WELSH WATER

A study of salmonid egg and fry survival in the R.Taff catchment

(SE/88/7).

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A study of salmonid egg and fry survival in the R.Taff catchment.

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1. Summary.

Green salmonid eggs were planted out at 8 sites in the Taff catchment, and eyed salmonid eggs were planted out at 27 sites. Gravel cores were taken at 18 of these sites and an analysis of their composition was carried out, particular attention being given to the percentage of particles less than 1mm.

The green egg experiment was unsuccessful, probably owing to the delicate nature of the eggs at this stage of their development.

The higher reaches of the main river and major tributaries and certain clean minor tributaries gave high eyed egg survivals (>70%) while the mid to lower reaches gave only moderate (30-70%) or poor (<30%) survivals, especially below known point discharges of suspended solids.

The gravel coring in general gave higher percentages of particles less than 1mm below known point discharges of suspended solids, and an attempt at producing a correlation between egg survival and fines percentage was moderately successful.

It is concluded that the mid and lower reaches of the river will probably not be capable of sustaining a naturally reproducing salmonid population without further improvements in water quality.

2. Introduction.

A fish population survey was carried out at 67 sites in the R. Taff catchment in the summer of 1985 (Brown et al. 1986), which inferred that approximately 65% of the catchment contained relatively poor brown trout (*Salmo trutta* L.) populations.

As a consequence of these findings, a salmonid egg survival study was carried out in the winter of 1985/86 in order to assess the suitability of the river gravels for spawning.

A review of the literature revealed that several workers have found salmonid egg survival to be related to the percentage of fine solids of less than 1mm. in the gravels (Cordone & Kelley, 1961; Phillips et al., 1975). Egg development is retarded in gravels containing high levels of fine particles (Wells & McNeil, 1970; Witzel & MacCrimmon, 1982; Olsson & Persson, 1986). This may be related to a decline in level of dissolved oxygen as a consequence of the reduced permeability of the gravel (McNeil & Ahnell, 1964; McNeil 1966; Turnpenny & Williams, 1980).

In view of the findings of these workers, an attempt was made to relate the egg survival to the percentage of fine solids in the spawning gravels of the River Taff.

3. Study Area.

A description of the study area has been given in Brown et al. (1986) and Thomas et al. (1986).

4. Methods.

Green (i.e. freshly fertilised) rainbow trout (*Salmo gairdneri* Richardson) eggs were planted out at 8 sites in the catchment in November 1985 (Figure 1), and eyed (i.e. partly developed) brown trout eggs were planted out at 27 sites in February 1986 (Figure 2). Eggs were placed in batches of 100 in plastic Netlon boxes (Harris, 1973) packed with washed site gravel and buried in the river bed to a depth of approximately 25cm. At the majority of sites 6 replicate boxes were buried, the exceptions being one or two sites in very small streams in the headwaters of the system. In addition, at a local hatchery, several batches of control eggs were held in several forms:-

1, eggs in boxes containing unwashed gravel and buried in an artificial redd.

2, ditto but with gravel washed and seived to remove fine particles <1mm.

3 & 4, both the aforementioned but not buried,

5, eggs loose within Harris boxes unburied.

At sites 14, 18, and 26 brown trout swim-up fry were stocked in April 1986 at a density of approximately two per square metre over a stretch of about 500m. Five minute semi-quantitative electrofishings were carried out at all three sites in July, and a quantitative electrofishing was carried out at site 18 in September to facilitate a population estimate using the method of Zippin (1958).

Three cores of river gravel were taken using a freeze-coring technique devised by Stocker & Williams (1972) at 18 of the above sites (Figure 3), concentrating on sites known to contain relatively poor brown trout populations (Brown et al. 1986) and the samples subjected to particle size analysis. For particle sizes above 0.5mm. dry seiving was employed, while for particle sizes below 0.5 mm. a Malvern 3600E Type Particle Size Analyser VA3 was used.

5. Results.

Green egg survival is shown in Table 1. Survivals were very poor even at control sites where the natural brown trout populations were known to be good (Brown et al. 1986), and in no box did survival exceed 16%.

Eyed egg survival is shown in Table 2 and Figure 2. The categories for mean egg survival shown in Figure 2 were derived from the statistical plot shown in Figure 4, and sites were separated into three groups:-

Good	>70% survival.
Moderate	30-70% survival.
Poor	<30% survival.

Mean survivals well in excess of 70% (range 59-100%) were recorded at the control sites known to contain good brown trout populations. Conversely, moderate mean survivals of 30-70% (range 23-82%) or poor mean survivals of <30% (range 0-72%) were recorded at test sites where the natural brown trout populations were known to be poor (Brown et al. 1986). However, some considerable within site variation between survival of eggs in individual boxes was recorded. Overall, it appeared that the headwaters of the main river and clean tributaries gave good results, while the rest of the catchment was moderate to poor.

