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PERSISTENCE AND IMPACTS OF FINE SEDIMENT IN THE PRAIRIE CREEK
WATERSHED

A Progress Report to
the California Department of Transportation
July 1992

INTRODUCTION

The following is a progress report to the California Department of Transportation (Caltrans) documenting the impacts and persistence of fine sediment in the Prairie Creek watershed following a damaging 1989 October storm. This report updates the last annual progress report "Monitoring the Impacts and Persistence of Fine Sediment in the Prairie Creek Watershed 1990-1991 (Coey et al. 1991)". Fisheries impacts are reported in the following section. Physical effects are reported in the report attached to this section.

FISHERIES

Fisheries results recently generated from data collected in the winter of 1990-1991 are presented and discussed. We also describe work performed during this past winter of 1991-1992, and work still to be accomplished.

Most work listed as "still needs to be accomplished" in Coey et al. 1991 has been completed. All results for winter 1990-1991 will be detailed and compared to other study years in a final report that will be submitted to Caltrans after the 1991-1992 annual report is submitted on December 31, 1992.

Winter 1990-1991 Results

The study objectives, study area and methods for collecting data in the winter 1990-1991 were described in Coey et al. 1991 (enclosed). The following supplements those descriptions:

Supplement to Methods for Determining Effects on Coho Salmon Egg Survival

Percent Fines. When stream gravel samples are sieved to determine proportions in each size class, fine-grained organic particulates settle out with fine sediment < 0.5 mm. Streams within watersheds of old-growth redwood forests such as Prairie Creek usually contain large amounts of organic particulate matter. These non-cohesive organics are not as likely to seal off interstitial gravel spaces, thereby killing eggs, as fine inorganic material. Thus, the organic/inorganic composition of "fines" was determined to truly evaluate the impact of the inorganic fine sediment originating from the bypass on fish egg survival. Moreover, excrement and mucus contributed by worms within egg baskets introduced more organic matter into the gravel sample. To remove the effect of the organic component of sample fines in hatching and emergence baskets, organics were combusted and tests rerun to evaluate the impacts of only the inorganic component of fines on egg survival.

Organic matter mostly occurred in the fine sediment fraction < 0.5 mm. This fraction was ignited to burn off the organic matter. We weighed five-gram subsamples before and after burning at 450° for 24 hours in a muffle furnace. The percent difference in weight was recorded as the percent of organic matter within the subsample. The average percent organic matter for all 5 samples was applied to the whole sample, and new particle size distribution curves that omitted this fraction were developed for each redd. We then tested for differences in percent of fine inorganic material between the control and affected reaches. To evaluate the contribution of organics by worms, we compared percent of organic fines in baskets with worms vs. those without worms. Oligochaete worms (Haplotaxis ichthyophagus) found in emergence

baskets were weighed to the nearest gram.

Data Analysis. When paired t-test assumptions were strongly violated, the Wilcoxon Sign test was used. Non-parametric tests were often used to evaluate the emergence basket data, and the test used is indicated in the results section only when parametric statistics were not used.

Supplement to Results for Determining the Effects on Coho Salmon Egg Survival

Egg Survival. Approximately 70% of the dead eggs in the emergence and hatching baskets had eyed. Eyeing occurred after the largest storm of the year (in January), but before the second largest storm of the year (in March).

Because eggs were determined to die before they hatched, egg survival-to-hatching can be compared between hatching and emergence baskets. Mean egg survival for all the emergence baskets was higher (17.6%, SE = 4.3) than the hatching baskets (4.9%, SE = 2.4) ($P < 0.01$). When all baskets were separated by whether they were subjected to the January 12 storm, mean egg survival was higher in those unaffected by the storm (21.1%, SE = 5.1) than those affected (4.8%, SE = 2.1).

