14/3/82	0.35
- do -	18/3/82	0.45
- do -	19/3/82	0.45
- do -	25/3/82	0.65
- do -	27/3/82	0.20

Fig. 1 Key to sampling points :-

A	River water supply within hatchery
C	R. Ribble below paper mill
E	Un-named tributary d/s of paper mill
G	R. Ribble at Locks Weir intake to mill lodge
J	Intake to turbine in mill lodge (alternative take-off point for hatchery water supply)
K	Outlet from troughs on river water supply
L	Spring water supply within hatchery
M	Outlet from troughs on water supply
T	Un-named tributary u/s of paper mill
U	R. Ribble above paper mill

Fig. 1. Sampling points - R. Ribble and Langcliffe Hatchery



Ⓐ, Ⓒ etc. = Sampling points.
(See Legend for details)

Fig. 2 LANGCLIFFE HATCHERY Fry Mortalities 1982

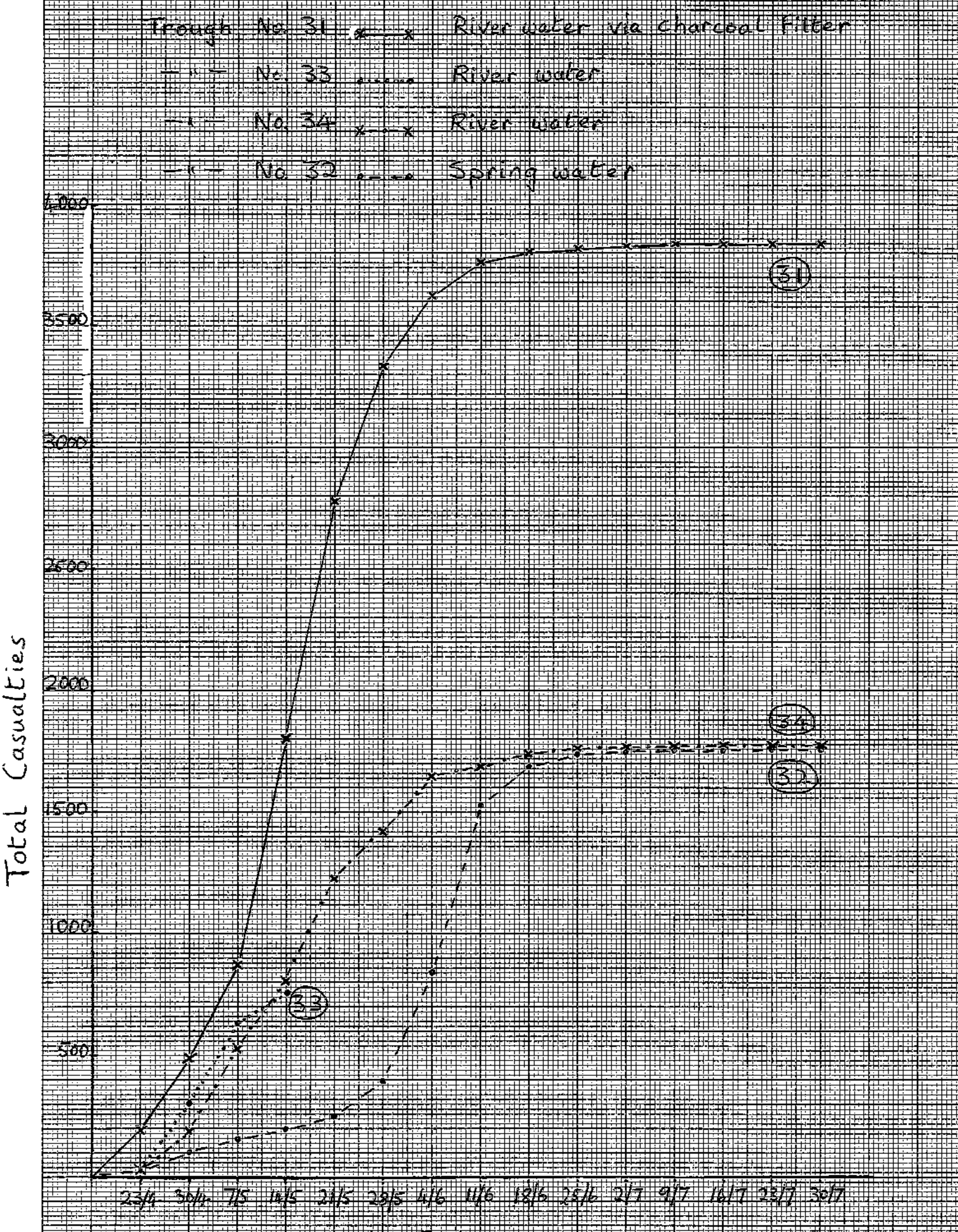
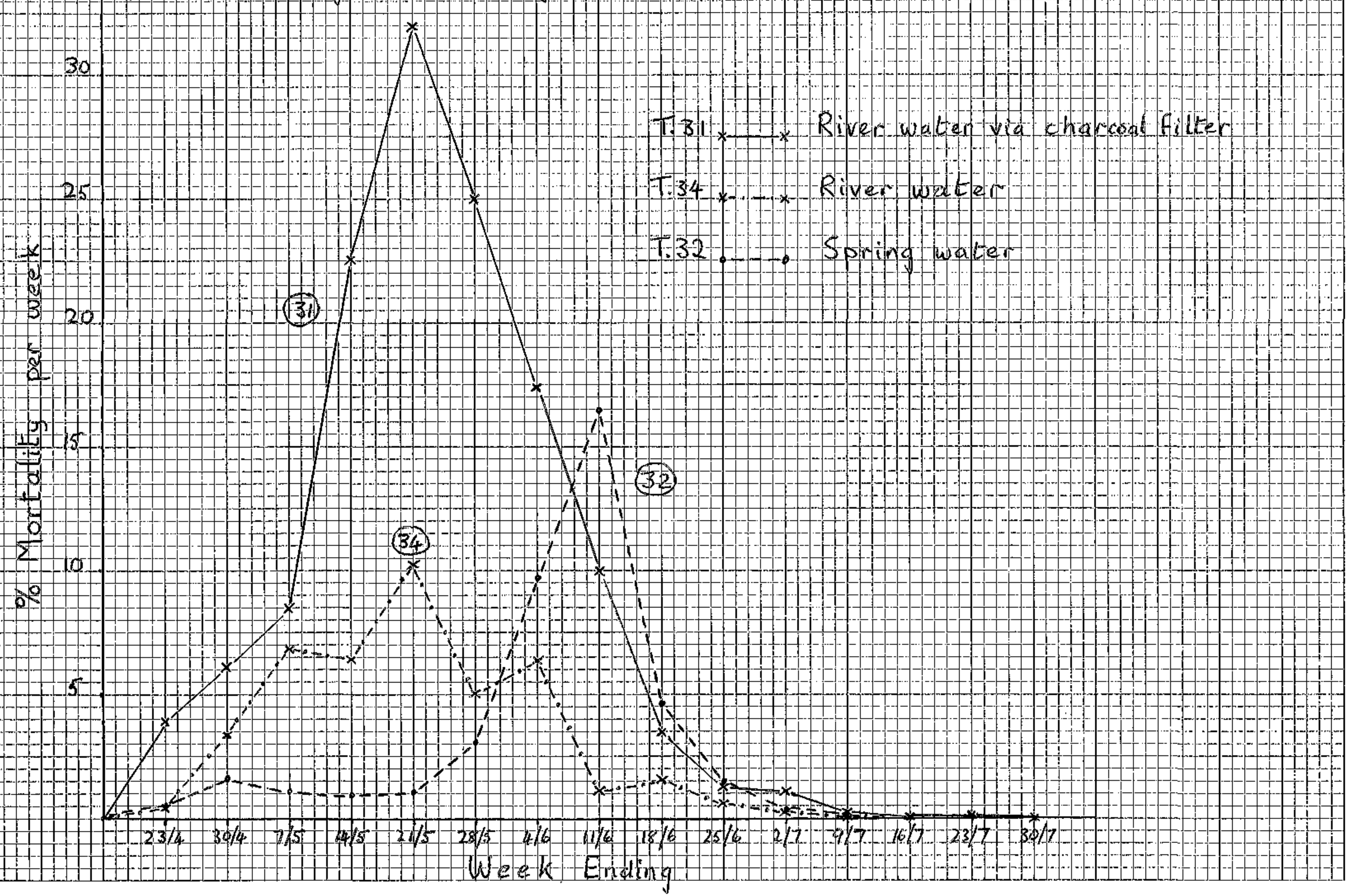