The control results indicated that there was no difference in survival between the different treatments, thus eliminating variation in gravel composition used within the boxes or burial technique as a factor in the survival of the eggs.

The fry stockings at Hirwaun on the Cynon (site 14) and Maerdy on the Rhondda Fach (site 26) were unsuccessful, a total of only two fish being caught at the former and none at the latter, despite six five-minute fishings being carried out at both sites. At Bedlinog on the Taf Bargoed (site 18) fry survival was good, a mean of 17 (range 12-21) 0+ fish being caught over six five-minute fishings in July, while the density of the stocked fry was 28 per $100m^2$ in September, representing a 14% survival of the fry originally stocked.

Gravel coring results are shown in Figure 3 and Table 3. The poorest sites in terms of percentage fines of less than 1mm. were found to be Whitchurch Brook (site 28) containing an average of 24% by weight of fines, mainly sand, and the Clydach below Lady Windsor Colliery (site 22) containing 20.6%, in this case coal solids. The site with the least amount of fines was Llandaf (site 13) with 5.5%.

A plot of mean percentage egg survival against mean percentage gravel fines <1mm. is given in Figure 5. The relationship is probably sigmoidal as shown by the dotted line drawn on the plot. The linear (solid) regression line on this plot was obtained from the analysis in Figure 6, carried out after removal of 0% survival values and outliers. Analysis indicated that there was a significant ($p=<0.05$) relationship between mean percentage egg survival and mean percentage gravel fines ≤1mm.

6. Discussion.

Several workers have shown previously that salmonid egg survival is related to the percentage of fine solids in the gravels. Cordone & Kelley (1961) in reviewing the subject concluded that even moderate silt deposition is detrimental and is probably one of the most important factors limiting the production of salmonids in streams. Since then other studies have confirmed this theory, amongst them Wells & McNeil (1970), Phillips et al. (1975), Witzel & MacCrimmon (1982), and Olsson & Persson (1986). High percentages of fine solids in the gravels reduce the permeability and therefore also reduce the dissolved oxygen concentration available for the eggs. (McNeil & Ahnell 1964, McNeil 1966, Turnpenny & Williams 1980); eggs starved of oxygen in this way are thus less likely to survive.

Salmonid egg survival has previously been shown to be poor in the rivers of industrial South Wales. In the R. Tawe survival was poor, with infiltration of gravel by fines occurring at all sites (FTUSW 1985). In the Taf Bargoed less than 3% survival was recorded below collieries, while at unpolluted sites egg survival was consistently above 80% (Scullion & Edwards 1980). In the R. Ebbw less than 2% of eggs survived during incubation below collieries, while 91% of eggs at control sites survived (Turnpenny & Williams 1980).

The experiment with green eggs failed probably because of the fact that eggs are more sensitive to mechanical shock at this stage of their development (Frost & Brown, 1967). Only a 10% maximum survival was recorded at the control sites. A similar failure was recorded by Turnpenny & Williams (1980).

In the R. Taff catchment eyed egg survival appears to be good (>70%) in the headwaters and clean tributaries identified by Brown et al. (1986), Thomas et al. (1986), and Bent et al. (1986), but below known discharges from colliery and coal processing sites, survival is generally poor (<30%) probably owing at least in part to the amount of fine solids in the gravel, (Figure 2, sites 10, 11, 12 and 13 on the Taff, 16 on the Cynon, 20 on the Taf Bargoed, 22 on the Clydach, and 24, 25 and 27 on the Rhondda). Thomas et al. (1986) showed a significantly higher concentration of suspended solids below the collieries in the Taff catchment, and one particular colliery was estimated to contribute 1496kg of solids per day to the river. This view was supported by the gravel coring exercise which showed in general that there was a higher proportion of fine solids in the gravels below collieries (Figure 3).

Percentage egg survival was correlated with mean percentage fines (Figures 5 and 6). In order to obtain this correlation, the following sites were excluded before carrying out the regression analysis summarised in figure 6; 11, 20 and 22 because the survival values were 0%, site 13 (gravel dewatered and caused 100% mortality), and sites 3, 21 and 28 which appeared to be outliers. It is worth considering the fact that the workers quoted above who found a distinct correlation between % fines and % egg survival were working on rivers receiving high suspended solids loads, but which were otherwise of good quality. However the River Taff is undoubtedly affected by pollutants other than fine solids such as ammonia (Thomas et al. 1986; Brown & Jones, 1985), and these pollutants probably have some effect on developing eggs, which may well have had a bearing on the results of this particular experiment.

The fry stocking experiment showed that survival was good at Bedlinog and, as the egg survival was also high, it is worth considering restocking this area of the Taf Bargoed, especially in view of the poor results at this site in the 1985 fish population survey (Brown et al. 1986). On the other hand, the fry survival was poor at Maerdy and Hirwaun suggesting coal solids problems at both sites, even though the egg survival results were more encouraging.