Fine Sediment. Similar to hatching baskets, fine sediment < 0.5 mm dominated the fine fraction < 4.7 mm in the emergence baskets, comprising 73% and 79% of the volume in the affected (Prairie Creek below Brown Creek) and control reach (Prairie Creek above Brown Creek), respectively. As was the case for hatching basket results, this report presents findings for the emergence baskets mostly for fines < 1.0 mm, unless otherwise stated, because statistical comparisons for fines < 0.5 mm and < 4.7 mm in these baskets were the same as for < 1.0 mm. Ratios of weight to volume < 1.0 mm determined for each basket were variable, ranging from 1.9 to 3.2. Therefore, both weights and volumes of fines are presented.

Mean fines by weight in emergence baskets was significantly greater in the affected reach than the control reach ($P < 0.10$), but the difference was not significant by volume using Kruskal-Wallis (K-W) or t-tests (Table 1).

Sites impacted by the January storm ($n = 4$, all in the control stream) had similar levels of fines in emergence baskets as sites not impacted in the control reach, and means were not significantly different ($P > 0.10$). The < 1.0 mm mean for storm-impacted sites was 2.0% by weight and 12.4% by volume (SE = 0.09 and 2.22); for other control sites it was 2.5% by weight and 12.0% by volume (SE = 0.71 and 2.66). When sites impacted by the January storm were removed from the analysis, differences in fines between control and affected reaches were no longer significant by either weight or volume ($P > 0.10$, K-W).

Only 12 freeze cores (6 from each reach) were successfully extracted from the 20 emergence baskets. One basket was destroyed by a bear, and three cores failed due to experimental error. Four other cores were incomplete samples because the gravel was not uniformly frozen.

Most of the fine sediment was located in the bottom strata where the egg pocket was located. Mean amounts < 1.0 mm and < 0.5 mm in this stratum were significantly greater in the affected reach than the control reach ($P < 0.10$, K-W) (Tables 2 and 3).

Due to experimental error, organic matter content was not obtained for one site above and one site below Brown Creek. Organic matter in fine sediment < 0.5 mm averaged over 9 hatching baskets did not significantly differ between the reaches above and below Brown Creek (K-W, $P > 0.10$). However, the percentages did differ between reaches for the infiltration bags, which included the hatching baskets and surrounding gravel ($P < 0.10$) (Table 4).

Table 1. Comparison of percent fines in emergence baskets after fry had emerged in the affected (below Brown) and control (above Brown) reaches of Prairie Creek, winter 1990-1991.

EMERGENCE FINES (%) < 1.0 mm						
PARTICLE SIZE (mm)	STATISTICAL TEST	MEAN BELOW BROWN	S.E.	MEAN ABOVE BROWN	S.E.	P*
BY WEIGHT						
< 4.7	T-Test	8.48	1.93	3.96	0.66	0.051
< 1.0	T-Test	4.51	0.90	2.29	0.39	0.048
< 0.5	T-Test	2.81	0.43	1.70	0.14	0.033
BY VOLUME						
4.7	Kruskal-Wallace	16.75	1.62	14.27	2.31	> 0.10
1.0	Kruskal-Wallace	13.58	0.97	12.18	1.67	> 0.10
0.5	Kruskal-Wallace	12.35	0.81	11.25	1.27	> 0.10

* Significance level: less than 0.10 was considered a significant difference between means.

After removing the organic component from fine sediment < 0.5 mm, percentages of the entire gravel sample in fines < 0.5 mm decreased only slightly (about 1%), and still did not significantly differ between the control and affected reaches (Table 4).

The effect of removing the organic component from emergence baskets and associated infiltration bags still needs to be determined.

Mean percent organic matter was not significantly different in baskets with any number of worms than those without ($P > 0.10$), but it was significantly greater in baskets with large amounts of worms than those without (Table 4).

Dissolved oxygen. Dissolved oxygen (DO) concentrations were high and similar in the affected and control stream reaches. In all locations tested within the artificial redd, DO did not significantly differ between the control and affected reaches ($P > 0.05$) (Table 5). Mean DO was higher in the overlying surface water than in the baskets in January and March ($P < 0.05$, paired t-test).