Fig 3. Mortality rates of fry in different water supplies



NWWA – RIVERS DIVN. SCIENTISTS DEPT. BIOLOGY SOUTH	TECHNICAL MEMORANDUM	Copies to: C. J. Clark, R. G. Chambers, R. Macauley, D. Crawshaw, K. Thornton, J. Nott, R. Parker, D. G. Holland, Biol. Lab. S., J. Leeming

Subject Biological survey of the R. Ribble and tributaries in the vicinity of Langcliffe, near Settle re. the suspicion of pollution causing extensive mortalities at Langcliffe Hatchery.

Date 7.5.82 **Author** W. T. Clough **Biol file.** B927

1. Introduction

As part of a major Fisheries Department investigation into the cause of extensive fish mortalities at Langcliffe Hatchery, a biological survey of waters in the immediate vicinity of the hatchery was requested. Accordingly several sites on the main river and tributaries were examined when plant material was collected for toxic metals analysis on 20/4/82 and further sites were examined during the Ribble routine biological survey on 21/4/82.

2. Methods

Kick samples to obtain representative invertebrate fauna were taken at 7 sites, see figure 1. These were examined in the field where taxa identification and abundance estimates were made.

Sites 2, 5, 6 and 7 were examined on 20/4/82 and sites 1, 3, and 4 were examined on 21/4/82.

3. Results

These are presented in table 1.

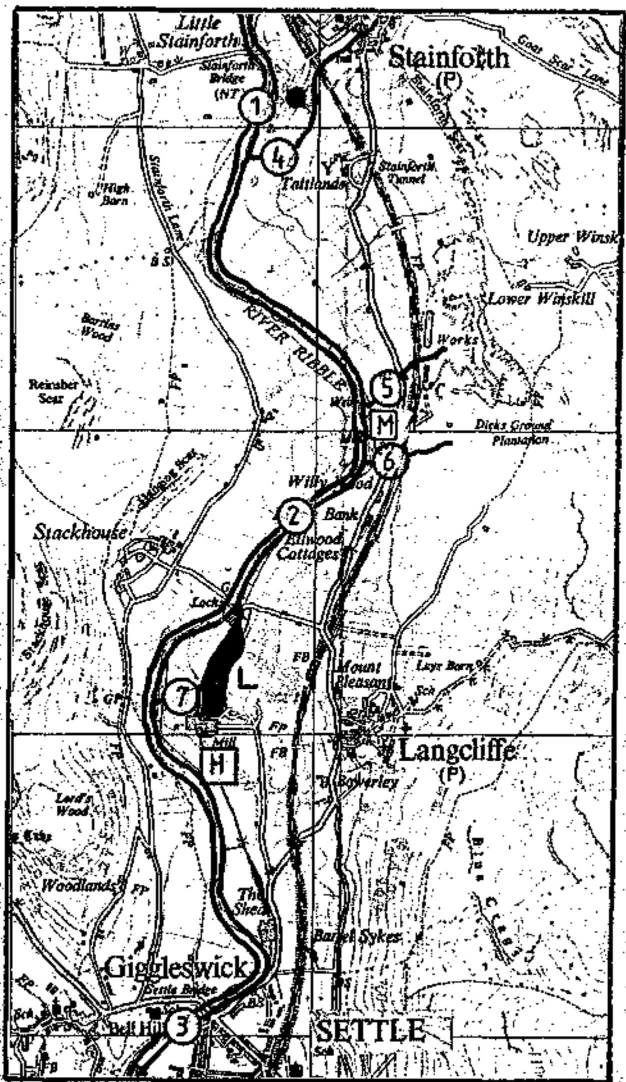


Fig. 1 Sample points and main features.