7. Conclusions.

A large proportion of the Taff catchment appears not to contain gravels suitable for successful salmonid spawning, probably partly as a result of the effects of point sources of suspended solids. Other contaminants such as unionised ammonia, or low intragravular dissolved oxygen concentration may be having an effect on survival at certain sites, e.g sites 11 and 16 (Cynon at Abercynon and Taff downstream of Cilfynydd Sewage Works respectively), but this would require further work to verify. However, lack of breeding success in those areas where egg survival was shown to be poor probably explains why trout populations are sparse in the mid to lower reaches of the system as found by Brown et al. (1986).

Further improvements in water quality and spawning gravel composition will undoubtedly be necessary before the mid and lower reaches of the catchment can support a naturally sustaining salmonid population. However, the upper reaches of the catchment support good salmonid populations (Brown et al. 1986), and provided that these areas are made accessible to migratory fish in the future, an improved yield should result.

8. Recommendations.

1. Further water quality improvements are needed in the catchment if a self-sustaining salmonid fishery is to be restored to the mid and lower reaches of the catchment.

2. The Taf Bargoed above Trelewis is possibly a case for restocking with brown trout in an attempt to recreate a fishery in this area, as both egg and fry survivals were good in the present study while the fish populations were poor in the 1985 survey (Brown et al. 1986).

3. In view of the recent closure of Maerdy Colliery at the head of the Rhondda Fach, a useful study could be undertaken of the structure of bed gravels and salmonid egg survival as the river recovers. This is one of the few areas within the catchment where suspended solids cause problems in an area where there are no other inputs of pollutants.

9. References.

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Table 1. R. Taff salmonid egg survival study. Green egg results.

SITE		N.G.R.	%SURVIVAL MEAN	%SURVIVAL RANGE
1.**	Taf Fawr d/s Llwyn-on	SO013108	0	0
4.	Taf Fechan at Cwm	SO060107	6	2-14
5.*	Nant Cwm-Moel	SO043098	3	0-10
7.***	Taff u/s Merthyr Weir	SO046061	0	0
14.	Cynon d/s Hirwaun	SN972052	2.5	2-3
15.*	Dare	SN994026	2.5	1-4
18.	Taf Bargoed u/s Bedlinog	SO088018	2	1-2
23.	Rhondda Fawr at Pentre	SS967958	6	2-16

* Control Site.

** Boxes lost by scouring during spate.

*** Boxes removed unintentionally during the course of land drainage operations.

Table 2. R. Taff salmonid egg survival study. Eyed egg results.

	SITE	N.G.R.	%SURVIVAL MEAN	%SURVIVAL RANGE
2.	Taf Fawr at Dan-y-Darren	SO022093	81	66-99
3.	Taf Fechan d/s Pontsticill	SO060114	88	66-95
5.*	Nant Cwm-Moel	SO043098	91	88-94
6.	Taff at Merthyr Gauging Sta.	SO042068	83	64-89
8.	Taff at Abercanaid	SO055041	88	75-99
9.	Taff at Pontygwaith	ST081975	63	43-82
10.	Taff u/s Cynon S.T.W.	ST081933	16	0-70
11.	Taff d/s Cilfynydd S.T.W.	ST085920	0	0
12.	Taff at Rhydyfelin	ST088883	17	1-61
13.**	Taff d/s Llandaf Weir	ST153785	0	0
14.	Cynon d/s Hirwaun	SN972052	76	62-90
15.*	Dare	SN994026	89	59-99
16.	Cynon at Abercynon	ST082955	26	0-64
17.	Taf Bargoed at Nant-y-Ffin	SO080053	62	0-93
18.	Taf Bargoed u/s Bedlinog	SO088018	93	82-100
19.	Taf Bargoed d/s Bedlinog	SO098002	77	66-90
20.	Taf Bargoed at Trelewis	ST104986	0	0
21.*	Clydach u/s Ffynon Dwym	ST045967	93	79-100
22.	Clydach d/s Lady Windsor	ST065932	0	0
23.	Rhondda Fawr at Pentre	SS967958	81	59-92
24.	Rhondda Fawr at Dinas	ST005919	25	6-72
25.	Rhondda d/s Porth	ST034910	44	32-61
26.	Rhondda Fach at Maerdy	SS975986	56	23-78
27.	Rhondda Fach at Porth	ST024916	12	1-36
28.	Whitchurch Brook	ST156797	91	77-98
29.*	Nant Ddu Controls	SO002150	95	95-95
30.*	Cantref Hatchery Controls ..	-------	98	98-100

* Control site.

** Gravel dewatered at this site.

Table 3. Gravel coring results. % fines <1mm.