In either the control or affected reaches, mean DO also did not differ in any of the pipes before and after the incubation period ($P > 0.05$) (Table 6). However, below Brown Creek, mean DO significantly increased in the overlying surface water, although the change was small. DO was measured three times during the incubation period, and at no time did concentrations drop below 9.6 ppm. DO was not negatively and significantly correlated with fine sediment of any size class in the egg baskets in either reach or in the reaches combined. Neither was it positively correlated to egg survival-to-hatching or emergence or ending permeability in the baskets.

Table 2. Composition of fine sediment < 1.0 mm within freeze-cores sampled within emergence baskets in artificial redds on affected and control reaches of Prairie Creek, winter 1990-1991.

PERCENT OF FINES < 1.0 mm BY WEIGHT						
SITE LOCATION	Percent of stratum composed of fine sediment			Distribution (%) of total core fines across all strata		
AFFECTED REACH	BOTTOM 20-30 cm	MIDDLE 10-20 cm	TOP 0-10 cm	BOTTOM 20-30 cm	MIDDLE 10-20	TOP 0-10
1 (most downstream)	8.96	5.98	6.33	42.13	28.11	29.76
2	6.83	0.59	0.06	91.31	7.89	0.80
6	2.22	0.21	0.00	91.36	8.64	0.00
7	4.08	1.14	1.57	60.08	16.79	23.12
9	3.28	1.38	*	70.39	29.61	*
10	0.81	0.10	0.03	86.17	10.64	3.19
Average	4.36	1.57	1.60	73.57	16.95	11.37
CONTROL REACH	BOTTOM	MIDDLE	TOP	BOTTOM	MIDDLE	TOP
4	3.09	0.06	*	98.10	1.90	*
5	2.04	0.13	*	94.01	5.99	*
6	1.70	0.09	* *	94.97	5.03	*
7	0.52	0.36	0.23	46.85	32.43	20.72
8	0.74	0.34	0.14	60.66	27.87	11.48
9	2.41	0.14	*	94.51	5.49	*
Average	1.75	0.20	0.19	81.52	14.64	16.1

* The top stratum did not freeze properly in the sample.

Worms. Worms were more abundant in the affected reach than the control reach and appeared to have a negative impact on egg survival-to-emergence. Average worm weight per emergence basket was 22.0 g in the affected reach and 14.8 g in the control reach. Sixty-eight percent of all emergence baskets were infested with worms. Eighty percent of emergence baskets below Brown and 55% of baskets above Brown Creek were infested. Mean egg survival-to-emergence in redds was 11.9% (SE = 4.3) in all worm-infested redds and 30.0% (SE = 8.7) in all redds without worms. Separated by reach, survival in worm-infested redds was 7.8% (SE = 4.6) below Brown Creek; above Brown it was 18.5% (SE = 8.1). When worm-infested baskets were excluded, mean egg survival-to-emergence increased 2 1/2 times to 30.2% (SE = 1.6, n = 2) in the affected reach and 1 1/5 times to 29.8% (SE = 13.7, n = 5) in the control reach.

Of all 39 hatching and emergence baskets, 61% were infested with worms. The January 12 storm did not strongly affect worm abundance. In the control stream, worm infestation (50%) was only slightly higher in emergence and

Table 3. Composition of fine sediment < 0.50 mm within freeze-cores sampled within emergence baskets in artificial redds on affected and control reaches of Prairie Creek, winter 1990-1991.