Key.

- River
- Tributaries
- ○ Sample point
- [H] Hatchery
- L Lodge
- [M] Mill
- ● S.T.W.

Table 1 Invertebrate data - River Ribble & tributaries - Stainforth to Settle.

Taxa	Main River			Tributaries			
	1	2	3	4	5	6	7
Taenopterygidae					o		
Nemoura	ooo		oo		o		
Amphinemoura			oo				
Leuctridae	ooo				o		
Isoperla			oo	oo	o		
Siphonuridae	oo	oo					
Ecdyonuridae	oooo	oooo	ooo	oooo			oo
Rhithrogena semicolorata	ooo	oooo	ooo	ooo			
Caenidae	ooo	oo	ooo				
Baetidae	oooo	oooo	oooo	oooo	o	ooo	ooo
Rhyacophilidae	ooo	oo	oo	ooo	o	ooo	
Philopotamidae		oo			o		
Polycentropidae	ooo	ooo			ooo	ooo	ooo
Hydropsychidae	ooo	ooo	ooo	oo	oo	oo	oo
Limnephilidae		ooo			ooo	oo	ooo
Sericostomatidae		ooo			oo	ooo	oo
Elminthidae	oo	oo	ooo	ooo		oo	oo
Dytiscidae		oo					oo
Simulidae	ooo		ooo	ooo			o
Chironomidae	ooo	ooo		ooo	oo	oo	oo
Gammarus	o	oo	oo	oo	oooo	ooo	oooo
Asellus							oo
Ancylus	oo		o	oo		ooo	ooo
Potamopyrgus					o		
Lymnea peregra					o	ooo	ooo
Planorbidae							o
Glossiphonia			o			ooo	oo
Erpobdella							
Planariidae				ooo	oo		ooo
Polycelis sp					oo	ooo	ooo
Dendrocoelidae							
Oligochaeta	oo	oo		oo	oo	o	oo
Agapetus							
Dicranota			ooo				
Perla sp.			o				
Hydracarina				o			
Valvatidae						o	o
T.B.I. / C.D.C.	10aa	9ba	10aa	9aa	10bb	8bb	10bb
B.M.W.P. score	92	93	80	76	104	71	93

4. Comments

Abundant and diverse fauna were recorded from both the main river and tributaries, resulting in generally excellent biotic indices throughout.

This was particularly so in the main river where Plecoptera, Ephemeroptera and Trichoptera were characteristic. However, close examination of the taxa lists does reveal the apparent absence of Molluscs, Hirudinea and Planariidae from this length of river. If so, this is unusual because these groups were recorded upstream of the Langcliffe area, at Horton in Ribblesdale and downstream, near Settle S.T.W. during the survey period and there is no reason to expect their absence from the known water chemistry of the river.

These groups were carefully looked for as they were known to be particularly sensitive to toxic metals and mercury is suspected as being a possible pollutant in the area.

It should be noted though that 2 other groups regarded as susceptible to metal toxicity - Crustacea and Oligochaetes - were present.

If the results are taken to indicate possible mercury contamination, then it would not appear that this is being carried into the main river by any of the tributaries examined. Molluses, Hirudinea and Planariidae were particularly varied in these becks. To further complicate the picture, the overflow from the mill lodge (which is, of course, fed by the river), contained the most diverse and abundant Molluscs, Planariidae and Hirudinea fauna of all the sites.

In the tributaries, the balance between organic pollution intolerant and tolerant groups did suggest organic enrichment of the water but not organic pollution.

Consistent with this indication was the abundance of algae in the becks, predominately filamentous green algae and in particular Cladophora. The main river sites also showed a profusion of filamentous green algae - particularly at site 2.

5. Summary

The invertebrate survey revealed no significant organic pollution in the main river nor in the tributaries in the vicinity of the hatchery. There was, however, an unusual apparent absence of Molluscs, Hirudinea and Planariidae in the main river - taxa particularly sensitive to toxic metals pollution. These results emphasise the value and importance of the analysis of the plant material for toxic metal contamination.