	SITE	MEAN	RANGE
3.	Taf Fechan d/s Pontsticill	10.5	5.9-13.1
9.	Taff at Pontygwaith	7.4	5.4-10.0
10.	Taff u/s Cynon S.T.W.	7.7	5.2-10.3
11.	Taff d/s Cilfynydd S.T.W.	11.8	8.2-14.7
12.	Taff at Rhydyfelin	10.7	6.9-12.9
13.	Taff d/s Llandaf Weir	5.5	3.9- 6.4
14.	Cynon d/s Hirwaun	5.6	4.9- 6.2
15.	Dare	5.3	4.7- 5.7
16.	Cynon at Abercynon	7.7	6.1- 9.0
18.	Taf Bargoed u/s Bedlinog	7.2	4.8-10.5
20.	Taf Bargoed at Trelewis	10.4	8.5-11.4
21.	Clydach u/s Ffynon Dwym	12.2	9.2-16.6
22.	Clydach d/s Lady Windsor	20.6	14.4-25.9
24.	Rhondda Fawr at Dinas	8.6	7.0-10.2
25.	Rhondda d/s Porth	9.7	9.1-10.8
26.	Rhondda Fach at Maerdy	3.5	2.5- 5.1
27.	Rhondda Fach at Porth	10.6	9.8-11.8
28.	Whitchurch Brook	24.2	23.8-24.8

FIGURE 1

RIVER TAFF CATCHMENT

Showing positions of sites (numbered) at which green eggs were planted.