PERCENT OF FINE SEDIMENT < 0.50 mm BY WEIGHT						
SITE LOCATION	Percent of stratum composed of fine sediment			Distribution (%) of total core fines across all strata		
AFFECTED REACH	BOTTOM 20-30 cm	MIDDLE 10-20 cm	TOP 0-10 cm	BOTTOM 20-30 cm	MIDDLE 10-20 cm	TOP 0-10 cm
1	4.13	3.05	3.60	38.32	28.30	33.38
2	5.27	0.48	0.06	90.66	8.30	1.04
6	1.83	0.15	0.00	92.25	7.75	0.00
7	2.51	0.73	0.90	60.53	12.71	21.76
9	1.78	0.82	*	68.36	31.64	*
10	0.55	0.05	0.00	91.03	8.97	0.00
Average	2.68	0.88	0.91	73.53	16.28	11.24
CONTROL REACH	BOTTOM	MIDDLE	TOP	BOTTOM	MIDDLE	TOP
4	2.00	0.01	*	99.64	0.36	*
5	1.70	0.11	*	94.08	5.92	*
6	1.63	0.06	*	96.22	3.78	*
7	0.27	0.23	0.19	39.56	33.37	27.06
8	0.41	0.16	0.07	63.82	24.94	11.24
9	1.94	0.11	*	94.70	5.30	*
Average	1.32	0.11	0.13	81.34	12.28	19.15

* The top stratum did not freeze properly in the sample.

Table 4. Comparison of percentage of fines < 0.5 mm composed of organic matter and percent of gravel sample composed of inorganic fine sediment < 0.5 mm in artificial redds in affected (below Brown) and control (above Brown) reaches of Prairie Creek, 1990-1991.

	Below Brown Creek		Above Brown Creek		P
	Mean	S.E.	Mean	S.E.	
Organics (%), HB ^a	12.3	1.40	13.6	1.54	>0.10
Organics (%), HIB ^b	12.2	1.95	16.7	1.65	0.098
Inorganics (%), HB	1.8	0.36	1.5	0.17	>0.10
Inorganics (%), HIB	1.7	0.29	1.6	0.17	>0.10
	With Worms, n=11		Without Worms, n=7		
Organics (%), HB	13.7	1.57	12.3	1.32	>0.10
	With Large # Worms, n=6		Without Worms, n=7		
Organics (%), HB	16.1	1.61	12.3	1.32	0.09

^aHB = hatching basket

^bHIB = hatching infiltration bag (includes hatching basket)

Table 5. Comparison of mean dissolved oxygen (ppm) in artificial redds and overlying surface water between the control (above Brown) and affected (below Brown) reaches of Prairie Creek, winter 1990-91. DO was measured when redds were first constructed (initial DO) and after the incubation period (final DO).

INITIAL MEAN DISSOLVED OXYGEN (ppm)						
PIPE LOCATION	STATISTICAL TEST	BELOW (Affected)	S.E.	ABOVE (Control)	S.E.	P
HATCHING BASKET	T-Test	10.8	0.1	10.9	0.1	>0.05
EMERGENCE BASKET	Kruskal-Wallace	11.0	0.1	11.2	0.1	>0.05
MILL CREEK PIPE	T-Test	11.1	0.1	11.2	0.1	>0.05
SURFACE WATER	T-Test	11.2	0.1	11.3	0.1	>0.05
FINAL MEAN DISSOLVED OXYGEN (ppm)						
PIPE LOCATION	STATISTICAL TEST	BELOW (Affected)	S.E.	ABOVE (Control)	S.E.	P
HATCHING BASKET	Kruskal-Wallace	11.0	1.8	10.4	0.2	>0.05
EMERGENT BASKET	Kruskal-Wallace	11.3	0.2	10.9	0.2	>0.05
MILL CREEK PIPE	Kruskal-Wallace	11.3	0.2	11.3	0.1	>0.05
SURFACE WATER	T-Test	11.6	0.1	11.4	0.2	>0.05

Table 6. Comparison of dissolved oxygen (ppm) in artificial redds and overlying surface water before and after the incubation period in the control (above Brown) and affected (below Brown) reaches of Prairie Creek, winter 1990-91.

MEAN DISSOLVED OXYGEN (ppm)						
PIPE	STATISTICAL TEST	BEFORE	S.E.	AFTER	S.E.	P
HATCHING BASKET (below)	Sign	10.9	0.1	11.0	0.2	> 0.05
HATCHING BASKET (above)	Paired T-Test	10.9	0.1	10.4	0.2	> 0.05
MILL CREEK PIPE (below)	Paired T-Test	11.0	0.1	11.3	0.2	> 0.05
MILL CREEK PIPE (above)	Sign	11.2	0.1	11.3	0.1	> 0.05
EMERGENCE BASKET (below)	Sign	11.0	0.1	11.3	0.2	> 0.05
EMERGENCE BASKET (above)	Sign	11.2	0.1	10.9	0.2	> 0.05
SURFACE WATER (below)	Paired T-Test	11.2	0.1	11.6	0.1	0.01
SURFACE WATER (above)	Paired T-Test	11.2	0.1	11.4	0.2	> 0.05

hatching baskets subjected to the storm than those not subjected to the storm. (40%). In the affected reach, 70% of all baskets exposed to the storm were infested versus 80% of all baskets not exposed to the storm.

A larger percentage of emergence baskets were infested than hatching baskets. However, numbers of worms were greater in those hatching baskets containing worms. This general observation was not quantified because weights of worms in the hatching baskets were not measured.

Correlations with Egg Survival-to-Emergence. Correlations found between egg survival-to-emergence and fines or permeability in the emergence baskets were very similar to the results found for egg survival-to-hatching. Egg survival-to-emergence was negatively correlated to percent fines < 1.0 mm by weight, but the relationship was weak with percent fines < 1.0 mm by volume (Table 7). A stronger correlation existed for sites below Brown Creek, but no significant correlations existed in sites above Brown Creek. Correlations between egg survival-to-emergence for fines < 4.7 mm and < 0.5 mm by weight and volume were similar, but in general, as particle size decreased from < 4.7 mm to < 0.5 mm, correlations became weaker and less significant. This is the opposite of the results for percent fines by volume in hatching baskets.

Permeability was not significantly correlated to egg survival-to-emergence for all sites or for just the sites in the control reach ($P > 0.10$). When only sites below Brown Creek were included, permeability variables (change in inflow rate and ending inflow rate) were correlated to egg survival-to-emergence ($r = 0.58$ and 0.60 , respectively, $P < 0.10$). Adding percent of volume in fines < 1.0 mm to this correlation improved the relationship ($r = 0.64$, $P = 0.056$, using change in inflow rate). Other variable additions did little to improve relationships.

Change in inflow rate in all emergence baskets was significantly and negatively correlated to the percent of fine sediment by weight (but not volume) found in these baskets. Separated by stream reach, this correlation was only significant below Brown Creek for fines < 4.7 mm. Most fines vs. ending flow rate correlations were not significant, except for < 4.7 mm below Brown Creek (Table 7).

Weight of worms in emergence baskets was not correlated to egg survival-to-emergence, nor did it contribute to any multiple regressions. Unlike hatching basket results, worm abundance did not significantly correlate with percentage of fines in the emergence baskets (Table 7).

The above results will be finalized and some graphed in the final report for winter 1990-1991. Some variables we had planned on analyzing will not be analyzed for the following reasons. Sediment < 0.125 can not be analyzed because the samples were so small that the expense of drying, combusting the organic matter, weighing, and analyzing these samples would probably not be worth the information gained. Size distribution of fry emerging from artificial redds will not be related to sediment impacts because size mainly varied with the time that investigators checked the trap tubes.

Table 7. Correlation coefficients (r) and significance (*) for variables sampled in artificial redds in Prairie Creek, winter 1990-1991.