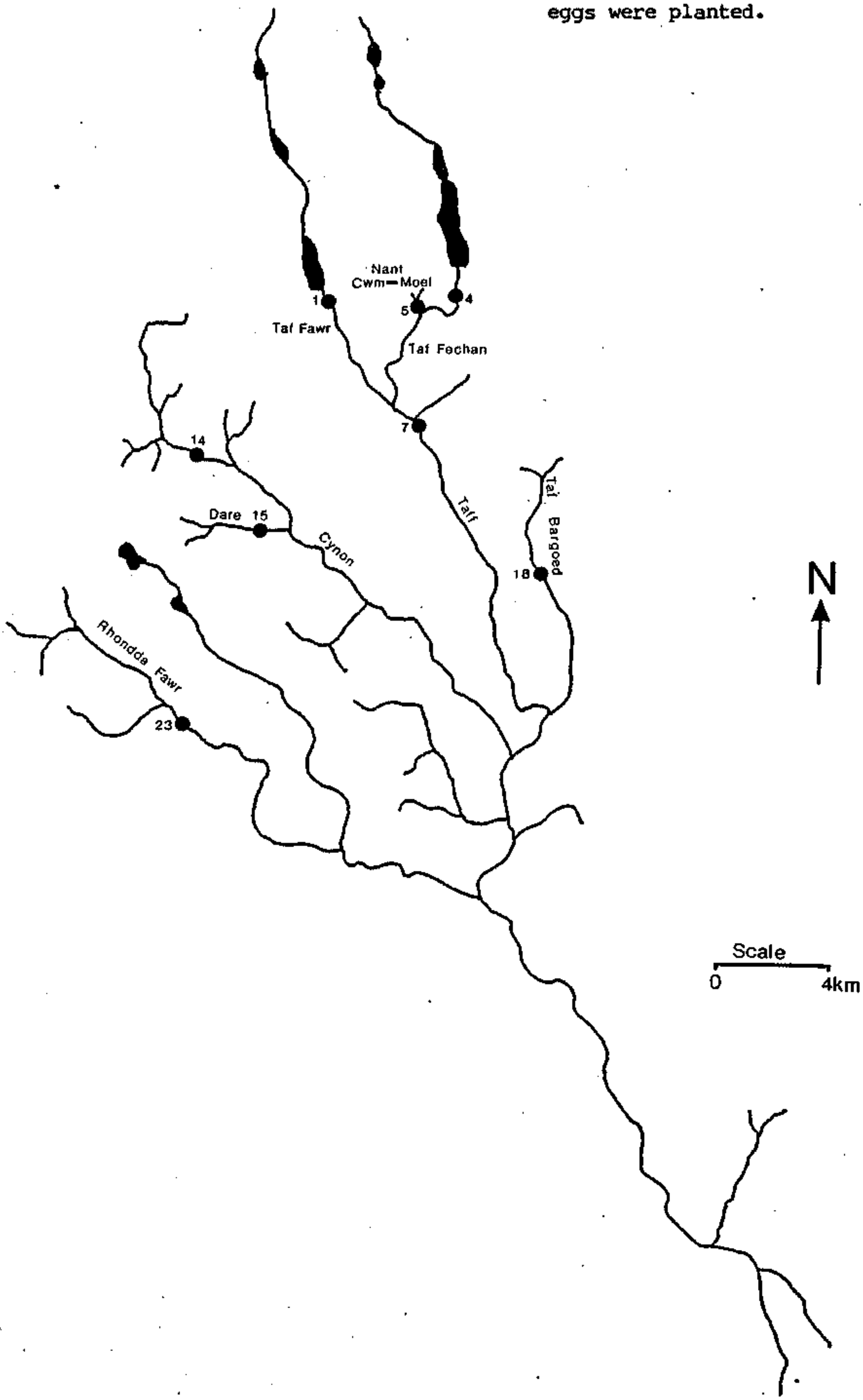
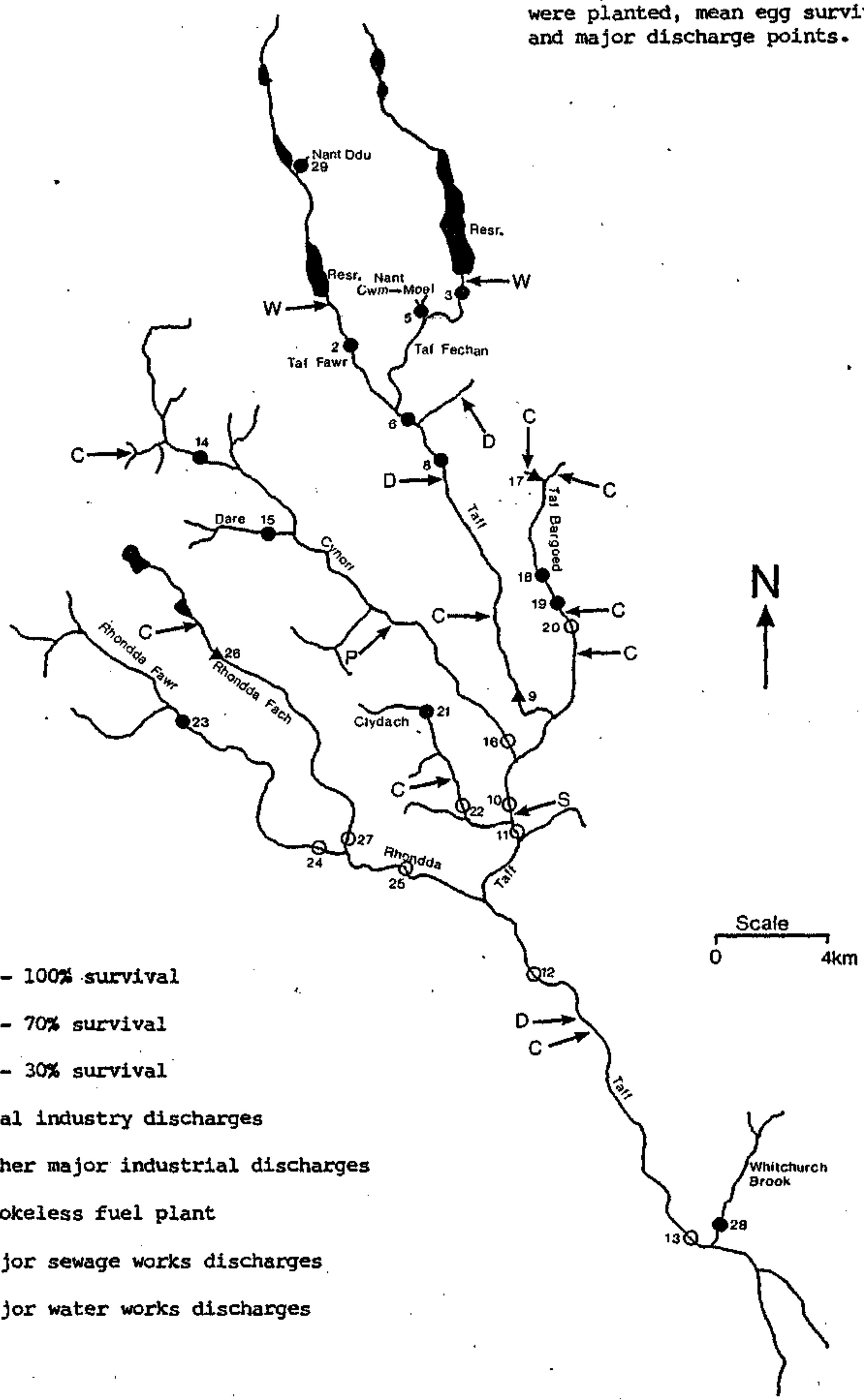


FIGURE 2

RIVER TAFF CATCHMENT

Showing positions of sites (numbered) at which eyed eggs were planted, mean egg survivals, and major discharge points.