	% SURVIVAL	PERMEABILITY		WORM WEIGHT
		% ▲ INFLOW	ENDING RATE	
PRAIRIE CREEK ABOVE AND BELOW BROWN CREEK				
BY WEIGHT				
< 4.7 mm	-0.64 ***	-0.57 **	-0.45 *	0.03
< 1.0 mm	-0.68 ***	-0.48 **	-0.31	0.10
< 0.5 mm	-0.72 ****	-0.46 **	-0.24	0.21
BY VOLUME				
< 4.7 mm	-0.51 **	-0.26	-0.14	0.03
< 1.0 mm	-0.47 **	-0.10	0.09	0.15
< 0.5 mm	-0.40 *	-0.01	0.22	0.25
PRAIRIE CREEK ABOVE BROWN CREEK (CONTROL)				
BY WEIGHT				
< 4.7 mm	0.03	-0.39	0.03	-0.21
< 1.0 mm	-0.21	-0.23	0.19	-0.02
< 0.5 mm	-0.46	-0.27	0.03	0.33
BY VOLUME				
< 4.7 mm	-0.22	-0.12	0.28	0.21
< 1.0 mm	-0.33	-0.08	0.26	0.38
< 0.5 mm	-0.38	-0.07	0.17	0.56
PRAIRIE CREEK BELOW BROWN CREEK (AFFECTED)				
BY WEIGHT				
< 4.7 mm	-0.87 ***	-0.48	-0.60 *	0.03
< 1.0 mm	-0.86 ***	-0.34	-0.46	0.08
< 0.5 mm	-0.82 ***	-0.27	-0.32	0.15
BY VOLUME				
< 4.7 mm	-0.76 **	-0.19	-0.43	-0.19
< 1.0 mm	-0.60 *	0.17	-0.01	-0.12
< 0.5 mm	-0.35	0.41	0.33	-0.06

* P < 0.10
 ** P < 0.05
 *** P < 0.01
 **** P < 0.001

Discussion

Many statistical tests were run on the results for the winter 1990 survival study using a significance level of 0.10. This means 10% of the tests showing significance may be in error. This random element was evaluated in the final report.

Although fine sediment and permeability were not measured before the January storm, comparison of redds exposed to the storm vs. those not exposed suggests that the January storm did not increase the amount of fine sediment infiltrating the redds, nor decrease permeability. Yet, egg survival to emergence was significantly less in exposed redds. Other variables were measured but related to the storm may be responsible. Superimposed on other fish, redd location, intragravel velocities will be evaluated in the final report.

The results suggest that grams of fine sediment infiltrating into the pockets of artificial redds decreased permeability, which may have caused low egg survival-to-emergence. This occurred in the emergence baskets in the affected reach, which had greater fines infiltration and lower permeability than the control reach. However, survival-to-emergence was as low in the control reach as it was in the affected reach. The additional data from winter 1991-1992 will hopefully help clarify variable relationships.

The volume of fines infiltrating redds did not show any strong relationship to survival or permeability. We expected volume to be more directly related to impacts than weight because fines fill in a specific volume of space within gravel. The variability in the volume/weight ratio for individual baskets may be an indicator that the correction factor for each size class to remove volume of water may not be sufficient. For the size classes, water weight seems to be highly variable.

All size classes of fines < 4.7 mm appear to have an effect on egg survival. A matrix of fine size classes dominated by < 0.5 mm that averages approximately 3 to 5% of the redd gravel weight appears to adversely affect egg survival.

Location of fines within the redds is important. Fines were always found in the egg pocket where it caused the greatest harm. The few eggs that survived to hatch were probably successful at emerging because they were not entrapped in the gravel by a surface layer sealed with fines.

Organic content was a relatively small fraction of the fine sediment in the baskets with a large amount of worms adding their excrement and organic matter to the sediment. Although organic matter was slightly greater in the control reach, its removal did not affect the results. These preliminary results suggest the organic fines were an unimportant variable compared to impacts from the bypass. Emergence basket data still needs to be evaluated, however, before making any conclusions.

The finding that the amount of worms in emergence baskets was not related to fines or egg survival but was related to hatching baskets is probably explained by timing of worm emigration. Once worms have fed on the eggs in the hatching basket, they seem to disperse. When hatching baskets were opened, worms were still present. By the time we opened emergence baskets, worms were more dispersed; probably, the majority had already emigrated.

Even though permeability rates decreased over time in the artificial redds in the affected reach, DO within the same redds did not significantly decrease. Moreover, DO levels were very high, only slightly lower than saturation concentrations, and adequate for developing salmonid eggs. Therefore, the fine sediment is not preventing oxygen permeation into the egg pockets.

for the fact that egg survival was markedly poor. DO measured within a pipe may not represent the DO concentrations infiltrating the gravel pores surrounding the eggs. After the apparent velocity results are calculated, delivery rates of DO into the egg pocket can be estimated to determine whether the water found to contain high levels of oxygen was supplied to the eggs.

Some of the data need to be combined for emergence and hatching baskets before the effect of the bypass in winter 1990-1991 can be determined. This information in conjunction with data collected in 1991-1992 should assist with sorting out bypass-related impacts and natural variability on streams. Results in the final report will also be compared to the scientific literature to assist in interpretation of the results.

Percent Fines in Natural Redds

Mean fine sediment amounts did not significantly differ among the affected and control reaches for any size classes ($P > 0.10$, K-W) (Table 8). Nor were there significant correlations in any reach between percent fines < 4.7, 1.0 and 0.5 mm and number of fry produced.

Table 8. Comparison of percentages of fine sediment found in natural redds after fry emerged on the affected Prairie Creek reach (below Brown Creek) and control reaches (Prairie above Brown and Lost Man Creek), winter 1990-1991,

Percentage of Fine Sediment							
	Prairie below Brown Creek		Prairie above Brown Creek		Lost Man Creek		
Size class	Mean	S.E. (n)	Mean	S.E. (n)	Mean	S.E. (n)	P
< 1.0 by weight	8.1	1.9 (6)	9.1	5.3 (3)	13.2	2.0 (3)	> 0.10
< 1.0 by volume	9.2	2.6 (6)	7.8	3.1 (3)	15.1	6.9 (3)	> 0.10

Discussion

Percentage of fines in natural redds were considerably larger and more variable than percentage of fines found within the artificial redds. However, these redds were created by natural spawners at different times, which probably accounts for the greater variance. Timing of emergence of natural and artificial redds were generally similar, however. We do not know if the McNeil samplers adequately sampled the entire egg pocket, but we know the infiltration bags sampled it and probably captured more of the infiltrated sediment than the McNeil samplers. Although the fry traps were in the stream only for a brief period of time, the fry traps may have caused some fine sediment to accumulate under the frames. For this reason, fine percentages in the redds after emergence may be artificially elevated. Fortunately, the traps were not on when the eggs were expected to still be incubating, so the elevated levels may not have affected the survival-to-emergence results. Fines in trapped natural redds will not be sampled in the future because of the apparent trap effect.

Size distribution of fry emerging from natural redds was variable because some fish stayed underneath the trap's netting for a while before swimming into the capture bottle. As a consequence, these data are difficult to interpret and are not reported here. They are available at the Arcata office.

Winter 1991-1992 study

Study Objectives

During the winter of 1991-1992 Redwood National Park continued the study initiated in winter 1989-1990 to determine sediment impacts caused by the Highway 101 Bypass construction project on salmonid redds. We are specifically studying the effects of infiltration of fine sediment, permeability, apparent velocity and dissolved oxygen on coho salmon egg survival.

Coho salmon egg mortality was very high in the winter of 1990-1991, particularly in stream sections heavily impacted by sedimentation. The relationships between egg survival and bypass-produced sediment were not clear. A second year of study was added to increase the sample size and to separate confounding natural and experimental design factors from bypass-related effects.