KEY

● 70 - 100% survival

▲ 30 - 70% survival

O 0 - 30% survival

C Coal industry discharges

D Other major industrial discharges

P Smokeless fuel plant

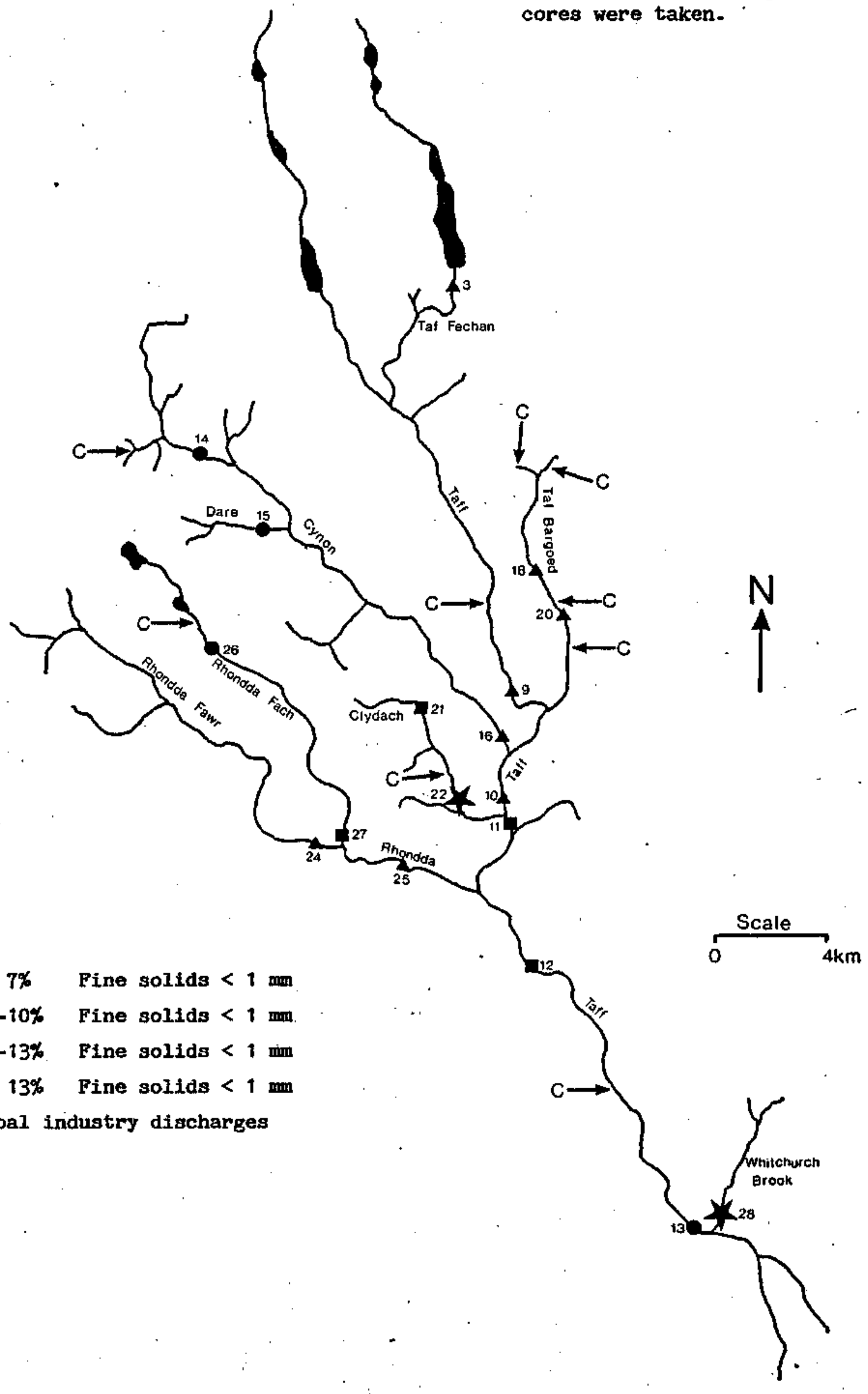
S Major sewage works discharges

W Major water works discharges

FIGURE 3

RIVER TAFF CATCHMENT

Showing positions of sites (numbered) at which gravel cores were taken.



KEY

●	< 7%	Fine solids < 1 mm
▲	7–10%	Fine solids < 1 mm
■	10–13%	Fine solids < 1 mm
★	> 13%	Fine solids < 1 mm
C		Coal industry discharges