Methods

Methods followed those described in Coey et al. 1991 except for the following changes:

The previous year of study suggested that several variables--proximity of redds to tributaries, geometric mean diameter of gravel, streambed slope, streamflow and sediment flux--influence infiltration of fines into redds. We attempted to hold most of these variables constant when selecting sites for artificial redd construction. However, sediment flux increases in a downstream direction as each tributary deposits more sediment into the mainstem. Sediment flux could not be held constant over the entire system. Therefore, similar to the previous year, sampling effort on Prairie Creek was stratified by reaches bounded by the tributaries, Brown, Big Tree, and Boyes Creeks. Unlike the previous year, however, each reach was split into two groups: (1) areas immediately below the bordering tributary and (2) the rest of the reach. We hypothesize that areas below the tributaries are subject to greater sedimentation from tributary inputs than areas farther downstream.

The Prairie Creek stream section above Brown Creek that served as a control reach during the previous year was found to be more impacted by sediment inputs from the bypass (from the affected tributary, Ten Tapo Creek) than previously thought. Thus, Lost Man Creek was added as a second control reach in winter 1991-1992. Five redds each were constructed in the control reach above Brown Creek and in Lost Man Creek; five each were constructed below Big Tree Creek and below Boyes Creek. Of the sets of five, two were in strata influenced by tributaries and three were in the strata not influenced by tributaries. Because numbers of natural redds have been low in the reach between Brown and Big Tree Creeks, this stratum was not included during initial sample allocation. To increase the sample size of sites influenced by tributaries, however, two additional redds were constructed just below the Brown Creek confluence.

Baskets designed to determine egg survival-to-emergence were omitted from the experiment since data in 1991 suggested mortality occurred during the egg stage prior to hatching. Instead, two baskets testing survival-to-hatching were placed in each redd to achieve replication within riffles.

To determine mortality due to handling, nine baskets containing eggs from each female used in the study were placed in a gravel-filled basket in a trough receiving streamflow from an unimpacted tributary of Prairie Creek. These were incubated until the eyed stage, removed, and number of dead eggs were counted.

Permeability and DO were measured only initially after placement of baskets in the redd in the stream and just before basket removal. Any worms found in baskets were weighed.

Natural redds were trapped within the same reaches the artificial redds were constructed. Ten natural redds on Prairie Creek (5 below Brown and 5 above) and nine natural redds on Lost Man Creek were capped to determine success and timing of natural fry emergence. Redds were capped earlier than in 1991 to prevent superimposition of redds by other spawners. Fines in gravel samples from last year's natural redds showed no relationship to fry emergence, which was attributed to the tendency of fry traps to accumulate fines. For this reason, testing gravel samples in natural redds for fine sediment content was omitted for the winter 1991-1992 study.

Work accomplished to date

Four female coho salmon contributed 4400 eggs for the 22 artificial redds and 900 eggs for the nine baskets that tested handling mortality. About half the eggs from each fish were not placed in baskets, but were incubated by PCFFA in hatch troughs to determine fertility rates.

Hatching baskets were removed during March. All stream and redd monitoring data has been entered onto computer spreadsheets; however, results have not been statistically analyzed. About half of the gravel samples have yet to be sieved. Fry from natural redds have recently completed emergence, and fry traps have been removed.

Preliminary Results

Due to hatch trough problems, egg baskets used to determine handling mortality yielded higher survival rates than fertility rates determined from the hatch troughs. Consequently, rather than use hatch trough rates to account for egg infertility, mean survival rates from the handling mortality test baskets for each fish will be used to adjust egg survival rates found in the artificial redd baskets. egg fertility.

Survival data has yet to be adjusted for fertility, but early indications are that infiltration of fines appears to be lower and egg survival-to-hatching appears higher than that in 1990-91. Annual precipitation was lower this year, also, and baskets were removed prior to the largest storm of the year on April 17, 1992. Number of emerging fry from the natural redds appears to be lower than last year. Fine sediment accumulation under the fry traps appeared to be high, possibly because the traps were placed on the redds sooner than last year.

Work Still to Be Accomplished

After the gravel samples are sieved, all data collected during this year's study will be analyzed and presented in a report to Caltrans by December 31, 1992.