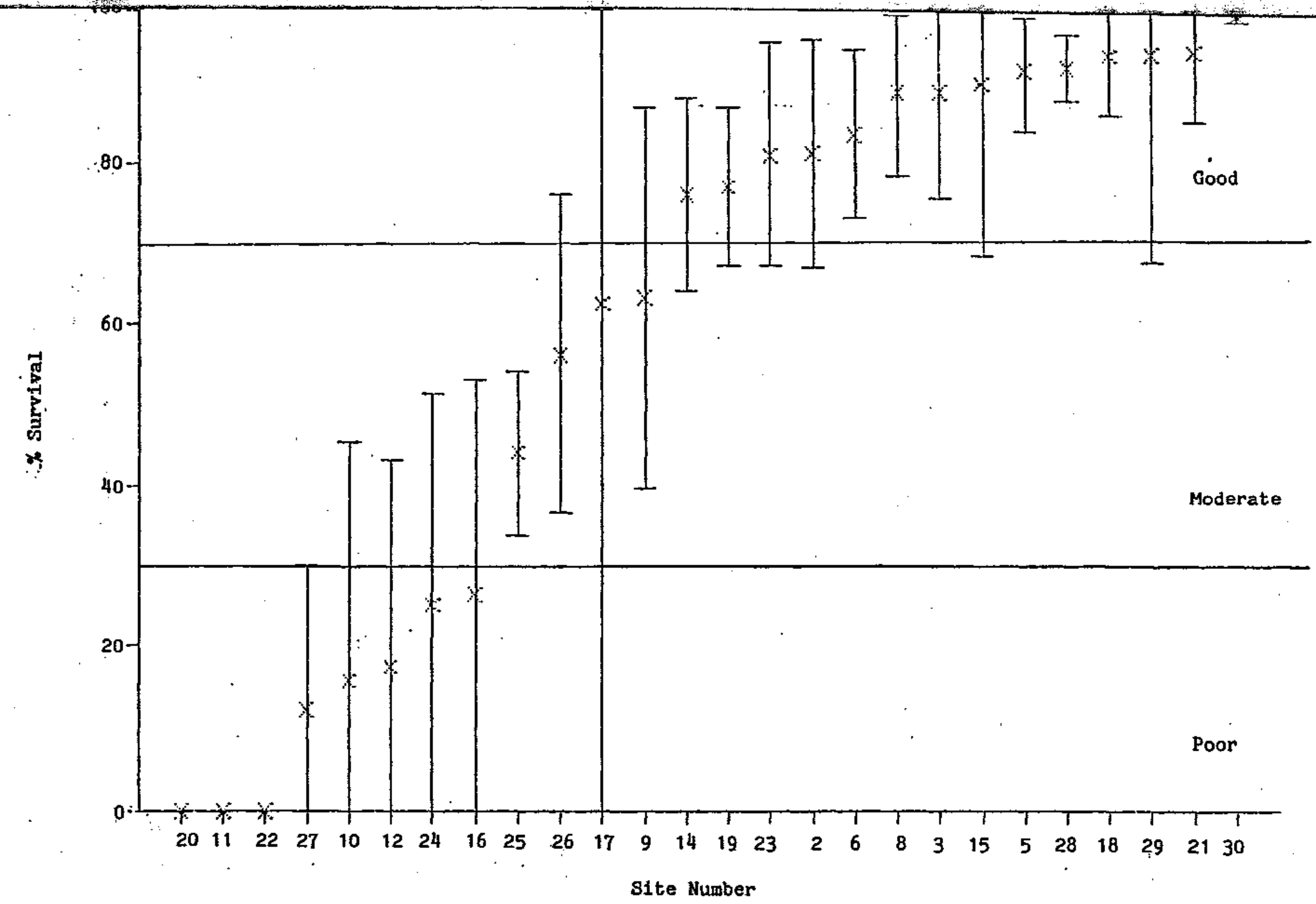


FIGURE 4 EGG SURVIVAL MEANS AND 95% CONFIDENCE LIMITS

FIGURE 5 **PLOT OF MEAN PERCENTAGE SURVIVAL AGAINST MEAN PERCENTAGE FINES < 1 mm**

All results are included except for site 13 (Taff at Llandaf) which dewatered.

The straight line was plotted from the regression equation in Figure 6. The points circled with site numbers adjacent represent results rejected in the regression analysis as being outliers (3,21,28) or those where 0% egg survival was recorded (11,20,22).

The inferred relationship is probably sigmoidal as shown by the dotted continuations at either end of the straight plot.

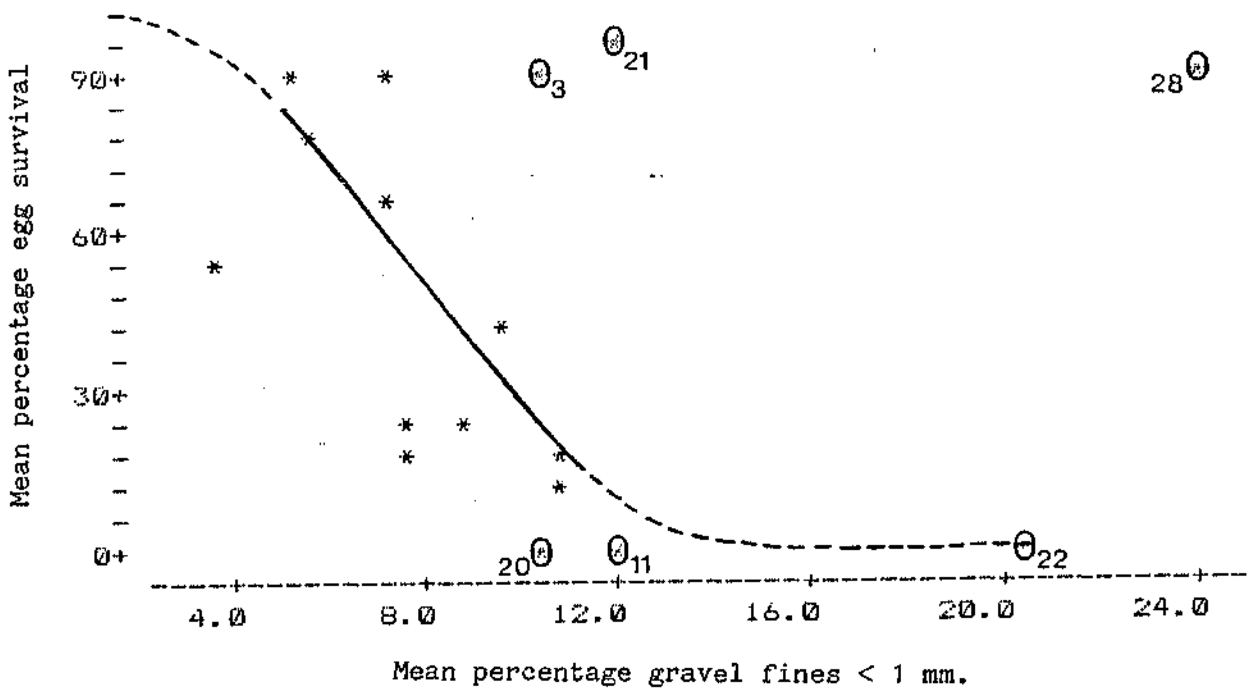
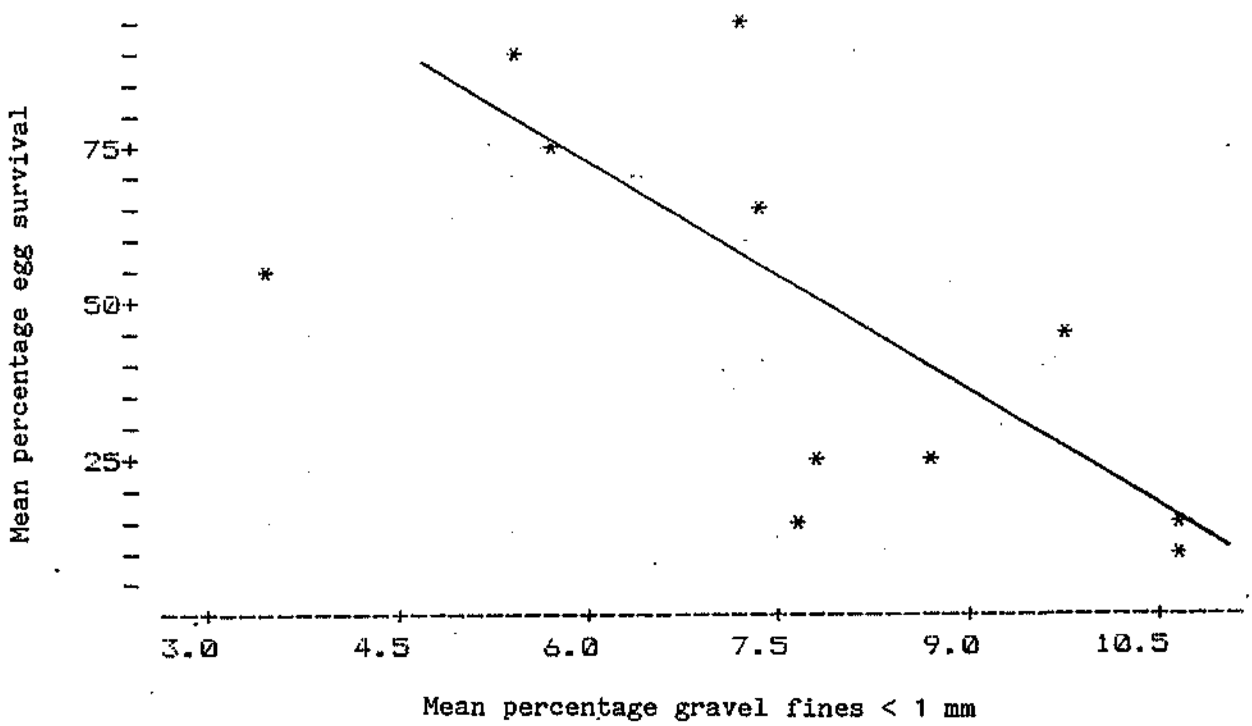


FIGURE 6 **REGRESSION ANALYSIS AND PLOT OF MEAN PERCENTAGE SURVIVAL AGAINST MEAN PERCENTAGE FINES < 1 mm**

The regression was obtained after removal of survival values of 0% and three others as shown in Figure 5.



The regression equation is
meansurv = 114 - 8.77 Mean

Predictor	Coef	Stdev	t-ratio
Constant	114.20	26.84	4.25
Mean	-8.774	3.380	-2.60

s = 24.02 R-sq = 42.8% R-sq(adj) = 36.5%

Analysis of Variance

SOURCE	DF	SS	MS
Regression	1	3888.0	3888.0
Error	9	5192.1	576.9
Total	10	9080.1	